KenGen

Kenya Electricity Generating Company Limited

APPENDIX 1:

EMPLOYER’S REQUIREMENTS /SPECIFICATIONS
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EMPLOYER’S REQUIREMENTS
/SPECIFICATIONS
1 GENERAL INFORMATION AND REQUIREMENTS

1.1 INTRODUCTION

1.1.1 Gitaru power plant is the largest power plant in Kenya; it has three (3) Francis turbine Hydro generating units, unit 2&3 were commissioned in 1978 and unit 1 in 1999. Unit 2&3 turbines drive 15KV generators of vertical shaft with salient pole design. Unit 2&3 are connected directly to step up transformer (15KV/132 KV) without switchgear in between. Synchronizing switchgear is on the 132KV side. The existing generator and GSU transformer protection is combined; electromechanical relays are currently in use for unit 2&3. The electromechanical relays were installed in 1977.

1.1.2 The control system in Gitaru is composed of two systems; automation PLC and the manual control system realized through relay logic. Manual control system has all requisite operator commands to the field devices via use of push buttons allowing control of all field equipment: - governor, pumps, excitation etc. All alarms and trip functions are wired individually to this system, but alarm facia is grouped for each system. The automation PLC receives status, alarm & trips signal from all field equipment and its able to send commands to all field equipment. A selector switch Manual /auto is used to interlock the two control systems. The commands sent from the PLC go to the field devices via the robust relays in the manual control system. The units are normally operated in auto mode by the PLC; PLC’s are interconnected to KenGen SCADA system. Operator monitoring, and commands are carried out from a remote-control centre.

1.1.3 In order to improve power plant operations, KenGen has decided to rehabilitate the Protection and some station low voltage distribution boards. KenGen also intends to install new generator switchgear for units 2 & 3 to allow synchronization at 15KV and independent operation of the GSU transformer.

1.1.4 The project scope covers: studying of existing systems; design, Manufacture, Testing and training at the Manufacturer’s Factory; shipping & delivery to site (DAP); removal of existing equipment, Erection, Site Testing and Commissioning; generator MV switchgear, LV switchboards and protection systems of Gitaru hydro power station in Kenya. Detailed scope is covered under clause 1.5 and clause 2 of specifications

1.1.5 The project shall be organised into the following three subsections:
(a) Unit 2&3 MV generator switchgear
(b) Unit 2&3 lprotection systems and SCADA systems
(c) Station low voltage switchboards

1.1.6 Detailed technical proposals must be submitted with the bid and separate tender form.
1.2 DEFINITIONS

Whenever the following terms or words are used in the specifications or any other documents forming part of this tender document, they shall have the following meaning unless otherwise stated:

1. AC: means Alternating Current
2. ACB: means Air Circuit Breaker
3. ADC: means Analogue to Digital Conversion
4. AVR: Automatic voltage regulator
5. BOM: shall mean Bill of materials or list of equipment
6. CB: means circuit breaker unless otherwise stated
7. CT: means current transformer
8. DAS: Data acquisition system - System whose main function is to acquire, format and transfer to another system for processing
9. D-AVR: Digital Automatic voltage regulator
10. DC: means Direct Current
11. EDG: means Emergency diesel generator
12. ETU: Shall mean electronic trip units commonly used in low voltage circuit breakers
13. FAT: Factory acceptance tests
14. FIDIC: Fédération Internationale des Ingénieurs Conseils (International Federation of Consulting Engineers)
15. GCB: shall mean generator circuit breaker
16. GSU: Generator step up transformer
17. HMI: Human machine interface - In this document refers to hardware and/or software required for human user to interface to the systems supplied for control and monitoring purpose
18. HV: High Voltage: operating voltage higher than 52.5 Kv
19. HVAC: Heating, ventilation and air conditioning
20. IED: Intelligent electronic device: refers to programmable microprocessor based electronic devices e.g. numerical protection relays, smart relays etc. used in industrial environment for instrumentation, metering, control or protection purposes.
21. IP xx: Ingress protection: means “Degree of Protection Provided by Enclosure”, and shall be according to IEC 60529
22. LAN: Local Area Network
23. LV - Low Voltage: operating voltage below 1000V. (For transformers, the term Low Voltage Winding is used for the side with lowest rated voltage regardless value)

24. MCCB: means Moulded case circuit breaker

25. MPCB - Motor protection circuit breaker

26. MCB: means Miniature circuit breaker

27. MV - Medium Voltage: operating voltage higher than 1000 V and up to 52.5 kV.

28. NC - Normally closed

29. NO - Normally open

30. NSTA- National Standards and Testing Authority

31. OEM - Original Equipment manufacturer

32. OLTC - On Load Tap Changer

33. OPC - Open Platform Communications (OLE for process control)-shall imply the widely-accepted communication platform for real-time plant data exchange between control devices from different manufacturers

34. OPC UA - OPC Unified architecture

35. OPC DA – OPC Data access

36. PC - Personal computer: Refers to IBM PC compatible computers i.e. intel X86/X64 based personal computers running windows operating system

37. PIMS - Plant information management system

38. PLC - shall mean Programmable Logic Controller unless otherwise defined in the document

39. SAS: Substation Automation System

40. SAT: Site acceptance tests

41. SCADA: -shall mean Supervisory control and data acquisition system. Client/KenGen SCADA shall mean the existing SCADA at the power plant operated by the client

42. SDG-SCADA data gateway- multi protocol converter for SCADA communication protocols

43. SLD: - shall mean single line diagram

44. SOE: - Sequence of events

45. SPST - Single pole single throw

46. SPDT - Single pole double throw

47. Station/plant - These words shall predominantly refer to Gitaru power station in the tender unless implied otherwise by the sentence

48. System- Could mean a physical (hardware) system or a software system
49. **Unit**: Shall in many occasions in this document refer to complete generation unit composed of Turbine, generator, GSU transformer, control system and balance electrical and mechanical system. (Gitaru has three units) unless implied otherwise by the sentence

50. VT: means voltage transformer
1.3 GENERAL MANDATORY SPECIFICATIONS

1.3.1 All documents shall be in ENGLISH language ONLY. The SI-system (meter, Newton, second) shall be used throughout the works covered by this Specification.

1.3.2 Systems specified in this tender and all associated systems shall be designed to ensure continuity of operation under all working conditions and to facilitate inspection, maintenance and repairs. All reasonable precautions shall be taken in the design of equipment to ensure safety of personnel concerned with the operation and maintenance of the equipment.

1.3.3 All components shall be adequately rated or sized for their most onerous duty at the specified environmental conditions. Due account shall be taken of any heat generated by the equipment therein and the components shall be appropriately selected, rated or de-rated as necessary to suit the most onerous operating temperature within the equipment.

1.3.4 All Works shall comply with the technical guarantee data stated in the specifications. The Contractor shall be responsible for any discrepancies, errors and omissions in the particulars and guarantees.

1.3.5 All apparatus, accessories or fittings which may not have been specifically mentioned, but which are usual or necessary in the respective equipment for the completeness of the finished work in an operable status, shall be deemed to be included in the Contract and shall be provided by the Contractor without any extra charge. All equipment shall be complete in all details, whether or not such details are mentioned in the Specifications.

1.3.6 Any reference in the quantity and price schedules, the delivery period schedule or in the various clauses and schedules of the text of either the Specification or the Bid, to any equipment shall imply equipment that is complete with all accessories, apparatus and fittings as outlined.

1.3.7 All materials and skilled labour, whether of temporary or permanent nature, required by the Contractor for the design, manufacture, erection and testing at site of the equipment shall be supplied and paid for by the Contractor.

1.3.8 If in conflict, the ranking of documents in the technical specifications, in decreasing priority, is as follows:

(a) Particular technical specifications
(b) Existing equipment drawings
(c) Scope of Works
(d) General technical specifications
(e) General specifications
If the Tenderer is of the opinion that there is conflict or disagreement between the particulars of the documents, standards etc, it must be clearly stated in the tenderer Bid offer document, failure to which, the materials and equipment offered shall be deemed to comply in every respect with the current Specification both in manufacture and in performance, and compliance thereof shall be insisted upon without additional cost to the Employer.

Specifications given in general technical requirements shall apply to all Equipment specified in the particular specifications. The equipment, devices etc. whose specifications have been provided in general technical specifications shall be used in the subsections of the project specified by each particular specification. If there is a conflict between general technical specifications and particular technical specifications the latter shall prevail.

The bidder shall visit the site and get acquainted with the actual requirements of site prior to quoting rates. No claims for inadequate description of the scope shall be entertained at a later date.

Deviations to this specification SHALL NOT be acceptable unless specifically indicated in the offer in the relevant schedule “deviation from specifications form”. All deviations shall be clearly spelt out by the Bidder and the price implication thereof. Any implied deviation or any deviation mentioned elsewhere in the offer shall not be considered.

It is not the intent of this specification to completely specify all details of design and construction herein. Nevertheless, the equipment and installation shall conform to high standards of engineering design and workmanship in all respects and shall be capable of performing continuous operation in a manner acceptable to the client. Reliability, availability and maintainability are of the utmost importance to the client in the design of the equipment described herein.

All equipment/components to be supplied should have spares available for the next 15 years after installation.
1.4 TENDER BID DOCUMENTATION BY TENDERER

Tender bid documentation will guide the client during the tender evaluation. Documents shall clearly demonstrate the bidders offer compliance to employer requirements. The following Documents shall be provided

1.4.1 Bidders’ Technical Proposal

1.4.1.1 A proposal containing drawings, data & information elaborate enough to enable the employer to comprehend and assess the vital details, features, capabilities and functioning of the equipment offered and their arrangements shall be included in the bid offer.

1.4.1.2 Bidders technical proposal shall offer a clear response to the employers’ specifications.

1.4.1.3 Technical proposal shall be provided in hard and soft copies

1.4.1.4 It shall clearly demonstrate the complete scope of work as defined by the specification and MUST include, but not be limited, to the followings: -

(a) Method statement -Proposal on how the project shall be implemented. The contractor shall respond to employers’ requirements in the general specifications (chapter 1.0 of employers’ requirements). Shall provide a response to employer’s requirements on project implementation services to be offered, elaborate how they intend to minimize machine outage time and demonstrate their work plan.

The proposal shall briefly (5-10 pages) demonstrate how the bidder proposes to carry out the following:

(i) Studying of Gitaru power plant and associated power system for design purpose

(ii) Design and design review/approval by client

(iii) Manufacture

(iv) Factory training

(v) Factory Inspection and acceptance testing, FAT

(vi) Packing and transportation

(vii) Storage at site

(viii) Pre-outage works and other preparation works

(ix) Disassembly of existing systems

(x) Erection and Installation

(xi) Site acceptance tests, commissioning and reliability run

(xii) On job training during installation and commissioning
(xiii) post commissioning site training
(xiv) Technical documentation as described in clause 1.7 of specifications

(b) **Implementation program**, in Gant chart format. The Gant chart shall illustrate a comprehensive [summary] work programme, showing all the activities and duration required, from tender award stage to full commissioning of the equipment in chronological order. ALL project activities and duration MUST be clearly illustrated

(c) **Quality control plan.** A brief quality control plan (2-5 pages) specific to this project is required it can be based on a similar project executed by the bidder

(i) The quality control plan shall demonstrate how the project shall be implemented to ensure adherence to employer specifications, approved designs and standards. The bidder shall borrow from their vast experience in similar projects but considering the conditions at site. It shall include narration of specific quality control mechanisms measures at design, construction, manufacture, erection, installation, testing and commissioning. The presentation shall include method of supervision of the subcontractors/sub suppliers and safety precautions during testing, installation and commissioning.

(ii) Bidders company quality control manuals are not required though they may be referenced and given in soft copy.

(d) **Preliminary Bill of materials (BOM)** dully filled and Bidder’s scope of supply if not covered by the provided preliminary bill of materials.

(e) **Single line diagrams** showing all major components to be offered i.e. Protection, LV switchboards and generator switchgear systems. Separate single line diagram for each system. The SLD’s shall show interconnection to all the relevant systems in the power plant that are not part of the scope e.g. generators, transformers etc. They shall be detailed enough to clearly show the basic functionality of each system and illustrate interconnection of most of the components stated in the list of equipment. Bidder may refer to specification drawings provided by the employer (volume 4) for guidance. The following SLD’s MUST be provided for the bid to be responsive

(i) Medium voltage switchgear for unit 2 & 3
(ii) Generator and GSU transformer and protection
(iii) Auxiliary supplies protection (EDG, alternative supply transformer and station transformer)

(iv) Protection physical ethernet communication layout
(v) Main station auxiliaries’ switchboard
(vi) SCADA communication gateway layout diagram

(i) **Dimensioned panel arrangement drawings** for all panels in the offer

(g) **Panels layout diagrams** dimensioned and showing the main components on each panel for: protection, SCADA interfacing cubicles, LV switchboard and generator MV switchgear systems.

(h) **Dimensioned generator switchgear housing and mounting structure**, showing switchgear housing dimensions and panel placement and Mounting structure dimensions

(i) **Technical schedules** duly filled

(j) **Deviation from technical specifications schedule** duly filled if applicable

(k) **Reference list of manuals, datasheets and catalogues** - a list of all manuals and technical data sheets provided by the bidder in softcopy shall be provided. The list shall contain the following information in columns

   (i) Equipment/device name
   (ii) File name of manual/data sheet of the soft copy provided
   (iii) Web address where the file can be accessed- where possible
   (iv) File access path if they are several folders and subfolders in the soft copies submitted e.g. (Vol5/protection/transformer IED manual)

1.4.2 **Type test reports & certificates**

1.4.2.1 Type test reports & certificates shall be certified by a EU/USA/Canadian National Standards and Testing Authority (NSTA) or by a third party (not manufacturer or manufacturer subsidiary) Reputable Testing Authority accredited by a EU/USA/Canadian National Standards and Testing Authority (NSTA).

1.4.2.2 Type Test Reports shall meet the following requirements:

   (a) Type Test Reports shall be carried out by a laboratory independent from the manufacturer.

   (b) Where a body other than NSTA stated above is used to certify the type-test reports, a copy of the certificate of accreditation shall be attached.

   (c) Results of type test shall have been conducted at least 6 months and not more than fifteen years prior to the date of tender submission. The contractor shall submit contact details (Title, email, and fax) of certifying laboratory during design.

   (d) Testing materials and equipment in Type Test Reports shall have the same code/ country / manufacturer and technical parameters as offered materials
and equipment. Type tests of non-conforming materials/equipment shall not be accepted.

(e) Type Test Reports shall include all items tested and results confirming that they meet the requirements of applied standards as stipulated in Tender Documents.

(f) Type Test reports shall have Report Numbers for authentication.

(g) Current contact information of the testing and certification authority shall be provided during design.

1.4.2.3 The following type tests reports and certificates for type tests carried out as per stated standard less than ten years from the date of bid opening for the following equipment specified in the tender MUST be included in the bid:

(a) Two (2) reports/certificate for MV Generator circuit breakers in accordance to IEEE C37.013 or IEC/IEEE 62271-37-013 for the following tests
   (i) Tests to verify short circuit interrupting current capability at 17.5kV for generator source faults @ short circuit current of 63kA. Tests to include ability of the circuit breaker to
      - interrupt Short Circuit Current with Delayed Current Zero
      - withstand rated Transient Recovery Voltage TRV for generator source faults
   (ii) Tests to verify minimum number of load switching operations at rated current (5,000A), report to show circuit breaker can endure severest number of operations defined in the standard
      One report or certificate is acceptable if it contains all the tests above

(b) Three (3) reports/certificates for MV Generator switchgear (complete switchgear) as per IEC62271-200 for the following tests
   (i) Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents (63kA/3s and 173kA)
   (ii) Tests to assess the effects of arcing due to an internal fault (for switchgear and control gear classification IAC A, FLR) for an arc of at least 63KA for a duration of at least 0.3.
   (iii) Temperature rise test at 4300A without forced cooling
      One report or certificate is acceptable if it contains all the tests above
(c) One (1) report/certificate for Low voltage switch board Arc resistance and protection test as per IEC TR 61641 for an arc of at least 50KA for a duration of at least 0.3s

(d) Five (5) Summary test report or certificate for each type of numerical protection relay as per IEC 60255-1 for
   (i) Generator protection relay A
   (ii) Generator protection relay B
   (iii) GSU transformer protection relay A
   (iv) GSU transformer protection relay B
   (v) Auxiliary supplies protection relay (3max)

(e) Five (5) KEMA Test certificates to show compliance to IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1 for
   (i) Generator protection relay A
   (ii) Generator protection relay B
   (iii) GSU transformer protection relay A
   (iv) GSU transformer protection relay B
   (v) Auxiliary supplies protection relay (3max)

1.4.2.4 During bidding stage, the bidder shall note the following
   (a) only a maximum of 20 summary test reports/certificates and a minimum of 16 summary test reports/certificates are expected in hardcopy all the other type test reports that bidders deem necessary for submission as supporting documents at bidding stage shall be submitted in soft copy.
   (b) Each summary test reports/certificates is not expected to exceed five pages in size. Detailed test reports to be submitted in soft copy
   (c) Where the available Type test report is not for the exact model on offer but for an equivalent model. Then a signed letter from the manufacturer shall be provided to proof that the type test report given is also applicable to the equipment model on offer, failure to which the test report shall be deemed not to have been submitted.

1.4.3 OEM Technical manuals
1.4.3.1 Comprehensive OEM Technical manual shall be provided for
   (a) Each type of numerical protection relay
   (b) Generator MV vacuum circuit breaker
   (c) Generator MV switchgear
1.4.3.2 Each Manual shall as a minimum, cover the following topics:

(a) Detailed description of equipment, including at minimum: the structural description and dimensions, functional descriptions with block diagrams, characteristic curves and logic diagrams, General assembly drawings, control and wiring diagrams, operating conditions, operation description, etc.

(b) Equipment rating: power, insulation, voltage, current, temperature, flow, fault withstand, breaking capacity, various operating characteristic curves, relevant clearances, tolerances, operating temperature etc.

(c) Range of features to be provided.

(d) Range of optional features not provided.

(e) Range of settings provided for all features, both offered and optional.

(f) Operation and maintenance

(g) Details of all the operating characteristics for each function of numerical relays or meters.

(h) Statement of performance under reference conditions.

(i) Variation of performance with departure from reference conditions.

(j) Effects of interruptions to dc auxiliary power supply.

(k) Current and voltage transformer requirements for IED’s and meters.

(l) inputs, outputs, interlocks, control logic, signal processing/flow etc. for IED’s and PLC’s

(m) Standards the equipment complies to

1.4.3.3 IEC61850 MICS, PICS and PIXIT conformance statements shall be provided in soft copy for

(a) All protection IEDs offered

(b) Generator power transducer

(c) Synchronising IED

(d) Protection gateway software (SAS) i.e.

(i) IEC61850 to Modbus TCP server

(ii) IEC61850 to OPC server

1.4.3.4 All Manuals to be provided in soft copies

1.4.3.5 All manuals provided MUST be listed in the Reference list of manuals, datasheets and catalogues forming part of bidders’ technical proposal as detailed in clause 1.4.1.4(k) for them to be considered to have been submitted.
1.4.4 **Technical data sheets**

1.4.4.1 Technical data sheets and or catalogues briefly describing: technical specifications; rated values; operating conditions; physical dimensions, standards of manufacture and testing, photo illustration of the equipment etc. shall be provided.

1.4.4.2 The equipment/item offered shall be clearly marked in the datasheet/catalogue

1.4.4.3 Data sheets and catalogue to be provided in soft copies

1.4.4.4 Datasheets and catalogues shall be provided for but not limited to each of the following:

1. Each type of numerical protection relays,
2. Each type of auxiliary relay (as per clause 3.5 of specifications) i.e. contactor relays, interface relays, supply supervision relays, trip supervision relays, trip lock out relays and voltage monitoring relays.
3. SCADA gateway industrial PC,
4. Servers
5. Hardware firewall
6. Each type of industrial Ethernet switches,
7. GPS Time server and master clock
8. Serial device servers (Ethernet gateways),
9. Automatic transfer controller switch,
10. Synchronizing relay
11. Each type of panel indication meters,
12. Each type of panel multifunctional meters,
13. Each type of terminal block,
14. Each type of cable,
15. Each type of panel/board,
16. Siren,
17. Each type of push button,
18. Each type of selector switch
19. Each type of panel indication lamps,
20. Each type of miniature circuit breakers,
21. Each type of MCCB & MPCB
22. Contactors,
23. Each type of sensor/transducer (flow, pressure, temperature, level etc.) to be provided,
24. Portable computers (laptops),
25. Each test equipment,
26. Each Maintenance tool,
27. Test block,
28. ferrules,
29. each type of earth switches,
30. each type of VT and CT’s,
31. each type of Panel fans
32. Each type of power supply unit
33. Inverter
34. Voltage monitoring relays
35. Capacitive voltage detectors
36. Surge diverter
37. Any other device stated in the bidder’s offer

1.4.5 All manuals, data sheets and catalogues provided MUST be listed in the Reference list of manuals, datasheets and catalogues forming part of bidders’ technical proposal as detailed in clause 1.4.1.4(k) for them to be considered to have been submitted.

1.4.6 Where a submitted catalogue, manual or datasheet contains more than one model of the device the bidders shall circle or highlight the model they are offering.

1.4.7 As a minimum, the bidder shall furnish the technical proposal and type test reports in two hard cover bound sets failing to which the bids shall be rejected. Soft copy of the documents shall also be handed over in a CD/DVD. Manuals, catalogue and data sheets to be provided in soft copies

1.4.8 In the event of any difference between the Drawings and the Specifications stated, the latter shall prevail. In the event of any difference between scaled dimensions and figures on the drawings, the figures shall prevail.
1.5 PROJECT SCOPE

1.5.1 The scope of works shall cover the following plant subsystems for Gitaru Hydro Power Plant:

(a) unit 2&3 MV generator switch gear,
(b) unit 2&3 protection
(c) station LV switchboard- main station auxiliaries’ switchboard
(d) unit 1 station transformer installation

1.5.2 In fulfilment of the above, the contractor shall carry out the following activities but not limited to:

(a) Studying of existing systems;
(b) Design /Engineering services;
(c) Manufacture,
(d) Factory training at manufacturer’s training centre
(e) Factory acceptance testing at the Manufacturer’s Factory;
(f) Packing for transport; insuring; shipping & delivering to the port of Kenya;
(g) Customs clearing in conjunction with the client;
(h) Local Transportation, insuring, delivery to Site, site storage and Unpacking;
(i) Disassembly/dismantling of existing systems
(j) Erection/Installation
(k) Civil works that may be necessary during site works
(l) On job training during installation and commissioning
(m) Site acceptance Testing and Commissioning;
(n) Maintenance equipment and tools provision and training on use;
(o) Defect reliability period;
(p) Post commissioning site training;
(q) Technical documentation provision and
(r) Warranty

1.5.3 Common systems scope shall include the following

(a) Station low voltage switch boards scope
(b) SCADA/communication interface equipment scope
(c) Unit 1 station transformer installation and any other work to be carried out on unit 1

1.5.4 works that are necessary for the execution of the project shall be the responsibility of the contractor.
1.6 PROJECT WORK PROGRAM

1.6.1 Work program shall contain refined method statements, quality control program and implementation plan with details as specified in clause 1.4 of specifications. The work program shall be detailed to cover all employer’s general specification requirement’s and shall define how the whole project shall be carried out.

1.6.2 After the tender award, the approved tenderer shall prepare a draft work program covering the design, manufacture, delivery, installation, testing, training and commissioning of the Works, in sufficient detail defining the various sections of the Works, including parts to be supplied by the Contractor. The implementation plan shall be prepared in the form of a Critical Path Method Network and a Gantt chart.

1.6.3 After tender award and prior to contract signing the client and Approved tenderer shall meet, discuss and review the draft work program, the contractor shall subsequently prepare a final work program for client approval.

1.6.4 The total project duration shall not exceed 30 months; the duration shall be time period from commencement to final commissioning and issuance of the final take over certificate or as otherwise defined in the conditions of contract.

1.6.5 Duration of power plant outage required to implement the project shall not exceed:

(a) 60 days outage time for each unit (unit 2&3) installation and commissioning,
(b) 5 days outage time for unit 1 installation and commissioning,
(c) 4 days of total station outage (in separate days not continuous i.e. 1 or 2 days at a time) for substation works and to test common systems if required

A minimum time gap of 14 days shall be allowed between unit outages and a maximum of 30 days. The maximum however, shall vary depending on the prevailing Kenyan electricity grid condition and climatic conditions.

1.6.6 The bidder shall furnish sequence of activities to be carried out to avoid / minimize the generation loss, likely to occur during the project works. The bidder shall note that work shall be completed within shut down period. The bidder shall also note that there may be uncertainty of Shutdown due to grid exigency. However, no additional cost/ compensation on this account shall be entertained.

1.6.7 In formulating the work program, the Contractor shall take into account the following activities, to be undertaken by the Client:

(a) Approval of drawings and designs
(b) Preparations to attend factory training and testing
1.6.8 Upon approval of the work program by the Client, it should thereafter be referred to as the Approved Construction Programme and shall become a part of the Contract.

1.6.9 In executing the Approved Construction Program of this Contract, the Contractor shall co-operate with the Client in order to effect timely completion of the works as a whole.

1.7 DOCUMENTATION

1.7.1 General Mandatory Requirements

1.7.1.1 The Contractor shall prepare and submit to the Project Engineer for approval dimensioned general and detailed design drawings and other pertinent information of all the Plant and equipment specified in the tender documents.

1.7.1.2 Approval of drawings shall not relieve the Contractor of his obligations to supply the Plant in accordance with the Specifications. The Contractor is responsible for any errors that may appear in the approved documents. He shall as soon as an error has been detected, deliver the corrected documents to the Project Engineer for re-approval.

1.7.1.3 All text on documents provided by the Contractor shall be in the United Kingdom ENGLISH LANGUAGE ONLY. Technical Documentation written in any other language SHALL BE REJECTED and presumed not to have been submitted.

1.7.1.4 All drawings and documents shall be dimensioned in millimetres

1.7.1.5 The Contractor shall, during the total project time, maintain a List of Documentation to be updated by him whenever needed. The List of Documentation shall include the date of original issue of each document submitted as well as the dates of every revision. The List of Documentation shall also include a time schedule for the submittal of the documentation.

1.7.1.6 Symbols used for electrical equipment and components shall be in accordance with IEC 60617. The Contractor shall establish a coherent system for physical and functional reference designation in accordance with IEC61346. A similar systematic scheme shall be defined for cable numeration. These schemes shall be used throughout on the drawings and documentation and the designation shall be labelled on the components and cables. Auxiliary relays shall be assigned alphanumeric device numbers in the drawings where the numeric part shall be as per IEEE C37.2-2008 (e.g. K51 for overcurrent auxiliary relay)
1.7.1.7 In addition to what is stated elsewhere in the tender, the following shall apply to all technical documentation handed over to the client after the project:

(a) The sizes of all documents and drawings shall conform to the ISO standard, i.e.: A1 (594mm x 841mm), A2 (420mm x 594mm), A3 (297mm x 420mm) & A4 (210mm x 297mm)

(b) Scales to be used on the drawings shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

(c) All drawings shall be dimensioned in millimetres

(d) Technical documentation e.g. manuals, test reports, list of materials, cable lists i.e. all technical documents including ALL drawings shall be provided in A4. Schematic diagrams shall be provided in both A4 and A3. Structural & mechanical drawings shall be provided in A4, A3 and A2/A1 (depending on drawing size).

(e) All drawings made special for this project shall be compiled on a computer aided drawing system and as part of the as built documentation be handed over on a CD with a format readable in latest version of AutoCAD and in any another editable format to be agreed upon and pdf in addition to the paper copies.

1.7.1.8 All drawings and technical documentation shall be bound in hard covers as per sample to be provided. NO document shall be folded to fit the book binding, the Binding covers shall be sized according to the containing documents i.e. there shall be A4, A3, and A2/A1 binding covers. Documents of different sizes SHALL NOT be bound together on the same cover. The number of pages per bound volume shall not exceed two hundred (200)

1.7.1.9 Any illegible copies of documentation submitted shall be rejected by the employer.

1.7.1.10 The SI-system (meter, Newton, gram second) shall be used throughout the works and documentation.

1.7.1.11 The Employer's technical specification drawings attached to the Bid Documents are of informative character. These drawings are intended to illustrate the basic requirements to be satisfied. It is the responsibility of the contractor to prepare a detailed layout/schematic for the new system

1.7.2 Technical Documentation

1.7.2.1 Technical documentation shall consist of but not limited to: -

(a) Technical manuals

(b) Bill of materials,
(c) All technical drawings i.e. schematic, wiring, panel layout drawings, mechanical & structural assembly drawings.

(d) Wiring schedules i.e. cable schedules and terminal diagrams

(e) Functional design specifications and calculations as detailed in clause 1.8.2 of specifications.

(f) Work program containing Method statements, work plans and quality control plans as detailed in clause 1.6 of specifications.

(g) Device setting/parameter configurations

(h) Project progress reports

(i) FAT and SAT plans/program

(j) Training programs and materials

(k) SAT and FAT reports

(l) Type test reports for all supplied equipment

1.7.2.2 Technical manuals shall contain:

(a) System description consisting of: Introduction/overview of components, functional description, overall Equipment operating philosophy and operating conditions.

(b) System/equipment rating: power, insulation, voltage, current, temperature, flow, fault withstand, various operating characteristic curves, relevant clearances, tolerances, operating temperature etc.

(c) Equipment overall design and specific detailed features of design including: Design calculations, descriptive drawings, schematic diagrams, layout diagrams, block diagrams, list of internal materials, connection and terminal list, equipment and components dimensional drawing and control diagram.

(d) Installation and assembly instructions

(e) Complete operating instructions: included shall be precautions and critical points to be observed, including suggested form to be used in taking periodic readings to maintain an operations record. There shall be a tabulation of possible operating difficulties with the probable causes listed and remedial action to be undertaken for each one. Emergency procedures

(f) Manufacturer catalogues and technical data sheets for all components and devices.

(g) Software Manuals for ALL software provided including manuals for Programs and application created for this project e.g. Logic diagrams, HMI application etc. Software manuals to detail: how to use the software, install and un install, license key, support, upgrading & updating, system requirements, troubleshooting etc.
(h) Detailed instructions for programming settings and configuration of all software configurable devices. Instructions for downloading, uploading and backing up settings & configurations,

(i) Complete instructions for ordering replacement parts in a manner that would prevent errors or misunderstanding. Recommended forms for tabulating replacement part information and instructions for returning materials to the factory shall be included.

(j) Maintenance instructions manuals split into:
   (i) Manuals for preventive maintenance indicating periodic inspections, tests, cleaning, lubrication and other routine maintenance. A clear concise document with CHECKLISTS detailing tests and inspections to be done after duration of time e.g. monthly, annual etc.
   (ii) Trouble shooting manual listing all possible failure and their remedy
   (iii) Repair manuals describing fault location, dismantling, re-assembly etc.

Four sets of manuals shall be provided for each equipment/ system i.e. protection, SCADA interface, MV generator switch gear, LV switch boards.

1.7.2.3 All technical Drawings shall be part of technical documentation.

1.7.2.4 Bill of materials as minimum shall contain device, equipment or material: designation or name, model no., quantity, manufacturer, and description. i.e. basic ratings, no. of inputs & outputs of each type, provided functions/features, optional functions/features not provided, no. of contacts etc.

1.7.2.5 Factory test report (FAT) and commissioning report (SAT) shall be the duly filled approved test plan with at least the following: plotted design characteristic curves, test result characteristic curves, Equipment set points for various parameters during testing e.g. pick up values, alarm and trips etc., tabulated results of all tests carried out etc.

1.7.2.6 The documentation shall leave the operators and maintenance personnel in position to operate the plant in a safe and optimal way and to perform repairs, upgrades and rehabilitation usual to be done by such personnel.

1.7.2.7 The Project Engineer shall approve all technical documents before final submission.

1.7.3 Drawings Requirements

1.7.3.1 engineering drawings shall include the following types of drawings: schematics, single line diagrams, layout, structural, mechanical, wiring, logic diagrams, terminal diagrams and all other technical drawings to be used during the project
1.7.3.2 Before starting manufacture of the equipment, dimensioned drawings showing all
the equipment and components details, detailed schematic, structural and layout
diagrams and detailed data of all the equipment and materials to be used shall be
submitted to the Client for approval.

1.7.3.3 Drawings shall have a KenGen identification number structured as below.

(a) KGN-GIT-TUR-XXXX – Turbine and associated systems e.g. governor,
turbine instruments etc.

(b) KGN-GIT-GEN-XXXX – Generator and associated systems i.e. excitation,
generator instruments etc.

(c) KGN-GIT-CAX-XXXX – Common auxiliaries e.g. low voltage switch boards,
common DC distribution, battery chargers etc

(d) KGN-GIT-SBS-XXXX – Substation equipment e.g. generator MV switchgear,
step up transformers, HV switchgear etc

(e) KGN-GIT-PROT-XXXX – Protection equipment e.g. Protection IED etc

(f) KGN-GIT-UCB-XXXX – Unit control boards e.g. unit control PLC, Unit MCC,
manual control panel, synchronizing equipment etc.

(g) KGN-GIT-MET-XXXX – Revenue metering equipment

(h) KGN-GIT-SCD-XXXX – SCADA equipment e.g. servers, network & telecom,
HMI systems etc.

Where XXXX shall be, a numeric number. This shall be further discussed and
agreed on during the preliminary design.

1.7.3.4 In addition to the information provided on drawings, each drawing shall carry a
revision number, date of revision and brief details of revision or designer notes
Wherever any revision is carried out, correspondingly revision number must be
updated. All revisions carried out (not initiated by the client) shall be highlighted
on the drawing and a Separate sheet furnished stating the reasons for such
revision. A note stating drawing is generally revised is not acceptable.

1.7.3.5 New equipment drawings will be interfaced to the plant equipment drawings; the
connection shall be documented in a coherent and overlapping way at least
containing identification in the other plant equipment drawing. Schematic
diagrams shall contain complete loops within new and interfaced equipment
drawing showing a terminal in the interfaced (interconnection)drawing.

1.7.3.6 All client’s drawings of power plant systems (not forming part of scope of this
project) interfaced to the new protection, metering, SCADA interface and
switchgear systems shall be reviewed and updated by the contractor. The client
shall provide pen marked drawings to the contractor who shall provide revised drawings in similar fashion to the drawings of systems supplied by the contractor.

1.7.3.7 These drawings shall be submitted within the times mentioned here under from the Date of tender award. Time shall be allowed to permit changes to be made if required by the Client. The drawings shall be modified as necessary if requested by the Client, and resubmitted for final approval.

1.7.3.8 After approval of drawings by the Client, the Contractor shall supply the approved drawings to the Client, as indicated below.

(a) Drawings for approval 1 Copy
(b) Approved drawings 1 Copy

1.7.4 Document Approvals

1.7.4.1 During project execution, technical documents shall be approved by the client as per provision of this clause (1.7.4). This shall apply to all technical documents, however; the documents below shall follow all the process described this clause (1.7.4):

(a) All drawings i.e. Structural, layout, schematic, logic diagrams, wiring schedules, device lists etc.
(b) Functional design specifications & design calculations as detailed in clause 1.8 of specifications
(c) Device setting/parameter configurations
(d) Work program
(e) FAT plan / programs
(f) SAT plan / programs
(g) Factory training program and syllabus
(h) Site Training program and syllabus

1.7.4.2 The Contractor shall provide the following documents within the first three months after the contract commencement for approval.

(a) Work program containing Method statements, implementation program and quality control plans as detailed in clause 1.6 of specifications
(b) Functional Design specifications & design calculations
(c) Safety, Health and Environmental plan

1.7.4.3 Detailed schematic, structural and layout drawings shall then be submitted after approval of the above preliminary documents.

1.7.4.4 When the Contractor prepares their work program, as required herein, they shall make allowance for document approval time and indicate it on the program.
Claims or extensions of time will not be approved if they are related to the late submission of drawings to the Client or if they involve delays caused by drawings not being approved by the Client.

1.7.4.5 During the design stage, the contractor shall send documents/drawings to the client for approval and comments. A copy of each document will be returned to the Contractor marked “Approved”, or “Approved as noted”, or “Not Approved”.

1.7.4.6 Documents submitted by the contractor for approval will be checked / reviewed by the employer and comments, if any, on the same will be conveyed to the contractor. It is the responsibility of the contractor to incorporate correctly all the comments conveyed by the Employer on the Contractor’s documents & drawings. If the Contractor is unable to incorporate certain comments in their design they shall clearly state in their forwarding letter such non-compliance along with valid reasons and justification.

1.7.4.7 Comment of “not approved” would imply the drawing/document must be re done as per comments given; meaning the client is not in agreement with the content, idea and implications of the drawing/document on the overall design and operation of the system. Comment of “approved as noted” shall imply the client agrees with the idea or implications of the drawing/document but requires some changes to be implemented before approval.

1.7.4.8 Documents with comments of “Approved as noted”, or “Not Approved” shall be reviewed by the contractor as per given comments and resubmitted to the employer for approval. The employer will review the resubmitted document as described in the previous clause. The process shall be repeated until all the submitted documents are approved.

1.7.4.9 Documents requiring revision shall be promptly dealt with and resubmitted as aforementioned. Thereafter, changes shall NOT be made in the Contractor’s drawing without written permission of the project Engineer. The above procedure shall be repeated for all authorized changes. It is to be understood, however, that approval of the drawings shall not relieve the Contractor of any responsibility in connection with the work.

1.7.4.10 All documents submitted for approval or sent to the Client for any other reason may be sent by courier or e-mail

1.7.4.11 Any work performed or material ordered by the contractor prior to receipt of drawings stamped ‘Approved’ by the employer shall be at the risk of the contractor. After print of any drawing has been returned ‘Approved’, the contractor may release the parts covered by the drawing, for production / construction.
1.7.4.12 All drawings and data supplied by the Contractor subsequent to the date of
contract, which cover changes in the work, extra work, or which supplement
existing drawings and data shall, upon approval by the Client Engineer, form part
of the contract documents.

1.7.4.13 If, at any time before the completion of the work, changes are made necessitating
revision of approved drawings/document, the contractor shall make such revisions
and proceed in the same routine as for the original approval.

1.7.4.14 To expedite the delivery and return of the required drawings, scanned drawings
shall be used and sent to the following KenGen E-mail addresses–

   jknjuguna@kengen.co.ke
   c.c:-
   imuoka@kengen.co.ke
   dwangariria@kengen.co.ke

   Or any other email supplied by the client.

1.7.4.15 The work shall be in accordance with the approved drawings and data and shall
not be commenced until such approval has been obtained. Subsequent changes
contemplated by the Contractor shall be indicated on revised drawings and data
resubmitted for approval. The Contractor shall make any changes in the design
which are considered necessary to make the work conform to the provisions and
intent of the specification without additional cost to KenGen.

1.7.4.16 Approval of the Contractor’s drawings and data shall in no way construe or imply
relief of the Contractor from responsibility for any error or omission therein or
from any obligation under the Contract.

1.7.4.17 After final approval of documents the contractor shall send to the client all the
documents listed in clause 1.7.4.1 stamped/or indicated as “factory as built”. These shall be used for factory acceptance tests and FAT report.

1.7.4.18 After installation and commissioning of all the systems in the project the contractor
shall send to the client all the documents listed in clause 1.7.4.1 stamped/or
indicated as “as built”

1.7.5 Final Documentation

1.7.5.1 After all items of the work have been manufactured, erected and commissioned;
complete sets of prints and softcopies of the technical documentation for all new
systems and interfaced existing plant systems shall be furnished as indicated below.
(a) Soft copies of **ALL** technical documentation as defined in section 1.7.2 well organised using document management application program linking all documents (in pdf format) in the project via hyperlinks. The document management application program shall
(i) Run on any PC without installation or requiring a licence.
(ii) enable searching of content easily
(iii) Organise all technical documentation in chapters or volumes for easy viewing of the contents
Document management application based on HTML that can easily be read by standard web browser is preferred.

(b) Soft copies of **ALL** as built drawings in AutoCAD electrical 2018 format and any other CAD software format if used or agreed upon with project engineer

(c) AutoCAD electrical 2019 software and any other CAD software used. Two licenses for each CAD software shall be provided

(d) **Four** Complete sets of bound prints for **ALL** technical documentation as detailed in section 1.7.2 and **ALL** as built drawings in **A4**

(e) **Four** Complete sets of bound prints for **ALL** as built SCHEMATIC drawings in **A3** ONLY

(f) **Four** Complete sets of bound prints for all as built structural and mechanical drawings in **A3** and **A2/A1**.

(g) All existing clients’ drawings interfaced to the new system reviewed and updated by the contractor in two sets one **A3** another **A4** size sheets

(h) Soft copies of **ALL** Logic diagrams in original software format and the software with a licence, used to create the logic diagrams/programs

1.7.5.2 Contractor shall generate four copies of A0 or larger updated Gitaru power plant power single line diagram (from 132&220KV lines to 415V switch boards) drawing in Manila paper

1.8 ENGINEERING SERVICES BEFORE INSTALLATION

1.8.1 **Studying Existing Systems**

1.8.1.1 The contractor shall study the existing Protection equipment, LV switch boards, generators, transformers, unit control systems, SCADA system and substation and all other associated plant systems to determine the interface and requirements of the new equipment.
1.8.1.2 It is a requirement that the contractor design Engineer visit the site as soon after the tender award to acquaint himself with the operation of the Units and gather the relevant technical aspects (data, As-Built Control Schematics, cable schedules, etc.) for the design phase.

1.8.1.3 This works includes the engineering of layout of equipment components, cabling & wiring and interface to existing control systems. This will ensure integration of electrical and mechanical equipment to form a well-functioning plant. All the materials and accessories required for the equipment/system to function shall be furnished by the contractor.

1.8.1.4 Drawings, manuals and information relating to the Units will be made available to the contractor. Two client Engineers conversant with the plant operation will be attached to the contractor during formulation and design stages. This will ease correspondence and confirmation of the interface requirements.

1.8.2 Design

1.8.2.1 Systems specified in this tender and all associated systems shall be designed to ensure continuity of operation under all working conditions and to facilitate inspection, maintenance and repairs. All reasonable precautions shall be taken in the design of equipment to ensure safety of personnel concerned with the operation and maintenance of the equipment.

1.8.2.2 All components shall be adequately rated or sized for their most onerous duty and the specified ambient temperature. Due account shall be taken of any heat generated by the equipment therein and the components shall be appropriately selected, rated or de-rated as necessary to suit the most onerous operating temperature within the equipment. A minimum safety factor of 1.2 shall be applied to all systems.

1.8.2.3 Design and calculations shall be governed by the design criteria given in the Bid Documents, standards and normal design practice. Necessary safety factors shall be included. The contractor shall assure himself and the client that the apparatus is suitable for intended use and the environment and stresses to which it will be exposed. Contractor must also assure that the equipment is compatible with equipment it shall be connected to, or work together with.

1.8.2.4 The contractor shall prepare a Functional Design Specification document containing System design parameters to conform to employer requirements. The functional design specification shall contain the following:

(a) A response to the employer’s technical specifications and scope of supply describing the equipment to be offered. Description shall include all
equipment technical data and the equipment functions. It shall give a clear response to all the clients requirements

(b) Detailed list of equipment/Bill of materials for each panel. The list of equipment shall include the manufacture, model and quantity

(c) Tabulation of tests and their reference standards to be carried at factory and site.

(d) Criteria and standards for design and design calculations

(e) Software description and functionality. This to include software licenses requirement, communication protocols, applications hierarchy, system software/firmware description, database structure & design, database applications description, signal list, list of symbols, hardware requirements, Graphical user interface etc

(f) Software Configuration Management methodology.

(g) Arrangement (location) drawings of all equipment and all panel layout drawings showing component installation position and detailed dimensions

(h) Detailed single line diagrams for all the systems. Block diagrams of the control philosophy for the control systems.

(i) List of inputs and outputs of all types (analogue & digital) for all IEDs, PLC’s and other software configurable devices. This list shall contain register/memory addresses and size/type of variables.

(j) OEM technical Specifications of all equipment to be supplied

1.8.2.5 The functional design specification shall be approved by the client engineer in similar fashion to drawings as specified in section 1.7.4 of specifications. The functional design specification after approval shall form basis for all tests and shall not be deviated from unless with the written consent of the project engineer. The functional design specification shall conform to all the standards specified in the employer specifications. It shall contain all the calculations and standards used to arrive at the specification.

1.8.2.6 The design shall be reliable and simple. The design shall incorporate every reasonable precaution and provision for the safety of the general public as well as for all those engaged in the operation and maintenance of the equipment itself or equipment connected to or installed in close proximity to it. All apparatus shall be designed to ensure reliable and safe operation under the atmospheric conditions prevailing at the Site and under such sudden variations of load and voltage as may be met with under working conditions of the system.
1.8.2.7 During design the contractor shall send drawings, functional design specifications, design calculations, FAT & SAT test plans, training syllabus and other documents stated in various sections of the tender for approval by the client as described in section 1.7 of specifications.

1.8.2.8 System design shall ensure easy maintenance of the systems supplied

1.8.3 **Power System Analysis Studies**

1.8.3.1 Contractor shall carry out a detailed power system analysis for all Gitaru power station electrical systems in accordance to guidelines given in IEEE 399 and other best industry practices.

1.8.3.2 The studies shall be carried out to arrive at optimum settings and rating (for some protective devices) of new equipment to be supplied and the other plant and power grid equipment that the new systems will be interfaced to. The studies shall also guide the employers’ future plant equipment upgrades and rehabilitation.

1.8.3.3 The studies shall be limited to Gitaru power station, however, modelling of the Power system connections to the plant shall be necessary, data required for these shall be sought from the grid operator by the employer. The contractor shall inform the employer of the necessary data early enough for the employer to seek the necessary data.

1.8.3.4 A minimum of the following studies shall be carried out

   (a) Short-circuit studies
   (b) Generator Stability studies
   (c) Cable ampacity studies
   (d) Protection Coordination studies
   (e) DC auxiliary power system analysis

1.8.3.5 Data collection on existing plant equipment shall be collected during design site visit. The study parameters, operating scenarios, Contingencies etc shall be agreed upon during design.

1.8.3.6 A detailed report of these studies and accompanying calculations shall be handed over to the employer during design stage in a similar fashion to the functional design specifications as per clause 1.7. The study models and analysis used shall be handed over to the employer in soft copy, in the original format of the analysis software.

1.8.3.7 Commonly available power system analysis software such as ETAP™ shall be used for these studies. The software used for these studies shall be supplied to the employer with at least one license.
1.8.3.8 The outcome of these studies shall be used to determine settings of excitation controller, the protection IED’s and LV switchboards–switching devices trip units.

1.8.3.9 Where the result of the studies indicate that a change of equipment specifications is required, the contractor shall highlight this to the employer.

1.8.3.10 The sizing of low voltage switching & metering devices and instrument transformers shall be optimised based on the result of these studies.

1.9 MANUFACTURING AND SHIPMENT

1.9.1 Quality Assurance Plan:
   1.9.1.1 The bidder shall invariably furnish along with his offer the quality assurance plan adopted by their sub-supplies in the process of manufacturing all major equipment/component.
   1.9.1.2 Precaution taken for ensuring usage of quality raw materials and sub-components shall be stated in the quality assurance plan.
   1.9.1.3 The bidder should specifically express their consent to accept additions, revisions to their quality assurance plan to meet the employer’s requirements if needed. The final quality assurance plan to be adopted, with mutual consent, shall be decided after discussion with successful bidder.

1.9.2 Places of Manufacture and Sub-Contractors
   1.9.2.1 All equipment offered should be the product of recognised and experienced manufacturers who have been manufacturing specified equipment for the last twenty years. Equipment shall be of basic design and size similar to such that has been in successful continuous operation for at least three years preferably under similar climatic conditions. Proven plant reliability and high availability are of prime importance and the attention of the tenderer is drawn to these particular requirements.
   1.9.2.2 The manufacturer's identity and places of manufacture, testing and inspection before shipment for the various portions of the Contract Works shall be specified in the Technical Schedules and shall not be departed from without the agreement of the Project Engineer.
   1.9.2.3 As soon as practicable after entering into the Contract, the Contractor shall, having obtained the Project Manager's consent in accordance with the Conditions of Contract, enter into the Sub-contracts he considers necessary for the satisfactory completion of the Contract Works.
1.9.2.4 All Sub-contractors and Sub-suppliers of components and materials shall be subject to the approval of the Project Engineer. Information shall be given on each Suborder sufficient to identify the material or equipment to which the sub-order relates, stating that the material is subject to inspection by the Project Manager before dispatch.

1.9.2.5 If the Employer at any stage in the design and production period finds out that the sub-contractor does not fulfil the requirements in the specifications and it is obvious that the required quality cannot be achieved by corrective measure he can request the subcontract to be suspended and the works to be produced elsewhere without extra cost for the Employer.

1.9.3 **Inspection and Testing**

1.9.3.1 Tendering requirements

(a) The manufacturer shall be responsible for performing or for having performed all the required tests specified under the specifications. Tenderer shall confirm the manufacturer's capabilities in this regard when submitting tenders. Any limitations shall be clearly specified.

(b) Full details of type tests performed on equipment identical to that being offered shall be submitted with the offer, accompanied by a proposed schedule of tests to be performed for each item of equipment.

(c) Type test reports & certificates submitted for tender evaluation shall be as detailed in clause 1.4.2

(d) In general, type test results shall show that the equipment being proposed for this Contract shall perform in accordance with its design specification in the environments to which it will be subject in its application on this Contract. The environmental factors include climatic (temperature humidity, wind, rain etc.), electromagnetic (radiated and conducted), mechanical (transport vibration, handling knocks, earthquake stresses) and chemical (salt laden atmosphere).

(e) Where appropriate, the type tests should also demonstrate that the equipment does not exceed accepted standards in terms of its impact on its environment (noise, mains harmonics etc.).

1.9.3.2 Manufacturing quality control, inspection and testing procedures

(a) All materials used in the Contract Works are subject to inspection by the Project Engineer and it is the Contractor's responsibility to advise the Project Engineer when equipment and materials are available for inspection, at least...
one month in advance. Factory tests on equipment shall be made according to the applicable IEC Standards, or as specifically specified or according to standards approved by the Project Engineer. Routine tests shall be made on each unit of all equipment.

(b) Type tests shall be made on one unit of each type of different equipment components. Instead of carrying out the type tests the Contractor may submit suitable certificates of tests made on equipment components of the same type; however, the employer reserves the right of accepting these certificates or to reject them partially or totally. Routine tests shall however be conducted on all assembled equipment; type tests reports will only be allowed as substitute for some components of the completed equipment.

(c) Measuring and test equipment to be used shall be approved by the Project Manager and if required shall be calibrated at the expense of the Contractor at an approved laboratory

1.9.3.3 Factory Inspection, testing and training program

(a) The Contractor shall prepare test procedures and result sheets for all tests. He shall also prepare a cross reference listing to show that all of the requirements of the Functional Design Specification have been included in the tests. The Contractor shall prepare and execute a testing program which will establish that specified requirements have been met and that the items furnished and installed will perform as specified and required.

(b) The Contractor shall submit to the Client for approval, during or immediately following the submission of drawings, testing plan/programs describing each test to be performed during factory acceptance tests (FAT), site commissioning and performance tests. The program shall establish the sequence of the tests, the equipment preparation and operation procedures to be followed and the DETAILED PROCEDURE for conducting each test.

(c) Inspection and test plans (program) may be of any form to suit the Contractor’s system, but shall as a minimum:

(i) Contain all tests specified in the particular specifications and all test requirements of the standard stated in the specifications.

(ii) Detail inspections in form of check lists to be carried out before testing.

(iii) Identify where subcontract services will be employed

(iv) Identify the characteristics to be inspected, examined, and tested at each point
(v) Give detailed procedures, acceptance criteria to be used and the applicable verifying document. Indicate basis of the acceptance criteria i.e. standard or specification applicable.

(vi) Indicate mandatory hold points established by the Project Engineer that require verification of selected characteristics of an item of process before this work can proceed.

(vii) Define or refer to sampling plans if proposed and where they will be used. Where applicable, specify where lots or batches will be used.

(viii) Duration required for each test and all tests for each system

(d) The program shall also contain performance guarantees, design values, technical particulars, or other criteria for the evaluation of each test. These programs shall be submitted for approval and distributed in the same manner as the drawings.

(e) Contractor shall submit a Factory training programme as per requirements given in section 1.11 of specifications and particular technical specifications. All training topics specified in the specifications shall be covered. The program and syllabus shall be approved by client engineer in similar manner to drawings prior to the FAT. The minimum duration shall be as specified however the contractor give the necessary time required to cover the training course successfully and include in the bid.

1.9.3.4 Attendance of Client’s Personnel at Factory Tests and Training

(a) The Contractor shall arrange for Client’s engineers or staff members to witness tests of major items of equipment at the Contractor manufacturing plant/s.

(b) The Contractor shall submit factory training and factory acceptance tests schedule for approval. After approval by the Client, the Contractor shall invite the Client’s engineers for training and factory acceptance tests. A period of at least one month shall be provided from date of invitation to the date of departure to the contractor’s country of manufacture to allow enough time for travelling preparations.

(c) Training as per clause 1.9.3.3(d) at manufacturer’s plant or a reputable training centre preferably one run by manufacturer in the country of manufacture shall be provided, in order to enable client engineers, understand the equipment design, operate and maintain the equipment successfully. Factory acceptance testing shall proceed after the training.
(d) The above two tasks shall be arranged to follow each other; training to precede the factory acceptance tests.

(e) Contractor shall be responsible for all travel within country of manufacture and all other associated costs of stay by client engineers other than accommodation and out of pocket expenses which will be catered by the client. Necessary expenses including internal air ticket cost between Contractor’s manufacturing facilities, inland travel charges in the Contractor’s country shall be included in the Tender. Where manufacturing facilities are located in different countries the contractor shall bear the cost of international travel and visa application between contractors main factory home country and the other countries

(f) The Client will be responsible for the round-trip airfares between Kenya and the Contractor’s main factory country, accommodation and out of pocket expenses.

(g) Contractor shall facilitate visa application for the client engineers by providing necessary support documents required by the contractors’ country government

1.9.3.5 **FAT**

(a) Prior to commencement of the tests, the equipment shall be inspected to ensure:

(i) Correct standards of workmanship and quality

(ii) Correct identification labels, cabling, tagging, housing and mounting etc.

(iii) Adequate accessibility

(iv) Compliance with the Specification and reviewed drawings (including compliance with fire safety and materials requirements)

(v) Verification of model numbers, quantities of items etc.

(b) All factory tests and training requirements detailed in the approved factory acceptance test plan/program and factory training program shall be carried out.

(c) Valid calibration certificates from a third party accredited laboratory for test equipment to be used during FAT shall be presented to the client engineers prior to the beginning of the FAT. Only test equipment with valid calibration certificates from a third-party laboratory credited by NSTA shall be used.

(d) Conduct of the Tests

(i) The Contractor shall conduct the tests in accordance with the approved test procedures and shall enter the results in the approved result sheets.
(ii) For each test, the Employer will determine whether the test has passed or failed. In general, the test will be considered to have failed if either:

- The result of the test is not in accordance with the expected result described in the test procedure, or
- The result of the test is in accordance with the expected result described in the test procedure, but some other unexpected or unexplained event occurred which the Employer considers to be a fault

(iii) Full use shall be made during the tests of operator manuals and other documentation provided by the Contractor to determine the accuracy of the tests.

(c) Failures

(i) The Contractor shall correct all faults found during testing, and shall arrange for the test to be repeated. The test shall only be repeated when the fault has been remedied and the equipment demonstrated to function correctly.

(ii) Where remedial measures involve significant modifications that might, in the Employer’s opinion, affect the validity of earlier tests then the Contractor shall repeat the earlier tests and obtain satisfactory results before repeating the test in which the fault was first identified.

(iii) The Employer shall have the right to order the repeat or abandonment of any test in the event that results demonstrate that the equipment is significantly non-compliant with the Contract requirements, without in any way prejudicing his rights under the contract.

(iv) The Employer shall have the right to suspend any test in the event that errors or failures have become unacceptable. The Employer shall also have the right to suspend any test in the event of a fault being detected by the Contractor but not reported to the Employer within 24 hours. In this event, the suspension shall remain in effect until reporting has been brought up to date to the satisfaction of the Employer.

(f) Repeat Tests

(i) The Contractor shall correct and re-test every fault detected during the tests.

(ii) Time spent by the Employer witnessing re-tests, or waiting at the Contractor's premises or the test site while corrections are made prior to
re-test, shall be charged to the Contractor at the standard hourly rate for the personnel concerned.

(iii) All other costs incurred by the Employer as a result of such re-tests, including accommodation, subsistence and travel charges, will be charged to the Contractor at cost. If the Employer is required to return to the Contractor's premises or the test site to witness such re-tests then time spent by the personnel concerned in travelling to the site of and witnessing such re-tests, and all charges incurred by them in so doing, including travel and accommodation shall be charged to the Contractor.

(g) After the tests, detailed test report and client inspection report shall be signed by the client engineers and contractor. These documents shall then become part of the contract.

(h) FAT meeting minutes duly signed by the contractor and the client representative shall form part of official project documentation and shall be required by the client to approve payment processing by the bank. As part of the terms of letter of credit.

(i) Client will give consent for shipping ONLY after ALL the issues discussed in the minutes and noted in the client inspection report have been rectified and evidence given to the client.

1.9.4 Packing, Transportation and Storage

1.9.4.1 The Supplier shall provide such packing of the Goods as is required to prevent their damage or deterioration during transit and temporary storage up to their final destination as indicated in the Contract. The packing shall be sufficient to withstand, without limitation, rough handling and exposure to extreme temperatures, salt and precipitation. Packing case size and weights shall take into consideration, the Goods' final destination and the absence of heavy handling facilities at all points in transit. Indoor electrical equipment must be enclosed in welded polythene envelopes inside packing cases and the envelopes shall be evacuated or have a desiccant inside.

1.9.4.2 The following information must be clearly stencilled or printed on each packing case, crate, cask, drum, bundle or loose piece, care being taken that the number and other particulars on each package agree with those entered in the packing list accompanying the Invoice:

(a) Employer's Identity
(b) Supplier's Identity  
(c) Destination  
(d) Project name  
(e) Contract No.  
(f) Package No.  
(g) Item Code  
(h) Weight, dimensions  

1.9.4.3 The marking above shall be durable and upon the body of the package. Marking upon a batten fastened on the case, etc. shall not be used. In the case of bags, bundles and loose pieces, the shapes of which do not permit the marks to be put on the actual package, each bag, bundle or loose piece shall have two metal labels each with two holes securely fastened by independent wires. Each label shall be die-stamped with the above particulars.  

1.9.4.4 The Contractor shall be responsible for all transportation from manufacturing site to Gitaru power station  

1.9.4.5 Employer shall give clearance for shipment of the equipment only after: all the finalised and approved Drawings, Instruction and maintenance manuals and software have been handed over to the client; any problems noted during FAT have been rectified and upon receipt of Authentic certified copies of the factory Test Reports  

1.9.4.6 Contractor will be responsible for equipment and tools handling on site.  

1.10 INSTALLATION AND COMMISSIONING  

1.10.1 Storage at Site  

1.10.1.1 The Contractor shall be responsible for proper storage of equipment when delivered until taking over. Care shall be taken to assure adequate storage to avoid damage to equipment due to rain or strong sunshine.  

1.10.1.2 The client will provide space for contractor to set up a storage facility and site office  

1.10.2 Erection, and installation supervision  

1.10.2.1 The Contractor shall carry out all erection, testing at site and commissioning of the new equipment specified in the Specifications. The Contractor shall perform all electrical, mechanical, civil works and furnish materials that might be necessary during the installation and mounting of the new equipment.
1.10.2.2 All work, methods of work and workmanship, whether fully specified herein or not, shall be of the highest order in all respects; the generally accepted requirements and commonly recognized good practice for first class work of the nature are to be adhered to.

1.10.2.3 The Contractor will make all materials, tools and equipment necessary for installation, testing and commissioning of the works available. The Client will assist if requested in clearing and bonding [with Kenya Customs Department] of installation and commissioning tools & equipment on receipt of Airway bill or Bill of Landing, list of tools & equipment with serial numbers, PFI [proforma invoice clearly marked ‘Value for ‘Customs Purposes Only’ and must show the price of each tool & equipment and extension thereof]. This assistance will only be applicable to installation and commissioning tools & equipment not to be supplied under this project and which shall be returned to contractor’s country of origin after the project. The Contractor shall meet the cost of shipment of these tools.

1.10.2.4 Contractor site manager with qualifications stated in qualification criteria schedule 6 shall manage the works IN PERSON. He/she is expected to be available throughout the project execution or to be represented by an equally qualified person. Works will only proceed when the stated person is present on site. The contractor’s design & commissioning engineers and installation supervisors shall meet qualifications given in the qualification criteria schedule 6. Evidence of this shall be provided prior to commencement of installation.

1.10.2.5 It shall be Contractor’s responsibility to provide all staff, such as engineers, supervisory staff, skilled and unskilled labour necessary to carry out and complete the Contract Works on schedule as specified. Information regarding site staff shall be provided to the project manager.

1.10.2.6 KenGen shall second skilled labour to carry out the works under supervision of the contractor except for specialized works e.g. welding, non-destructive tests, onsite machining, pipework etc. This secondment shall be free of charge to the Contractor for the number of persons and duration specified. The exact number will be agreed upon at contract negotiations and before commencement of installation. In counterpart, the Contractor shall offer proper on the job training to these personnel.

1.10.2.7 It shall be MANDATORY to attach client staff during installation and commissioning who shall be assigned tasks by the contractor for on job training. If some personnel seconded by the Employer does not perform as expected, the Contractor may request the Employer for replacement. Client’s personnel shall be involved in every aspect of the project.
1.10.2.8 Unskilled labour required for installation services shall be sourced from Kenya. Employer shall not allow use of unskilled labour from outside the country. Foreign contractors shall subcontract a portion of the work that can carried out locally to a Kenyan company, bidders shall note it’s a mandatory requirement for all foreign bidders to subcontract a portion of the work to a Kenyan registered company.

1.10.2.9 Work shall only be carried out in the time of day approved by the project engineer. No work shall be carried out in the plant in absence of client personnel.

1.10.2.10 Prior to installation the contractor shall carryout a pre-installation training, the training shall be carried out at site and shall prepare the client staff for the project. Training shall enable clients’ skilled staff to be attached with the contractor during installation to understand contractor’s system. During the training, pertinent issues on how the installation shall be carried shall be discussed and agreed upon prior to the start of the project. The content and scope of this training shall be as per other clauses of this specification.

1.10.2.11 Prior to machine outage, pre-outage works shall be carried out to minimise the duration of machine outage. Pre-outage works shall include activities such as delivering of cables to the plant and positioning them for faster installation, marking of old cables and equipment meant for removal and any other logistical works that do not require shutting down the machine.

1.10.2.12 The contractor shall disassemble and remove existing equipment and then store them at a yard provided by the client. The contractor shall take due care for the equipment and parts to be reused.

1.10.2.13 Disassembly and removal of old equipment such as panels, cables etc. shall be carried out under supervision of the client. No equipment shall be removed without the client representative present and with his/her approval. All existing equipment shall be the property of the client.

1.10.2.14 The contractor shall indicate the period required at site to install and commission the equipment. The contractor shall submit a program that shall be agreed upon during contract negotiations.

1.10.2.15 Installation & commissioning shall be performed on separate periods for the two units.

1.10.2.16 Client shall carryout internal modifications to panels not forming part of scope of supply especially unit control panels but shall be interfaced to the new systems. The contractor shall however terminate new cables to these panels and provide all necessary wiring materials and equipment necessary to carry out modifications on the panels to be modified by the client.

1.10.2.17 Work on Live panels & Substation.
Substation modification and LV board installation works may involve working on live substations and panels. For these and other instances the following factors are of paramount importance: (i) Minimisation of outage time and (ii) adaptation to operational constraints. All work must be planned with this in mind. The Contractor must obey all instructions and safety rules given by the Government and the Employer and must strictly follow all instructions from the Employer’s supervisory personnel.

1.10.2.18 All outages shall be discussed with the Employer and the Project Manager at least one week before the outage is required. The Contractor will normally only be allowed to have only one unit out of operation at a time apart from the works requiring total station outage. No work shall start before Employer’s engineer has authorised the work, established the required earthing and marked the safe area. Switching off live parts shall be done by the Employer.

1.10.2.19 Total Station outage and temporarily supplies

(a) During installation of LV distribution board and substation modification for MV switchgear installation, total station outage may be necessary. These total station outages shall only be available during the day for maximum of 8 hours. The Contractor and their personnel must respect the physical constraints as well as constraints for scheduling set by these circumstances. However, the Employer will co-operate in making the work conditions and the scheduling as efficient as possible for the Contractor and keep some responsible personnel with switching authority at site during all working hours.

(b) Gitaru Power station is the largest power plant in the country hence total station outage shall have to be optimised. In this respect the contractor in agreement with the employer shall form work shifts if necessary to ensure work continues throughout the outage period.

(c) During LV switch board installation, the Contractor shall as far as possible erect and connect the new cabinets temporarily adjacent to the one in operation. A quick disconnection and removal of the old cabinets can then be performed and the new cabinets pulled in with most of its cables already fitted.

1.10.2.20 At the completion of the Contract, the Employer reserves the right, at his discretion, to take over tools, special tools, test equipment (not included in the bid document) and other construction equipment used by the Contractor in connection with the Contract, at depreciated prices to be mutually agreed upon at that time.
1.10.3 **Site Acceptance Testing and Commissioning**

1.10.3.1 After equipment has been erected and connected to other plant systems on site, the Contractor shall carry out to the satisfaction of Employer such tests as may be required to prove compliance with the Specification, independent of any factory tests. The tests shall be as per the designed standard and as stated in the particular specifications.

1.10.3.2 Prior to site acceptance testing and commissioning the contractor shall carry out a pre-SAT training, the training shall be carried out at site and shall prepare the client engineers for commissioning. Training shall cover the tests to be carried, how they will be carried out, procedures to be followed, precautions and expected results and. During the training the client engineers will also advise the contractor engineers on the plant systems that shall be tested together with the new systems. The training shall ensure the client engineers understand the clients tools especially the software tools to enable full participation of client engineers during the testing. The contractor will take advantage of this training to ensure that the commissioning engineers disseminate all useful information pertaining to the testing s to the client engineers so as to minimise the number queries from the client engineers thereby reducing commissioning time. The content and scope of this training shall be as per other clauses of this specification.

1.10.3.3 In support of the Site testing activities, the Contractor shall prepare an overall test plan that covers all testing to be carried out on Site. The test plan shall indicate test precedence and dependencies and should be coordinated with the Contractor’s general program of work. It shall conform to the relevant requirements for documentation set out in section 1.7 of specifications.

1.10.3.4 The test plan will be subject to the approval of the Employer and should be closely coordinated with the Employer in terms of the availability of plant for testing and the timely provision of the associated permits to work.

1.10.3.5 Inspection and test plans (program) may be of any form to suit the Contractor’s system, but shall as a minimum:

(a) Contain all tests specified in the particular specifications and all test requirement of the standard stated in the specifications.

(b) Detail inspections in form of check lists to be carried out before testing.

(c) Identify the characteristics to be inspected, examined, and tested at each point

(d) Give detailed test procedures
(e) Give acceptance criteria to be used and the applicable verifying document. Indicate basis of the acceptance criteria i.e. standard or specification applicable.

(f) Indicate mandatory hold points established by the Project Engineer that require verification of selected characteristics of an item of process before this work can proceed.

(g) Duration required for each test and all tests for each system

(h) Show the sequence to follow step by step in all connections, including wet tests and other pertinent factors

1.10.3.6 Client will then include tests related to the modified plant control system as part of commissioning schedule and forward to contractor to create a final test plan to be approved by the client.

1.10.3.7 Site acceptance testing plans shall be sent to the client for approval in a similar fashion as drawings as per section 1.7.4 of specifications

1.10.3.8 The Employer shall have the right, to waive some tests and require additional tests to be carried out if findings on Site indicate additional or alternative tests are required to properly demonstrate that the works comply with the requirements of the Contract.

1.10.3.9 The general requirements for testing and factory testing set out in the preceding Clauses 1.9.3 of this specification are also applicable to Site testing.

1.10.3.10 Testing at site shall be carried out by experienced commissioning engineers as stated in evaluation and qualification criteria. Functional tests shall be inherent in test procedures. The Contractor shall record the test results in the approved test plan in such a manner that the test reports can be used as the basis for future maintenance tests. Test methods, test equipment and test equipment calibration details shall be noted on the test sheets.

1.10.3.11 Commissioning shall be carried out by the Contractor together with Employer's engineers.

1.10.3.12 During site testing and commissioning the factory as built drawings shall be marked/highlighted (to track checks on each circuit) and modified to suite the final installed systems. Two copies of these marked/highlighted and modified drawings shall be made. One copy shall be left at site while one copy shall be used by the contractor to develop final as built drawings and submission as per provision of section 1.7 of specifications

1.10.3.13 The Site test plans shall be filled by the commissioning engineers and approved by the client engineer at site. These site test plans shall be copied and one copy left at
site the other copy shall be used to develop final report and submission as per provision of section 1.7 of specifications

1.10.3.14 Client shall also handover pen marked modified drawings of power plant systems (not forming part of scope of this project) interfaced to the new installed systems to be updated by the contractor. The client shall provide pen marked drawings to the contractor who shall provide revised drawings in similar fashion to the drawings of systems supplied by the contractor.

1.10.3.15 Client commissioning engineers at site shall keep a copy of complete record of the test results. One copy of corrected drawings shall also be kept at site after commissioning

1.10.3.16 A complete final test report in 4 sets shall be handed over to the Project Manager not later than one month after the Plant is commissioned

1.10.4 Instruction/Training on Site for maintenance and test procedures

1.10.4.1 During the installation and commissioning periods, the Contractor’s site manager, commissioning engineers/supervisors shall give ‘on the job’ instruction /training to the client skilled staff. The Contractor’s Engineer/supervisor shall train the client’s staff in such disciplines as;

(a) Maintenance and test procedures and techniques on the Equipment using test equipment provided by contractor.

(b) Operational techniques relative to the Equipment both for local and remote operation as appropriate.

(c) Step by step procedure in pre-commissioning and commissioning of the Equipment into operation.

(d) Erection, mounting or joining/assembly of the systems supplied under the contract

(e) Cable terminations

(f) Settings configuration on the various IED’s and computers.

1.10.4.2 In order to ease on job training, it’s a requirement of this tender as specified in other clauses that the installation and commissioning shall be carried out by both contractor and client personnel. Prior to installation the contractor shall carry out a brief structured training to the client personnel in order to bring them to par with contractor’s personnel, this will minimise the amount of explaining to be demanded from the contractor’s personnel during installation. The Installation
Kick-off training shall cover all important aspects of installation and commissioning and shall ease integration of client staff to the project.

1.10.4.3 Programming and configuration of IED’s/PLCs and Computers shall be performed by the contractor for the first unit while training the client engineers. The client engineers shall then carry out programming and configuration under supervision of contractor engineers for the second unit. Contractor shall create software tools e.g. ms office excel/access macros that shall ease programming, configuration and database creation. These tools shall be handed over to the client and shall be used for future modifications especially of the SCADA systems.

1.10.4.4 The contractor shall document detailed maintenance procedures and checklists for all systems supplied as part of the contract and hand over to the client for use during plant maintenance.

1.10.4.5 The contractor shall furnish all equipment that is necessary for test and maintenance of the supplied equipment. These shall include but not limited to: - test blocks for the protection relays, voltage and current injection kits, programming tools (Lap top with installed software and accessories) and any other test equipment that may be necessary for maintenance and integrity checks of the supplied equipment. This equipment is detailed in the particular specifications.

1.10.5 **Accommodation of Contractor's Personnel**

1.10.5.1 Accommodation will be provided to a maximum of four Contractor’s employees at matendeni staff camp 6km from Gitaru power station. Cost of meals and other personal expenses will be the responsibility of the Contractor. Meals can be obtained at the Client’s Club located near the site.

1.10.5.2 Transport (including local airport connection) at the site during the works will be the responsibility of the Contractor.

1.10.6 **Health, environment and safety**

1.10.6.1 The contractor shall forward to the employer during design stage a Safety, Health and Environmental plan –This shall Include a narration of expected safety risks, taking into account local conditions and mitigation measures that will be adopted to ensure that the projects are completed without accidents, with minimum negative impact on the environment.

1.10.6.2 The Contractor shall follow all Kenyan rules and regulations related to workers’ safety and health as well as regarding protection of the environment.
1.10.6.3 The Contractor shall be responsible for equipping all their workers and their subcontractors with necessary personal protective equipment such as helmets, eye protection glasses, safety shoes and safety belts and enforcing the use of such. Nobody will be allowed to work in the client site without proper personal protective equipment.

1.10.6.4 No toxic material (such as Halon, PCB, and Asbestos etc.) shall be utilised neither during construction nor under operation and maintenance.

1.10.6.5 The Contractor shall at all times during the course of work prevent accumulation of debris caused by the work. He shall also remove all debris and temporary structures when finishing the work.

1.10.6.6 All surplus material should be disposed in an environmental satisfying way. Particular attention shall be given to safe disposal of environmentally hazardous substances. Workable equipment shall be handed over to the Employer.

1.11 TRAINING

1.11.1 Overall Requirements

1.11.1.1 Training is a core deliverable of this tender and as such the bidder is expected to go through the requirements for training in this tender carefully. All training requirement in this tender shall be offered by the contractor and the bidder shall include all the costs in the bid.

1.11.1.2 The training shall cover both theory and practical aspects of the systems. The content of the trainings shall include theory on the power plant systems, specific theory related to particular equipment supplied and practical lessons on design, installation, operation and maintenance of equipment supplied.

1.11.1.3 The training shall enable client personnel to design, install, operate and maintain the systems supplied under the project and apply the knowledge to similar plant systems. It shall also enable the client personnel to design necessary interfaces for the new system to allow interfacing to plant systems. Training shall have an emphasis on preventive maintenance, troubleshooting, repair and upgrades/rehabilitation. Detailed training on repair especially of electromechanical systems e.g. circuit breakers shall be carried by the contractor.

1.11.1.4 Contractor shall engage experienced professional trainers and staff from OEM to carry out training where their personnel do not have the capability to do so. Client shall require the credentials of the proposed trainers during design stage. Pre-
installation, pre-SAT and other on job training shall be carried out by the contractor's staff involved in the project.

1.11.1.5 All trainers shall be experienced, fluent and have excellent command of English language. Trainers with poor command of English language SHALL NOT be entertained.

1.11.1.6 All topics detailed in the particular technical specifications MUST be covered by the end of the last training. The topics listed in the particular specifications are indicative and the contractor shall develop a detailed syllabus for the trainings. The content of the trainings shall be approved in a similar fashion to drawings as detailed in clause 1.7 of specifications.

1.11.1.7 Contractor will send to the client project engineer training aids, presentations and documents to be used for training two weeks prior to the training to ensure it covers the content of the approved training program.

1.11.1.8 Three kinds of training shall be offered
(a) Factory training (pre-FAT)
(b) On job training:
   (i) pre-installation and
   (ii) pre-SAT training
(c) Site training -post commissioning

1.11.2 **Factory Training**

1.11.2.1 Factory training shall be carried out in the contractors', OEM or other training facilities prior to FAT. The training facilities shall have access to various testing and demonstration equipment and professional trainers. These training facilities shall have training rigs and test benches for the equipment to be supplied under the contract. The demonstration equipment shall be very similar (where applicable same model and make) to equipment to be supplied. The bidder shall include in their bid a catalogue showing their training facilities and the training equipment available in this facility, where the bidder does not have such facilities they shall get the facilities from a third party. Immediately after the training FAT shall be carried out.

1.11.2.2 Content of factory training shall be geared towards understanding the systems design and equipping the client personnel with detailed understanding of the systems to be supplied. The training shall take client engineer through the design, manufacture, assembly and testing process in detail.

1.11.2.3 Factory training shall take the client engineers through the design process to understand how various parameters were arrived at and the calculations and
simulations used. The trainer shall demonstrate the design, programming and configurations by carrying out similar designs together with the client on demonstration equipment. Trainer shall task the client staff to carryout similar design, programming and configurations on the demonstration equipment on their own to ensure maximum transfer of knowledge and skill.

1.11.2.4 Factory training shall be detailed and cover the engineering processes. In this respect the contractor shall use experienced trainers with in-depth knowledge of the various engineering processes. The contractor shall give basic academic requirements for client personnel who shall attend this training, the requirements shall however not be above a degree in engineering.

1.11.2.5 Classroom lecturers to be video recorded, and the materials sent to the client.

1.11.2.6 Factory training programme shall be split into three modules as follows:

(a) Protection and SCADA systems-minimum duration of 4 weeks for at least four engineers

(b) MV generator switchgear & LV switchgear systems - minimum duration of 2 weeks for at least two engineers and two technicians

1.11.2.7 The durations given above is the minimum requirement however the bidder shall indicate the necessary duration for successful training and include the cost in the bid. This duration shall however not be less than indicated duration above.

1.11.2.8 Training shall also include detailed training on assembly and repair of the various electromechanical systems. Trainer shall disassemble and reassemble various electromechanical/structural components with the client. This shall also involve assembly and disassembly of each type of circuit breakers to its various building blocks. The client engineers shall be able to carry out repairs and part replacement of circuit breaker electromechanical parts by the end of this training.

1.11.2.9 Practical training on various demonstration equipment shall take precedence over classroom training and emphasis shall be on “learn by doing”.

1.11.2.10 Factory training shall include training on how various factory acceptance tests shall be carried and basis for each acceptance criteria. Training shall also describe the various test equipment and test rigs to be used during FAT.

1.11.3 **On job training**

1.11.3.1 On job training, shall cover both structured and unstructured training to be carried by contractor’s personnel during site works. Unstructured training during installation and commissioning shall be carried out by attaching client skilled personnel to the contractor’s’ staff to carry out the job while getting instructions from the contractor.
1.11.3.2 On job training for SCADA, PLC and IED configuration and programming shall involve the contractor carrying out the task for one unit and supervising the client as they carry out configurations and programming for the other unit. (project covers two units of Gitaru power station, unit 2 and unit 3 and common systems)

1.11.3.3 Two structured trainings shall however be carried out in order to smoothen the on-job training. These shall be pre-installation training and pre-SAT training.

1.11.3.4 **Pre-Installation training**

(a) This shall be carried out on site prior to commencement of the work

(b) It shall be carried out by contractors’ staff who shall carry out installation work

(c) Shall ease integration of attached client personnel to contractor’s staff.

(d) Shall take a minimum duration of three days

(e) To be carried out together with pre-outage works

(f) To cover topics related to how installation shall be carried out, use of contractors’ installation tools and equipment, demonstration on how contractor intends to carry out the installation.

(g) Detailed content of this training shall have been approved two weeks prior to site works.

(h) Shall serve to create a good working relationship between client staff and contractors’ staff

(i) Shall address all expected challenges and remedies.

1.11.3.5 **Pre-SAT training**

(a) This training shall be carried out prior to commencement of SAT by the commissioning engineers.

(b) Shall take at minimum three days

(c) Shall be carried out while installation is ongoing but close to finalisation. Equipment shall be ready for SAT immediately after the training.

(d) Shall be attended by client engineers to be involved in SAT and commissioning

(e) Commissioning engineers shall arrive on site earlier (before equipment is ready for SAT) in order to carry out this training.

(f) The training shall serve to create a good working relationship between client engineers and contractors’ commissioning engineers

(g) During the training the harmonised commissioning program for the whole unit shall be discussed between the teams from each subsystem to ensure smooth commissioning the interconnected system.
(h) Various constraints and expected challenges shall be discussed and addressed during this training.

(i) The training shall be interactive between the trainers and the client engineers.

(j) The training shall cover
   (i) Step by step SAT procedures
   (ii) Test plan and acceptance criteria
   (iii) Equipment inspection and pre-checks
   (iv) Configurations and or programming to be carried out during SAT
   (v) Measuring points and preparations
   (vi) Necessary modifications to be carried during SAT
   (vii) Various equipment limits and precautions to be observed during SAT
   (viii) Requirements given in the particular specifications
   (ix) Use of test equipment and test set ups
   (x) Any other necessary topic for employer’s engineer to fully participate in SAT and commissioning activities

1.11.4 Site training

1.11.4.1 This shall be detailed training to be carried out after the commissioning of the first unit. It shall cover topics listed in the particular specifications but with a greater emphasis on operation and maintenance of installed equipment.

1.11.4.2 Shall take a minimum of six weeks for all systems as follows:
   (i) Protection at least two weeks
   (ii) SCADA at least two weeks
   (iii) MV and LV switchgear at least two weeks

   (a) Duration above is only indicative and the bidder shall indicate no. of days required for fruitful training of content detailed in particular specification which shall however not be less than the duration given above.

   (b) These training for each system SHALL NOT be carried out concurrently and shall run one after the other to ensure client staff attend all the above sections.

1.11.4.3 It shall cover topics similar to the factory training but with an emphasis on operation and maintenance. Some of the topics covered in the factory training shall be repeated for the benefit of staff who shall not have attended the factory training. The detailed content shall be agreed upon in the design stage. The bidder shall however note that all topics listed in particular specifications MUST be covered during site and factory training.
1.11.4.4 Training shall be conducted in client’s facilities and on site using installed equipment, spare equipment supplied will be configured and used for demonstrations. Power plant outage will be booked in order to carry out practical training; during this period Contactor, shall also carry out identified defects corrections.

1.11.4.5 Contractor shall provide certified and experienced trainers who are fluent and have excellent command of English language.

1.11.4.6 Client will provide projectors and other necessary training facilities.

1.11.4.7 Theory training will be conducted for a group of up to thirty client personnel or any other number communicated to the contractor two weeks prior to the training. Practical training will be done in small groups to be agreed upon with the client and will be held in the power plant using installed equipment. Theory training shall include demonstrations using the spares to be supplied.

1.11.4.8 Contractor shall supply training aids including a detailed training guide or document well prepared in advance. Contractor is expected to be well prepared for the training with necessary presentations specific for the training. Contractor will also prepare and present certificates to participants at the end of the training.

1.12 SPARES

1.12.1 All the spare listed in the scope of works MUST be quoted for in the schedule of prices. Failure to quote for a stated spare shall render the bid unresponsive.

1.12.2 All spares MUST be 100% similar to installed components.

1.12.3 All spares not listed in the scope of works/particular specifications but are critical to equipment proposed by the bidder or are sub components/complementary components of the listed spares MUST be included in the bid offer. Where such spare part / equipment is not listed by the bidder but its considered critical it shall be supplied at no extra cost to the client.

1.12.4 All spares shall be tested by the contractor in presence of the client engineer prior to acceptance. These spares shall be tested at site with the installed systems. Untested spares shall not be accepted by the client.

1.12.5 Spare IED’s, PLC cards and other software loaded, and configured devices shall be configured and loaded with the necessary software and then tested prior to acceptance by the client.

1.12.6 It is a condition of this contract that all malfunctioning items during the warranty period – to start after issue date of Take over Certificate – shall be replaced by the Contractor at their own cost.
1.13 MAINTENANCE EQUIPMENT & TOOLS

1.13.1 General requirements

1.13.1.1 All maintenance and test equipment required shall be included in the price schedule and shall be handed over to the client in good order on completion of commissioning tests.

1.13.1.2 Tools and equipment listed in this specification MUST be included in the bid offer and quoted for otherwise the bid shall be considered unresponsive.

1.13.1.3 The bidder shall however note the employer reserves the right of selecting a particular tool or test equipment and some tools and equipment might not be accepted for supply.

1.13.1.4 Installation and testing equipment/tools required for SAT/commissioning but not accepted for supply under the contract shall be shipped to the site and back to contractor’s home country by the contractor where requested the client shall assist in clearing at the port of entry for such equipment.

1.13.1.5 The tools and equipment shall be unused and in new condition at the time of handover. Test equipment, however shall be used during site testing.

1.13.2 Test equipment

1.13.2.1 Contractor shall supply all test equipment and tools necessary for site testing and commissioning.

1.13.2.2 Bidder shall include in their offer all equipment listed below and any other major test equipment required which will be taken over by the client after commissioning.

1.13.2.3 The following test equipment shall be included in the bid offer:

(a) One (1) Three Phase Motorised Variable Transformers (Variac) for testing purposes with the following features:

(i) Transformer shall be cast resin dry type with a fixed input voltage and variable output voltage

(ii) Rated continuous input voltage: 415V AC +5%

(iii) Rated continuous current @40°C: 150A AC

(iv) Surge current rating: 1500A for 1sec

(v) Rated continuous output voltage: 0–485V AC

(vi) Max power rating: 126 KVA

(vii) Enclosure: IP20 with wheels and natural cooling

(viii) Protection: input circuit breaker
(ix) Operational features:
• Output Terminal Block
• Digital Voltmeter for output voltage with selector switch
• Ammeter for output current with selector switch
• Up and Down push button for output voltage control

(x) Operating mechanism: motor driven brush gear with smooth commutator

(b) One (1) 433/3300V Three Phase Voltage Booster Transformers for testing purposes with the following features:
(i) Cast resin dry type transformers
(ii) Rated continuous input voltage: 433V AC +5%
(iii) Rated continuous current @40°C: 150A AC
(iv) Surge current rating: 1500A for 1 sec
(v) Rated output voltage: 3300V +5% AC
(vi) Max power rating: 126 KVA
(vii) Enclosure: IP20 with wheels and natural cooling

(c) Two (2) sets of each type of CT/VT isolation test block plugs

1.13.2.4 Client shall only accept test equipment manufactured in Western Europe, USA or Canada.

1.13.2.5 Contractor shall offer detailed training for each of the above test equipment during commissioning and after commissioning.

1.13.3 **Tools**

The following tools shall be included in the bid offer to be supplied under the contract in new unused condition (they shall not be used during the project):

1.13.3.1 Fluke 190 Series II Scope Meter® model 190-504/S with Colour Scope Meter, 500 MHz, 4 channels plus DMM/Ext. Input, SCC-290 Kit (Fluke View Software for Scope Meter (SW90W) and Carrying Case (C290) Kit) and the following accessories
(a) Four (4) 80i-110s AC/DC Current Probes (100 A)
(b) One (1) i6000sFlex AC Current Probe (6000 A)
(c) One (1) i1000s AC Current Clamp (1000 A)

1.13.3.2 Two sets of Bosch cordless power screw driver set each with the following features and accessories:
(a) Integrated bit cylinder containing the 12 most important screwdriver bits, torque setting adapter,
(b) 32-piece Screwdriver Bit Set,
(c) 20+1 clutch setting for perfect torque adjustments and precise screwing
(d) 2 reversible speed settings (0-350 RPM for high torque screw driving, and 0-1300 RPM for high speed drilling)
(e) Variable speed trigger, Bright LED light to illuminate work spaces,
(f) Soft grip
(g) Maximum torque of 265 in-lbs,
(h) 30-minute charger with 2 lithium ion batteries with at least 6AH capacity, and
(i) a carry case.

1.13.3.3 Three Weidmuller crimping sets each with weidmuller bootlace crimp tool 0.5mm²-5mm², weidmuller wire stripper 0.08mm²-10mm² and 3100 assorted bootlace ferrules (0.5mm²-6mm²)

1.13.3.1 Partex pro marking machine with a minimum of the following features, accessories and consumables.
(a) Features:
   (i) Compact, portable printer for cable, wire and component marking on site.
   (ii) The printer feeds, marks and cuts bulk Partex profiles.
   (iii) Creates markers using Partex FO/FOZ, FO punched, PP and PPA, PHZ profiles, and PL and PLL self-adhesive labels.
   (iv) Marking information may be entered manually using the integrated keyboard and LCD screen.
   (v) Can be controlled from a PC via USB port (USB cable included).
(b) Accessories:
   (i) soft carry case,
   (ii) Aluminium hard case,
   (iii) Profile Auto-Feeder unit,
   (iv) tube attachment unit,
   (v) two cutter sets,
   (vi) power adapter,
   (vii) five 100m ribbon cassettes,
   (viii) tube attachment,
   (ix) cleaning unit,
   (x) USB cable,
   (xi) software and user manual.
(c) Consumables
Tender for rehabilitation of Gitaru Power Station Generator MV Switchgear, Protection systems and LV Switchboards

(i) Five (5) Packs of 250 m reel PO oval profile markers,
(ii) Three (3) packs of 40m reel PO Punched Profile for Cable Marking,
(iii) Five (5) packs of 50m reel of flat PP Marker Profile for PT and PM holders,
(iv) Three (3) packs of 17m disc PP Flat Profile for Terminal Block Marking,
(v) Three (3) packs of 10m discs of PPA Self Adhesive Marker Strip,
(vi) Five (5) packs of 100m reel of Halogen-Free Heat Shrink Tube,
(vii) Two (2) - 6mm and 12mm wide - 30 m white self-adhesive tape cassette,
(viii) Ten (10) packs of 200 holders per pack PT & PT+ Wire Marking holders,
(ix) Three (3) bags 100-piece PM holders.

1.13.3.2 A set of Special tools for operation of the LV switchboards and MV switchgear i.e. trolley, cranking pins, etc. and all other special tools required for assembly and disassembly of any equipment supplied under the contract. Suitable special spanners shall be provided for bolts and nuts, which are not properly accessible by means of an ordinary spanner.

1.13.3.3 Control plug extension cables
(a) 3m extension cable for the GCB control plug
(b) 3m extension cable for the LV switchboard ACB
(c) 3m extension cable for LV switchboard withdrawable modules auxiliary terminal plug

1.13.3.4 Fibre optic installation and testing toolkit with the following:
(a) Rugged Case
(b) Test equipment
   (i) 1x power meter wavelengths:800~1700nm; with universal adapter for ST, LC & SC connectors.
   (ii) 1x Visual Fault Locator for both SM & MM fibres
   (iii) 1x Single mode 1310/1550nm laser light source
   (iv) 1x Multimode 850/1300nm LED light source
   (v) 1x 400x Fibre Optic Microscope with adapters for fibre optic connectors
   (vi) 2x Reference Test Cables of each type (i.e. size 62.5/125, 50/125 or SM and connector type ST, SC & LC) tested and known to be low loss
   (vii) 1x set of connector mating adapters with metal or ceramic alignment sleeve of the various types i.e. ST/ST, SC/SC, LC/LC, ST/SC, ST/LC, SC/LC
(c) Splicing kit
   (i) Fusion splicer
   (ii) Fusion splice protectors
   (iii) Fibre cleaver

(d) Cleaners
   (i) 2x 2.5mm fibre optic one-click cleaner pen for FC, ST and SC
   (ii) 2x 1.25mm fibre optic one-click cleaner pen for LC&MU
   (iii) 1x fibre optic cassette cleaner

(e) Stripping & polishing tools
   (i) 1x Buffer tube stripper
   (ii) 1x Jacket stripper
   (iii) 1x Tri-hole Fibre stripper
   (iv) 1x Kevlar scissors
   (v) 1x Black marker
   (vi) 1x Drop cable stripper
   (vii) 1x 6” Steel wire clamp

(f) Cleaning Supplies
   (i) 1x 250ml Bottle of Alcohol with Lock
   (ii) General Purpose Cotton Swabs
   (iii) 1x 2.5mm Economy Fibre Swab packets (200 pieces per packet)
   (iv) 1x Fibre Optic Ferrule Cleaner
   (v) 1xCotton Friction Tape 3/4” X 60’
   (vi) Lint-Free Alcohol Wipes
   (vii) 1x Fibre Splinter Removal Tweezer

(g) Cutting tools
   (i) 1x Tubing Cutter 1/8” to 1-1/8”
   (ii) 1x Low-Cost Splicer’s Snips
   (iii) 1x6” Diagonal Cutting Plier
   (iv) 1x6” Standard Long-Nose Plier with Side Cutters
   (v) 1x9” High-Leverage NE Side Cutter
   (vi) 1xCable Sheath Cutter
   (vii) 1x High-Leverage Cable Cutter
   (viii) 1x Retractable Utility Knife
   (ix) 1x 0.5mm2 – 4mm2 Multi Wire Stripper

(h) Utility tools
   (i) 1x 8 Piece, 5 to 12 mm insulated nut driver set
   (ii) 1x 13-piece insulated screw driver set with:
• 4 x Slotted Bits 2.5, 3.5, 4 and, 5.5mm;
• 2 x Phillips Bits PH1 and PH2;
• 2 x Phillips Bits PHS1 and PHS2;
• 2 x Pozidriv Bits PZ1 and PZ2;
• 2 x Pozidriv Bits PZS1 and PZS2 and
• 1 x Voltage Tester Phillips Screwdriver #1

1.13.3.5 A universal fibre optic connector (SC, FC, ST, LC, MU) termination tool kit, for termination of any type of fibre optic connector

The kit shall at minimum contain the following:
(a) 1x 24 Port Connector heat oven
(b) Rugged carry case
(c) Fibre Cable Stripping Tools
   (i) 1x Round cable slitter
   (ii) 1x Buffer tube stripper
   (iii) 1x Jacket stripper
   (iv) 1x Fibre stripper
   (v) 1x Kevlar scissors
(d) Fibre Scribe Tools
   (i) 1x Carbide scribe tool
(e) Connector Crimp Tools
   (i) 1x Universal crimp tool for SC, ST and FC connectors
   (ii) 1x Crimp tool for LC and MU connectors
(f) Connector Inspection Tool
   (i) 1x 200x Universal Microscope for SC, ST and FC connectors
   (ii) 1x LC, MU adapter for universal microscope
(g) Connector Polishing Tools and Supplies
   (i) 1x Black work mat
   (ii) 1x Glass polish plate
   (iii) 1x Rubber polish pad
   (iv) 1x Universal polish puck for SC, ST, FC connectors
   (v) 1x Universal polish puck for LC, MU connectors
   (vi) 5x 5µm lapping film
   (vii) 5x1.5µm lapping film
   (viii)5x 1µm lapping film
   (ix) 5x 0.5µm diamond lapping film
   (x) 5x 0.3µm lapping film
(xi) Connector termination instruction for SC, ST, FC, LC and MU connectors
(xii) 1x Black marker
(xiii) 1x Ruler
(xiv) 1x Fabric tape measure
(h) Epoxy and Dispensing Tool
   (i) 5x 4-gram Blue dye epoxy
   (ii) 10x Syringes
(i) Anaerobic Adhesive and Dispensing Tool
   (i) 1x Anaerobic Adhesive Hardener
   (ii) 1x Anaerobic Primer
(j) Safety Supplies
   (i) 1x Safety glasses
   (ii) 1x Fibre disposal unit
(k) Cleaning Supplies
   (i) 1x Connector reel cleaner
   (ii) 1x Piano wire
   (iii) 5x Degreaser wipes
   (iv) Cleaning solvent
   (v) 50x Foam swabs
   (vi) Fibre optic wipes
(l) Other Utility Tools and Supplies
   (i) 1x Utility knife
   (ii) 1x Tweezers
   (iii) 1x Needle nose pliers
   (iv) 1x 6" Side cutting pliers
   (v) 1x 1/2" Nut driver
   (vi) 1x 4 Bit screw driver
   (vii) 1x PVC electrical tape

1.13.3.6 50(fifty) pieces of each type of fibre optic connectors (LC/SC/ST) to be used during the project

1.13.3.7 Three key cabinets shall be supplied and installed for storing all the keys supplied under the project. Two key cabinets shall be installed at the power house (one for each unit) and another shall be installed at the control room for control room devices

1.13.3.8 The Contractor shall supply lockable boxes, for the Employer’s use, to store any special tools supplied.
1.13.4 **Software**

1.13.4.1 Programming/configuration software for all devices supplied under the contract (PLC, IED’s, HMI, meters etc.) with a minimum of two licences for each software and each software installable into two computers.

1.13.4.2 Testing and calibration software for all test equipment supplied under the contract.

1.13.4.3 Hardware connections necessary to connect the programming laptop to the programmable & software configurable devices supplied.

1.13.5 **Portable Computers**

1.13.5.1 At least **FOUR** portable computers (laptops) shall be supplied for the project.

1.13.5.2 Laptops shall be delivered with all software and licences necessary to achieve the specified functionality as well as the software necessary for programming, testing, service and maintenance through the lifetime of the equipment.

1.13.5.3 Laptop shall be strong and durable and shall meet US military MIL-STD-810G standards for reliability and performance under extreme conditions, namely temperature, altitude, humidity, dust, shock and vibration. The Laptops shall feature a magnesium alloy chassis, anodized aluminium lid and palm rests and spill-resistant keyboards.

1.13.5.4 Each laptop shall have at minimum the following specifications

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<th>Minimum Requirement</th>
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| Ruggedness | Tested as per MIL-STD-810G and passed the following tests:  
- Drop test in accordance with MIL-STD-810G, Method 516.6 Procedure IV  
- Shock test in accordance with MIL-STD-810G, Method 516.6 Procedure I  
- Vibration Resistance test in accordance with MIL-STD-810G, Test Method 514.6 Procedure I  
- Dust Resistance in accordance with MIL-STD-810G, Method 510.5, Procedure I (Dust)  
- Humidity test in accordance with MIL-STD-810G, Method 507.5, Procedure II  
- Altitude test in accordance with MIL-STD-810G, Method 500.5, Procedure I (Storage) and II  
- High Temperature test in accordance with MIL-STD-810G, Method 501.5, Procedure I (Storage) and II  
- Sand test in accordance with MIL-STD-810G, Method 510.4 Procedure II  
- bench handling test in accordance to the MIL-STD-810G, |
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| Processor               | Method 516.6 Procedure VI  
• Crash hazard test in accordance to the MIL-STD-810G, Method 516.5 Procedure V  
**NB** HP ZBook 15 G4, HP ZBook 15u G4, HP ZBook 15 G4, HP ZBook Studio G4 have been tested and passed all the above tests |
| RAM                     | Type: Intel® Core™ i7-7700HQ with Intel® HD graphics 630, Processor speed: 2.80 GHz, Number of cores: Four (4), Number of threads: Eight (8), Memory bus speed: 2400 MHz, L3 Cache: 6 MB, TDP: 45W |
| RAM                     | At least 16GB, DDR4-2400                                                                                                                                 |
| Solid state drive       | 512 GB, M.2 NVMe MLC Solid State Drive (No hard disk allowed)                                                                                       |
| Display                 | At least 15.6-inch, 15.6" diagonal LED backlit FHD UWVA IPS eDP anti-glare+ PSR Panel Self Refresh), 16:9, 1920 x 1080 resolution                                |
| Operating Systems:      | Latest Genuine 64bit Windows (windows10 pro or higher) ultimate/professional edition                                                              |
| Applications            | • Fully activated complete 64bit latest edition Microsoft office (2016 or higher) suite with license and key,  
• latest edition and licensed VMware Workstation Pro &  
• Activated latest edition Kaspersky internet security anti-virus with license |
| Optical Drive:          | DVD+/−RW Super Multi DL - external drive with USB 3.0                                                                                               |
| Integrated Communications| Intel® Dual Band Wireless-AC 8265 802.11 AC/a/b/g/n (2x2) WiFi + Bluetooth® 4.2 Combo Adaptor*(vPro)                                           |
| Integrated Security     | Security Lock Slot plus steel cable (5.5mm thick) with a combination lock                                                                      |
| Interfaces              | • Two (2) USB 3.0,  
• One (1) USB 2.0,  
• One (1) HDMI Display Port,  
• One (1) VGA port  
• One (1) stereo microphone in  
• One (1) stereo headphone/line-out,  
• One (1) 1394a,  
• One (1) AC power,  
• One (1) RJ-45  
• One (1) secondary battery connector,  
• One (1) E-sata /USB 2.0 Combo, |
| Pointing Devices        | Touchpad with on/off button, two-way scroll, gestures, two pick buttons                                                                           |
| Keyboard                | Full-size, spill resistant keyboard with drains                                                                                                    |
| Mouse                   | optical wireless mouse                                                                                                                                 |

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**April 2018**
<table>
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<tr>
<th>Item</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warranty</td>
<td>2 Year Warranty</td>
</tr>
<tr>
<td>Battery</td>
<td>9-cell ,90 WHr Li-Ion</td>
</tr>
<tr>
<td>Power Supply</td>
<td>240V AC, 50Hz, 3pin British plugs</td>
</tr>
<tr>
<td>Carrying Case</td>
<td>Genuine Leather Carrying Case</td>
</tr>
</tbody>
</table>

### 1.14 WARRANTY

1.14.1.1 The Contractor shall warrant that goods supplied under the Contract are brand new, unused, of the most recent or current models, and that they incorporate all recent improvements in design and materials unless provided otherwise in the Contract.

1.14.1.2 The Contractor further shall warrant that all Goods supplied under this Contract shall have no defect arising from design, materials, or workmanship or from any act or omission of the Contractor, or that may develop under normal use of the supplied Goods in the conditions prevailing in the country of final destination.

1.14.1.3 This warranty shall remain valid for twelve (12) months after the Equipment, or any portion thereof as the case may be, have been commissioned and take over certificate signed by both parties, or for thirty-six (36) months after arrival of equipment at site whichever period concludes earlier.

1.14.1.4 The bidder guarantees supplying maintenance spares and services as well as repairing of the supplied systems where called upon to do so after expiry of the warranty period at employers cost for a period of 15 years.
2 SCOPE OF WORKS

2.1 PREAMBLE

2.1.1 The Bidder shall examine the scope of works in this section in close connection with the other documents and particulars forming these Bidding Documents. Special attention shall be paid to Particular Technical Specifications and drawings of the existing systems in order to develop the scope of supply by the bidder.

2.1.2 All the functionality and features of the existing system shall be part of the scope of supply whether specifically mentioned in this scope or not. The bidder shall study the existing drawings, carry out a site visit and request all necessary information prior to developing their scope of supply. Where there is a conflict or omission in this scope of works, or conflict between functionality and features of the existing systems and employer’s requirements, the bidder shall seek clarification and correction from the client as stipulated in clause 7 of ITT.

2.1.3 The tenderer shall indicate make, type, model number and manufacturer of equipment in their bid offer.

2.1.4 All functions, devices, accessories or fittings which may not have been specifically mentioned, but which are usual or necessary for the proper and safe completion, operation, and maintenance of the equipment in question, shall be deemed to be included in the scope of supply and shall be supplied.

2.1.5 Any alternative/ additional system or device considered necessary for providing complete effective and reliable system shall also be included in the scope of supply by the bidder.

2.1.6 In the event of any conflict between the particular specifications and the Scope of works, the particular specifications shall prevail. In the event of any conflict between scaled dimensions and figures on the Drawings, the figures shall prevail.

2.1.7 Should the Bidder find discrepancies or omissions in these Specifications or, should they be in doubt as to their meaning, they should immediately contact the Project Manager for interpretation, clarification or correction thereof before submitting their Bid.

2.1.8 The equipment listed in the subsequent clauses under scope of supply are indicative major components and shall not be assumed to cover the whole scope of supply for each system.

2.1.9 All the system and devices listed under scope of supply are to use the station auxiliary DC power supply of 110VDC or 240VAC/415VAC. Where power supply units or
power transformers are required to power the devices, they shall be part of scope of supply whether mentioned or not.

2.2 GENERAL SCOPE OF WORKS

The requirement under this general scope of works are applicable to all the project sections i.e. Generator MV switchgear scope, Protection systems scope and LV switchboards scope. The scope of the works shall include but not limited to the listed activities and any other works required to fulfilling all the requirements in this specification.

2.2.1 The contractor shall study the plant equipment i.e. generators, generator step up transformers, control systems, Turbine systems, station transformers, alternative supply transformer, diesel generator, Station DC system, other associated equipment and any other system necessary in order to offer a complete solution. In particular, a detailed study of the existing LV switch boards, existing unit 2&3 protection system and the substation in order to provide a complete solution covering all existing functionality and additional functions as specified in the subsequent clauses of the specification. Contractor shall also study the power system connections to Gitaru power station and other related power system properties where necessary.

2.2.2 The contractor shall carryout power system analysis studies detailed in clause 1.8.3. Advise the client on any requirements that are not included in the scope of the project that are necessary for successful implementation of the project.

2.2.3 The contractor shall design the new systems including calculations and drawings and sending designs to client for approval at each stage of design. Design and development of all software application programs required for operation of systems to be supplied. This shall include preparation of all documentation and review as specified in clause 1.7 of specifications.

2.2.4 The contractor shall manufacture & procure all the equipment detailed in the subsequent clauses of this specification and any additional equipment necessary for a complete solution.

2.2.5 The contractor shall carry out factory training for client engineers at manufacturers training facilities prior to acceptance testing as detailed in clauses 1.9 and 1.11 of specifications.

2.2.6 The contractor shall carry out factory acceptance testing witnessed by client engineers at manufacturers factory for all systems to be supplied as detailed in particular specifications and clauses 1.9 of specifications.

2.2.7 The contractor shall supply: factory wired Complete Panels with all components as specified in subsequent chapters of this specification, cables & other free-standing
2.2.8 The contractor shall supply cables & conductors, lugs, connectors, screws, nut, bolts, washers, terminal blocks, cable lugs, bootlaces, auxiliary relays and all other installation accessories required for retrofitting the new system and interfacing to the plant systems specified subsequent chapters of this specification.

2.2.9 The contractor shall supply all accessories which are necessary for satisfactory operation of complete system though not individually or specifically mentioned in the specification.

2.2.10 The contractor shall supply software’s and application programs with licences for all IED’s, PLC’s, other software-based devices and computers supplied. This shall include software required for interrogating the IED’s, PLC’s and other software configurable devices via a portable computer, software loaded in the IED’s, PLC’s & computers and all application programs /configuration files made for the project running on the PLC’s, IED’s & computers.

2.2.11 The contractor shall supply and carry out training on all test equipment and maintenance tools specified in the specifications.

2.2.12 The contractor shall remove existing unit 2 & 3 protection equipment, unit 2 & 3 substation 15kV switchgear, main station switchboard auxiliaries ‘section and any other existing equipment to be removed and transportation to client designated storage within the power station.

2.2.13 The contractor shall install new panels in place of existing panels including shifting from storage with required mounting hardware, blanking plates, Glands, Earthing strip, relevant fabrication and other relevant accessories. Complete wiring and terminations, grounding and wiring modifications to include all functions as per specifications. Cabling and wiring to interface the new systems to the other plant systems.

2.2.14 The contractor shall install new generator MV switchgear housing including carrying out necessary substation modifications to carry out the installation. Construction of the switchgear housing mounting structure. Assembly and installation of the switchgear enclosure. Installation of any other free-standing equipment detailed in the specifications.

2.2.15 The contractor shall carry out of all civil and structural works required for installation of the panels and the MV switchgear housing.

2.2.16 The contractor shall carry out Software configuration and installation on the new systems. Software modification and configuration on client SCADA equipment in conjunction with the client engineers as specified in the subsequent chapters of this specification.
<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.17</td>
<td>The contractor shall carry out Site Acceptance Testing and commissioning of modified systems as specified in the specifications.</td>
</tr>
<tr>
<td>2.2.18</td>
<td>The contractor shall carry out on job training during installation &amp; commissioning and post commissioning site training as detailed in section 1.11 of specifications and particular technical specifications.</td>
</tr>
<tr>
<td>2.2.19</td>
<td>The contractor shall replace any supplied equipment and software found defective during commissioning or defects liability period.</td>
</tr>
<tr>
<td>2.2.20</td>
<td>The contractor shall provide all final documentation as per clause 1.7 of specifications.</td>
</tr>
<tr>
<td>2.2.21</td>
<td>The contractor shall provide warranty for supplied Systems.</td>
</tr>
<tr>
<td>2.2.22</td>
<td>The contractor shall modify/review and update all client drawings of the plant systems interfaced to the new systems or modified to accommodate the new systems and submission to the client as specified in clause 1.7 of specifications.</td>
</tr>
<tr>
<td>2.2.23</td>
<td>The contractor shall provide any other services or requirements not mentioned or included in this tender but which the contractor deems critical for the completion of the contract. These shall be itemized by the bidder in the offer and price schedule where necessary.</td>
</tr>
</tbody>
</table>
2.3 GENERATOR MV SWITCH GEAR SCOPE OF SUPPLY

2.3.1.1 Contractor shall manufacture, test, supply, install and commission Two (2) (unit 2 & 3) indoor type Medium Voltage Generator switchgear systems each rated as follows:

(a) Rated voltage: 17.5 kV
(b) Rated frequency: 50 Hz
(c) Rated power-frequency withstand voltage: 50kV, 1 minute
(d) Rated lightning impulse withstand voltage: 110kV, 1.2/50 µs
(e) Rated short-time withstand current: 63kA
(f) Rated duration of short circuit: 3s
(g) Rated peak withstand current: 173kA
(h) Rated continuous current of bus bar @40°C: 4300A
(i) Rated continuous of Generator CB current @40°C: 5000A

Detailed requirements as per particular specifications

2.3.1.2 Each Medium Voltage Generator switchgear systems for unit 2 and 3 to be supplied shall consist of two/three cubicles:

(a) Generator circuit breaker cubicle, housing: 17.5 kV, 5000A withdrawable vacuum generator circuit breaker, current transformers, voltage transformers, motorised earth switch, surge capacitor, surge arrester, bus bars, control panel and other termination devices

(b) Generator step up transformer interface (bus riser) cubicle, housing: interconnection bus bar, main bus bar, voltage transformer, motorised earth switch, surge arrester, surge capacitor, control panel and other termination devices. *This cubicle may be integrated into the station transformer cubicle if all components detailed in the particular specification are included without compromising safety standard (as defined by the relevant IEC62271 standard) of the cubicle*

(c) Station transformer interface cubicle housing: motorised fused load break switch, motorised earth switch, current transformers, pressure release duct, control panel and other termination devices (ca)

2.3.1.3 Contractor shall manufacture, test, supply, install and commission two (2) (unit 2 & 3) walk in switchgear enclosure/housing in the substation measuring Length = 6800mm X Width = 5200mm X Height=3600mm to house the MV switchgear. shall be installed in the substation in the area currently occupied by the 15KV outdoor bus bars and their terminations, the mounting structures shall be supplied and installed by the contractor as per particular requirements.
2.3.1.4 Contractor shall construct two (2), one for each unit, steel supporting structures for mounting the switchgear enclosures, the supporting structures shall have a minimum of twelve (12) steel columns as per particular specifications. Existing 15kV structures shall be removed and the steel supports reused where possible to make the steel columns for the mounting structure. Existing plinths shall be reused where possible, new plinths constructed for the rest of the steel columns.

2.3.1.5 Contractor shall manufacture, test, supply, install and commission two (2) (unit 2 and 3) Station transformer HV side connection MV cables and two (2) (unit 2 and 3) GSU transformer LV side interconnection solid insulated bus bars.

2.3.1.6 Contractor shall carry out the following for unit 1
   (a) Install and commission the existing station transformer (one station transformer is currently in the store) on the plinth at unit 1
   (b) Install and commission HV overhead conductors and terminations to the unit 1 transformer
   (c) Supply, install and commission an LV cable from station transformer 1 to the main station switchboard.

2.3.1.7 MV switchgear Control, metering, protection and auxiliary supplies shall be interconnected to the plant for the three units. Cables and all wiring accessories shall be provided. New control and metering devices shall be installed on the manual control panel for each unit for remote switchgear operation and monitoring.

2.3.1.8 The following mandatory spares shall be provided
   1. One (1) complete Vacuum Generator circuit breaker (VGCB)
   2. Two (2) Generator circuit breaker shunt release coil (solenoid)
   3. Two (2) Generator circuit breaker closing coil (solenoid)
   4. Two (2) Generator circuit breaker spring charging motor
   5. Two (2) Generator circuit breaker position limit switches of each type (disconnected, test, in service)
   6. One (1) complete earth switch with all components
   7. Two (2) earth switch motors
   8. One (1) load break switch complete contact assembly
   9. One (1) load break switch motor
   10. Five (5) load break switch HRC fuses properly rated for the station transformers and the MV cables.
   11. Three (3) current transformers for GCB cubicle
   12. Three (3) current transformers for station transformer feeder cubicle
   13. Three (3) voltage transformers for bus riser cubicle
14. Three (3) voltage transformers for GCB cubicle
15. Five (5) HV AC HRC fuses for each type and rating for Voltage transformers
16. Three (3) surge capacitors
17. Three (3) surge diverters
18. One (1) complete Integrated capacitive voltage detecting system
19. Three (3) Mimic position LED indicators
20. Two (2) resistance temperature detectors, RTD’s of each type used
21. Two (2) solenoid valves of each type (fire protection)
22. One (1) door interlock key for CO₂ release
23. Five (5) discrepancy switches
24. Six (6) Digital indication meter for Instrument/process signals with a 4-20mA DC current input

2.4 PROTECTION SYSTEM SCOPE OF SUPPLY

2.4.1.1 Protection system will consist of protection schemes for

(a) Generator protection scheme: unit 2 & unit 3
(b) GSU transformer: unit 2 & unit 3
(c) Station transformer: unit1, unit2 & unit3
(d) Alternative supply transformer
(e) Emergency diesel generator (EDG)

2.4.1.2 Contractor shall manufacture, test, supply, install and commission six panels for protection scheme with the following components

(a) Panel 1 will host unit 2 generator protection set A and generator protection set B
(b) Panel 2 will host unit 2 GSU transformer protection set A, GSU transformer protection set B and station transformer 2 protection set
(c) Panel 3 will host unit 3 generator protection set A and generator protection set B
(d) Panel 4 will host unit 3 GSU transformer protection set A, GSU transformer protection set B and station transformer 3 protection set
(e) Panel 5 will host station transformer 1 protection set, alternative supply transformer protection set, and emergency diesel generator protection set
(f) Panel 6 shall host IEC61850 communication gateway equipment consisting of Ethernet LAN equipment, industrial PC, GPS time server, touch monitor display and other equipment as per speciation’s

2.4.1.3 Contractor shall interface the new protection panels to all necessary plant equipment e.g. circuit breakers, CT’s, unit & common PLC etc. New cables shall be supplied, installed and commissioned for all control, metering, protection & auxiliary supply cabling existing cables shall not be reused.

2.4.1.4 Contractor shall manufacture, test, supply, install and commission 2 (two) (one for each unit) **Shaft Brush gear** with all associated devices for generator shaft earthing, shaft current protection and rotor earth fault sensing.

2.4.1.5 Contractor shall implement an IEC61850 communication scheme (substation automation system) for inter IED communication and IED to SCADA interface system via Ethernet LAN and hardwiring to plant automation system as detailed in the particular specification. Contractor shall supply, install and commission a SCADA communication gateway to facilitate protection IED to SCADA communication as detailed in particular specification.

2.4.1.6 Contractor shall supply, develop and commission an Alarms and events management system as detailed in clause 7.6.2 of specification. Consisting of

   (a) One server cabinet with a pair of redundant servers, Ethernet switches, hardware firewall, and other necessary hardware

   (b) Alarm server software applications supply and development

   (c) Alarm and events data acquisition systems (DAS) for installation into employers’ DBS servers supply and development

   (d) Alarm system client applications supply and development

2.4.1.7 Supply of all programming/configuration software each with at least two licences and installed into two laptops. Supply of all software applications developed for the project i.e. IED configuration files, IED logic diagrams, ALL SCADA applications

2.4.1.8 A minimum of the following **mandatory spares** shall be provided

   1. 2(two) Generator numerical protection relays one from each manufacturer

   2. 2(two) GSU transformer numerical protection relays one from each manufacturer

   3. Two (2) protection IED’s for Station transformer, alternative supply transformer & EDG protection if they are of the same type or model (if they are interchangeable) else one (1) of each type of protection IED’s for Station transformer, alternative supply transformer & EDG protection

   4. 1(one) synchronizing relay
5. Two (2) 100% stator earth fault accessories (injection set, filter and CT.), one from each manufacturer
6. Two (2) rotor earth fault accessories (injection set & resistor box) one from each manufacturer
7. 1(one) complete rack mount Industrial Ethernet switch
8. 2(two) Digital power transducers
9. 2 (two) test blocks/switches
10. 2(two) Lockout trip relays with 20 SPST contacts each
11. 2(two) Lockout trip relays with 10 SPST contacts each
12. 2(two) Lockout trip relays with 5 SPST contacts each
13. 20 (twenty) control auxiliary contactor relays each with 8 SPST contacts
14. 30(thirty) miniature interface auxiliary relays each with 4 SPDT contacts
15. 4(four) circuit breaker trip coil supervision relays
16. 6 (six) 110 V DC supply supervision relays
17. 10 (ten) DC DP Miniature circuit breakers of each type and rating
18. 5(five) AC DP Miniature circuit breakers
19. 1(one) complete panel siren/buzzer
20. 3(three) Emergency pushbutton
21. 5(five) push buttons
22. 3(three) three position key operated switch
23. 3(three) two position key operated switch
24. 2(two) two position selector switch
25. 2(two) three position centre zero (raise-neutral-lower) with spring return switch
26. 5 (five) status indication LED lamps
27. 4(four) 4-20mA signal amplifiers/isolators

2.5 LV SWITCHBOARDS SCOPE OF SUPPLY

2.5.1.1 The following LV switchboards shall be manufactured, tested, supplied, installed and commissioned under this scope:
(a) Main station auxiliaries' switchboard
(b) DC distribution boards

2.5.1.2 Supply, installation & commissioning of all control, metering & protection cabling and wiring to various Station equipment from the new switchboards and
associated equipment. New cables shall be supplied for all control, metering, protection & auxiliary supply cabling existing cables shall not be reused

2.5.1.3 Supply of all programming/configuration software each with at least two licences and installed into two laptops. Supply of all software applications developed for the project i.e. IED configuration files, IED logic diagrams, ALL SCADA applications

2.5.1.4 Supply and install panel multifunction meters in the main switchboard (not in scope of supply)

2.5.1.5 The new mains station auxiliaries’ switchboard shall be installed in the control room in front of the protection panels. The available space in front of the protection panels is 5000mm X 600mm. A cable trench of 10000mmX800mm shall be constructed inside the control room for cable installation. The cable trench shall be similar to the control room cable trenches with tiled covers.

2.5.1.6 Cable marshalling cabinets shall be installed in the position where the existing main station switchboard auxiliaries section is situated. The cable marshalling cabinet shall interface the new main station auxiliaries’ switchboard to the existing power station cables

2.5.1.7 The following mandatory spares shall be provided

1. 1(one) ACB carriage
2. 1(one) 800A ACB
3. 1(one) 315A MCCB
4. 2(two) 160A MCCB
5. 2(two) 63A MPCB
6. 4(four) 32A MPCB
7. 4(four) 16A MPCB
8. 2(two) MCCB/MPCB door-coupling rotary operating mechanism
9. 2(two) 75KW/160A contactor
10. 2(two) 37KW/80A contactor
11. 2(two) 63A SP AC MCB
12. 4(four) 32A SP AC MCB
13. 4(four) 16A SP AC MCB
14. 2(two) switchboard current transformers for each CT ratio
15. 2(two) switchboard voltage transformers, for each burden rating
16. 1(one) automatic transfer controller/switch
17. 1(one) Serial device server with at least four Ethernet ports and four serial ports
18. 2(Two) panel digital multifunctional meter
19. 1(one) Digital AC voltmeter with serial output
20. 2(two) Digital AC Ammeter
21. 2(two) three-phase voltage monitoring relay
22. 1(one) 4KW, 125V DC contactor
23. Three phase digital AC current transducers with serial output, of each type or rating.
24. One (1) set of PLC modules (one of each type) if PLC is to be used as per particular specifications
25. Two (2) Motor management controllers for each rating or type if it’s to be used as per particular specifications

2.5.1.8

2.6 CABLES SCOPE OF SUPPLY

2.6.1 MV cables

2.6.1.1 Contractor shall manufacture, test, supply, install and commission two (2) (unit 2 and unit 3) Station transformer HV side connection MV cables to connect the station transformers and the new MV generator switchgear. Cables shall be sized and rated as per clause 6.2.5.1

2.6.1.2 Contractor shall supply and construct concrete cable trenches at the substation to guide the cables from the MV switchgear to the station transformers. Trenches shall be covered with concrete blocks.

2.6.1.3 Existing Generator MV cables (from generator terminals at the power house to the 15KV busbars at the substation) shall be re used and are not in scope of supply.

2.6.2 LV Power Cables

2.6.2.1 Contractor shall manufacture, test, supply, install and commission new power cables meeting the requirements in clause 3.7 to connect the main station auxiliaries to the main station switchboard duty and reserve feeders. Cables shall have a minimum rating of 1600A @40°C ambient and fault level of at least 50KA/1s with an approximate length of 30m

2.6.2.2 Contractor shall manufacture, test, supply, install and commission new power cables meeting the requirements in clause 3.7 to connect the main station auxiliaries to the cable marshalling panel. The approximate length of cables is 20m. Cables shall be rated the same as the cable feeder modules or motor DOL starter module rating or higher. Fault level rating of at least ≥20KA/1s for feeder cables
2.6.2.3 Contractor shall manufacture, test, supply, install and commission new power cables meeting the requirements in clause 3.7

(a) To connect unit 1 station transformer to the main station switchboard with a minimum rating of 1600A @40°C ambient and fault level of at least 50KA/1s with an approximate length of 80m
(b) To connect each switchgear housing to the main station auxillaries’ switchboard rated as per the cable feeder rating (32A) with an estimated length of 90m for unit 1, 170m for unit 2 and 50m for unit 3.

2.6.3 **Control & Auxiliary power supplies cables**

2.6.3.1 The contractor shall remove all control and auxiliary power supply cables terminated to the existing protection, and any other panel to be removed in the scope of supply in the preceding clauses. Accurate cable lengths of existing cables are not available, bidders who wish to get the accurate lengths can visit the station and measure.

2.6.3.2 Contractor shall manufacture, test, supply, install and commission new control and auxiliary supply cables to cover all the functions required by the particular specifications.

2.6.3.3 The table below gives the estimated distances along cable routes between most of the equipment that require interfacing as per tender specifications. The distances are estimates and do not factor in cable lengths inside the panel. The approved bidder during design site visit shall collect the accurate required cable lengths, employer shall not be liable if the cables supplied by the contractor are not sufficient to connect the systems.

<table>
<thead>
<tr>
<th>No</th>
<th>ORIGIN</th>
<th>DESTINATION</th>
<th>Estimated distance (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>U2 MV Switchgear (proposed-substation)</td>
<td>Protection panels (Control room)</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>U2</td>
<td>U2 Unit control PLC</td>
<td>220</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>U2 Manual control panel</td>
<td>220</td>
</tr>
<tr>
<td>5</td>
<td>U3 MV Switchgear (proposed-substation)</td>
<td>Protection panels (Control room)</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>U3</td>
<td>U3 Unit control PLC</td>
<td>250</td>
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<tr>
<td>7</td>
<td></td>
<td>U3 Manual control panel</td>
<td>250</td>
</tr>
<tr>
<td>8</td>
<td>Protection panels (control room)</td>
<td>Power house main wiring marshalling kiosks (power house cable gallery)</td>
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<td>9</td>
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<td>U2 Generator neutral marshalling kiosk</td>
<td>230</td>
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<tr>
<td>10</td>
<td>U3 Generator neutral marshalling kiosk</td>
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<td>11</td>
<td>U2 Unit control PLC</td>
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<tr>
<td>12.</td>
<td>U3 Unit control PLC</td>
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<td>13.</td>
<td>U2 Manual control panel</td>
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<tr>
<td>14.</td>
<td>U3 Manual control panel</td>
<td>230</td>
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<tr>
<td>15.</td>
<td>U2 132kV CT&amp;VT Marshalling kiosk</td>
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<tr>
<td>16.</td>
<td>U3 132kV CT&amp;VT Marshalling kiosk</td>
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<tr>
<td>17.</td>
<td>Station transformer 1 local control cubicle</td>
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<tr>
<td>18.</td>
<td>Station transformer 2 local control cubicle</td>
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<td>Station transformer 3 local control cubicle</td>
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<tr>
<td>20.</td>
<td>U2 132kV line VT, Isolator &amp; earth switch Marshalling kiosks</td>
<td>70</td>
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<tr>
<td>21.</td>
<td>U3 132kV line VT, Isolator &amp; earth switch Marshalling kiosks</td>
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<tr>
<td>22.</td>
<td>U2 GSU transformer local control cabinet</td>
<td>80</td>
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<tr>
<td>23.</td>
<td>U3 GSU transformer local control cabinet</td>
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<tr>
<td>24.</td>
<td>U2 132kV circuit breaker</td>
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<td>25.</td>
<td>U3 132kV circuit breaker</td>
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<tr>
<td>26.</td>
<td>KPLC RTU (For Kamburu inter trips)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>Main station switch board</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>DC distribution board (proposed)</td>
<td>30a</td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>Alternative supply transformer local control cabinet</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>EDG local control cabinet</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>31.</td>
<td>Protection communication panel (proposed)</td>
<td>30a</td>
<td></td>
</tr>
<tr>
<td>32.</td>
<td>Main station auxiliaries’ switchboard (control room)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>DC distribution board (proposed)</td>
<td>30a</td>
<td></td>
</tr>
<tr>
<td>34.</td>
<td>SCADA cabinet (control room SCADA ethernet switches)</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

*a-the distance with depend on positioning of the proposed panel*
3 GENERAL TECHNICAL SPECIFICATIONS

3.1 STANDARDS

3.1.1 Ratings, characteristics, tests and test procedures, etc. for the electrical equipment encompassed by this Specification shall comply with the provisions and requirements of British standards institute (BS) and International Electro-Technical Commission (IEC) standards or International Electrical & Electronic Engineers – IEEE unless otherwise expressly stated in Particular Technical Specifications.

3.1.2 Where the BS or IEC or IEEE standards do not fully cover all provisions and requirements for the design, construction, testing, etc. and for equipment and components that are not covered by IEC recommendations. The European Committee for Standardization (EN) standards, rules of CEE (International Commission for the approval of electrical equipment), the standards of CENELEC (Comité Européen de Normalisation Electrotechnique) and other recognised national/international standards LISTED BELOW shall be applied. The other recognized national and international standards are:

(a) International standardization organization – ISO
(b) Telecommunications Industry Association (TIA)
(c) International Telecommunication Union (ITU)
(d) German – DIN
(e) American National Standards Institute - ANSI
(f) American Society of Mechanical Engineers – ASME
(g) American Society for Testing and Materials - ASTM
(h) International Society of Automation- ISA

3.1.3 Equipment and works shall conform to standards of the bodies indicated clause 3.1.1 and 3.1.2 ONLY no other standards from other bodies shall be allowed.

3.1.4 The latest revision or edition in effect at the time of Bid Invitation shall apply for all standards used or stated in this tender document. Where references are given to
numbers in the old numbering scheme from IEC it shall be taken as to be the equivalent number in the new five-digit number scheme.

3.1.5 The Tenderer shall state the Precise Standard, complete with identification number, to which the various equipment and materials are manufactured. The tender documents do not contain a full list of all standards to be used; the contractor shall give the precise standard which the equipment and work shall conform to.

3.2 GENERAL MATERIALS AND EQUIPMENT SPECIFICATIONS

3.2.1 General

3.2.1.1 The equipment shall withstand without permanent weakening or deformation from short circuit current within the rating of the apparatus (including those due to faulty synchronising) as well as normal atmospheric over voltages taking into account the use of lightning arresters. Special considerations shall be given to pressure rises by short circuits and fire risk. All material and equipment shall be designed and arranged so that over pressure will be relieved in a safe direction and so that fire risk is minimised and consequences of a fire reduced.

3.2.1.2 All plastic material used in boxes, panels and boards shall be halogen free and self-extinguishable.

3.2.1.3 The contract supplies shall be designed to facilitate inspection, cleaning and repairs and for operation, in which continuity of service is the first consideration.

3.2.1.4 All conductors current carrying parts must be dimensioned with ample cross sections so that temperatures are kept within limits in operation and under short circuits. Temperature rises on all equipment shall be kept within limits set in IEC standards provided nothing else is specified. For all current carrying parts the permissible short circuit duration shall be at least 3 second. All electrical connections shall be secured by bolts or set screws of ample size, fitted with locknuts or lock washers of approved types. The equipment shall as far as possible be factory mounted with internal cables and internal equipment installed before shipment. Plug-in components can be shipped separately.

3.2.1.5 Equipment for use in live panels shall not be flammable and shall be self-extinguishable and resistant to flame propagation.

3.2.1.6 Equipment for use outdoors or in wet or damp rooms shall be constructed so that water runs off. It shall also have devices draining any inside condensation that may
form. Axial bearings on such equipment must be equipped with durable sealing preventing water to ingress.

3.2.1.7 Cast iron shall not be used for chambers of oil-filled apparatus or for any part of the equipment that is in tension or subject to impact stresses. Exception is made where it can be shown that service experience has been satisfactory with the grade of cast iron and the duty proposed.

3.2.1.8 Materials shall be new; the best quality of their respective kinds and such as is usual and suitable for work of like character. All materials shall comply with the latest issues of the specified standard unless otherwise specified or permitted by the Employer.

3.2.1.9 Iron and Steel are generally to be painted or galvanized as appropriate. Indoor parts may alternatively have chromium or copper-nickel plates or other approved protective finish.

3.2.1.10 Workmanship shall be of the highest class throughout to ensure reliable and vibrations free operations. The design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not cause distortion, undue wear, or damage under the most severe conditions encountered in service.

3.2.1.11 All parts shall conform to the dimensions shown and shall be built in accordance with approved drawings. All joints, datum surfaces and meeting components shall be machined and all castings shall be spot faced for nuts. All machined finished shall be shown on the drawings. All screw, bolts, studs and nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization covering these components and shall all conform to the standards for metric sizes. All materials and works that have cracks, flaws or other defects or inferior workmanship will be rejected by the Employer.

3.2.1.12 Casting shall be true to pattern, of workmanlike finish and of uniform quality and condition, free from blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, shall be satisfactorily cleaned for their intended purpose.

3.2.2 Electrical Equipment Materials

3.2.2.1 All materials supplied under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified. They shall withstand the variations of temperature and atmospheric conditions arising under
working conditions (including start and stop) without distortion, deterioration or undue stresses in any parts and also without affecting the suitability of the various parts of the Works for which they were designed. The equipment shall be designed for a lifetime of 25 years.

3.2.2.2 No welding, filling or plugging of defective parts shall be permitted.

3.2.2.3 Materials that are susceptible to mould growth under tropical conditions shall be treated to exclude moisture and prevent growth of mould after all machining has been carried out.

3.2.2.4 Cables and bus bars shall be of the highest quality copper. Aluminium conductors shall not be allowed unless specified in particular specifications for a particular component only.

3.2.2.5 Small iron and steel parts (other than rustless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms shall be treated in an appropriate manner to prevent rusting.

3.2.2.6 Copper and aluminium used as electrical conductors shall be of the electrolytic type and comply with the respective DIN or ASTM Standards.

3.2.2.7

3.2.3 **Bolts, Studs, Nuts, Screws, Washers, etc.**

3.2.3.1 All bolts, studs, nuts, etc., shall have a standard metric threading and conform to the relevant standards as regards shape and tolerance. They shall be of Strength Class 8.8 and marked accordingly.

3.2.3.2 All bolts, studs, nuts, washers, screws, etc., used outdoor or in wet or moist environment shall be made of stainless steel.

3.2.3.3 All bolts and nuts shall be hexagonal, either normally or of the round head socket type and secured in an approved manner against becoming loose during operation. The Contractor shall supply the net quantities plus 5% of all permanent bolts, screws and other similar items and materials required for installation of the works at the site. Any such rivets, bolts, screws, etc. which are surplus after the installation of the equipment has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

3.2.3.4 Taper pins shall have threaded stems with nuts where dismantling of the pins is likely to be required.

3.2.3.5 Bolts shall not protrude more than 10 mm beyond the nut but not less than three full threads.
3.2.4 Surface Treatment and Painting of Panels, Support Structures & Electrical equipment

3.2.4.1 Panels, boards, cubicles and cabinets. for indoor use in dry rooms shall have interior surfaces painted with at least one priming and one finishing coat of anti-corrosion paint. Exterior surfaces shall be adequately treated to be substantially corrosion resistant, with one priming coat, and two finishing coats.

3.2.4.2 Outdoor installations and indoor installations in wet and damp rooms shall at least have one priming coat and two layers of paint on zinc powder basis applied after perfect cleaning.

3.2.4.3 Structural supports outdoor and in wet or moist rooms and parts that cannot be readily painted, shall be hot-dip galvanised. All galvanising shall be in accordance with BS 729 or other internationally approved standards. Steel below ground shall in addition to galvanising be protected with Bitumen or a substance of similar quality.

3.2.4.4 The humid and tropical conditions shall be taken into account on selection of the paints and painting procedure.

3.2.4.5 All External surfaces panels, cubicles, cabinets, structural supports etc. shall be painted using RAL7035 colour.

3.2.5 Insulating Liquids

3.2.5.1 All electrical equipment requiring insulating oil or other insulating liquids shall be furnished with the first filling including flushing, if required. An excess of 10% of the net amount of oil or liquid required for each component shall also be furnished by the Contractor as spare.

3.2.5.2 The Contractor shall endeavour to employ, as far as practicable, one type and make of insulating oil only for all the electrical equipment.

3.2.6 Sulphur hexafluoride gas (SF6)

3.2.6.1 The SF6 gas shall comply with the requirements of IEC 60376. In addition to the quantity of gas required to fill the equipment supplied, 20% shall be supplied as spare.

3.2.6.2 The high-pressure cylinders for shipment and storage of the SF6 gas shall comply with the applicable national regulations. All the necessary pipes, couplings, flexible
tubes and valves for coupling to the switchgear for filling or evacuating all the gases to be used, with all necessary instructions for the storage of this equipment, shall be provided.

3.2.7 **Nameplates and signs**

3.2.7.1 All nameplates and signs shall be made of non-corrosive weatherproof material such as traflolyte, aluminium or stainless steel.

3.2.7.2 Marking shall be in corrosion resistant material with engraved and coloured lettering. All equipment shall be marked in accordance with standards and local practice. The Contractor must mark all components in a clear and unambiguous way so that it can be related to the documentation.

3.2.7.3 Letters shall be white and engraved on black background. For aluminium and steel signs black letters on metallic background shall be used. For warning signs, red background shall be used.

3.2.7.4 All panels, cubicles, switchboards, switchgear compartments, outdoor equipment and structures and all devices & equipment mounted in the panels shall be labelled with name plates. All operating mechanisms as pushbuttons, switches and handles must be marked in a precise way and necessary warning signs must be supplied.

3.2.8 **Equipment Working Stress and Reliability**

3.2.8.1 The design, dimensions and materials of all parts shall be such that they will not suffer damage under the most adverse conditions nor result in deflections and vibrations, which might adversely affect the operation of the equipment.

3.2.8.2 Mechanisms shall be constructed to avoid sticking due to rust or corrosion. The equipment and apparatus shall be designed and manufactured in the best and most substantial and workmanlike manner with materials best suited to their respective purpose and generally in accordance with up-to-date recognized standards of good practice.

3.2.8.3 The equipment shall be designed to cope with 0.20g seismic acceleration on their centres of gravity.

3.2.8.4 All equipment shall be designed to minimize the risk of fire and consequential damage, to prevent ingress of vermin and dust and accidental contact with electrically energized or moving parts.

3.2.8.5 Panels and switch boards shall be capable of continuous operation with minimum attention and maintenance in the exceptionally severe conditions likely to be obtained in a tropical climate
3.2.9 **Degree of Protection**

3.2.9.1 Enclosures for electrical equipment shall offer the following degree of protection at minimum (ref. IEC 60034, IEC 60059, IEC 60529 and IEC 60947) where it’s not stated in the particular specifications:

(a) Motors/Motor Terminal boxes IP 54/IP 65
(b) Dry Transformers IP 2x
(c) Limit switches IP 65
(d) Indoor switches IP 5x
(e) Outdoor switches IP 65
(f) Low voltage switchgear and control cabinets:
   (i) Indoor IP 3x
   (ii) Outdoor IP 54
   (iii) Junction boxes IP 65
(g) Light fittings
   (i) Outdoor and wet areas IP 44
   (ii) Indoor IP 2x

3.2.9.2 Printed circuit boards **SHALL NOT** be mounted on the panels. All printed circuit boards shall be contained in enclosures with an ingress protection of at least IP30 with terminal blocks and ports on the enclosures for interface.

3.2.10 **Locking Devices and Padlocks**

3.2.10.1 All panels, cubicles, switchboards, switchgear compartments and Facilities for applying safety isolation i.e. circuit breaker operating mechanisms, disconnectors & switches operating handles, control switches, bus bar shutters etc. shall be provided with locks. Locks with at least three keys will be provided. Padlocks will only be used where other locks are not appropriate.

3.2.10.2 Three keys with labelled trafolyte holder shall be provided for each lock, key operated devices and padlocks.

3.2.11 **Tool Rack for switchgear operations**

3.2.11.1 A tool rack shall be installed in a cubicle/compartment close the switchgear for each switchboard. It shall house all the handles and tools required for operation of the switchgear. The rack shall be easily accessible to operators and not cause obstruction to operations.
3.2.11.2 Three key cabinets shall be supplied and installed for storing all the keys supplied under the project. Two key cabinets shall be installed at the power house (one for each unit) and another shall be installed at the control room for control room devices.

3.3 AUXILIARY POWER SUPPLY EQUIPMENT

Auxiliary power for the purposes of this clause shall mean power supply powering plant control, metering and protection devices.

3.3.1 General Auxiliary Power Supply Requirement

3.3.1.1 The electricity supplies for auxiliary supply will be as follows:

(a) 415 volts 3-phase 50 Hz 4-wire for heavy power application such as OLTC motors.
(b) 240 volts’ single phase 50 Hz for light power application such as lighting, indication, anti-condensation heaters and oil pumps.
(c) 110 volts DC for control, metering, indication and protection devices and all power circuit breakers closing, tripping and spring charging supplies.
(d) 110 volts DC for power operated isolators and earthing switches.
(e) 24V DC for electronics supply where specified

3.3.1.2 Alternating Current (AC)

(a) All mains auxiliary supplies shall be switched and protected with a circuit breaker. Double-pole circuit breakers shall be used to break single-phase ac mains supplies. For multi-phase supplies, each phase shall be switched simultaneously.
(b) Miniature circuit breakers shall be used in auxiliary AC power circuits rated 63 amps and below unless otherwise stated in particular specifications. They shall be approved as circuit breakers and have a breaking capacity sufficient to break the short circuit at the place of use (i.e. no upstream backup fuses for reduction of fault level shall be necessary).
(c) Except where prior approval is obtained, wires external to the equipment shall be colour coded as stated elsewhere this specification

3.3.1.3 Direct Current (DC)
(a) All DC circuits shall be switched and protected by appropriately rated circuit breakers, the circuit breakers must be approved for the relevant DC voltage and current, fuses to be used for ratings of 1A and below only unless otherwise specified in the particular specifications.

(b) Double pole circuit breakers shall be used for switching and protection of all DC supply circuits rated above 1A, they shall be rated appropriately to break DC short circuit without the necessity of upstream backup fuses.

(c) Where found necessary, backup fuses shall be used to prevent tripping of main DC supplies.

(d) If electronic equipment or system require the use of local internal batteries approval must be obtained. Where approval is given, batteries used inside equipment shall be: totally sealed, leak-proof type, have no possibility of explosion even at ambient temperature above 40°C, available in the local market and rated below 5V. Use of internal batteries shall be avoided unless where specified.

(e) Equipment supplied under this contract shall be rated for direct use of 110VDC without external power supply units. Where this is not possible or appropriate 24VDC auxiliary supply shall be used. Other than 110VDC, only 24VDC shall be allowed for auxiliary DC supply to control, metering and protection equipment.

3.3.2 Fuses

3.3.2.1 Carriers and bases for fuses and links shall be in accordance with IEC 269 standard and colour coded to permit identification of the circuit rating.

3.3.2.2 The contacts of the fixed portion of the fuse or link shall be shrouded so that accidental contact with live metal cannot be made when the moving portion is withdrawn.

3.3.2.3 Main supply fuse links shall, unless otherwise specified, be of the high rupturing capacity cartridge type. Where fuse carriers are mounted vertically, the incoming (supply) circuit shall be connected to the top terminals. Where fuses are used, the Contractor shall ensure that proper discrimination between main and sub-circuits is maintained.

3.3.2.4 Where LV power fuses above 63 amps are specified they shall be of high rupturing capacity cartridge, type NH gl, according to DIN VDE 0636 and IEC 60269. All fuse bases shall have a load switching capacity and a thermal rating equal to the rating of the largest fuse it can accommodate. Fuse replacement shall be possible without use of special tools and with IP 20 protection against live parts.
3.3.3 **Miniature Circuit Breakers**

3.3.3.1 Miniature circuit breakers, shall be designed and tested in accordance with IEC 60947 and supplementary requirements of this specification.

3.3.3.2 They shall be suitably rated for both the continuous and short circuit loadings of the circuits they are protecting under all service and atmospheric conditions stated in the specification and ensure that correct discrimination is maintained between main and sub-circuits.

3.3.3.3 Where circuit breakers are used in circuits containing inductive loads, e.g. operating coils, it is essential that they are suitable for satisfactory operation in the circuit in which they are used, i.e. account is taken of the circuit time constant.

3.3.3.4 All MCB’s shall be provided with two auxiliary contact(s) for remote indication of circuit breaker operation and interlocking purposes.

3.3.3.5 Means shall be provided to prevent the circuit breakers being inadvertently switched to the ‘OFF’ position.

3.3.3.6 Circuit breakers shall be mounted in such a manner so as to give easily visible indication of breaker position and shall be grouped and spaced.

3.3.4 **Motor Protection Circuit Breaker, MPCB**

MPCB’s shall be special kind of MCCB’s for three phase loads rated below 100A. They shall meet the following requirements.

3.3.4.1 Designed for motor and other three phase loads protection. They shall be used for protection of all three phase control circuits/supplies such as such as VT inputs and outputs, voltage monitoring relays input etc.

3.3.4.2 The MPCB’s shall be suitably rated for the application, with overload settings as low as 0.1A for control circuits protection.

3.3.4.3 Shall have an adjustable overload setting, with a dial on the front side for adjustment. Overload shall be settable from at least 10% to 100% MPCB rating.

3.3.4.4 The current ratings given in the specifications take into account that the Overload shall be settable from at least 10% to 100%. Overload setting and trip classes shall be computed during design.

3.3.5 **Power Supply Units (PSUs)**

3.3.5.1 PSUs shall be of approved design and such that they do not impose parasitic or harmonic voltages on the station battery system or electronic equipment.

3.3.5.2 Protection circuits incorporated into PSUs shall be such that any overload of the output or short circuit current does not damage any components within the PSU.
3.3.5.3 **PSUs shall incorporate over-voltage and overcurrent protection devices to protect the components that comprise the output load.**

3.3.5.4 **All PSU’s shall have at least one SPDT alarm contact to annunciate failure of the PSU.**

3.3.6 **Electrical Sockets**

3.3.6.1 Single phase electrical sockets installed for lamps, hand tools, measuring equipment etc., shall be the British standard type with 3 square pin sockets type with earth connection. The sockets shall be rated for at least 16A (lower rating shall not be used).

3.3.6.2 Three phase sockets shall be according IEC 60309 (CEE type).

3.3.6.3 Contractor shall use sockets available in the local market.

### 3.4 CONTROL DEVICES GENERAL REQUIREMENTS

3.4.1 **Instruments/Transducers**

3.4.1.1 **General Requirements**

(a) Pressure sensors and transmitters shall be of corrosion proof material, degree of protection IP 54, vibration class I (ISO 2372). Their scale shall indicate bar. The measuring pipe shall be equipped with stop chock. If the indicator is exposed to vibration it shall be filled with damping liquid (glycerine).

(b) Limit switches for pressure, temperature and flow (even if combined with the indicators) shall be of class 1, conforming to IEC 60536 without noticeable hysteresis. Where more than one limit is required each limit shall be independently settable. Set points shall be easily readable.

(c) Limit switches not mounted in enclosures shall be of the proximity type without need for separate power supply and equipped with light emitting diodes to indicate position where necessary.

(d) Flow meters shall be graded in litres/s or M³/s from zero to 150% above required value. They shall be electronic without moving mechanical parts.

3.4.1.2 **Resistance temperature detectors (RTD)**

(a) They shall be industrial grade PT 100 type protected to suit the environment where there are to be used.

(b) They shall conform to the IEC 60751: 2008 Standard
(c) They shall meet accuracy class B as per IEC 60751 i.e Class B = ± (0.30 + 0.005\*t) for (-50 to 500\°C). Accuracy of ±0.8\°C at 100\°C

(d) Shall have an operating range of at least –200\°C to + 500\°C

(e) Shall be wire wound with good vibration resistance

(f) They shall either be four wire or three wire connection type. Two wire types SHALL NOT be accepted for any application

3.4.2 Panel Indication meters

3.4.2.1 General requirements

(a) All Panel mounted instruments and meters shall be flush-mounted, back-
connected, dust-proof and heavy-duty. They shall have a removable cover,
either transparent or with a transparent window.

(b) Panel indication shall be of digital type unless where specified in particular
specifications.

3.4.2.2 Analogue panel indication meters

Where Analogue panel meters are used, they shall have at minimum the following
features:

(a) scale plates shall be of a permanent white circular or rectangular finish with
black pointer and markings,

(b) shall be have a clear transparent non-reflective window and clearly readable
long scale

(c) Shall be of accuracy class 1.5 or better, the maximum error shall be not
more than one and a half (1.5) percent of full-scale range.

(d) Their cut out shall be DIN standard 1/4DIN, or 1/8 DIN

3.4.2.3 Digital Panel Indication Meters

(a) There shall be four types digital panel meters depending on inputs, these are:

(i) Digital indication meter for Instrument/process signals with a 4-20mA
DC current input

(ii) Digital DC voltmeter/Ammeter with a DC input voltage whose range is
selectable and an external shunt for DC current ammeter

(iii) Digital AC ammeter with a AC current input from a CT

(iv) Digital AC voltmeter with a AC voltage input (phase-phase or phase-
neutral)

(b) The meters shall site programmable/configurable for scaling, range set up
etc. They shall have at least three buttons on the front for this purpose.

(c) Indication meters shall meet or exceed accuracy Class 1, according to IEC
62053-11.
(d) Display MUST be 5-digit LED with characters sized at least 14mm for all digital meters

(e) They Shall be panel mounted, flush mounted on the front of the panel with connections from the rear.

(f) They shall have buttons and menu for configuring their parameters such as:
   (i) Input range
   (ii) Output range
   (iii) VT/CT ratio
   (iv) Scaling factor

(g) They shall meet the following minimum specifications

   (i) **Inputs and accuracy range**

<table>
<thead>
<tr>
<th>Input Range</th>
<th>Resolution</th>
<th>Input Resistance</th>
<th>Error at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Current</td>
<td>1.0 µA</td>
<td>10 Ω</td>
<td>0.01% FS ± 2 counts</td>
</tr>
<tr>
<td>DC Voltage</td>
<td>10 µV</td>
<td>1 GΩ</td>
<td>0.01% FS ± 2 counts</td>
</tr>
<tr>
<td>AC Current</td>
<td>1 mV</td>
<td>10 MΩ</td>
<td>± 0.4 V</td>
</tr>
</tbody>
</table>

   AC Voltage for digital AC voltmeter
   | 0-300.0 V         | 100 mV     | 1 MΩ            | ± 0.8 V       |
   | 0-600.0 V         | 100 mV     | 1 MΩ            | ± 0.8 V       |

   (ii) **Display**

   Readout: 5 LED digits, 7-segment, 14.2 mm (.56’’), red or green.
   Range: -99999 to 99999
   Indicators: Minus sign, decimal point, 2 red LED lamps (configurable)
   Display update rate: 3 per second

   (iii) **A-to-D Conversion**

   A-to-D rate: >50 per second
   Output update rate
   Signals > 50 Hz: >50 per second
   Signals >3 to 50 Hz: Signal frequency
   Signals > DC to 3 Hz: 3 per second
(iv) Maximum input Signal
Max applied voltage 600 VAC for 20, 200 and 300 V ranges, 125 V AC for other ranges
Current protection 8x for 20 mA, 1x for 5 A

(v) Power supply
Voltage range 85-264 VAC or 90-300 VDC
nominal 110 VDC ± 20%
Consumption less than 3 VA

(vi) Excitation Output (if specified in particular specifications)
level 24 VDC ± 5%, 50 mA
Output isolation 50 VDC to meter ground

(vii) Analog Output (if specified in particular specifications)
Output levels 4-20 mA, 0-20 mA, 0-10V, -10 to +10V (jumper selectable)
Scaling Zero and full scale adjustable from -99999 to +99999
Resolution 16 bits (0.0015% of full scale)
Isolation 250V RMS working, 2.3 kV RMS per 1 min test

(viii) Relay Outputs (if specified in particular specifications)
Relay types Two independent SPDT relays
Current ratings 8A at 250 VAC / 24 VDC
Output common Isolated commons for each SPDT relay
Isolation 250V RMS working, 2.3 kV RMS per 1 min test

(ix) Serial Data I/O (if specified in particular specifications)
Interface RS485, RJ45 or terminal block connection.
Protocols Modbus RTU
Data rates 300 to 19200 baud
Isolation 250V RMS working, 2.3 kV RMS per 1 min test

(x) Environmental
Operating temperature 0°C to 55°C
Storage temperature -40°C to 85°C
Relative humidity 95% at 40°C, non-condensing
Ingress Protection IP65
### (xi) Dimensions

<table>
<thead>
<tr>
<th>Panel Cut-out</th>
<th>1/8 DIN 92mm X 45mm OR 1/4 DIN 92mm X 92mm depending on particular specifications or design requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front dimensions</td>
<td>96mm X 48mm OR 96mm X 48 mm depending on particular specifications or design requirement</td>
</tr>
<tr>
<td>Device overall depth</td>
<td>less than 125mm without the connections</td>
</tr>
</tbody>
</table>

### (xii) Connections

<table>
<thead>
<tr>
<th>Type</th>
<th>Screw type</th>
</tr>
</thead>
<tbody>
<tr>
<td>wire size</td>
<td>2X2.5mm²</td>
</tr>
</tbody>
</table>

### 3.4.3 Indicating lamps and Push buttons

- **3.4.3.1** All status and position indication lamps shall be of the light emitting diode type and be replaceable without use of soldering or special tools. A switch for lamp test shall be put in all panels, neighbouring panels can be grouped together with one test switch.

- **3.4.3.2** All indication contacts shall be galvanic isolated and potential free.

- **3.4.3.3** Indicating lamp assemblies shall be of the switchboard type, insulated for 110 V DC service, with appropriately coloured lens and integrally mounted resistors for 110-volt service. The lens shall be made of a material, which will not be softened by the heat from the lamps.

- **3.4.3.4** For the Circuit Breakers, isolators and motors status indications, Red indicating lamps shall be used for “ON/CLOSED” position, green lamps for “OFF/OPEN” position Indication and Amber for Transition.

- **3.4.3.5** For alarms/warnings, yellow indicating lights shall be used while for trips/faults, red indicating lamps shall be used.

- **3.4.3.6** All semaphores SHALL be of LED type.

- **3.4.3.7** Emergency push buttons shall be protected from accidental operation by a glass cover.

- **3.4.3.8** Emergency push button shall remain latched when operated until reset. Resetting shall be done by twisting or rotating the button.

- **3.4.3.9** Illuminated pushbuttons shall consist of a command push button and a status LED lamp. The LED lamp shall indicate the status of the device/primary circuit commanded by the push button.
3.4.3.10 Discrepancy switches shall be used for operation of switchgear, they shall have the following specifications

(a) They shall be operated by Push, turn and control
(b) They shall have an integrated LED for position indication
(c) Shall be rated for 110V DC or 24 V DC depending on application
(d) Shall have a big knob made of transparent polycarbonate completely illuminated by a coloured LED inside.
(e) LED shall be lit depending on the position of the switch and the controlled device
(f) Each discrepancy switch shall at minimum have four (4) SPDT contacts

3.4.3.11

3.4.4 Instrument Transformers General Requirements

3.4.4.1 Bidder shall study all the drawings and information supplied to determine if the existing CT & VT are sufficient and suitable for the new systems. Where new instrument transformers are required the bidder shall include them in their bid offer.

3.4.4.2 All instrument transformers to be supplied shall satisfy all IEC requirements on testing and design. Type test reports shall be provided with the bid offer. Routine tests shall be carried out by the contractor and results sent to the employer prior to shipment.

3.4.4.3 Burden for the current transformers shall be arrived at during design stage in order to ensure safe and accurate operation of connected meters and to prevent early saturation of protection CT’s. CT Burden indicated in the tender documents shall be used for during bidding for cost estimation etc.

3.4.5 Digital Panel Multi-Function Meters

3.4.5.1 Panel multifunctional meters shall be power transducers with an integrated display flush mounted on the panel used to indicate AC power parameters and transmit to remote equipment

3.4.5.2 They Shall be panel mounted, flush mounted on the front of the panel with connections from the rear.

3.4.5.3 The meters shall be site programmable/configurable for scaling, range set up etc. They shall have at least three buttons on the front for this purpose.

3.4.5.4 Shall meet accuracy class 0.2 as per IEC 61557-12

3.4.5.5 Shall have a fast Ethernet port 100base-T and support Modbus TCP

3.4.5.6 Shall have a large graphical LCD backlit display (at least 72 mm x 54 mm)

3.4.5.7 Shall be interfaced to SCADA system via Ethernet communication
3.4.5.8 They Shall have the following specifications

(a) Measuring inputs

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement rate</td>
<td>continuous</td>
</tr>
<tr>
<td>AC input voltage range</td>
<td></td>
</tr>
<tr>
<td>Phase-to-neutral L-N</td>
<td>3~ 400 V AC (+ 20 %)</td>
</tr>
<tr>
<td>Phase-to-phase L-L</td>
<td>3~ 690 V AC (+ 20 %)</td>
</tr>
<tr>
<td>Voltage input type</td>
<td>Direct connection or voltage transformers</td>
</tr>
<tr>
<td>Rated Input current</td>
<td>3 phase AC 1A/5A selectable</td>
</tr>
<tr>
<td>Continuous current rating</td>
<td>10 A</td>
</tr>
<tr>
<td>Current input type</td>
<td>from current transformers</td>
</tr>
<tr>
<td>Surge withstand capability</td>
<td>100 A for 1 s</td>
</tr>
<tr>
<td>Connection type</td>
<td>3P4W i.e. 3 phases, 4 conductors</td>
</tr>
</tbody>
</table>

(b) Measuring accuracy

<table>
<thead>
<tr>
<th>Measured variable</th>
<th>Accuracy class acc. to IEC 61557-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS Voltage</td>
<td>0.2</td>
</tr>
<tr>
<td>RMS current</td>
<td>0.2</td>
</tr>
<tr>
<td>Apparent power</td>
<td>0.5</td>
</tr>
<tr>
<td>Active power</td>
<td>0.2</td>
</tr>
<tr>
<td>Reactive power (VAR)</td>
<td>1.0</td>
</tr>
<tr>
<td>Cos ϕ</td>
<td>0.20%</td>
</tr>
<tr>
<td>Power factor</td>
<td>2</td>
</tr>
<tr>
<td>Phase angle</td>
<td>+/- 1°</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.1</td>
</tr>
<tr>
<td>Apparent energy</td>
<td>0.5</td>
</tr>
<tr>
<td>Active energy</td>
<td>0.2</td>
</tr>
<tr>
<td>Reactive energy</td>
<td>2.0</td>
</tr>
</tbody>
</table>

(c) Power supply

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated range</td>
<td>95 … 240 V AC (50Hz) or 110 … 340 V DC</td>
</tr>
<tr>
<td>Nominal</td>
<td>110VDC ± 20%</td>
</tr>
<tr>
<td>Power consumption</td>
<td>&lt; 10 VA</td>
</tr>
</tbody>
</table>

(d) Display & controls

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Monochrome, graphical LCD, light backlighting, dark text and digits</td>
</tr>
<tr>
<td>Resolution</td>
<td>128 x 96 pixels</td>
</tr>
<tr>
<td>Size W X H</td>
<td>at least 72 mm x 54 mm</td>
</tr>
<tr>
<td>Display refresh rate</td>
<td>0.33-3/sec adjustable</td>
</tr>
<tr>
<td>keyboard</td>
<td>at least four keys for Parameterization and viewing</td>
</tr>
<tr>
<td>Parameterization</td>
<td>Menu-driven parameterization and operation with plaintext</td>
</tr>
</tbody>
</table>
(e) **Digital inputs and outputs**

<table>
<thead>
<tr>
<th>Number</th>
<th>at least 2 Digital Inputs &amp; 2 Digital outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Input rating</td>
<td>24VDC/7mA</td>
</tr>
<tr>
<td>Digital output rating</td>
<td>24VDC/100mA</td>
</tr>
</tbody>
</table>

(f) **Communication**

| Interface protocol | Ethernet 10/100 base-TX (fast Ethernet) Modbus TCP/IP |

(g) **Connections**

<table>
<thead>
<tr>
<th>Type</th>
<th>Screw terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>measuring and power supply terminals</td>
<td>Solid 1 x 0.5 ... 4.0 mm² 2 x 0.5 ... 2.5 mm²</td>
</tr>
<tr>
<td></td>
<td>Finely stranded with end sleeve 1 x 0.5 ... 2.5 mm² 2 x 0.5 ... 1.5 mm²</td>
</tr>
<tr>
<td>Digital inputs &amp; outputs</td>
<td>Solid 1 x 0.2 ... 2.5 mm² 2 x 0.2 ... 1.0 mm²</td>
</tr>
<tr>
<td></td>
<td>Finely stranded with end sleeve 1 x 0.2 ... 2.5 mm² 2 x 0.2 ... 1.5 mm²</td>
</tr>
<tr>
<td>Ethernet</td>
<td>RJ45(8P8C)</td>
</tr>
</tbody>
</table>

(h) **Enclosure**

<table>
<thead>
<tr>
<th>Housing design</th>
<th>Switching panel housing to IEC 61554</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing dimensions W x H</td>
<td>96 mm x 96 mm</td>
</tr>
<tr>
<td>Overall depth</td>
<td>&lt;60 mm</td>
</tr>
<tr>
<td>Mounting position</td>
<td>vertical</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>Front: IP65</td>
</tr>
<tr>
<td>according to IEC 60529</td>
<td>Rear: IP20</td>
</tr>
</tbody>
</table>

(i) **Environmental conditions**

| Temperature range             | Operating temperature - 10 °C to + 55 °C |
| Storage and transport temperature | - 25 °C to + 70 °C                     |
| Relative humidity             | 95% at 25°C without condensation (normal conditions) |
| Operating altitude above sea level | up to 2000m or higher               |
| Degree of pollution           | 2                                     |

(j) **Functions and Features**

| Measurement values                        | Derivation of various RMS power parameters from the basic measured variables with maximum and minimum values, as well as mean values for phase-to-neutral voltages, phase-to- |
Phase-to-phase voltage, Phase-to-neutral voltage, Current, Apparent power per phase, Active power per phase import/export, Reactive power per phase positive/negative, Total apparent power, Total active power import/export, Total reactive power positive/negative, Power factor, Total power factor, Line frequency, THD voltage, THD current, Active energy import / export, Reactive energy positive4 / negative, Apparent energy accessible registers for all measured values

Counters and power demand
A total of 10 energy counters capture active energy, reactive energy, apparent energy for off-peak and on-peak, import and export Counters and power demand Calculation and storage of the last demand period mean value for active power and reactive power for simple generation of load profiles using software. Programmable demand period from 1 to 60 mins. Configurable universal counter for counting limit violations and status changes at the digital input or output, or for indicating the active power or reactive power of a connected pulse encoder Working hours’ counter for monitoring the runtime of a connected load.

Monitoring functions
Monitoring of 6 limit values. The limit values can be combined according to logic AND/OR. A group message that indicates the violation of at least one limit value can be generated using an OR operation. Phase sequence monitor. Status monitoring of the digital input. Monitoring the operating status of the meter

Input & outputs
Multifunctional digital input for tariff changing, demand period synchronization, status monitoring or acquisition of energy pulses from third-party devices. Multifunctional digital output, programmable as energy pulse output for active energy or reactive energy pulses, for showing the direction of rotation, indicating the working hours of the meter, outputting limit violations, or as a switching output for
remote control via PC.

Standards

Electromagnetic compatibility

- EMC for industrial sector: IEC 61000-6-2 respectively IEC 61326-1:2005, table 2
- EMC against unloading: IEC 61000-4-2: 2001-04
- EMC against high frequency fields: IEC 61000-4-3: 2006-02
- EMC against conducted LF disturbance variables (industry): IEC 61000-6-4
- EMC against conducted disturbance variables via HF fields: IEC 61000-4-6: 2001-12
- EMC against magnetic fields with power engineering frequencies: IEC 61000-4-8: 2001-03
- EMC against quick, transient electrical disturbances: IEC 61000-4-4: 2005-07
- EMC against voltage drops and interruptions: IEC 61000-4-11: 2004-03
- EMC against surge voltages: IEC 61000-4-5: 2001-12

Other pulse emitter: according to IEC62053-31

Mechanical dynamic stress

- Low-temperature test: DIN EN 60068 Part 2-1:1995-03
- Seismic conditioning (conditions of use) in accordance with IEC 60068 Part 3-3:1991-02/ EN 60068 Part 3-3:1993-09
- Mechanical stability against bump and impact (conditions of use): IEC 60068-2-75:1997-08
- Free fall of the unpacked device (transport conditions): IEC 60068-2-32:1975

3.4.6 Digital Power Transducers

3.4.6.1 Digital power transducers shall be used for accurate metering of power circuits and transmit measured values via analogue outputs and communication interface
3.4.6.2 Transducer Rated voltage input shall be 400VAC and rated current input shall be 1A

3.4.6.3 The transducer shall have an Ethernet interface or serial output communication interface as per particular specifications

3.4.6.4 Transducer power supply shall have a rated range of 24-250VDC and 110-230VAC. Nominal power supply input shall be 110VDC±20%

3.4.6.5 Transducer inputs connection shall be four voltage inputs (3P4W) and three current inputs (3P3W)

3.4.6.6 Transducer Shall meet accuracy class specified in particular specification as per IEC 61557-12 and IEC 62053-22

3.4.6.7 Digital Transducer measuring error at 25 °C and 50hz shall be less than 0.1% for both current and voltage input as per IEC 60688

3.4.6.8 Digital Transducer shall have a minimum of 4 DC analogue outputs each with a rated output current of -20 mA to 20 mA. They shall each be individually configurable to output the various power measured values

3.4.6.9 Digital Transducer shall at minimum be able to measure /calculate and transmit the following Electric power quantities:

(a) AC voltage phase-neutral conductor (neutral conductor connected to protective ground; star connection) Vph-N: V_a, V_b, V_c

(b) AC voltage phase-phase (delta connection) Vph-ph: V_ab, V_bc, V_ca

(c) AC current I_r (current through the conductor): I_a, I_b, I_c

(d) AC voltage across the neutral conductor: V_N

(e) Unbalanced voltage: V_{unbal}

(f) Unbalanced current: I_{unbal}

(g) Mean value of the 3 phase voltages: V_{avg}

(h) Current in neutral conductor: I_N

(i) Mean value of the 3 phase currents: I_{avg}

(j) Active power factor \cos \phi: \cos \phi (a), \cos \phi (b), \cos \phi (c), \cos \phi

(k) Power factor PF: PF_a, PF_b, PF_c, PF

(l) Phase angle \phi: \phi_a, \phi_b, \phi_c, \phi

(m) Frequency (power frequency): f

(n) Active power P: P_a, P_b, P_c, P

(o) Reactive power Q: Q_a, Q_b, Q_c, Q

(p) Apparent power S: S_a, S_b, S_c, S

(q) Active energy WP: WP_a, WP_b, WP_c, WP (for supply and demand respectively–four quadrants)
(r) Reactive energy WQ: WQa, WQb, WQc, WQ (inductive and capacitive respectively- four quadrants)
(s) Apparent energy WS: WSa, WSb, WSc, WS

3.4.7 **Siren**

3.4.7.1 Alarms and trips shall be marshalled to energize a general siren to alert the operator.
3.4.7.2 The siren shall have adjustable sound level (0-90dB)
3.4.7.3 shall be mounted on top of the specified panel
3.4.7.4 Shall have the following components
   (a) Rotating orange beacon
   (b) Steady Orange/amber/yellow light
   (c) Steady Red light

3.4.8 **Serial device server**

A serial (EIA RS485, RS422, RS232) to Ethernet TCP/IP communication converter/gateway/server with an integrated Ethernet switch allowing multiple hosts on the TCP/IP network to communicate to multiple legacy serial devices. Shall have the following features

3.4.8.1 Serial Device Server features
   (a) 4 (four) RJ45/terminal block serial port interfaces
   (b) Full Modbus RTU support on the serial ports with baud rates up to 230 kbps
   (c) Convert Modbus RTU to Modbus TCP/IP
   (d) Transparent Modbus TCP Client or Server mode
   (e) Support at least 16 (sixteen) Modbus TCP masters in slave (server) mode
   (f) Support at least 32 (thirty-two) Modbus TCP slaves in master (client) mode
   (g) Fully compliant EIA/TIA RS485, RS422, RS232 serial ports (software selectable)
   (h) Raw socket mode allowing conversion of any serial protocol
   (i) Transmit serial data over an IP network
   (j) Support for Modbus TCP, DNP3, WIN, TIN, and Microlock serial protocols
   (k) Point-to-point and multi-point serial modes
   (l) Baud rates up to 230 kbps

3.4.8.2 Integrated Ethernet Switch features
   (a) 4-8 (four to eight) fast /gigabit Ethernet ports
Tender for rehabilitation of Gitaru Power Station Generator MV Switchgear,
Protection systems and LV Switchboards

(b) Support various 10/100/1000BaseTX or 100BaseFX port options:
(c) RJ45 for 10/100baseTX ports and LC/SC/ST ports for 100 base FX ports
(d) High performance and throughput Ethernet switching
(e) Full IEEE 802.3 compliance: 802.3-10BaseT; 802.3u-100BaseTX,
100BaseFX; 802.3x-Flow Control; 802.3D-MAC Bridges; 802.1D-Spanning
Tree Protocol; 802.1p-Class of Service; 802.1Q-VLAN Tagging; 802.1w-
Rapid Spanning Tree Protocol; 802.1x-Port Based Network Access Control;
802.1Q-2005 MSTP;
(f) Non-blocking, store and forward switching with Switching latency not
exceeding 5 μs at 100Mbps
(g) Switching bandwidth: 1.2 Gbps
(h) MAC addresses: 2048
(i) MAC address table size: 16kbytes

3.4.8.3 Cyber Security Features
(a) Multi-level user passwords
(b) SSH/SSL/SFTP (128-bit encryption)
(c) Enable/disable ports, MAC based port security
(d) Port based network access control (802.1x)
(e) VLAN (802.1Q) to segregate and secure network traffic
(f) RADIUS centralized password management
(g) SNMPv3 authentication and 56-bit encryption

3.4.8.4 Fully managed switch with the following software features
(a) Simple plug and play operation – automatic learning,
(b) negotiation, and crossover detection
(c) MSTP (802.1Q – 2005, formerly 802.1s
(d) RSTP (802.1D-2004) and Enhanced Rapid Spanning Tree
(e) (eRSTP) network fault recovery (<5ms)
(f) Quality of Service (802.1p) for real-time traffic
(g) VLAN (802.1Q) with double tagging and GVRP support
(h) Link aggregation (802.3ad)
(i) IGMP snooping for multicast filtering
(j) Port rate limiting and broadcast storm limiting
(k) Port configuration, status, statistics, mirroring, security
(l) SNTP time synchronization (client and server)

3.4.8.5 Device Management/configuration
(a) HTTPS graphical web-based, SSL (128-bit encryption) interface
(b) SNMP v1, v2c, v3 (56-bit encryption)
3.4.8.6 Rugged Rated for Reliability in Harsh Environments

(a) Immunity to EMI and heavy electrical surges
   (i) Meets IEEE 1613 (electric utility substations)
   (ii) Exceeds IEC 61850-3 (electric utility substations)
   (iii) Exceeds IEC 61800-3 (variable speed drive systems)
   (iv) Exceeds IEC 61000-6-2 (generic industrial)
(b) Fully independent 2kV (RMS) isolated serial ports
(c) -40°C to +85°C operating temperature (no fans)
(d) Contain no moving parts such as fans
(e) galvanized steel enclosure at least 18 AWG thick

3.4.8.7 Mounting and enclosure:

(a) DIN or panel mount
(b) Ingress protection: at least IP40
(c) galvanized steel enclosure

3.4.8.8 Power Supply.

(a) Fully integrated power supply (no external adaptors)
(b) Universal high-voltage range: 88-300VDC
(c) Screw connection terminal blocks
(d) Shall be connected to 110 ± 20% VDC station supply

3.4.8.9 Environmental Testing.

shall be tested to the same standards as protective relays including IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3, IEC 60255-26:2013, EN 61000-4-2, EN 61000-4-4, and IEEE C37.90.1.

3.4.8.10 Alarm Output.

There shall be an alarm contact output to signal internal errors and device malfunctions. The alarm contact shall be fail safe

3.4.8.11 Warranty: 5 years
3.5 **AUXILIARY RELAYS**

3.5.1 **General requirements**

3.5.1.1 Resetting of relays and contactors MUST be possible without dismantling of any covers and without risk for electrical shock. All contactors and relays used in DC circuits must be approved for the relevant DC voltage and current.

3.5.2 **Lockout trip Relays**

3.5.2.1 Lock out trip relay shall be a high-speed trip relay with: high burden, latching contacts, front panel hand reset button, reset coil for remote electrical reset and Independent hand reset flag. Trip functions specified in the particular specifications shall be wired to energize this relay.

3.5.2.2 Relays shall be of the bi-stable type, well supported to avoid malfunctioning. A reset button shall be wired to put the relay to normal position after the latched signals from the protection schemes have been reset.

3.5.2.3 Relay shall be a single unit (without a separate base) it shall have a heavy duty metallic cover

3.5.2.4 Shall be panel mounted, flush mounted on the front of the panel with connections from the rear.

3.5.2.5 Relays shall have maximum operating time of 10milliseconds.

3.5.2.6 Relays operating coil shall have a minimum Operating Current of 100MA and Operating Voltage Range Between 72VDC and 130VDC

3.5.2.7 Surge suppressor devices shall be provided across relays coils and contacts as necessary

3.5.2.8 Relay shall have a mechanical flag (similar to electromechanical relays flags) indication with red colour for tripped which shall be clearly visible and shall require hand reset.

3.5.2.9 Relays shall have heavy duty, voltage free contacts able to withstand continuous current of 25A at 120VDC and an insulation resistance of 1kVrms for 60s across normally open contacts

3.5.2.10 Relays shall have either 5 ,10 or 20 SPST contacts

3.5.2.11 Relays latched contacts shall not be able to reset during a failure of auxiliary power supply.

3.5.2.12 Manual online testing facility shall be provided for testing without isolation of any circuit from panel TB. Necessary test blocks/plugs shall be flush mounted on the panel near or next to each lockout relay.

3.5.2.13 Push button/s shall be installed on the panels for resetting lockout relays
3.5.2.14 Relays insulation must comply with IEC 60255-5 standard with a minimum insulation resistance of 2KVRms for 60s between all terminals and earth and 2KVRms for 60s between independent circuits.

(a) Relays shall also conform to the following standards:
(b) Vibration: IEC 60255-21-1 Class1
(c) Shock and bump: IEC 60255-21-2 Class1
(d) Seismic: IEC 60255-21-3 Class1
(e) Enclosure: IP5x
(f) Humidity IEC 60068-2-78
(g) Temperature IEC 60068-2-1/2

3.5.2.15 Trip Lockout relays type tests reports as per IEC 60255 from a third party reputable testing laboratory certified by the National Standards and Testing Authority (NSTA) or a laboratory accredited to the NSTA shall be submitted

3.5.3 Control Contactor Relays

3.5.3.1 These relays shall be used for control and tripping purposes
3.5.3.2 They MUST meet ALL the following specifications:

(a) Manufacturer: Siemens/ABB
(b) Model/series: 3RH2/3RH1/NFZ contactor relays,
(c) Number Contacts: 4poles 4 SPST OR 8 poles 8 SPST depending on application
(d) Contacts current rating at 110VDC: At least 3A
(e) Magnetic coil voltage rating: 24VDC/110VDC with a range of +/- 20%
(f) Magnetic coil maximum power rating for closing and holding: 4W
(g) Structure: Relays shall be a single unit i.e. without a separate base for mounting and shall have a capability to plug an auxiliary unit on top with 4 contacts poles (4 SPST)
(h) Base unit: Relay base unit shall have four contacts poles (4 SPST) and the operating coil
(i) Auxiliary plug in unit: relays shall have an auxiliary plug in unit with four contacts poles (4C/O)
(j) Connection type: screw-type terminals
(j) **Type of connectable conductor cross-section** (for auxiliary and control current circuit): at least 2X4mm² solid conductors or 2X2.5mm² stranded cores with bootlace.

(k) **Mounting type**: Snap-on mounting on a DIN rail

(l) **Size of relays**: S00

(m) **Resetting**: Relays shall be self-resetting

(n) **Protection class on the front**: IP20

(o) **Degree of pollution**: 3

(p) **Insulation voltage**: 690 V

(q) **Surge voltage resistance**: 6kV

(r) **Mechanical service life (switching cycles)**: at least 30,000,000

(b) These relays shall be provided with voltage free contacts for operating with associated circuits. The contacts shall be amply rated for their A.C or D.C duty with snap action where possible and magnetic blow – out devices. Surge suppressor devices shall be provided across relays coils and contacts.

### 3.5.4 Coupling/Interfacing relays

3.5.4.1 These relays shall be used to isolate two systems at the same voltage or different voltages. Digital inputs and output Signals from and to the plant control system shall be coupled to the new systems via these relays where specified in the particular specifications

3.5.4.2 There shall be two types of coupling relays

   (a) Highly compact micro-relay modules with 1 SPDT or solid state micro plug in relays

   (b) Miniature interface auxiliary relays modules with 4 SPDT electromechanical plug in relays

**3.5.4.3 Highly compact micro-relay modules (optocouplers)**

   (a) Highly compact micro-relay modules shall be used to interface contact outputs or inputs between two systems using different common supply, for circuit isolation or wherever else it may be necessary as per design or particular specification

   (b) They shall consist of a power terminal block and a plug in micro relay

   (c) The power terminal block shall have the following general features:

      - Integrated filter to protect against interference voltages or currents
      - The housing shall be made of Polyamide PA non-reinforced
      - Shall permit operating voltages of up to 250VAC
      - Shall accommodated a solid state or electromechanical relay
- Permit a continuous current of 10 A
- Safe isolation according to DIN EN 50178 between coil and contact
- Screw connection terminals
- Support wide range of input voltages from 12 V DC to 230 V AC
- Shall have Integrated yellow LED and interference suppression circuit on the input circuit
- Output circuit Protection against polarity reversal and surge protection
- Support conductor cross section of 0.2 mm² ... 4 mm² for solid / stranded connections
- Contact material - AgNi
- Dimensions W / H / D - 6.2 mm / 80 mm / 94 mm or equivalent
- Insulation - input/output 4 kV (50 Hz, 1 min.)
- Ambient temperature (operation) - 20 °C ... 55 °C
- Mechanical service life - min 2 x 10⁷ cycles
- Standards/regulations - IEC 60664, EN 50178, IEC 62103
- DIN rail mounting

(d) Plug-in micro relays (electromechanical) shall have the following general features:
- Typical input current at rated voltage shall be within range of 3-7mA
- Shall have a response time of less than 5ms at rated voltage
- Contact material shall be made of silver nickel AgNi
- The contacts shall be double throw (SPDT)
- Switching voltage up to 250V AC/DC depending on the application
- Power contacts up to 16 A
- High degree of protection IP67
- Safe isolation according to DIN EN 50178 between coil and contact
- Dimensions W / H / D - 5 mm / 28 mm / 15 mm or equivalent
- Insulation - input/output 4 kV (50 Hz, 1 min.)
- Ambient temperature (operation) - 40 °C ... 85 °C
- Mechanical service life - min 2 x 10⁷ cycles
- Standards/regulations - IEC 60664, EN 50178, IEC 62103

(e) Plug-in solid state relays shall have the following general features:
- Typical input current at rated voltage shall be within range of 3-7mA
• Shall have a typical switch-on time of 20µs at rated voltage
• Contact material shall be made of silver nickel AgNi
• Switching voltage up to 250V AC/125V DC depending on the application
• Contacts continuous current of up to 5 A
• High degree of protection IP67 and Vibration and shock-resistant
• Dimensions W / H / D - 5 mm / 28 mm / 15 mm or equivalent
• Insulation - input/output 2.5 kV (50 Hz, 1 min.)
• Ambient temperature (operation) - 25 °C ... 60 °C
• Standards/regulations - IEC 60664, EN 50178, IEC 62103

3.5.4.4 MINIATURE INTERFACE AUXILIARY PLUG-IN RELAY MODULES

(a) These relays shall be used for interface circuits where contact multiplication is required and other interfacing functions as per particular specification or design requirements
(b) The relay module shall consist of a plug-in relay, socket and a holder
(c) The relays shall have 4 c/o (4 SPDT) contacts rated 6 A continuous current
(d) Rated coil voltage shall be 110VDC or 24VDC depending on application
(e) Relay shall have gold contacts Cadmium-free
(f) Shall have an integrated LED and freewheeling diode
(g) Shall have Integrated test button for manual actuation and locking of output contacts
(h) Relay Shall have clearly visible mechanical status indication
(i) The socket shall have screw connection terminals.
(j) The relay shall be held in place by a wide thick plastic holder
(k) The Holder shall have Snap-on mounting on DIN rail
(l) The socket shall not be wider than 27mm
(m) Basic ratings:

(i) PLUG-IN RELAY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated control supply voltage, Ur</td>
<td>24VDC or 110VDC</td>
</tr>
<tr>
<td>Coil Operating voltage</td>
<td>Ur ±20%</td>
</tr>
<tr>
<td>Coil power consumption</td>
<td>&lt;1W</td>
</tr>
<tr>
<td></td>
<td>11-12/14, 21-22/24, 31-32/34, 41-42/44</td>
</tr>
<tr>
<td>Output circuits</td>
<td></td>
</tr>
<tr>
<td>Contact material</td>
<td>AgNi/Au 5 µm</td>
</tr>
<tr>
<td>Maximum switching voltage</td>
<td>250 V DC / 250 V AC</td>
</tr>
</tbody>
</table>
Contacts rated operational current 6A
Maximum switching (breaking) power 1500 VA
Contact resistance \( \leq 100 \text{ m}\Omega \)
Mechanical lifetime \( > 2 \times 10^7 \text{ switching cycles} \)
Electrical lifetime \( > 10^5 \text{ switching cycles} \)
Operating time \(<16\text{ms} \)
rated insulation voltage \( > 250\text{VAC} \)
Rated impulse withstand between coil and contacts 2.5 kV AC
between open contacts 1.5 kV AC
between c/o (SPDT) contacts \( \geq 2 \text{ kV AC} \)
Clearance between coil and contacts \( \geq 1.6 \text{ mm} \)
Creepage distance between coil and contacts \( \geq 3.2 \text{ mm} \)
Degree of protection IP 40
Ambient temperature range \(-40...+70^\circ\text{C} \)
Product standard EN 60810-1, EN 60255-23, IEC 61810-7

(ii) Socket
Rated current 12A
Degree of protection IP 20 B (EN 60529)
Temperature range \(-40...+85^\circ\text{C} \)
Connection type screw connection
Maximum number of wires per connecting terminal 2
Wire size with wire end ferule 2 x 1.5 mm\(^2\)
Wire size without ferule 2 x 2.5 mm\(^2\)
Mounting DIN rail (EN 50022)
Socket Material PA 6+GF - V2
contacts Material CuZn33
contact surface 5 \( \mu\) tinned
terminals 8 \( \mu\) galvanized
combi screw M3 8.8 Steel, 5\( \mu \) nickelized
Insulation voltage \( > 3 \text{kV} \)
Isolation between coil and contacts EN 61984
Isolation between coil and contacts EN 61984

3.5.5 Trip circuit/coil supervision relays.

3.5.5.1 Trip circuit/coil supervision relays shall be provided for circuit breakers trip circuit/coil supervision and Lockout trip relay circuit/coil supervision

3.5.5.2 Trip circuit supervision relays shall have a time delayed drop off (100 millisecond minimum) and shall be provided with self-resetting indicators or approved equipment.

3.5.5.3 Monitoring of breaker trip coil in both open and close position shall be provided.
3.5.5.4 Relays will have green LED which will light when circuit is okay
3.5.5.5 Relays shall have a minimum of two SPDT heavy duty contacts with at least 3A continuous current rating at 125V for interface to existing control and automation system.
3.5.5.6 The relay shall be designed and have rugged construction for reliability / dependability over a wide temperature range, even under extreme environmental conditions.
3.5.5.7 The supervision current shall always be less than 1.5 mA to avoid unwanted operation of the trip coils.
3.5.5.8 Shall be panel mounted, flush mounted on the front of the panel with connections from the rear.

3.5.6 **DC Supply supervision relay**

3.5.6.1 The relay shall be capable of monitoring the DC supply to which it is connected and indicating failure. It shall have at least 4NC potential free contacts
3.5.6.2 The relay shall have a 'time delay on drop-off' of not less than 100 milliseconds and be provided with operation indicator/flag/LED clearly visible. Green LED shall be lit on the relay when supply is available and okay
3.5.6.3 The relay shall detect supply DC failure after DC voltage falls below 70–90% (dependent on application) rated or exceeds 120% rated for a time period exceeding 100ms
3.5.6.4 Green colour supervision lamps of clustered LED type shall be provided on the panel to indicate availability of healthy DC supply.

3.5.7 **AC Voltage monitoring relays**

3.5.7.1 They shall Monitor under and over voltage in each phase for a three-phase relay. There shall be a dial for setting the under-voltage level and another dial for setting the over voltage level.
3.5.7.2 They shall detect Phase failure from over or under voltage as described above or from frequency failure and output an alarm
3.5.7.3 They shall monitor Phase sequence and output an alarm in case of failure
3.5.7.4 They shall have an Adjustable hysteresis for output contact drop off or pick up
3.5.7.5 They shall have an Adjustable time delay for output contact drop off or pick up
3.5.7.6 Shall have at least four (4) SPDT contacts
3.5.7.7 Shall have at least three status indication LED’s. They shall have a green LED for healthy status, yellow LED status for unhealthy status and a blinking LED for time delay.
3.6 SWITCHBOARDS, PANELS AND CABINETS REQUIREMENTS

3.6.1 General requirements

3.6.1.1 Switchboards, panel and cabinets shall be of robust construction, formed of a steel frame and covered with smooth steel plate. The steel plate shall be folded sheet steel of not less than 2.0mm thick and properly stiffened to prevent distortion. Panels shall normally be covered at their rear with hinged doors. The frames of the boards and panels shall be designed to permit firm anchoring on the floor. The frames shall permit easy erection, and allowance shall be made for extension of the board by similar additional panels. All enclosures shall be ventilated so that the temperature inside the enclosure does not rise more than 5°C above ambient even with possible heaters connected.

3.6.1.2 All Equipment and materials for use in Switchboards, panel and cabinets shall not be flammable and shall be self-extinguishable and resistant to flame propagation.

3.6.1.3 Outdoor-cabinets and cabinets for moist environments shall be provided with thermostat-controlled heaters to inhibit collection of moisture. The heater must be arranged not to overheat any cables or equipment. Openings for drainage of condense shall be provided at the lowest point in the cabinets.

3.6.1.4 Panels and other enclosures shall be designed with an ingress protection suitable for the equipment mounted inside. However, as a minimum all outdoor panels and cubicles shall have IP rating of 55 or higher and for indoor panels and cubicles IP rating of 42 and higher.

3.6.1.5 All major or important compartments containing electrical equipment shall be provided with a single phase 16 A square pin socket and internal LED lighting facilities switched off by a door switch.

3.6.1.6 Unless otherwise specified or agreed upon, all instruments, apparatus and devices on the panel fronts shall be provided for flush mounting. Panels with flush mounted devices shall be provided with transparent cover. The cover shall be a hinged to allow resetting and adjustment. All terminals and all equipment shall be accessible without dismantling other components. Equipment shall not be mounted in swing-out doors. However, proper swing out frames may be used provided they can be opened will full load without twisting or distorting the panel. Windows shall be provided in front of rack mounted equipment.
3.6.1.7 All panels shall be provided with LED Lamp lighting fixture rated for 240V AC/110V DC/24VDC supply, controlled by panel door switch and fuse. The number of such LED lighting fixtures shall be at least two per panel.

3.6.1.8 All panels, boards and cabinets doors shall be provided with handles and key operated locks. All doors and removable covers shall be gasketed all round with neoprene gaskets, ventilating louvers with screen and filters.

3.6.1.9 The panel shall be provided with 240V, 50Hz, 15 A, 3 pin British type universal socket with switch. The socket with switch shall be mounted inside the panel at convenient location.

3.6.1.10 The new panels, cabinets and switchboards shall be constructed to fit in the existing space where the current panels, boards & cabinets are located with cable entry from bottom.

3.6.1.11 They shall have easy access to the wiring inside through the rear side of the panel.

3.6.1.12 The panels shall be factory wired with the reception terminal blocks for connection to the instrumentation transformers, circuit breakers tripping coils, alarm circuits and plant equipment.

3.6.1.13 The panels shall be mounted on approved form of anti-vibration mounting.

3.6.1.14 Relays, electronic cards and devices shall be identified with labels permanently attached to the device. All relays shall be firmly supported on their bases to avoid mal-operation due to vibrations when the unit is running.

3.6.1.15 Printed circuit boards **SHALL NOT** be mounted on the panels. All printed circuit boards shall be contained in enclosures with an ingress protection of at least IP20 with terminal blocks and ports on the enclosures for interface.

3.6.1.16 The bottom of the panels shall be sealed by means of removable gasketted steel plates. Gland plates for the bottom entry shall be at 100mm above the floor.

3.6.1.17 A base plate for each panel shall be provided not exceeding 10cm in height.

3.6.1.18 All panels shall incorporate a common internal copper Earthing bar onto which all panel earth connections shall be made. Suitable stud or holes with the right screws shall be provided for connection to the main earth.

3.6.1.19 Appropriate eye bolts shall be provided to facilitate for easy lifting of the panels.

3.6.1.20 Panels and switchboards shall be labelled on the front and back at the top.

3.6.1.21 Marshalling cabinets, panels or boxes containing terminal blocks only shall be at least 400mm wide with a hinged door/s.

3.6.2 **Wiring**
3.6.2.1 All panel internal wiring shall be stranded flexible copper conductor with, suitable for operation at voltages below 1000 V and in compliance with the provisions of the applicable IEC Recommendations. Conductors shall not be smaller than 2.5 mm² for current & voltage transformer circuits and 1.0mm² for all other control circuits. The selection of conductor sizes for current transformer circuits shall be supported by calculations.

3.6.2.2 Wire runs shall be neatly arranged in trunks and properly clamped. Wiring shall be securely supported, neatly installed by lacing and tying, readily accessible and connected to equipment terminals and terminal blocks. Flame retardant, plastic wiring channels/troughs with strap on plastic covers shall be used for this purpose. Sufficient space in channel for modification of wiring shall be kept. For wiring within boards the "bunch" pattern shall be adopted. Ample space shall be provided for running of cable within the enclosures.

3.6.2.3 The screens or screened pairs of multicore cables shall be earthed in accordance with a coherent Earthing philosophy to be worked out by the Contractor and approved by the Project Engineer. The screen and earth wires shall be terminated in terminals dedicated for this use. All free conductors in connecting cables shall be terminated in terminals that shall be temporarily connected to earth and special marked as specified in proceeding clauses.

3.6.2.4 Multi-stranded conductor ends shall be fitted with a suitable crimped thimble (bootlace ferrule type). The thimble shall be of correct type and length according to the core size and crimple tools shall be specially adapted to the thimble and cross section used. Each wire shall be separately terminated unless otherwise approved.

3.6.2.5 All connections shall be made at numbered terminal blocks; joints, splicing or paralleling of wires will not be accepted.

3.6.2.6 Accidental short circuiting of certain wires is likely to result in malfunction of equipment, such as closing or tripping of a breaker or positive and negative wires, these wires shall not be terminated on adjacent terminal blocks.

3.6.2.7 It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard/panel dead.

3.6.2.8 Wire termination shall be made with solder less crimping type of tinned copper lugs which firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

3.6.2.9 Engraved core identification plastic ferrules, factory marked to correspond with panel wiring diagram shall be fitted at both ends of each conductor. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from
terminal blocks. These markers (ferrule) shall be of an approved type attached to the conductor insulation.

3.6.2.10 The wire numbers shown in the wiring diagram shall be in accordance with BS152/BS156.

3.6.2.11 The ferrules shall be factory numbered, indelibly marked by engraving with black letter on a white background PVC castings. All wires directly connected to trip circuit breaker or devices shall be distinguished by white letter on a red background PVC castings.

3.6.2.12 The method of ferruling shall be subject to approval by the Employer; Wire marker (ferrule) shall contain both origin device/terminal block terminal Number and destination device/terminal block terminal. If single numeric digit ferrule is to be used Number 6 and 9 shall not be used.

3.6.2.13 The unused space on the front or rear of the panels shall be kept clear of wiring to facilitate addition of devices without rewiring associated portion of the panels.

3.6.2.14 The contractor shall be responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

3.6.3 **Phase arrangement**

3.6.3.1 The standard phase arrangement when facing the front of the panel shall be L1-L2-L3-N, and L-N from the left to right, from top to bottom, and front to back for A.C three-phase and single-phase circuits. For DC circuit it shall be N-P from left to right, P-N from top to bottom and front to back. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement wherever possible.

3.6.4 **Terminal blocks**

3.6.4.1 **General requirements**

(a) All panel wiring shall terminate at terminal blocks, the terminal blocks shall be of the moulded type and provided with barriers to separate power from control cables. It shall be possible to replace a single terminal block without dismantling a whole column. They shall be clearly marked, the designations being those entered in the respective wiring diagrams. ALL terminal blocks shall be capable of receiving 2.5mm² conductors.

(b) Only one conductor shall be connected to each side of a terminal block and the branch-offs shall be made by interconnecting the necessary number of neighbouring blocks by means of shorting plugs.

(c) Terminal blocks using screws acting directly on the wire (conductor) as well as spring type terminal blocks are NOT acceptable. To avoid squeezing of the
wire the screw pressure shall be applied by a pressure plate having smooth edges. ‘OBA’ terminal blocks are not acceptable. Only terminal blocks that are operated using screw drivers are acceptable.

(d) Terminal blocks for different voltages SHALL NOT be mixed between one another. All conductors in a multi-core cable shall be terminated on the same terminal block column if they are of the same voltage. The blocks shall be grouped for each voltage and they shall be clearly marked for easy identification of the system voltage. Terminations on T.B. shall be grouped function wise on one region of T.B. (may not be full T.B)

(e) There shall be at least 20 % spare terminal blocks on each block.

(f) All spare contacts/terminals of the panel mounted equipment and spare cores/conductors of cables terminated in a panel shall be wired up to terminal blocks with ferrule numbers starting with U.

(g) Moulding materials making up the terminal blocks shall be self-extinguishing or resistant to flame propagation, substantially non-hydroscopic and shall not carbonized when tested for tracking. The insulation between any terminal and frame work between adjacent terminals shall with stand test of 2kV RMS for one minute. The moulding shall be mechanically robust to withstand handling while making terminations.

(h) Terminal blocks shall be located at least 300mm from the bottom of the panel and shall be easily accessible. All terminal blocks shall be vertically oriented in a panel; horizontally aligned terminal blocks shall NOT be accepted. Marshalling Panels containing terminal blocks only shall be at least 400mm wide.

(i) Each Individual Terminal Block shall be marked with a distinctive Number, which shall be the same Number used in the drawings, for identification purposes. The TB number shall be engraved in black numbers in white background.

(j) Each set of terminal Block shall be identified by a label to distinguish it from another set of terminal block with similar Numbers for the individual terminal blocks. The labels used will match those used in the drawings.

3.6.4.2 Terminal blocks for CT, VT and auxiliary power supply AC/DC, wiring:

(a) Shall be rated as follows:

(i) Voltage: ≥800V AC,

(ii) Continuous current rating @ 40°C ambient: ≥40 A,

(iii) Rated impulse withstand voltage: ≥8KV
(iv) Cross sectional area: ≥ 6 mm²
(b) Shall be provided with test links and isolating facilities
(c) Shall have “banana” sockets on both sides of the terminals for testing;
(d) Terminals shall be so arranged that they fall into closed position when loose;
(e) CT terminal blocks shall be
   (i) equipped with a sliding splice for separation
   (ii) have cross connectors to short neighbouring terminals before sliding
        links open.
   (iii) shall be arranged in a manner to allow connection of additional circuit
        in series;
(f) Shall be suitable for connecting multi-stranded conductors of cross-sectional
    area of 1 mm² – 4 mm² with edge processing (bootlace)

3.6.4.3 Terminal blocks for control circuits
(a) Shall be used for all control/metering/protection circuits (all other circuits
    apart from those described in clause 3.6.4.2) rated up to 125V DC wiring:
(b) Shall be rated as follows:
   (i) Voltage: ≥ 600V AC,
   (ii) Continuous current rating @ 40°C ambient: ≥ 16 A,
   (iii) Rated impulse withstand voltage: ≥ 6KV
   (iv) Cross sectional area: ≥ 6 mm²
(c) Shall have a Knife disconnect/isolator between the wire terminals
(d) shall have two slots on both sides of the knife disconnect for inserting
    shorting plugs or “banana” test plugs.
(e) Each terminal block shall have two terminals for wire connections on each
    side of the terminal block i.e four connections per terminal block
(f) Shall be suitable for connecting multi-stranded conductors of cross-sectional
    area of 1 mm² – 4 mm² with edge processing (bootlace)

3.6.4.4 Power terminal blocks
(a) Shall be used for single phase and three phase power feeder circuits rated
    below 150A
(b) Shall be rated as follows:
   (i) Voltage: ≥ 1000V AC,
   (ii) Continuous current rating @ 40°C ambient: 75–250 A,
   (iii) Rated impulse withstand voltage: ≥ 8KV
(c) Shall be flame resistant and suitable for operating voltages of 1kV.
(d) Shall consist of threaded studs and nuts M4-M12, partition plates and covers. Cable lugs (eye/horse shoe) shall be used to terminate the cables to the power terminal blocks.

(e) Nuts shall be locknut, locking nut type that can resist vibrations.

(f) The conductors shall be attached to the terminals using crimped cable lugs. Each connection shall be secured by tightening the hexagonal nut. The cable lugs shall be put between the washer on the clamp support.

(g) The terminals shall have an integrated hinge cover, with a high degree of finger safety. When closed, the cover shall lock onto the terminal and protect the contact from accidental contact.

(h) Neighbouring terminals shall have Shock protection provided by partition plates. The cover strips shall be locked into the guides of the partition plates and held with clips to prevent them slipping to the side.

(i) Shall be suitable for connecting conductors of cross sectional area 2.5mm² – 50mm².

(j) Circuits rated over 150 A shall use busbar connections and not terminal blocks.

3.6.5 **Labelling**

3.6.5.1 All Panels, switch boards, cubicles and all front mounted equipment as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved for identification. The labels or escutcheon plates shall be mounted directly above the respective equipment with English description and also where appropriate the IEC Number.

3.6.5.2 The Device Name/Number shall correspond to the Name/Number used in the drawings. All panel devices shall also be provided tag numbers corresponding to the ones shown in the panel internal wiring drawing to facilitate each tracing of wiring. These labels shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

3.6.5.3 Labels shall be made of Aluminium anodized plate P.V. Castings. The entries on the plates shall be indelibly marked by engraving with black letter on a white background. The plates shall be made of weatherproof and corrosion-proof materials and shall not be deformed under the service conditions at the site.

3.6.5.4 All devices e.g. relays, timers, MCB’s, instruments etc. shall be given standard IEC abbreviation numbers with name of device, corresponding to the ones shown in the panel internal wiring drawings.
3.6.5.5 Major equipment shall be provided with a rating plate containing the necessary information specified in the relevant IEC standards.

3.6.6 **Auxiliary Supply**

3.6.6.1 Contractor shall reconnect the existing AC / DC supply for Switches, Panel illumination, space heater etc. and supplies for control and protections of existing panels. Where deemed necessary a fresh connection shall be made from the power distribution boards, the contractor shall be expected to supply cables and associated switchgear e.g. circuit breakers where necessary.

3.6.6.2 Devices and equipment shall be suitable or adopted for 110V (±20%) DC supply and 240V/415V (±10%) AC supply which is existing at the station

3.6.7 **Earthing (Grounding)**

3.6.7.1 There shall be exposed and accessible Earthing bars in all panels connected to the existing station Earthing/grounding system. Cables shall be earthed and shielded in accordance with Earthing philosophy worked by contractor. All connections between equipment and the Earthing network shall be exposed (not embedded) and easily accessible for checking of the transition points.

3.6.7.2 Contractor shall take the necessary measures and furnish the required material for the safe Earthing of:

(a) All steel structures, metal parts and overhead ground wires.
(b) All metal parts, even if these do not constitute a conducting part of an electric system of the plants, such as machinery, operating desks, piping, sewers, rails, metal tanks, lighting, fixtures, cable racks, etc.
(c) All operational electric systems such as power and instrument transformers, lightning arresters etc.

3.7 **CABLES AND CONDUCTORS**

3.7.1 **General Requirements**
3.7.1.1 ALL CABLES SHALL BE ARMOURED.

3.7.1.2 The cables shall be marked with item designation in both ends as well as by entrances in enclosures. The cable marking shall be fire proof.

3.7.1.3 Cable markers shall be installed at the beginning and end of the cable.

3.7.1.4 Cables shall be neatly arranged, well supported and labelled at the glanding or termination point.

3.7.1.5 No joints shall be allowed.

3.7.1.6 Cables shall be wound on strong drums arranged to take a round spindle of a section adequate to support the loaded cable drum during installation and handling. The drums shall be lagged with closely fitting battens that shall be securely fixed to prevent damage to the cable. Wooden drums shall be constructed of seasoned timber to prevent shrinkage of drums during shipment and subsequent storage at site. Each drum shall be clearly marked including indication of direction of rolling.

3.7.1.7 The ends of the cables shall be suitably sealed to prevent ingress of moisture. The end of the cable left projecting from the drum shall be securely protected against damage by mishandling during transport and storage.

3.7.1.8 All control wiring shall be carried out with 1100V grade multi strand flexible copper conductor wires with HRPVC insulation and shall be flame retardant, vermin and rodent proof. Cables with twisted pairs for analogue signals (4-20mA, 0-10V etc.) shall be shielded to reduce EM interference.

3.7.1.9 All conductors shall be multi-stranded copper. The conductor shall be new, clean, uniform in size, shape and quality, smooth and free from scale, splits, sharp edges and other harmful defects. The conductor shall be in accordance with IEC 60228. The conductor shall be filled with swelling powder to stop axial ingress of moisture.

3.7.1.10 The maximum continuous current carrying capacity and maximum permissible continuous conductor temperature, and the factors for determining such rating and temperature shall be based on recommendations found in BS 7671 requirements for industrial installations and IEC 60287, subsequent amendments and all conditions prevailing on the Site.

3.7.1.11 All conductors cross section must be checked against max load current, allowable burden on measuring transformers, short circuit values, voltage drop, protection requirements and selectivity. Conductors however shall have minimum cross sections as follows:

(a) Measuring cables from VT & CT output - 2.5 mm²

(b) Control and other measuring cables - 1.0 mm²
3.7.1.12 The standard phase colours for AC supply conductors including CT & VT output are: Red for L1 phase, Yellow for L2 phase, Blue for L3 phase, black for neutral and Green with yellow stripe for Earth/ground wires or as per relevant recent IEC standard.

3.7.1.13 For auxiliary DC Supply, Red for Positive and black for negative. Conductors for instrumentation and control signals shall be numbered clearly along the whole cable length for easy identification.

3.7.2 Cable Laying and Routing

3.7.2.1 The final routing of HV and LV cables in indoor and outdoor installations shall be determined by the project engineer, from the directives given in Particular Specifications, and the principles shown in the layouts on the drawings. All cable routing must adapt to obstacles as tubes and ventilation channels. All penetrations of fire zone separations shall have the same fire classification as the separation itself.

3.7.2.2 Cables shall be laid on corrosion resistant (aluminium or hot dipped galvanised) cable trays and racks and by raising cables fixed to cable ladders. The trays shall be dimensioned and fixed so that it allows one man to climb on it in addition to the cable load. Each tray shall have at least 15% spare capacity. The distance between each tray shall at least be 300 mm. For exposed outdoor installations cables shall be laid in covered cable trenches, plastic or steel ducts, depending on the available space.

3.7.2.3 Branch offs to individual equipment shall be fixed and supported all the way to the connection box. Cables and cable supports shall be properly fixed and secured against movement under short-circuit and strain caused by erection work. Particular attention shall be given to termination in confined areas where personnel may climb under erection and maintenance. Flexible tubes of “spiral type” shall not be used whereas tubes of “plica” type can.

3.7.2.4 Low power cables, i.e. cables for control, metering, etc. shall not be run in close parallel to high power cables or earth wires but shall be run at the greatest possible separating distance. The minimum distances are:

3.7.2.5 High and medium voltage versus control and measuring cables 800 mm
3.7.2.6  Low voltage power cables versus control and measuring cables 400 mm

3.7.2.7  Necessary EMC consideration shall be taken in accordance with EMC standards.

3.7.2.8  Additionally, cables for extra low power, i.e. mA and mV circuits and cables connected to low power solid state electronic circuits, shall be laid in separate sheet steel trays with covers.

3.7.2.9  Single-phase power cables shall be run in trefoil configuration, single-phase AC power cables shall be run in parallel. Special care shall be taken so that closed magnetic circuits do not form around single-phase cables.

3.7.2.10 Cables shall be laid in full runs and not spliced unless approved by Project Engineer. Termination of multi-stranded conductor ends shall be with a suitable crimped thimble as specified above. All other cable lugs or similar shall be of crimped type adapted to the cable type and cross-section used. The tools used should be special approved for the lugs and cable type used.

3.7.2.11 All cables shall be well marked with heat and oil resistant markers

3.7.2.12 The cable supplier’s instructions regarding handling and bending radius shall be followed.

3.8 SOFTWARE

3.8.1 Submission

3.8.1.1 One copy of each different type of Software in a CD Rom, for Protection Relays, communication gateways, SCADA/HMI systems and other measuring and Control Devices whose Configuration and Settings is Software based and the connection Cable (Two for each type of device) shall be provided to employer when equipment is shipped to site

3.8.1.2 Logic diagrams/programs, PLC application programs, HMI/SCADA application programs, document management application and all other programs developed by the contractor or his supplier or subcontractor for operation of any device supplied under this project shall be provided to employer in editable format when equipment is shipped to site

3.8.1.3 Software used to develop Logic diagrams/programs, PLC application programs, HMI/SCADA application programs, document management application and all
other programs required for operation of any device supplied under this project shall be provided for installation into at least two portable computers with all necessary licences

3.8.1.4 Intellectual property rights for IED/ controller Logic diagrams/programs, PLC application programs, HMI/SCADA application programs, document management application and all other programs developed by the contractor or his supplier or subcontractor specifically for operation of any device supplied under this project/contract SHALL BE CEDED to the employer after commissioning

3.8.1.5 All the software required for configuring or programming IED’s, PLC’s industrial PC’s or any other programmable device whether explicitly mentioned in the specifications or not shall be supplied for installation to two portable PC’s. The software shall also be capable of downloading and analysing data from the IED/measuring device.

3.8.1.6 It shall be possible to load the configuration/programming software into at least two different Laptop Computers without requirement for additional licenses, to facilitate Operations. Where additional licenses are required, the cost shall be considered to have been included in the bid.

3.8.1.7 All software/programs running on any of the supplied devices which may be required for installation/reinstallation into the device at any point in the lifetime of the device e.g. after changing some parts or repairing shall be supplied

3.8.1.8 One set of hard cover manuals for each type of software Supplied providing detailed

3.8.2 Software Configuration Management Plan

3.8.2.1 A Software Configuration Management (CM) Plan shall be produced defining the manner in which the changes to software are controlled and logged during the lifecycle of the project.

3.8.2.2 The Contractor shall identify the CM procedures to be applied to software development.

3.8.2.3 Specifically, the Contractor shall ensure that procedures exist to identify, document, control and maintain all software design changes. The procedures shall include a method for:

(a) Program and/or module version identification, registration and updating
(b) Obtaining approval to implement a modification
(c) Producing build documents at baseline
(d) Ensuring that modifications are properly integrated
3.9 INTERFACING TO OTHER PLANT SYSTEMS

3.9.1 Cabling and terminations

3.9.1.1 The new panels control wiring to existing systems and instruments shall be replaced with correctly rated armoured cabling. It shall be the duty of the contractor to make a detailed study of the systems to be interface so as to size the cables appropriately to fit available cable trays and pathways and at the same time fulfil guidelines in clause 3.7 of specifications and offer all required functions in the particular section. It shall be the responsibility of the contractor to remove the existing cables.

3.9.1.2 Cable terminations to other power plant panels shall be carried out by the contractor under supervision of the employer. Internal wiring modifications of the power plant control panels to uptake signals from or offer power supply to new panels shall be carried out by the employer. Contractor shall however provide all necessary tools and accessories including but not limited to: terminal blocks, ferrules, lugs, auxiliary relays and any other accessory required to do so.

3.9.2 Interfacing to plant control system

3.9.2.1 Potential free contacts shall be made available and wired to the external interface terminal block for connection to the manual control panel and plant automation PLC panels for signals provided for in the particular technical specification.

3.9.2.2 IED’s, PLC’s and other control & metering devices shall be interfaced to plant control system by hardwiring and via TCP/IP Ethernet communication interface as detailed in particular specifications.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.9.2.3</td>
<td>All tripping outputs shall be hard wired. Hardwiring will take precedence and all important signals including those not explicitly mentioned in the particular specifications but required for optimal operation and monitoring shall be provided.</td>
</tr>
<tr>
<td>3.9.2.4</td>
<td>IED’s, PLC’s and other control &amp; metering devices providing events &amp; alarms shall be time synchronized with the GPS clock system for events &amp; alarms time stamping. The contractor shall supply and install a complete GPS clock &amp; time server system for this purpose.</td>
</tr>
<tr>
<td>3.9.2.5</td>
<td>Contractor shall test all existing instrument transformers and other instrumentation devices to be connected to the new system before connecting to the new system.</td>
</tr>
</tbody>
</table>

### Modification of existing plant control system

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.9.3.1</td>
<td>The contractor shall develop drawings of the new panels to include termination points on the manual control and automation PLC drawings as per requirements of clause 1.7. The employer on receiving the final design drawings of the new equipment shall develop an interface drawing to the existing manual control and automation PLC panels. The modified drawings will be used during installation and commissioning and will then be forwarded to contractor after commissioning for them to develop updated drawings of manual control panels and automation PLC panels as per requirements of clause 1.7 of specifications</td>
</tr>
<tr>
<td>3.9.3.2</td>
<td>The contractor shall provide all the necessary interface material for connection to the manual control panel and the automation PLC system. These shall include but not limited to: pushbuttons, relays, timers, opto-couplers and all other devices as shall be specified in the particular specifications.</td>
</tr>
<tr>
<td>3.9.3.3</td>
<td>Employer shall carry out modifications on the SCADA system software and unit control PLC logic to accommodate the new systems prior and during project execution. In order to enable the client to interface the plant control system to the new systems supplied by the contractor, contractor shall furnish the client with all necessary information as requested by the employer</td>
</tr>
</tbody>
</table>
4 GITARU POWER PLANT MAJOR EQUIPMENT DATA

4.1 Overview

4.1.1 Gitaru power plant consists of three vertical Francis turbines driving generators of the salient type.

4.2 Generators

4.2.1 Unit 1 Generator

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated power</td>
<td>95000kVA</td>
</tr>
<tr>
<td>2</td>
<td>Maximal continuous overload</td>
<td>Temperatures rise in acc. to class F</td>
</tr>
<tr>
<td>3</td>
<td>Rated voltage</td>
<td>15000V</td>
</tr>
<tr>
<td>4</td>
<td>Operating range of voltage</td>
<td>±5% at rated load</td>
</tr>
<tr>
<td>5</td>
<td>Rated current</td>
<td>3657A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>Rated frequency</td>
<td>50Hz</td>
</tr>
<tr>
<td>7</td>
<td>Rated power factor</td>
<td>0.85</td>
</tr>
<tr>
<td>8</td>
<td>Service factor</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Number of phases</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>Number of poles</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>Rated speed</td>
<td>272.7rpm</td>
</tr>
<tr>
<td>12</td>
<td>Overspeed</td>
<td>490rpm</td>
</tr>
<tr>
<td>13</td>
<td>Duty</td>
<td>S1</td>
</tr>
<tr>
<td>14</td>
<td>Class of insulation</td>
<td>Stator: F Rotor: F</td>
</tr>
<tr>
<td>15</td>
<td>Temperature rise for rated output (above 40°C air temperature)</td>
<td>Stator: 85K Rotor: 80K</td>
</tr>
<tr>
<td>16</td>
<td>Maximum altitude of installation</td>
<td>1000m</td>
</tr>
<tr>
<td>17</td>
<td>Ambient temperature</td>
<td>40°C</td>
</tr>
<tr>
<td>18</td>
<td>Rated excitation current</td>
<td>808A</td>
</tr>
<tr>
<td>19</td>
<td>No. load excitation current</td>
<td>454A</td>
</tr>
<tr>
<td>20</td>
<td>Rated Excitation voltage (130°C)</td>
<td>267V</td>
</tr>
<tr>
<td>21</td>
<td>Method of excitation</td>
<td>Static</td>
</tr>
<tr>
<td>22</td>
<td>Reactances in p.u.</td>
<td>Unsaturated</td>
</tr>
<tr>
<td></td>
<td>Xd</td>
<td>1.07</td>
</tr>
<tr>
<td></td>
<td>X’d</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>X’d’</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Xq</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>X’q</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>X2</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>X0</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Xσ1</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Xp</td>
<td>0.12</td>
</tr>
<tr>
<td>23</td>
<td>Short circuit ratio (Iko/In)</td>
<td>1.01p.u.</td>
</tr>
<tr>
<td>24</td>
<td>Time Constants; T’d0</td>
<td>7.80s</td>
</tr>
<tr>
<td></td>
<td>T’d</td>
<td>1.80s</td>
</tr>
<tr>
<td></td>
<td>T’d’</td>
<td>0.04s</td>
</tr>
<tr>
<td></td>
<td>T’d’0</td>
<td>0.06s</td>
</tr>
<tr>
<td></td>
<td>Td</td>
<td>0.19s</td>
</tr>
<tr>
<td></td>
<td>T’d’</td>
<td>0.05s</td>
</tr>
<tr>
<td></td>
<td>T’d’0</td>
<td>0.16s</td>
</tr>
<tr>
<td>25</td>
<td>Manufacturer</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>26</td>
<td>Fly wheel effect(GD)²</td>
<td>625 tm²</td>
</tr>
</tbody>
</table>
## Unit 2 & 3 Generators

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1   Power Rating</td>
<td>85MVA</td>
</tr>
<tr>
<td>2   Rated reactive power at zero leading power factor 80-105% voltage range without becoming unstable</td>
<td>69MVAR</td>
</tr>
<tr>
<td>3   Rated Power Factor</td>
<td>0.85</td>
</tr>
<tr>
<td>4   Rated Voltage</td>
<td>15kV</td>
</tr>
<tr>
<td>5   Range of voltage variation</td>
<td>±5%</td>
</tr>
<tr>
<td>6   Speed</td>
<td>273 rpm</td>
</tr>
<tr>
<td>7   Generator field current at rated kVA, rated voltage and 0.85 power factor</td>
<td>1060 A</td>
</tr>
<tr>
<td>8   Generator field current at rated kVA, rated voltage and unity power factor</td>
<td>1270A</td>
</tr>
<tr>
<td>9   Rated frequency</td>
<td>50Hz</td>
</tr>
<tr>
<td>10  Direct axis synchronous reactance</td>
<td>110%</td>
</tr>
<tr>
<td>11  Direct axis transient reactance-unsaturated</td>
<td>24%</td>
</tr>
<tr>
<td>12  Direct axis transient reactance-saturated</td>
<td>21.6%</td>
</tr>
<tr>
<td>13  Direct axis sub-transient reactance - unsaturated</td>
<td>14.4%</td>
</tr>
<tr>
<td>14  Direct axis sub-transient reactance – saturated</td>
<td>12.5%</td>
</tr>
<tr>
<td>15  Direct axis transient open circuit time constant T’d0</td>
<td>9.23s</td>
</tr>
<tr>
<td>16  Direct axis sub transient short circuit time constant T’d</td>
<td>0.031s</td>
</tr>
<tr>
<td>17  Quadrature axis sub-transient reactance-unsaturated</td>
<td>16.1%</td>
</tr>
<tr>
<td>18  Quadrature axis sub-transient reactance- saturated</td>
<td>16.1%</td>
</tr>
<tr>
<td>19  Ratio of quadrature axis sub-transient reactance to direct axis sub-transient reactance of damper windings</td>
<td>114</td>
</tr>
<tr>
<td>20  Negative sequence reactance unsaturated</td>
<td>15.2%</td>
</tr>
<tr>
<td>21  Negative sequence reactance – saturated</td>
<td>13.2%</td>
</tr>
<tr>
<td>22  Zero sequence reactance</td>
<td>7.6%</td>
</tr>
<tr>
<td>23  Resistance of stator winding per phase at 25°C</td>
<td>5.66mΩ</td>
</tr>
<tr>
<td>24  Resistance of field winding at 75°C</td>
<td>120mΩ</td>
</tr>
<tr>
<td>25  Generator and exciter total losses @100% rated KVA</td>
<td>989kW</td>
</tr>
<tr>
<td>26  Short circuit time constant T’d (sub transient)</td>
<td>0.031 seconds</td>
</tr>
<tr>
<td>27  Open circuit time constant T’d</td>
<td>9.23 seconds</td>
</tr>
<tr>
<td>28  Stator flux density at rated output in the stator core</td>
<td>1 Tesla</td>
</tr>
</tbody>
</table>
27. Stator flux density at rated output in the stator teeth: 1.58 Tesla
28. Stator impulse design voltage phase to earth: 52.5kV
29. Stator impulse design voltage phase to phase: 75kV
30. Type of stator winding: Double layer wave winding, Roebel bar
31. Flux density in rotor poles: 1.35 Tesla
32. Rotor excitation at rated output and voltage at:
   - 0.85 power factor: 1060 A
   - Unity power factor: 830 A
33. Rotor excitation at 50 MVAR zero leading power factor:
   - 110%: 344A
   - 100%: 218A
   - 90%: 110A
34. Manufacturer: SIEMENS

### 4.3 Generator Step up transformers

#### 4.3.1 Unit 1 GSU transformer

<table>
<thead>
<tr>
<th>Plant Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Output</td>
<td>95MVA</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>220000/15000V</td>
</tr>
<tr>
<td>Tap changer</td>
<td>ON Load</td>
</tr>
<tr>
<td>Tap Range</td>
<td>Tap1 264375V – Tap17 205625V</td>
</tr>
<tr>
<td>Vector Group</td>
<td>YNd1</td>
</tr>
<tr>
<td>Impedance</td>
<td>11.62%</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Hyundai</td>
</tr>
</tbody>
</table>

#### 4.3.2 Unit 2 GSU transformer

<table>
<thead>
<tr>
<th>Plant Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Output</td>
<td>85MVA</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>132000/15000V</td>
</tr>
<tr>
<td>Tap changer</td>
<td>Off circuit</td>
</tr>
<tr>
<td>Tap Range</td>
<td>Tap1 145200V – Tap6 125400V</td>
</tr>
<tr>
<td>Vector Group</td>
<td>YNd1</td>
</tr>
<tr>
<td>Impedance</td>
<td>12.5%</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>JSHP</td>
</tr>
</tbody>
</table>

#### 4.3.3 Unit 3 GSU transformer
## Plant Details

<table>
<thead>
<tr>
<th>Plant Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Output</td>
<td>85MVA</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>132000/15000V</td>
</tr>
<tr>
<td>Tap changer</td>
<td>Off circuit</td>
</tr>
<tr>
<td>Tap Range</td>
<td>Tap1 145200V – Tap7 125400V</td>
</tr>
<tr>
<td>Vector Group</td>
<td>YNd1</td>
</tr>
<tr>
<td>Impedance</td>
<td>12.17%</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Jeumont Schneider</td>
</tr>
</tbody>
</table>

### 4.4 Station Transformers

#### 4.4.1 Unit 1 Station Transformer

Not yet installed, to be installed during the project.

<table>
<thead>
<tr>
<th>Plant Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Output</td>
<td>750KVA</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>15000/433V</td>
</tr>
<tr>
<td>Tap changer</td>
<td>ON Load motor driven</td>
</tr>
<tr>
<td>Tap Range</td>
<td>Tap1 17250V – Tap 11 13500V</td>
</tr>
<tr>
<td>Tap step</td>
<td>375V = 25%</td>
</tr>
<tr>
<td>Vector Group</td>
<td>Dyn1</td>
</tr>
<tr>
<td>Impedance</td>
<td>5.18%</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Crompton Greaves</td>
</tr>
</tbody>
</table>

#### 4.4.2 Unit 2 & 3 Station Transformers

<table>
<thead>
<tr>
<th>Plant Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Output</td>
<td>750KVA</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>15000/433V</td>
</tr>
<tr>
<td>Tap changer</td>
<td>ON Load motor driven</td>
</tr>
<tr>
<td>Tap Range</td>
<td>Tap1 17250V – Tap 11 13500V</td>
</tr>
<tr>
<td>Tap step</td>
<td>375V = 25%</td>
</tr>
<tr>
<td>Vector Group</td>
<td>Dyn1</td>
</tr>
<tr>
<td>Impedance</td>
<td>5.18%</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Italtrafo</td>
</tr>
</tbody>
</table>

#### 4.4.3 Alternative supply station Transformer

<table>
<thead>
<tr>
<th>Plant Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Output</td>
<td>750KVA</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>33000/433V</td>
</tr>
<tr>
<td>Tap changer</td>
<td>OFF Load</td>
</tr>
<tr>
<td>Tap Range</td>
<td>Tap1 36300V – Tap7 31350V</td>
</tr>
<tr>
<td>Tap step</td>
<td>825V = 25%</td>
</tr>
<tr>
<td>Vector Group</td>
<td>Dyn1</td>
</tr>
<tr>
<td>Impedance</td>
<td>5.18%</td>
</tr>
</tbody>
</table>
4.5 Operating Conditions

4.5.1 The generators are operated in a network with other generators and are connected to the supply system network via generator step-up transformers.

4.5.2 Gitaru generators are the biggest in the Kenyan grid and play a big role in grid frequency and voltage regulation.

4.5.3 **Temperature and Humidity**

4.5.4 The equipment shall withstand, without impairing the component function, the following ambient conditions:

4.5.4.1 Temperature range: $-10^\circ C$ to $+45^\circ C$

4.5.4.2 Relative humidity: 85% at 40°C

4.5.5 The dew-point shall not be reached. If necessary, special measures shall be taken [cooling, fanning].

4.5.6 **Other environmental conditions**

(a) 24-hour average temperature: $+10^\circ C$ — $+35^\circ C$

(b) Relative humidity: 90 - 100%

(c) Height above sea level: 930 m

(d) EMC Class (IEC 61000): Industrial environments

(e) Seismic coefficient: Not available

(f) Rainfall conditions Average: 500-800 mm/year

(g) Indoor Pollution degree: III

(h) Earthquake acceleration-Horizontal acceleration: not available

(i) Earthquake Acceleration-Vertical acceleration: not available

(j) 132kV bus bar estimated fault level: 2627 MVA

(k) 220kV bus bar estimated fault level: 2698 MVA
5 PARTICULAR TECHNICAL SPECIFICATIONS: **
6 PARTICULAR TECHNICAL SPECIFICATION: GENERATOR MV SWITCHGEAR

6.1 INTRODUCTION

6.1.1 KenGen seeks to procure two medium voltage generators synchronizing circuit breakers and 17.5kV MV, air insulated, compact, indoor generator switchgear for Gitaru Unit 2 and 3 generators

6.1.2 Currently Unit 2 and unit 3 generators are directly coupled to their corresponding step up transformers. This shall create an isolation/separation point between the generator and transformer.

6.1.3 KenGen is seeking bids to procure and install a suitable switchgear steel housing to be installed in the substation for housing the switchgear for unit 2 and 3.

6.1.4 Bidder shall provide all equipment and design/installation services necessary for a complete generator MV switchgear and the enclosure whether indicated in the requirements below or not.

6.2 MV GENERATOR SWITCHGEAR REQUIREMENTS

6.2.1 MV Switchgear Technical Characteristics

The MV switchgear cubicles shall be air insulated rated for a minimum of the following:

(a) Rated voltage: 17.5 kV
(b) Rated frequency: 50 Hz
(c) Rated power-frequency withstand voltage: 50kV, 1 minute
(d) Rated lightning impulse withstand voltage: 110 kV, 1.2/50 µs
(e) Rated short-time withstand current: 63kA
(f) Rated duration of short circuit: 3s
(g) Rated peak withstand current: 173kA
(h) Rated continuous current of bus bar @40°C: 4300A
(i) Rated continuous Generator CB current @40°C: 5000A
(j) Internal arc category, IAC as per IEC 62271-200: A, FLR
(k) Internal arc performance @17.5 kV: ≥63 kA / 0.3s
(l) Loss of service continuity category, LSC: 2B
(m) Partition class as per IEC 62271-200: PM
(n) Switchgear insulation medium: air
(o) Number of phases: 3
(p) No of cubicles per unit: 2 or 3
(q) Generator CB cubicle switching device: withdrawable VCB
(r) GSU transformer cubicle switching device: none, Bus riser panel
(s) Auxiliary(station) xfmr cubicle switching device: fixed load break switch
(t) MV switchgear design standard: IEC 62271-200
(u) AC disconnectors and earthing switches standard: IEC 62271-102
(v) Generator circuit breaker design/testing standard: IEEE C37.013 or IEC/IEEE 62271-37-013
(w) GCB short circuit breaking current @17.5kV: 63kA
(x) GCB Asymmetrical breaking current @17.5kV: 86kA
(y) GCB breaking current DC component: 65%
(z) GCB short circuit making current @17.5kV: 173kA
(aa) GCB switching medium: vacuum
(bb) GCB rated short time withstand current: 63kA, 3s
(cc) GCB Endurance class as per IEC 62271-200: E2 - M2
(dd) Load break switch interrupt rating: 1250KVA
(ee) Rated (continuous) ambient temperature: -5°C – 40°C
(ff) Rated Altitude of installation: ≥1000m ASL
(gg) Rated (continuous) Humidity: ≥90%
(hh) Seismic/vibration withstand: 0.25g
(ii) Enclosure Ingress protection: IP42
(jj) Degree of protection of the internal partitions: IP2X
(kk) External cable/bus bars connections: from bottom
(ll) Seismic withstand type testing: As per IEEE 693

6.2.2 Generator Circuit Breaker, GCB Incomer Cubicle

6.2.2.1 Components
Circuit-breaker panel meeting all the MV switchgear requirements of clause 6.4.1 shall be installed with the following compartments:

(a) circuit breaker compartment
   Shall contain the withdrawable 5000A,17.5KV vacuum circuit breaker and its manual operation devices

(b) connection compartment
   shall contain the following
   (i) Cable termination isolated bus bars
   (ii) Six (6) current transformers each with four secondary cores
   (iii) six (6) voltage transformers each with three secondary cores
   (iv) Motorised earth switch,
(v) surge capacitor  
(vi) surge diverter  
(vii) circuit breaker contact mechanism  

(c) bus bar compartment  
shall contain the main bus bars  

(d) Low-voltage compartment  
Shall contain circuit breaker control and interface circuits  

(e) Pressure duct/channel  

6.2.2.2 Circuit breaker compartment  

(a) Vacuum circuit breaker meeting all requirements of clause 6.4.2 shall be installed in the circuit breaker compartment.  

(b) The compartment Shall support a withdrawable breaker with all the necessary devices for racking in and out the circuit breaker  

(c) Circuit breaker panel shall provide for three circuit breaker positions:  
   (i) Service position: this shall be the normal operating position of the circuit breaker. In this position, the circuit breaker, connection and bus bar compartments will be in circuit. Service position shall be monitored by a limit switch with at least 2NO+2NC contacts  
   (ii) TEST Position: this shall be for testing of the breaker operating mechanism. The connection and bus bar compartments shall be separated from the circuit breaker conductors via the shutters. The circuit breaker controls shall be operational and OPEN/ CLOSE commands can be executed. The circuit breaker shall be racked to this position with the compartment door closed. Test position shall be monitored by a limit switch with at least 2NO+2NC contacts  
   (iii) OFF Position: This shall be the position of the circuit breaker when completely isolated from the circuit. All circuit breaker commands shall be inoperable in this position. The earth switch shall be integrally applied in this position. disconnected position shall be monitored by a limit switch with at least 2NO+2NC contacts  

(d) Bus bars shall be covered with metal shutters which shall open when the breaker is racked in and close when the circuit breaker is racked out. While racking the circuit breaker from the service to the test position or vice versa, the withdrawable part shall open or close the metal shutters (positively driven) covering the fixed contacts in the connection and bus bar compartments
(e) Circuit breaker panel shall provide latches to hold the circuit breaker in position after it has been racked in. The latches shall be metallic and shall prevent any movement of the breaker while in service position. Access hole shall be provided on the compartment door for operating the latch.

(f) Racking of the breaker into test position shall be carried out while the breaker compartment door is closed. Access holes shall be provided on the compartment door for racking the breaker.

(g) The connection of the low-voltage wiring between the withdrawable part and the fixed part of the panel shall be done via a plug connection.

(h) An inspection window shall be provided for inspecting the circuit breaker mechanical indicators and for monitoring the circuit breaker temperature with a thermal imaging camera.

6.2.2.3 *Interlocks*

(a) There shall be an electrical interlock between the motorised earth switch operation and circuit breaker position.

(b) Circuit breaker door compartment shall only open and close with the circuit breaker racked to test position.

(c) Connection compartment door shall only open and close after the earth switch has been applied.

(d) Other interlocks for circuit breaker safe operation shall be provided.

6.2.2.4 *Connection Compartment*

(a) Connection compartment shall contain the cable termination bus bars, earth switch, surge capacitor, voltage transformers and current transformers. A cable termination chamber shall be separated from the connection compartment by metallic partition.

(b) Access to the connection compartment shall require prior closing of the earthing switch. The connection compartment shall thus be “interlock-based accessible compartment” according to IEC 62271-200.

(c) A motorised earth switch meeting requirement of clause 6.4.3 shall be installed. The earth switch shall be operable both electrically and mechanically. Operating tools and access holes on the compartment doors for operating the earth switch mechanically shall be provided.

(d) Electrical operation of the earth switch shall be possible both locally on the panel and remotely from the unit control system.
(e) A total of six (6) voltage transformers, two for each phase, meeting requirements of clause 6.4.6 shall be installed, with the following features

(i) VT ratio for all VT cores shall be 15KV/110V

(ii) VT 1 Shall have three secondary cores, as follows

- Core 1–generator protection set 1 VT: protection class 3P
- Core 2–synchronising and metering: metering class 0.5
- Core 3–Generator main Tariff metering: metering class 0.2

(iii) VT 2 Shall have three secondary cores, as follows

- Core 1–generator protection set 2 VT: protection class 3P
- Core 2–synchronising and metering: metering class 0.5
- Core 3–Generator back up Tariff metering: metering class 0.2

(iv) The burden of the VT’s shall be determined at design stage, however at minimum the following burden shall be provided

- Protection class 3P VT’s: 50VA
- Metering class 0.5 VT’s: 20VA
- Metering class 0.2 VT’s: 10VA

(f) A total of six (6) current transformers, two for each phase, meeting requirements of clause 6.4.5 shall be installed, with the following features

(i) CT ratio for all CT cores shall be 4000/1A

(ii) CT 1 Shall have four secondary cores, as follows

- Core 1–GSU transformer protection set 1 CT: protection class 5P20
- Core 2–GSU transformer protection set 2 CT: protection class 5P20
- Core 3–Excitation AVR 1 stator current input: metering class 0.5
- Core 4–Generator main Tariff metering: metering class 0.2s

(iii) CT 2 Shall have four secondary cores, as follows

- Core 1–Generator protection set 1 CT: protection class 5P20
- Core 2–Generator protection set 2 CT: protection class 5P20
- Core 3–Excitation AVR 2 stator current input: metering class 0.5
- Core 4–Generator back up Tariff metering: metering class 0.2s

(iv) The burden of the CT’s shall be determined at design stage, however at minimum the following burden shall be provided

- Protection class 5P20 CT’s: 30VA
- Metering class 0.5 CT’s: 10VA
- Metering class 0.2s CT’s: 5VA
(v) Metering CT’s shall have an instrument safety factor of 120% (shall not saturate below 120% In at rated burden)

(g) Three (3) surge capacitors, one per phase, with capacitances of 250 nF – 300 nF per phase shall be installed to ensure safe limitation of the possible stresses on the generator side.

(h) Three (3) surge diverters, one per phase, meeting requirements of clause 6.4.7 shall be installed.

(i) Two (2) resistance temperature detectors, RTD’s meeting requirements of clause 3.4.1.2 of specifications with three wire/four wire connection shall be installed for panel temperature monitoring. The RTD’s shall be wired to the unit control PLC.

(j) The existing twelve (four per phase) generator incomer cables shall be terminated in the cable termination chamber. Cable glands, flanges, copper flexes and all other termination equipment shall be supplied and used to carry out the termination. Contractor shall carry out the terminations and provide all required equipment for cable termination.

(k) During cable termination, minimum bending radius shall meet IEEE 1185 requirements

6.2.2.5 Low-voltage compartment

(a) Shall house generator incomer control and metering devices and all external interface to the generator control, metering and protection circuits.

(b) Bottom entry for external control cables by means of gland plates shall be provided with cut outs as necessary. All control cables to generator incomer shall be glanded and terminated to terminal blocks.

(c) All CT, VT, GCB & earth switch auxiliary terminals and all other control circuits shall be terminated and wired in this cubicle as described in clause 3.6 and 3.7 of specifications.

(d) All auxiliary terminals of the GCB and the earth switch and all the CT & VT outputs including all the spares shall be wired to terminal blocks in this compartment.

(e) For each CT and VT secondary outputs, the two leads shall be terminated on the terminal block i.e. grounding/star point wiring shall be done on the LV cubicle terminal block.

(f) The following control devices and functions shall be provided

(i) One (1) Key operated switch for LOCAL/REMOTE interlock

(ii) At least Four (4) illuminated push buttons (with command push button and status LED) shall be provided for:
- GCB close
- GCB open
- Generator earth switch close
- Generator earth switch open

(iii) Mimic diagrams with position LED indicators for GCB and earth switch position.

(iv) Integrated capacitive voltage detecting system meeting requirements of clause 6.4.8

(v) At least 4 (four) status indication LED lamps for the following status.
- GCB in service position
- GCB withdrawn
- GCB in test position
- 110 V DC control Supply unavailable

(vi) Circuit for remote and local operation of the GCB and earth switch with all the requisite interlocks shall be realised using contactor relays meeting requirements of clause 3.5.3. (at least eight (8) relays)

(vii) At least one 110V DC voltage supervision relays meeting requirements of clause 3.5.6 for 110V DC supervision

(viii) An emergency pushbutton for emergency tripping of the GCB and the generator

(ix) Interface relays with 4SPDT contacts for indication circuits interface.

(x) At least three (3) DC DP Miniature circuit breakers 110V DC supplies

(xi) At least one (1) AC DP Miniature circuit breakers for panel lighting supplies

(g) Metering devices for voltage and current indication shall be provided as follows

(i) One (1) Digital panel AC voltmeter meeting requirements of clause 3.4.2.3 and voltmeter selector switch connected to the metering VT output

(ii) One (1) Digital panel AC ammeter meeting requirements of clause 3.4.2.3

(iii) At least one (1) Motor protection circuit breaker (MPCB) suitably rated for protection of the digital voltmeter VT input
6.2.2.6 **GCB control interfacing**

(a) GCB panel controls and monitoring circuits shall be interfaced to the manual control panel, unit PLC panel, generator and generator transformer protection panels and excitation regulators panel. All signals and circuits shall be wired as described in the protection particular specifications.

(b) As a minimum and in supplement to the protection particular technical specifications, the following shall be hard wired to the generator protection panel:

(i) Generator protection set 1 CT (4 wire)
(ii) Generator protection set 2 CT (4 wire)
(iii) Generator main Tariff metering CT (4 wire)
(iv) Generator backup Tariff metering CT (4 wire)
(v) Generator protection set 1 VT (4 wire)
(vi) Generator protection set 2 VT (4 wire)
(vii) Generator main Tariff metering VT (4 wire)
(viii) Generator backup Tariff metering VT (4 wire)
(ix) At least eight (8), 4NC+4NO, GCB auxiliary contacts
(x) GCB closing inputs
(xi) GCB trip coil 1 input
(xii) GCB trip coil 2 input
(xiii) GCB trip coil 1 supervision
(xiv) GCB trip coil 2 supervision
(xv) At least four (4), 2NC+2NO, generator earth switch auxiliary contacts
(xvi) 110V DC supply failure alarm contact
(xvii) At least the following alarms and annunciation (hardwired or via remote IO):

- GCB in withdrawn position
- GCB in test position
- GCB operation selected LOCAL
- GCB in service position
- GCB operation selected REMOTE
- GCB spring charged
- Grouped DC MCB’s trip
- GCB spring charge failure

(c) As a minimum and in supplement to the protection particular technical specifications, the following shall be hard wired to the generator step up transformer protection panel:

(i) GSU transformer protection set 1 CT (4 wire)
(ii) GSU transformer protection set 2 CT (4 wire)
(iii) GCB trip coil 1 input
(iv) GCB trip coil 2 input

(d) As a minimum of the following shall be hard wired to the excitation regulators panel for future use, they shall be terminated to a terminal block.
(i) Excitation AVR 1 stator current input CT (4 wire)
(ii) Excitation AVR 2 stator current input CT (4 wire)
(iii) Four (4), 2NC+2NO, GCB auxiliary contacts

(e) As a minimum, the following shall be hard wired to the manual control panel and unit PLC panel as per clause 6.2.7
(i) Generator synchronising and metering VT 1 (4 wire)
(ii) Generator synchronising and metering VT 2 (4 wire)
(iii) At least four (4), 2NC+2NO, GCB auxiliary contacts
(iv) GCB closing inputs
(v) GCB trip coil 1 input
(vi) GCB trip coil 2 input
(vii) Generator Earth switch closing command input
(viii) Generator Earth switch opening command input
(ix) At least four (4), 2NC+2NO, generator earth switch auxiliary contacts
(x) Two RTD’s to unit control PLC
(xi) At least the following alarms and annunciation ‘contacts

<table>
<thead>
<tr>
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<th>GCB in test position</th>
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<td>Grouped DC MCB’s trip</td>
<td>GCB spring dis charged</td>
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<tr>
<td>110V DC control supply failure</td>
<td>GCB spring charge failure</td>
</tr>
</tbody>
</table>

6.2.3 **Generator Step Up Transformer Feeder (Bus Riser) Cubicle**

6.2.3.1 **Components**

Bus riser panel meeting all the MV switchgear requirements of clause 6.4.1 shall be installed with the following compartments:

(a) Switching device compartment
   Vacant but available for future changes

(b) connection compartment
   shall contain the following
   (i) Insulated bus bar termination bus bars
   (ii) Sis (6) voltage transformers each with two secondary cores
   (iii) Motorised earth switch,
(iv) Surge diverter and surge capacitor
(c) Bus bar compartment
   shall contain the main bus bars
(d) Low-voltage compartment
   Shall contain indication and control interface circuits
(e) Pressure duct/channel

This cubicle may be integrated into the station transformer cubicle if all components detailed in the subsequent clauses are included without compromising safety standard (as defined by the relevant IEC62271 standard) of the cubicle

6.2.3.2 Connection Compartment
(a) An insulated bus bar shall be used to interface the bus riser to the GSU transformer LV terminals.
(b) Connection compartment shall contain the insulated bus bar termination bus bars, earth switch, surge diverter, surge capacitor and voltage transformers. An insulated bus bar termination chamber shall be separated from the connection compartment by metallic partition.
(c) The connection compartment of bus riser cubicle shall be “tool-based accessible compartment” according to IEC 62271-200.
(d) A motorised earth switch meeting requirement of clause 6.4.3 shall be installed. The earth switch shall be operable both electrically and mechanically. Operating tools and access holes for operating the earth switch mechanically shall be provided.
(e) Electrical operation of the earth switch shall be possible both locally on the panel and remotely from the unit control system.
(f) A total of six (6) voltage transformers, two for each phase, meeting requirements of clause 6.4.6 shall be installed, with the following features
   (i) VT ratio for all VT cores shall be 15KV/110V
   (ii) VT 1 Shall have two secondary cores, as follows
      • Core1–GSU transformer protection set 1: open delta VT: class 3P
      • Core2–synchronising and metering: metering class 0.5
   (iii) VT 2 Shall have two secondary cores, as follows
      • Core1–GSU transformer protection set 1: open delta VT: class 3P
      • Core2–synchronising and metering: metering class 0.5
   (iv) The burden of the VT's shall be determined at design stage, however at minimum the following burden shall be provided
- Protection class 3p VT’s: 50VA
- Metering class 0.5 VT’s: 30VA

(v) One of the secondary VT cores shall be an open delta winding for zero sequence voltage sensing.

(g) Three (3) surge capacitors, one per phase, with capacitances of 250 nF – 300 nF per phase shall be installed to ensure safe limitation of the possible stresses on the generator transformer LV side.

(h) Three (3) surge diverters, one per phase, meeting requirements of clause 6.4.7 shall be installed.

(i) Two resistance temperature detectors, RTD’s meeting requirements of clause 3.4.1.2 of specifications with three wire/four wire connection shall be installed for panel temperature monitoring. The RTD’s shall be wired to the unit control PLC.

(j) Solid insulated bus bars shall be connected to the GSU transformer LV terminals from the bus riser cubicle

6.2.3.3 Low-voltage compartment

(a) Shall house earth switch control, metering devices and all external interface to the generator control, metering and protection circuits.

(b) Bottom entry for external control cables by means of gland plates shall be provided with cut outs as necessary. All control cables to generator incomer shall be glanded and terminated to terminal blocks.

(c) All VT & earth switch auxiliary terminals and all other control circuits shall be terminated and wired in this cubicle as described in clause 3.6 and 3.7 of specifications.

(d) All auxiliary terminals of the earth switch and all the VT outputs including all the spares shall be wired to terminal blocks in this compartment.

(e) For each VT, secondary outputs, the two leads shall be terminated on the terminal block i.e. grounding/star point wiring shall be done on the LV cubicle terminal block.

(f) The following control devices and functions shall be provided

   (i) One (1) Key operated switch for LOCAL/REMOTE interlock

   (ii) At least two (2) illuminated push buttons (with command push button and status LED) shall be provided for:

       • GSU transformer earth switch close
       • GSU transformer earth switch open
(iii) Mimic diagrams with position LED indicators showing earth switch position.

(iv) Integrated capacitive voltage detecting system meeting requirements of clause 6.4.8.

(v) At least 2 (two) status indication LED lamps for the following status.
- 110 V DC control Supply unavailable
- Earth switch motor failure

(vi) Circuit for remote and local operation of the earth switch with all the requisite interlocks shall be realised using contactor relays meeting requirements of clause 3.5.3. (at least three (3) relays)

(vii) At least one 110V DC voltage supervision relays meeting requirements of clause 3.5.6 for 110V DC supervision.

(viii) An emergency pushbutton for emergency tripping of the 132KV circuit breaker and the generator.

(ix) Interface relays with 4SPDT contacts for indication circuits interface.

(x) At least one (1) DC DP Miniature circuit breakers 110V DC supplies

(xi) At least one (1) AC DP Miniature circuit breakers for panel lighting supplies.

(g) Metering devices for voltage and current indication shall be provided as follows.

(i) One (1) Digital panel AC voltmeter meeting requirements of clause 3.4.2.3 and voltmeter selector switch connected to the metering VT output.

(ii) At least one (1) Motor protection circuit breaker (MPCB) suitably rated for protection of the digital voltmeter VT input.

6.2.3.4 Bus riser cubicle control interfacing

(a) Bus riser cubicle controls and monitoring circuits shall be interfaced to the manual control panel and generator transformer protection panels. All signals and circuits shall be wired as described in the protection particular specifications.

(b) As a minimum and in supplement to the protection particular technical specifications, the following shall be hard wired to the generator step up transformer protection panel.

(i) GSU transformer protection VT (4 wire)

(ii) GSU transformer protection—open delta VT (2 wire)
(iii) GSU transformer Earth switch closing command input
(iv) GSU transformer Earth switch opening command input
(v) At least four (4), 2NC+2NO, GSU transformer earth switch auxiliary contacts

(c) As a minimum, the following shall be hard wired to the manual control panel and unit PLC panel as per clause 6.2.7
   (i) Generator synchronising and metering VT (4 wire)
   (ii) GSU transformer Earth switch closing command input
   (iii) GSU transformer Earth switch opening command input
   (iv) At least four (4), 2NC+2NO, GSU transformer earth switch auxiliary contacts
   (v) Two RTD’s to unit control PLC
   (vi) At least the following alarms and annunciation
       Grouped DC MCB’s trip
       110V DC control supply failure
       Earth switch motor failure

6.2.4  **Station Transformer Feeder Cubicle**

6.2.4.1  **Components**

Auxiliary transformer panel meeting all the MV switchgear requirements of clause 6.4.1 shall be installed with the following compartments:

(a) Disconnector compartment
    Shall contain the fused load break switch (disconnector) and its manual operation devices

(b) connection compartment
    shall contain the following
    (i) Cable termination isolated bus bars
    (ii) Three (3) current transformers each with four secondary cores
    (iii) Motorised earth switch,

(c) bus bar compartment
    shall contain the main bus bars

(d) Low-voltage compartment
    Shall contain station transformer HV side control and interface circuits

(e) Pressure duct/channel
6.2.4.2 **Disconnector compartment**

(a) Fused load break switch meeting all requirements of clause 6.4.4 shall be installed in the disconnector compartment.

(b) The load break switch shall be operated electrically-motorised or mechanically. Operating tools and access holes on the compartment doors for operating the load break switch mechanically shall be provided.

(c) An inspection window shall be provided for inspecting the load break switch position and for monitoring the temperature with a thermal imaging camera.

(d) The compartment door shall be interlocked to the load break switch position. The door shall only be operable when the load break switch is in opened position. Opening of the door shall prevent operation of the load break switch.

6.2.4.3 **Connection Compartment**

(a) Connection compartment shall contain the cable termination bus bars, earth switch and current transformers. A cable termination chamber shall be separated from the connection compartment by metallic partition.

(b) Access to the connection compartment shall require prior closing of the earthing switch. The connection compartment shall be “interlock-based accessible compartment” according to IEC 62271-200.

(c) A motorised earth switch meeting requirement of clause 6.4.3 shall be installed. The earth switch shall be operable both electrically and mechanically. Operating tools and access holes on the compartment doors for operating the earth switch mechanically shall be provided.

(d) Motorised earth switch shall be interlocked to the load break switch position. Earth switch shall be inoperable both mechanically and electrically when the load break switch is closed.

(e) Electrical operation of the earth switch and load break switch shall be possible both locally on the panel and remotely from the employer’s unit control system.

(f) A total of three (3) current transformers, one for each phase, meeting requirements of clause 6.4.5 shall be installed, with the following features

   (i) CT ratio for all CT cores shall be 50/1A

   (ii) CT Shall have four secondary cores, as follows

       • Core1–GSU transformer protection set 1 CT: protection class 5P20
       • Core2–GSU transformer protection set 2 CT: protection class 5P20
Core 3—station transformer protection CT: protection class 5P20
Core 4—station transformer metering: metering class 0.5

(iii) The burden of the CT’s shall be determined at design stage, however at minimum the following burden shall be provided
• Protection class 5P20 CT’s: 30VA
• Metering class 0.5 CT’s: 10VA

(iv) Metering CT’s shall have an instrument safety factor of 120% (shall not saturate below 120% In at rated burden)

(g) New station transformer HV feeder cables shall be terminated in the cable termination chamber. Cable glands, flanges and all other termination equipment shall be supplied and used to carry out the termination.

6.2.4.4 Low-voltage compartment

(a) Shall house station transformer HV side control and metering devices and all external interface to the station control, metering and protection circuits.

(b) Bottom entry for external control cables by means of gland plates shall be provided with cut outs as necessary. All control cables to station transformer feeder shall be gloanded and terminated to terminal blocks.

(c) All CT, load break switches & earth switch auxiliary terminals and all other control circuits shall be terminated and wired in this cubicle as described in clause 3.6 and 3.7 of specifications.

(d) All auxiliary terminals of the load break switch and the earth switch and all the CT outputs including all the spares shall be wired to terminal blocks in this compartment.

(e) For each CT secondary output, the two leads shall be terminated on the terminal block i.e. grounding/star point wiring shall be done on the LV cubicle terminal block.

(f) The following control devices and functions shall be provided
   (i) One (1) Key operated switch for LOCAL/REMOTE interlock
   (ii) At least Four (4) illuminated push buttons (with command push button and status LED) shall be provided for:
       • Load break switch close
       • Load break switch open
       • Station transformer earth switch close
       • Station transformer earth switch open
   (iii) Mimic diagrams with position LED indicators for load break switch and earth switch position.
(iv) Integrated capacitive voltage detecting system meeting requirements of clause 6.4.8

(v) At least 4 (four) status indication LED lamps for the following status.
   - Load break switch operation failure
   - Earth switch failure
   - 110 V DC control Supply unavailable

(vi) Circuit for remote and local operation of the load break switch and earth switch with all the requisite interlocks shall be realised using contactor relays meeting requirements of clause 3.5.3. (at least six (6) relays)

(vii) at least one 110V DC voltage supervision relays meeting requirements of clause 3.5.6 for 110V DC supervision

(viii) Interface relays with 4SPDT contacts for indication circuits interface.

(ix) at least two (2) DC DP Miniature circuit breakers 110V DC supplies

(x) At least one (1) AC DP Miniature circuit breakers for panel lighting supplies

(xi) One (1) Digital panel AC ammeter meeting requirements of clause 3.4.2.3

6.2.4.5 Station Transformer HV Side Control Interfacing

(a) Station transformer HV feeder panel controls and monitoring circuits shall be interfaced to the manual control panel; unit PLC panel and generator transformer protection panels All signals and circuits shall be wired as described in the protection particular specifications.

(b) As a minimum and in supplement to the protection particular technical specifications, the following shall be hard wired to the generator step up transformer protection panel

(i) GSU transformer protection set 1 CT (4 wire)

(ii) GSU transformer protection set 2 CT (4 wire)

(iii) Station transformer protection CT (4 wire)

(iv) Station transformer metering CT (4 wire)

(v) At least eight (8), 4NC+4NO, load break switch auxiliary contacts

(vi) Load break switch closing input

(vii) Load break switch opening input

(viii) Station transformer Earth switch closing command input

(ix) Station transformer Earth switch opening command input

(x) At least four (4), 2NC+2NO, station transformer earth switch auxiliary contacts
(c) As a minimum, the following shall be hard wired to the manual control panel and unit PLC panel as per clause 6.2.6
(i) At least eight (8), 4NC+4NO, load break switch auxiliary contacts
(ii) Load break switch closing input
(iii) Load break switch opening input
(iv) Station transformer Earth switch closing command input
(v) Station transformer Earth switch opening command input
(vi) At least four (4), 2NC+2NO, station transformer earth switch auxiliary contacts
(vii) At least the following alarms and annunciation

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<th>Earth switch failure</th>
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<td>Grouped DC MCB’s trip</td>
<td>110V DC control supply failure</td>
</tr>
</tbody>
</table>

6.2.5 MV Cabling and Solid Insulated Bus Bars

6.2.5.1 Station transformer HV terminals shall be interfaced to the MV switchgear feeder panel using HV cables. The cables shall meet the following requirements
(a) Shall meet requirements of clause 3.7 of specifications
(b) Cables shall be steel armoured, XLPE insulated, with stranded high grade stranded copper and meet requirements of IEC60502-2
(c) Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 60502-2, shall be provided
(d) Conductors shall be manufactured and sized in accordance to IEC60228 and IEC 60287 taking into considerations all the requirements below
(e) Cable shall be rated and sized for the following
(i) Rated continuous current: \( \geq 100 \text{A} \)
(ii) Rated short-time current withstand: 50 kA, 3 s
(iii) Rated peak withstand current: 125 kA
(iv) Rated operating voltage: 17.5 kV
(v) Rated Power frequency withstand voltage: 38 kV, 1 minute
(vi) Rated lightning impulse withstand voltage: 95 kV, 1.2/50 \( \mu \text{s} \)
(f) Shall be suitable for outdoor use at average temperature of 0°C (min) – 45°C (max)
(g) Mounting steel structures and supports shall be provided for installing the cable and connecting to station transformers
(h) Cables shall be terminated to the existing station transformers HV terminals from the MV switchgear panel. All installation devices shall be supplied, and terminations carried out by the contractor.

(i) Contractor shall supply and construct concrete cable trenches at the substation to guide the cables from the MV switchgear to the station transformers. Trenches shall be covered with concrete blocks. Design of trenches shall be approved by the Engineer.

6.2.5.2 GSU transformer LV terminals shall be interfaced to the MV switchgear panel using solid insulated bus bars for the three units. The solid insulated bus bars shall meet the following requirements:

(a) Solid insulated bus bars shall be made of high grade electrolytic copper or aluminium and shall have insulation suitable for outdoor use.

(b) Shall be rated for the following:

(i) Rated continuous current @ 40°C: 5000A
(ii) Rated short-time current withstand: 63 kA, 3s
(iii) Rated peak withstand current: 173 kA
(iv) Rated operating voltage (L-L): 17.5kV
(v) Rated Power frequency withstand voltage: 38kV, 1 minute
(vi) Rated lightning impulse withstand voltage: 95kV, 1.2/50 µs
(vii) Operating ambient temperature: 0–45°C

(c) Solid insulated bus bars shall be designed and tested to meet requirements of applicable IEC and ASTM standards. The busbars shall however meet design and test requirements identical to MV switchgear standards IEC 62271-1 and IEC 62271-200. Bidder to state applicable standard.

(d) Solid insulated bus bars shall be made of short sections of various shapes and with expansion joints. One bus bar shall be provided for each phase.

(e) Supporting steel structures and supports shall be installed.

(f) The solid insulated bus bars shall be routed in a manner to leave adequate space on top of the substation pathways.

(g) Solid insulated busbars outer cover/jacket/insulation shall be made of tough material able to withstand harsh environmental conditions and mechanical stress from heavy falling objects.

(h) All termination equipment including copper flexes necessary for connecting the bus bars to the GSU transformer LV terminals shall be provided. The termination shall be carried out by the contractor.

(i) Where the solid insulated busbar conductive material is made of aluminium bimetallic termination clamps shall be provided for interconnecting to
copper conductors. At least six spare bimetal termination clamps shall be provided if aluminium is used.

(j) Solid insulated bus bars terminals shall have allowance for connecting various types of transformer LV bushings, directly or using other bus bars. The solid insulated bus bars terminals shall be in such a manner that the employer can connect other types of transformer bushing other than the existing transformers.

6.2.6 Interfacing to Unit control systems

6.2.6.1 Preamble

(a) MV switch gear remote control signals shall be wired to the manual control panel at the power house. Manual control panel and the unit PLC shall be able to control all the switching devices in the MV switch gear.

(b) The following devices shall be installed at the manual control panels of unit 2 and 3
(i) MIMIC panel
(ii) Control/interfacing relays and wiring termination devices
(iii) Digital panel indication devices

6.2.6.2 MIMIC panel

(a) Two MIMIC panels all similar shall be supplied for installing on the manual control panel doors of each unit

(b) The mimic panel shall have discrepancy switches for closing, opening and status indication of the following
(i) GCB
(ii) Generator earth switch
(iii) Field circuit breaker
(iv) GSU transformer LV side earth switch
(v) Station transformer load break switch
(vi) Station transformer earth switch
(vii) 132kV circuit breaker

(c) MIMIC panel shall also have LED position indicators for
(i) GCB in test or service position
(ii) 132kV or 220kV isolator open and closed position
(iii) 132kV or 220kV Earth switch open and closed position

(d) MIMIC panel shall be exactly the same colour as the manual control panel door or shall be RAL7035

(e) MIMIC panel shall be flash mounted on the manual control panels.
(f) Contractor shall modify the manual control panels to fit the MIMIC. Modification implies cutting out part of the existing manual control panel and fitting the MIMIC panel.

(g) All Mounting accessories required shall be provided for mounting the mimic panel on the manual control panel doors.

6.2.6.3 Control and interfacing wiring

(a) All the commands from the discrepancy switch shall pick a contactor relay (meeting requirements of clause 3.5.3) whose contacts shall then be wired to the controlled device closing coil/motor at the MV switch gear panels. The contactor relays shall also be wired to be picked by PLC output (interlocked to control selection at the PLC). At least seven (7) contactor relays shall be provided for each unit.

(b) Status outputs from the switchgear panels shall be wired to interface relays for contact multiplication. Contacts shall be wired to the discrepancy switches and the unit control PLC. At least ten (10) interface relays meeting requirements of clause 3.5.4 and each with four SPDT contacts shall be supplied for each unit.

(c) Terminal blocks and all other wiring accessories necessary for the MCP wiring shall be provided.

6.2.6.4 Digital Panel Indication Devices

The following digital panel indication meters shall be provided for mounting on the manual control panels of each unit:

(a) Four (4) Digital panel AC voltmeter meeting requirements of clause 3.4.2.3 and three voltmeter selector switches connected to the following metering VT outputs:

(i) Generator VT at the GCB panel
(ii) GSU transformer LV side VT at the bus riser panel
(iii) GSU transformer HV side VT (existing)
(iv) 132/220kV Line VT (existing)

(b) Three (3) Digital panel AC ammeter meeting requirements of clause 3.4.2.3 connected to the output of generator metering CT’s at the GCB panel.

(c) Two (2) Digital indication meter for Instrument/process signals with a 4-20mA DC current input, meeting requirements of clause 3.4.2.3, connected to field voltage and current 4-20mA DC signal in the manual control panel.
6.3 WALK IN SWITCHGEAR ENCLOSURE (HOUSING) REQUIREMENTS

6.3.1 Introduction

6.3.1.1 Two (unit 2 and 3) factory fabricated metal enclosure with environmental control, specifically designed to house medium voltage electrical equipment shall be provided to house the MV switch gear.

6.3.1.2 The housing shall be installed in the substation at the space currently occupied by the 15kV outdoor bus bars, VT and Overhead line. The existing structures shall be removed for each unit at a time, mounting structures shall be constructed and housing installed.

6.3.1.3 The housing shall be mounted on a mounting structure of at least 1.5m height off the ground level to ease installation of the existing generator MV cables. The existing 15kV bus bar structural supports shall be re used to construct the mounting structure.

6.3.1.4 The housing shall provide ingress protection equivalent to IP55 to indoor MV switchgear with the doors and ventilation air vent shutters closed.

6.3.1.5 The available space for the housing installation in the substation Length, 6900 mm x Width, 5280 mm x Height, 4000mm

6.3.1.6 The contractor shall carry out a detailed structural design and give a report with mechanical and civil Calculations for the required steel housing and mounting structures. The steel structure to be supplied shall have adequate mechanical and structural safety factors for the most severe application mode including faults gusty winds, earthquake, massive rainfall etc. This report shall be part of the functional design specification and shall be submitted as detailed in clause 1.7 of specifications. The steel thickness and sizing shall not be below the employers’ estimate.

6.3.2 Dimensions

6.3.2.1 The enclosure dimensions shall be: -

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>6800mm</td>
</tr>
<tr>
<td>Width</td>
<td>5200mm</td>
</tr>
<tr>
<td>Height</td>
<td>3600mm</td>
</tr>
</tbody>
</table>

6.3.2.2 Ground clearance of the enclosure to facilitate termination and minimum cable bending radius shall be at minimum 1500mm above ground.
6.3.2.3 The enclosure shall meet the design requirements of the switchgear cubicles. This shall consider the overall weight & weight per square area of the cubicle supports and allowable clearance between the enclosure walls and the switchgear cubicles.

6.3.2.4 An allowance of at least 200mm shall be provided behind the switchgear panels and allowance of at least 1500mm in front of the switchgear panels shall be provided.

6.3.2.5 Space shall be provided for a future cubicle with a size similar to the GCB cubicle to be installed next to the station transformer feeder cubicle.

6.3.2.6 The aisle shall be spacious enough to all Circuit breakers to be rolled out into the aisle and serviced without exposure to the elements.

6.3.2.7 The enclosure shall have a shipping split into two parts for ease of transportation/shipping. The two pieces shall be factory built and then assembled into one at site using bolts and nuts. Alternatively, the housing can be fully assembled at site to lower installation cost and time.

6.3.3 **Housing Structural requirements**

6.3.3.1 **Base**

(a) The base shall be constructed of a welded structural steel frames and a base plate with a thickness of at least 3 mm welded to the frames. The thickness of the frames shall be suitable to support the weight of the housing and the MV switchgear equipment.

(b) The base frames shall be all welded construction of ASTM A-36 or equivalent structural steel members, sized and arranged for proper strength and durability which shall be able to withstand the stress and loads.

(c) The base structural members shall not interfere/obstruct areas designed for routing of the power/control cables.

(d) The base shall have at minimum two (2) copper grounding pads located at diagonally opposite corners of the structure. This shall be mechanically bonded to the base steel and to a bare copper ground loop located under the floor plate.

6.3.3.2 **Floor**

(a) The floor shall be made of steel plate with a minimum thickness of 7mm welded to the perimeter members and to the cross members of the base and shall have a non-skid additive.

(b) Floor shall be designed to withstand a floor load of at least 1000kg/m² and a point load of at least 5KN
(c) Floor cut-outs with gasketed removable 12-gauge steel shall be provided for bottom access of the electrical equipment. Bus duct or cable entry provisions shall be provided as required for MV switchgear equipment.

(d) An opening shall be provided under each switchgear frame for conduit access. Covers shall be supplied for all floor openings.

(e) The enclosure floor shall be fitted with a 17kV working voltage electrical switchgear rubber matting. The rubber mat shall be dielectric tested at 30kV to ASTM D178 / ANSI JS.7 Type II Class 1 standards including full testing over the entire mat surface and stamped on the reverse every 100cm with identification coding.

(f) Insulation shall be placed between the base plate and the floor plate

6.3.3.3  
Walls

(a) Each wall shall consist of frames and two walls with an insulation in between.

(b) Walls shall be each be supported welded structural steel frames. The thickness of the frames shall be suitable to support walls that can withstand windspeeds of up to 201Km/h

(c) The exterior walls shall be paint quality folded galvanized steel panels at least 3mm thick and shall consist of formed interlocking panels.

(d) The interior walls shall be plain aluminium or stainless-steel plates at least 16 gauge (1.6mm) thick

(e) Nominal thickness of the walls including the required frame structure shall be at minimum of 5 inches (125mm)-including the insulating panels

(f) The walls shall be designed to withstand wind loading of up to 125 mph.

(g) Interior walls, supporting panels, and structural, shall be designed so that interior loads of 400 pounds per linear foot of wall length may be attached to the wall without compromising the 125 mph design wind loads.

(h) Ventilation openings shall be provided, at least two at each end of the longer wall, for installation of air vents and standby fans.

(i) The air vents shall have shutters for covering them when not required. The shutters shall close fully to prevent air/dust entry

(j) Opening shall be provided for connecting the MV switchgear pressure relief duct to the outside. The duct shall be joined firmly to the housing sealed prevent any ingress of moisture. On the outside the pressure duct shall be covered with plate sealing the channel from the environment
6.3.3.4 **Doors**

(a) The enclosure/housing shall be equipped with two personnel doors to gain access into the switchgear housing, the main door and emergency exit.

(b) The main door shall be and 2100 mm high and 1800 mm wide for double doors on either side of the housing, while the emergency door shall be at least 2100mm by 900mm

(c) The doors shall be of insulated steel with panic hardware and stainless-steel hinges.

(d) Access doors shall be secured to prevent unauthorised access;

(e) Access doors shall open outwards and be provided with safety signs in accordance with HPC-2AA-07-0001-2012: Guideline - General Application of Signs Used on Distribution Equipment;

(f) A drip shield shall be provided above each door and all wall openings.

(g) Doors shall be positioned such that they do not create a personnel hazard

(h) Emergency exit door shall have panic release bars fitted to facilitate opening in an emergency from the inside, even when they are locked from the outside;

(i) Each access door shall be formed from two 12-gauge (2.78 mm) stainless steel plates with insulation in the middle, and will be sealed with a continuous neoprene gasket attached to the doorsill.

(j) Each access door will be secured using four bolts with captive nuts and will include a door prop, drip shield, and provisions for a padlock.

6.3.3.5 **Roof and Ceiling**

(a) Roof shall consist of steel frames (trusses) an exterior roof and an interior roof with an insulation in between.

(b) The exterior roof shall be made of, paint quality galvannealed steel panels at least 5mm thick with fully welded seams.

(c) The roof shall have a one directional slope with a 2-degree pitch and shall be designed to support interior or exterior equipment loads without compromising the roof load design.

(d) The ceiling shall consist of formed 16-gauge paint quality galvannealed steel panels attached to the trusses. The ceiling assembly shall be designed to retain the insulation and provide a smooth ceiling surface.

(e) Lifting lugs shall be provided on the outdoor enclosure at each corner of the enclosure.
6.3.3.6 **Insulation**

(a) Three- (3) inch fiberglass insulation providing R-13 value shall be provided in the roof, floor and walls. Sagging of wall insulation shall be prevented with a minimum of two metal retainers fastened near the top.

(b) Equipment access doors and removable access panels shall also be insulated.

6.3.3.7 **Weather Proofing**

(a) All joints shall be designed to minimize the loss of conditioned or pressurized air and to prevent entry of rain, sleet, or moisture.

(b) All wall seams and areas where metal to metal contact is made shall be liberally caulked with a polyurethane based elastomeric adhesive/sealant.

(c) All roof seams shall all be completely welded.

(d) The enclosure shall provide IP66 ingress protection with the doors and ventilation air vent shutters closed.

6.3.3.8 **Paint**

(a) All interior and exterior surfaces shall be primed before application of the finish coat.

(b) Exterior colour shall reflective (e.g. RAL 9006 or equivalent) to limit heat gain from radiation.

(c) The floor shall have a finish coat of ANSI 61, grey polyurethane enamel, with a non-skid additive.

6.3.3.9 **Wiring**

(a) Sufficient space shall be provided to accommodate conduit openings, cable entrance or bus entrances.

(b) The switchgear shall have rear cable terminal compartments. The cable minimum bending radius shall meet IEEE 1185 requirements.

(c) The enclosure shall be raised above ground to facilitate the ease of dressing the incoming and exiting cables as most of cables will exit out the bottom of the enclosure.

(d) For safety, all internal wiring shall be run in enclosed ducts or conduits.

6.3.4 **Mounting/Supporting Steel Structures**

6.3.4.1 A supporting steel structure shall be constructed at site suitable for the housing support. The structures shall elevate the housing to at least 1500mm of the ground for cable terminations.
6.3.4.2 The mounting structure shall be constructed in the substation area currently occupied by 15kV bus bars. The housing shall be secured to the structure by bolts and nuts.

6.3.4.3 New plinths shall be constructed but existing plinths shall be re-used where applicable. Construction of plinths shall preferably begin before the unit outage begins.

6.3.4.4 At least twelve (12) main steel column supports shall be constructed at site to support the enclosure. The steel columns shall be bolted to the plinths using at least four anchor bolts each.

6.3.4.5 The existing 15kV bus bar supports shall be modified and re-used as the steel columns where possible. Additional galvanized steel columns shall be added if existing structures are not adequate.

6.3.4.6 The mounting base shall be made of horizontal rails and cross bar frames made of galvanized steel IPE or Z beams. Beams shall be firmly secured to the steel columns.

6.3.4.7 Beam size shall be selected based on design calculation to be suitable for the enclosure weight and loading per square area, the IPE beams shall be at minimum be IPE 140 (EU 19-57 standard) in size.

6.3.4.8 Two stair cases shall be constructed of galvanised steel frames and plates at least 5mm thick. Removable guard rails shall be provided. The main entrance shall have a loading bay with a large area suitable for loading and offloading the switchgear cubicles off the enclosure.

6.3.5 **HVAC**

6.3.5.1 HVAC equipment shall be provided to maintain an interior temperature range of 18–25°C with an ambient temperature average of 5°C (min)–45°C (max) and the MV switchgear fully loaded to 5000A.

6.3.5.2 The HVAC equipment shall consist of self-contained wall mount units, complete with supply and return grilles, lockable circuit breaker or disconnect switch, manual thermostat, barometric fresh air damper, and a one-inch disposable air filter. Voltage and surge protection devices shall be supplied for each HVAC unit.

6.3.5.3 Three (3) HVAC units shall be installed in each housing. Two (2) HVAC units shall be capable of regulating the enclosure temperature as per clause (6.3.5.1) and shall each be rated at least 20000btu/hr. A third standby unit shall be installed for use in case of failure of one of the two units.

6.3.5.4 Four Standby cooling fans each with a flow rate of at least 14400m³/hr shall be installed as backup to failure of the HVAC units. The fans shall be driven by three
phase motors, each fan shall be rated at least 1hp (1KVA). The fans shall only be used in case of failure of the three HVAC units.

6.3.5.5 Air vents with filters shall be provided for operation of the fans. The fans shall be mounted on the walls. The openings for fans and air vents shall be covered with shutters which will remain closed unless the HVAC units fail.

6.3.5.6 Operation of the fans shall be manual by operator action. Two DOL starters shall be installed for starting two fans at a time.

6.3.5.7 Two Resistance temperature detectors (PT100) shall be installed at convenient locations in the housing for monitoring temperature. They shall be wired to the common PLC for housing temperature monitoring.

6.3.6 **Auxiliary Supplies**

6.3.6.1 415V AC Distribution board

(a) A 6-way TP-N three phase AC distribution board shall be installed for housing HVAC, lighting, socket outlets and other supplies.

(b) The distribution board shall be supplied from main station auxiliaries’ switchboard cable feeder.

(c) Suitably rated LV cable meeting requirements of clause 3.7 and 8.7 shall be supplied and installed to connect distribution board to the main station auxiliaries’ switchboard.

(d) Shall have an incoming supply three-phase isolator with a continuous current rating of 100A at 40°C ambient temperature.

(e) Shall have a minimum of the following circuits

(i) Four (4) three phase feeder circuits with adequately rated MPCB for

- Standby cooling fans supply
- Station transformer three phase auxiliary supply
- Three phase socket outlets
- Other/spare

(ii) Six (6) single phase feeder circuits with adequately rated MCB for:

- HVAC units
- HVAC units
- Lighting
- Single phase socket outlets
- Other/spare

(f) The board shall the following features and rating.
(i) Shall have Neutral and protective earthing (PE) connection terminals
(ii) Shall have current rating of at least 125A at 40°C ambient temperature.
(iii) Rated short-time withstand current (Icw): ≥25KA/1s
(iv) Rated operational voltage Ue: 433VAC
(v) Rated insulation voltage: ≥800VAC
(vi) Rated impulse withstand voltage Uimp: ≥6KV
(vii) All live parts shall be covered

6.3.6.2 Two three phase socket outlets and four single phase double socket outlets shall be provided.

6.3.6.3 Light switches and fan start stop push buttons shall be supplied an installed on suitable locations

6.3.6.4 DC distribution shall be supplied for emergency lighting and any other housing controls (not switchgear)

(a) Shall have at least three DC DP MCB’s
(b) Shall be connected to the control room DC supplies
(c) Emergency lights shall turn on automatically on failure of the main lighting. A voltage monitoring relay shall monitor the AC lighting supply.

6.3.7 Lighting

6.3.7.1 Interior lighting shall consist of ceiling mounted LED fixtures, with 3 way switches located near each personnel entrance door. Wall-mounted duplex receptacles at each personnel entrance door.

6.3.7.2 Exterior lighting shall be provided above each personnel door. The lighting shall be suitable for use in wet conditions with photo control.

6.3.7.3 Emergency lighting shall be provided that shall be supplied from 110V DC supply with two directionally adjustable illuminating heads. This shall automatically come on in the event of loss of AC supply This shall automatically turn off on resumption of normal power supply.

6.3.8 Fire protection system

6.3.8.1 General

(a) A fire protection system using carbon dioxide shall be installed in the switchgear housing.
(b) The supplied fire protection scheme shall be of the latest protection and control system in the market and shall meet applicable NFPA standards
(c) Fire protection wiring shall use heat resistant cables as per NFPA standards
(d) Three fire extinguishers shall be mounted strategically inside the switchgear enclosure and two extinguishers on the enclosure doors.
6.3.8.2 Fire detection
(a) Detection of fire shall be through heat sensors and smoke sensors. Heat sensors shall be the primary source of detection, control and carbon dioxide discharge.
(b) Activation of one smoke sensors will be used for early warning, whilst activation of more than one sensor shall serve as fire detection and shall initiate carbon dioxide release
(c) Detection of fire output shall activate a siren and send a trip to the generator and the HV line breakers
(d) At least four heat detectors and eight smoke detectors shall be installed in each housing

6.3.8.3 Fire control panel
(a) The control panel shall communicate with and or control the following types of equipment used to make up the system: heat & smoke detectors, CO2 discharge valve, manual release/abort key, alarm notification appliances, releasing components and other system-controlled devices.
(b) It shall be installed next to the switchgear housing in an IP66 panel suitable for outdoor installations.
(c) Fire control system shall utilise the station 110VDC supplies from switchgear housing and a backup battery with a 240V AC charger supplied from the housing auxiliary supplies.
(d) Fire control panel logic diagrams and control application shall be provided. Software for configuration and programming shall be provided for installation into two laptops. Training shall be carried out on configuration of the fire control panel

6.3.8.4 Fire suppression system
(a) Adequate CO2 cylinders suitable for outdoor use shall be supplied and installed close to the switchgear housing. The contractor shall compute the
required number of CO2 cylinders and forward the calculation to the employer for approval.

(b) Carbon dioxide system shall be installed with automatic weight monitoring of the cylinder

(c) The carbon dioxide system shall be deactivated before opening the switchgear doors and activated on closing the switchgear doors. A key interlock shall be installed in the door to prevent entry when the carbon dioxide system is enabled.

(d) On disabling the CO2 system, the fire protection system shall still be active but shall not be able to release the carbon dioxide

(e) The CO2 shall be released with a scented gas for personnel safety.

(f) Manual mechanism shall be provided for activating the CO2 system from outside the housing.

6.3.8.5 **Interfacing Unit Control System**

(a) The following alarms shall be wired to the unit control PLC from the fire system control panel

(i) Fire/smoke alarm

(ii) Fire detected

(iii) CO2 released

(iv) CO2 disabled

(v) CO2 weight alarm

(vi) Fire protection supply failure

(vii) Battery charger failure

(viii) Controller failure/watchdog

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**6.4 Equipment Specifications**

6.4.1 **MV Switchgear Cubicles**

6.4.1.1 **Standards and General Requirements**

(a) MV switchgear cubicles and equipment shall be factory-assembled, type-tested, metal-enclosed, air insulated and metal-clad switchgear for indoor installation, designed according to the standards IEC 62271-1 and IEC 62271-200

(b) Type tests shall have been carried out according to the standards IEC 62271-200. Switching devices used in the switchgear shall be type-tested according to IEC 62271-100 / -102.
(c) Type test reports & certificates certified by a EU/USA/Canadian National Standards and Testing Authority (NSTA) or by a third party (not manufacturer or manufacturer subsidiary) Reputable Testing Authority accredited by a EU/USA/Canadian National Standards and Testing Authority (NSTA) for type tests carried according to IEC 62271-1 and IEC 62271-200 shall be provided by the bidder

6.4.1.2 Dimensions
The switchgear cubicles shall be sized as per current rating, 17.5KV voltage rating, arc withstand, fault level withstand, insulation rating, partition class, environmental condition etc. however the cubicle dimensions SHALL NOT EXCEED:
   (a) Width-1500mm,
   (b) Height-3000mm and
   (c) Depth-3200mm

6.4.1.3 Switchgear Structure and operation
(a) switchgear cubicles shall be compliant with general specifications in clause 3.6 of specifications.
(b) The panels shall be metal-enclosed, free-standing compartmentalized, modular type suitable for indoor installation. Each switch gear cubicle shall be compartmentalized into four types of compartments i.e.
   (i) connection compartment
   (ii) bus bar compartment
   (iii) Switching device compartment
   (iv) Low-voltage compartment
   (v) Pressure duct/channel
(c) The switchgear shall have partition class PM (partitions metallic -partitions and shutters made of metal) as per IEC 62271-200 latest requirements. Partitions shall ensure that only earthed steel sheets can be touched during access to the individual compartments hence guaranteeing the highest possible personal safety during maintenance work.
(d) The compartments shall be separated by IP2X metal partitions
(e) Each switchgear cubicle shall be equipped with a top mounted pressure duct system, overlapping all switchgear panels. In case of internal fault, the pressure of the panel compartments will be relieved into the pressure duct and out of the switchgear. The duct shall be connected to the Switchgear housing to release the hot gases to the outside.
Switching devices shall be equipped with motor operating mechanisms which shall be incorporated in the electrical interlocking scheme.

The switching device compartment door operation shall be interlocked with the switching device position. The compartment shall thus be “interlock-based accessible compartment” according to IEC 62271-200.

The switching devices and earth switches shall be manually operable, operating tools and access holes for inserting the operating tools shall be provided on the compartment doors.

The cubicles shall be factory assembled, wired and tested.

All compartment doors shall be locked with a key. Three sets of keys shall be provided for each compartment door.

6.4.1.4 **Cubicle Enclosure**

(a) The cubicle enclosure shall be zinc-plated steel and earthed. Each cubicle shall be built on a self-supporting chassis made of folded steel plates. The whole switchgear enclosure shall be earthed, earth Bus bar shall be provided all around the cubicles at the bottom and it shall be rated for the switchgear fault level.

(b) Doors and lateral switchgear end walls shall be powder-coated with resistant epoxy resin, all other walls are of galvanized steel or non-magnetic material.

(c) The Switchgear cubicles enclosure shall provide a degree of ingress protection of not less than IP42 as per IEC 60529, for indoor installation. The degree of protection for the internal partitions shall be at least IP2X as per IEC 60529

(d) The standard enclosure including all internal surfaces shall be epoxy powder-coated with colour RAL 7035. The enclosure shall be designed for inductively coupled reverse current in order of 100 % of the rated current.

(e) Inspection windows and access holes for the emergency operating tools shall be provided for all switching devices.

(f) The switchgear panels front covers/doors shall have a mimic diagram showing the devices inside the switchgear. The mechanical position indicators and control elements of the respective switching devices shall be visibly integrated in a mimic diagram in the door of the switching device compartment and low voltage compartment.

(g) Equipment to be mounted on the external surfaces of the cubicle enclosure shall be flush mounted on cubicle door. No externally mounted equipment shall be mounted above 1.8m or below 0.4m above floor level.
6.4.1.5 **Accessibility and service continuity**

(a) The MV switchgear shall have a loss of service continuity category LSC 2B, providing the highest possible service continuity as per IEC 62271-200 latest requirements. This shall allow access to compartments while other adjacent compartments remain in operation. For example, it shall be possible to keep the connection compartment and bus bar compartment of the same panel, as well as all compartments of the adjacent panels, in operation while the switching device compartment is open.

(b) The switchgear design shall ensure safe access to switch gear compartments with a loss service continuity category LSC 2B. The accessibility to the compartments shall be as follows in accordance to IEC 62271-200:

(i) All Bus bar compartments: Tool-based

(ii) All Switching-device compartments: Interlock-controlled

(iii) GCB Connection compartment: Interlock-controlled

(iv) Station Tx Connection compartment: Interlock-controlled

(v) Bus riser Connection compartments: Tool-based

(c) The complete enclosure as well as the partitions between the individual compartments and shutters shall be metallic and earthed. All doors at the operating side shall be bolted with hinges. They shall guarantee the highest possible loss of service continuity category LSC 2B of the switchgear (metal-clad design) and the highest possible personal safety with partition class PM according to IEC 62271-200.

6.4.1.6 **Internal arc withstand**

(a) Protection of operating personnel by means of tests for verifying the internal arc classification must be performed in accordance with IEC 62271-200

(b) The switchgear shall comply with all criteria specified in the standards

(c) MV switchgear shall have been tested for resistance to internal faults and shall fulfil all six criteria of the internal arc classification IAC A FLR according to IEC 62271-200.

(d) It shall be tested for 63KA at 17.5KV for 0.3 seconds.

(e) It shall be adequate for access from all sides i.e. FLR (front (F), lateral (L) and rear (R) side).
6.4.1.7 **Bus bars**

(a) The bus bars shall be single and air insulated. The bus bars and connections shall be made of high conductivity, high grade copper, and shall be in unit lengths.

(b) Bus bars, connections and their support shall be rated for the rated continuous current under ambient conditions and capable of carrying the short-time current rating specified in the switchgear requirements.

(c) Provision shall be made for locking main bus bar and cable termination bus bars shutters separately in the circuit Breaker compartment.

(d) The Bus bar shall be made of flat copper bars, of the same cross-section (for the same rating) over the whole width of the switchboard.

6.4.1.8 **Cable and Insulated Bus Bars External Connections**

(a) Cable termination chamber shall be provided partitioned from the connection compartment. The chamber shall be at least 400mm wide for ease of working.

(b) Access to the cable termination chamber from bottom shall be covered with nonmagnetic sheet metal which shall be cut out according to the number and size of cables or insulated bus bars.

(c) The chamber bottom cover shall be properly sealed to eliminate ingress of dust and splashing water, providing an ingress protection of at least IP55 to the cable termination chamber from the outside. The bottom cover plate shall be thick enough (at least 3mm) to withstand external environmental conditions.

(d) External connections (cable/bus bars) to the switchgear shall be from the bottom. Terminations shall be made of tinned copper with an insulation layer.

(e) It shall be possible to connect the existing four 1000mm² XLPE type single core aluminium cables per phase from the generator incomer. Cable connection will be made with bolts of adequate size and strength.

6.4.1.9 **Seismic withstand capability**

(a) MV switchgear shall have been type-tested in accordance with the following internationally accepted requirements:

(i) IEC / TS 62271-210,

(ii) IEC 68-2-6,

(iii) IEC 68-2-57,

(iv) IEEE 693.
(b) The switchgear cubicles shall be suitable for use in an environment with constant vibrations of 0.20g. Dampers and other devices shall be installed to prevent movement of internal components of the switchgear cubicle.

6.4.2 **Vacuum Generator Circuit breaker (VGCB)**

6.4.2.1 **Standard**

(a) The generator circuit breaker shall be designed and tested as per IEEE Standard C37.013 or IEC/IEEE 62271-37-013.

(b) Type tests shall have been carried out according to the standards IEEE C37.013. Type test reports & certificates certified by a EU/USA/Canadian National Standards and Testing Authority (NSTA) or by a third party (not manufacturer or manufacturer subsidiary) Reputable Testing Authority accredited by a EU/USA/Canadian National Standards and Testing Authority (NSTA) for type tests carried according to IEEE C37.013 shall be provided by the bidder.

6.4.2.2 **Overall Technical Characteristics**

The vacuum generator circuit breaker shall be rated for a minimum of the following:

(a) Rated Voltage: 17.5kV

(b) Frequency: 50Hz

(c) Rated Power frequency withstand voltage: 50kV, 1 minute

(d) Rated lightning impulse withstand voltage: 110kV, 1.2/50 µs

(e) Rated short time withstand current: 63kA

(f) Rated duration of short circuit: 3s

(g) Rated peak withstand current: 173kA

(h) Rated continuous current @40°C: 5000A

(i) Asymmetrical breaking current: 86kA @ 17.5kV

(j) DC component: 65%

(k) Rated short circuit making current: 173kA @17.5KV

(l) Switching medium: vacuum

(m) Rated operating sequence: CO – 30min – CO

(n) Endurance classes: E2 - M2 - C2
6.4.2.3 Features and equipment

The vacuum GCB shall have the following basic equipment as a minimum:

(a) Operating Mechanism - Electrical/Manual (hand crank) mechanism
(b) Closing - Closing solenoid & manual mechanical closing
(c) 1st release - 110VDC Shunt release
(d) 2nd release - 110VDC Shunt release
(e) Auxiliary switch - 12NO+12NC
(f) Auxiliary terminals Plug connector
(g) Anti-pumping circuit
(h) Spring charged (signal indication)
(i) Interlocking - Electrical & Mechanical
(j) 3metre auxiliary plug extension cable for testing
(k) The following mechanical indications and devices
   (i) Mechanical ON and OFF push buttons
   (ii) Mechanical operations counter
   (iii) Mechanical indicators for open closed state
   (iv) Mechanical indicators for spring charged or discharged
   (v) Mechanical indicators to show the position of the circuit breaker in the carriage i.e. service & disconnected position to be provided

6.4.2.4 Pole assemblies:

(a) This shall contain the vacuum interrupters and the interrupter support mechanism.
(b) The vacuum interrupters shall be air insulated and accessible for cleaning maintenance procedures
(c) The vacuum interrupter shall be firmly/ rigidly mounted on the interrupter support mechanism
6.4.2.5 Operating mechanism

(a) Operating Mechanism Box shall house the whole operating mechanism with releases, auxiliary switches, indicators, and the actuating devices

(b) The GCB operating mechanism shall be of stored energy mechanism.

(c) Manual and electrical spring charging shall be provided. Electrical spring charging shall use 110V DC

(d) The closing spring shall be charged either electrically or manually operated and shall latch tightly at the end of the charging cycle. This stored energy shall be transmitted to the pole assemblies via operating levers

(e) To close the breaker, the closing spring shall be unlatched either mechanically with the ON push button or electrically/ remotely from the manual control panel.

(f) The closing spring shall charge the opening/contact pressure spring as the breaker closes and the discharged closing spring shall be automatically/manually charged again.

(g) The charged state of the springs shall be monitored electrically via position switches in the charging mechanism.

(h) The GCB shall have a trip free mechanism as per IEC 62271 – 100. If an opening command is issued after a close command, the moving contacts shall return to the open position and latch even if the close command is sustained.

(i) Spring charging DC motor shall be protected from failure due mechanism failure’s, continuous motor energisation shall be prevented in case of mechanism failure. An alarm shall be configured/wired for operating mechanism failure.

6.4.2.6 Tripping/release mechanisms

(a) The GCB shall have the electrical release mechanisms for opening and closing commands

(b) Two shunt releases to be used for the automatic tripping of the vacuum GCB either from protection relays or electrically operated OFF command.

(c) Under voltage release: this shall comprise a stored energy mechanism, unlatching mechanism and an electromagnetic system which shall be connected to auxiliary voltage while the GCB is in the closed position. If voltage drops below permissive values for a set duration, the circuit breaker shall trip. Timer shall be provided for delaying the tripping

(d) Manual mechanical release shall be provided via a push button
6.4.2.7 **Closing mechanism**

(a) Manual mechanical closing: this shall be done locally by mechanically unlatching of the closing spring via a push button

(b) Electrical closing: this shall be done from the control circuits using auxiliary supply. Closing solenoid shall unlatch the charged closing spring of the vacuum GCB.

(c) Switchgear related interlocks shall be implemented to prevent local closing of the breaker while in service position.

6.4.2.8 **Interlocks**

(a) The vacuum GCB shall have interlock mechanisms to prevent application of the earth switch with the breaker is in the closed position. This shall be implemented both electrically and mechanically.

(b) Electrical interlocking of the earth switch shall be via a magnetic lock-out mechanism controlled by an auxiliary contact of the GCB. Electrical interlocks shall also be implemented to prevent local closing of the circuit breaker while it’s in service position.

(c) The mechanical interlock shall use a sensor to check the position of the circuit breaker and earth switch and prevent the open circuit breaker in a reliable way from being closed mechanically/electrically.

6.4.2.9 **Environmental rating**

(a) The circuit breaker shall be suitable for use under normal operating conditions as defined by IEC 62271-100. Condensation can occur and the GCB is suitable for use as per IEC 60721, Part 3-3

(i) Climatic ambient conditions  
-5 to 40°C  Class3K4

(ii) Biological ambient conditions  
Class3B1

(iii) Mechanical ambient conditions  
Class3M2

(iv) Chemically active substances  
Class 3C2

(v) Mechanically active substances  
Class3S2

(b) The GCB shall be rated to operate at an ambient temperature of 40°C and the current carrying capacity shall be rated for 5000A.

6.4.2.10 **Operating times**

The operating times of the vacuum GCB shall at minimum meet the following specifications:

(a) Opening time  
≤80ms

(b) Closing time

(i) 1st Shunt release  
≤65ms

(ii) 2nd & 3rd Shunt release  
≤50ms
6.4.2.11 Circuit breaker movable truck assembly

The circuit breaker shall have a movable truck assembly for ease of isolation and maintenance procedures. The switching device truck shall meet the following minimum requirements:

(a) The truck frame is a precision structure of rigidly welded sheet-steel (at least 4mm thick) elements

(b) At least 4 NO + 4 NC auxiliary switch contacts at the carriage mechanism indicate the service and test position of the truck

(c) Interlocks to the panel door and the earthing switch are integrated in the operating mechanism box

(d) The truck is mechanically interlocked with the circuit-breaker

(e) The truck shall have mechanism for latching into panel when in service position to prevent any movement of the breaker while in operation.

6.4.3 Earth Switch

6.4.3.1 Earth switch shall be designed in accordance to IEC 62271-102 requirements. Type test reports & certificates certified by a EU/USA/Canadian National Standards and Testing Authority (NSTA) or by a third party (not manufacturer or manufacturer subsidiary) Reputable Testing Authority accredited by EU/USA/Canadian National Standards and Testing Authority (NSTA) for type tests carried according to IEC 62271-102 shall be provided.
6.4.3.2 The earth switch shall utilize a motor operating mechanism with a switching angle of 90°.

6.4.3.3 There shall be provision of manually operating the earth switch via a hand crank in the event of failure of its auxiliary power supply.

6.4.3.4 Earth switches shall have provisions for mechanical interlocks which shall be provided for as per requirements.

6.4.3.5 The earth switches shall have short circuit making capacity class E2/E1 as per IEC 62271-102.

6.4.3.6 Shall have auxiliary contact block with at least 8NC and 8NO contacts.

6.4.3.7 The earth switch shall have a minimum of the following technical requirements:

   (a) Insulating medium  Air
   (b) Rated voltage  17.5 kV
   (c) Rated frequency  50 Hz
   (d) Rated power-frequency withstand voltage  50 kV, 1 min
   (e) Rated lightning impulse withstand voltage:  110 kV, 1.2/50 µs
   (f) Rated short-time withstand current  63 kA/3 s
   (g) Operating mechanism  Motor
   (h) Position indication  Mechanical and Electrical
   (i) Electrical switching capacity  No load
   (j) Auxiliary switch  8 NC+8 NO
   (k) Rated auxiliary voltage  110 V DC±20%
   (l) Mechanical endurance class  M1 or M2 (IEC 62271-102)
   (m) Mechanical endurance  ≥2000 operating cycles
   (n) Earth switch class as per IEC 62271-102  E1 or E2

6.4.3.8 Earth Switch auxiliary contacts shall be wired to the existing plant control system.

6.4.4 **Load Break Switch**

6.4.4.1 Load break switch shall be designed in accordance to IEC 62271-102 requirements. Type test reports & certificates certified by EU/USA/Canadian National Standards and Testing Authority (NSTA) or by a third party (not manufacturer or manufacturer subsidiary) Reputable Testing Authority accredited by EU/USA/Canadian National Standards and Testing Authority (NSTA) for type tests carried according to IEC 62271-102 shall be provided.

6.4.4.2 Fused load break switch shall have a motor operating mechanism with a switching angle of 90°. operation shall be done electrically (local and remote) or manually by means of a hand crank for operating the motor operating mechanism from outside the cubicle door.
6.4.4.3 Load break switch shall have HRC fuses suitably rated for the station transformer overload and short circuit protection.

6.4.4.4 Load break switches shall have provisions for mechanical interlocks which shall be provided for as per requirements.

6.4.4.5 Load break switch shall be rated for switching a transformer load of 1250KVA at 17.5KV

6.4.4.6 Shall have auxiliary contact block with at least 8NC and 8NO contacts

6.4.4.7 The load break switch shall have a minimum of the following technical requirements

   (a) Insulating medium      Air
   (b) Rated voltage          17.5 kV
   (c) Rated frequency        50 Hz
   (d) Rated power-frequency withstand voltage 50 kV,1min
   (e) Rated lightning impulse withstand voltage: 110kV, 1.2/50 µs
   (f) Fuse rating sized to cable and tx rating
   (g) Operating mechanism    Motor
   (h) Position indication    Mechanical/ Electrical
   (i) Electrical switching capacity 1250KVA @17.5 kV
   (j) Auxiliary switch       8 NC+8 NO
   (k) Rated auxiliary voltage 110 V DC±20%
   (l) Mechanical endurance class M2 (IEC 62271-102)
   (m) Mechanical endurance  ≥10000 operating cycles
   (n) Rated continuous current @40°C  ≥50A

6.4.5 **Current Transformers**

6.4.5.1 Current transformers shall be dry cast resin type and shall be accommodated inside the cubicles, in the cable/switchgear compartment

6.4.5.2 The current transformers shall be in accordance with the requirement of IEC 61869-1&2 and shall have the specified accuracy under load conditions and shall be able to withstand the effect of short-circuit fault current rating of the MV switchgear

6.4.5.3 Current transformers shall have a rated burden calculated for sufficient operation of the numerical relays and the highest accuracy for meters and instruments.

6.4.5.4 Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 61869-2, shall be provided

6.4.5.5 MV switchgear CT’s shall meet the following minimum requirements:
6.4.6 **Voltage Transformers**

6.4.6.1 Voltage transformers shall be dry cast resin type and shall be accommodated inside the switchgear cubicles, in the cable/metering compartment.

6.4.6.2 The voltage transformers shall be in accordance with the requirement of IEC 61869-1&3 and shall have the specified accuracy under load conditions and shall be able to withstand the effect of over voltages on the MV switchgear.

6.4.6.3 Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 61869-3 shall be provided.

6.4.6.4 The VTs shall be fixed mounted with primary HRC fuses.

6.4.6.5 One of the VT primary terminal shall be earthed either solidly or via an impedance where necessary. The VT shall be able to withstand zero-sequence overvoltage of 50kV for 1 minute on VT primary winding terminal without thermal failure.

6.4.6.6 MV switchgear VT’s shall meet the following minimum requirements:

- (a) VT ratio: 15kV/110V
- (b) Protection Cores Class: 3P
- (c) Rated primary operating voltage, Un: 24kV/√3
- (d) Continuous voltage overload capacity: >120% Un
- (e) Rated Power frequency withstand voltage: 50kV, 1 minute
- (f) Rated lightning impulse withstand voltage: 110kV, 1.2/50 μs

6.4.7 **Surge Diverters**

6.4.7.1 Metal oxide varistor surge diverters shall be provided.

6.4.7.2 Surge diverters shall be designed and tested as per IEC 60099-4. Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 60099-4, shall be provided.

6.4.7.3 The surge diverters shall be suitable for grounding of all possible over voltages transferred via the step-up transformer or transmission of zero-sequence voltages via the step-up transformer. The surge diverters shall however at minimum meet the following requirements:
Tender for rehabilitation of Gitaru Power Station Generator MV Switchgear, Protection systems and LV Switchboards

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
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<tbody>
<tr>
<td>(a) Nominal discharge current $I_n$</td>
<td>10 kA</td>
</tr>
<tr>
<td>(b) Maximum continuous operating voltage $U_{c}$</td>
<td>48 kV</td>
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<tr>
<td>(c) Rated voltage $U_r$</td>
<td>60 kV</td>
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<tr>
<td>(d) Long duration current impulse</td>
<td>325 A</td>
</tr>
<tr>
<td>(e) High current pressure relief</td>
<td>20 kA</td>
</tr>
<tr>
<td>(f) Low current pressure relief</td>
<td>600 A</td>
</tr>
<tr>
<td>(g) High-current impulse</td>
<td>100 kA</td>
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<td>(h) Maximum permissible static service load</td>
<td>350 Nm</td>
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<tr>
<td>(i) Maximum permissible service load (MPSL)</td>
<td>500 Nm</td>
</tr>
<tr>
<td>(j) Energy absorption capability</td>
<td>$3.5 \text{ kJ/kV } U_r$</td>
</tr>
</tbody>
</table>

6.4.8 **Capacitive Voltage Detecting System**

6.4.8.1 Shall be installed for detection of voltage condition in high voltage equipment according to IEC61243-5.

6.4.8.2 Shall be used to indicate presence of voltage on the MV switchgear for use by of maintenance personnel during isolations.

6.4.8.3 Shall have an integrated continuous three phase voltage indication

6.4.8.4 Shall have an LCD display with the indication of voltage displayed permanently by its specific display with dedicated symbols for each phase.

6.4.8.5 They shall have a cover lid to protect the device from mechanical impacts

6.4.8.6 and hide the test sockets for phase comparison

6.4.8.7 Test points shall be provided for phase comparison and phase sequence test.

6.4.8.8 Shall be wired to the incomer or feeder voltage.

6.4.8.9 The device shall be panel mounted on the low voltage compartments

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6.5 **TECHNICAL DOCUMENTATION**

6.5.1 **Drawing**

6.5.1.1 The function of each drawing shall be clearly indicated. Related drawings shall be arranged sequentially and have the same drawing numbers but different sheet numbers.

6.5.1.2 Drawings shall adhere to ALL conditions of clause 1.7 of general specifications

6.5.1.3 MV switchgear drawings shall include the following;
(a) AC single line & AC Schematic drawing in two sets one A3 another A4 size sheets
(b) DC, control, protection & metering Schematics in two sets one A3 another A4 size sheets
(c) Terminal blocks wiring schedule, terminal block diagrams and cable schedules in A4 size sheet only
(d) Panel device layout drawing two sets one A3 another A4 size sheets
(e) General layout drawings for the switchgear panels in two sets one A2 another A3 size sheets
(f) Parts list in A4 size sheet only
(g) Generator circuit breakers, earth switches and load break switches internal assembly drawings shall be provided in two sets one A3 another A4 size sheets. The drawing shall be a complete assembly drawing showing all the individual components and the assembled parts.

6.5.1.4 MV switchgear enclosure/housing drawings shall include the following;
(a) Structural drawings of the enclosure and mounting structures in three sets A1, A3 and A4 size sheets
(b) Enclosure electrical wiring drawing and schematics in two sets one A3 another A4 size sheets
(c) Fire protection system
   (i) structural & mechanical drawings/schematics
   (ii) electrical wiring drawing and schematics
   (iii) Control panel logic diagrams
   in two sets one A3 another A4 size sheets

6.5.2 **Operating and Maintenance Instructions**

6.5.2.1 The Contractor shall supply detailed instructions manuals concerning the correct manner of assembling/Installing/Erection, configuring, setting, Testing and Commissioning, operating and maintaining the equipment and devices constituting the MV Switchgear, and other devices installed on the enclosure.

6.5.2.2 The maintenance details of each component shall also be described, including the frequency of inspections and lubrication.

6.5.2.3 The instruction manual shall include a separate and complete section describing the normal and emergency operating procedures for the Switchgear, and shall include explanatory diagrammatic drawings to facilitate understanding the instructions.
6.5.2.4 The Manufacturer shall, in preparing the instruction manuals, consider the lack of experience and familiarity of the Operators with this type of equipment.

6.5.2.5 The manual shall give specific information on consumable materials e.g. grease needed for maintenance operations. This information shall include brand names and manufacturer’s numbers or designations for at least two brands available in Kenya, preferably manufactured in Kenya.

6.5.2.6 Documentation shall adhere to requirements given in clause 1.7 of general specifications.

6.5.2.7 Detailed instruction (service) manual shall be provided for assembly and installation of the switchgear cubicles and component devices. Shall show in great detail the parts and their dimensions, tool to use, precautions, procedure etc.

6.5.2.8 Detailed instruction (service) manual shall also be provided for repair of generator circuit breaker, earth switch and load break switch. The manual shall in great detail describe device components, show assembly drawings and required tools and their handling while disassembling and reassembling the switching device.

6.6 TESTS

6.6.1 Type tests

6.6.1.1 Type tests shall have been carried out by an independent (not manufacturer or manufacturer subsidiary) laboratory accredited by National Standards Testing Authority, NSTA of a western European (EU) country, USA or Canada.

6.6.1.2 Type test reports shall be submitted as detailed in clause 1.4 of specifications at bidding and design stage.

6.6.1.3 Type test reports /certificates shall be submitted for the following tests on the MV switch gear including the switching devices in accordance to IEC 62271-200

(a) Tests to verify the insulation level of the equipment

(b) Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of circuits

(c) Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents

(d) Test to prove the making and breaking capacity of the included switching devices

(e) Tests to prove the satisfactory operation of the included switching devices and removable parts
(f) Tests to verify the protection of persons against access to hazardous parts and the protection of the equipment against solid foreign objects

(g) Tests to verify the protection of persons against dangerous electrical effects

(h) Tests to assess the effects of arcing due to an internal fault (for switchgear and control gear classification IAC)

(i) Electromagnetic compatibility tests (EMC)

(j) Tests to verify the protection of the equipment against external effects due to weather

(k) Tests to verify the protection of the equipment against mechanical impact

6.6.1.4 Type test reports /certificates shall be submitted for the following tests on the MV switchgear earth switches and load break switch in accordance to IEC 62271-102

(a) Tests to prove satisfactory operation and mechanical endurance

(b) Tests to verify short circuit making capacity of earth switches

(c) Tests to prove satisfactory operation at minimum and maximum ambient air temperature

(d) Tests to verify proper functioning of position indication devices

(e) Tests to prove the bus charging current switching capacity of disconnectors used in metal enclosed switchgear

6.6.1.5 Type test reports /certificates shall be submitted for the following tests on the generator circuit breaker in accordance to IEEE C37.013 or IEC/IEEE 62271-37-013.

(a) Tests to verify Rated power frequency withstand voltage

(b) Tests to verify Rated full wave impulse withstand voltage

(c) Tests to verify minimum number of operations at continuous current switching

(d) Tests to verify Symmetrical interrupting current capability at rated maximum voltage

(e) Tests to verify Asymmetrical interrupting current capability at rated maximum voltage

(f) Tests to verify Short-time current-carrying capability for system source faults - Transient Recovery Voltage TRV for system source faults

(g) Tests to verify Short-time current-carrying capability for generator source faults -
   (i) Short Circuit Current with Delayed Current Zero capability
   (ii) Transient Recovery Voltage TRV for generator source faults

(h) Tests to verify Rated Continuous Current-Carrying capacity

(i) Tests to verify Mechanical Endurance Life Test
6.6.1.6 Type test reports /certificates shall be submitted for all type tests (mandatory and optional) on the current transformers and voltage transformers in accordance to IEC 61869

(a) Temperature-rise test
(b) Impulse voltage withstand test on primary terminals
(c) Tests for accuracy
(d) Short-time current tests
(e) Measurement of capacitance and dielectric dissipation factor
(f) Internal arc fault test
(g) Determination of the instrument security factor (FS) of measuring current transformers

6.6.1.7 Type test reports /certificates shall be submitted for type tests (mandatory and optional) on surge diverters in accordance to IEC 60099-4.i.e

(a) Insulation withstand tests
(b) Residual voltage tests
(c) Test to verify long term stability under continuous operating voltage
(d) Test to verify the repetitive charge transfer rating, Qrs
(e) Heat dissipation behaviour of test sample
(f) Operating duty test
(g) Power-frequency voltage-versus-time test
(h) Short-circuit tests
(i) Test of the bending moment
(j) Environmental tests
(k) Seal leak rate test
(l) Test to verify the dielectric withstand of internal components

6.6.1.8 Type tests certificates for MV switchgear Seismic withstand capability tests in accordance with the requirements of IEC / TS 62271-210 and IEEE 693.

6.6.2 Factory Tests

6.6.2.1 General Requirements

(a) Tests given in this clause are not comprehensive and only highlight the minimum required tests. The contractor shall prepare detailed test plans as per clause 1.9.3.3 of specifications, covering all detailed tests necessary as per requirements of IEC 62271-1, IEC 62271-200, IEEE Standard C37.013, IEC/IEEE 62271-37-013, IEC 62271-102, IEC 61869, IEC 60099-4 and all other applicable standards.
(b) Factory acceptance tests shall be witnessed by client engineers
(c) All the checks/tests will be carried out in presence of client engineers, however tests on current transformers and voltage transformers may be carried out prior to factory acceptance tests and results presented to the client engineers who may decide to order repeat of the tests or carry out sample tests or accept the results as presented.

6.6.2.2 **Tests on Each Earth Switch and Load Break Switch**
A minimum of the following tests shall be carried out on each earth switch and load break switch as per 62271-102 routine tests in presence of the client engineers
(a) Dielectric tests on main circuit
(b) Dielectric tests on auxiliary circuit
(c) Measurement of resistance of main circuit
(d) Tightness test
(e) Design and visual checks
(f) Mechanical operating tests

6.6.2.3 **Tests on each current transformer**
The following tests shall be carried out according to IEC 61869-2
(a) Power-frequency voltage withstand tests on primary terminals
(b) Tests for accuracy
(c) Determination of the secondary winding resistance (Rct)
(d) Test for rated knee point e.m.f. (Vk) and exciting current at Vk

6.6.2.4 **Tests on each voltage transformer**
The following tests shall be carried out according to IEC 61869-3
(a) Power-frequency voltage withstand tests on primary terminals
(b) Partial discharge measurements
(c) Tests for accuracy

6.6.2.5 **Tests on Each Generator Circuit Breaker**
The following tests shall be carried out according to IEEE Standard C37.013, or IEC/IEEE 62271-37-013 or IEC 62271-100 in presence of the client engineers
(a) Tests on auxiliary and control circuits
   (i) Inspection of auxiliary and control circuits, and verification of conformity to the circuit diagrams and wiring diagrams
   (ii) Functional tests
   (iii) Verification of protection against electrical shock
   (iv) Dielectric tests
(b) Measurement of the resistance of the main circuit
(c) Tightness test

(d) Design and visual checks

(e) Mechanical operating tests

(f) Dielectric tests of the main circuit
   (i) Tests with direct and alternating voltage
   (ii) Tests with lightning impulse voltage
   (iii) Tests with switching impulse voltage
   (iv) Tests with very low frequency voltages

(g) Vacuum interrupters integrity tests

(h) Timing tests

(i) Load current breaking tests

6.6.2.6 **Tests on Each Complete and Assembled MV Switchgear**

The following tests shall be carried out on the complete switchgear with all components and cubicles connected, according to IEC 62271-200 in presence of the client engineers

(a) Dielectric tests on the main circuit
   (i) Tests with direct and alternating voltage
   (ii) Tests with lightning impulse voltage
   (iii) Tests with switching impulse voltage

(b) Tests on auxiliary and control circuits
   (i) Inspection of auxiliary and control circuits, and verification of conformity to the circuit diagrams and wiring diagrams
   (ii) Functional tests
   (iii) Verification of protection against electrical shock
   (iv) Dielectric tests

(c) Measurement of the resistance of the main circuit

(d) Tightness test

(e) Design and visual checks

(f) Temperature rise test at MV switchgear rated current.

6.6.2.7 **Tests on solid insulated busbars**

(a) Measurement of resistance

(b) Design and visual checks

(c) Dielectric tests of the main circuit
   (i) Tests with direct and alternating voltage
   (ii) Tests with lightning impulse voltage
   (iii) Tests with switching impulse voltage
6.6.3 **Site Tests**

6.6.3.1 Tests given in this clause are not comprehensive and only highlight the basic required tests. The contractor shall prepare test plans as per clause 1.10.3 of specifications, covering all detailed tests necessary for commissioning of the MV switchgear and associated equipment.

6.6.3.2 The following minimum tests will be carried out during commissioning:

   (a) Wiring verification
   (b) Primary injection to confirm the CT secondary circuits are correctly connected to the relays, meters, instruments etc.
   (c) Switching devices operation checks
   (d) Dielectric tests/checks

6.6.3.3 Current transformers and voltage transformers

   (a) Ratio and polarity checks
   (b) Secondary wiring resistance checks
   (c) Test for rated knee point e.m.f. (Vk) and exciting current at Vk

6.6.3.4 MV cables and solid insulated bus bar

   (a) Dielectric tests
      (i) Power frequency tests
      (ii) Absorption and polarisation
      (iii) capacitance and dielectric dissipation factor
   (b) Resistance measurements
   (c) Primary current injection checks (hotspot and connection tightness)

6.6.3.5 Generator circuit breaker

   (a) Charging-manual/electrical
   (b) Racking in /out checks
   (c) Open/close (manual/auto)
   (d) Remote close/trip
   (e) Timing

6.6.3.6 Panel Meters and devices

   (a) configuring/programming
   (b) Accuracy checks/verification
   (c) Scheme checks (via primary injection)

6.6.3.7 Interface checks as per approved designs

6.6.3.8 Announcer/Indications/alarms; all indications to be tested and confirmed through initiation from the process.

6.6.3.9 Interlock tests/verification
(a) GCB mechanical interlocks
(b) All Earth switch operation interlocks (electrical and mechanical)
(c) Switchgear compartment doors interlocks

6.6.3.10 Open circuit checks (soaking checks)
6.6.3.11 Short circuit checks (generator full load current)
6.6.3.12 Heat run (reliability) tests/check (72hrs)

6.7 TRAINING

Training shall at minimum cover the following:

6.7.1 MV switchgear theory and application
   (a) Design of MV supply and distribution arrangements
   (b) selection of equipment for MV switchgear
      (i) designing schemes for protection of persons and property and correct functioning,
      (ii) compatibility with the supply, and arrangement of circuits
      (iii) determination of fault levels for effective switchgear component selection
      (iv) Design calculations
   (c) Design and testing of MV switchgear as per IEC 62271
   (d) Design and testing generator circuit breakers as per IEEE Std C37.013 and IEC/IEEE 62271-37-013. Theory on design requirements for generator circuit breakers covering topics such as:
      (i) symmetrical and asymmetrical short circuit making and breaking,
      (ii) rate of rise of recovery voltage (RRRV) and Transient recovery voltage (TRV),
      (iii) Delayed current zero capability,
      (iv) DC component of fault current for generators
      (v)
   (e) Study of the electrical characteristics and technology of MV switchgear
      (i) Vacuum circuit breakers
      (ii) MV earth switches and MV disconnectors/load break switches
      (iii) surge arresters
      (iv) Grounding systems
      (v) Protection and safety equipment: insulation monitor, capacitive voltage detectors
6.7.1.2 Practical training on Design, installation and commissioning
   (a) Detailed training on generator circuit breaker internal operations including
       (i) Operating mechanisms
       (ii) Electromagnetic coils
       (iii) Vacuum interrupter
       (iv) Pole assembly-installation and testing
       (v) Practical dis-assembly and reassembly of the circuit breaker from
            component devices to complete unit
       (vi) Testing and replacement of parts such as the operating mechanism,
            electromagnetic coils, spring, vacuum interrupter, truck assembly etc.
       (vii) Breaker Internal preventive maintenance

6.7.1.3 Commissioning of MV systems from first principles.
   (a) Dielectric tests
   (b) Primary injection testing
   (c) Open circuit and short circuit tests
   (d) Operation tests

6.7.1.4 Operation and Maintenance
   (a) Generator circuit breakers operations such as racking in and out and
       interlocks
   (b) Earth switch and load break switch operations and interlocks
   (c) Detailed practical training on use of the special switchgear tools provided
   (d) All other switchgear operations particular to the switchgear installed
   (e) Routine system checks and testing procedures.
       (i) This will include practical training on preventive maintenance testing
           of all MV switchgear components i.e. circuit breakers, load break
           switch, earth switches, instrument transformers metering and control
           devices, etc.
       (ii) Detailed procedures complete with check lists for quarterly semi-
            annual, annual, triennial/quadrennial etc. checks and tests to be
            provided.
   (f) Routine/preventive mechanical maintenance procedures such as greasing of
       moving parts of withdrawable components etc.
   (g) Practical training on replacement of faulty switchgear parts and devices
(h) Detailed practical training on removing switchgear covers and reassembly after replacement of failed switchgear parts such as bus bars, bus bar shutters, earth switches, cable terminals etc.

(i) Detailed practical training on repair and internal parts replacement of generator circuit breaker, earth switch and load break. To cover

   (i) Trouble shooting (common problems)
   (ii) Practical Dis assembly and re assembly of the switching device to component parts.
   (iii) Identifying failed parts
   (iv) Testing after repair

(j) Any other training on operation and maintenance of the MV switchgear equipment provided
7 PARTICULAR TECHNICAL SPECIFICATION: PROTECTION SYSTEMS

7.1 INTRODUCTION

7.1.1 Gitaru power station has three (3) Francis turbine Hydro generating units. Unit 2 and 3 have two protection panels and one shared panel hosting filters for differential and negative sequence electromechanical protection relays. There is an alternative supply transformer protection panel hosting electromechanical relays. Additionally, there is a diesel generator whose protection is housed in the main station switch board.

7.1.2 The existing six protection panels, housing electromechanical relays shall be replaced with new protection panels housing the numerical protection relays.

7.1.3 Details of the generators, transformers, instrument transformers and circuit breakers are provided in section 4 and appendices section 10. Bidder must study all the data provided in entirety before making the proposal. Bidders are advised to get themselves acquainted with actual inputs at site.

7.1.4 Any alternative/ additional protections or equipment considered necessary for providing complete effective and reliable protection but not indicated in the specifications shall also be included in the bid.

7.1.5 The protection equipment shall be designed to ensure continuity of operation under all working conditions and to facilitate inspection, maintenance and repairs.

7.1.6 All reasonable precautions shall be taken in the design of the equipment to ensure safety of all personnel concerned with the operation and maintenance of the equipment.

7.2 EXISTING PROTECTION EQUIPMENT

7.2.1 The existing protective system consists of electromechanical relays each implementing a single protection function.

7.2.2 The existing scheme of protection, CT, PT detail, Transformer detail etc. have been furnished with this specification in the appendix, however bidder should visit the site to access the requirement, quantum of work, scheme logic, location, dimension detail etc. before submitting the bid. The bidder shall submit complete detail of the scheme to be offered i.e. Relays, panel, configuration of scheme logic, protection function and features etc.
7.2.3 The existing protection scheme is for combined generator and generator step up
transformer, station transformers, alternative supply transformer and diesel generator
transformer.

7.2.4 The list below summarises the existing electromechanical protection functions. Detailed
information to be found on [drawing] provided.

<table>
<thead>
<tr>
<th>No</th>
<th>PROTECTION FUNCTION</th>
<th>RELAY MODEL</th>
<th>Manufacturer</th>
<th>Pickup setting</th>
<th>Trip Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51V – Voltage Restrained Overcurrent Protection</td>
<td>61EG1023A5</td>
<td>GEC</td>
<td>1.25 A</td>
<td>IDMT TMS=0.14</td>
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<tr>
<td>2</td>
<td>40 – Generator loss of excitation Protection</td>
<td>YCGF11</td>
<td>GEC</td>
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<td>3</td>
<td>46 – Generator Unbalanced Load Protection</td>
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<td>4</td>
<td>59 Generator Over voltage</td>
<td>VAG/SPEC64AF140A</td>
<td>GEC</td>
<td>125V</td>
<td>DT 1s</td>
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<td>5</td>
<td>59N- Stator Earth Fault (SEF)</td>
<td>CDG11AP90A5</td>
<td>GEC</td>
<td>0.1 A</td>
<td>IDMT TMS=0.1</td>
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<tr>
<td>6</td>
<td>81U/O–Under/over frequency protection</td>
<td>FM2-110</td>
<td>BBC</td>
<td>66Hz</td>
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<td>7</td>
<td>87U – Unit Differential protection</td>
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<td>8</td>
<td>51N- 132KV Earth fault current</td>
<td>CDG13AF89A5</td>
<td>GEC</td>
<td>0.3 A</td>
<td>IDMT TMS=0.34</td>
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<td>9</td>
<td>59N – 15KV Earth Fault -Neutral Voltage Displacement</td>
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<td>20 V</td>
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<td>10</td>
<td>Station Transformer over current OCIT</td>
<td>CDG31EG84A5</td>
<td>GEC</td>
<td>1A</td>
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<td>11</td>
<td>Station Transformer 2nd Stage Overcurrent (OCHS)</td>
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<td>12</td>
<td>Station Transformer Restricted Earth Fault</td>
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<td>25V</td>
<td>INST</td>
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<tr>
<td></td>
<td>voltage</td>
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<tr>
<td>13</td>
<td>GSU Transformer Buccholz alarm</td>
<td>VAA61 (6 flag relays)</td>
<td>GEC</td>
<td>Contact s</td>
<td>INST</td>
</tr>
<tr>
<td></td>
<td>GSU Transformer Winding temperature alarm</td>
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<tr>
<td></td>
<td>GSU Transformer Oil temperature alarm</td>
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<tr>
<td></td>
<td>Station Transformer Buccholz trip</td>
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<td>Station Transformer OLTC Buccholz trip</td>
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<td></td>
<td>Station Transformer Winding temperature trip</td>
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<tr>
<td></td>
<td>Station Transformer Oil temperature trip</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>14</td>
<td>GSU Transformer Buccholz alarm</td>
<td>VAA61 (6 flag relays)</td>
<td>GEC</td>
<td>Contact s</td>
<td>NO TRIP</td>
</tr>
<tr>
<td></td>
<td>GSU Transformer Winding temperature alarm</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
7.3 PROTECTION SCHEME REQUIREMENTS

7.3.1 General Protection Scheme requirements

7.3.1.1 Bidder shall include all requirements of each scheme (to cover all functionality of the existing system and to provide suitable protection for the equipment of its size, application and importance as per internationally accepted practices) in the bid including those that may not have been mentioned in the specifications.

7.3.1.2 The details of each protection scheme function are not explicitly mentioned in these specifications. Each function shall be dependent on the equipment being protected and the optimal fault isolation. Contractor shall study all information supplied to develop details of each scheme function.

7.3.1.3 All functions, devices, accessories or fittings which may not have been specifically mentioned, but which are usual or necessary in the respective scheme for the completeness and effective operation shall be supplied.

7.3.1.4 Any alternative/ additional protections or relays considered necessary for providing complete effective and reliable protection shall also be included in the scope of supply.

7.3.1.5 The entire protection scheme from instrument transformers to the circuit breakers shall be optimised to be highly reliable (dependable & secure), highly selective, very fast in operation, highly sensitive and very stable. All devices under scope of supply shall be chosen for this optimum operation.

7.3.1.6 Devices and functions shall also be chosen and optimised for interfacing to existing equipment in the protection scheme (e.g. circuit breakers and instrument transformers) that are not part of scope of supply.
7.3.1.7 CT inputs, VT inputs, binary outputs and some critical binary inputs to the numerical protection relays shall be hardwired from field devices to the relays as detailed in the clauses that follow. Communication interface may be provided for non-critical binary inputs and outputs. CT/VT inputs to the numerical relay via communication interface shall only be used as backup if offered.

7.3.1.8 Where logic functions are to be implemented the programming shall be done in IEC61131-3 function block diagram language or continuous functional chart (CFC) language. No other programming language shall be used.

7.3.2 **Generator protection schemes:**

7.3.2.1 The contractor shall study the existing protection scheme, generator and associated equipment data and come up with a comprehensive protection scheme. The scheme shall cover all existing protection functions and other specified below.

7.3.2.2 The scheme described below shall be duplicated for both unit 2 and 3. The schemes shall be similar for both units.

7.3.2.3 **Protection functions**

(a) The following generator protection functions **MUST** be provided:

1. Generator differential protection $\Delta I, (87G)$
2. Stator earth-fault protection 95% $V_0 >$, and 100% $V_0$ 3rd harmonic $> (59N)$
3. 100% stator earth fault protection by 20hz injection, $RSEF (20 \text{ Hz voltage}) <, (64S)$
4. Over excitation protection (Volt/Hertz) $V/f, (24)$
5. Generator overvoltage protection $V >, t = f (V), (59)$
6. Under excitation protection (loss-of-field protection) $I/X_d, (40)$
7. Rotor ground fault protection (64R) with low frequency injection
8. Negative-sequence (Generator unbalance) protection $I2 >, t = f (P), (46)$
9. Accidental energization protection $I >, V <, (50/27)$
10. Frequency (four stage, under & over) protection $f<, f>, (81U, 81O)$
11. Reverse-power protection -P, (32R)
12. Generator voltage restraint inverse-time over current protection, $I >, I_p = f(v) (51V)$
13. Generator circuit breaker failure protection $I_{\text{min}} >, (50BF)$
14. Shaft current protection (50GN)
15. Excitation transformer instantaneous, definite-time and inverse time over current protection, $I >, I >>, I >>> (50, 51)$
16. Backup Stator overload protection $P_f, (49)$
17. Back up under impedance protection $Z_\text{r}$, (21)
18. Backup Generator under voltage protection $V_\text{r}$, $t = f(V)$, (27)
19. Backup 15KV zero sequence overvoltage protection $V_\text{r}$, (59N)
20. VT Fuse failure monitor $V_\text{r} / V_1$, $I_2 / I_1$, (60FL)
21. Trip circuit supervision T.C.S. (74TC)
22. External trips initiation-excitation trip, turbine trip, control PLC trip etc.
23. Generator circuit breaker supervision alarms: -trip circuit failure, lockout etc.
24. Lockout function (86G)

(b) During the design stage, the client may include any other protection functions (available in the specified numerical relay) deemed necessary for the safe operation of the system

(c) 100% stator earth fault protection by 20hz injection,
(i) All the necessary accessories i.e. injection set, filter and current transformer shall be supplied and installed
(ii) Two sets of accessories shall be supplied for each protection set i.e. each numerical relay shall have its own injection sets
(iii) Shall detect ground faults in the entire winding range (100%) including the machine neutral point.
(iv) The measuring principle shall not be influenced by the operating mode of the generator (overexcited, under excited, full load or low load).
(v) Shall measure the presence of stator circuit including the neutral grounding even with the generator at standstill/de-energized

(d) Rotor ground fault protection (64R) with low frequency injection function.
(i) All necessary accessories for rotor earth fault detection i.e. injection unit and series resistor, shall be supplied and installed
(ii) Two sets of accessories shall be supplied for each protection set i.e. each numerical protection relay shall have its own accessories
(iii) Low frequency injection sets and series resistors shall be installed at the excitation panels one for each set.
(iv) Function shall have two stages a warning stage and a trip stage
(v) Shall have a very high sensitivity i.e. shall be able to detect fault resistances of up to 80 kΩ
(vi) Shall be insensitive to disturbances from the excitation (harmonics) a very low-frequency (1-3Hz) shall be used
(vii) The rotor earth fault protection scheme shall also measure the rotor insulation resistance and transmit measured values to SCADA.
(e) Shaft Brush gear with all associated devices for generator shaft earthing, shaft current protection and rotor earth fault sensing shall be installed on the generator shaft.

7.3.2.4 Dual redundant protection scheme
(a) To achieve a high degree of security in function, dual protection system for each generator shall be provided. It shall consist of two separated protection sets, system A and system B. Each protection set will consist of:
   (i) Generator Numerical protection relay
   (ii) Lockout/tripping relays
   (iii) Protection trip coil circuit supervision relays
   (iv) Circuit breaker trip coil supervision relays
   (v) At least 3 DC supply supervision relays
   (vi) Auxiliary relays and
   (vii) Other supporting elements
(b) The two protection sets for generator shall be divided into two electrically separate parts by means of having:
   (i) Separate DC power supply from auxiliary supply board,
   (ii) separate current transformer cores,
   (iii) separate voltage circuits,
   (iv) separate tripping lock out relays,
   (v) separate cables,
   (vi) Separate protection supply supervision
   (vii) Wiring to different circuit breaker tripping coil.

7.3.2.5 Generator Numerical protection relays:
(a) Two numerical protection relays compliant with all specifications in clauses 7.4.2 and 7.4.3 shall be installed and tested for each generator.
(b) Each generator numerical relay shall be from different manufacturers each meeting all the requirements in in clauses 7.4.2 and 7.4.3
(c) One of the generator numerical relay MUST be manufactured by Siemens or ABB

7.3.2.6 Field inputs to the protection system
(a) CT and VT inputs shall be hardwired from the instrument transformer marshalling kiosk to the numerical relay.
(b) A separate CT core shall be hardwired to each numerical relay.
(c) At least four CT inputs from the generator neutral side, at least three CT inputs from generator terminal side, at least three CT inputs from excitation
transformer terminal side and shaft current input shall be hardwired to each numerical relay.

(d) separate VT shall be hardwired from the VT marshalling kiosk for each protection set.

(e) At least four VT inputs from the generator terminal side (GCB cubicle) and at least one VT input from the generator neutral side shall be hardwired to each numerical relay.

(f) Some field digital inputs shall be wired to auxiliary relays which will do contact multiplication for input to the two numerical relays. At least 15 (fifteen) contactor relays compliant with all specifications in clause 3.5.3 and with at least 2NC & 2NO potential free contacts shall installed for inputs coupling.

(g) The numerical relay Signalling and control binary inputs to be wired shall include but not limited to:

<table>
<thead>
<tr>
<th>Excitation trip</th>
<th>emergency PB trip</th>
<th>Incoming VT MCB trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>mechanical trip (86M)</td>
<td>field breaker open</td>
<td>GCB open</td>
</tr>
<tr>
<td>Transformer trip (86T)</td>
<td>field breaker closed</td>
<td>GCB closed</td>
</tr>
<tr>
<td>De-loading trip (94E)</td>
<td>Guide vanes closed</td>
<td>GCB trip coil failure</td>
</tr>
<tr>
<td>Unit control PLC trip</td>
<td>Shutdown valve closed</td>
<td>GCB open command</td>
</tr>
<tr>
<td>Earth switch open</td>
<td>Shutdown valve open</td>
<td>GCB close command</td>
</tr>
<tr>
<td>Earth switch closed</td>
<td>GCB spring charge failure</td>
<td>GCB grouped alarm</td>
</tr>
<tr>
<td>GCB withdrawn</td>
<td>GCB in service position</td>
<td>GCB in test position</td>
</tr>
</tbody>
</table>

(h) At least two isolated binary inputs on each numerical relay shall be wired for the two lock out relays (86G & 86X) trip coil supervision else two trip supervision relays shall be installed.

7.3.2.7 Tripping and annunciation

(a) Each numerical relay shall have tripping binary outputs hardwired independently for each protection set to the following devices:

- Lockout relay 86G
- lockout relay 86M
- lockout relay 86X
- lockout relay 86T
- Unit PLC input1
- Trip relay 94E
- Unit PLC input2

(b) On each protection set two numerical binary outputs shall be hardwired each to a contactor relay with 8 contacts compliant with clause 3.5.3 for circuit breaker open/trip and close command. The open command contactor
relays shall be labelled 94G and shall be used to open the circuit breaker without tripping the unit. The four Contactor relays (two for each set) contacts shall be hardwired to the circuit breaker coils and unit PLC binary inputs.

(c) At least ten IED signalling binary outputs shall be wired to auxiliary relays for contact multiplication for hard wiring to the unit control PLC & manual control system. At least 12 interface relays or contactor relays compliant with specifications in clause 3.5.4.4 or 3.5.3 respectively and with at least four potential free contacts shall installed

(d) Numerical relay signalling binary outputs to be hardwired shall include but not limited to:
- Generator differential trip
- Protection grouped alarm
- excitation transformer trip
- Siren/buzzer

(e) A number (dependent on design) of binary outputs shall be hardwired to manual control panel and the GCB panel for circuit breaker closing interlocks.

(f) Each numerical relay LED’s shall be configured for annunciation of, but not limited to the following functions:
- General trip
- differential trip
- loss of excitation trip
- generator unbalance trip
- over current trip
- reverse power trip
- stator earth fault trip
- frequency trip
- breaker failure trip
- Over excitation trip
- VT fuse failure
- excitation transformer trip
- external trip
- Grouped alarm

(g) A Siren shall be supplied and installed by the contractor on the generator protection panel. Operation of the protection scheme (Alarm and Trip) shall initiate the soft siren

7.3.2.8 **Lockout relays**

(a) Two Lock out relays (86G), one for each protection set, each with at least 20 SPST contacts and compliant with all specifications given in clause 3.5.2, shall be installed They shall be hardwired independently for each protection set, to a minimum of the following field devices:
- Generator circuit breaker  
- Field circuit breaker trip  
- Excitation D-AVR 1 trip input  
- Excitation D-AVR 2 trip input  
- Governor stop input  
- Lockout relay 86E  
- Lockout relay 86M  
- Unit PLC input  
- Emergency shutdown valve  
- Circuit breaker closing interlocks

(b) Two Lock out relays (86X), one for each protection set, each with at least 5 potential free contacts and compliant with all specifications given in clause 3.5.2. shall be installed. They shall be hardwired independently for each protection set, to a minimum of the following field devices:

- 132KV circuit breaker  
- Unit PLC input

7.3.2.9 **Supervision relays**

(a) Each protection set shall have at least 4 (four) circuit breaker trip coil supervision relays for Generator circuit breaker and field circuit breaker trip coil supervision in CB open and CB closed state.

(b) There shall be at least three DC supply supervision relays on each protection set for: numerical relay DC supply supervision, protection trip supply supervision and Circuit breaker trip supply supervision. DC supply supervision relays shall have at least 4 potential free contacts.

(c) Auxiliary contacts of DC supply circuit breakers (MCB’s), DC supply supervision relays and breaker trip coil supervision relays shall be hardwired to the unit control PLC by the contractor. Potential free contacts shall be available for this purpose.

7.3.2.10 **Generator Power Tariff Metering**

(a) A Digital power transducer meeting requirement of clause 3.4.6 shall be installed on the generator protection panel. The transducer shall be connected to metering CT and VT cores.

(b) The transducer analogue outputs shall be hardwired to KPLC SCADA panel or unit control panels as shall be elaborated during design stage. Four signal amplifier/isolators shall be installed in the protection panel for interfacing the analogue outputs from the transducer.

(c) At least three VT inputs and three CT inputs shall be hardwired from the metering CT and VT cores on the generator MV switch gear or generator neutral terminals.

(d) The transducer shall have an Ethernet port and shall be interfaced to the protection network.
(e) Transducer nominal power supply input shall be 110VDC±20%

(f) Transducer inputs connection shall be four voltage inputs (3P4W) and three current inputs (3P3W)

(g) Transducer Shall meet and exceed accuracy class 0.2 as per IEC 61557-12 and shall meet accuracy class 0.2s as per IEC 62053-22

(h) Digital Transducer measuring error at 25 °C and 50hz shall be less than 0.1% for both current and voltage input as per IEC 60688

(i) Digital Transducer shall be accurate and secure for revenue/tariff metering by the utility company.

(j) Digital Transducer shall have an Ethernet 100Base-T acc. to IEEE802.3 RJ45 port. With full 100Mbps fast Ethernet support.

(k) Digital Transducer Shall support both Modbus TCP and IEC 61850(server) communication protocols.

(l) Digital Transducer shall support both external and internal time synchronization. It shall be equipped with an SNTP (Simple Network Time Protocol) client that can be connected to 2 NTP (Network Time Protocol) servers, the primary and the secondary (redundant) NTP server. The time synchronization error shall be less than 5 ms referred to UTC time of the NTP server.

7.3.2.11 Other devices and functions

(a) At least two test blocks shall be mounted on the front side of the panel. Test blocks shall isolate CT, VT and tri circuits when test plug is inserted to enable online testing of the numerical and lockout relays

(b) Emergency pushbutton and lockout relays reset button to be installed on front side of the panel.

(c) status LED lamps shall be installed on the front side of the panels for DC supply failure annunciation and trip indication.

7.3.3 Generator Step-up (GSU) transformer protection scheme

7.3.3.1 The contractor shall study the existing protection scheme, generator transformer and associated equipment data and come up with a comprehensive protection scheme. The scheme shall cover all existing protection functions and other specified below.

7.3.3.2 The scheme described below shall be duplicated for both unit 2 and 3. The schemes shall be similar for both units.
7.3.3.3 **Protection functions**

(a) The following GSU transformer protection functions **MUST** be provided:

1. Transformer differential protection $\Delta I$, (87T)
2. Transformer Restricted earth fault protection $\Delta I_n$, (87TN)
3. Over excitation protection (Volt/Hertz) $V/f$, (24)
4. Transformer time over current protection, $I_\text{r}$, (51)
5. MV (15KV) Neutral voltage displacement (NVD) $V_0$, (59N)
6. HV (132KV) Sensitive earth-fault protection $I_{EE}$, (51N)
7. HV (132KV) over voltage protection $V$, $t = f(V)$, (59)
8. HV circuit breaker failure protection $I_{\text{min}}$, (50BF)
9. Back up Transformer Thermal overload protection $F_l$, (49)
10. Backup under voltage protection $V$, $t = f(V)$, (27)
11. Back up Frequency (under & over) protection $f$, $f_\text{r}$, (81U, 81O)
12. Back up line distance protection $Z$, (21)
13. Station transformer HV side over current protection, $I_\text{r}$, (50/51)
14. 132KV synchro check, (25)
15. VT Fuse failure monitor $V_2/V_1$, $I_2/I_1$, (60FL)
16. Trip circuit supervision $T.C.S.$ (74TC)
17. Transformer protections via binary inputs: Bucholz surge trip, oil temperature trip, winding temperature trip, pressure relief device trip etc.
18. External trip initiation-station transformer trip, station flooding trip, line trip etc.
19. circuit breaker supervision alarms: -trip circuit failure, lockout etc.
20. Lockout function, 86T

(b) During the design stage, the client may include any other protection functions (available in the specified numerical relay) deemed necessary for the safe operation of the system

7.3.3.4 **Dual redundant protection scheme**

(a) To achieve a high degree of security in function, dual protection system for each GSU transformer shall be provided. It shall consist of two separated protection sets, system A and system B. Each protection set will consist of:

(i) GSU transformer Numerical protection relay
(ii) Lockout/tripping relays
(iii) Protection trip coil circuit supervision relays
(iv) Circuit breaker trip coil supervision relays
(v) At least 3 DC supply supervision relays
(vi) Auxiliary relays and
(vii) Other supporting elements

(b) The two protection sets for GSU transformer shall be divided into two electrically separate parts by means of having:
   (i) Separate DC power supply from auxiliary supply board,
   (ii) separate current transformer cores,
   (iii) separate voltage circuits,
   (iv) separate tripping lock out relays,
   (v) separate cables,
   (vi) Separate protection supply supervision
   (vii) Wiring to different circuit breaker tripping coil.

7.3.3.5 GSU transformer Numerical protection relays:
(a) Two numerical protection relays compliant with all specifications in clauses 7.4.2 and 7.4.4 shall be installed and tested for each GSU transformer.
(b) Each GSU transformer numerical relay shall be from different manufacturers each meeting all the requirements in in clauses 7.4.2 and 7.4.4
(c) One of the GSU transformer numerical relay MUST be manufactured by Siemens or ABB

7.3.3.6 Field inputs to the protection system
(a) CT and VT inputs shall be hardwired from the instrument transformer marshalling kiosk to the numerical relay.
(b) A separate CT core shall be hardwired to each numerical relay.
(c) At least four CT inputs from the GSU transformer HV side, and at least six CT inputs from the GSU transformer LV side shall be hardwired to each numerical relay.
(d) separate VT circuits shall be hardwired from the VT marshalling kiosk for each protection set. Separate wiring, with paralleling done at the VT panel where necessary.
(e) At least three VT inputs from the GSU transformer HV side, at least one VT input from the 132KV Line and at least four VT inputs from the GSU transformer LV side shall be hardwired to each numerical relay.
(f) At least two isolated binary inputs on each numerical relay shall be hardwired for the two lockout relays (86T-1 & 86T-2) trip coil supervision else two trip supervision relays shall be installed.
Some field binary inputs to the protection IED’s shall be hardwired to auxiliary relays which will do contact multiplication for input to the two numerical relays. At least 8 (eight) contactor relays compliant with clause 3.5.3 and 12 (twelve) interface relays as per clause 3.5.4.4 shall be installed for inputs coupling.

Each numerical relay signalling & control binary inputs to be wired shall include but not limited to:

- Station TX trip (86ST)  Oil temp alarm  132 KV CB open
- Generator trip (86G)  Oil temp trip  132 KV CB Closed
- Buccholz surge alarm  PRD trip  132 KV CB lockout
- Buccholz surge trip  Oil level low alarm  132 KV CB trip coil failure
- Winding R temp alarm  Oil flow alarm  132 KV CB gas low alarm
- Winding R temp trip  Oil flow trip  132 KV CB spring charge failure
- Winding B temp alarm  Cooler supply fail  132 KV CB grouped alarm
- Winding B temp trip  Grp Cooler failure  132 KV CB Remote selection
- HV VT MCB trip  Tap changer alarm  132 KV CB operations Remote
- emergency PB trip  Tap changer trip  132 KV isolator closed
- Sync start/enable  Sync override ON  132 KV isolator open
- 132 KV E/Switch open  Kamburu Inter trip receive
- 132 KV Earth switch closed

### Tripping, control and annunciation

(a) Each numerical relay shall have tripping binary outputs hardwired independently for each protection set to the following devices:

- Lockout relay 86T-1  lockout relay 86M
- lockout relay 86T-2  lockout relay 86E
- **lockout relay 86ST**  Common PLC input
- lockout relay 86G  Unit PLC input

(b) On each protection set one numerical relay’s binary output shall be hardwired each to a contactor relay with 8 contacts compliant with clause 3.5.3 for circuit breaker open/trip. This contactor relays shall be labelled 94T and shall be used to open the circuit breaker for protection trips that do not require to stop the unit. The two Contactor relays (one for each set) contacts shall be hardwired to the circuit breaker coils and unit PLC binary inputs.
(c) At least six signalling IED binary outputs shall be hardwired to auxiliary relays for contact multiplication for hard wiring to the unit control PLC & manual control system. At least 10 interface relays or contactor relays compliant with specifications in clause 3.5.4.4 or 3.5.3 respectively and with at least four potential free contacts shall installed.

(d) Signalling and control IED binary outputs to be hardwired to field devices shall include but not limited to:

- Protection grouped alarm
- GSU transformer relay A failure (watchdog)
- Siren/buzzer
- GSU transformer relay B failure (watchdog)
- GSU transformer differential trip
- Prot. IED A communication failure alarm
- Sync start/on
- Prot. IED B communication failure alarm
- Sync stop/off
- 132 KV CB Close command
- 132 KV CB open command

(e) A number (dependent on design) of binary outputs shall be hardwired for circuit breaker closing interlocks

(f) Each numerical relay LED’s shall be configured for annunciation of, but not limited to the following functions:

<table>
<thead>
<tr>
<th>General trip</th>
<th>Buccholz surge alarm</th>
<th>Kamburu line trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential trip</td>
<td>Buccholz surge trip</td>
<td>Winding temp alarm</td>
</tr>
<tr>
<td>REF trip</td>
<td>Winding temp trip</td>
<td></td>
</tr>
<tr>
<td>Over excitation trip</td>
<td>Oil temp alarm</td>
<td></td>
</tr>
<tr>
<td>over current trip</td>
<td>Oil temp trip</td>
<td></td>
</tr>
<tr>
<td>NVD trip</td>
<td>Oil pressure trip (PRD)</td>
<td></td>
</tr>
<tr>
<td>breaker failure trip</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(g) A Siren shall be supplied and installed on the GSU transformer protection panel. Operation of the protection scheme (Alarm and Trip) shall initiate the soft siren

7.3.3.8 **Lockout relays**

(a) Two Lock out relays (86T-1), one for each protection set, each with at least 20 potential free contacts and compliant with all specifications given in
clause 3.5.2 shall be provided. They shall be hardwired independently for each protection set, to a minimum of the following field devices:

- 132KV circuit breaker trip STX 415V ACB
- Field circuit breaker trip Unit PLC input
- Excitation controller trip input Emergency shutdown valve
- Governor stop input Circuit breaker closing interlocks

(b) Two Lock out relays (86T-2), one for each protection set, each with at least 5 potential free contacts and compliant with all specifications given in clause 3.5.2. shall be provided. They shall be hardwired independently for each protection set, to a minimum of the following field devices:

- Kamburu line inter-trip Unit PLC input

7.3.3.9 Supervision relays

(a) Each protection set shall have at least 2 (two) circuit breaker trip coil supervision relays for 132KV circuit breaker trip coil supervision in CB open and CB closed state. Each trip circuit supervision relay shall have at least two potential free contacts.

(b) There shall be at least three DC supply supervision relays on each protection set for: numerical relay DC supply supervision, protection trip supply supervision and Circuit breaker trip supply supervision. DC supply supervision relays shall have at least 4 potential free contacts.

(c) Auxiliary contacts of DC supply circuit breakers (MCB's), DC supply supervision relays and breaker trip coil supervision relays shall be hardwired to the unit control PLC by the contractor. Potential free contacts shall be available for this purpose.

7.3.3.10 Remote HV breaker control and Synchronizing scheme

(a) A comprehensive 132KV HV circuit breaker operation control scheme shall be realised via a combination of IED logic program and hardwired interlocks. The functions shall include:

(i) CB opening command and interlocks,
(ii) CB closing command and interlocks and
(iii) Automatic generator synchronisation at GSU transformer HV side

(b) Most of the control system (SCADA/PLC) CB operations requests and signalling shall be via communication interfaces, however a few critical control signals shall be hardwired.
(c) Generator, GSU transformer and station transformer protection schemes shall be designed to allow unit to trip to house load during an external fault. After the external fault, has cleared synchronising of the unit back to the grid shall be carried out at the HV side circuit breaker.

(d) In order to enable automatic generator synchronisation at the GSU transformer HV side an automatic synchronising relay meeting requirement of clause 7.5.2 shall be installed.

(e) Circuit breaker close command from the synchronising relay shall be interlocked with circuit breaker closing command from the numerical protection relay.

(f) Synchronising relay excitation & governor lower/raise pulses shall be hardwired to the manual control system.

(g) A three-position key operated Synch override switch shall be installed on the GSU transformer protection panel to enable closing of the 132KV breaker to a dead bus. The switch shall have three potential free contacts.

(h) A discrepancy (illuminated) switch with at least three auxiliary contacts shall be installed for circuit breaker closing and opening operations. The switch to be operated by twisting and pressing in order to make contacts.

(i) A two-position selector switch shall also be installed for 132KV CB local/remote operation selection. Remote operations shall be via the station common PLC. The selector switch shall have at least three potential free contacts. CB closing request, opening request and synchronisation start/enable from the common PLC shall be interlocked to this selector switch in the IED logic.

(j) A two-position selector switch shall also be installed for 132KV CB auto synchronisation ON/OFF selection in local mode. The selector switch shall have at two potential free contacts.

(k) Circuit breaker open command shall be interlocked with GCB open status. A circuit breaker open request while the unit is synchronised to the grid shall first send a unit stop command to the unit control system. Emergency push button shall trip the breaker instantaneously.

(l) Circuit breaker close command shall be interlocked to sync override and protection IED closing permit outputs (for both IEDs). Breaker closing interlock shall be programmed into the protection IED’s and shall prevent accidental dangerous operation of the breaker e.g. closing into an asynchronous system. Breaker closing command shall be interlocked to synchronising relay breaker command when sync override is off.
(m) At least 10 (ten) contactor relays with 4NC and 4NO contacts and compliant with clause 3.5.3 shall be provided for, but not limited to the following control functions.

<table>
<thead>
<tr>
<th>Control Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV CB close command</td>
<td>Remote selection</td>
</tr>
<tr>
<td>HV CB open command</td>
<td>Local selection</td>
</tr>
<tr>
<td>Synchronization ON</td>
<td>Unit Stop command</td>
</tr>
<tr>
<td>Synchronization OFF</td>
<td></td>
</tr>
<tr>
<td>Synchronization override ON</td>
<td></td>
</tr>
<tr>
<td>Synchronization override OFF</td>
<td></td>
</tr>
</tbody>
</table>

(n) The relays shall be wired to the various field devices to realise the circuit breaker control scheme.

### 7.3.3.11 Other devices and functions

(a) At least three test blocks shall be mounted on the front side of the panel. Test blocks shall isolate CT, VT and trip circuits when test plug is inserted to enable online testing of the numerical and lockout relays.

(b) At least four inter trip isolation links shall be mounted on the relay panel.

(c) Emergency pushbutton and lockout relays reset button to be installed on front side of the panel.

(d) status LED lamps shall be installed on the front side of the panels for DC supply failure annunciation and trip indication.

### 7.3.4 Station Transformers Protection Scheme

#### 7.3.4.1
The contractor shall study the existing protection scheme, station transformers and associated equipment data and come up with a comprehensive protection scheme. The scheme shall cover all existing protection functions and others listed below.

#### 7.3.4.2
The scheme described below shall be replicated for unit 1, unit 2 and unit 3 station transformers. The schemes shall be similar for all units.

#### 7.3.4.3 Protection functions

(a) The following station transformer protection and control functions **MUST** be provided:

(i) Transformer Restricted earth fault protection $\Delta In$, (87TN)

(ii) Transformer instantaneous & time over current protection, $I>$, (50/51)

(iii) LV circuit Breaker failure protection $I_{min}>$, (50BF)

(iv) LV side sensitive earth-fault protection, $IEE>$, (51N)

(v) Backup LV side over & under voltage protection (27,59)

(vi) Back up LV side neutral over voltage/displacement (59N)
(vii) Automatic voltage (OLTC) control (90V)
(viii) Trip circuit supervision T.C.S. (74TC)
(ix) Transformer protections via binary inputs: Buchholz surge trip, oil
temperature trip, winding temperature trip, tap changer oil pressure
trip, pressure relief device etc
(x) External trips-bus bar trip, etc.
(xi) Circuit breaker supervision alarms: -trip circuit failure, lockout etc
(xii) Lockout 86ST

(b) During the design stage, the client may include any other protection
function (available in the specified numerical relay) deemed necessary for
the safe operation of the system

c) 7.3.4.4 Station transformers numerical relays

(a) A numerical protection relay compliant with all specifications in clauses
7.4.2 and 7.4.5 shall be installed and tested for each unit.

(b) Another numerical relay shall be supplied for tap changer (OLTC) automatic
voltage control (AVC) if the main protection relay cannot offer all the inputs
and outputs as detailed in clause 7.4.5.6

(c) The AVC numerical relay if offered:
(i) shall comply to all specifications in clause 7.4.2.
(ii) shall have a minimum of the following IO: 11 binary inputs, 9 binary
outputs, 4 CT inputs and 4 VT inputs.
(iii) shall meet all the other requirements of clause 7.4.5 apart from binary,
CT and VT inputs requirements.
(iv) Shall be connected to station transformer HV side CT and LV VT inputs
(v) The following functions shall be configured: HV side overcurrent
(50/51) and automatic voltage control (90V)

7.3.4.5 Field inputs to the protection system

(a) CT and VT inputs shall be hardwired from the instrument transformer
marshalling kiosks and switchboard to the numerical relay.

(b) At least three CT inputs from the station transformer HV side shall be
hardwired to the main numerical protection relay. This connection is
optional, Station transformer HV side overcurrent protection may be
provided for in the GSU transformer protection scheme.

(c) At least four CT inputs from the station transformer LV side shall be
hardwired to the main or AVC numerical protection relay.
(d) At least four VT inputs from the station transformer LV side shall be hardwired to the main or AVC numerical protection relay.

(e) Some field binary inputs to the protection system shall be hardwired to auxiliary relays which will do contact multiplication for input to numerical relays and employer’s common PLC. At least 5 (five) contactor relays compliant with all specifications in clause 3.5.3 with at least 2NC & 2NO potential free contacts and at least 15 (fifteen) interface relays as per clause 3.5.4.4 with 4SPDT potential free contacts shall installed for inputs coupling

(f) At least one isolated binary input shall be hardwired for the lock out relay (86ST) trip coil supervision else a trip supervision relay shall be installed.

(g) Numerical protection relay signalling & control binary inputs to be wired from field devices shall include but not limited to:

<table>
<thead>
<tr>
<th>Input Description</th>
<th>Output Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buchholz surge trip</td>
<td>Generator TX trip (86T-1)</td>
</tr>
<tr>
<td>Buchholz surge alarm</td>
<td>Oil temp trip</td>
</tr>
<tr>
<td>Winding temp trip</td>
<td>Oil temp alarm</td>
</tr>
<tr>
<td>Winding temp alarm</td>
<td>OLTC Oil pressure trip</td>
</tr>
<tr>
<td>Extreme tap</td>
<td>OLTC Oil level low alarm</td>
</tr>
<tr>
<td>Tap Out of step</td>
<td>OLTC control supply failure</td>
</tr>
<tr>
<td>STX aux supply fail</td>
<td>OLTC motor supply failure</td>
</tr>
</tbody>
</table>

**Tap changer (OLTC) control inputs**

<table>
<thead>
<tr>
<th>Input Description</th>
<th>Output Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap position BCD bit0</td>
<td>OLTC drive selected local</td>
</tr>
<tr>
<td>Tap position BCD bit1</td>
<td>Tap change in progress</td>
</tr>
<tr>
<td>Tap position BCD bit2</td>
<td>Voltage control Auto mode</td>
</tr>
<tr>
<td>Tap position BCD bit3</td>
<td>Voltage control Remote mode</td>
</tr>
<tr>
<td>Tap position BCD bit4</td>
<td>Voltage control Manual mode</td>
</tr>
</tbody>
</table>

**Tripping, control and annunciation**

(a) Numerical relays shall have tripping binary outputs hardwired to the following devices:

<table>
<thead>
<tr>
<th>Input Description</th>
<th>Output Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockout relay 86T-1</td>
<td>Common PLC input</td>
</tr>
<tr>
<td>Lockout relay 86ST</td>
<td>Unit PLC input</td>
</tr>
<tr>
<td>Lockout relay 86G</td>
<td></td>
</tr>
</tbody>
</table>

(b) Four binary outputs shall be hardwired to a contactor relays with 8 contacts compliant with clause 3.5.3 for 415V circuit breaker closing and trip and OLTC tap raise and lower. The trip relay shall be labelled 94ST and shall be used to open the circuit breaker without tripping the unit. The Contactar
relays contacts shall be hardwired to the circuit breaker coils, OLTC and common PLC binary input

(c) At least five signalling & control binary outputs shall be hardwired to auxiliary relays for contact multiplication for hard wiring to common PLC & panel LED lamps indication. At least 5 (five) interface relays compliant with specifications in clause 3.5.4.4 respectively and with at least four potential free contacts shall installed.

(d) The signalling and control binary outputs to be hardwired to field devices shall include but not limited to:

- Tap Raise
- Tap lower
- OLTC AVC failure
- Protection grouped alarm
- Siren/buzzer
- LV side Voltage failure
- ACB close command

(e) A number (dependent on design) of binary outputs shall be hardwired for circuit breaker closing interlocks

(f) Numerical relay LED’s shall be configured for annunciation of, but not limited to the following functions:

- General trip
- REF trip
- over current trip
- Earth fault trip
- breaker failure trip
- Buccholz surge alarm
- Buccholz surge trip
- Winding temp alarm
- Winding temp trip
- OLTC AVC failure
- Oil temp alarm
- Oil temp trip
- Tap changer Oil pressure trip
- Tap changer oil level low
- OLTC grouped alarm

(g) Operation of the protection scheme (Alarm and Trip) shall initiate the soft siren installed on the GSU transformer protection panel.

7.3.4.7 **Lockout relay**

(a) A Lock out relay (86ST), with at least 10 potential free contacts and compliant with all specifications given in clause 3.5.2. shall be provided it shall be hardwired to a minimum of the following field devices:

- 132KV circuit breaker trip
- STX 415V ACB
- Switchboard changeover interlock
- Common PLC input
7.3.4.8 **Supervision relays**

(a) At least 2 (two) circuit breaker trip coil supervision relays for 415V circuit breaker trip coil supervision in CB open and CB closed state. Each trip circuit supervision relay shall have at least two potential free contacts.

(b) There shall be at least five DC supply supervision relays for: numerical relay DC supply supervision, protection trip supply supervision, Circuit breaker trip supply supervision, OLTC AVC relay & controls supply (if separate relay is used) and tap changer (OLTC) DC supply. The supervision relays shall have at least 4 potential free contacts.

(c) Auxiliary contacts of DC supply circuit breakers (MCF’s), DC supply supervision relays and breaker trip coil supervision relays shall be hardwired to the unit control PLC by the contractor. Potential free contacts shall be available for this purpose.

7.3.4.9 **Station transformers Tap changer (OLTC) control scheme**

(a) Automatic voltage control function (90V) shall be configured in the station transformers protection IED’s.

(b) 415V supplies from station transformers shall automatically be regulated within a range of ±0.5 to ±3% of 415V through an automatic voltage control function. An acceptable dead band shall be allowed within acceptable limits to avoid frequent operation of the tap changer (OLTC) device. Provisions are also provided to manually raise/lower voltage on the local control panel or control remotely through PLC through manual/auto-remote selector switch.

(c) Manual tap change raise lower function shall also be realised in the protection IED logic. Two of the protection IED’s function keys shall be configured for manual tap raise and lower operation. The IED shall have a GUI screen to ease local manual tap changer operations on the relay. Remote manual tap changer control from the communication interface shall be configured to allow tap raise and lower from SCADA.

(d) Relay logic for remote hardwired Control of the tap changer of each transformer from the common PLC shall be provided (this is an existing functionality).

(e) Three position Key operated tap changer control selector switch for AUTO/MANUAL/REMOTE selection shall interlock operations of tap changer. Remote hardwired OLTC control shall be interlocked with remote selection. Connections for Remote tap changer RAISE/LOWER commands from plant common PLC shall be provided. Contactor relays compliant with
clause 3.5.3 shall be used for the hardwired control circuit. Remote hardwired raise/lower commands shall directly pick the raise and lower contactor relays without the numerical relay.

(f) The three position Key operated tap changer control selector switch for AUTO/MANUAL/REMOTE shall have at least three SPDT contacts for each selection. Three (one for each position) voltage free contacts of this switch shall be provided for connection to the plant common PLC. The remote function shall be done from the employer’s plant common PLC.

7.3.4.10 Other devices and functions
(a) At least two test blocks shall be mounted on the front side of the panel. Test block switches shall isolate CT, VT and trip circuits when a test plug is inserted to enable online testing of the numerical and lockout relays.

(b) Emergency pushbutton and lockout relays reset button to be installed on front side of the panel.

(c) Status LED lamps shall be installed on the front side of the panels for:
   (i) DC supply failure annunciation,
   (ii) Grouped protection alarm annunciation,
   (iii) Grouped communication failure alarm,
   (iv) Grouped automatic tap changer control failure alarm,
   (v) Station transformer trip indication.

7.3.5 Alternative Supply Transformers Protection Scheme
7.3.5.1 The contractor shall study the existing protection scheme, station transformers and associated equipment data and come up with a comprehensive protection scheme. The scheme shall cover all existing protection functions and others listed below.

7.3.5.2 Protection functions
(a) The following station transformer protection and control functions **MUST** be provided:
   (i) Transformer Restricted earth fault protection ΔIn, (87TN)
   (ii) Transformer HV side over current protection, I>, (50/51)
   (iii) LV circuit Breaker failure protection Imin>, (50BF)
   (iv) LV sensitive earth-fault protection, IEF>, (51N)
   (v) Back up transformer LV side over current protection I>, (50/51)
   (vi) Backup LV side over & under voltage protection (27,59)
   (vii) Back up LV side neutral over voltage/displacement (59N)
(viii) Trip circuit supervision T.C.S. (74TC)
(ix) Transformer protections via binary inputs: Buchholz surge trip, oil temperature trip, winding temperature trip, tap changer oil pressure trip, pressure relief device etc
(x) External trips - bus bar trip, etc.
(xi) Circuit breaker supervision alarms: - trip circuit failure, lockout etc
(xii) Lockout function 86 AST

(b) During the design stage, the client may include any other protection function (available in the specified numerical relay) deemed necessary for the safe operation of the system

c)

7.3.5.3 Alternative supply transformers numerical relay

(a) A numerical protection relay compliant with all specifications in clauses 7.4.2 and 7.4.5 shall be installed and tested.

7.3.5.4 Field inputs to the protection system

(a) CT and VT inputs shall be hardwired from the instrument transformer marshalling kiosks and switchboard to the numerical relay.

(b) At least three CT inputs from the alternative supply transformer HV side shall be hardwired to the numerical protection relay.

(c) At least four CT input from the alternative supply transformer LV side shall be hardwired to the numerical protection relay.

(d) At least three VT inputs from the station transformer LV side shall be hardwired to the numerical protection relay.

(e) At least one isolated binary inputs shall be hardwired for lockout relay trip coil supervision else a trip supervision relay shall be installed.

(f) The following Numerical protection relay signalling & control binary inputs from field devices shall be wired. They shall include but not limited to:

- Buchholz surge trip
- Buchholz surge alarm
- Winding temp trip
- Winding temp alarm
- Bus coupler ACB open
- Bus coupler trip coil fail

- Oil temp trip
- Oil temp alarm
- VT supply failure
- Oil pressure trip
- Bus coupler ACB closed
- Bus coupler trip coil fail

- emergency PB trip
- 415V CB open
- 415V CB closed
- 415V CB trip coil fail
- Lockout reset input
7.3.5.5 **Tripping and annunciation**

(a) At least one IED binary output shall be hardwired to a contactor relay with 8 contacts compliant with clause 3.5.3 for 415V circuit breaker open/trip. This relay shall be labelled 94AST. The Contactor relay contacts shall be hardwired to the 415V circuit breaker trip coil and common PLC binary input.

(b) At least one IED binary output shall be hardwired to a contactor relay with 8 contacts compliant with clause 3.5.3 for 415V bus coupler circuit breaker open/trip. This relay shall be labelled 94BS. The Contactor relay contacts shall be hardwired to the 415V circuit breaker trip coil and common PLC binary input.

(c) Two IED binary output shall be hardwired each to a contactor relay with 8 contacts compliant with clause 3.5.3 for 415V alternative supply and bus coupler circuit breakers closing command.

(d) The numerical relay signalling and control binary outputs to be hardwired to field devices shall include but not limited to:

- Protection grouped alarm
- Protection IED failure (watchdog)
- Siren/buzzer
- Alternative supply transformer tripped
- LV side Voltage failure
- IED communication failure alarm
- Bus coupler ACB close command
- Bus coupler ACB open command
- Alternative supply ACB close comm.
- Alternative supply ACB close comm.

(e) A number (dependent on design) of binary outputs shall be hardwired for circuit breaker closing interlocks.

(f) Numerical relay LED’s shall be configured for annunciation of, but not limited to the following functions:

- General trip
- Reference (REF) trip
- Over current trip
- Earth fault trip
- Bucchoz surge alarm
- Bucchoz surge trip
- Winding temp alarm
- Winding temp alarm
- Oil temp alarm
- Oil temp trip
- Breaker failure trip
- Earth fault trip
- Winding temp trip

(g) Operation of the protection scheme (Alarm and Trip) shall initiate the soft siren installed on the GSU transformer protection panel.
7.3.5.6 **Lockout relay**
(a) A Lock out relay (86AST), with at least 10 potential free contacts and compliant with all specifications given in clause 3.5.2. shall be provided it shall be hardwired to a minimum of the following field devices:
- 33KV isolator/auto recloser
- Alt supply 415V ACB
- Switchboard changeover interlock
- Common PLC input

7.3.5.7 **Supervision relays**
(a) At least 4 (four) circuit breaker trip coil supervision relays for alternative supply and bus coupler 415V circuit breakers trip coil supervision in CB open and CB closed state. Each trip circuit supervision relay shall have at least two potential free contacts.
(b) There shall be at least two DC supply supervision relays for: numerical relay DC supply supervision and Circuit breaker trip supply supervision. The supervision relays shall have at least 2 potential free contacts.
(c) Auxiliary contacts of DC supply circuit breakers (MCB’s) and DC supply supervision relays shall be hardwired to station common PLC. Potential free contacts shall be available for this purpose

7.3.5.8 **Other devices and functions**
(a) At least two test blocks shall be mounted on the front side of the panel. Test block switches shall isolate CT, VT and trip circuits when a test plug is inserted to enable online testing of the numerical and lockout relays.
(b) Emergency pushbutton and lockout reset button to be installed on front side of the panel.
(c) Three status LED lamps shall be installed on the front side of the panels for:
   (i) DC supply failure annunciation,
   (ii) grouped protection alarm/trip annunciation
   (iii) grouped communication failure alarm

7.3.6 **Emergency Diesel Generator (EDG) Protection & control Scheme**

7.3.6.1 The contractor shall study the existing protection scheme, emergency diesel generator and associated equipment data and come up with a comprehensive protection scheme. The scheme shall cover all existing protection functions and others listed below

7.3.6.2 **Protection functions**
(a) The following EDG protection and control functions MUST be provided:
1. EDG Restricted earth fault protection $\Delta I_n$, (87N)
2. Voltage controlled over current protection, $I>$, (51V)
3. Instantaneous, over current protection, $I>>$, (50HS)
4. Negative-sequence (Generator unbalance) protection $I_2>$, $t = f(I_2)$, (46)
5. Earth-fault protection, IEE>, (50 N, 51N)
6. EDG overvoltage protection $V<$, $t = f(V)$, (59)
7. Frequency protection $f<$, $f>$, (81U, 81O)
8. Synchro check, (25)
9. EDG reverse power protection (32R)
10. Under voltage protection (27)
11. Breaker failure protection $I_{min}>$, (50BF)
12. Trip circuit supervision T.C.S. (74TC)
13. EDG protections via binary inputs: engine failure, etc.
14. External trips-bus bar trip, etc.
15. Circuit breaker supervision alarms: trip circuit failure, lockout etc.
16. Lockout function 86DG

(b) During the design stage, the client may include any other protection function (available in the specified numerical relay) deemed necessary for the safe operation of the system

(c) 7.3.6.3 **EDG protection numerical relay**

(a) A numerical protection relay compliant with all specifications in clauses 7.4.2 and 7.4.5 shall be installed and tested.

7.3.6.4 **Field inputs to the protection system**

(a) CT and VT inputs shall be hardwired from the instrument transformer marshalling kiosks and switchboard to the numerical relay.

(b) At least four CT inputs from the EDG switchboard incomer shall be hardwired to the numerical protection relay.

(c) At least three VT inputs from the EDG switchboard incomer and at least one VT input from Main station switchboard bus bar VT shall be hardwired to the numerical protection relay.

(d) At least two isolated binary inputs shall be hardwired for 415V circuit breaker trip coil supervision in both open and closed position else two trip supervision relays shall be installed.
(e) Some field binary inputs to the protection & control system shall be hardwired to auxiliary relays which will do contact multiplication for input to the numerical relay and common PLC. At least 15 (fifteen) interface relays as per clause 3.5.4.4 with 4SPDT potential free contacts shall installed for inputs coupling

(f) Numerical protection relay signalling & control binary inputs from field devices to be wired shall include but not limited to:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Numerical</th>
<th>Auto Control On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse power</td>
<td>EDG ACB Open</td>
<td></td>
</tr>
<tr>
<td>low oil pressure</td>
<td>EDG ACB Closed</td>
<td>Alternator Running</td>
</tr>
<tr>
<td>high water temperature</td>
<td>EDG ACB Trip Coil Failure</td>
<td>Mains Bar to Load</td>
</tr>
<tr>
<td>EDG overspeed</td>
<td>Voltage Ok In EDG</td>
<td>Mains Bar to Load</td>
</tr>
<tr>
<td>Failed to Start</td>
<td>Battery charger fault</td>
<td>Engine Fault</td>
</tr>
<tr>
<td>Low Fuel Level</td>
<td>Sync start</td>
<td>Sync override</td>
</tr>
<tr>
<td>Battery voltage low</td>
<td>Lockout reset input</td>
<td>Remote control ON</td>
</tr>
</tbody>
</table>

7.3.6.5 Tripping, control and annunciation

(a) The numerical relay signalling and control binary outputs to be hardwired to field devices shall include but not limited to:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>EDG ACB Open</th>
<th>EDG ACB Trip Coil Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection grouped alarm</td>
<td>Protection IED failure (watchdog)</td>
<td></td>
</tr>
<tr>
<td>Siren/buzzer</td>
<td>EDG tripped</td>
<td></td>
</tr>
<tr>
<td>EDG Voltage failure</td>
<td>IED communication failure alarm</td>
<td></td>
</tr>
<tr>
<td>EDG auto start</td>
<td>EDG auto stop</td>
<td></td>
</tr>
<tr>
<td>EDG ACB close command</td>
<td>EDG ACB open command</td>
<td></td>
</tr>
<tr>
<td>Voltage raise</td>
<td>Voltage lower</td>
<td></td>
</tr>
<tr>
<td>Frequency raise</td>
<td>Frequency lower</td>
<td></td>
</tr>
</tbody>
</table>

(b) A number (dependent on design) of binary outputs shall be hardwired for circuit breaker closing interlocks

(c) Numerical relay LED’s shall be configured for annunciation of, but not limited to the following functions:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>EDG ACB Trip Coil Failure</th>
<th>Auto Control On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low oil pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth fault trip</td>
<td>Battery &amp; charger fault</td>
<td>Alternator Running</td>
</tr>
<tr>
<td>EDG overspeed</td>
<td>Low Fuel Level</td>
<td>Mains Bar to Load</td>
</tr>
<tr>
<td>Failed to Start</td>
<td>Over current trip</td>
<td>Engine Fault</td>
</tr>
<tr>
<td>EDG protection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EDG protection trip
Operation of the protection scheme (Alarm and Trip) shall initiate the soft siren installed on the GSU transformer protection panel.

7.3.6.6 Supervision relays

(a) There shall be at least three DC supply supervision relays for: numerical relay DC supply supervision, controls supply supervision and Circuit breaker trip supply supervision. The supervision relays shall have at least 2 potential free contacts

(b) Auxiliary contacts of DC supply circuit breakers (MCB’s) and DC supply supervision relays shall be hardwired to the station common PLC. Potential free contacts shall be available for this purpose

7.3.6.7 EDG remote control scheme

(a) The emergency diesel generator is supposed to start automatically after failure of all 415V supplies from station transformers. This auto start automation is to be carried out both in the common PLC and the EDG Protection panel.

(b) EDG is regularly tested, to allow manual start and stop provisions shall be made in the EDG protection panel. Provisions are also to be provided to manually raise /lower voltage and frequency on the EDG protection panel. Remote control of the EDG through common PLC shall be made through manual/auto/remote selector switch.

(c) Three position Key operated switch shall be installed for EDG start control selection with AUTO/MANUAL/REMOTE selections to interlock the EDG start/stop function. Three voltage free contacts of this switch shall be provided for connection to the plant common PLC. The remote function shall be done from the plant common PLC.

(d) Two centre zero (Lower/Neutral.Raise) switches for manual raise and lower of voltage and frequency shall be installed.

(e) Relay logic for Manual and auto start/stop of the EDG shall be realized incorporating the selector switch for AUTO/MANUAL/REMOTE as interlock. Auto start command shall be either from the protection IED or the main station switchboard or Station common PLC. Auto start command shall be interlocked with both main station bus bars voltage fail signal from the switchboard. EDG Circuit breaker closing command shall be interlocked with voltage ok signal, main switchboard local/remote selection and sync override selection. Contactor relays compliant with clause 3.5.3 shall be used for the hardwired control circuit.
(f) Manual synchronisation facility shall be provided for load testing the EDG. The following devices and functionalities shall be provided
(i) Manual synchronisation (functions & interlocks) logic shall be programmed into the protection IED
(ii) shall involve manual voltage & frequency raise/lower to achieve sync conditions. Manual breaker close command shall be interlocked with the numerical relay breaker close command.
(iii) Two of the numerical protection IED function keys shall be configured for circuit breaker open/close command and shall be used for breaker closing command.
(iv) A graphical user interface (GUI) screen shall be programmed in the relay and displayed on the relay LCD to create a visual reference for the operator while carrying out manual synchronisation. The GUI screen shall display the parameters (voltage, frequency and phase difference) of the two systems being synchronised. Where this is not possible a double voltage meter, synchro scope and double frequency meter shall be installed.
(v) Two position key switch for sync override off/on with three potential free contacts shall be installed.
(g) Automatic synchronisation function for the EDG shall also be configured in the relay, interlock between manual synch and auto synch shall be implemented on the relay. Menu selections shall be offered in the relay HMI for choosing auto and manual synch option.
(h) At least four push buttons shall be provided for the following
  Sync start         EDG stop command
  EDG Remote alarm reset    EDG start command

(i) At least 12 (twelve) contactor relays with 8 contacts and compliant with clause 3.5.3 shall be provided for the following control functions.
  EDG CB close command  Frequency raise command  EDG stop command
  EDG CB open command  Frequency lower command  EDG start command
  EDG Remote alarm reset Voltage raise command  Sync start
  Voltage lower command  Sync override

(j)
### 7.3.6.8 Other devices and functions

(a) At least one test block shall be mounted on the front side of the panel. Test block switches shall isolate CT, VT and trip circuits when a test plug is inserted to enable online testing of the numerical and lockout relays.

(b) Emergency pushbutton and lockout reset button to be installed on front side of the panel.

(c) Four status LED lamps shall be installed on the front side of the panels for:
   - DC supply failure annunciation,
   - grouped protection alarm/trip annunciation
   - grouped communication failure alarm
   - grouped EDG failure alarm

### 7.3.7 Tripping matrix

#### 7.3.7.1

The following minimum tripping matrix shown in the diagram below shall be established. However; the scheme requirements are as illustrated in the tender document and drawings.

#### 7.3.7.2

This matrix will be adjusted further during design stage and site commissioning to suite the contractors design and situation at site.

<table>
<thead>
<tr>
<th>Generator Protections</th>
<th>Generator 15 KV CB</th>
<th>415Y ACB Altern. TX</th>
<th>415Y ACB Altern. TX</th>
<th>415Y ACB Altern. TX</th>
<th>41KV Generator TX</th>
<th>132 KV Kamburu line CB</th>
<th>Field Suppression</th>
<th>Governor Shutdown</th>
<th>Diesel Engine step</th>
<th>Alarm annunciation</th>
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</thead>
<tbody>
<tr>
<td>Differential protection</td>
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<td></td>
<td></td>
<td></td>
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<td>Oil temperature Trip</td>
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<td>Tap changer oil pressure trip</td>
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<td>Oil temperature Trip</td>
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<td>Inverse Time Over Current</td>
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<td>Under/over frequency</td>
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</tbody>
</table>
7.3.8 Communication Scheme (Substation Automation System)

7.3.8.1 General requirements

(a) Inter IED information exchange and IED to SCADA information exchange shall be implemented based on substation automation standard IEC61850. This shall be implemented for protection schemes via communication, control functions and for monitoring and fault analysis as detailed in the clauses that follow.

(b) Information exchange in the communication scheme (IED’s, servers and communication network) shall be implemented using IEC61850 (GOOSE & MMS) station bus communication protocols. The scheme shall also be configured for future application of IEC61850-9 SAMPLED VALUES process bus peer to peer network protocol.

(c) The contractor shall carry out all wiring and software provision, programming and configuration necessary to achieve full IEC61850 communication between all IED’s and between all IED’s to SCADA communication gateway.

(d) All IED’s supplied shall be IEC61850 edition 1&2 compliant and all the requisite KEMA certification shall be provided.

(e) The protection communication network shall be configured to meet IEC61850 edition 2 quality of service requirements.

(f) In order to facilitate communication between protection IED’s to employers’ SCADA (which does not support IEC61850) communications gateway shall be installed. Communication between the protection IED’s and the station control PLC’s shall also be provided via a IEC61850 to Modbus TCP/IP gateway.

(g) Contractor shall also configure a gateway to interface LV switchboard devices to the Employer’s SCADA.

7.3.8.2 Functions of the Communication scheme

(a) Protection IED’s time stamped events and alarms shall be exchanged between IED’s and to SCADA. The detailed list or number shall be agreed upon during design stage however at minimum for all configured/enabled protection functions (e.g. differential, overcurrent etc.):

(i) trip/alarm operated (OP)

(ii) trip/alarm Pickups (PKP)

(iii) trip/alarm drop off’s (DPO)

(iv) trip/alarm delay time or operation time
(v) all binary inputs and outputs status
(vi) Other relevant events
for each phase and measuring point (logical node) shall be availed.

(b) Trip/fault log file (IED sequence of event log) shall be sent to SCADA. Trip
log file shall contain time stamped pickup values, trip values and drop off
values for current (differential, restraint, line, neutral, average, zero
sequence, positive sequence, negative sequence etc.), voltage (L-L, L-N,
Average, zero sequence, positive sequence, negative sequence etc.), phase
angles, power, frequency, Digital inputs, digital outputs GOOSE IO etc.
(Trip/fault log is generated by IED’s after occurrence of a fault similar to
COMTRADE files)

(c) Disturbance record data file in COMTRADE format shall be sent over
communication interface to SCADA system. This functionality shall be
implemented for all IED’s with careful consideration not to cause network
overload hence fail to meet IEC61850 GOOSE messaging quality of service
requirements. Automation of this function can be carried out in the
communication gateway server

(d) Protection IED’s configuration data remote access

(e) Measured values from each protection IED measurement point shall be
exchanged between IED’s and SCADA. Instantaneous, RMS, average and
power/energy metering values of, but not limited to:
(i) voltage (L-L, L-N, Average, zero sequence, positive sequence, negative
sequence etc.),
(ii) current (differential, restraint, line, neutral, average, zero sequence,
positive sequence, negative sequence etc.),
(iii) power (P, -P, Q, -Q, S),
(iv) power factor,
(v) frequency,
(vi) energy (WP, -WP, WQ, -WQ, WS),
(vii) harmonic content,
(viii) phase angles etc.
from each configured measurement input.

(f) 132KV circuit breaker control, interlocks and commands shall be
implemented via communication interface with some hardwired interlocks

(g) 415V switchboard incomer ACB breaker fail protection shall be
implemented via information exchange between station loads protection
incomer IEDs' i.e. station transformers protection IED’s, alternative supply protection IED and EDG protection IED.

(h) Station transformer tap changer control and EDG start stop from SCADA shall be implemented via communication interface and hardwiring.

(i) Over current grading and zone selective interlocking functionality

7.3.8.3 Ethernet Local area network set up

(a) All protection IED shall have two 100 or 1000 base-X fibre optic Ethernet ports. All protection IED’s shall be connected each to two Ethernet switches via fibre optic cabling.

(b) Two networks shall be established for redundancy with each network device attached to both networks.

(c) The redundant network shall consist of four (two per network) industrial Ethernet switches and the necessary fibre optic cables, STP cables and terminating equipment.

(d) The industrial Ethernet switches shall have enough ports to support all the IED’s (each with two connections to the switches).

(e) At least four Ethernet switches meeting all the requirements of clause 7.5.3 shall be offered, each Ethernet switches, shall have at least

(i) 12 (twelve) 100 or 1000 base-X fibre optic ports,

(ii) 2 (two) 1000 base-X fibre optic ports for uplink connection

(iii) 8 (eight) 10/100/1000 base-T or 10/100 base-TX Ethernet ports and

(iv) 2 (two) 10/100/1000 base-T gigabit Ethernet ports for uplink connection.

(f) Ethernet switch shall have a Switching bandwidth of at least 28 Gbps

(g) SC or LC or ST connectors shall be used for fibre optic terminations

(h) All Ethernet ports shall be configured for PTP 1EEE1588v2 hardware time stamping/synchronisation

(i) Each Ethernet switch two power supplies shall be connected directly to 110VDC station DC supply.

(j) Each Ethernet switch shall have a SPDT alarm relay with the relay contacts hardwired to the common PLC.

(k) Ethernet switches shall be configured to prevent external access of the protection IED’s. All external communication to the protection network shall be handled by the communication gateway

7.3.8.4 IEC61850 Substation configuration manager

(a) Configuration manager shall be provided to enable configuration of all the IED’s supplied in SCL.
(b) The configuration manager shall have full support of IEC61850 Substation configuration language (SCL). It shall have a simple graphical user interface as previously detailed.

(c) The network and the IED’s shall be configured to prevent IED configuration outside the local area network.

(d) Configuration manager shall be provided for installation to four portable computers, if licences are required four sets of licenses shall be provided supporting unlimited tags and hosts.

(e) Configuration manager shall be a windows application and shall support the latest windows operating system (windows 10 or higher)

7.3.8.5 **IEC61850 Communication Gateways – Software Requirements**

(a) Two industrial PC’s meeting hardware requirements in clause 7.3.8.6 shall be provided to host a communication gateway that shall serve to interface the IE61850 protection IED’s to SCADA and other plant systems.

(b) The two gateways shall be redundant in an active-standby configuration, with the standby gateway taking over in case of failure of the active gateway. All functions in these specifications shall be provided for each gateway.

(c) Communication gateway shall serve as the protocol translator

(i) IEC61850 to Modbus TCP for interfacing to plant control PLC’s and LV circuit breakers as detailed in clause 7.3.8.7

(ii) IEC61850 to OPC for interfacing IED’s to Employers’ SCADA server and other OPC clients as detailed in clause 7.3.8.8

(iii) Modbus TCP to OPC for interfacing LV switchgear to Employers’ SCADA server and other OPC clients as detailed in clause 7.3.8.9

(d) Communication gateways shall be X86/X64 based PC supporting windows and Linux operating systems. The gateways shall support VMware® ESXi™, Microsoft Windows Server 2012 R2 and other Linux based operating systems.

(e) Microsoft Windows Server 2012 R2 or higher shall be provided. At least two (2) Microsoft Windows Server 2012 R2 or higher licences shall be supplied for each gateway.

(f) VMware® software (server edition) shall also be provided for each gateway.

(g) To improve speed and reliability a stable stripped-down Linux based operating system may be installed and windows server 2012 or higher installed as a virtual operating system using VMware. In this configuration, the following may be realised:
(i) Two windows operating systems may be installed on the same hardware failover arrangement such that failure of one operating system switches to the other operating system.

(ii) Virtual windows operating systems may be configured to share the gateway tasks by each operating system serving different functions or handling tasks from IEDS/PLC’s from one unit.

(h) Use of proprietary real time operating system for better system reliability and speed may considered however the system shall be X86/X64 compatible and shall support OPC UA tunneller installation in addition to the gateway applications specified.

(i) The windows operating system shall be optimised and if possible customised to handle fast real time data transfer time to meet requirements of GOOSE message transfer time.

(j) To improve reliability and speed only required applications shall be installed on the gateways. The protocol conversion software shall be optimised to allow fast real time data transfer and low failure rate.

(k) The operating system/s shall be optimized to allow continuous running without reduction in performance.

(l) Gateway shall contain a programmable Logical Processor for logic functions programming and compliant with provisions of IEC61131 for industrial programmable controllers. The (software based) logic controller shall support IEC61131-3 programming languages. Shall support a library with wide range function blocks for automation of some functions at the gateway level.

7.3.8.6 **IEC61850 Communication Gateways – Hardware requirements**

(a) Two industrial PC’s compliant with all requirements of clause 7.5.4 shall be installed and configured as the communication gateway /SCADA interface server.

(b) The industrial PC’s shall have high performance, reliability, and low maintenance and suitable for use in extreme, harsh environments. The gateways shall have performance and reliability similar to protection numerical relays. They shall meet IEC 61850-3:2013 and IEEE 1613-2009 requirements for communication equipment in utility substations.

(c) **SHALL NOT** contain moving parts, such as rotating hard drives and fans.

(d) The gateways shall have an Intel Core i7 processor which shall at minimum have
(i) 4 (four) cores and 8 (eight) threads
(ii) Processor Base Frequency of at least 2.10 GHz
(iii) 6 MB L3 Cache
(iv) 4 x 256 KB L2 Cache

c) The gateways shall have at least 8GB DDR3 ECC PC3-10600 (1333 MHz) RAM

d) Shall contain high-quality single-level cell (SLC) solid-state storage drives; and error-correcting memory technology

e) Shall each have two (2) SATA II 3.0 Gb/s, 512GB SSD’s secondary storage

f) Shall support 10/100/1000 base-TX Ethernet and 1000 base-X fibre optic Ethernet. Shall each have:
   (i) Four (4) 1000Mbps Copper RJ45 Ports and
   (ii) 2 (two) 1000 Mbps fibre optic LC/SC/ST ports.

(g) The Ethernet ports shall support IEEE1588v2 time synchronisation or the PC shall have IRIG-B00X port

(h) The gateway shall be time synchronised to the station PTP grandmaster clock via the Ethernet or via IRIG-B00X

(i) Shall have a dual modular, hot-swappable, DC power supplies connected directly to the 110VDC station DC supply. The power supply shall have a DC input range of 100-130VDC

(j) Shall have at least one SPDT alarm relay. The relay contact shall be hardwired to the common PLC for each gateway.

### 7.3.8.7 IEC61850 to Modbus TCP/IP Gateway Application

(a) Shall host Modbus TCP/IP client (Modbus master) updating the plant modbus devices such as PLC ACB’s and MCCB’s with critical information from the protection IED’s and sending commands from PLC’s to protection IED’s. Translator software shall act as Modbus TCP client (master) with the Modbus devices as server(slave)

(b) IEC61850 to Modbus TCP/IP interface software shall have the following features and functionality

   (i) Translate the plant information by converting the common data types from a Modbus register base approach to the highly structured and named approach of IEC 61850 datatypes using the IEC61850 standard dictionary.
(ii) Creation of IEC61850 standard LNs (Logical Nodes), data objects and CDCs (Common Data Class) for the plant equipment on Modbus network

(c) A configuration file shall be created and loaded into the gateway defining translation rules

(d) The gateway shall be configured and operated to ensure fast transfer of unicast/multicast GOOSE messages from the IEC 61850 network to Modbus devices in time period mimicking a hardwired binary output from relay to PLC. The message transfer time from the creation of IED message (IED time stamp) to the time of receiving the message in the Modbus device (PLC time stamp) shall not exceed 20ms for fast trip messages.

(e) Modbus master in the gateway shall be configured to poll all the configured Modbus devices and update the registers when changes occur in the IEC61850 network. The gateway shall build an internal cache from the Modbus registers to answer IEC 61850 communication request

(f) Modbus to IEC61850 commands shall be transferred seamlessly between the Modbus devices to the protection IED’s. A list of allowable commands shall be configured in the gateway with various access level defined in the configuration file

(g) Modbus to IEC61850 communication errors shall be transmitted to the SCADA server via OPC and annunciate to the operator

(h) Configuration Manager with graphical interface shall be provided to develop and manage gateway configuration files, as well as to view communication and network diagnostics. Such as

   (i) Import CID and SCD files
   (ii) Drag and drop IEC 61850 Data Attributes for Modbus mapping
   (iii) PLC Tag names creation
   (iv) export mapped tag list
   (v) Import PLC Tag file (.CSV or .txt)
   (vi) Import and export data to Microsoft office applications
   (vii) Configuration manager shall be provided for installation to four portable computers, if licences are required four sets of licenses shall be provided supporting unlimited tags and hosts.
   (viii) Configuration manager shall be a windows application and shall support the latest windows operating system (windows 10 or higher)

(i) Only critical signals to equipment protection shall be exchanged with the Modbus devices as shall be agreed upon during design stage.
(j) IEC61850 to Modbus TCP/IP server shall be configured to communicate to a minimum of the following mod bus devices for plant protection & control purposes
   (i) Unit 1 PLC
   (ii) Unit 2 PLC
   (iii) Unit 3 PLC
   (iv) Common PLC
   (v) Main station auxiliaries’ switchboard incomer ACB’s
   (vi) Other Modbus devices considered necessary for protection functionality

(k) Over current grading and zone selective interlocking functionality may be implemented by obtaining data from the Modbus devices

(l) In conjunction with the client contractor shall configure the gateway software to read and write to PLC registers to be provided by the client. It shall be the responsibility of the contractor to ensure seamless transfer of the information to client PLC.

7.3.8.8 **IEC61850 OPC server**

(a) Shall host an I61850 to OPC interface, to enable communication to SCADA server and plant information server. Shall support transfer of all IED events, alarms, fault data, disturbance record (COMTRADE) files and measured values.

(b) Shall support:
   (i) OPC Data Access server
   (ii) Communication diagnostics
   (iii) IEC 61850 data modelling
   (iv) Supervision of IEC 61850 device communication
   (v) IEC 61850 command services.
   (vi) All IEC 61850 data objects:
   (vii) IEC 61850 buffered and unbuffered reporting services
   (viii) IEC 61850 File Transfer
   (ix) IEC 61850 GOOSE receive (received GOOSE data updated to OPC)
   (x) Automatic Disturbance Recording upload using IEC 61850 file transfer or FTP
   (xi) Time synchronization:
   (xii) Multiple instance support
   (xiii) GOOSE Analyzer support
(c) Contractor shall supply and configure the following
   (i) OPC DA server with tags described in clause 7.3.8.2
   (ii) OPC UA tunneller to employers DBS server
   (iii) Carry out IEC61850 client configuration to access tags described in clause 7.3.8.2
   (iv) Configure transfer of event time stamp from the IED to employers DBS server
   (v) Configure Automatic download of disturbance record files and trip log (IED fault SOE) files from IEDs

(d) **Configuration Manager** with graphical interface shall be provided to develop and manage IEC61850 OPC server configuration, as well as to view communication and network diagnostics. Shall support functions such as
   (i) Import and export all types of SCL files i.e. CID, ICD, IID and SCD files
   (ii) Create and configure IEC61850 data objects
   (iii) Perform server and communication diagnostics
   (iv) Monitor communication
   (v) GOOSE and MMS communication protocols configuration and analysis
   (vi) OPC DA server configuration
   (vii) export tag list
   (viii) Import Tag files (.CSV or .txt)
   (ix) Shall be simple to use with a detailed help menu
   (x) Shall have capability of importing and exporting data to/from Microsoft applications
   (xi) Configuration manager shall be provided for installation to four portable computers, if licences are required four sets of licenses shall be provided supporting unlimited tags and hosts.
   (xii) Configuration manager shall be a windows application and shall support the latest windows operating system (windows 10 or higher)

7.3.8.9 **Modbus OPC server for LV switchgear devices**

(a) The low voltage switchboard incomers and feeders shall be interfaced to the SCADA system via communication as described in clause 8.3 of specifications.
(b) Devices such as MCCB’s, some ACB’s, Interfacing PLC’s, panel digital multifunction meters, some digital voltmeters and digital current transducers shall be connected to the SCADA Ethernet switches in the
SCADA cabinet either directly or indirectly via serial device servers as as described in clause 8.3 of specifications.

c) The LV switchboard devices shall communicate via Modbus protocol.

d) Contractor supply, install and configure two (2) Modbus OPC UA or DA servers to interface Modbus devices to the employer SCADA.

(i) Two licenses of Modbus OPC server shall be provided.

(ii) Redundancy with failover shall be provided between the two Modbus OPC servers.

e) The Modbus gateway shall have the following features and functions that shall be configured by the contractor:

(i) Shall communicate with LV switchboard Modbus devices such as MCCB’s, some ACB’s, panel digital multifunction meters, some digital voltmeters and digital current transducers

(ii) Shall handle Time stamping of Modbus devices data and transfer of time stamps from Modbus devices with time stamping capabilities e.g. PLC.

(f) Several tags shall be configured for communication to SCADA system for control monitoring and energy management. Some of the tags shall include

(i) Time stamped LV switch gear status e.g. circuit breaker ON/OFF state, switch gear position (withdrawn, test etc.) from all circuit breakers and withdrawable plug in modules

(ii) Time stamped LV switchgear alarms e.g. overload, overcurrent etc. from all the LV ACB’s, MCCB’s, ATC’s or MMC’s

(iii) LV Switch gear operation commands such as circuit breaker close command etc. for all LV ACB’s, motorised MCCB’s, ATC’s, MMC’s and LV switchgear trip reset commands etc.

(iv) Switchgear operations counter for all MCCB’s, ACB’s and ATC’s

(v) Metering information for all switchboard incomers from the digital multifunction meters such as:

- AC voltage phase-neutral conductor Vph-N: Va, Vb, Vc
- AC voltage phase-phase Vph-ph: Vab, Vbc, Vca
- AC phase current (current through the conductor): Ia, Ib, Ic
- AC voltage across the neutral conductor: VN
- Unbalanced voltage: Vunbal
- Unbalanced current: Iunbal
- Mean value of the 3 phase voltages: Vavg
- Current in neutral conductor: IN
- Mean value of the 3 phase currents: Iavg
- Active power factor $\cos \varphi$: $\cos \varphi (a), \cos \varphi (b), \cos \varphi (c), \cos \varphi$
- Power factor PF: PFa, PFb, PFc, PF
- Phase angle $\varphi$: $\varphi_a, \varphi_b, \varphi_c, \varphi$
- Frequency (power frequency): f
- Active power P: Pa, Pb, Pc, P
- Reactive power Q: Qa, Qb, Qc, Q
- Apparent power S: Sa, Sb, Sc, S
- Active energy WP: WPa, WPb, WPc, WP (for supply and demand respectively- four quadrants)
- Reactive energy WQ: WQA, WQB, WQC, WQ (inductive and capacitive respectively- four quadrants)
- Apparent energy WS: WSa, WSB, WSc, WS

(vi) Metering information from all switch board cable feeders such as
- Phase currents Ia, Ib, Ic
- Neutral conductor / residual currents, In
- Time stamped Max Phase currents

(vii) Switchboards bus bar voltages

(viii) Other LV switchgear data relevant to plant monitoring, control and management

(g) Configuration Manager for configuring the Modbus OPC server with graphical interface shall be provided.

(i) It shall be used to develop and manage the Modbus devices and OPC server configuration, as well as to view communication and network diagnostics.

(ii) Shall support the following functions:
- Create and configure OPC data objects
- Configure mod bus devices
- Perform server and communication diagnostics
- Tag database creation and update
- Monitor communication
- OPC UA or DA server configuration
- Export tag list
• Import Tag files (.CSV or .txt)
  (iii) Shall be simple to use with a detailed help menu
  (iv) Shall have capability of importing and exporting data to/from Microsoft applications
  (v) Configuration manager shall be provided for installation to four computers, if licences are required four sets of licenses shall be provided supporting unlimited tags and hosts.
  (vi) Configuration manager shall be a windows application and shall support the latest windows operating system (windows 10 or higher)
  (vii) A tool for easy management of plant tags e.g. in Microsoft access or excel with macros shall be provided for updating the tag databases and for future update of tags
  (h) A configuration/programming software shall be provided for the Switchboard interfacing PLC if used to interface the switch boards to SCADA. The software shall have at least two licences for installing the software into at least two computers

7.3.8.10 OPC UA tunneller

(a) Shall link OPC DA server to OPC DA clients across a network
(b) Shall convert OPC DA to OPC UA at the server side and then convert back OPC UA to OPC DA for OPC DA clients
(c) Transport across the network shall be as per OPC UA (HTTPS, native binary+TCP etc)
(d) Shall provide a link between an OPC DA server and OPC UA client
(e) Shall support the following OPC protocols
   (i) OPC UA 1.03 and higher
   (ii) OPC DA 3.0 and higher
(f) Contractor shall supply and configure OPC UA tunneller for interfacing the two gateways OPC UA/DA servers to the employers SCADA DBS server OPC DA client for all tags described in the previous clauses.
(g) Tunneller shall support installation to windows 2012 R2 server.
7.3.8.11 **Communication Gateway Panel**

(a) A panel shall be provided to house the components of the communication gateway. The cabinet shall meet the requirements in clause 7.5.1.

(b) The panel shall contain all equipment and devices necessary for the operation of the communication scheme as detailed in the preceding clauses. At minimum it shall contain the following:

(i) Four (4) rack mount Industrial Ethernet switches as detailed in clause 7.3.8.3.

(ii) Two (2) gateway industrial PC meeting requirements of clause 7.3.8.6.

(iii) One (1) PTP Grandmaster clock/Time server meeting requirements of clause 7.3.8.6.

(iv) One (1) 19” industrial Touch monitor and KVM switch

(v) At least Three (3) 24 port rack mount Fibre optic patch panels

(vi) At least Two (2) 24 port rack mount RJ45 STP ethernet patch panels

(vii) at least two (2) DC DP Miniature circuit breakers

(viii) at least two (2) AC DP Miniature circuit breakers

(ix) A set of terminal blocks for auxiliary supplies wiring

(x) A set of terminal blocks for control wiring

(xi) At least two panel fans each with Air throughput of at least 500m³/h

(xii) 2(two) panel LED lighting lamps

(xiii) 2(two) door operated switches

(xiv) Two (2) European type single phase socket outlets

(xv) Two (2) British type single phase socket outlets

(xvi) Other devices required for communication gateway and protection IED communication

(c) Each gateway industrial shall be connected to two redundant independent networks i.e. protection network and SCADA network. Two gigabit ethernet ports (twisted pair 10/100/1000 base-T, RJ45) of each server shall be wired to the Employers’ SCADA cabinet where they are two ethernet LAN’s. The gateway shall also be connected to the two protection ethernet LAN’s via two fibre optic ports with SC/LC/ST connectors

(d) PTP Grandmaster clock/Time server shall be connected to both SCADA and protection networks. One NTP ethernet port shall be wired to the Employers’ SCADA cabinet ethernet switch.
7.3.9 **Protection Devices Software Licences**

All software’s and licences shall be provided all software configurable devices and applications supplied under the contract. This Clause only summarises the software licences requirement for the bidder, the licences requirements are not limited to what is stated below. It’s the bidders’ obligation to supply at least two necessary licences that are not stated below. All Licenses **MUST be one off license** without any annual payment. Where annual payment is required the employer shall when evaluating add a cost of 15-year licences payment to the bidders’ price for bid comparison.

7.3.9.1 A minimum of four (4) configuration (programming) manager licences are expected, two from each manufacturer of the IED’s. If IED’s are from more than two manufactures, or more than one software is required from one manufacturer then two software licences shall be provided for each software. Two (2) IED configuration manager licences for installation into two portable computers shall be provided for each of the following:

(a) Generator protection A IED  
(b) Generator protection B IED  
(c) GSU transformer protection A IED  
(d) GSU transformer protection B IED  
(e) Station transformers protection IED  
(f) Alternative supply transformer protection IED  
(g) EDG protection IED  
(h) Synchronising IED  
(i) Any other protection IED offered

7.3.9.2 Two (2) licenses for installation into two portable computers for each of the devices below. Web configuration with access to all settings may be provided instead of licensed software for devices listed below. Configuration software with license where applicable to be provided for the following software configurable devices:

(a) Generator power transducer  
(b) PTP grandmaster clock/time server  
(c) Industrial ethernet switches

7.3.9.3 Four (4) Licences of IEC61850 substation configuration manager

7.3.9.4 System Software License requirements for the IEC61850 gateway
7.3.9.5 Communication protocols Software License requirements for the IEC61850 gateway

(a) Three (3) OPC (DA or UA) servers and IEC6180 client for IEC61850 OPC servers supporting both GOOSE and MMS, licences, one for each gateway and one extra for employers’ use

(b) Three (3) Modbus TCP client (RTU master) and IEC6180 client for IEC61850 Modbus gateways supporting both GOOSE and MMS, licences, one for each gateway and one extra for employers’ use

(c) Three (3) OPC (DA or UA) servers and Modbus TCP client for Modbus OPC servers one for each gateway and one extra for employers’ use

(d) Four (4) OPC UA tunneller licences one for each gateway and two extra for employers’ use

7.3.9.6 Software applications Configuration Managers License requirements for the IEC61850 gateway

(a) Four (4) IEC61850 Modbus TCP client configuration manager licences for installation into four portable computers

(b) Four (4) IEC61850 OPC server configuration manager licences for installation into four portable computers

(c) Four (4) Modbus OPC server configuration manager licences for installation into four portable computers

(d) The above (a-c) three configuration managers may be provided as one or two applications supporting all the functions described in the previous clauses. In this case four licenses to be provided for each application

7.3.9.7 Two (2) Gateway hardware configuration (IEC61131-3 programming) manager licences for installation into two portable computers

7.3.9.8
7.4 NUMERICAL PROTECTION RELAYS SPECIFICATIONS

7.4.1 General Specifications of numerical protection relays

7.4.1.1 Numerical relays shall be microprocessor-based relays with programmable scheme logic and advanced digital signal processing capabilities.

7.4.1.2 All numerical relays shall conform to the requirements of the following standards.

(a) device design meets the technical specifications of IEC 60255 and IEEE C37.90

(b) Electrical tests shall be performed as per IEC 60255 (product standards)

(c) IEEE-1613 & IEC61850-3 testing requirements for communications networking devices in electric power substations.

(d) Automation functions for protection and automation can be freely created in the operating program according to IEC 61131

(e) Function device numbers, acronyms, contact designation and device representation shall be as per IEEE C37.2-2008 apart for communication functions which shall be as per IEC61850

(f) IEC 61850 substation control and automation standard. KEMA Certification for the particular model offered with respect to IEC61850 Protocol

(g) Other relevant IEC or IEEE standards

7.4.1.3 ALL numerical relays shall be suitably rated to use station 110VDC supply DIRECTLY without intermediary power supply units.

7.4.1.4 Relays menu and software shall be in ENGLISH LANGUAGE ONLY

7.4.1.5 All relay shall be designed for satisfactory performance under tropical and humid conditions specified. Special mention, shall be made in the technical deviation schedule of the bid for those relays, if any, that Bidder proposes to use, which differ from specified requirements.

7.4.1.6 All devices required for correct operation of each relay shall be provided by contractor without any extra cost.

7.4.1.7 The contractor shall ensure that the terminals of the contacts of the relays are readily brought out for connections as required in the final approved scheme. The type of relay case offered shall not create any restrictions of the availability of the contact terminals for wiring connections.

7.4.1.8 All protection relays shall have a provision for online testing with necessary test blocks for isolating VT’s inputs, CT’s inputs & trip out puts without withdrawing the relays from the panel. These test blocks shall be mounted on the front side of
the panel and shall be accessible without opening the panel. Each relay shall have its own test block close to where the relay is mounted.

7.4.2 **Principal Technical Specifications for all Numerical Protection Relays/IEDs**

All Numerical relays shall conform to the following specifications:

7.4.2.1 **Relay construction and mounting**

(a) Shall be panel mounted, flush mounted on the front of the panel with connections from the rear.

(b) Complete mechanical/electrical & atmospheric environmental protection/immunity as per relevant standards.

(c) Relays shall meet the requirement of IEC 60255.

(d) Shall be rated for operation at ambient temperature up to 55°C and Humidity of up to 100%

(e) They shall be contained in dust proof flush mounted cases with glass fronts.

(f) All relays shall have a provision for online testing with necessary test blocks (to be located on the front panels) without withdrawing the relays from the panel.

(g) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

(h) All relays shall be well labelled on the front and at the back of the relay.

(i) All unused terminals shall also be provided with screws washers, lugs etc. and wired to terminal blocks.

(j) Relay ingress protection on the front shall be at least IP54 and at least IP 20 at the back according to IEC 60529

(k) To provide the necessary immunity against electromagnetic interference the physical separation of the interfaces from the signal processing shall be ensured. Galvanic isolation from shielded interposing transformers as well as relays for binary outputs shall be provided.

(l) Each IED shall be clearly marked with manufacturer’s Name, type, serial number and electrical rating data. Name plates shall be made of anodized aluminium with white engraving on black surface.

7.4.2.2 **Relay basic features**

The following shall be possible with all the numerical relays:

(a) Setting of parameters on device display and using a laptop.

(b) Logging and display of time stamped events.
(c) Recording and display of fault data
(d) Non-volatile storage of settings
(e) Testing of relay functions.
(f) Transmittal of data to external equipment via communication interface
(g) binary Inputs of status/alarms/trips from external devices
(h) CT/VT current/voltage inputs
(i) Tripping and signalling binary outputs
(j) Local display (on relay) of events, faults, settings and metering values
(k) Time synchronisation

7.4.2.3 Relay Human Machine Interface features and functionality

(a) The relays shall have a local friendly password-protected user man-machine interface (MMI) comprising of a graphical backlit LCD display, LED’s and a soft touch key pad to access the settings, events and records in the relay.
(b) Graphical LCD MUST be at minimum be 100mm X 65mm in size. Displayed characters shall be big enough be clearly legible 2metres away from the relay. Single line diagrams shall be configured easy viewing of switchgear status on the relay local display
(c) Relays Shall have a numeric keypad and at least 4 freely assignable function keys
(d) The relays shall have a minimum of the following displays/menus on the LCD to be used for setting, measuring and diagnostic purposes: -
   (i) Menu/screen for display of measured values. (U, I, P, Q, f, Ø, pf etc.)
   (ii) Menu/screen for display of event log
   (iii) Menu/screen for display of trip log
   (iv) Menu/screen for display of general system data of protected equipment
   (v) Menu/screen for display of binary input and output status.
   (vi) Menu/screen for forcing binary inputs and outputs
   (vii) Menu/screen for setting and display of all protection function settings
   (viii)Menu/screen for display of device settings
   (ix) Menu/screen for display of diagnostic status.
(e) The relays shall annunciate faults via both labelled LEDs (which shall remain latched until reset by user) and on the LCD display window.
(f) Software package with requisite license keys shall be supplied for installation into at least two portable computers(laptop) to provide a graphical user interface (GUI) to the relay.
(g) Software provided shall enable a full interface to all relay functionality, displaying all relay parameters, allowing logic programming and relay
settings adjustment. User shall easily connect the laptop to the relay via a front USB/Ethernet port

(h) Relay shall be able to communicate to SCADA system via Ethernet ports. The SCADA system shall be able to read/extract: relay settings, metering values, binary input & outputs status, fault and event records, oscillographic (disturbance) records and relay status

(i) The user manuals must be user-friendly and divided into: general hardware and software description and setting manual describing the enabled functions and necessary settings for the different types of equipment in the plant

7.4.2.4 Metering function

(a) Relays shall carry out measurement and display of power parameters such as RMS current, I; RMS voltage, U; Active power, –P/P; Reactive power, Q/-Q; Apparent power, S; Energy, KWH (four quadrants); power factor and frequency.

(b) Transmittal of this metering values to SCADA shall be possible via IEC61850 communication interface

(c) Metering accuracy shall be at least 0.3% for voltage & current and 0.5% for power measurements

7.4.2.5 Event and fault-recorder

(a) Event logger

(i) Protection IED’s shall contain a record of events such as

- change of binary input and output status
- Operation of a protection function
- Change of IED setting
- Any other important event

(ii) The events shall be stored in a chronological order and shall be stored in non-volatile relay memory.

(iii) All protection IED’s shall be capable of storing at least 200 events in the IED’s event log

(iv) The IED event log shall be accessible on the relay display and remotely via communication.

(b) fault Logger (Sequence of events recorder-SOE)
(i) During a fault the protection IED’s shall be configured to store operating data/measured values and record sequence of events with time stamps during the fault

(ii) Each fault log (SOE) file shall contain all the necessary discrete variables that change state leading to the fault and during the fault with time stamps. The measured values with time stamp shall be captured at the instance of protection function pickup, operation and drop-off

(iii) All necessary measured values from the CT/VT inputs shall be included in each fault log file as a minimum the following shall be included:
   - Instantaneous current in each winding (A) both magnitude and phase for zero sequence, negative sequence and positive sequence currents
   - Differential current (A) and restraint current (A)
   - All phase-phase, phase-neutral and neutral to ground Voltage (V) both magnitude and phase
   - Frequency (Hz), power factor and slip
   - Active, reactive & apparent Power (P, -P, Q, -Q, S)

(iv) The fault log files shall be stored be in a chronological order and shall be stored in non-volatile relay memory.

(v) All protection IED’s shall be capable of storing at least ten fault logs in the IED’s non-volatile memory

(vi) Fault logger shall be accessible on the relay display, using a laptop and through SCADA interfaces.

(vii) The relay shall have capability to upload fault log file to the SCADA system

(c) Disturbance recorder

(i) For any trip function of the relays, the disturbance recorder shall record all inputs and outputs prior, during and after fault. Recording of analogue signals and digital signals (inputs & outputs) before, during and after the pickup of the protection function (fault data) shall be stored as oscillographic (disturbance) records in standard COMTRADE format.

(ii) The Oscillographic fault recorder shall have a sampling rate of at least 20 samples per cycle. Shall accurately record 5th harmonic and above

(iii) The recording shall be for at least 10 seconds before the fault and at least 30 seconds after the fault.
(iv) Any disturbance record shall automatically be numbered sequentially in chronological order. The recording of events shall be in a chronological order and shall be stored in non-volatile flash memory.

(v) All protection IED’s shall be capable of storing at least ten disturbance records in the IED’s non-volatile memory

(vi) A minimum of the following Measurements shall be recorded during a fault for oscillographic (disturbance) records in standard COMTRADE format:

- Current in each phase of the protected object (A)
- Differential and restraint current for each phase of the protected object (A)
- All phase-phase, phase-neutral and neutral to ground Voltage (V)
- Frequency (Hz)
- Active, reactive & apparent Power (P, -P, Q, -Q, S)
- At least 20 binary inputs and outputs such as Trip outputs and breaker status inputs

(vii) The necessary tools for data retrieval shall be furnished to the employer after commissioning.

(viii) The relay shall have capability to upload fault & disturbance records to the SCADA system

7.4.2.6 Relay Inputs and outputs

(a) The numerical relays inputs & outputs shall have galvanic isolation. Optical isolation for all binary inputs and outputs, transformer isolation for CT & VT inputs, relay isolation for trip outputs and suitable galvanic isolation dependent on application for all other inputs and outputs.

(b) Numerical Relay CT inputs shall a nominal rating of 5A &1A (selectable) and VT inputs shall have a nominal rating of 110/400VAC

(c) Analogue CT & VT inputs shall be rated as follows

(i) Sampling rate: >8Khz

(ii) Input resolution:

- Voltage: <0.01V
- Current: <0.005A

(iii) measurement tolerance at ambient temperature of 0°C — 50°C and 100% humidity

- Voltage and current inputs: <±0.3 %
- Frequency: ≤ ±10 mHz
- Power factor :<±0.02

(d) There shall be galvanic isolation on all inputs and outputs including power supply input.

(e) All relay inputs terminals shall be ring lug screw terminals

(f) All numerical relay inputs must accept the rated operating voltage from 24-240 V AC/DC without the use of external resistors and without external reconnections.

(g) Protection IED tripping binary outputs contacts shall have a rating of at least 5A continuous current at 120Vdc and Make current rating of 30A for 1s

(h) Numerical relays shall be suitable for direct connection to circuit breaker tripping coils and thus the tripping binary outputs shall be able to withstand breaker trip coil current as per above

(i) Protection IED's outputs (output relays) operating time shall be less than 5 milliseconds

7.4.2.7 Monitoring and diagnostic features

(a) The relays shall have a self-monitoring and diagnostic feature that shall enable the protection system to recognize any defective unit immediately.

(b) The relay shall annunciate via an LED and open a normally closed contact if the relay is faulty i.e. irregularities in the hardware/software are detected or when relay loses auxiliary power supply

(c) Self-tests shall include a minimum of the following functions:

(i) Continuous self-monitoring by the hardware.

(ii) Cyclically performed testing routines by software.

(iii) Power supply checks.

(iv) Memory integrity checks.

(v) Validity of data exchange between memories, process units and I/O modules.

(d) Relay shall have inbuilt capability for continuous monitoring and supervision of CTs & VTs circuit and tripping circuit status

7.4.2.8 Auxiliary supply

(a) The relay's power supply must accept a rated operating voltage input range from 24-240 VDC without the use of external resistors and without external reconnections and shall be designed to withstand the high voltage interference which is normally experienced in high voltage switching stations
(b) Relay nominal rated auxiliary supply voltage shall be 110VDC. The relays shall operate at voltages down to 70% of the rated voltage and up to over 130% rated voltage without compromising any of its functionality.

(c) All possible precautions shall be taken to ensure that DC operated relays which perform a tripping function are not liable to mal-operation. For this reason, the total capacitance to earth of all connections to either pole of the tripping battery shall not exceed 10 microfarads.

7.4.2.9 Configuration and settings

(a) The relays shall be easily adaptable to various protection objects of different ratings and according to desired scope of protection.

(b) Relays shall have wide setting ranges with fine setting steps for each of the protection function. All the protection functions shall be set within their wide predetermined ranges, with limitations preventing inadmissible settings.

(c) Binary inputs shall be freely assignable to any logic input.

(d) Each configurable output shall be free to assign different parameters and should be independently latched.

(e) Trip outputs and LED’s shall remain latched even after the fault clears until reset by a reset button on relay faceplate or via binary input or via communication interface. This feature shall be configurable for each protection function.

(f) The relay settings shall be provided with adequate password protection.

(g) It shall be possible to change the relay setting from the front panel using the keypads.

(h) Relays shall have capability for retrieval of relay settings through a local display, a portable computer/laptop and HMI/SCADA system.

(i) Setting of numerical relay parameters, shall only be possible via a portable PC/laptop and via the local display with the aid of a password.

7.4.2.10 Communication interface

(a) Relays MUST have either Ethernet or USB port on front side for communication with portable computer.

(b) Relays MUST have at least two fibre optic 100 Base-X or 1000 Base-X Ethernet ports with LC/SC/ST connector on rear side for communication with SCADA system and other relays.

(c) Necessary licensed copy of software and hardware to up load/ down load data to/from the relay or from/to the SCADA system shall be provided. Relay shall be interfaced by Fibre Optic to Ethernet switch to be supplied by the contractor.
The relays MUST have full IEC 61850 ed.2 support over Ethernet.

Relay should generate GOOSE message as per IEC 61850 standard for interlocking and tripping. GOOSE messaging Interoperability with third party relays shall be guaranteed.

IEC61850 Conformance Test certificate by KEMA shall be submitted along with Bid.

7.4.2.11 Relay software

Relay software shall support all the specified functions and have a versatile graphical user interface to enable easy and versatile setting configuration.

Relay software shall be suitable for operations like switching, retrieval of information or changing of setting groups, retrieval of oscillographic fault data from the relay memory and to store fault record data oscillographic records in standard COMTRADE format.

The software shall be suitable to provide oscillographic data into several different graphical representations that can be used to analyse the fault or event captured by the relay. It shall also be possible to calculate additional values from the captured signals and displaying analogue curve with time base phasor diagram locus diagrams, harmonic graphs etc.

It shall be possible to transfer the fault/disturbance data stored in the numerical relay to computer on IEEE/COMTRADE format. The data format shall be compatible for dynamic protection relay testing on relay test kit. COMTRADE Data viewer software is to be provided.

Software shall include testing features using the relay display & keypad such as forcing binary inputs and outputs or through a software loaded in a laptop.

The relay should have native (without protocol converter) IEC 61850 Communication Protocol.

Corporate license for installation on unlimited number of PCs shall be provided.

Relay software shall include a Graphic logic editor for creating powerful automation functions in the device. Large number of logic blocks and timers for user adaptation shall be provided.

Relay shall support IEC61131-3 function block diagram language or continuous functional chart (CFC) language.

At least one laptop shall be provided with all relay software’s & applications, settings backup and test objects. Laptop shall be as specified in clause 1.13.5.
7.4.2.12 **Date and Time stamping and Time synchronisation**

(a) All numerical protection relays shall have an internal real time hardware clock powered from internal rechargeable cell. Real time clock setting shall not be required after every DC switching. The internal rechargeable cell shall not require replacement thought the lifetime of the protection IED, the internal cell shall have a lifespan of at least 15 years.

(b) All numerical protection relays shall support IEEE1588 Precision Time Protocol, Time Synchronization on both Ethernet ports OR Shall support IRIG B00X time synchronisation with a fibre optic DCLS IRIG port for time synchronisation. Where relay has IRIG port a converter shall be provided for converting PTP to IRIG time code standard and interface.

(c) Time synchronisation accuracy shall exceed 10µs (shall be below 10µs)

(d) All fault records and events shall be time stamped to 1ms accuracy by the relay.

(e) Relay shall be synchronized to a time server on the network via PTP directly or through an IRIG port.

(f) Where an IRIG port is used time code format shall be B00X with year information, the interface port shall be fibre optic DCLS with ST/LC/SC connector

7.4.2.13 **Relays’ setting determinations**

(a) Using the existing current transformers, voltage transformers, generators, transformers, circuit breakers etc. the contractor shall carry out calculations to determine the required settings for all the protection functions. The contractor will request the required data from the client after the tender award.

(b) The contractor shall also determine through calculations whether existing current transformers and voltage transformers are suitable and enough for the new digital relays.

(c) A list of the settings to be applied to all protection systems together with all associated calculations, shall be provided for review and approval prior to shipment of equipment

(d) Any limitations imposed on the power system because of the settings proposed shall be explicitly stated.

(e) Relay settings configuration file shall be created, reviewed and approved in a similar fashion to drawings
(f) In the absence of system data required for calculation purposes, assumptions may be made providing these are clearly identified as such in the relevant calculations.

7.4.2.14 **Numerical relays Lifespan**

The bidder shall mention following:

(a) Product maturity: The Bidder should mention the time period for which the product has been in the market

(b) Expected production life of the relay

(c) Hardware/Firmware change notification process. Upgrades to be provided free of cost within the warranty period, if needed.

(d) Lifespan of standard tools and processes for relay configuration, querying and integration

7.4.2.15 **Support service for numerical relays**

The Bidder shall give guarantee of at least 15 years from the date of last supply in respect of service support and availability of spares. Any problem in the said period should be attended whenever asked for inclusive of repair/replacement of relays/component (both Hard Ware, Soft Ware) at the employer’s cost after warranty period.

7.4.3 **Generator Numerical Protection Relays Specifications**

In addition, or as complimentary to the principal specifications for all numerical relays to be supplied, generator protection relay must fulfil the specifications below. Where specifications given in this clause contradict principal specifications, specifications in this clause shall prevail for generator numerical protection relays.

7.4.3.1 Generator protection IED’s shall have At least 4 freely assignable function keys and a Numeric keypad

7.4.3.2 Generator protection IED’s shall have a large graphical LCD which MUST at minimum be **100mm X 65mm** in size

7.4.3.3 Generator protection IED’s shall have at least 14 freely programmable LEDs

7.4.3.4 Generator protection relays shall have current transformer inputs Rated at 5A/1A, selectable.

7.4.3.5 Generator protection IED’s shall have at least **twelve (12)** current inputs, **eight (8)** voltage inputs, 3 analogue (4 -20 mA) inputs, **twenty-four (24)** binary inputs and **twenty-four (24)** binary outputs and 1 life contact(watchdog)
7.4.3.6 Generator protection IED’s rated auxiliary voltages shall be: 60 to 250 V DC and 115 to 230 V AC. They shall operate at nominal supply voltage of 110VDC±30%.

7.4.3.7 Generator protection IED’s shall have Ethernet or USB Front operating interface.

7.4.3.8 Generator protection IED’s shall have two IEC61850 Ethernet, 100 Base-X or 1000Base-X fibre optical ports, with LC/ST/SC connectors, integrated switch and full IEC 61850 support communication interface.

7.4.3.9 The IEC61850 Ethernet ports shall support Precision Time Protocol(PTP), IEEE1588v2 and relay shall be synchronised to the station PTP grandmaster clock. Where relay does not support PTP v2, relay shall have an IRIG-B00X fibre optic DCLS port and a converter for PTP to IRIG-B00X fibre optic ST/LC connector shall be provided.

7.4.3.10 Generator protection IED’s shall have a graphic logic editor for creating powerful automation functions in the device. Large number of logic blocks and timers for user adaptation shall be provided.

7.4.3.11 Generator protection IED’s MUST support all the following integral protection and control functions:

1. 100% stator ground fault protection with 20 Hz voltage injection (64G)
2. 100% stator ground fault protection by 3rd harmonics (27 TH, 59 TH)
3. 95% Stator ground fault protection (59N/64)
4. Inter-turn fault protection (59N (IT))
5. Impedance protection (21)
6. Over excitation protection (24)
7. Under voltage protection (27)
8. Reverse power protection (32R)
9. Power supervision (32P/Q)
10. Temperature supervision (38)
11. Under excitation protection (40)
12. DC voltage/DC current protection (59N, 51N (DC))
13. Unbalanced load protection (46)
14. Phase-sequence-voltage supervision (47)
15. Thermal overload protection for the stator (49)
16. Instantaneous over current protection (50/50N)
17. Time-over current protection (51/51N)
18. Sensitive ground-current protection (51N)
19. Shaft current protection (50GN)
20. Breaker failure protection (50BF)
21. Over current protection, voltage restrained (51V)
22. Inadvertent energization / protection (50/27)
23. Overvoltage protection (59)
24. VT fuse fail monitoring (60FL)
25. Rotor ground fault protection with low frequency injection (64R)
26. Dir. time-over current protection, phases (67)
27. Directional stator ground fault protection (67Ns)
28. Trip-circuit supervision (74TC)
29. Out-of-step protection function (78)
30. Frequency (under & over) protection (81)
31. Lockout (86)
32. Differential protection (87)
33. Differential ground-fault protection, REF (87N)
34. Power swing detection & blocking
35. Changeover of setting group (automatic/programmable)
36. Measured values
37. Switching statistic counters
38. Logic editor
39. Fault recording of analogue and binary signals
40. External trip initiation
41. Circuit breaker test & monitoring
42. Control, Monitoring and supervision

7.4.4 Generator Step-up Transformer Protection Numerical Relays Specifications

In addition, or as complimentary to the principal specifications for all numerical relays to be supplied, generator transformer protection relay must fulfil the specifications below. Where specifications given in this clause (7.4.4) contradict principal specifications, specifications in this clause (7.4.4) shall prevail for generator transformer protection relays.

7.4.4.1 Generator step up transformer protection relays shall be suited for transmission level transformers. They shall be optimised for generator step up transformer.

7.4.4.2 Generator transformer protection relays shall have freely assignable function keys, Numeric keypad and scroll keys all scratch resistant.

7.4.4.3 They shall have Flexible adaptation to the transformer vector group and various transformer ratios, controlling of closing and over excitation processes and safe behaviour in the case of current transformer saturation.
7.4.4.4 **They shall have differential protection with add-on stabilization and inrush stabilization**

7.4.4.5 **They shall have Adaptive adjustment of the trip characteristic to the transformer tapping**

7.4.4.6 **They shall have at least 16 LED’s freely programmable**

7.4.4.7 **They shall have a large graphical LCD which MUST at minimum be 100mm X 65mm in size**

7.4.4.8 **They shall have current transformer inputs Rated at 5A / 1A, selectable.**

7.4.4.9 **The number of inputs and outputs shall be flexible and adaptable in a modular system.**

7.4.4.10 **Relays shall be for suited for a two-winding transformer with four measuring points.**

7.4.4.11 **They shall have at least: 14 (fourteen) current inputs, 8 (eight) voltage inputs, 38 (thirty-eight) Binary inputs, 24 (twenty-four) Binary Outputs and 1 life contact (watchdog).**

7.4.4.12 **They shall have rated auxiliary voltage of 60 to 250 V DC and 115 to 230 V AC. Nominal supply to the IED shall be 110VDC±30%**

7.4.4.13 **They shall have an Ethernet or USB Front operating interface**

7.4.4.14 **They shall have a graphic logic editor for creating powerful automation functions in the device. Large number of logic blocks and timers for user adaptation shall be provided**

7.4.4.15 **They shall have two IEC61850 Ethernet, 100 Base-X or 1000Base-X fibre optical ports, with LC/ST/SC connectors, integrated switch and full IEC 61850 support communication interface.**

7.4.4.16 **The IEC61850 Ethernet ports shall support Precision Time Protocol(PTP), IEEE1588v2 and relay shall be synchronised to the station PTP grandmaster clock. Where relay does not support PTP v2, relay shall have an IRIG-B00X fibre optic DCLS port and a converter for PTP to IRIG-B00X fibre optic ST/LC connector shall be provided**

7.4.4.17 **They Shall have all the following integral protection and control functions**

1. Distance protection (21)
2. Over excitation protection (24)
3. Synchro check, synchronizing function (25)
4. Under voltage protection (27)
5. Power protection active/reactive power (32, 37)
6. Temperature supervision (38)
7. Negative sequence over current protection (46)
8. negative-sequence voltage protection (47)
9. Thermal overload protection (49)
10. Hot spot calculation and aging (49H)
11. Instantaneous over current protection (50/50N)
12. Inverse time-over current protection (51/51N)
13. Circuit-breaker failure protection (50BF)
14. Voltage dependent over current protection (51V)
15. Overvoltage protection (59)
16. Neutral voltage displacement (59N)
17. VT fuse fail monitoring (60FL)
18. Directional over current protection (67, 67N)
19. Trip-circuit supervision (74TC)
20. Frequency (under & over) protection (81)
21. Rate-of-frequency-change protection (81R)
22. Lockout (86)
23. Differential protection (87)
24. Differential ground-fault protection, REF (87N)
25. Automatic voltage control (90V)
26. Measured values
27. Logic editor
28. Switching-statistic counters
29. Inrush-current detection
30. External trip initiation
31. Control, Monitoring and supervision
32. Fault recording of analogue and binary signals
33. Changeover of setting group (automatic/programmable)
34. Circuit breaker test
35. Fault locator FL
36. Circuit breakers wear monitoring
37. Power-swing blocking

7.4.5 Station transformers & EDG Protection Numerical Relays Specifications

Numerical relays shall be supplied for protection of station transformers, alternative supply transformer and emergency diesel generator. Relays shall be suitable for wide range of protection schemes i.e. feeder protection, generator protection and transformer protection.
7.4.5.1 They shall have at least 4 (four) freely assignable function keys and a Numeric keypad.

7.4.5.2 They shall have at least 16 LED’s freely programmable.

7.4.5.3 They shall have a large graphical LCD which MUST at minimum be 100mm X 60mm in size.

7.4.5.4 They shall have Current transformer inputs Rated at 5A / 1A, selectable.

7.4.5.5 The number of inputs and outputs shall be flexible and adaptable in a modular system.

7.4.5.6 They shall have the following analogue and binary input/output options:

(a) For Station transformers protection IED
   (i) One protection IED with at least: 4 current inputs, 4 voltage inputs, 34 Binary inputs, 25 Binary Outputs and 1 life contact (watchdog).
   OR
   (ii) Two protection IEDs,
       first the main protection IED with at least 4 current inputs, 4 voltage inputs, 23 Binary inputs, 16 Binary Outputs and 1 life contact (watchdog).
       Second the OLTC AVC IED with at least 4 current inputs, 4 voltage inputs, 11 Binary inputs, 9 Binary Outputs and 1 life contact (watchdog).

(b) For alternative supply transformer protection IEDs at least: 7 current inputs, 4 voltage inputs, 22 Binary inputs, 16 Binary Outputs and 1 life contact (watchdog).

(c) For EDG protection IEDs at least: 4 current inputs, 4 voltage inputs, 23 Binary inputs, 16 Binary Outputs and 1 life contact (watchdog).

7.4.5.7 Their rated auxiliary voltages shall be 60 to 250 V DC and 115 to 230 V AC. They shall operate at nominal supply voltage of 110VDC±30%.

7.4.5.8 They shall have Ethernet or USB Front operating interface.

7.4.5.9 They shall have a graphic logic editor for creating powerful automation functions in the device. Large number of logic blocks and timers for user adaptation shall be provided.

7.4.5.10 They shall have two IEC61850 Ethernet, 100 Base-X or 1000Base-X fibre optical ports, with LC/ST/SC connectors, integrated switch and full IEC 61850 support communication interface.

7.4.5.11 The IEC61850 Ethernet ports shall support Precision Time Protocol(PTP), IEEE1588v2 and relay shall be synchronised to the station PTP grandmaster clock. Where relay does not support PTP v2, relay shall have an IRIG-B00X fibre optic...
DCLS port and a converter for PTP to IRIG-B00X fibre optic ST/LC connector shall be provided

7.4.5.12 They Shall have all the following integral protection and control functions

1. Synch-check, synchronizing function (25)
2. Under voltage protection (27)
3. Power protection active/reactive power (32, 37)
4. Negative-sequence over current protection (46)
5. Phase-sequence-voltage supervision (47)
6. Thermal overload protection (49)
7. Over current protection, phase (50/51)
8. Circuit-breaker failure protection (50BF)
9. Voltage dependent over current protection (51V)
10. High speed instantaneous over current protection (50Hs)
11. Over current protection, ground (50N/51N)
12. Overvoltage protection phase/neutral (59, 59N)
13. Directional time-over current protection, phase (67)
14. Directional time-over current protection for ground-faults (67N)
15. Trip-circuit supervision (74TC)
16. Frequency protection (81u/o)
17. Rate-of-frequency-change protection (81R)
18. Lockout (86)
19. Restricted ground-fault protection (87N)
20. Automatic voltage control (90V)
21. Measured values
22. Switching-statistic counters
23. Logic editor
24. Inrush-current detection
25. External trip initiation
26. Control, Monitoring and supervision
27. Circuit breaker test
28. Fault recording of analogue and binary signals
29. Changeover setting groups (automatic/programmable)
30. Fault locator (FL)
7.5 GENERAL PROTECTION SYSTEM SPECIFICATIONS

7.5.1 Protection Panels and Wiring Requirements

7.5.1.1 Shall abide to all specifications in clauses 3.6 & 3.7 of general technical specifications

7.5.1.2 All protection panels shall have a minimum of two doors. Rear door and a front cover door for covering and protecting panel mounted devices. All doors shall have locks.

7.5.1.3 Numerical relays, synchronising relays, lockout relays, trip supervision relays, selector/key switches, push buttons and LED status indication lamps shall be mounted flush on front of panel

7.5.1.4 Relays shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment.

7.5.1.5 Test blocks shall be flash mounted on the front side of the panels to allow for isolation of external instruments during tests.

7.5.1.6 The new protection panels shall be installed in the same location where the existing panels are located. Dimensions of existing panels are included in the drawings provided by the employer

7.5.1.7 All protective relays shall be with proper on-line testing facilities without isolation from TB where CT, VT inputs and trip outputs are wired. All main relays shall be provided with test plug to test the relay on line. Necessary test plugs/ test handles per panel shall be supplied

7.5.1.8 For wires with trip signals, ferrules and terminal blocks shall be marked in white with red background

7.5.2 Synchronising Relay

ABB SYNCHROTACT® 5 SYN 5202 synchronising relay or equivalent shall be supplied and installed with the following minimum specifications:

7.5.2.1 Shall have features and capabilities for:
   (a) Automatic synchronizing functionality for synchronous generators
   (b) Paralleling of two synchronous/asynchronous/voltage-free lines

7.5.2.2 Shall perform the following functions:
   (a) Synchro check function
   (b) Voltage matching
   (c) Frequency matching

7.5.2.3 Shall have the following major features:
(a) Dual-channel synchro check system (with two interlocked circuit breaker closing commands)
(b) Support a number of parameter sets/groups
(c) Support IEC61850 Ethernet communication (have an Ethernet port)
(d) Use Auxiliary supply voltage of 110±10% VDC
(e) Parameter setting by PC Tool connected via Ethernet and viewing of parameters via the network
(f) Parameter setting without PC
(g) Panel flush mounting
(h) Have at least two circuit breaker-closing relay output
(i) Have relay outputs for frequency & voltage matching
(j) Have at least three signalling binary outputs
(k) Have at least four binary inputs

7.5.2.4 Shall be connected to the IEC61850 protection network

7.5.2.5 Auxiliary voltage supply input range
   (a) Nominal voltage range 24 to 250 V DC
   (b) Permissible voltage range 18 to 300 VDC

7.5.2.6 Measuring inputs U1, U2
   (a) Nominal voltage range 50 to 130 V AC
   (b) Voltage range 0 to 130% Un
   (c) Nominal frequency 50 Hz
   (d) Frequency range 10 to 100 Hz

7.5.2.7 Paralleling relays features
   (a) Maximum contact voltage 250 V AC/V DC
   (b) Limiting continuous current 10 A
   (c) Maximum switching power ON AC/DC 1500 VA/W
   (d) Maximum switching power OFF AC/DC (resistive) 1500/150 VA/W

7.5.2.8 Parameter setting range

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Step</th>
<th>Range</th>
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<tr>
<td>Actual value calibration</td>
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<td>Nominal voltage</td>
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<td>50 to 130 VAC</td>
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<td>Voltage matching (between U1 and U2)</td>
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<td>Angle matching</td>
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<td>±180 DEG</td>
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<td>Slip limit</td>
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<td>0 to 6 %</td>
</tr>
<tr>
<td>Angle limit (angle window)</td>
<td>1 DEG</td>
<td>1 to 99 DEG</td>
</tr>
<tr>
<td>Maximum voltage difference</td>
<td>1%</td>
<td>0 to 40 %</td>
</tr>
<tr>
<td>Maximum voltage</td>
<td>1%</td>
<td>100 to 130 %</td>
</tr>
<tr>
<td>Minimum voltage</td>
<td>1%</td>
<td>50 to 95 %</td>
</tr>
<tr>
<td>Dead bus conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum zero voltage for dead bus</td>
<td>1%</td>
<td>0 to 49 %</td>
</tr>
<tr>
<td>Voltage matcher</td>
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<td></td>
</tr>
<tr>
<td>Voltage adjustment</td>
<td>0.01 %/s</td>
<td>0 to 5 %/s</td>
</tr>
<tr>
<td>Interval between pulses</td>
<td>1s</td>
<td>1 to 20 s</td>
</tr>
<tr>
<td>Minimum pulse duration</td>
<td>0.01 s</td>
<td>0.05 to 2 s</td>
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<tr>
<td>The length of adjusting pulses to be proportional to the voltage difference.</td>
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<td></td>
</tr>
<tr>
<td>Frequency matcher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency adjustment</td>
<td>0.01 %/s</td>
<td>0 to 5 %/s</td>
</tr>
<tr>
<td>Interval between pulses</td>
<td>1s</td>
<td>1 to 120 s</td>
</tr>
<tr>
<td>Minimum pulse duration</td>
<td>0.01 s</td>
<td>0.05 to 2 s</td>
</tr>
<tr>
<td>The length of adjusting pulses to be proportional to the slip.</td>
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<td></td>
</tr>
<tr>
<td>Synchro check (2nd channel)</td>
<td></td>
<td></td>
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<tr>
<td>Slip limit</td>
<td>0.10%</td>
<td>0.1 to 2 %</td>
</tr>
<tr>
<td>Angle limit</td>
<td>5 DEG</td>
<td>5 to 40 DEG</td>
</tr>
<tr>
<td>Maximum voltage difference</td>
<td>5%</td>
<td>5 to 40 %</td>
</tr>
<tr>
<td>Maximum zero voltage for dead bus</td>
<td>5%</td>
<td>0 to 50 %</td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>5 V</td>
<td>50 to 130 VAC</td>
</tr>
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</table>

7.5.2.9 Shall conform to IEC 60255 environmental testing features similar to numerical protection relays.
7.5.2.10 Shall operate optimally at ambient temperatures between 5°C to 55°C
7.5.2.11 Shall have ingress protection of at least IP54 for the front side

7.5.3 **Industrial Ethernet switches**

Shall meet the following requirements

7.5.3.1 Rugged Rated for reliability in harsh environments
(a) Immunity to EMI and heavy electrical surges
(b) Zero-Packet-Loss Technology
   (i) Meets IEEE 1613 Class 2 (electric utility substations)
   (ii) Exceeds IEC 61850-3 (electric utility substations)
   (iii) Exceeds IEC 61000-6-2 (generic industrial)
(c) -40°C to +85°C operating temperature (fan less)
(d) Ingress Protection of at least IP40
(e) 18 AWG (1.27mm) galvanized steel enclosure
(f) Shall not contain moving parts e.g. fans
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
</table>
| 7.5.3.2 | Extreme flexibility  
(a) Shall be modular with field replaceable modules  
(b) Support field replaceable port modules (4-port modules or 2-port modules)  
(c) Support full 10/100/1000TX, full 1000SX/LX, full 100FX or any mixture therein with different connector options and a minimum of two ports per module  
(d) -40°C to +85°C operating temperature (fan less)  
(e) All-aluminium construction |
| 7.5.3.3 | Has two (dual redundant) smart power supplies  
(a) That are hot-swappable  
(b) Have terminal block screw terminal connections  
(c) Whose rated input voltage is 88 – 300 VDC  
(d) Smart power supplies able to detect loss of input voltage |
| 7.5.3.4 | Shall have a critical alarm relay with at least one SPDT contact |
| 7.5.3.5 | Compliant with IEC 61850-9-2 Sampled Values and IEC 61850-8-1 GOOSE Message |
| 7.5.3.6 | Compliant with IEE 802.3, 802.3u, 802.3x, 802.3ab, 802.1d, 802.1p, 802.1Q, 802.1Q-2005, 802.1w’, Link Aggregation etc. |
| 7.5.3.7 | Store & Forward switching method with Switching latency not exceeding 10.5 μs |
| 7.5.3.8 | Shall be a managed switch with a Rugged Operating System (ROS®) supporting the following features  
(a) Simple plug-and-play operation – automatic learning, negotiation, and crossover detection  
(b) MSTP 802.1Q-2005  
(c) RSTP (802.1w) and Enhanced Rapid Spanning Tree  
(d) eRSTP network fault recovery  
(e) Quality of service (802.1p) for real-time traffic  
(f) Port rate limiting  
(g) Port configuration, status, statistics, mirroring, security  
(h) SNTP time synchronization (client and server)  
(i) Web-based, Telnet, CLI management interfaces  
(j) SNMP v1/v2/v3  
(k) Remote monitoring (RMON)  
(l) Rich set of diagnostics with logging and alarms |
| 7.5.3.9 | Rugged Operating System (ROS®) shall support the following Cyber security features  
(a) Multilevel user passwords |
(b) Secure File Transfer Protocol (SFTP) using SSH
(c) Web-based management using SSL
(d) RADIUS-Authentication service for device management
(e) 1024-bit RSA encryption for key management and key exchange
(f) Integrated router/firewall/VPN;
(g) Full IPsec virtual private networking;
(h) VPN with 3DES, AES128, AES256 support;
(i) Enable/disable ports,
(j) MAC-based port security;
(k) Port-based network access control (802.1x);
(l) VLAN (802.1Q) to segregate and secure network traffic;
(m) SNMPv3 encrypted authentication

7.5.3.10 Precision Time Protocol (PTP) support.
(a) Shall support time synchronisation on all the ports at an accuracy exceeding 1µs
(b) All ports shall support transparent clock, slave clock or master clock time synchronisation features as per IEE1588 v2.
(c) Some ports shall be configured as master clock and boundary clocks for downstream switches

7.5.4 **SAS Gateway Industrial PC**

The industrial PC’s shall meet the following specifications

7.5.4.1 **Mounting:** Shall be rack mounted. Enclosure shall be 2U/3U thick and 19 inch wide, for rack mounting.

7.5.4.2 **Power Supply.** Shall be powered by (two) dual modular, hot-swappable redundant power supplies with an input range of 100–300 VDC.

7.5.4.3 **Temperature.** Shall be capable of continuous operation over a temperature range of –40°C to +60°C at 100 percent processor burden. shall be type tested to IEC 60068–2–1:2007 (Test Ad 16 hr at –40°C), IEC 60068–2–2:2007 (Test Bd 16 hr at+60°C), and IEC 60068–2–30:2005 (Test Db 12 + 12-hour cycle at 25° to 55°C, 6 cycles).

7.5.4.4 **Environmental Testing.** shall be tested to the same standards as protective relays including IEC 60255–21–1, IEC 60255–21–2, IEC 60255–21–3, IEC 60255–26:2013, EN 61000–4–2, EN 61000–4–4, and IEEE C37.90.1.
7.5.4.5 **Reliability for Utility substation use.** Shall be designed and built to operate reliably in harsh environments, conforming to IEEE C37.90 and IEC 60255 Protective Relay Standards, IEC61850-3 and IEEE 1613 Standard Environmental and Testing Requirements for Communication Networking Devices in Electric Power Substations. Shall meet or exceed specifications for vibration, electrostatic discharge, fast transient, radiated emissions, dielectric strength, and pulse magnetic field disturbances.

7.5.4.6 **Communications Ports.** shall have two front-panel USB ports, four rear-panel USB ports, two rear-panel serial ports, two rear-panel 100/1000 base-TX Ethernet ports and two 1000base-X fibre optic Ethernet ports. All communications ports shall be ESD and RFI protected.

7.5.4.7 **Hot-Swappable Industrial Solid-State Drives:** shall have high quality, industrial-temperature rated, single-level cell (SLC) NAND Flash solid-state drives. All drives shall support hot-swapping. The SATA SSD drives shall be easily accessible from the front panel.

7.5.4.8 **RAID (Redundant Array of Independent Disks).** RAID levels 0 and 1 shall be supported to allow for speed, availability, and disaster recovery, depending upon application.

7.5.4.9 **CIS OS Security Benchmarks:** Operating systems shall provide a mechanism to quickly enable the Centre for Internet Security benchmark configurations to improve the device security posture.

7.5.4.10 **Configuration.** Configuration of messages and data processing functions shall be through a simple GUI interface. Configuration interface shall be through local keyboard, mouse, and monitor port or via Windows Remote Desktop or Intel Active Management Technology (AMT).

7.5.4.11 **Alarm Output.** There shall be an alarm contact output to signal internal errors and malfunctions. The alarm contact shall be supervised by an internal watchdog system that independently monitors the operating system.


7.5.4.13 **Non-volatile Storage.** There shall be Flash memory used as non-volatile storage of settings, configuration, and incoming and calculated data within the device. Data stored in the non-volatile memory shall be available for retrieval after sustained power outage, including failure of the internal battery.
7.5.4.14 **Moving Parts and Vent Holes.** The device **shall not** include any rotating disk drives, fans, moving parts, or vent holes.

7.5.4.15 **Reliability.** The vendor shall supply the actual measured Mean Time Between Failures (MTBF) for the device upon request.

7.5.4.16 **Power consumption:** Power consumption at maximum loading shall not exceed 100W

7.5.4.17 **Service.** The device shall include no-charge technical support for the life of the product.

7.5.4.18 **Manufacturer.** The device shall be manufactured in the United States, Canada or western Europe by reputable industrial computer manufacturers e.g. SEL, ABB or Siemens

7.5.4.19 **Warranty.** The device shall include a ten-year, no-questions-asked warranty for all material and workmanship defects. In addition, the warranty shall cover accidental customer-induced damage

7.5.5 **PTP Grandmaster clock/Time server**

7.5.5.1 Shall be rack mount with a 2U/1U enclosure

7.5.5.2 Shall have an integrated GNSS (GPS/GLONASS etc.) time receiver

7.5.5.3 Shall be equipped with high precision oscillator with

(a) short term stability of ≤ 5X10^-12

(b) PPS accuracy of < ±50 ns

(c) Frequency accuracy of ≤ ±5mHz after a 24hour free run

(d) GPS-synchronous- 24h average accuracy ≤ ±1X10^-12

7.5.5.4 Shall support Synchronization of IEEE1588-2008 (PTPv2) compatible clients. Shall support the following PTP Profiles:

(a) Default Profile (Multicast, Unicast or Hybrid)

(b) ITU-T G.8265.1 Telecom Profile

(c) IEEE C37.238-2011 Power Profile

7.5.5.5 Shall support Synchronization of NTP and SNTP compatible clients

7.5.5.6 Shall have GPS Antenna/Converter Unit connected with up to 300m of standard coaxial cable RG58

7.5.5.7 Shall have at least four independent RJ-45 Ethernet interfaces 10/100 Mbit with at least two IEEE 1588-2008 Ethernet ports

7.5.5.8 Shall have a Web-based status and configuration interface and console-based graphical configuration utility
7.5.5.9  Shall support the following net protocols: IPv4, IPv6, PTP/IEEE 1588-2008, NTP, SNTP, DAYTIME, DHCP, HTTP, HTTPS, FTP, SAMBA, SFTP, SSH, SCP, SYSLOG, SNMP, TIME, TELNET, W32TIME

7.5.5.10  Shall have Full SNMP v1, v2, v3 support with own SNMP-daemon for status and configuration and SNMP Trap messages

7.5.5.11  Shall have a front USB Port for installing firmware updates and backup/restore of configuration and log files
7.6 SCADA EVENTS & ALARMS INTELLIGENT MANAGEMENT SYSTEM

7.6.1 Introduction

7.6.1.1 KenGen intends to acquire an event and alarms management solution to solve the following challenges that minimises operator response and maintenance personnel response and troubleshooting of faults

(a) Nuisance alarms, Operator is bombarded with too many alarms that do not require their response.
(b) Tags that remain in alarm for extended periods that interfere with operator response to active alarms
(c) Occurrence of too many alarms after a fault occurs
(d) Lack of a prioritisation scheme for the alarms, rate of response to the alarms pegged to operator experience
(e) Alarms that are generated by out of service equipment that unnecessarily fill the alarm window
(f) Operator ignoring or failing to act on some alarms leading to a fault
(g) Multiple alarms to indicate the same incident
(h) Lack of means to access events and alarms from the corporate network
(i) Telling the sequence of events after they occur, HMI doesn’t arrange the events in the order of occurrence based on source time stamp
(j) Lack of means to automatically notify personnel outside the control room when critical alarms or faults occur.
(k) Lack of a clear strategy on how to create and manage alarms

7.6.1.2 The Contractor shall develop an event and alarm management system to deal with the above challenges, the system shall be customised for hydroelectric plants.

7.6.1.3 The event and alarm management system shall be developed as per the guidelines of ANSI/ISA-18.2-2009/2016 or IEC 62682

7.6.1.4 The event and alarm management system shall meet the following objectives or features

(a) Mechanism of availing only relevant alarms to each user group, alarms presented to different types users group i.e operators, maintenance, management, SCADA administrators etc shall be relevant. Alarm GUI shall display events and alarms relevant to user group dependent on source of alarm and type of alarm
(b) Mechanism of suppressing alarms such as
(i) Shelving of alarms by operators with a time limit of how long they can shelf
(ii) Automatic shelving of alarms when a certain action has been triggered e.g. when preventive scheduled maintenance is in progress
(iii) Out of service alarm shelving of specific alarms by maintenance personnel e.g. during a breakdown maintenance of a certain equipment
(c) Mechanism of escalating alarms to other users if they have not been acted upon in the set time
(d) Automatically notifying configured users when certain critical alarms occur via SMS and email.
(e) Automatic report generation of alarms such as for the following
   (i) Number of alarms occurrence per set duration eg a day
   (ii) Frequent events/alarms with the number of occurrences per set duration eg a day
   (iii) Set logging of number of occurrence for certain events/alarms per set duration eg a day
   (iv) Daily reports on acknowledged alarms, suppressed alarms, acknowledged persistent active alarms, duration of response etc
   (v) Chattering/fleeting alarms, identity and quantity
   (vi) Others as necessary or as per the standard
(f) Mechanism of users configuring automatic generation of event and alarm reports e.g. Setting a report to be generated when certain events occur together, to log the number of certain event per set duration.
(g) Event and alarm Historian/archive server for all events and alarms in relational database with capacity to hold and access the specified tags for over ten years
(h) Provide sequence of events page in the user interface HMI. Provide sequence of events log/report before and after a fault occurs and automatically send the fault log to users via email
(i) Extract IED fault logs (IED SOE fault log) and IED oscillographic disturbance records from the Protection gateway or the SCADA server and send them via email to the configured users.
(j) Provide raw events and alarms to users

7.6.1.5 The Contractor shall develop an alarm management life cycle plan as per ISA 18.2 suitable for HEP plants and train the employer on the application. The plan shall guide the contractor bidder while developing the alarm system and it shall also guide the employer in the future on how to configure new alarms and manage the
existing alarms. The plan shall be developed in close consultations with the employer.

7.6.2 **Scope of work**

7.6.2.1 Contractor shall supply, configure and commission

(a) A pair of redundant event and alarms server with the historian to be in the employers’ corporate network (DMZ)

(b) Alarm and events acquisition system to be installed on the employers SCADA servers

(c) Communication drivers utilising OPC UA to connect the Alarm server to the data acquisition system across the SCADA WAN.

(d) Web server and applications to interface users to the alarm server

(e) Client Applications installed into client computers for accessing the event and alarm server if necessary as detailed in proceeding clauses

7.6.2.2 The SCADA events alarm management system shall manage alarms from five power stations owned by the employer. Contractor shall configure the system for two power stations while training the client who will carry configuration for the other three stations as detailed in the clauses that follow.

7.6.2.3 Contractor shall install, configure and commission alarm and events acquisition system (DAS) for Gitaru power station to acquire events from employers SCADA OPC DA server and the protection gateway OPC servers. A minimum of 10,000 tags shall be configured by the contractor. This shall involve a minimum of the following

(a) Tag database configuration of the DAS in Gitaru for a minimum of 10,000 tags

(b) Configure event capture settings for discrete values for a minimum of 8,000 tags

(c) Configure event capture settings (high and low setpoints) for analogue values for a minimum of 500 tags.

(d) SOE logs automatic generation on occurrence of a fault

(e) Configure automatic event triggered data capture logs generation for a minimum of five different triggers

(f) Configure automatic periodic data capture logs generation for a minimum of five different time periods

(g) Configure automatic plant maintenance events generation/capture for a analogue values provided by employer and a minimum of one plant
maintenance event generation based on a formulae programming (formulae to be provided by employer)

(h) Carry out all other setting configuration and programming to meet requirements in clause 7.6.3

7.6.2.4 Contractor shall when installing and configuring the DAS for Gitaru train the employer who shall then carry out configurations in Kamburu power station under contractors’ supervision. Contractor shall support the employer while carrying out configurations for the other stations

7.6.2.5 Contractor shall supply, install and commission the alarm server hardware as specified in clause 7.6.5. The servers shall be installed at Kamburu power station or Hydro plaza (near Kamburu) this will be clarified after tender award.

7.6.2.6 Contractor shall supply, install, configure/program alarm server applications as specified in clause 7.6.3. This shall include

(a) Tags/variables from Gitaru and Kamburu power stations from two DAS applications

(b) Configuring/programming all applications with tags and files from these two stations

(c) Configure at least eight alarm system client applications

7.6.2.7 Contractor shall when installing and configuring Alarm servers with tags and files from Gitaru and Kamburu train employer who shall then carry out configuration for tags and files from other three power stations. Contractor shall support the employer while carrying out configurations for the other stations.

7.6.2.8 Bulk of the alarm system development shall be carried out at site to allow maximum participation of employer staff. The scope of work to be carried out before site work shall only be for activities that cannot be carried out at site, this shall be discussed and agreed on during negotiations and design stage.

7.6.2.9 All software activities shall be carried by contractor while training the employer engineers. Contractor shall not carry out any software activity without involving the employer. During FAT training the contractor shall carry out detailed training to employers’ staff to enable them to participate fully at site.

7.6.2.10 The Contractor shall develop an alarm management life cycle plan as per ISA 18.2 suitable for HEP plants and train the employer on the application. The plan shall guide the contractor while developing the alarm system and it shall also guide the employer in the future on how to configure new alarms and manage the existing alarms. The plan shall be developed in close consultations with the employer.
7.6.2.11 The contractor shall provide all software and hardware and carry out software development and configurations necessary for a complete system to achieve the objectives/goals given at the introduction and to meet guidelines of standards such as ISA-18.2-2009/2016 or IEC 62682, IEC 62443/ISA 99 and ISA 95 whether specified on the clauses that follow or not.

7.6.2.12 All the applications specified in the clauses that follow shall be supplied, developed and configured as specified.

7.6.3 **Events and alarms management system**

7.6.3.1 **Architecture**

The system shall consist of:

(a) Two redundant alarm and event servers hosting the master alarms and event system, web server and archive/historian. All configured users shall access this single application. The server application shall be installed on the hardware servers to be provided in the scope.

(b) The alarm and event server composed of three independent application servers each serving a specific function and each with its own independent communication drivers via OPC UA, the application servers shall be installed to the same hardware in redundant failover mode during the project. However, each server may be installed to separate hardware by the employer during or after the project depending on future demands thus each application server shall have independent communication drivers i.e.

(i) Alarm server for retrieving data from the source applications and performing alarm management functions described in the proceeding clauses. With OPC UA server, OPC UA client and ODBC client

(ii) Web server providing clients access to the alarm server via web clients With OPC UA client and ODBC client

(iii) Archive server an SQL relational database server for archiving alarms and events, reports and logs with ODBC support

(c) Alarm servers shall acquire data from data acquisition systems (DAS) located close to the source of events and alarms. Several (at least twelve licences to be provided) data acquisition systems for performing the following:

(i) acquiring raw events from the process data and updating the servers,

(ii) generating log files as per configuration and uploading to the servers,

(iii) acquiring event logs and COMTRADE files from source systems and uploading to the servers.
Contractor shall configure two DAS applications for Gitaru while training the employer who shall configure for Kamburu under contractor supervision. The contractor shall equip the employer with all tools necessary to configure the other DAS applications.

(d) Client graphical user interface (GUI) for accessing the alarm and event server. Two types of client GUI shall be provided

(i) Web based access to the event and alarm server via ordinary web browser including HTML 5 support

(ii) Several (At least Fourteen (14) licences if required) Client Applications installed into client computers for accessing the event and alarm server. These shall be optional and not preferred by the employer if the events can be effectively managed via web access only

(e) Authentication and user management system in the servers

(f) Redundancy and failover shall be provided for all the applications specified in the clauses below except alarm system client applications

7.6.3.2 Data Acquisition System (DAS) Application

(a) General requirements

(i) DAS application Shall be installed in the two employers’ SCADA DBS servers. DBS servers will contain windows 2012 R2 server

(ii) Data acquisition systems shall have

• OPC DA client for accessing raw events from OPC DA servers’ data sources

• Configuration to capture discrete events when the status changes

• Configuration to generate events when analogue values exceed the set points

• Configuration to capture and log process values when a certain configured event occurs or after a set time

• Archive to store raw events for a period of at least 30 days and overwritten them in FIFO method

• OPC UA server to provide real time and archived raw events to the alarm and event servers and file transfers to the servers

(iii) DAS applications shall be provided for installation on a pair of hardware servers, they shall have redundancy and failover between themselves

(iv)
(b) **Access to data sources**

(i) OPC DA client shall have access to all the plant tags available at the SCADA servers at the plant. Shall access employers’ SCADA OPC DA server which has tags for all the units in the plant.

(ii) OPC DA client shall also access OPC servers in the IEC61850 gateway via OPC UA tunneller.

(iii) OPC DA client shall have capability to access at least 20,000 tags from multiple OPC servers.

(iv) When link to a data source fails the OPC DA client shall generate an alarm and set the data quality status appropriately.

(v) All DAS communications shall be via open communication protocols proprietary communication protocols shall not be allowed.

(c) **Real time database**

(i) DAS real time database shall support a minimum of 20,000 tags.

(ii) A real time database shall be developed for all tags available in the Employers DBs server OPC DA server (approximately 7,000 tags) and all the tags configured in the IEC61850 Gateway OPC DA server as detailed in clause 7.3.8.

(iii) A configuration manager shall be provided to easily configure multiple tags into the application.

(iv) Tag names shall be the same as those maintained in the Employer’s SCADA servers.

(v) Tags shall be created for events generated by analogue values exceeding or falling below certain setpoints.

(vi) Real time database shall contain process values of the configured tags.

(d) **Raw Event/Alarms capture**

(i) The DAS application shall monitor all discrete variables and capture all discrete tags that change states plus the time stamp and store in an SQL database. The events shall be stored with the source time stamp.

(ii) The DAS application shall monitor all configured analogue values and generate raw events/alarms when tag real time value exceeds or falls below the set points.

(iii) DAS application shall provide for configuring of event/alarm setpoints for analogue values. Events and Pickups/drop-offs (for timed events) for all configured tags shall be archived in the SQL database with the source time stamp.
(iv) The DAS shall send the captured events to the alarm and event server immediately they occur. The alarm server shall monitor the DAS real time database and update its database whenever changes occur in the DAS.

(e) **Process/fault data logging**

(i) The DAS application shall be configured to capture (take a snapshot) configured process values when certain events occur e.g. faults, critical events, monitored events etc. These shall easily be configured by the user when required.

(ii) The logs to be configured shall include

- Sequence of events log
- Event triggered data capture logs
- Periodic data capture logs
- Other user configured logs

(iii) Each captured process value shall be stored with all the information defined in the source data model such as quality, time stamp, engineering units, object, value etc

(iv) The logs shall be in a simple txt format or other open file format

(v) The log files shall be stored and uploaded to the alarm and event server immediately its created

(vi) DAS application shall also download IED fault logs and COMTRADE files and upload them to the alarm and event server

(vii) All logs shall also be temporarily stored locally for a period of 30 days or other configured time after which they shall be overwritten.

(f) **Sequence of Events Logs**

(i) Automatic generation of sequence of events logs shall be configured in the DAS application

(ii) An event shall lead to automatic generation of sequence of events, such events shall include faults, some critical alarms etc, this event is referred to as a trigger event

(iii) The sequence of event log shall store events that had occurred 30 seconds prior to the trigger event and events that occur 30 seconds after the trigger event. Or other settable time duration. The events shall be sorted in the order of the source device time stamp.

(iv) To ease setting up of these logs a user interface shall be provided for configuring up
• trigger event
• Setting time duration to capture sequence of events

(v) The SOE log shall contain raw events from the plant equipment in the order of their occurrence source time stamp.

(vi) Contractor shall configure automatic SOE logging for different trigger events such as mechanical trips.

(vii) Tools such as excel formatted template file for configuring large number of trigger events shall be provided for generating SOE logs and downloading to the DAS application.

(g) Periodic and event triggered Data capture logs

(i) Other than sequence of event logs other logs without capture of sequence of events shall be configured.

(ii) These logs in a similar fashion to sequence of event log shall be triggered by event, by time lapse after a certain event or for every set period.

(iii) On trigger event the DAS application shall take a snapshot of configured analogue and discrete tag values at the exact moment of occurrence and store them in the log. Some of the analogue values to be configured shall include generator power, current, stator temperature, guide vane opening, oil levels etc and discrete values such as switchgear status.

(iv) To ease setting up of these logs a user interface shall be provided for configuring up the following:

• for event triggered log
  — trigger event
  — setting the tags values to be monitored (capable of adding at least fifty analogue tags and fifty discrete tags)
  — Setting time duration from the trigger event occurring to taking of the snapshot.

• For periodic events
  — Time of the hour, hour, day, month etc for taking the snapshot of the tags eg every thirty minutes, 24:00 hrs every day, 24:00 hrs on each first day of the month etc for periodic event logs
  — setting the tags values to be monitored (capable of adding at least fifty analogue tags and fifty discrete tags)
(v) Contractor shall configure at a minimum of the following automatic logs

- Energy values, power outputs, every 30 minutes
- Energy values, power outputs, every first hour of the month
- Fault log for generator faults to capture generator output, stator temperature etc after a mechanical trip

(vi) Contractor shall train the employer on how to configure automatic generation of logs

(vii) Tools such as excel formatted template file for configuring large number of trigger events and monitored tag values shall be provided for generating the logs and downloading to the DAS application

(h) **Plant maintenance notifications**

(i) These shall be special events signifying equipment requires attention of the maintenance team.

(ii) The plant maintenance notifications shall be designed to warn the maintenance personnel to plan to maintain an equipment before equipment generates alarms

(iii) The plant notifications shall be generated from either

- Setpoint values on certain analogue values
- Methods/formulas/programs created to monitor many tags over a certain period and generate a notification

(iv) For notifications generated by formulae/programming a log shall also be generated capturing important tags.

(v) Contractor will configure at least one formulae-based notification configuration to guide the employer

(i) **Archiving**

Shall host a SQL database server capable of storing all the raw events for a period of at least 30 days in FIFO method. The historian

(i) Shall serve as data buffer for the alarm servers in case of WAN communication failure so that no events and alarms are lost

(ii) Shall store all raw events and time stamp

(iii) shall be in a format that can be accessed by ODBC clients

(iv) Archived data files shall be in an open format that can be accessed by another database software’s e.g. .dbf
(v) Archiving client driver shall be provided in the DAS application to manage archiving and retrieving data in the SQL server application

(vi) Shall use a relational database preferably Microsoft SQL

(j) **Interface to the alarm server and other remote applications**

(i) DAS application shall have an OPC UA server to provide data to remote OPC UA clients via WAN.

(ii) Tag data shall be modelled as per OPC UA data model

(iii) OPC UA secure transport shall be applied for moving data to the alarm server

(iv) OPC UA server shall provide access to the real time data and to the archive data

(v) OPC UA methods or other file transfer methods shall be used to automatically upload files to the alarm server.

(vi) OPC UA server shall be configured to allow communication with only configured OPC UA clients and shall authenticate clients before allowing access to data. Secure methods shall be utilised to allow access data as per the guidelines of ANSI/ISA-99 / IEC 62443

(vii) If the DAS application doesn’t have an inherent support for OPC UA server a SCADA data gateway supporting OPC DA client and OPC UA server shall be provided. SCADA data gateway not OPC tunneller shall be provided. The SDG OPC UA server shall be configured as described above

(k) **Configuring the DAS Application**

(i) A graphical user interface shall be provided for configuring the DAS application.

(ii) The user interface shall provide configuration of

- OPC UA server
- OPC DA client
- Other communication settings
- Tag creation and formatting
- Importing and exporting tags
- Setting of set points for monitored analogue tags
- Discrete tags configuration (alarm state for low to high or for high to low)
- SOE logs automatic creation
- Periodic and event triggered logs automatic creation
- Methods creation (programming/scripting) to automate certain functions
- Archiving and retrieval settings
- Project creation and settings

(iii) User interface shall have a minimum of two windows/MIMICs
- For viewing real time sequence of events
- For viewing real time raw events and viewing archived raw events by scrolling or searching specific time and shall provide manual filtering of events by entering the filtering criteria in the MIMIC

7.6.3.3 **Server applications Functions**

(a) Server Application shall monitor data on all DAS applications and update its real time database via OPC UA

(b) Shall carry out classification of alarms and events according to source, prioritisation and type

(c) Shall perform all users' actions such as alarm suppression, alarm acknowledgement etc via client application HMI

(d) Shall generate reports as per configuration

(e) Provide access to event logs, disturbance records and other log files

(f) Shall archive all classes of events and alarms such as raw events, acknowledged alarms, suppressed alarms etc

(g) Shall generate notifications to configured users via SMS through the SMS gateway already existing on the corporate network and email via the corporate email server.

(h) Shall perform user management, authentication and configuration

(i) Shall provide interface to client applications to perform user actions, view data and perform server configurations/administration

(j) Shall host a web server to allow remote clients to connect to the server via a web browser

(k) Shall provide link to ERP software to generate work orders, and other business-related function by sending notification to ERP applications

(l)

7.6.3.4 **Server Communication drivers**

(a) Alarm server application shall have an OPC UA client to access the DAS applications across the SCADA WAN.
(b) The alarm server shall also have an OPC UA server for providing data to other clients in the corporate or SCADA network. OPC UA server shall avail all the tags configured in the alarm server tag database.

(c) Communication between the DAS applications shall be secured as per the guidelines of ANSI/ISA-99 / IEC 62443.

(d) Communication link to the DAS clients shall be through a firewall linking the corporate network to the SCADA network.

(e) ODBC client shall be provided for archiving and retrieving data in an SQL server.

(f) The alarm server OPC UA client shall continuously monitor the links to the DAS applications and generate alarms when there is problem with the link.

(g) When a link to a DAS fails, the alarm server shall continue monitoring the link until it resumes. When the link resumes the alarm server, shall make automatic historical data request to the DAS and retrieve all the archived alarms and events since the link went off. The time duration for link failure that server can request data for and the quantity of data that can be requested shall be set for effective bandwidth usage and effective alarm management.

(h) If the alarm server doesn’t have an inherent support for OPC UA server and client, a data gateway supporting OPC DA client, OPC UA client and OPC UA server shall be provided. Data gateway not OPC tunneller shall be provided supporting unlimited tags. The gateway OPC UA server and OPC UA client shall be configured as described in the preceding clauses whilst the OPC DA client shall be used to interface to the alarm server application.

(i) All server communications shall be via open communication protocols proprietary communication protocols shall not be allowed.

7.6.3.5 **Events and Alarms configuration on the server**

(a) The Alarm server shall be configured to classify all the raw events depending on the source and type.

(b) The following classifications shall be configured

(i) Raw events and alarms - all monitored discrete values that change state and discrete values obtained when analogue values exceed or fall below set points. No classification will have been applied on these.

(ii) Alerts - events that do not require operator action

(iii) Alarms – events that require operator action

(iv) Alarm priorities configuration
• Critical alarms - alarms that if not attended to will result to a fault in a short time (in less than 10 mins or equivalent) or have the likelihood of causing great danger/hazard if not attended to
• High priority alarms – Alarms that if not attended to will lead to a fault, but gives operator some time to act
• Low priority alarms- Alarms that can be shelved i.e not likely to escalate to faults but pose a certain risk or may curtail automatic functions such as sequences leading to down time e.g. control level selections
(v) Faults – events generated to signify a fault has already occurred e.g. protection trips
(vi) Operator Actions- Commands given by the operator to the control system (these shall be obtained from the employer SCADA system)
(vii) User actions- Events generated when user performs an action on the alarm server e.g. Alarm Acknowledgment
(viii) Maintenance alerts (notification) - events configured to inform maintenance personnel on the condition of the equipment that require maintenance action but not operator action.

(c) Events and alarms shall also be classified by the source station, there shall be one DAS per station. Events and alarms shall be sorted by the source station at the alarm server

(d) The Alarm server tag database/real time database shall be configured to sort/classify the events and alarms as per the classification.

(e) Each event or alarm availed to users or archived shall contain the following information
   (i) Event/ alarm tag as configured in the DAS (source)
   (ii) Description
   (iii) Time stamp from the source device with millisecond resolution
   (iv) Source station
   (v) Type as per classification above (clause b) e.g. alert, critical alarm, fault, maintenance notification etc
   (vi) For Alarms and faults - the following status shall be appended
       • Active and not acknowledged
       • Active and acknowledged
       • Inactive but not acknowledged
       • shelved
- Suppressed by system
- Out of service
- In maintenance- Alarms which have been escalated to maintenance personnel by the operator or by system

(vii) ID of the user who acted on the alarm (acknowledge or suppress), is assigned the alarm or operator for operator actions
(viii) Time of user action
(ix) For maintenance notification user or user group assigned to act on the alarm
(x) Other relevant information to ease management of alarms as per the ISA 18.2 standard, EEMUA 191 guide lines and best practices for power plants

(f) Alarms and faults shall remain available / active as long as the source device is giving the alarm/faulted condition or if the source device gave out an alarm and then cleared but the operator has not acknowledged.

(g) During communication failures Active status of the alarms/faults shall remain unknown. The alarms/faults whose source status is unknown shall be displayed in different colour to signify that the current active/inactive status is unknown. This shall be applicable to alarms and faults which were active before the communication failure.

(h) The server shall allow for the following user actions from the client HMI or from a web client
(i) Acknowledgment of alarms – This will be reserved for the operator’s user group who shall who shall on occurrence of alarms shall acknowledge the alarm and take the necessary action to rectify the situation
(ii) Shelving of Alarms – This shall be reserved for the operators’ user group who shall postpone acting upon an alarm depending on their circumstance
(iii) Setting Out of service alarms – this shall be reserved for the maintenance and system administrator group to set alarms to out of service if equipment is out of service or if there is configuration problem
(iv) Escalation of events/alarms by user – Operators and other users shall escalate alarms to other user groups after acknowledgment for alarms that they cannot address.

(i) Escalation of alarms
(i) System shall automatically escalate
   • active alarms that have not been acknowledged by the operator after a set duration
   • active alarms which have been acknowledged but have not cleared after a set time
   • shelved alarms which have not been acted upon after a set time
(ii) Automatically escalated alarms shall send a notification email to dispatch management group to act on them
(iii) The active and unacknowledged alarms which have been escalated shall remain in active state until cleared from the source or suppressed
(iv) The operator can choose to escalate alarms after acknowledging them to the responsible user group. After escalation the alarms shall change state to in maintenance status which shall be cleared by the responsible group or suppressed.
(v) When escalating alarms users shall be required to attach a short note describing the actions taken and the nature of alarm. These notes shall appear as an attachment to the alarm and shall also be sent via email to the users whom the alarm has been escalated to.
(j) Plant Maintenance notifications
   (i) Plant Maintenance notifications will be special events alerting the plant maintenance personnel of equipment condition that requires attention, but which has not developed into an alarm
   (ii) Plant Maintenance notifications shall not be visible to the operator as they will not require any operator action
   (iii) Plant Maintenance notifications will be generated the DAS as described in the previous clauses
   (iv) Plant Maintenance notifications will remain active until closed by the assigned plant maintenance personnel
   (v) Plant Maintenance notifications will be accompanied by reports and logs to provide more information to the user

7.6.3.6 Alarm and events Reports
   (a) There shall be two types of reports
      (i) Reports configured by the SCADA system developer to report on certain events and alarms characteristics and reports necessary to audit the alarming system
      (ii) Reports configured by System users such as
• operator who requires certain information on some activity for operation reporting purposes
• Maintenance personnel who want to monitor certain equipment performance data
• System administrator trying to monitor certain system performance issues

(b) Reports to configured by system developer during the project shall include reports such as
   (i) Number of alarms occurrence per set duration e.g. a day
   (ii) Frequent events/alarms with the number of occurrences per set duration eg a day
   (iii) Number of occurrence for certain events/alarms per set duration eg a day
   (iv) Daily/hourly etc reports on number of acknowledged alarms, suppressed alarms, acknowledged persistent active alarms,
   (v) Report on duration of response
   (vi) Chattering/fleeting alarms, identity and quantity
   (vii) Others as necessary or as per the ISA 18.2 standard or EEMUA 191 guidelines

(c) The reports shall contain
   (i) simple line/bar graphs, charts, tables to display relational data e.g. number of occurrence of a certain event per day/hour etc
   (ii) text detailing the data
   (iii) Tag information for tags in the report e.g. source, description etc
   (iv) Meta data such as
      • Title
      • Time and date of creation
      • Location of file on the server
      • File size
      • Other meta data configured by user or necessary

(d) Reports shall be available in four formats
   (i) On the client HMI application format for viewing on the alarm system client HMI application
   (ii) Html 5 format for viewing on web browsers
   (iii) Pdf format when requested by user
(iv) open file format for archiving such as pdf, xml, xhtml or any other open file format that will not require proprietary applications to read

(e) Reports shall be archived in the server for duration to be set during the project. The archive server shall be capable of archiving and retrieving the reports for a period of not less than ten years.

(f) A means of searching for report files in the server shall be provided, report file shall be automatically named before archiving in manner that shall easy to search for. Names shall be composed of automatic given report name and metadata such as date of creation, source station, etc.

(g) Server shall maintain a list of available report files with a description of the content this list shall be available for access in the client HMI application.

(h) Server shall provide means for client HMI application and the web server to search for a report file and downloading it to the client computer. FTP shall be the preferred means of providing access to these report files.

7.6.3.7 Log files

(a) A minimum of the following log files shall be provided in the alarm server

(i) Event log files generated by the DAS application i.e. SOE logs, periodic data capture logs and event triggered data capture logs

(ii) IED Fault logs (SOE) logs generated by IED when a trip occurs

(iii) COMTRADE records files generated by IED’s and other controllers after a fault occurs

(iv) System logs – Software logs for certain actions or events as per software design

(v) User action logs- logs of user actions on the alarm system

(vi) User access/authentication logs- logs of all users authenticated into the system or refused access by the system

(vii) Communication logs- logs generated by the system to communication events such as failures, time delays etc

(b) For all the above logs except system logs, IED fault logs and COMTRADE records

(i) automatic generation/creation shall be configured by the contractor during the project.

(ii) shall be in an open format preferably .xls format

(iii) Shall be readable /viewable/accessible in the client HMI application and via the web for users dependent on their user rights
(c) Log files shall be archived in the archive server for duration to be set during the project. The archive server shall be capable of archiving and retrieving the logs for a period of not less than ten years.

(d) A means of searching for log files in the server shall be provided, Log file shall be automatically named before archiving in manner that shall easy to search for it the archive and arrange similar logs. Names shall be composed of metadata such as date of creation, source station, source device, event/fault leading to creation etc. Periodic logs file names shall contain time of creation, function, station and any other identification information.

(e) Server shall maintain a list of available log files with a description of the content this list shall be available for access in the client HMI application

(f) Server shall provide means for client HMI application and the web server to search for a log file and downloading it to the client computer. FTP shall be the preferred means of providing access to these log files

7.6.3.8 **Alarm HMI system**

(a) Alarm HMI system shall be optimised to allow effective operator response to alarms as per the guidelines of ISA 18.2 or EEMUA 191

(b) The Alarm system shall be through

(i) Client HMI application (this optional if web access is comprehensive to cover all alarm HMI applications)

(ii) Web server serving web clients

(c) Client Alarm HMI applications if offered shall access the contents of the server directly. Local tag database at the client application, and broad configurations shall not be necessary. Client applications shall subscribe to the server HMI system which shall update the user applications as events change.

(d) Web clients shall connect to the webserver to access the alarm system

(e) The Alarm HMI system shall provide the following functions

(i) See current active, unacknowledged, shelved, and disabled alarms.

(ii) View archived alarms and events.

(iii) easily sort by date/time and filter by source station, tag or priority.

(iv) Acknowledge, escalate, shelf or disable alarms even while configuring.

(v) Print any range of the alarm or event history.

(vi) View and download reports

(vii) View and download logs

(viii) View and configure server settings
(f) In order to optimise response to alarms user shall only view alarms which are relevant to them. This relevance shall be by area of responsibility such as
(i) Station operators shall only access alarm and events in the station level
(ii) Dispatch operators shall view alarms from all the stations
(iii) Operators shall only access alarms relevant to operator group they shall for example not access plant maintenance notifications

(g) HMI pages or windows
A minimum of the following HMI pages or windows shall be provided

(i) Master Alarm list: shall be the main alarm monitoring page or window
   Shall list all alarms in the following states
   - Active and not acknowledged alarms
   - Active and acknowledged alarms (but not disabled/suppressed)
   - Faults which are active and not acknowledges
   Faults which have been acknowledged shall automatically clear from this list

(ii) Alarms under review: shall contain alarms that operator has shelved, has been assigned to maintenance or operator has postponed for review later. Shall list all alarms in the following states
   - Inactive but not acknowledged
   - shelved
   - In maintenance

(iii) Active Faults list: shall list faults that have not been cleared and are still active

(iv) Disabled alarms: list shall list Alarms that have been disabled but are active at the source. Shall list all alarms in the following states
   - Suppressed by system
   - Out of service

(v) History Alarm list: shall list all alarms active and inactive available in the archive server. Tools for filtering and searching shall be utilised to view the required tags. Alarms shall be listed chronologically and shall contain all the alarm information as per preceding clauses

(vi) Raw events list: shall list all events, alarms and faults as received from the DAS. List shall contain both real time and archived events, Tools for filtering and searching shall be utilised to view the required archived events.
(vii) Operator actions list- shall list all operator commands to the plant as obtained from the employers’ SCADA system. The operator action lists shall be arranged in reverse chronological order with the source time stamps.

(viii) User Action list- shall list user actions on the alarm systems such as acknowledging alarms, suppressing alarms etc

(ix) Plant Maintenance notifications list: shall contain plant maintenance notification events as detailed in the preceding clauses.

(x) Sequence of events list: shall be similar to the raw events list except that the events shall be arranged as per the source time stamp and not the time of arrival at the server

(xi) Report pages

For all configured automatic alarms, a page shall be created for viewing the status of the monitored events such as

- Number of alarms occurrence per set duration e.g. cumulative per day
- Frequent events/alarms with the number of occurrences per set duration e.g. cumulative per day
- Number of occurrence for certain events/alarms per set duration e.g. cumulative per day
- Daily/hourly etc reports on number of acknowledged alarms, suppressed alarms, acknowledged persistent active alarms,
- Report on duration of response
- Chattering/fleeting alarms, identity and quantity
- User configured reports shall be displayed in a separate window

(xii) Logs page

Page shall be provided for viewing available logs arranged in reverse chronological order. Logs generated by the alarm system shall also be viewable on this page on the web browser. Tools for searching for archived log files shall be provided. Tools for downloading the logs shall also be provided

(xiii) Analogue set points list and configuration page: list of the active analogue setpoints for each DAS shall be available for viewing on this page. Depending on the user rights reviewing of these settings and uploading to the DAS shall be configured
(xiv) HMI setting pages: setting pages shall be provided for setting user preferences on how data shall be presented in the HMI pages

(xv) System Settings page: shall be provided for setting up the server for users with privileges these pages shall only be visible to the configured system administrators users group

(xvi) Other relevant pages to be developed by contractor

(h) **Design of the HMI**

(i) The HMI shall be designed to allow easy access to alarms for operators

(ii) The HMI pages shall be linked to tabs which on clicking shall direct to the respective page

(iii) Master alarm list page shall act as the home page where all other tabs linking the pages shall be found

(iv) Each page shall contain a link to the other pages the Master alarm list page shall have easily accessible link in all HMI pages

(v) Events text will appear with unique colours as follows for easy identification

- Faults – red when active green when it clears
- Critical alarms – Orange when active green when it clears
- Other alarms – yellow when active green when it clears
- Plant maintenance notifications-blue when active green when its closed
- Other events – green when status changes to high and black/white (dependent on background white/black) when status changes to low
- Alarms/faults with unknown status after communication failure – grey

(vi) Un acknowledged alarms and faults will blink until acknowledged

(vii) Symbols or short text will be used to indicate each of the following event/alarm status

- Active and not acknowledged
- Active and acknowledged
- Inactive but not acknowledged
- shelved
- Suppressed by system
- Out of service
- In maintenance
(viii) The alarm HMI graphical interface shall be designed taking into mind guidelines of EEMUA 191 and other world best practices.

(i) **Audible alerts**

(i) HMI shall generate audible alerts for configured alarms or events
(ii) Tag configuration shall provide for an option of enabling or disabling audible alert for each event/alarm/fault tag
(iii) Client application or web browser shall output sound to the client computer audio device
(iv) Tool shall be provided in the HMI to mute or adjust the volume of the audio alert.
(v) Tool shall also be provided to silence (acknowledge) the audio alert
(vi) The audio alerts shall be timed and shall not output sound continuously before silencing

(j) **Tools on the HMI**

The following tools shall be available on the HMI pages
(i) Icons for performing user actions on the alarms such as acknowledging, shelving etc
(ii) Icons for multiple alarms acknowledgment or shelving
(iii) Tools for creating notes when supressing or escalating alarms
(iv) Tools for filtering events/alarms by date, time, source, tag components e.g. similar objects, source device etc
(v) Tools for accessing searching files and downloading
(vi) Tools for creating custom reports
(vii) Tool to mute or adjust volume of audible sounds and for silencing (acknowledging) audio alert
(viii) Other tools necessary by the user to access the HMI effectively

*7.6.3.9 Webserver*

(i) Web server shall be developed to perform all the HMI functions described in the clauses above (7.6.3.8)
(ii) Shall support various kinds web clients such as browsers in android phones & tablets, computers, large display units etc the web server shall adjust the web pages to suit the connected devices
(iii) The web server shall be a separate application from the alarm server and shall be designed to interface to remote HMI clients to the alarm server application via HTTPS.
(iv) The web server shall be the front-end server of the alarm system while the alarm server shall be the back-end system of the alarm system

(v) Web server shall have an OPC UA client for interfacing to the alarm server and ODBC client for accessing the archive server

(vi) Web server shall be supplied as a separate application designed in a way it can be installed in a separate hardware from the alarm server.

(vii) Configuration manager for configuring the web server shall be provided

7.6.3.10 **Archive Server /Historian**

(a) An SQL database server shall be provided for hierarchical storing, searching and retrieval of:

(i) event data such as
  - all the alarms,
  - raw events from DAS,
  - faults,
  - plant maintenance notifications,
  - user actions,
  - operator actions and
  - all other relevant data

(ii) files such as
  - event and alarm reports
  - SOE logs
  - Event triggered data capture logs
  - Periodic data capture logs
  - IED fault logs
  - COMTRADE files
  - System logs
  - User action logs
  - Communication logs
  - User notes when escalating alarms
  - Other specified files

(b) The archive server shall be able to archive data for over twenty years and be able to retrieve data more than twenty years old

(c) Archived data shall be in a format that can be accessed by ODBC clients
(d) Archived data files shall be in an open format that can be accessed by another database software’s e.g. .dbf
(e) Archiving client driver shall be provided in the alarm server and web server application to manage archiving and retrieving data in the SQL server application
(f) Shall use a relational database software
(g) Archive server shall be supplied as a separate application designed in a way that it can be installed in a separate hardware from the alarm server.
(h) The contractor shall configure archiving of all configured tags and files

7.6.3.11 User Management and Authentication

(a) introduction
(i) Alarm server shall manage users who can access the system and the level of access granted to each user. The alarm server shall also display events/alarms and give access to archived reports/ logs depending on the user rights
(ii) Alarm server shall have user groups, each group shall be assigned specific rights to access the server. Users shall be members of a single group or several groups

(b) User groups
A minimum of the following user groups shall be provided
(i) System administrators- shall have access to all alarm server applications and functionalities and rights to alter any system setting
(ii) SCADA management group - shall have rights to access events/alarms reports, logs from all stations and have access to all settings related to alarm management such as setpoints, log generation settings, tag settings, archiving settings, web server settings etc. shall have access to all alarm system applications. Shall have access to all HMI pages
(iii) Dispatch management group- shall have rights to access events/alarms, reports and some logs from all stations. Rights to access operator actions. shall not have rights to acknowledge or shelve alarms but will be able to act alarms escalated to them by the system or the operator. Dispatch management group shall set rights for which group between the dispatch operator groups and station operator groups shall be responsible for responding to alarms. Shall have access to all HMI pages
(iv) Dispatch operator groups- shall have rights to access operator relevant alarms, events, faults, logs, reports from all stations. Shall be able to create custom reports. Shall be able to acknowledge, shelve alarms, escalate alarms and other operator relevant actions for all stations which have been assigned to them by the dispatch management group. Shall have access to relevant HMI pages only

(v) Station management group- shall have rights to access events/alarms, reports and some logs from a specific station. Rights to access operator actions, for the specific station etc. shall not have rights to acknowledge or shelve alarms but will be able to act alarms escalated to them by the system or the operator. Shall have access to relevant HMI pages only

(vi) Station operator groups- shall have rights to access operator relevant alarms, events, faults, logs, reports from the specific stations. Shall be able to create custom reports for the specific station. Shall be able to shelve alarms, escalate alarms and other operator relevant actions for the station if assigned to do so by the dispatch management group. Shall have access to relevant HMI pages only

(vii) Central Plant maintenance management group. shall have rights to access all events/alarms, reports and some logs from all stations. Rights to access operator actions and maintenance user groups actions. shall not have rights to supress alarms but will be able to act alarms escalated to them by the system or the operators by assigning them to maintenance personnel. Plant maintenance management group assign escalated alarms to users in the Central plant maintenance group and or station plant maintenance groups. Shall have access to relevant HMI pages only

(viii) Station Plant maintenance management group. shall have rights to access all events/alarms, reports and some logs from the specific station. Rights to access operator actions and maintenance user groups actions for the specific station. shall not have rights to supress alarms but will be able to act alarms escalated to them by the system or the operators by assigning them to station maintenance personnel. Plant maintenance management group assign escalated alarms to users in the station plant maintenance group. Shall have access to relevant HMI pages only

(ix) Central plant maintenance group - shall have rights to access maintenance relevant alarms, events, faults, logs, reports from all stations.
stations. Shall be able to create custom reports. Shall be able to suppress alarms escalated to them to out of service and other plant maintenance relevant actions for all stations which have been assigned to them by the plant maintenance management group. Shall have access to relevant HMI pages only

(x) Central plant maintenance group - shall have rights to access maintenance relevant alarms, events, faults, logs, reports from the specific station. Shall be able to create custom reports for the station tags. Shall be able to suppress alarms escalated to them to out of service and other plant maintenance relevant actions for assigned station which have been assigned to them by the station or central plant maintenance management group. Shall have access to relevant HMI pages only

(xi) General user groups- with rights to view some specific HMI pages without any rights to act on any alarm or create custom reports

(xii) Guest user groups - with rights to view some specific HMI pages without any rights to act on any alarm or create custom reports

(c) **User action logging**

(i) All user actions shall be logged and archived in the archive server for a period exceeding ten years.

(ii) User action logs shall be read only, no user shall be able to alter the logs

(iii) User actions on the alarm system shall be listed on a HMI page accessible to relevant groups

(d) **User accounts**

(i) The alarm system shall inherit windows domain user accounts from the corporate system.

(ii) Alarm system shall seek password authentication of domain user accounts from the domain controller

(iii) Alarm system local user accounts shall be created for system administrative purposes only. Local user accounts shall also be created for managing the DAS applications

(iv) On the alarm system, local system administrator user account shall assign some domain user accounts to the system administrator group described in the previous clause.

(v) Domain users who are members of the system administrator group shall be able to assign members to the other user groups described in the preceding clauses.
(vi) System administrator group users shall also be able to assign roles and rights to all the other user groups

(e) DAS system access

(i) DAS applications shall have local user accounts for administrative purposes for the system development and not for routine setting changes or data access.

(ii) User access to the DAS system shall be managed by the alarm server. User accounts and passwords with access to the DAS applications shall be managed by the alarm server.

(iii) Domain user accounts shall not be able to access the DAS system directly

7.6.3.12 Remote Alarm Notification System

(a) Alarm notification system will send alerts to configured users via SMS and email. It will also automatically send log files, reports user notes on escalation of alarms to configured users via email.

(b) Notifications will only be sent to specific users for each configured event/alarm or for each group of events/alarms i.e. Users will only receive SMS/email that are relevant to them

(c) Each notification will contain the event description (tag description) timestamp, source station.

(d) SMS/email notification will be sent immediately when certain configured event/fault/alarm occurs. For alarms which are not configured to send SMS/email immediately they occur an SMS/email shall be sent to configured users if the alarm is not acknowledged by the operators after a certain set time.

(e) A configuration window shall be provided to configure alarm notification systems, it shall provide for configuration of a notification configuration file with each notification configuration file containing

(i) Individual or a group of event/alarm/fault to trigger the notification

(ii) Users to receive this notification

(iii) Configure tag status to be appended on the SMS/email this will include the specific trigger event/fault/alarm plus tag status/values of other related tags

(iv) For email notifications the log file or report to be attached to the email
(f) Contractor shall configure at least five notification configuration files while training the employer who will do others.

(g) SMS Notifications
   (i) SMS Notifications will be generated for configured alarms, faults and events.
   (ii) The alarm server shall send the SMS notifications to the corporate SMS gateway which is already existing on the employers’ network. The Corporate SMS gateway uses a web client to receive requests by users to send SMS’s.
   (iii) The alarm server shall send the message recipients and message body to the gateway. Details of the gateway configuration/design necessary will be provided at design stage.
   (iv) SMS notification system shall create a log file for all the notifications sent.

(h) Email notifications
   (i) The alarm server shall have a windows mail exchange client with SSL that will send email alerts to users via employer’s corporate exchange server.
   (ii) Email notifications shall be sent on Event/fault/alarm trigger or Periodically to send reports to configured users.
   (iii) For SOE logs, event triggered logs, and periodic logs email notification shall be sent to all configured users whenever a new log is generated at the DAS. The email shall contain the content of the log in the email and an attachment of the log.
   (iv) IED disturbance records and fault logs shall be sent to configured users as an attachment immediately a file is available in the server.
   (v) Periodic emails shall be sent to configured users for periodic reports or logs.
   (vi) Email reference shall contain the trigger event description while for logs the email reference shall contain the log name or the report name.
   (vii) Email client application/API in the alarm server application shall allow configuration of email settings such as
       - Automatic deletion of emails when storage capacity in the email server is exceeded
       - Password configuration
       - Other email configuration necessary as per the employers’ windows mail exchange server
7.6.4 **SCADA Alarm System Security**

7.6.4.1 Alarm servers shall be connected to both SCADA network and corporate network. To ensure the SCADA network is cyber secure measures shall be taken limit access from corporate to SCADA network.

7.6.4.2 The corporate and SCADA networks shall be segregated to the guidelines of ANSI/ISA 95.

7.6.4.3 A hardware firewall shall be installed between the servers and the SCADA network. The firewall shall be configured to prevent traffic from other computers other than alarm servers to pass through to SCADA network and vice versa.

7.6.4.4 Contractor shall design and implement the alarm system to meet the cyber security requirements and guidelines of IEC 62443/ISA 99.

7.6.4.5 A software firewall shall be installed in the alarm server to manage traffic between the alarm server and hosts on the corporate network.

7.6.5 **Alarm Servers Hardware Specification**

7.6.5.1 **Server Hardware Specifications**

(a) Processor:
   (i) Type: Intel® Xeon® Gold 6148 (16 core, 2.1 GHz, 30MB, 120W)
   (ii) Number of processors: two (2)
   (iii) Processor cores (for each processor): 16 (sixteen)

(b) Motherboard & interface
   (i) Expansion slots: 2 (two) PCIe
   (ii) USB 3.0 ports: 2 rear, 1 front, 2 internal
   (iii) Video ports: one VGA/DVI rear port and 1 VGA/HDMI front port
   (iv) SD Connector: 1 micro SD Internal

(c) Memory
   (i) Size: 64GB (2x32GB) RDIMM DR 2666 MT/s
   (ii) Memory slots: 24 DIMM slots
   (iii) Memory type: DDR4 Registered (RDIMM) Smart Memory

(d) Storage:
   (i) Total secondary storage required: 6.4TB
   (ii) SSD drives 4 X 1.6TB
   (iii) In two redundant stacks of (2X1.6TB) + (2X1.6TB)
(iv) Storage drives bay: 8 SFF
(v) Type of SSD drives: 6G, SATA, SFF, 2.5-inch, Hot Plug SSD drives
(vi) Optical drive: DVD-RW
(vii) Storage controller: 12GB/s SAS

(c) Network
   (i) Ethernet ports: 4 (four) Gigabit Ethernet ports
   (ii) Network controller: 4-port 1GB/s and 2 port 10GB/s

(f) Casing:
   (i) Mounting: rack type
   (ii) Form factor (fully configured): 1U/2U

(g) Power supply type:
   (i) 2 (two) 800W Flex Slot Platinum hot plug power supply kit

7.6.5.2 Operating System Software Requirements
(a) Windows server 2012 R2 or other later version of Microsoft server
    Operating System to be agreed upon at design stage dependent on
    application requirements
(b) Appropriate licensed firewall from a third party and not Microsoft)
(c) Latest VMware software server edition with licenses
(d) Latest licensed (two-year licences) Kaspersky Security for Windows Server

7.6.5.3 Server cabinet

(a) A server cabinet shall be provided to house the components of the alarm
    server. The cabinet shall meet the requirements below

<table>
<thead>
<tr>
<th>Features</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of cubicle</td>
<td>42U graphite Rack</td>
</tr>
<tr>
<td>Colour</td>
<td>Graphite Metallic</td>
</tr>
</tbody>
</table>
| Dimensions (HxDxW)    | • Height: 79"
                        | • Width: 24"
                        | • Width for Server Mount: 19"
                        | • Depth w/doors: 41"
                        | Total Cabinet Area 78.7 x 39.69 x 24 in/ 2,000 x 1,008.17 x 612.77 mm |
| Front door            | Perforated                                               |
| Rear door             | Split And perforated                                     |
| Side panels           | Included                                                 |
| Cable egress in rack  | included                                                 |
Depth of rails | 29”
---|---
Width for server mount | 19”

### Power distribution units
- Modular PDU control unit
  - in: (1x) C20, 16A
  - Out: (2x) c19, 240V
- 2X HP Modular PDU Extension Bar EO4601, 8 port or equivalent

### Additional forced cooling
- 4X Top mounted cooling fans
- Each with Air throughput of at least 500m$^3$/h
- Voltage rating of 240V AC
- Two sets included (front and rear)

(b) The panel shall contain all equipment and devices necessary for the operation of the alarm server as detailed in the preceding clauses. At minimum it shall contain the following:

(i) Two (2) servers meeting requirements of clause 7.6.5.1

(ii) One (1) 8 port KVM switch as per requirements below

<table>
<thead>
<tr>
<th>Features</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface provided</td>
<td>RJ-45</td>
</tr>
<tr>
<td>Connector Type Qty</td>
<td>2</td>
</tr>
<tr>
<td>Connector Type</td>
<td>Keyboard (USB)</td>
</tr>
<tr>
<td>Connector Type</td>
<td>Mouse (USB)</td>
</tr>
<tr>
<td>Keyboard Mouse Interface</td>
<td>USB</td>
</tr>
<tr>
<td>KVM Local Users Qty</td>
<td>1 local user</td>
</tr>
<tr>
<td>Server Connection Via Twisted Pair</td>
<td>CAT5</td>
</tr>
<tr>
<td>Rack Mounting Kit</td>
<td>Included</td>
</tr>
<tr>
<td>Features</td>
<td>On-Screen Display</td>
</tr>
<tr>
<td>Form Factor</td>
<td>Rack-mountable</td>
</tr>
<tr>
<td>Ports Qty</td>
<td>8</td>
</tr>
<tr>
<td>Stackable</td>
<td>Cascadeable</td>
</tr>
<tr>
<td>Subcategory</td>
<td>KVM</td>
</tr>
<tr>
<td>Networking Subtype</td>
<td>KVM</td>
</tr>
<tr>
<td>Networking Type</td>
<td>KVM switch</td>
</tr>
<tr>
<td>Frequency Required</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Nominal Voltage</td>
<td>AC 230 V</td>
</tr>
<tr>
<td>Power supply Type</td>
<td>Internal power supply</td>
</tr>
</tbody>
</table>

(iii) One (1) integrated flat panel monitor and keyboard as per requirements below
<table>
<thead>
<tr>
<th>Feature</th>
<th>Minimum requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display size</td>
<td>43.9 cm (17.3 inch)</td>
</tr>
<tr>
<td>Display type</td>
<td>Flat panel, active matrix-TFT LCD</td>
</tr>
<tr>
<td>Viewable image size</td>
<td>43.9 cm (17.3 inch) diagonal</td>
</tr>
<tr>
<td>Resolution</td>
<td>1440 x 900 (WXGA+) (recommended for maximum performance) 640 x 480 (VGA) through 1280 x 1024 (SXGA)</td>
</tr>
<tr>
<td>Monitor input</td>
<td>Plugs into a standard VGA connector; does not require a special graphics adapter card</td>
</tr>
<tr>
<td>Keyboard with touchpad</td>
<td>Three-button touchpad with scroll bar</td>
</tr>
<tr>
<td>Power supply</td>
<td>12v DC/36 Watt</td>
</tr>
<tr>
<td>Scroll keys</td>
<td>Four scroll keys (inverted T)</td>
</tr>
<tr>
<td>Response time</td>
<td>&lt;16ms</td>
</tr>
<tr>
<td>Brightness</td>
<td>&gt;187 (cd/m^2)</td>
</tr>
<tr>
<td>Contrast ratio</td>
<td>&gt;500:1</td>
</tr>
<tr>
<td>Input rating</td>
<td>90 to 264 V AC, 47 to 63 Hz</td>
</tr>
<tr>
<td>Power consumption</td>
<td>&lt;36w</td>
</tr>
<tr>
<td>Warranty</td>
<td>3 years</td>
</tr>
</tbody>
</table>

(iv) Two (2) Cisco C3850-24XU-S or equivalent ethernet switches meeting the following requirements

<table>
<thead>
<tr>
<th>Feature</th>
<th>Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Type</td>
<td>Switch - 24 ports - L3 - managed - stackable</td>
</tr>
<tr>
<td>Subtype</td>
<td>Gigabit Ethernet</td>
</tr>
<tr>
<td>Downlink Ports</td>
<td>24 x 10/100/1000 (UPOE)</td>
</tr>
<tr>
<td>Uplink ports</td>
<td>2 x 1000 base x fibre optic</td>
</tr>
<tr>
<td>Power Over Ethernet</td>
<td>UPOE</td>
</tr>
<tr>
<td>PoE Budget</td>
<td>580W</td>
</tr>
<tr>
<td>Performance</td>
<td>Switching capacity: 92 Gbps</td>
</tr>
<tr>
<td></td>
<td>Stacking bandwidth: 480 Gbps</td>
</tr>
<tr>
<td></td>
<td>Forwarding performance (64-byte packet size): 460 Mpps</td>
</tr>
<tr>
<td>Capacity</td>
<td>IPV4 routes: 24000</td>
</tr>
<tr>
<td></td>
<td>NetFlow entries: 24000</td>
</tr>
<tr>
<td></td>
<td>Switched virtual interfaces (SVIs): 1000</td>
</tr>
<tr>
<td></td>
<td>Virtual interfaces (VLANs): 4000</td>
</tr>
<tr>
<td>Jumbo frame Support</td>
<td>9198 bytes</td>
</tr>
<tr>
<td>Authentication Method</td>
<td>Kerberos, RADIUS, Secure Shell (SSH), TACACS+</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>2 GB</td>
</tr>
<tr>
<td>MAC Address Table</td>
<td>32000 entries</td>
</tr>
<tr>
<td>Size</td>
<td>Rack-mount 1U</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Stackable</td>
<td>stackable</td>
</tr>
<tr>
<td>Advanced Switching</td>
<td>Layer 3</td>
</tr>
<tr>
<td>Features</td>
<td>802.1x authentication, ARP inspection, Dynamic Trunking Protocol (DTP) support, Energy Efficient Ethernet, Link Aggregation Control Protocol (LACP), Multiple Spanning Tree Protocol (MSTP) support, PIM snooping, Port Aggregation Protocol (PAgP) support, Quality of Service (QoS), Rapid Per-VLAN Spanning Tree Plus (PVRST+), Remote Switch Port Analyzer (RSPAN), SSH support, ARP support, Shaped Round Robin (SRR), Syslog support, Trivial File Transfer Protocol (TFTP) support, Uni-Directional Link Detection (UDLD), VLAN Trunking Protocol (VTP), Virtual Route Forwarding-Lite (VRF-Lite), Virtual Routing and Forwarding (VRF), Weighted Tail Drop (WTD), radio resource management (RRM), Access Control List (ACL) support, Bridge protocol data unit (BPDU), Cisco Stack Power technology, Cisco StackWise-480 technology, Control plane protection (CoPP), DHCP snooping, DHCP support</td>
</tr>
<tr>
<td>Manageable</td>
<td>Yes</td>
</tr>
<tr>
<td>Routing Protocol</td>
<td>EIGRP, RIP-1, RIP-2, RIPng</td>
</tr>
<tr>
<td>Remote Management Protocol</td>
<td>CLI, RMON 1, RMON 2, SNMP 1, SNMP 2c, SNMP 3, SSH, TFTP, Telnet</td>
</tr>
<tr>
<td>Power Provided</td>
<td>1100 Watt</td>
</tr>
<tr>
<td>Nominal Voltage</td>
<td>AC 230 V AC - British type ports and connectors</td>
</tr>
<tr>
<td>Frequency Required</td>
<td>50 - 60 Hz</td>
</tr>
<tr>
<td>Camera installed size</td>
<td>2 GB</td>
</tr>
<tr>
<td>Power Redundancy</td>
<td>optional</td>
</tr>
<tr>
<td>Power Redundancy Scheme</td>
<td>1+1 (with optional power supply)</td>
</tr>
<tr>
<td>Compliant Standards</td>
<td>CISPR 22 Class A, CISPR 24, EN 61000-3-2, NOM, EN 61000-3-3, EN55024, EN50082-1, EN 61000-6-1, EN 61000-4-4, EN 61000-4-2, EN 61000-4-3, EN 61000-4-6, CCC, ICES-003 Class A, EN 61000-4-5, FCC CFR47 Part 15, UL 60950-1, IEC 60950-1, EN 60950-1, UL 60950-1 Second Edition, KCC, RoHS, FCC Part 15 A, AS/NZS 3548 Class A, BSMI Class A, CAN/CSA</td>
</tr>
</tbody>
</table>

Service included: Advance parts replacement, consulting

Software Type: Cisco IOS IP Base

(v) One (1) Cisco ASA 5525-X Firepower Services or equivalent hardware

Firewall

<table>
<thead>
<tr>
<th>Feature</th>
<th>Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form factor:</td>
<td>1 rack unit (RU)</td>
</tr>
<tr>
<td>Minimum system flash:</td>
<td>8 GB</td>
</tr>
<tr>
<td>Maximum 3DES/AES VPN throughput:</td>
<td>300 Mbps</td>
</tr>
<tr>
<td>Output steady state:</td>
<td>75W</td>
</tr>
<tr>
<td>Maximum Cisco AnyConnect IKEv2 remote access VPN or clientless VPN user sessions:</td>
<td>750</td>
</tr>
<tr>
<td>Maximum new connections per second:</td>
<td>20000</td>
</tr>
<tr>
<td>Stateful inspection throughput (multiprotocol):</td>
<td>1 Gbps</td>
</tr>
<tr>
<td>Maximum heat dissipation:</td>
<td>369 BTU/hr</td>
</tr>
<tr>
<td>USB 2.0 Ports:</td>
<td>2</td>
</tr>
<tr>
<td>Packets per second (64 byte):</td>
<td>700000</td>
</tr>
<tr>
<td>Maximum concurrent sessions:</td>
<td>500000</td>
</tr>
<tr>
<td>Memory:</td>
<td>8 GB</td>
</tr>
<tr>
<td>Stateful inspection throughput (max):</td>
<td>2 Gbps</td>
</tr>
<tr>
<td>Dedicated management port:</td>
<td>Yes (1 GE)</td>
</tr>
<tr>
<td>Output Maximum Peak:</td>
<td>108W</td>
</tr>
<tr>
<td>Serial ports:</td>
<td>1 RJ-45 console</td>
</tr>
<tr>
<td>Maximum AVC and NGIPS throughput:</td>
<td>650 Mbps</td>
</tr>
<tr>
<td>Power input (per power supply) AC current:</td>
<td>4.85A</td>
</tr>
<tr>
<td>VLANs:</td>
<td>200</td>
</tr>
<tr>
<td>Power:</td>
<td>240V AC/110V DC</td>
</tr>
<tr>
<td>Maximum site-to-site and IPsec IKEv1 client VPN user sessions:</td>
<td>750</td>
</tr>
<tr>
<td>Application control (AVC) or NGIPS sizing throughput (440-byte HTTP):</td>
<td>375 Mbps</td>
</tr>
<tr>
<td>Dimensions (H x W x D):</td>
<td>1.75 x 17.5 x 14.25 inches (4.45 x 20.04 x 36.20 cm)</td>
</tr>
<tr>
<td>Operating Acoustic Noise:</td>
<td>64.2 dBA max</td>
</tr>
<tr>
<td>Cisco Cloud Web Security users:</td>
<td>4000</td>
</tr>
<tr>
<td>Solid-state drive:</td>
<td>1 slot, 120 GB multiline configurator self-encrypting drive (MLC SED)</td>
</tr>
<tr>
<td>Maximum application visibility and control (AVC) throughput:</td>
<td>1,100 Mbps</td>
</tr>
<tr>
<td>High-availability support:</td>
<td>Active/active and active/standby</td>
</tr>
</tbody>
</table>

(vi) One (1) Rack mount pure sine wave inverter power supply meeting the following requirements:

- Overall rating 3000VA, 110VDC to 240VAC converter
- Output power
  - Continuous output power: ≥ 2500W
  - Max power output (3min): ≥2800W
  - Surge rating: ≥5000W
- AC output
  - Output waveform: Pure Sine Wave (THD < 3%)
  - Output voltage: 240V ± 3%
  - Frequency: 50Hz
  - Rated output current: 20A
- DC Input
  - Nominal input voltage: 110VDC
  - Maximum input voltage: ≥130VDC
  - Minimum input voltage: ≤88 VDC
  - Fused
- AC input in bypass mode
  - Input voltage: 240VAC
  - Input AC Circuit breaker: 35A
  - Synchronous AC transfer: required
  - Transfer switch: 35A
  - Transfer time: Inverter to Mains AC<10ms
  - Transfer time: Mains AC to Inverter <20ms
- Efficiency
  - Efficiency (full load): >90%
  - No Load Current Draw: <1A
— Stand-By Current Draw: <0.2A

- protection functions
  — Overload
  — Short Circuit
  — Reverse Polarity (Fuse)
  — Over Temperature
  — Battery Over/Under Voltage
  — AC Input Circuit Breaker
  — LED’s
  — AC load level
  — battery level
  — mains supply status

- Connections: screwed

- Cooling: Load controlled cooling fan

(vii) At least Two (2) 24 port rack mount Fibre optic patch panels
(viii) At least Two (2) 24 port rack mount RJ45 STP ethernet patch panels
(ix) At least two (2) AC DP Miniature circuit breakers
(x) At least two (2) AC DP Miniature circuit breakers
(xi) A set of terminal blocks for auxiliary supplies wiring
(xii) Two (2) panel LED lighting lamps
(xiii) One (1) door operated switches
(xiv) Two (2) European type single phase socket outlets
(xv) Two (2) British type single phase socket outlets
(xvi) Other devices required for alarm server operation

(c) One ethernet switch shall be connected to the corporate network while the other ethernet switch shall be connected to the firewall.

(d) Firewall shall connect the Alarm servers on the corporate network to data sources in the SCADA network.

(e) Each server shall be connected to two redundant independent networks i.e. corporate network and SCADA network.

7.6.6 Configuration managers

7.6.6.1 A graphical interface shall be provided to develop and manage SCADA Alarm server applications and DAS applications
7.6.6.2 Configuration managers shall be able to perform all configuration and programming/scripting functions specified in the preceding clauses.

7.6.6.3 Shall support configuration of all the application servers which will include functions such as:

- (a) Tag creation and management
- (b) User creation and management
- (c) Project files development
- (d) Alarms/events/faults/plant maintenance alerts creation and management
- (e) Communication drivers’ management/configuration
- (f) File creation and management
- (g) Alarm notification configuration

7.6.6.4 Shall support export and import of Tag files (.CSV or .txt)

7.6.6.5 Shall be simple to use with a detailed help menu

7.6.6.6 Shall have capability of importing and exporting data to/from Microsoft office applications such as ms excel and ms access

7.6.6.7 Configuration manager shall be provided for installation to four computers, if licences are required four sets of licenses shall be provided supporting unlimited tags and hosts for each application

7.6.6.8 Configuration manager shall be a windows application and shall support the latest windows operating system (windows 10 or higher)

7.6.6.9 It shall be used to develop and manage OPC servers and clients’ configuration, as well as to view communication and network diagnostics.

7.6.6.10 A tool for easy management of plant tags e.g. in Microsoft access or excel with macros shall be provided for updating the tag databases and for future update of tags

7.6.7 Software licenses Requirements

7.6.7.1 All software’s and licences shall be provided for all software configurable devices and applications supplied under the contract. This Clause (clause 7.6.7.3) only summarises the software licences requirement for the bidder, the licences requirements are not limited to what is stated below. It’s the bidders’ obligation to supply at least two necessary licences that are not stated below (clause 7.6.7.3).

7.6.7.2 All Licenses MUST be one off license without any annual payment. Where annual payment is required the employer shall when evaluating add a cost of 15-year licences payment to the bidders’ price for bid comparison.

7.6.7.3 A minimum of the following software licences shall be provided
(a) Twelve (12) Licenses of Alarm system DAS application with all features (event capture, log file generation, archive server, tag database, OPC UA etc) described in the preceding clauses each supporting a minimum of 20,000 tags.

(b) Three (3) licences of the Alarm server application with all features (alarm server, web server, archive server, tag database, OPC UA etc) described in the preceding clauses each supporting a minimum of 300,000 tags and unlimited number of hosts.

(c) Fourteen (14) licences **if required** for alarm server client applications installed into client computers for accessing the event and alarm server. Ten applications to support a minimum of 20,000 tags and four applications to support a minimum of 300,000 tags.

(d) Two (2) licenses of Microsoft Windows Server 2012 R2 or higher (2016) one for each alarm server.

(e) Two (2) VMware® software (server edition) licenses one for each server.

(f) Two (2) software firewall server edition licenses from third party i.e. not Microsoft one for each server.

(g) Two (2), two-year licences for Kaspersky Security for Windows Server one for each server.

7.6.7.4

7.6.8 **Training Requirements**

7.6.8.1 Contractor shall offer detailed training to the employer staff in order for them to be able to develop and maintain the alarm management system.

7.6.8.2 The training shall be both theory and practical hands on to the employer staff.

7.6.8.3 To ensure maximum knowledge transfer two or three client staff shall be attached to the contractor for the duration of the project from design to commissioning. The attached staff shall be assigned duties by the contractor.

7.6.8.4 Contractor shall carry out all software, configurations, programming with the client engineers. They shall assign these tasks to the employer staff and supervise them.

7.6.8.5 By the end of the project the employer staff shall be able to carry out configuration for other power stations with minimal assistance from the contractor.

7.6.8.6 To ensure full participation of employer’s staff SCADA system development shall be carried out at site together with employer staff.

7.6.8.7 Contractor shall carry out class room training/theoretical training on a minimum of the following
(a) OPC UA and OPC DA
   (i) Basic theory
   (ii) Data model
   (iii) Communication settings (COM, DCOM, OPC binary, HTTPS, SOAP, TCP etc)
   (iv) Adding tags to servers and browsing tags on clients
   (v) Troubleshooting and diagnostics

(b) On each type of SCADA software to be used for alarm management
   (i) Software installation and configuration
   (ii) Tag database creation and management
   (iii) Mass import and export of tags
   (iv) Graphical user interface configuration
   (v) Scripting/programming to automate functions e.g. report generation and for logical and mathematical functions
   (vi) Project files creation and management tools
   (vii) Project files back up and administration
   (viii) Communication settings/configuration
   (ix) Archiving settings
   (x) Event management settings
   (xi) User action management settings
   (xii) Use of Microsoft applications excel/access to create and manage tags and tags properties
   (xiii) User creation and management
   (xiv) Security features
   (xv) MIMIC creation if supported by the software
   (xvi) Redundancy and failover
   (xvii) All other topics relevant to the project

(c) On each type of Archive server to be used
   (i) Basic theory on SQL and ODBC
   (ii) ODBC client and server drivers’ configuration
   (iii) SQL queries - basics and all relevant information
   (iv) File management and back up
   (v) Redundancy and failover
   (vi) All other topics relevant to the project

(d) Web server to be used
   (i) Software installation and configuration
(ii) Basics on programming used
(iii) Web pages configuration
(iv) Archiving and archive retrieval
(v) File transfer (FTP etc)
(vi) Redundancy and failover
(vii) All other topics relevant to the project

7.7 TECHNICAL DOCUMENTATION

7.7.1 Drawings

7.7.1.1 The function of each drawing shall be clearly indicated. Related drawings shall be arranged sequentially and have the same drawing numbers but different sheet numbers.

7.7.1.2 The drawings shall include the following;

(a) Ac single line & AC Schematic drawings showing connection of protected equipment, CTs and PT’s and associated protective relays in two sets one A3 another A4 size sheets

(b) DC, control, protection scheme, tap changer control scheme, communication interface and SCADA interface Schematic drawings in two sets one A3 another A4 size sheets

(c) Functional Drawings in two sets one A3 another A4 size sheets

(d) Terminal blocks wiring schedule, terminal block diagrams and cable schedules in A4 size sheet.

(e) Panel device layout drawing showing exploded view of the rear and front panel indicating the disposition of various equipment inside the control panel in two sets one A3 another A4 size sheets

(f) Dimensioned drawings of the control panel indicating front and rear views with the layout of instruments, mimic diagram, control switches, indication LEDs push buttons, relays and other equipment etc. clearly marked in two sets one A3 another A4 size sheets

(g) General layout drawings for the panels location in two sets one A3 another A4 size sheets

(h) Parts list in A4 size sheet
(i) Logic diagrams of all IED’s provided in two sets one A3 another A4 size sheets
(j) Logic diagrams of SCADA interface system and the communication networks provided in two sets one A3 another A4 size sheets
(k) Drawing showing the legend of various references/codes adopted for equipment, relays and all other accessories used in the panels in A4 size
(l) Drawing for name plates/identification labels engraving details in A4 size
(m) Any other drawings considered necessary.
(n)

7.7.2 Operating and Maintenance Instructions

7.7.2.1 The Contractor shall supply detailed instructions manuals concerning the correct manner of assembling/Installing/Erection, configuring, setting, Testing and Commissioning, operating and maintaining the equipment and devices constituting the supplied protection system

7.7.2.2 The basic maintenance schedule along with the troubleshooting, diagnostic chart shall be submitted.

7.7.2.3 The relays should be supplied with manuals with all technical and operating instructions.

7.7.2.4 All the internal drawings indicating the logics and block diagram details explaining principle of operation should be given at the time of supply.

7.7.2.5 Mapping details shall be submitted in IEC format.

7.7.2.6 Standard documentation per Relay, according to IEC 61850 shall be provided including:
   (a) MICS document (model implementation conformance statement)
   (b) PICS (protocol implementation conformance statement)
   (c) Conformance Test certificate by KEMA (to be submitted along with Bid.)
   (d) ICD file
   (e) CID file
   (f) SCD file
   (g) PIXIT Document.

7.7.2.7 Detailed testing procedure by secondary injection and primary injection shall be supplied for all the functions enabled in all the numerical relays. The procedures shall be clear and detailed for all the functions. Checklists to be followed during testing shall be included
7.7.2.8 ALL factory routine tests, all Site routine tests, commissioning tests and all type test reports shall be provided as part of technical documentation. The test report shall include the procedures followed and results obtained.

7.7.2.9 The maintenance details of each component shall also be described, including the frequency of inspections, testing, replacement etc.

7.7.2.10 Software manuals detailing configuration and programming procedures for all software provided

7.7.2.11 Configuration manuals for the Software application for each application developed for the project for employer engineers and application developers

7.7.2.12 Operation manuals for the operators and users of the software Applications

7.7.2.13 The Manufacturer shall, in preparing the instruction manuals, take into account the lack of experience and familiarity of the Operators with this type of equipment.

7.7.2.14 Documentation shall adhere to requirements given in clause 1.7 of general specifications

7.8 INSPECTION AND TESTING

All components and assemblies of protection Panels and relays shall be tested in accordance with the relevant IEC Standards to verify compliance with the requirements of the Standards and Specification.

7.8.1 Type Test

7.8.1.1 The relays offered shall be fully type tested as per the relevant standards. Type Test certificate as per IEC60255 and IEC61850 not older than 10 years shall be supplied along with offer by the bidder.

7.8.1.2 Type test reports for numerical protection relays from a third party reputable testing laboratory certified by the National Standards and Testing Authority (NSTA) or a laboratory accredited to the NSTA of USA or EU country shall be submitted during design to confirm protection relays conforms to the following:

(a) Insulation tests as per IEC – 60255-5.
(b) High frequency disturbance test as per IEC-60255-4 Class III
(c) Fast transient test as per IEC 1000-4 Level III.
(d) Relay characteristics, performance and accuracy test as per IEC 60255.
   (i) Steady state characteristics and operating time.
   (ii) Dynamic Characteristics and operating time for distance protection Relays and current differential protection relays.
(iii) For Disturbance recorder and even logger only performance tests are intended under this item.

(e) Tests for thermal and mechanical requirements as per IEC-60255-6
(f) Tests for rated burden as per IEC – 60255-6
(g) Contact performance test as per IEC – 60255-0-20.
(h) DC Supply Interruption and AC Ripple on DC supply as per IEC 60255-11
(i) Voltage Dips and Short Interruptions as per IEC 61000-4-11
(j) High frequency Disturbance ripple as per IEC 60255-22-1
(k) Class III Fast Transient Disturbance as per IEC 60255-22-4
(l) Class IV Surge withstand capability as per IEEE/ANSI C 37.90.1(1989)

7.8.1.3 Wherever the above-mentioned standards and IEC 61850 overlap, the latter will prevail.

7.8.1.4 KEMA Test certificates to show compliance to IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1 shall be provided during design for
(a) Each type of protection IED
(b) IEC61850 Gateway
(c) Each type of ethernet switches

7.8.1.5 Test certificates to show compliance to IEC 61850-3 and IEEE1613 shall be provided during design for
(a) IEC61850 Gateway
(b) Each type of ethernet switches

7.8.2 Factory Acceptance Tests

7.8.2.1 Tests given in this clause are not comprehensive and only highlight the minimum required tests. The contractor shall prepare detailed test plans as per clause 1.9.3.3 of specifications, covering all detailed tests necessary as per requirements of IEC 60255, IEC61850, IEEE C37.90 and IEEE 1613

7.8.2.2 The client shall witness the factory tests.

7.8.2.3 The protection systems shall have functional tests carried out at the factory before dispatch to prove that all components operate together as a system and that all protection functions and device responses are satisfactory. It shall be the responsibility of the contractor to provide test boxes and other test equipment for sufficiently comprehensive tests.
7.8.2.4 All cubicles shall be subject to inspection during manufacture and on completion to verify compliance with all the requirements of the Specification, including surface finish and insulation resistance.

7.8.2.5 Tests shall include but not limited to

(a) Visual Checks: General Check of the control panel in respect of dimension, finishing, construction, wiring & ferules verification lay out equipment on the panel, make and rating of instrument etc.

(b) Insulation Resistance as per IEC 60255 standards

(c) Dielectric strength as per relevant IEC60255 standards

(d) Operational tests: Operation tests on all equipment to prove correctness of wiring of various circuits including indications, alarms, operation of relays and annunciation etc.

(e) Setting range and Functional tests

(f) IEC61850 Conformance Testing and other necessary tests for numerical relays, industrial PC’s and industrial Ethernet switches.

(g) Functional testing of the SCADA communication gateway

7.8.3 **Site Tests**

7.8.3.1 Tests given in this clause are not comprehensive and only highlight the basic required tests. The contractor shall prepare test plans as per **clause 1.10.3** of specifications, covering all detailed tests necessary for commissioning of the protection system and associated equipment.

7.8.3.2 The Contractor’s test schedules shall include comprehensive check lists for testing of the protection systems, tripping matrix and fault indication facilities.

7.8.3.3 The preliminary tests shall include the following:

(a) Insulation resistance measurements at the specified voltages appropriate to the circuits and equipment.

(b) Relay auxiliary D.C. supply checks

(c) CTs and associated secondary wiring tests

(d) VTs and associated secondary wiring tests

(e) Secondary injection testing to determine relay settings and operation within manufacturers stated parameters

(f) Primary injection tests for main protection schemes. Procedures shall be detailed by the contractor for review and approval by the client

(g) Signal Test: Proof of correct connection and continuity of wiring for all control, protection, auxiliary and alarm equipment in accordance with the overall diagrams as provided by the Contractor.
(h) Functional tests to prove that all protection functions operate together as a system and that all tripping signals and device responses are satisfactory and reach the desired equipment including operation of relevant CB’s. It shall be the responsibility of the Contractor to provide test programme and test equipment for sufficiently comprehensive tests.

(i) Tests of all indications, displayed quantities and analogue outputs to show such items are accurate.

(j) Communication system functional checks including inter IED communication and communication between the station equipment (PLC’s etc.) and the protection IED’s.

(k) IEC61850 automation functional tests

(l) IEC61850 GOOSE messaging performance requirements conformance tests as per IEC61850-5 and IEC61850-10

7.8.3.4 The Tests on Completion shall include the following:

(a) Demonstration that all protection functions, alarms/trips and indications operate correctly.

(b) Demonstration that all protection trips to the control system and Shutdown controls operate correctly. When the unit is running.

(c) Open circuit tests

(d) Short circuit tests

(e) Communication scheme tests including GOOSE inputs and outputs trip tests

(f) Demonstration of proper functioning of all the communication interfaces and protocols i.e GOOSE (inter IED and IED to other devices) SAMPLED VALUES between merging units and protection IED’s (if configured) and MMS client server communication between protection IED’s and SCADA systems.

7.8.3.5 The Contractor shall submit for approval SAT procedure as detailed in clause 1.7 and 1.10 of specifications for approval. The Commissioning Programme shall include, as a minimum, the following:

(a) List of the site test for all protection systems/relays and associated power equipment (CTs/VTs etc.)

(b) Procedures and methods for each commissioning test including those to be performed on-load.

(c) Testing equipment and instruments necessary for performing of each test

(d) Format of site test reports for each test.
7.9 TRAINING

7.9.1 Training shall cover the following:

7.9.1.1 Power systems protection theory and application
   (a) Introduction, types of faults and fault calculations
   (b) Generator protection schemes, transformer protection schemes and bus bar protection schemes
   (c) Details on setting calculations and determination of functions to use for the above schemes for various types of generators, transformers & bus bars
   (d) Protection coordination and grading
   (e) Power system transient and steady state stability

7.9.1.2 Protection IED setting and parameterization
   (a) Protection functions setting parameterization
   (b) input/output configuration
   (c) SCL configuration
   (d) Configuring and using protection IED Diagnostic features
   (e) Using the numerical relays logic editor. Practical on creating and editing schemes using the logic editor.

7.9.1.3 Testing various protection schemes using secondary injection test set.
   (a) Automatic testing of major functions e.g. differential, over current, phase shift functions and voltage functions shall be carried out.
   (b) Creating and configuring test objects and test plans for automatic testing
   (c) Contractor shall develop and provide test objects for the relays supplied
   (d) Creating test reports
   (e) Importing relay configuration files to test plans

7.9.1.4 Commissioning testing of generator and transformer protection systems from first principles.
   (a) Primary injection testing
   (b) Short circuit tests
   (c) Open circuit tests

7.9.1.5 Operation and Maintenance
   (a) Routine protection system checks and testing procedures. This will include training on maintenance testing of the whole protection system components i.e. instrument transformers, protection relays, lockout relays, circuit breakers etc.
   (b) Configuration, Installation and replacement of protection relays and other protection system components. Client engineers will be taken through step
7.9.1.6 Detailed theory and practical training on IEC 61850 standard
   (a) Introduction and overview of IEC61850 standard
   (b) SCL language-configuration and configuration files management
   (c) Abstract Communication Service Interface (ACSI)
   (d) Use of Common Data Classes (CDC) and various IE61850 object libraries
   (e) IEC61850 GOOSE configuration and testing
   (f) IEC61850-9 SAMPLED VALUES configuration and testing
   (g) IEC61850-8 MMS configuration and testing
   (h) IEC61850-10 conformance testing

7.9.1.7 Detailed training on OPC and interfacing to SCADA communication protocols.
   (a) Configuring OPC UA and OPC DA communication interfaces
   (b) IEC61850-OPC interfacing
   (c) IEC61850-ModBus TCP interfacing
   (d) Modbus-OPC interfacing
   (e) Training on applications/configuration files developed for interfacing the
       protection system to SCADA system via communication
   (f) Detailed training on using configuration managers provided

7.9.1.8 Detailed training on the SCADA communication gateway
   (a) Detailed training on using configuration managers provided
   (b) Communication configuration (OPC etc.)
   (c) Importing new tags and
   (d) Detailed training on configuring all the applications in the SCADA
       communication gateway
   (e) Cyber security- Standards, industry trends, implementation, security systems
       management, risk assessment, recovery plans

7.9.1.9 Detailed practical training of fibre optic termination and testing
   (a) Fibre optic termination
   (b) Fibre optic splicing
   (c) Fibre optic testing and troubleshooting
   (d) Use of tools and kits provided.

7.9.1.10 Detailed training on SCADA alarm management system as detailed in clause 7.6
7.9.2 In order to maximise knowledge transfer to the client engineers the following shall be carried out

7.9.2.1 Protection IED configuration and offline tests shall be carried out together with the client engineers for one unit. The second unit configuration and offline tests shall be carried out by client engineers under supervision from the contractor.

7.9.2.2 All commission and Site acceptance tests shall be carried out by both client and contractor engineers with the contractor commissioning engineer in charge.

7.9.2.3 Carrying out development and configuration of the communication gateway and network applications with client engineers.
   (a) Contractor shall carryout all software configurations together with client engineers. At least three client engineers shall be attached to the contractor for the whole duration of SCADA system development and configuration.
   (b) Client engineers will carry out development and configuration of various applications for the second unit under supervision and directions of the contractor
   (c) Detailed class room training on OPC and IEC61850 shall be carried out for at least one week. It shall entail all that is necessary for client engineers to be able to develop and configure applications for OPC and IEC 61850.
   (d) Training aids including a software trainer, video’s and printed materials shall be availed

7.9.2.4 By the end of the project the client engineers should be able to develop applications (programming) and configure all the protection IED’s, PLC, gateways, Ethernet LAN and SCADA communication gateway. In that retrospect:
   (a) Other necessary training requirements necessary for this shall be included by the bidder.
   (b) During the design stage, other training modules necessary for this shall be added
   (c) Contractor shall forward minimum qualifications requirements for client engineers to be involved, however academic qualification shall not exceed bachelor’s degree
   (d) Contractor/bidder shall factor in the fact that the client engineers are not conversant with contractors’ systems/equipment/software platforms
8 PARTICULAR TECHNICAL SPECIFICATION: STATION LOW VOLTAGE SWITCHBOARDS

8.1 INTRODUCTION

8.1.1 Gitaru power station has a number of LV switch boards for supplying various station loads. All the switch boards are supplied from the main station switch board located at the control building; main station switch board has four incoming supplies from the station transformers and diesel generator. The main switch board has two bus bars a duty bus bar and reserve bus bar each with two incomers, only one incomer is connected to the bus bar at any one time.

8.1.2 Main station auxiliary board (auxiliary section) supplies common station loads like lighting, ventilation dewatering pumps etc. its located in the control building next to the main station switchboard.

8.1.3 The station general services switchboard is supplied from station auxiliary switchboard located at the power house. The station auxiliary board also supplies the three units’ motor control centres (MCC’s)

8.1.4 Station general services switchboard supplies loads common to the three units at the power house and other general supplies like power house lighting.

8.1.5 There is an intake gate control centre at the intake gates control building and spill way gates control centre at the spillway gates control housing.

8.1.6 KenGen wishes Install a new Main station auxiliaries’ switchboard in the control room and other small AC and DC distribution boards

8.1.7 Bidder shall study the existing switch boards and make a proposal based on that and the scope and specifications provided in this document.

8.1.8 The new boards and equipment must ensure continuous supply for FOURTY YEARS Without interruptions. They MUST withstand the prevailing environmental conditions as provided in the plant equipment data section 4 of specifications

8.1.9 Any alternative / additional equipment considered necessary for providing complete, effective and reliable switchboards but not indicated in the specifications shall also be included in the bid.

8.2 EXISTING LOW VOLTAGE SWITCHBOARDS

8.2.1 The existing switchboards were installed in 1978. They have feeders and incomers as described below
# Tender for rehabilitation of Gitaru Power Station Generator MV Switchgear, Protection systems and LV Switchboards

## 8.2.1.1 Main station switch board

<table>
<thead>
<tr>
<th>CELL</th>
<th>CIRCUIT</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DUTY BUS SECTION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incomer cubicles</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Unit 1 station transformer</td>
<td>1200A</td>
</tr>
<tr>
<td>5</td>
<td>Unit 3 station transformer</td>
<td>1200A</td>
</tr>
<tr>
<td></td>
<td>Cable feeder cubicle compartments</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Power house auxiliaries' switchboard</td>
<td>600A</td>
</tr>
<tr>
<td>21</td>
<td>Station general services switch board</td>
<td>600A</td>
</tr>
<tr>
<td>24</td>
<td>Intake gates control supply</td>
<td>250A</td>
</tr>
<tr>
<td>23</td>
<td>Spill way gates control supply</td>
<td>250A</td>
</tr>
<tr>
<td>3</td>
<td>Bus coupler cubicle</td>
<td>1200A</td>
</tr>
<tr>
<td></td>
<td>RESERVE BUS SECTION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incomer cubicles</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>DG</td>
<td>1200A</td>
</tr>
<tr>
<td>2</td>
<td>Alternative supply transformer</td>
<td>1200A</td>
</tr>
<tr>
<td></td>
<td>Cable feeder cubicle compartments</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Power house auxiliaries' switchboard</td>
<td>600A</td>
</tr>
<tr>
<td>17</td>
<td>Station general services switch board</td>
<td>600A</td>
</tr>
<tr>
<td>20</td>
<td>Intake gates control supply</td>
<td>250A</td>
</tr>
<tr>
<td>19</td>
<td>Spill way gates control supply</td>
<td>250A</td>
</tr>
</tbody>
</table>

## 8.2.1.2 Main station auxiliary’s switchboard

<table>
<thead>
<tr>
<th>CELL</th>
<th>CIRCUIT</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INCOMER CUBICLE</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Duty bus section</td>
<td>500A</td>
</tr>
<tr>
<td>25</td>
<td>Reserve bus section</td>
<td>500A</td>
</tr>
<tr>
<td></td>
<td>FEEDER CIRCUITS</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Dewatering pump 1</td>
<td>100A, DOL 22KW</td>
</tr>
<tr>
<td>29</td>
<td>Dewatering pump 2</td>
<td>100A, DOL 22KW</td>
</tr>
<tr>
<td>30</td>
<td>Dewatering pump 3</td>
<td>100A, DOL 22KW</td>
</tr>
<tr>
<td>35</td>
<td>Ventilation fan1</td>
<td>250A</td>
</tr>
<tr>
<td>47</td>
<td>Ventilation fan2</td>
<td>250A</td>
</tr>
<tr>
<td>48</td>
<td>Staff dwellings (decommissioned)</td>
<td>160A</td>
</tr>
<tr>
<td>36</td>
<td>110V Battery charger</td>
<td>100A</td>
</tr>
<tr>
<td>37</td>
<td>50V Battery charger</td>
<td>100A</td>
</tr>
<tr>
<td>39</td>
<td>415V Power outlet 1</td>
<td>100A</td>
</tr>
<tr>
<td>40</td>
<td>415V Power outlet 2</td>
<td>100A</td>
</tr>
<tr>
<td>41</td>
<td>Lift supply</td>
<td>80A</td>
</tr>
<tr>
<td>38</td>
<td>Control &amp; office buildings supplies</td>
<td>100A</td>
</tr>
</tbody>
</table>
8.3 SWITCH BOARDS REQUIREMENTS

8.3.1 General LV Switchboards Requirements

8.3.1.1 Project involves design, installation and commissioning a
(a) Complete LV AC Main station auxiliaries’ switchboard
(b) Control building emergency DC lighting distribution board
(c) Power house emergency DC lighting distribution board
(d) Protection DC circuits supply distribution board
(e) Other minor 3Φ & 1Φ AC distribution boards
8.3.1.2 The switch boards and their components shall be designed, constructed and tested in accordance with IEC 61439, IEC 60947 and IEC 60529. The boards shall be complete with all the relevant components including, bus bars, circuit breakers; cable compartment; instrument transformers; protection & control relays; instruments, meters and other control devices. Three phase connections shall ALL be 4 WIRE and DC connections 2 WIRE unless where specified otherwise.

8.3.1.3 The new switchboards shall cover all the functionality of the existing switchboards plus the new requirements. Bidders must study the existing switchboard before making their offer. Necessary drawings and equipment data will be supplied during the site visit.

8.3.1.4 The switchboards control, metering and protection shall be interfaced to the Gitaru plant control system and the new protection system. The client shall furnish the contractor with the interface drawing to the manual control and the automation system after the tender award.

8.3.1.5 Components, devices or parts of the switchboard not mentioned in the specification but required for complete working of the switchboard or for providing functionality of the existing switchboards and new requirements shall be included in the bid and shall form part of equipment to be supplied.

8.3.1.6 The switchboards and their components shall conform to ALL the specification given in the subsequent sections and other parts of this document.

8.3.1.7 Power cables for incomer and feeder cables shall be reused except where new cables have been specified.

8.3.1.8 Auxiliary supply, Control, metering and protection cabling shall be replaced with new cables.

8.3.2 **Main Station Auxiliaries Switch Board**

8.3.2.1 **Switchboard requirements**

(a) The switchboard shall have two incomer supplies from the main station switchboard duty bus section and reserve bus section.

(b) The following incomers and feeder circuits with the indicated switchgear ratings shall be provided in the new switch board:

<table>
<thead>
<tr>
<th>INCOMER CUBICLE/S (two) - One existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomer cubicle/s</td>
</tr>
<tr>
<td>Duty bus section incomer</td>
</tr>
<tr>
<td>Reserve bus section incomer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FEEDER CUBICLES (three/four) - Four existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard sized plug in modules</td>
</tr>
</tbody>
</table>
### Feeder cubicle compartments

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Module rating</th>
<th>Module Type</th>
<th>MCCB rating</th>
<th>Contactor rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dewatering pump 1</td>
<td>125A</td>
<td>55KW</td>
<td>DOL Motor starter</td>
<td>160A 75KW</td>
</tr>
<tr>
<td>2</td>
<td>Dewatering pump 2</td>
<td>125A</td>
<td>55KW</td>
<td>DOL Motor starter</td>
<td>160A 75KW</td>
</tr>
<tr>
<td>3</td>
<td>Dewatering pump 3</td>
<td>125A</td>
<td>55KW</td>
<td>DOL Motor starter</td>
<td>160A 75KW</td>
</tr>
<tr>
<td>4</td>
<td>Spare</td>
<td>125A</td>
<td>55KW</td>
<td>DOL Motor starter</td>
<td>160A 75KW</td>
</tr>
<tr>
<td>5</td>
<td>Ventilation fan 1</td>
<td>250A</td>
<td>Cable feeder</td>
<td></td>
<td>315A N/A</td>
</tr>
<tr>
<td>6</td>
<td>Ventilation fan 2</td>
<td>250A</td>
<td>Cable feeder</td>
<td></td>
<td>315A N/A</td>
</tr>
<tr>
<td>7</td>
<td>Spare</td>
<td>250A</td>
<td>Cable feeder</td>
<td></td>
<td>315A N/A</td>
</tr>
<tr>
<td>8</td>
<td>110V Battery charger</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>9</td>
<td>50V Battery charger</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
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<tr>
<td>10</td>
<td>Power outlet 1</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>11</td>
<td>Power outlet 2</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>12</td>
<td>Lift supply</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>13</td>
<td>Control &amp; office buildings supply board</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>14</td>
<td>Unit 1 generator transformer kiosk</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>15</td>
<td>Unit 2 generator transformer kiosk</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>16</td>
<td>Unit 3 generator transformer kiosk</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>17</td>
<td>Spare</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
<tr>
<td>18</td>
<td>Spare</td>
<td>125A</td>
<td>Cable feeder</td>
<td></td>
<td>160A N/A</td>
</tr>
</tbody>
</table>

Small sized or Standard sized plug in modules

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Module rating</th>
<th>Module Type</th>
<th>MPCR rating</th>
<th>Contactor rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Air conditioning board</td>
<td>63A</td>
<td>Cable feeder</td>
<td>80A</td>
<td>N/A</td>
</tr>
<tr>
<td>20</td>
<td>UPS supply 1</td>
<td>63A</td>
<td>Cable feeder</td>
<td>80A</td>
<td>N/A</td>
</tr>
<tr>
<td>21</td>
<td>UPS supply 2</td>
<td>63A</td>
<td>Cable feeder</td>
<td>80A</td>
<td>N/A</td>
</tr>
<tr>
<td>22</td>
<td>Spare</td>
<td>63A</td>
<td>Cable feeder</td>
<td>80A</td>
<td>N/A</td>
</tr>
<tr>
<td>23</td>
<td>Spare</td>
<td>63A</td>
<td>Cable feeder</td>
<td>80A</td>
<td>N/A</td>
</tr>
<tr>
<td>24</td>
<td>Unit 1 station transformer &amp; MV switchgear supply</td>
<td>32A</td>
<td>Cable feeder</td>
<td>32A</td>
<td>N/A</td>
</tr>
<tr>
<td>25</td>
<td>Unit 2 station transformer &amp; MV switchgear supply</td>
<td>32A</td>
<td>Cable feeder</td>
<td>32A</td>
<td>N/A</td>
</tr>
<tr>
<td>26</td>
<td>Unit 3 station transformer &amp; MV switchgear supply</td>
<td>32A</td>
<td>Cable feeder</td>
<td>32A</td>
<td>N/A</td>
</tr>
<tr>
<td>27</td>
<td>EDG &amp; Alternative supply transformer auxiliary supply</td>
<td>32A</td>
<td>Cable feeder</td>
<td>32A</td>
<td>N/A</td>
</tr>
<tr>
<td>28</td>
<td>Spare</td>
<td>32A</td>
<td>Cable feeder</td>
<td>32A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Type</td>
<td>MCB rating</td>
<td>MCB rating</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------</td>
<td>---------------</td>
<td>------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Water treatment plant</td>
<td>63A 32KW</td>
<td>DOL Motor starter 80A 37KW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Street &amp; station flood lights</td>
<td>63A 32KW</td>
<td>DOL Motor starter 80A 37KW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Shaft lighting</td>
<td>63A 32KW</td>
<td>DOL Motor starter 80A 37KW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>spare</td>
<td>63A 32KW</td>
<td>DOL Motor starter 80A 37KW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Control & office buildings supply distribution/panel board compartment

<table>
<thead>
<tr>
<th></th>
<th>Feeder circuit</th>
<th>Type</th>
<th>MCB rating</th>
<th>MCB rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch room</td>
<td>Three phase circuit</td>
<td>32A N/A</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ventilating room</td>
<td>Three phase circuit</td>
<td>32A N/A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>spare</td>
<td>Three phase circuit</td>
<td>32A N/A</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>spare</td>
<td>Three phase circuit</td>
<td>32A N/A</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Lift and cable room</td>
<td>Single phase circuit</td>
<td>N/A 15A</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Corridors</td>
<td>Single phase circuit</td>
<td>N/A 15A</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>External area</td>
<td>Single phase circuit</td>
<td>N/A 15A</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Services and battery room</td>
<td>Single phase circuit</td>
<td>N/A 15A</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Office</td>
<td>Single phase circuit</td>
<td>N/A 15A</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Ventilating room ring main No 3</td>
<td>Single phase circuit</td>
<td>N/A 32A</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Services and office rooms ring main No 2</td>
<td>Single phase circuit</td>
<td>N/A 32A</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Switch room ring main No.1</td>
<td>Single phase circuit</td>
<td>N/A 32A</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>spare</td>
<td>Single phase circuit</td>
<td>N/A 32A</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>spare</td>
<td>Single phase circuit</td>
<td>N/A 32A</td>
<td></td>
</tr>
</tbody>
</table>

### Switchboard Basic rating

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main busbar rating In</td>
<td>800A</td>
</tr>
<tr>
<td>2</td>
<td>Distribution busbar rating In</td>
<td>500A</td>
</tr>
<tr>
<td>3</td>
<td>Switchboard short-time withstand current(Icw)</td>
<td>≥50KA/1s</td>
</tr>
<tr>
<td>4</td>
<td>Rated operating voltage</td>
<td>433V AC</td>
</tr>
</tbody>
</table>

(c) Switchboard and switchgear shall be compliant with specifications in **clause 3.6, 8.4 & 8.5**.

(d) Main station auxiliaries’ switchboard shall meet following:

(i) Rated short time withstand current: 50 kA / 1s

(ii) Rated internal arc withstand current: ≥ 50KA for 0.3s

(iii) Rated continuous current of the main bus bars: ≥800A

(iv) Rated continuous current of the distribution bus bars: ≥500A

(v) Nominal frequency: 50 Hz

(vi) Rated insulation voltage: 1000 V

(vii) Rated operating voltage: 433 V

(viii) Rated impulse withstand voltage: 6 kV

(ix) form of separation as per IEC 61439-2: form 4b
(x) IP degree of protection as per IEC 60529: IP 54  
(xi) Cooling: Natural  
(xii) Ambient air temperature: 40 °C  
(xiii) Relative humidity (@40 °C): ≥90 %  
(xiv) Rated altitude: ≥1000m ASL  
(xv) Over voltage category: III  
(xvi) Pollution severity: 3  
(xvii) Cable entry: from the bottom  
(e) Switch board shall contain four bus bars for each phase and neutral. Both main and distribution bus bars shall consist of four bus bars  
(f) The switchboard shall conform to the IEC 61439-2 Form 4b form of separation and external ingress protection IP54 according to IEC 60529. Switchgear and metering compartments shall be separated from each other by finger-proof partitions (IP2X). Bus bar and cable compartments shall be separated from the switchgear and metering compartments by finger-proof partitions (IP2X).  
(g) The new mains station auxiliaries’ switchboard shall be installed in the control room in front of the protection panels. The available space in front of the protection panels is 5000mm X 600mm. A cable trench of 10000mmX800mm shall be constructed inside the control room for cable installation. The cable trench shall be similar to the control room cable trenches with tiled covers.  
(h) Cable marshalling cabinets shall be installed in the position where the existing main station switchboard auxiliaries section is situated. The cable marshalling cabinet shall interface the new main station auxiliaries’ switchboard to the existing power station cables  

8.3.2.2 Incomer cubicle/s  
(a) The switchboard shall have two incomers housed in two cubicles, each cubicle shall have four compartments for bus bar; cable connection; Air circuit breaker and Protection, metering & control.  
(b) Each incomer shall have a withdrawable air circuit breaker compliant with all specifications in clause 8.6.1 and each with communication capability via Modbus RTU (RS485)  
(c) Incomer ACBs Communication interface shall be configured to provide data and enable commands similar to MCCB’s as detailed in clause 8.6.3.9
(d) Neutral link rated at least 800A shall installed for each incomer linking the
neutral bus bars to the incomers neutral if a three pole ACB’s are used
(e) Each incomer shall have at least 4(four) (one per phase) 500/1 A current
transformers meeting requirements of clause 8.6.7
(f) Each incomer shall have at least 1(one) three phase voltage transformers
meeting requirements of clause 8.6.8
(g) Each incomer shall have a minimum of the following control, metering &
protection devices and functions:
   (i) Digital Panel multi-function meter meeting all requirements of clause
       3.4.5
   (ii) Local manual incomer operation via push buttons shall be provided for
each incomer, Auto changeover control shall be provided by the
automotive transfer controller and remote-control circuit shall be
provided and interfaced to common PLC.
   (iii) At least three Motor protection circuit breaker (MPCB) suitably rated
for protection of the three phase control circuits
   (iv) An emergency pushbutton for emergency tripping of the ACB
   (v) At least three illuminated pushbuttons for ACB local opening, ACB
closing and ACB trip reset with integrated indication lamps
   (vi) A set of contactor relays for circuit breaker control & interlocks
   (vii) A set of miniature interface relays with 4 SPDT contacts for interfacing
(viii) At least 4 (four)status indication LED lamps for the following status.
          ACB tripped          Supply unavailable
          ACB in service position  ACB in test position
   (ix) at least two DC DP Miniature circuit breakers
   (x) At least one AC DP Miniature circuit breakers

(h) A digital AC voltmeter shall be connected to the switchboard main bus bar
via a three-phase voltage transformer for measurement of bus bar voltage
   (i) The digital AC voltmeter shall be as per requirements of clause 3.4.2.3
   (ii) The digital AC voltmeter shall be flash mounted on the duty incomer
cubicle
   (iii) The digital AC voltmeter shall have an EIA 485, Modbus RTU
communication output, which shall be wired to the serial device server
   (iv) The digital AC voltmeter shall be wired to a voltage transformer line-
line output
(v) A three-phase voltage transformer meeting requirement of clause 8.6.7 shall be connected to the main bus bar.

(i) An automatic transfer controller (ATC) meeting requirements in clause 8.6.4 shall be flash mounted on the duty incomer cubicle for automatic change over control.

(i) The ATC communication port shall be wired to the serial device server.
(ii) The transfer digital input and two digital outputs for incomer status shall be wired to the common PLC.
(iii) The ATC three phase inputs shall be wired directly to the incomer cables or via the voltage transformers.
(iv) A three-position key operated ACB operation LOCAL/AUTO/REMOTE mode selector switch shall be provided for interlocking circuit breaker operation.

(j) The following signals must be hardwired to the common PLC:

<table>
<thead>
<tr>
<th>Duty incomer ACB ON</th>
<th>Reserve incomer ACB ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duty incomer ACB OFF</td>
<td>Reserve incomer ACB OFF</td>
</tr>
<tr>
<td>Duty Incomer supply available</td>
<td>Reserve Incomer supply available</td>
</tr>
<tr>
<td>ATC transfer input</td>
<td>ATC fail/watchdog</td>
</tr>
<tr>
<td>ACB operation selected LOCAL</td>
<td>Grouped MCB trip</td>
</tr>
</tbody>
</table>

**8.3.2.3 Feeder cubicles**

(a) The switchboard shall have two or three or four feeder cubicles (dependent on contractor design). Each feeder cubicle shall have compartments housing withdrawable plug in modules, a cable compartment and a bus bar compartment.

(b) The feeder cubicles shall have compartments for standard sized plug in module (modules spanning the entire width cubicle) and optionally compartments for small sized plug in modules (multiple modules along the width of the cubicle). There shall be two special compartments for a distribution board and pumps control.

(c) The cubicles shall have compartments with a minimum of the following installed:

(i) 4(four) 55KW standard sized withdrawable motor DOL starter modules meeting requirements of clause 8.6.10.
(ii) 4(four) 32KW standard or small sized withdrawable motor DOL starter modules meeting requirements of clause 8.6.10

(iii) 3 (three) 250A standard sized withdrawable cable feeder modules meeting requirements of clause 8.6.9

(iv) Eleven (11) 125A standard sized withdrawable cable feeder modules meeting requirements of clause 8.6.9

(v) 5(five) 63A standard sized or small sized withdrawable cable feeder modules meeting requirements of clause 8.6.9

(vi) 10(ten) 32A standard sized or small sized withdrawable cable feeder modules meeting requirements of clause 8.6.9

(vii) 1(one) Lighting and small power 12 Way TPN distribution board

(viii) Dewatering pumps automatic controls panel

8.3.2.4  **Lighting and small power 12 Way TPN distribution board**

(a) A 12-way TP&N distribution board shall be provided either mounted on one switch board compartment or on a suitable nearby wall.

(b) The board shall meet requirements of clause 8.5.9

(c) A minimum of the following circuit breakers shall be mounted on the board

(i) 4(four) 32A MPCB’s compliant to requirements of clause 8.6.5

(ii) 4(four) 32A AC DP/SP Miniature circuit breakers with Icu ≥15KA @ 240VAC and at least one SPDT auxiliary contacts

(iii) 6(six) 15A AC DP/SP Miniature circuit breakers with Icu ≥15KA @ 240VAC and at least one SPDT auxiliary contacts

(iv) 1(one) 1.2A MPCB compliant to requirements of clause 8.6.5 for emergency lighting control circuit

(d) The board’s bus bar shall have continuous current rating of at least 125A at 40°C ambient temperature.

(e) A grouped circuit breaker trip signal shall be hard wired to the common PLC

8.3.2.5  **Dewatering pumps auto controls compartment**

(a) One compartment of the switchboard shall host the dewatering pumps auto controls.

(b) All the existing automatic control functions of the dewatering pumps shall be provided. Dewatering pumps auto controls unit shall control dewatering pumps when selected remote in the DOL starters. A hardwired scheme shall be configured or if an interfacing PLC is used as per clause 8.3.2.9 a control logic shall be configured in the interfacing PLC
(c) Contactor relays compliant with requirements of clause 3.5.3 shall be used for hardwired pump control circuits.

(d) A six-position selector switch (if pump control is hardwired) or three-position selector switch (if an interfacing PLC is used) for priority pump selection shall be mounted on the compartment door. The switch shall be used to set three pumps priority configurations for auto start mode.

(e) Level switches and other existing drainage control devices shall be wired to this compartment from the turbine floor.

(f) A minimum of the following existing signals shall be hardwired to the common PLC or interfacing PLC if used as per clause 8.3.2.9 from the dewatering pumps control compartment:

- Stop pumps level
- Start duty pump level
- Start reserve pump level
- Flooding level
- Drainage pumps duty selector p4
- Drainage pumps duty selector p5
- Drainage pumps duty selector p6
- Drainage pit water level normal 767m - pumps stop
- Drainage pit water level high 770m - duty pumps start
- Drainage abnormal alarm
- Drainage pit water level high alarm 772m standby pumps start
- Dewatering control voltage supervision alarm
- Drainage pit water level too high trip
- Drainage pumps duty selector

(g) If an interface PLC is used as per clause 8.3.2.9 then all the above signals shall be wired to the interface PLC however the following must be hardwired to the common PLC:

- Flooding level
- Drainage pit water level high alarm 772m standby pumps start
- Drainage pit water level too high trip
8.3.2.6 **Dewatering pumps maintenance cabinets**

(a) 3(three) dewatering pumps maintenance cabinets (one for each dewatering pump) shall be installed at the turbine floor for local start/stop and emergency stop for maintenance purposes.

(b) The cabinet shall contain all necessary devices for local stop and start of each dewatering pump at the turbine floor. A minimum of the following devices shall however be installed in the cabinet:

(i) 1(one) Digital panel AC ammeter meeting requirements of clause 3.4.2.3.

(ii) 2(two)illuminated pushbutton (ON/OFF)

(iii) 1(one) emergency stop push button

(iv) 4(four) status LED lamps (trip, feeder withdrawn, feeder in test position, maintenance operation selected.)

(v) 1(one) Running hour’s counter

8.3.2.7 **Street & Flood lighting 4 Way TP&N distribution board**

(a) A 4-way TP&N distribution board shall be provided mounted on a suitable nearby wall for connection of station outdoor flood lighting protection and control circuit.

(b) Shall be supplied by Street & station flood lights feeder DOL starter. All station flood & street lighting shall be wired to this distribution board.

(c) The board shall meet requirements of clause 8.5.9.

(d) A minimum of the following circuit breakers shall be mounted on the board:

(i) 6(six) 15A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

(ii) 2(two) 32A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

(e) The board’s bus bar shall have continuous current rating of at least 125A at 40°C ambient temperature.

(f) A grouped circuit breaker trip signal shall be hard wired to the common PLC.

8.3.2.8 **Power cables**

(a) New cable shall be supplied for connecting the main station auxiliaries’ switchboard to the main switchboard. The approximate length of cables is 30m. Shall be rated as per incomer rating with minimum fault level rating of 50KA/1s.

(b) New LV copper power cables shall be installed to connect the main station auxiliaries to the cable marshalling panel. The approximate length of cables...
is 20m. Cables shall be rated the same as the cable feeder modules or incomer rating or motor DOL starter module rating or higher and a fault level of over 20KA/1s

(c) New LV copper power cables shall be provided to supply the new MV switchgear housing and station transformer one auxiliary supply. The cables shall be rated as per the feeder rating and a fault level of over 20KA/1s

(d) The cables shall be compliant with all specifications in clause 8.7

8.3.2.9 Interfacing to SCADA system

(a) One of two methods below shall be used to interface coil inputs and contact outputs for incomers and feeders other than those listed in clause 8.3.3.2(j) from/into the switchboard to the employers SCADA system:

(i) Programmable logic controller (PLC)

(ii) Hardwiring all signals listed below (clause (c)) to employers’ common PLC

(b) If Programmable logic controller (PLC) is to be used for interfacing

(i) It MUST be either of the following brands

- Schneider Modicon: momentum/M340/M580
- Siemens: S7-1200/S7-1500/S7-400
- ABB: AC 500 /AC 800M

(ii) It shall be wired to all the stated signals below (clause (c))

(iii) Shall be programmed in IEC61131-3 function block diagram/Ladder logic language or continuous functional chart (CFC) language only

(iv) At least 16 (sixteen) spare digital inputs and 8(eight) spare digital outputs shall be provided for future use

(v) Shall have two 10/100/1000 base-TX Ethernet ports or 100 base-FX Ethernet ports or 1000 base-X fibre optic Ethernet ports.

(vi) Shall be connected to the two SCADA Ethernet switches

(vii) Contractor shall configure the supplied PLC to write and read the common PLC via Modbus TCP on the registers to be provided by the employer

(viii) PLC programming software and PLC logic diagrams shall be provided. The software shall have at least two licences for installing the software into at least two computers
(c) The following binary inputs and outputs shall be interfaced to client SCADA from the source device contacts or coils. Potential free contacts shall be provided

(i) For the Incomers

Duty incomer ACB ON  
Duty incomer ACB OFF  
Duty incomer ACB ETU trip  
Duty incomer ACB in test position  
Duty incomer ACB withdrawn  
Duty incomer ACB in service position  
Duty incomer ACB ready to close  
Duty Incomer supply available  
Duty Incomer ACB close command  
Duty Incomer ACB open command  
Duty Incomer ACB ETU trip reset  
Duty Incomer emergency trip  
Duty Incomer 3Ø control supply fail  
ACB operation selected LOCAL  
Grouped MCB trip

Reserve incomer ACB ON  
Reserve incomer ACB OFF  
Reserve incomer ACB ETU trip  
Reserve incomer ACB in test position  
Reserve incomer, ACB withdrawn  
Reserve inc. ACB in service position  
Reserve incomer ACB ready to close  
Reserve Incomer supply available  
Reserve Incomer ACB close command  
Reserve Incomer ACB open command  
Reserve Incomer ACB ETU trip reset  
Reserve Incomer emergency trip  
Reserve Incomer 3Ø control supply fail  
ACB operation selected REMOTE  
ACB operation selected AUTO

(ii) for each DOL motor starter.

- Motor/lights ON status  
- Motor tripped (protection)  
- module in withdrawn position  
- Module in test position  
- Local selection  
- Maintenance selection  
- Motor/lights ON command  
- MCBB trip reset command

- Motor/lights OFF status  
- MCCB/MPCB OFF  
- MCCB/MPCB ON  
- module in service position  
- Remote selection  
- Motor/lights OFF command  

(iii) for each Cable feeder module

- MCCB/MPCB ON  
- MCCB protection (ETU) trip (for modules rated above 125A)  
- MCCB/MPCB OFF

- Module in test position
Tender for rehabilitation of Gitaru Power Station Generator MV Switchgear, Protection systems and LV Switchboards

- module in withdrawn position  
- module in service position

(iv) For the lighting and small power distribution board
  - Group 1 MCB trip
  - Group 2 MCB trip

(d) A serial device server meeting requirement of clause 3.4.8 with 4 EIA 485 serial ports and 4 (four) 10/100 base TX Ethernet ports shall be installed in the incomer cubicle for Modbus RTU to Modbus TCP/IP protocol conversion and as an Ethernet switch.
  (i) The serial device server shall be connected to the following on the serial ports
      - All feeder module MCCB’s
      - Incomer ACB’s
      - All the three-phase digital current transducers
      - Automatic transfer controller
      - The main bus bar AC voltage digital AC voltmeter
      - Motor management controllers/relays if used
  (ii) The serial device server shall be connected to the following on the Ethernet ports
      - The two-digital panel multifunction meter on serial device server Ethernet ports
      - To the two Ethernet switches in the SCADA cabinet on serial device server Ethernet ports
  (iii) Industrial ethernet switch may be used to connect ethernet devices if the serial device server ethernet ports are not enough to connect all the devices to the SCADA switches
  (e) Contractor shall supply and configure interface software to handle communication between the LV switchboard devices and the employers SCADA system as detailed in clause 8.3.5

8.3.2.10 **Cable marshalling panels**

(a) Due to space limitation in the control room the new main station auxiliaries’ switchboard shall be installed in a different location from the location currently occupied by the auxiliary section of the main station switchboard. To connect the new board to the existing feeder cables terminated at the
auxiliary section of the main station switch board marshalling panels shall be installed to replace the old switchboard

(b) Panels shall be positioned to fit all the existing cables. Panels shall meet the requirements of clause 3.6

(c) Power terminal blocks meeting requirements of clause 3.6.4.4 or higher shall be used to connect the cables with conductors sized 35mm² and below. The terminal blocks shall meet the following
   (i) Shall be flame resistant and suitable for operating voltages of 1kV.
   (ii) The terminal blocks current rating shall be at least twice the feeder circuit rating.
   (iii) All cables shall be terminated using cable lugs with single or multi bolt stud holes.
   (iv) Threaded studs and nuts M3-M12 shall be used to terminate the cables to the power terminal blocks

(d) Each set of three phase/single phase cable termination shall be separated from each other with appropriate insulating covers to allow personnel to work on some circuits while the switchboard is live

(e) Bimetal terminal blocks and or cable lugs shall be used to terminate existing aluminium cables

(f) Panels shall have earthing busbar and other necessary termination equipment necessary to Marshall the power circuits.

8.3.3 **DC distribution boards**

8.3.3.1 Three DC distribution boards shall be supplied. The boards shall have two incoming DC supplies from the two station batteries.

8.3.3.2 DC circuits shall be protected by double pole (DP) DC MCB’s suitably rated for inductive DC loads and with at least 5KA @ 125V DC breaking capacity. MCB’s shall switch both positive and negative lines.

8.3.3.3 The current rating and overload tripping characteristic shall be determined during design stage for all the MCB’s. The MCB’s shall be suitably rated for the expected DC loads

8.3.3.4 **Protection and other control room devices DC distribution board** shall have

   (a) 2 (two) incoming DC MCB’s from the two 110V DC station batteries suitably rated for the loads
(b) at least 10(ten) DC DP MCB’s suitably rated protection scheme DC supply, LV switch boards auxiliary 110DC supply and MV switch gear auxiliary 110DC supply connected to one station battery

(c) at least 10(ten) DC DP MCB’s suitably rated protection scheme DC supply, LV switch boards auxiliary 110DC supply and MV switch gear auxiliary 110DC supply connected to the other station battery

8.3.3.5 **Control room Emergency DC lighting distribution board** shall have
(a) 2 (two) incoming DC DP MCB’s from the two 110V DC station batteries suitably rated for the loads
(b) at least 5(five) DC DP MCB’s suitably rated for the lighting loads connected to one station battery
(c) at least 5(five) DC DP MCB’s suitably rated for the lighting loads connected to the other station battery
(d) Three phase AC circuit for monitoring loss of lighting supply shall be wired from the main station auxiliaries switch board to this board for monitoring normal lighting failure.
(e) A three-phase voltage monitoring relay meeting requirement of clause 3.5.7 shall be installed for the emergency lighting start. The lights shall come on when main lighting supply fails
(f) At least 2(two) contactors each with the following features
(i) suitably rated for switching of at least 4KW DC inductive load
(ii) continuous current rating of at least 40A @40°C ambient temperature
(iii) rated voltage 125V DC
(iv) Insulation level ≥500V DC
(v) Shall have two SPDT auxiliary contacts
(g) An auxiliary contact of each contactor shall be hardwired to the common PLC for emergency lights status indication.

8.3.3.6 **Power house Emergency DC lighting distribution board** shall have
(a) 2 (two) incoming DC DP MCB’s from the two 110V DC station batteries suitably rated for the loads
(b) at least 5(five) DC DP MCB’s suitably rated for the lighting loads connected to one station battery
(c) at least 5(five) DC DP MCB’s suitably rated for the lighting loads connected to the other station battery

(d) Three phase AC circuits for monitoring loss of lighting supply shall be wired from the general services switch board- DB1 and Turbine level and runner access areas lighting distribution board-DB2 to this board for monitoring normal AC lighting failure.

(e) 2(two) three-phase voltage monitoring relay meeting requirements of clause 3.5.7 shall be installed for the emergency lighting start. The lights shall come on when either of the main lighting supply fails

(f) At least 2(two) contactors each with the following features
   (i) suitably rated for switching of at least 4KW DC inductive load
   (ii) continuous current rating of at least 40A @40ºC ambient temperature
   (iii) rated voltage 125V DC
   (iv) Insulation level ≥500V DC
   (v) Shall have two SPDT contacts

(g) An auxiliary contact of each contactor shall be hardwired to the common PLC for emergency lights status indication.

8.3.4 Other equipment

8.3.4.1 Main station switchboard incomer meters

(a) Four (4) Digital Panel multi-function meter meeting all requirements of clause 3.4.5 shall be supplied and installed on the main switchboard incomers.

(b) Modifications shall be carried out in the incomer cubicles to fit the meters.

(c) The meters shall be connected via ethernet to the SCADA ethernet switches at the employers SCADA cabinet or to the serial device servers ethernet ports or an industrial ethernet switch shall be provided to interface them.

(d) Meters CT inputs and VT inputs shall be connected in series and parallel respectively to the existing meters.

8.3.4.2
8.3.5 **LV switchboard Software Licences**

All software’s and licences shall be provided all software configurable devices supplied under the contract. This Clause only summarises the software licences requirement for the bidder, the licences requirements are not limited to what is stated below. It’s the bidders’ obligation to supply at least two necessary licences that are not stated below.

8.3.5.1 Two (2) switchboard PLC configuration (IEC61131-3 programming) manager licences for installation into two portable computers. This is only applicable if an interfacing switchboard PLC is used.

8.3.5.2 Web configuration without software licences requirement shall be the preferred method of configuration for most of the switchboard devices with ethernet ports such as meters. For devices without ethernet ports and for those where web configuration is not applicable configuration software with licences if required to be provided as the clause below.

8.3.5.3 Two (2) licenses for installation into two portable computers for each configuration software. Configuration software with license where applicable to be provided for all software configurable devices such as

(a) Serial device server
(b) Panel multifunction meters
(c) Automatic transfer switches/controllers
(d) Digital current transducers
(e) Motor management controller (if used)
(f) ACB’s and MCCB’s communication units
8.4 GENERAL SPECIFICATIONS FOR LV AC SWITCHBOARDS EQUIPMENT

Switchboards and associated equipment shall comply with general technical specifications in clause 3.6. In addition, they shall have the specifications below:

8.4.1 Standards

8.4.1.1 Ratings, characteristics, tests and test procedures, etc. for the 415V AC Metal-Clad Switchgear Board and all the Protection Relays, Measuring and Indicating Instruments and the control and monitoring devices and Accessories, including Current transformers shall comply with the provisions and requirements of the standards of the International Electro-Technical Commission (IEC), and also relevant IEEE/ANSI Standards as Specified.

8.4.1.2 The Bidder shall specifically state the Precise Standard, complete with identification number, to which the various equipment and materials are manufactured and tested.

8.4.1.3 Some of the standards to be used are:

(a) Design & testing verification of Power switchgear and control gear assembly as per IEC 61439-2 and distribution boards as per IEC 61439-3

(b) Low voltage switchgear as per latest editions of IEC60497

(c) Testing under conditions of arcing due to internal fault as per IEC 61641

(d) Vibrations withstand as per IEC 60068-3-3, IEC 60068-2-6, IEC 60068-2-57 & IEC 60980

(e) Protection against electric shock as per EN 50274

8.4.2 Service Conditions

8.4.2.1 In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which the switchgear panels shall be called upon to work. The Manufacturer of the Switchgear panels shall submit details of his usual practice of tropicalization which have proven satisfactory for application to the Switchgear panels and associated equipment to prevent Rusting and Ageing in the Tropical Climate Zone. The Applicable standards for tropicalization shall be listed.

8.4.2.2 The Switchgear shall be installed in a room without forced air conditioning. All the Protection and control devices employed therefore, shall be capable of operating in this environment without failure for their designed life time. Particularly the power supply modules of the Protection and Control devices shall be designed for minimum heat generation and effective heat dissipation to ensure that the temperature of these devices enclosed in the relay panels at the above listed
Ambient temperatures shall not exceed the Maximum operating temperature of the device.

8.4.2.3 All equipment must be designed for operations in the severe tropic climate conditions and fully comply with climatic aging tests as per IEC 60932-class 2

8.4.3 **Equipment /Apparatus Design**

8.4.3.1 Switch boards shall be capable of continuous operation with minimum attention and maintenance in the exceptionally severe conditions likely to be obtained in a tropical climate and where the switchgear is called upon to frequently interrupt fault currents on the system and also where the duty of operation is high.

8.4.3.2 The Manufacturer shall provide all control, indication, alarm and protection devices and all auxiliary equipment with wiring and interconnecting cable which are integral parts of or are directly associated with or mounted on the Switchgear panels to be supplied under this Tender.

8.4.3.3 The design of Protection and Control schemes for the switchgear panels shall be subject to approval by the Employer.

8.4.3.4 Interlocking devices shall be incorporated in the control circuit to ensure Safety, and Proper sequence and correct operation of the equipment.

8.4.3.5 Low voltage equipment and installation shall be designed in accordance with relevant EMC directives.

8.4.3.6 The rating and design criteria for low voltage equipment shall be as follows:

(a) AC Supply Rating

<table>
<thead>
<tr>
<th>Rated voltage between phase</th>
<th>415V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three phase Connection type</td>
<td>3ph 4wire</td>
</tr>
<tr>
<td>Single phase Connection type</td>
<td>3 wire (P-N-E)</td>
</tr>
<tr>
<td>Rated voltage between phase to earth</td>
<td>240 V</td>
</tr>
<tr>
<td>Grounding system</td>
<td>Solid Earthing</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 HZ</td>
</tr>
<tr>
<td>Voltage variation</td>
<td>+/-10%</td>
</tr>
<tr>
<td>Frequency variation</td>
<td>+/-2%</td>
</tr>
<tr>
<td>Power frequency 1 min, Test Voltage</td>
<td>3 KV</td>
</tr>
</tbody>
</table>

(b) Unless otherwise specified, the equipment provided under this Tender is to be capable of reliable operation at voltages as low as 80% of the rated voltage, and to withstand continuously up to 120% supply voltage above the rated value of 240V single phase or 415V AC three phase.
(c) DC Auxiliary Supply Rating

Nominal DC Rated voltage  
Voltage supply range  
Connection type  

110V DC  
88-132 VDC  
2 wire

(d) Auxiliary DC Supply shall be used for controls, indication, alarm, protection devices, and Circuit breaker tripping and closing circuit and all other control & metering functions

(e) All equipment and apparatus including the Circuit Breakers, Protective relays, Control devices and Accessories, Measuring and Indicating Instruments and electronic equipment shall be capable of satisfactory operation at 80% to 120% of the rated auxiliary supply voltage.

8.4.4 Assembly

8.4.4.1 Necessary items of equipment shall be assembled in the factory prior to shipment and routine tests shall be performed by the Manufacturer as per the requirements of the latest issue of IEC to demonstrate to the satisfaction of the Employer that the Switchgear panels comply with the requirements of the relevant IEC standards.

8.4.5 Operational Details

8.4.5.1 Instructions shall be engraved on the switchgear panel, on the circuit breaker compartment describing in simple steps how to carry out correct and safe Isolation, racking-in and switching operations on the circuit breaker. Similar details shall be provided for the operation of the earth switch.

8.4.6 Labelling

8.4.6.1 Each compartment shall be labelled with white trafolyte or aluminium plates with black lettering on a white background, to the approval of the Engineer.

8.4.6.2 Naming shall be as agreed during design stage

8.4.7 Drawings

8.4.7.1 The function of each drawing shall be clearly indicated. Related drawings shall be arranged sequentially and have the same drawing numbers but different sheet numbers.

8.4.7.2 Drawings shall adhere to ALL conditions of clause 1.7 of general specifications

8.4.7.3 The drawings shall include the following;

(a) AC single line & AC Schematic drawing in two sets one A3 another A4 size sheets
(b) DC, control, protection & metering Schematics in two sets one A3 another A4 size sheets
(c) Functional Drawings in two sets one A3 another A4 size sheets
(d) Terminal blocks wiring schedule, terminal block diagrams and cable schedules in A4 size sheet only
(e) Panel device layout drawing two sets one A3 another A4 size sheets
(f) General layout drawings for the switchgear panels in two sets one A2 another A3 size sheets
(g) Parts list in A4 size sheet only
(h) Logic diagrams of all IED’s provided in two sets one A3 another A4 size sheets
(i) Air circuit breakers internal assembly drawings provide in two sets one A3 another A4 size sheets

8.4.8 Operating and Maintenance Instructions

8.4.8.1 The Contractor shall supply detailed instructions manuals concerning the correct manner of assembling/Installing/Erection, configuring, setting, Testing and Commissioning, operating and maintaining the equipment and devices constituting the Switchgear board, including the board itself.

8.4.8.2 The maintenance details of each component shall also be described, including the frequency of inspections and lubrication.

8.4.8.3 The instruction manual shall include a separate and complete section describing the normal and emergency operating procedures for the Switchgear, and shall include explanatory diagrammatic drawings to facilitate understanding the instructions.

8.4.8.4 The Manufacturer shall, in preparing the instruction manuals, take into account the lack of experience and familiarity of the Operators with this type of equipment.

8.4.8.5 The manual shall give specific information as to oil, grease, or any other materials needed for maintenance operations. This information shall include brand names and manufacturer’s numbers or designations for at least two brands available in Kenya, preferably manufactured in Kenya.

8.4.8.6 Documentation shall adhere to requirements given in clause 1.7 of general specifications
8.5 DETAILED SPECIFICATIONS FOR LV AC SWITCHBOARD CUBICLES

8.5.1 LV AC Switchboard Cubicles Structure

8.5.1.1 The switchboard shall be made of steel.
8.5.1.2 Switchboards shall be built up of separate metal clad-compartmented cubicles with earthed metal partitions. Partition steel plates, fastened to the structure, shall divide the cubicles into compartments.
8.5.1.3 The cubicle frames shall be made of steel bars at least 2.5 mm thick while Partition plates shall be of mild steel at least 2 mm thick. Steel shall be thoroughly cleaned by shot blasting or other approved methods before applying protective coating.
8.5.1.4 The position of the partition steel plates shall be adjustable to easily adapt the height of the compartments in steps of 25mm.
8.5.1.5 Each compartment shall be closed by an individual practicable steel door on the front, and by independent steel covers on the sides and back.
8.5.1.6 Fully independent compartments shall be provided for:
   (a) Bus bars
   (b) Cabling
   (c) Switch-gear (circuit breakers, isolators, switches)
   (d) Metering, control and protections.
8.5.1.7 Extensions of the switchboard, by addition of similar structures, shall be possible both to the right and to the left of the initial structure.
8.5.1.8 The switchboards shall be constructed to IP54 degree of protection to external environment in accordance with IEC 60529. A type test report for the degree of protection of the switchgear panels from a third party reputable testing laboratory certified by the National Standards and Testing Authority (NSTA) or a laboratory accredited to the NSTA shall be submitted with the tender for evaluation purposes.
8.5.1.9 The complete switchgear shall be such that the complete switchboard is of flush-front design.
8.5.1.10 The panels shall be equipped with eye bolts for lifting purposes.
8.5.1.11 The cubicles shall be tropical vermin proof.

8.5.2 LV AC Switchboard Cubicles Covers and doors

8.5.2.1 All accessible parts of the switchboard shall be conveniently earthed by their assembly means, and shall not require any supplementary specific Earthing lead.
8.5.2.2 When installed, covers and doors shall ensure a minimum IP54 degree of protection according to IEC 60529.
8.5.2.3 Cover and doors shall be made of steel plates at least 2mm thick.
8.5.2.4 Side- and back-covers
(a) Side- and back-covers shall be flush-mounted on the structure by means of spacers and self-tapping screws, which shall ensure the Earthing of the covers.
(b) For ease of maintenance, the covers shall be interchangeable and re-usable on any compartment of the same dimensions.

8.5.2.5 Doors
(a) Covers and doors shall be made of stainless steel sheet at least 2mm thick to ensure stability
(b) The doors shall be provided with internal hinges, ensuring the Earthing of the door.
(c) The doors shall be capable of withstanding the effects of maximum internal arcing fault without being blown off and causing danger to other equipment/personnel.
(d) The minimum opening angle of the door shall be 130° to 180° degrees.
(e) The doors shall be pre-punched to accommodate at any time:
   (i) Door locks
   (ii) Meters and other control components
   (iii) Plates for auxiliary components
(f) Doors for switchgear compartments shall be provided with an interlock, avoiding the opening of the door without previously switching-off the voltage supply to the compartment.
(g) All doors shall be equipped with at least two locks to avoid unauthorised access
(h) Circuit breakers knobs on compartment doors shall be provided with provisions for padlocking.
(i) ACB compartments doors shall have provision for padlocking the ACB: in isolated position and in off position to prevent unauthorised operation.

8.5.3 LV AC Switchboard Cubicles Compartments

8.5.3.1 All compartments shall be able to withstand arcing without flashover to neighbouring compartments as per IEC 61641 standard. The different compartments formed by the partition plates, shall comply with the following conditions:

8.5.3.2 Bus bar compartments
(a) The bus bar compartments shall be separated from the other compartments by finger-proof & fire proof shrouds.
(b) Bus bar compartment shall be located at the rear or top of the switchboard. But not at the bottom part of the switchboard.

(c) The Bus bar compartment shall contain all phase and Neutral conductors, duly marked L1, L2, L3, and N.

(d) Protective conductors shall be located in a separate compartment and shall be duly marked PE.

(e) All fixed connections shall be maintenance-free.

(f) The Bus bars shall be supported by insulators, made of flameproof and leakage-proof material.

8.5.3.3 Cable compartments

(a) The cable compartment shall contain the out-going terminals for power and control circuits.

(b) Cable compartments shall be located either in the front or back of the cubicles depending on the available space as long as they isolated from the bus bars as per specified form of internal separation.

(c) Compartments MUST be at least 400mm wide for ease of working.

(d) All external control and power cables shall be terminated in the cable compartments.

(e) Form of internal separation 4b shall be adhered to. In that respect:

(i) The cable compartment shall be separated from the other compartments by metallic shutters providing a degree of protection of minimum IP20 according to Standard BS EN 60529, to avoid the accidental downfall of parts from upper compartments.

(ii) Out-going feeders shall have a degree of protection of minimum IP20 according to Standard BS EN 60529, to avoid accidental contacts.

(f) Out-going feeders copper bars shall be provided as terminals, to allow the connection of several cables in parallel.

(g) All connection terminals and cables shall be mounted in such a way as to avoid any traction or compression forces being exerted on them.

(h) The bars and cable supports shall be designed to withstand the rated short circuit withstand current of the switchboard.

(i) Incoming and outgoing cables shall enter the compartment by the top or the bottom, with front or rear access provided to the connections.

(j) The cable compartments should have an anti-vermin guard plate giving protection against rats, rodents etc.
(k) The control cable terminations and power cable terminations shall be separated using a transparent arc barrier, to allow safe working on the control wiring termination while the switchboard is live.

8.5.3.4 Switch-gear and control compartments

(a) Switch-gear and metering/control compartments shall be equipped with universal fixing plates, with holes in fixed steps allowing for the mounting of the different switch-gear and metering and protection components.

(b) The air circuit breakers compartments shall have an inbuilt carriage for where ACB shall be mounted to facilitate isolation and withdrawal of the air circuit breaker.

(c) Switching device (ACB, MCCB and withdrawable modules) compartment doors shall be interlocked to the circuit breaker open/off position. The compartment doors shall not open unless the circuit breaker is switched off.

(d) ACB’s compartment door shall have openings be covered by a transparent clear cover for viewing ACB status.

(e) ACB compartments will have provision for padlocking the ACB in isolated or on/off position for safe isolations and operations.

(f) Withdrawable modules compartments shall have mechanism to allow installation of plug in modules described in this specification. It shall have provision to place a padlock at the front of module racks to prevent unauthorised insertion of plug in modules.

(g) All the Protection Relays, Auxiliary Relays, power Meters Indication Lamps, Instruments, Control and selection switches and any other associated accessories shall be mounted in the Protection and Control compartments.

(h) Meters, switches, push buttons & signal lamps shall be mounted on the hinged door of the compartment, which shall be pre-punched to accommodate them.

8.5.4 Protection and finish

8.5.4.1 Protection against corrosion

(a) A zinc coating, providing protection against corrosion according to Standard EN10142, shall protect all steel parts forming the structure.

(b) All ferrous parts e.g. hinges, mounting parts, shall be protected by an electro galvanic zinc coating.

(c) Protection shall be verified in accordance with Standard BS EN 50298. Following tests shall be made:
(i) “Wet heat”, 6 cycle 24 hours with 95% relative humidity at 40ºC, according to Standard IEC 68-2-30
(ii) “Salt fork”, 2 cycle 24 hours at 35ºC, according to Standard IEC 68-2-11

8.5.4.2 **Finish**

(a) All edges shall be bent-over to avoid sharp edges
(b) All external doors and covers shall be flush-mounted to the structure.
(c) No hinges, fixing screws or bolts shall be visible from the front of the switchboard
(d) All external parts shall be given a primary coat of epoxy powder of minimum 75-micron thickness and two coats of contrasting colour of durable and weather resisting paint. The top coat shall be of uniform colour, preferably RAL 7035 or as shall be specified by the project engineer at design stage.
(e) The final thickness of the paint shall not be less than 80 Microns at any point within the switchgear panel
(f) External mounted equipment shall be flush mounted and shall be suitably labelled with permanent labels, black lettering on a white background, to the approval of the Engineer.

8.5.5 **Arc Resistance & Protection**

8.5.5.1 Switchboards shall meet requirements of IEC TR 61641
8.5.5.2 Main bus bars shall be Insulated to prevent the occurrence of arcing. Distribution bus bars shall have arc barriers to restrict the effects of arching
8.5.5.3 Switchboard shall be designed to have arc protection limiting arcing fault effects to the place of origin ONLY.
8.5.5.4 In addition, all possible Arc protective measures to limit the effects of an arc shall be employed such as:
   (a) Arc barriers for limitation of arcs arc resistance to one section
   (b) high-quality insulation of live parts
   (c) provision of arc-resistant hinge and locking systems,
   (d) provision for safe operation of withdrawable units or circuit breakers behind a closed door
   (e) arc barriers on ventilation openings at the front
8.5.5.5 All possible protection of limiting the effects of internal arcing faults inside the switchboard shall be employed. In a worst-case scenario:
(a) Opening of doors and covers must be impossible
(b) Parts must not fly off
(c) No holes must form in the enclosure
(d) Indicators must not ignite
(e) PE conductor circuit for touchable cubicle parts must be functioning

8.5.5.6 A type test report for the switchboard arc testing in accordance with IEC TR 61641 from a third party reputable testing laboratory certified by the National Standards and Testing Authority (NSTA) or a laboratory accredited to the NSTA shall be submitted during design

8.5.6 **Bus bars specifications**

8.5.6.1 The bus bars and connections shall be made of high conductivity, high grade copper, and shall be in unit lengths.

8.5.6.2 Bus bars, connections and their support shall be rated for the rated continuous current under ambient conditions and capable of carrying the short-time current rating specified in the switchboard requirements

8.5.6.3 Provision shall be made for locking main bus bar and cable termination bus bars shutters separately in the circuit Breaker compartment.

8.5.6.4 The bus bar shall be made of flat copper bars, of the same cross-section (for the same rating) over the whole width of the switchboard.

8.5.6.5 Main bus bars shall allow extensions of the switchboard both left and right with minimum possible disturbance to the existing bus bar.

8.5.7 **Cubicles Wiring**

8.5.7.1 Each cubicle shall have a terminal block at the cable compartments where all external control cables such as Auxiliary DC supply, and control signals shall be terminated. All circuits for connection to external cables such DC & AC auxiliary supplies, control and Indications shall be wired up to the terminal Block at the cable compartments where external cables shall be connected. At least 10% spare terminals shall be provided on the terminal board for any future requirements.

8.5.7.2 Power cables to feeder and incomer circuits shall be terminated on the cable compartment to cable termination bus bars.

8.5.7.3 Power cables shall be terminated to termination busbars and not terminal blocks, for cables with conductors sized 35mm² and below Power terminal blocks meeting requirements of clause 3.6.4.4 or higher may be used with permission from the project engineer

8.5.7.4
8.5.7.5 Anti-condensation heaters shall be provided inside each cubicle. They shall be located so as not to cause injury to personnel or damage to equipment. The heaters shall be controlled by a hygrostat with a variable humidity and temperature setting. The Heaters shall be dimensioned to ensure that condensation cannot occur within the switchgear panel.

8.5.7.6 The 240V AC supply, for the heaters shall be controlled by a suitably rated single pole miniature circuit Breaker. All the switchgear panels shall be rodent and vermin

8.5.7.7 The metal cases of all devices and equipment shall be connected to the earth bars with green/yellow insulated copper conductors of minimum 2.5 mm² cross-section area.

8.5.7.8 All the Compartments including the hinged doors and all the Earthing points of the equipment installed/mounted in the cubicle shall be connected to the cubicle grounding conductor for external connection to the station Earthing System.

8.5.7.9 Earthing conductors shall be of annealed high conductivity copper. The earthing conductor on the primary equipment such as the Earth Switch and also for inter-cubiclle earth-bonding as well as for external connection to the substation Earthing – grid shall be adequate to carry the rated switchgear short-circuit current

8.5.8 **Withdrawable plug in modules Specifications**

8.5.8.1 Withdrawable plug in modules shall contain switch gear and control circuits for feeder circuits.

8.5.8.2 There shall be two kinds of withdrawable plug in modules;

(a) standard sized modules- one unit along the width of the feeder cubicle and

(b) Small sized modules- multiple units along the width of the feeder cubicle.

8.5.8.3 All the plug-in modules shall contain an MCCB or an MPCB with a door-coupling rotary operating mechanism, for breaker closing and manual opening. The shaft/handle shall be joined to a knob at the compartment door.

8.5.8.4 Modules frame shall be made of stainless (protected against corrosion) steel plates at least 2mm thick.

8.5.8.5 The plug-in modules shall have a special contact mechanism that allows changing their position while the compartment door is closed. The mechanism shall control the connection of the withdrawable module unit to the switchboard compartment bus bar and feeder power contacts. The following positions shall be possible:

(a) Idle (disconnected) mode - Main circuit open & auxiliary circuit open

(b) Test mode- Main circuit open & Auxiliary circuit closed
8.5.8.6 The module contact mechanism shall have the following features:

(a) Shall be operated by a key (rod) that shall be inserted into the plug-in module while the compartment door is still closed.

(b) The key shall be operated in a rotary motion using a small force, a maximum rotatory force of 10 Nm.

(c) Module shall have two positions for inserting and operating the key switch. The first position shall move the module from operating to idle mode or vice versa, the second shall move the module from test to idle mode or vice versa.

8.5.8.7 The following control elements for the contact mechanism shall be on the compartment door:

(a) The two key insertion positions;

(b) A display window showing the operating mechanism mode with the following colours green for idle mode, blue for test mode and red for operating mode.

(c) Contact mechanism service opening cover with locking provision to prevent unauthorised contact mechanism operation.

A mechanical interlock shall prevent opening the compartment door when the contact mechanism is in operating mode.

8.5.8.8 Module shall have a mechanical interlock preventing withdrawal of the module when it's in operating or test mode. Module shall have mechanical locking/unlocking latches for locking the plug module in place in the compartment. Mechanical unlocking latches shall have to be pressed by user before removing the unit from the compartment.

8.5.8.9 Modules shall have provisions for pressing the mechanical unlocking latches before removing the module. Modules shall also have provisions (handles) at the front side to ease carrying the module out of the compartment.

8.5.8.10 Modules shall have a 'pull out lock' to prevent it from falling down when you pull it out. The pull-out lock shall make sure you can pull out the module only as far as necessary before lifting up.

8.5.8.11 Modules shall have steel plate separating the bus bar & cable terminals contacts at the back of the module from the switchgear and associated circuitry on the front side of the module. Control and switchgear devices and the circuitry shall be mounted on the front side (facing compartment door) of this plate.

8.5.8.12 Bus bar contacts and outgoing feeder contacts shall be separated at both ends.

8.5.8.13 MCCB & MPCR shall only be actuate-able from the compartment door only if the compartment door is closed.
8.5.8.14 Module shall have a control plug at the side or front of the module
8.5.8.15 Modules shall be withdrawable and insert-able while the bus bars are energized.
8.5.8.16 Modules shall be positioned to test or operating mode only if the MCCB/MPCB is off.
8.5.8.17 Control plug extension cable at least three meters long shall be provided for testing of the modules outside the switchboard. The cable shall plug in to the compartment control plug port and the plugin module control plug port

8.5.9 **Distribution/panel board specifications**

8.5.9.1 There shall be a three-phase distribution/panel board located in one compartment of the switch boards or mounted separately as specified in the switchboard requirements

8.5.9.2 The distribution boards if mounted on a switchboard compartment shall not be connected to the distribution bus bars of the switch board and it shall be completely isolated from the switch board bus bars. It shall be supplied by one withdrawable plugin module.

8.5.9.3 MCB’s/MPCB’s shall be mounted on DIN rails. The MPCB’s/MCB’s shall be linked to the boards bus bar and to the feeder cables using insulated copper strips/bars

8.5.9.4 It shall be possible to easily replace an MCB without shutting down the whole board.

8.5.9.5 The distribution board, bus bars shall be insulated or shall have shutters or any other proper mechanism of covering bus bars in order to prevent users from coming into contact with the bus bars while replacing the MCB’s. The bus bars shall be insulated or have an IP protection of 4X

8.5.9.6 For distribution boards mounted on a switchboard compartment, copper strips/bars shall be used to terminate the panel boards’ outgoing feeder cables at the cable compartment.

8.5.9.7 Power terminal blocks meeting requirements of clause 3.6.4.4 or higher shall be used to connect the cables with conductors sized 35mm² and below for free standing distribution boards (distribution boards not mounted inside the switchboard)

8.5.9.8 The board’s bus bar shall have Neutral and protective earthing (PE) connection terminals shall be provided

8.5.9.9 Shall have the following basic ratings

(a) All distribution boards bus bars rated continuous current rating at 40°C ambient temperature.: ≥125A
8.6 SWITCHGEAR EQUIPMENT SPECIFICATION

8.6.1 Air Circuit Breakers, ACB

8.6.1.1 Principle features
The circuit breakers shall be three/four pole, air break, motor wound, spring operated, and horizontal draw out type and have inherent fault making and breaking capacity as per the provided ratings equipped with the following:

(a) Open/close mechanical pushbuttons
(b) Auxiliary contacts block with at least 12(twelve) SPST contacts for control and protection
(c) Mechanical operations counter
(d) Internal Current and voltage transducers
(e) Electronic trip units
(f) Auxiliary limit switches
(g) Two (2) 110VDC trip coils (shunt release)
(h) Under voltage release
(i) 110VDC closing coil
(j) Anti-pumping relay
(k) 110 V dc motor wound store charged spring closing mechanism
(l) Mechanically operated indicator to show whether the circuit breaker is open or closed
(m) Mechanically operated indicator showing ready to close indication
(n) Mechanically operated indicator to show the position of the circuit breaker in the carriage i.e. service, test or isolated
(o) Frame Earthing contact point

8.6.1.2 Primary rating
(a) All switch board air circuit breakers shall be rated as follows

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of poles</td>
<td>3/4</td>
</tr>
<tr>
<td>2</td>
<td>Rated operational voltage Ue:</td>
<td>433 V AC</td>
</tr>
<tr>
<td>3</td>
<td>Rated insulation voltage: 1000VAC</td>
<td>1000 V AC</td>
</tr>
<tr>
<td>4</td>
<td>Rated impulse withstand voltage, Uimp of Main conducting paths</td>
<td>≥12 KV</td>
</tr>
</tbody>
</table>
5. Rated impulse withstand voltage, U_{imp} of Auxiliary circuits \geq 4 \text{ KV}
6. Rated impulse withstand voltage, U_{imp} of Control circuits \geq 2.5 \text{ KV}
7. Operating times; Make-time \leq 35 \text{ ms}
8. Operating times; Break-time \leq 38 \text{ ms}
9. Design and testing standard IEC 60947
10. Auxiliary supply rating (control & coils) 110 \text{ V DC \pm 30\%}
11. Spring charging motor rating 110 \text{ V DC \pm 20\%}

(b) Main station auxiliaries switch board incomer ACBs current ratings
1. Continuous current rating at 40\%C ambient temperature, I_n \geq 800 A
2. Ultimate Short-circuit breaking capacity at 500V AC, (I_{cu}) \geq 55 \text{ kA}
3. Service Short-circuit breaking capacity (Ics) \geq 55 \text{ kA}
4. short-circuit making capacity (I_{cm}) at 500V AC \geq 121 \text{ kA}
5. Rated short-time withstand current (I_{cw}) \geq 50 kA for 1 sec
6. Power loss at I_n with 3-phase symmetrical load \leq 200 \text{ W}

8.6.1.3 **Auxiliary supply**

(a) circuit breaker shall be rated for auxiliary supply of 110VDC \pm 20\%.

(b) Trip coils shall operate with auxiliary supply as low as 77VDC

8.6.1.4 **Breaker contacts positioning mechanism**

(a) Each circuit breaker shall be provided with three contact mechanism positions i.e. service, test and isolated. There shall also be fully withdrawn position.

(b) The test position shall allow the circuit breaker to be tested for operation without energizing the power circuits.

(c) A hand operated handle shall be used for cranking the ACB into position. Rotary motion will be used to crank the breaker with minimal rotary force requirement

8.6.1.5 **Circuit breaker carriage; withdrawal & insertion operations**

(a) Each circuit breaker shall be mounted on a carriage to give ease of withdrawal onto the circuit breaker truck.

(b) The carriage shall be fixed in the compartment and shall not allow complete withdrawal of the air circuit breaker outside its compartment without the use of purposely built trolley.

(c) A purposely built trolley shall be provided equipped with a lowering/raising gear to lower the air circuit breaker to the floor and to raise the circuit breaker to its compartment by one switching operator.
8.6.1.6 **Structural and mechanical features**

(a) The circuit breakers of the same current and voltage ratings shall be fully interchangeable, both electrically and mechanically.

(b) ACB’s of different current ratings shall not be interchangeable.

(c) Name plate for the circuit breaker shall be provided with all the required details as per IEC Standards.

(d) Mechanical ON/OFF indicator, with inscription:
   (i) “ON” white letters on red background and
   (ii) “OFF” white letters on green background shall be provided for on the circuit breaker.

(e) Mechanical indication of the state of the spring, with inscription:
   (i) “SPRING CHARGED” - white letters on red background and
   (ii) “SPRINGS FREE” - white letters on green background shall be provided for on the circuit breaker.

(f) Mechanical indication of the state of the breaker external contacts, with inscription:
   (i) “SERVICE” - white letters on red background and
   (ii) “TEST” - white letters on blue background
   (iii) “ISOLATED”/”DISCONNECTED” - white letters on green background shall be provided for on the circuit breaker.

(g) It shall be easy to access the circuit breaker external contacts for maintenance purposes.

(h) Automatically operated safety shutters with padlocking facility shall be provided in the breaker carriage for bus bars isolation

(i) Neutral link shall be installed for three pole circuit breakers

(j) Control cable and plug for connecting circuit breaker controls to switchboard shall be offered with a latching mechanism to prevent accidental disconnection while in operation

(k) An extension cable for the ACB control cable at least 3m long with both male and female connectors shall be provided to allow testing of the ACB’s while racked out.

8.6.1.7 **Breaker operation**

(a) For maintenance operation, slow closing of the circuit breaker shall be possible.

(b) It shall not be possible to render the electrical tripping feature inoperative by any mechanical locking device.
(c) Circuit breaker closing in service position shall ONLY be possible when it’s correctly positioned in the carriage

8.6.1.8 **Auxiliary contacts terminals**

(a) Auxiliary circuits shall remain connected in both “service” and “test” positions. Auxiliary circuits shall be disconnected when the breaker is in the “fully withdrawn” or “isolated” position.

(b) The auxiliary contacts terminals shall be of the plug-in type, with the male contacts mounted on the Breaker carriage and the female contacts on the plug-in cable connected to the Panel wiring. Other options may be considered where there is adequate proof that the auxiliary contacts will always be making firmly without mis-alignment. Finger contacts will however not be acceptable.

(c) All auxiliary contacts of the breaker shall be connected to the auxiliary terminals. These shall include breaker ON/OFF status contacts, motor contacts, trip/close inputs, trip outputs, trip reset input etc. spare contacts shall all be wired to the terminals and onwards to the panel terminal block. Air circuit breakers shall have a minimum of twelve (12) SPST auxiliary contacts for breaker open/close status irrespective of rating or application

(d) Limit switches shall be provided for status indication of circuit breaker contact positions (service, test, withdrawn) and wired to the SCADA common PLC for indication

8.6.1.9 **Mechanical interlocks**

ACB’s shall have mechanical interlocks prevent the following operations:

(a) Tripping the circuit breaker by attempted isolation.

(b) Closing or opening the circuit breaker when in an intermediate position between “service”, “test” or “fully withdrawn” positions.

(c) Closed circuit breaker being withdrawn from or inserted into the “service” position.

(d) Closing of the circuit breaker in the “service” position when the auxiliary contacts are not fully made.

(e) Opening or closing the Compartment door with the breaker closed/ON

(f) Closing the circuit breaker in service position with the compartment door open

8.6.1.10 **The circuit breaker spring operating mechanism**

(a) Operating mechanism shall be motor wound spring operated, power closing with electrical release and with provision for hand charge.

(b) Mechanical indication shall be provided to indicate the state of the spring.
8.6.1.11 **Electronic trip unit (solid state relay)**

(a) The electronic trip unit shall be included in each ACB to be supplied

(b) Shall offer the following protection functions

(i) Overload protection

(ii) Short-time delayed short-circuit protection

(iii) Instantaneous short-circuit protection

(iv) Neutral conductor protection

(v) Ground-fault protection

(vi) Lockout

(vii) Remote trip reset

(c) A reset push button and Remote hardwired trip reset input shall provided

8.6.1.12 **Operations and maintenance**

(a) The Circuit Breaker Maintenance and Operations Manual shall contain clear instructions on the Maintenance requirements of the Circuit Breaker (if any), to prevent Switchgear failure in service, due to excessive Fault Current Clearance or any other cause.

(b) Clear instructions on cranking the breaker in and out, placing the purposely built trolley on the carriage and lowering and raising operations shall be inscribed on a plate to be mounted on the switchboard at a position to be agreed upon with the project engineer.

(c) Maintenance operations necessary on the breaker and its accessories e.g. carriage, trolley moving parts shall be provided

(d) Circuit breaker internal structural, mechanical and electrical drawings shall be provided. Clear instruction manual for internal assembly/disassembly shall also be provided. The manual shall allow maintenance personnel to be able to replace internal parts such as trip coils, charging spring etc.

(e) Control plug extension cable at least three meters long shall be provided for testing of the circuit breaker outside the switchboard. The cable shall plug in to the compartment control plug port and the circuit breaker control plug port

(f)
8.6.2.1 Shall be provided with Mechanical Interlocks to ensure correct switching operation.

8.6.2.2 Earth switch shall short circuit all the three phases and neutral and link them to ground terminal.

8.6.2.3 The earth switch shall be easy to operate by one operator and be spring loaded to ensure Effective Make Operation independent of the Operator Action.

8.6.2.4 The earth switch shall be rated to make and carry for 3 seconds; the rated short-circuit current of the Air Circuit Breaker.

8.6.2.5 The Status of the earth Switch shall be visible from the front of the Panel.

8.6.2.6 The operation of the Earth Switch shall be set in such a way that during both the Close and Open Operations, a clearance of at least 25 mm shall be maintained between the operating handle and the bottom of the switchgear panel.

8.6.2.7 It shall not be possible to insert the Earth switch Operating handle into Position except when the Circuit breaker is in the Test or Isolated Position.

8.6.2.8 Shall meet the following minimum ratings:
   (a) Rated short-time withstand current (Icw): \( \geq 29\text{KA}/3\text{s} \) (50KA/1s)
   (b) Rated operational voltage Ue: 433VAC
   (c) Rated insulation voltage: 1000VAC
   (d) Rated impulse withstand voltage Uimp: 12KV
   (e) Rated continuous current: same as incomer

8.6.3 **Moulded case circuit breakers, MCCB**

8.6.3.1 Moulded case circuit breakers shall be used for all three phase low voltage circuits rated above 100A where an ACB is not necessary.

8.6.3.2 MCCB’s rated 160A and above shall meet all the following requirements.

<table>
<thead>
<tr>
<th>No.</th>
<th>Type (Basic rating)</th>
<th>160A</th>
<th>250A</th>
<th>400A</th>
<th>630A</th>
<th>800A</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Rated continuous current, In, at 50°C [A]</td>
<td>160</td>
<td>250</td>
<td>400</td>
<td>630</td>
<td>800</td>
</tr>
<tr>
<td>(b)</td>
<td>Rated continuous current, In, at 70°C [A]</td>
<td>128</td>
<td>200</td>
<td>320</td>
<td>504</td>
<td>640</td>
</tr>
<tr>
<td>(c)</td>
<td>Rated ultimate symmetrical breaking current, Icu, at 415VAC as per IEC 60947-2, [kA]</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>(d)</td>
<td>Rated Service symmetrical breaking current, Ics, at 415VAC as per IEC 60947-2, [kA]</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>70</td>
</tr>
</tbody>
</table>
8.6.3.3 MCCB’s mounted in the withdrawable plug in units shall have a door-coupling rotary operating mechanism with a knob attached to the compartment door.

8.6.3.4 All MCCB’s rated above 160A shall have an electronic trip unit and support Modbus RTU (RS 485) serial communication.

8.6.3.5 There shall be two types of electronic trip units (ETU) for all MCCB’s rated over 160A:
   (a) Line protection ETU for cable feeder modules MCCB
   (b) Motor protection ETU for motor DOL starter modules MCCB

8.6.3.6 Line protection electronic trip unit shall have the following functions and features:
   (a) Overload protection (settable from at least 10% to 100% MCCB rating)
   (b) Short-time and long-time delayed short-circuit protection
   (c) Instantaneous short-circuit protection
   (d) Neutral conductor protection
   (e) Ground-fault protection
   (f) Dials for setting the pickup and time delay settings
   (g) Two signalling LED’s for ETU status and protection trip/alarm

<table>
<thead>
<tr>
<th></th>
<th>Rated insulation voltage, Ui, in accordance with IEC 60947-2 [V AC]</th>
<th>1000</th>
<th>1000</th>
<th>1000</th>
<th>1000</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|   | Rated impulse withstand voltage, Uimp (Main current paths/Auxiliary circuits) [kV] | 8/4 | 8/4 | 8/4 | 8/4 | 8/4 |
|---|---|---|---|---|---|
| (f) | | | | | | |

|   | Rated operating voltage, Ue, at IEC 50 / 60 Hz [V AC] | 433 | 433 | 433 | 433 | 433 |
|---|---|---|---|---|---|
| (g) | | | | | | |

|   | Maximum DC contact resistance at 40°C [mΩ] | 0.55 | 0.35 | 0.2 | 0.15 | 0.15 |
|---|---|---|---|---|---|
| (h) | | | | | | |

|   | Maximum power loss with a balanced load at rated current, In, and at 40°C [W] | 40 | 60 | 90 | 160 | 250 |
|---|---|---|---|---|---|
| (i) | | | | | | |

|   | Utilization category as per IEC 60947-2 | A | A | A | A | A |
|---|---|---|---|---|---|
| (j) | | | | | | |

|   | Permissible ambient Operating temperature [°C] | -25 to 70 | -25 to 70 | -25 to 70 | -25 to 70 | -25 to 70 |
|---|---|---|---|---|---|
| (k) | | | | | | |

|   | Trip mechanism | ETU | ETU | ETU | ETU | ETU |
|---|---|---|---|---|---|
| (l) | | | | | | |

|   | Modbus RTU communication | YES | YES | YES | YES | YES |
|---|---|---|---|---|---|
| (m) | | | | | | |

|   | Number of poles | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 |
|---|---|---|---|---|---|
| (n) | | | | | | |

|   | Number of auxiliary SPDT contacts | ≥4 | ≥4 | ≥4 | ≥4 | ≥4 |
|---|---|---|---|---|---|
| (o) | | | | | | |

|   | Current metering error (up to 120% rated) | ≤1% | ≤1% | ≤1% | ≤1% | ≤1% |
|---|---|---|---|---|---|
| (g) | | | | | | |

8.6.3.3 MCCB’s mounted in the withdrawable plug in units shall have a door-coupling rotary operating mechanism with a knob attached to the compartment door.

8.6.3.4 All MCCB’s rated above 160A shall have an electronic trip unit and support Modbus RTU (RS 485) serial communication.

8.6.3.5 There shall be two types of electronic trip units (ETU) for all MCCB’s rated over 160A:
   (a) Line protection ETU for cable feeder modules MCCB
   (b) Motor protection ETU for motor DOL starter modules MCCB

8.6.3.6 Line protection electronic trip unit shall have the following functions and features:
   (a) Overload protection (settable from at least 10% to 100% MCCB rating)
   (b) Short-time and long-time delayed short-circuit protection
   (c) Instantaneous short-circuit protection
   (d) Neutral conductor protection
   (e) Ground-fault protection
   (f) Dials for setting the pickup and time delay settings
   (g) Two signalling LED’s for ETU status and protection trip/alarm
(h) A reset push button and remote hardwired trip reset input

8.6.3.7 Motor protection electronic trip unit shall have the following functions and features:

(a) Overload protection with thermal image function to reduce trip time following an overload trip. Overload shall be settable from at least 10% to 100% MCCB rating
(b) Over current protection with motor start time and permitted starts set up
(c) Instantaneous short-circuit protection
(d) Phase failure/phase unbalance protection
(e) LCD display
(f) Direct, user-friendly, menu-driven setting of the absolute values of the protection parameters in absolute ampere values via buttons and LCD display
(g) A reset push button and remote hardwired trip reset input

8.6.3.8 Data from MCCB shall be transferred via Modbus RTU to plant control system. The following data and functions shall be available:

(a) Switching MCCB on or off (in conjunction with a motorized operating mechanism)
(b) MCCB ON or OFF status
(c) Tripped signals
(d) Tripped signals with cause of tripping operation, tripping current and time stamp
(e) Alarm (e.g. overload)
(f) Alarms with time stamp (e.g. overload, phase unbalance current, etc.)
(g) Max. phase current of a phase
(h) Phase currents with max. value and time stamp
(i) Neutral conductor current with min./max. value and time stamp
(j) Read/write to ETU
(k) Number and type of tripping operations: Long-time delay, Short time delay, Instantaneous, or Ground fault
(l) Number of switch operations under load
(m) Operating hours
(n) Type of trip unit (functions supported)
(o) 3/4-pole switch
(p) Current sensor rating
(q) Serial no. of the trip unit
8.6.3.9 The following features shall be offered if necessary or stated in the switchboard requirements:

(a) The motorized operating mechanism for remote switching
(b) Under voltage release to trip the moulded case circuit breaker when the voltage fails. The under-voltage level shall be settable
(c) Shunt release for remote tripping of the moulded case circuit breaker.

8.6.4 **Automatic Transfer Controller (ATC)**

8.6.4.1 **Function:** To control the transfer between two switchboard incomer power supplies automatically, while talking into consideration the set limit values and delay times.

(a) Shall detect fluctuations occurring in the main power supply quickly and switch to the standby power supply.
(b) The ATC only switches to the standby power supply after it has ensured that the standby supply is delivering the required power supply quality.
(c) Shall have a digital input for external initiation of transfer between the two power supplies.

8.6.4.2 **Incomer supply inputs:** Shall have two three phase four wire voltage inputs for direct connection to 690V L-L AC supplies.

8.6.4.3 **Digital inputs & outputs:**

(a) Shall have at least 8 (eight) digital inputs, 6 (six) of which are programmable and 7 (seven) relay outputs, 5 (five) of which are programmable
(b) Digital outputs shall be rated at least 8A @125 V DC
(c) Shall have a digital input for setting the line priority (initiating changeover)
(d) Shall have two digital outputs configured for Main incomer and reserve incomer supply status (healthy/unavailable)

8.6.4.4 **Operation features:**

(a) Shall have an LED or LCD display for display of incomer voltages and for device parameterisation
(b) Shall have the following parameters settable on the device display:
(i) Time delay before the circuit breaker on the main supply side opens
(ii) Time delay before the circuit-breaker on the standby supply side closes.
(iii) Time delay before the circuit-breaker on the standby supply side opens
(iv) Time delay before the circuit-breaker on the main supply side closes
(v) Under and over voltage threshold holds
(vi) Frequency limits
(vii) Main and standby supply input (priority)
(c) Shall monitor the voltage of the main and standby supply for the following parameters
   (i) Under and over voltage
   (ii) Under and over Frequency
   (iii) Phase rotation/symmetry
   (iv) Voltage imbalance
   (v) Frequency imbalance
(d) Shall have 4 (four) selectable operating modes: off, manual, automatic, test
(e) Have a non-volatile memory (flash) for storing data, parameter and logged events (e.g. power failure, faults)
(f) Display the status of the circuit breakers or contactors
(g) Real time clock

8.6.4.5 Power supply: Shall have a DC power supply

8.6.4.6 Communication:
   (a) Shall have an RS485 port/terminals.
   (b) Shall support Modbus RTU
   (c) Shall transmit all logged events and alarms via communication. A minimum
       of the following signals shall be available
       (i) Circuit breaker/contactor status
       (ii) Incomer supply available/unavailable
       (iii) Supply status alarms e.g. Over voltage, under voltage, over/under
            frequency, phase rotation etc.
       (iv) Time delay and incomer priority settings
   (d) Shall be configured for device parameterisation via communication
   (e) Shall be configured for circuit breaker closing/opening commands via communication

8.6.4.7 Voltage & insulation ratings
   (a) Rated operational voltage Ue: 433V AC
   (b) Rated insulation voltage: 1000V AC
   (c) Rated impulse withstand voltage Uimp: ≥ 4KV
8.6.5 **Motor Protection Circuit breaker, MPCB**

MPCB’s shall be special kind of MCCB’s for three phase loads rated below 100A. They shall meet the following requirements.

8.6.5.1 Designed for motor and other three phase loads protection. Shall be used for protection of three phase loads rated below 100A

8.6.5.2 Shall have an adjustable overload setting, with a dial on the front side for adjustment. Overload shall be settable from at least 10% to 100% MPCB rating

8.6.5.3 Shall have a short-circuit current breaking capacity (Icu) of at least 50KA at 400V AC (three phase)

8.6.5.4 Shall have the following minimum ratings and features

(a) No of poles: 3(three)

(b) Rated operating voltage: 690 V AC

(c) Rated impulse withstand voltage, Uimp: ≥6KV

(d) Overcurrent & short circuit release: thermomagnetic

(e) Short-circuit current breaking capacity (Icu) @400VAC: ≥50KA

(f) Auxiliary contacts: At least 2(two) SPDT contacts

(g) Terminals: screw type

(h) Conductor size on main terminals: up to 2X 25 mm² stranded conductor

(i) Rated ambient Operating temperature: -20 to +60 °C

8.6.5.5 MPCB’s rated below 3A with overload adjustable to less than 1A shall be used for protection of three phase control circuits such as VT inputs and outputs, voltage monitoring relays input etc.

8.6.5.6 The current ratings given in the specifications take into account that the Overload shall be settable from at least 10% to 100%. Overload setting and trip classes shall be computed during design

8.6.6 **Digital AC Current Transducer**

8.6.6.1 Digital current transducers shall be installed on low power three phase feeders (63A and below) to enable energy monitoring/management

8.6.6.2 They shall be compliant with provisions of IEC 60044-8 or IEC 61869-9:2016

8.6.6.3 The digital current transducers may have separate current transformers or integrated current transformers with a conductor window suitable for conductors sized 35mm² and below

8.6.6.4 Three phase digital current transducers shall be used for three phase circuits and shall have three primary wire connections
8.6.6.5 They shall have an EIA 485, Modbus RTU serial output. Several sensors (up to 32) shall be wired in a multi drop bus arrangement.
8.6.6.6 Shall support primary currents of up to 63A AC or higher
8.6.6.7 Shall have an external DC auxiliary power supply
8.6.6.8 They shall be of reasonable cost for the application
8.6.6.9 Shall have hardware provision such as DIP switches for basic parameter setting e.g. EIA 485 device ID/address
8.6.6.10 Transducer shall transmit a minimum of the following data
   (a) Phase currents
   (b) Maximum and minimum phase current over a set duration
   (c) Residual current
8.6.6.11 Shall meet the following minimum basic ratings
   (a) Accuracy class according to IEC 60044-8: Class 1 or better
   (b) Rated insulation voltage: ≥433 V AC
   (c) Rated impulse withstand voltage, Uimp: ≥2.5KV
   (d) Sensitivity: ≤100mA primary current
   (e) Output Resolution: ≥12 bit
   (f) Analogue to Digital conversion rate: ≥50Hz
   (g) Frequency: 45-65Hz
   (h) Rated ambient Operating temperature: -10 to +55 °C

8.6.7 Current transformers, CT

8.6.7.1 Current transformers shall be dry cast resin type and shall be accommodated inside the cubicles, in the cable/switchgear compartment
8.6.7.2 The current transformers shall be in accordance with the requirement of IEC 61869-1&2 and shall have the specified accuracy under load conditions and shall be able to withstand the effect of short-circuit fault current rating of the switchboard
8.6.7.3 Current transformers shall have a rated burden calculated for sufficient operation of the numerical relays and the highest accuracy for meters and instruments.
8.6.7.4 Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 61869-2 shall be provided.
8.6.7.5 Current transformers shall meet a minimum of the following requirements
   (a) CT ratio: as specified
   (b) Number of cores: at least 1(one) metering core
(c) Accuracy class: 0.5 or better
(d) Instrument security factor (ISF): 120%
(e) Burden: at least 3VA (to be determined at design stage)
(f) Rated short-time withstand current (Icw): ≥50KA/1s
(g) Rated operational voltage Ue: 433VAC
(h) Rated insulation voltage: 1000VAC
(i) Rated impulse withstand voltage Uimp: 12KV
(j) Meets requirements of IEC 61869-2

8.6.8 **Voltage transformers, VT**

8.6.8.1 Voltage transformers shall be dry cast resin type and shall be accommodated inside the cubicles, in the cable/metering compartment

8.6.8.2 The voltage transformers shall be in accordance with the requirement of IEC 61869-1&3 and shall have the specified accuracy under load conditions and shall be able to withstand the effect of short-circuit fault current rating of the switchboard

8.6.8.3 Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 61869-3 shall be provided.

8.6.8.4 Low voltage switchboard VT’s shall meet a minimum of the following requirements
   (a) VT ratio: 415V/110V
   (b) Burden: 5-50VA (dependent on application/load)
   (c) Accuracy class: 0.5
   (d) Rated operational voltage Ue: 433VAC
   (e) Rated insulation voltage: 1000VAC
   (f) Rated impulse withstand voltage Uimp: 12KV
   (g) Meets requirements of IEC 61869-3

8.6.9 **Withdrawable Cable Feeder Modules**

8.6.9.1 Cable feeder modules shall be used to supply switchboards and other mixed loads. The number of devices contained in the cable feeder module shall be dependent on the rating of the module. The cable feeder modules shall be used for circuits not requiring frequent switching

8.6.9.2 All cable feeder modules shall meet withdrawable module requirements in **clause 8.5.8**

8.6.9.3 Withdrawable cable feeder modules rated above 125A shall contain an MCCB with the following features:
(a) The MCCB’s shall have line protection ETU and Modbus RTU communication interface

(b) The MCCB serial output shall be connected to a serial device server for data transmission to SCADA system

8.6.9.4 Withdrawable cable feeder modules rated below 100A shall contain an MPCB and a digital current transducer

8.6.9.5 630A rated cable feeder modules shall contain the following:
(a) 800A MCCB meeting requirements in clause 8.6.3
(b) At least 1(one) current transformer meeting requirements in clause 8.6.7 for the digital AC ammeter
(c) At least 1(one) Digital panel AC ammeter meeting requirements of clause 3.4.5
(d) MCCB isolating switch joined to a knob at the compartment door.

8.6.9.6 250A rated cable feeder modules shall contain the following:
(a) 315A MCCB meeting requirements in clause 8.6.3
(b) At least 1(one) current transformer meeting requirements in clause 8.6.7 for the digital AC ammeter
(c) At least 1(one) Digital panel AC ammeter meeting requirements of clause 3.4.5
(d) MCCB isolating switch joined to a knob at the compartment door.

8.6.9.7 125A rated cable feeder modules shall contain the following:
(a) 160A MCCB meeting requirements in clause 8.6.3
(b) MCCB isolating switch joined to a knob at the compartment door.

8.6.9.8 63A rated cable feeder modules shall contain the following:
(a) 63A MPCB meeting requirements in clause 8.6.5
(b) a three-phase digital AC current transducer meeting requirement in clause 8.6.6, with the serial output wired in a multi droop bus to the serial device server
(c) MPCB isolating switch joined to a knob at the compartment door.

8.6.9.9 32A rated cable feeder modules shall contain the following:
(a) 32A MPCB meeting requirements in clause 8.6.5
(b) a three-phase digital AC current transducer meeting requirement in clause 8.6.6, with the serial output wired in a multi droop bus to the serial device server
(c) MPCB isolating switch joined to a knob at the compartment door.

8.6.9.10 For each cable feeder module, Potential free contacts shall be provided for a minimum of the following signals
8.6.10 Withdrawable Motor DOL (Direct on line) starter feeder modules

8.6.10.1 Motor DOL starter modules shall be used to supply motors and other inductive loads requiring frequent switching. The number of devices contained in the motor DOL feeder module shall be dependent on the rating of the module.

8.6.10.2 All motor DOL starter feeder modules shall meet withdrawable module requirements in clause 8.5.8.

8.6.10.3 55KW standard sized withdrawable motor DOL feeder modules, shall meet the following minimum requirements:

(a) Shall have 160A MCCB meeting requirements in clause 8.6.3
   (i) The MCCB shall have a motor protection electronic trip unit with an LCD display
   (ii) The MCCB serial output shall be connected serial device server for data transmission to SCADA system
   (iii) MCCB LCD display shall be configured to indicate the motor currents and motor status

(b) Shall have a 75KW contactor
   (i) Rated for DOL starting of 100hp (75KW) motors
   (ii) Rated continuous current of 160A at 40°C ambient temperature
   (iii) Insulation rated at 1000V AC
   (iv) With at least 2NO and 2NC potential free contacts

(c) Shall the following devices
   (i) At least 2(two) miniature circuit-breakers for control circuit protection
   (ii) At least 2(two) contactor relays
   (iii) A set of interface relays with SPDT contacts
   (iv) A current transformer meeting requirement in clause 8.6.7 for panel meter

8.6.10.4 32KW standard sized or small sized withdrawable motor DOL starter modules, shall meet the following minimum requirements:

(a) Shall have 63A MPCB meeting requirements in clause 8.6.5

(b) Shall have an 37KW contactor
   (i) Rated for DOL starting of 50hp (37KW) motors
   (ii) Rated continuous current of 80A at 40°C ambient temperature
(iii) Insulation rated at 1000V AC
(iv) With at least 2NO and 2NC potential free contacts

(c) Shall have a three-phase digital AC current transducer meeting requirement in clause 8.6.6, with the Modbus RTU serial output wired in a multi droop bus to the serial device server

(d) Shall the following devices

(i) At least 2(two) miniature circuit-breakers for control circuit protection
(ii) At least 2(two) contactor relays
(iii) A set of interface relays with SPDT contacts
(iv) A current transformer meeting requirement in clause 8.6.7 for panel meter

8.6.10.5 11KW standard sized or small sized withdrawable motor DOL starter modules, shall meet the following minimum requirements:

(a) Shall have 32A MPCB meeting requirements in clause 8.6.5
(b) Shall have an 18.5KW contactor

(i) Rated for DOL starting of 25hp (18.5KW) motors
(ii) Rated continuous current of 38A at 40°C ambient temperature
(iii) Insulation rated at 1000V AC
(iv) With at least 2NO and 2NC potential free contacts

(c) Shall have a three-phase digital AC current transducer meeting requirement in clause 8.6.6, with the Modbus RTU serial output wired in a multi droop bus to the serial device server

(d) Shall the following devices

(i) At least 2(two) miniature circuit-breakers for control circuit protection
(ii) At least 2(two) contactor relays
(iii) A set of interface relays with SPDT contacts
(iv) A current transformer meeting requirement in clause 8.6.7 for panel meter

8.6.10.6 7.5 KW standard sized or small sized withdrawable motor DOL starter modules, shall meet the following minimum requirements:

(a) Shall have 16A MPCB meeting requirements in clause 8.6.5
(b) Shall have a 7.5KW contactor

(i) Rated for DOL starting of 10hp (7.5KW) motors
(ii) Rated continuous current of 16A at 40°C ambient temperature
(iii) Insulation rated at 1000V AC
(iv) With at least 2NO and 2NC potential free contacts
(c) Shall have a three-phase digital AC current transducer meeting requirement in clause 8.6.6, with the Modbus RTU serial output wired in a multi droop bus to the serial device server.

(d) Shall the following devices:
(i) At least 2(two) miniature circuit-breakers for control circuit protection
(ii) At least 2(two) contactor relays
(iii) A set of interface relays with SPDT contacts
(iv) A current transformer meeting requirement in clause 8.6.7 for panel meter

8.6.10.7 The Motor DOL starter Withdrawable plug in modules shall have a minimum of the following devices mounted on their compartment doors:
(a) 1(one) Digital panel AC ammeter meeting requirements of clause 3.4.2.3
(b) 3(three)illuminated pushbutton (ON/OFF/TRIP RESET)
(c) 3(three) status LED lamps (trip, service position, test position)
(d) 1(one)Running hour’s counter
(e) 1(one) 3-position key-operated switch for motor start/stop interlock LOCAL/MAINTENANCE/REMOTE.

8.6.10.8 Potential free contacts shall be provided for a minimum of the following signal outputs for each motor DOL starter module:
- Motor/lights ON
- Motor tripped (protection)
- module in withdrawn position
- Module in test position
- Local selection
- Maintenance selection
- Motor/lights OFF
- MCCB/MPCB OFF
- MCCB/MPCB ON
- module in service position
- Remote selection

8.6.10.9 The following inputs/ commands with a 24/110VDC common supply shall be provided for each motor DOL starter module:
- Motor/lights ON
- MCCB trip reset
- Motor/lights OFF

8.6.10.10 Optionally Motor DOL starter Withdrawable plug in modules may contain a motor management controller/relay (MMC) suitably rated for the DOL starter. If a motor management relay/ controller is used the following requirements shall be met:
(a) Relay/controller shall be compact, with remote LCD display, shall be directly connected to the motors and shall have serial communication interface. It shall provide the following protection functions and features
(i) Protection against over-currents
(ii) Protection against thermal overloads, settable and with choice of trip class
(iii) Protection against ground faults
(iv) Protection against phase imbalances
(v) Protection against mechanical jams during or after the start-up phase.
(vi) Protection against idling
(vii) Protection against excessive starts

(b) Shall have a minimum of two (2) auxiliary SPDT contacts for hardwired signalling of trip and relay faulty alarm

(c) Shall have a digital input for trip reset

(d) Shall Meter and display motor currents, motor operating hours, number of motor starts & trips/stop, cause of motor trip.

(e) Shall have a serial port supporting Modbus RTU or ethernet supporting Modbus TCP.

(f) Shall be interfaced to the serial device server and transfer the following information to employers’ SCADA Interface application via Modbus RTU/TCP.

(i) Motor switching state (on, off, jammed etc),
(ii) Current in phases 1, 2 and 3 and maximum current in A
(iii) Voltage in phases 1, 2 and 3 in V
(iv) Real power in W
(v) Apparent power in VA
(vi) Power factor in %
(vii) Phase unbalance in %
(viii) Switching ON/OFF command
(ix) Tripped signals with cause of tripping operation, tripping current and time stamp
(x) Alarms with time stamp (e.g. overload, phase unbalance current, etc.)
(xi) Number of motor operating hours, also resettable
(xii) Motor stop times, also resettable
(xiii) Number of motor starts, also resettable
(xiv) Number of permissible starts remaining
(xv) Number of overload tripping, also resettable

(g) If the MMC is used, then

(i) The following DOL starter configuration shall be allowed:
- MCCB + MMC + Contactor for DOL starters rated 55KW
- 3P MCB (3phase) + MMC+ Contactor for DOL starters rated 32KW and below

(ii) It shall not be mandatory for MCCB to have an ETU and LCD, the MCCB may have Thermal magnetic trip unit with settable overload dial.

(iii) Digital current transducers shall not be required

(iv) Digital panel AC ammeter and current transformer will be optional if the motor management controller shall have a HMI unit mounted on the compartment door with an LCD displaying characters sized at least 10mm

(v) 3(three)illuminated pushbutton (ON/OFF/TRIP RESET) shall be installed on the compartment door and wired directly to the contactor for motor/lights ON and motor/lights off. Trip reset shall be wired to a trip reset input of the MMC

(vi) status LED lamps shall not be required

(vii) Running hour’s counter shall not be required if the function is available in the MMC and displayed on the MMC HMI

(viii) 1(one) 3-position key-operated switch for motor start/stop interlock LOCAL/MAINTENANCE/REMOTE. shall be installed on the compartment door

(ix) Signals in clause 8.6.10.8 and 8.6.10.9 shall be availed and hardwired to the switchboard PLC or the employer’s common PLC

(h) Software for configuration of the MMC’s shall be provided with licences for installation into at least two laptops

8.6.11 **Contactors**

8.6.11.1 All contactors shall be DC controlled type, with coils rated 110VDC ±20%

8.6.11.2 Contactors shall comply with provisions of IEC 60947-4

8.6.11.3 The contactors shall be well supported on their bases to avoid malfunctioning during operation due to vibrations.

8.6.11.4 Pick-up and drop-off voltages for electricity held-in contactors shall comply with IEC 60947-4-1. Latched contactors shall pick-up and latch-in between 80% and 115% of nominal control supply voltage and shall trip between 75% and 115% of nominal control supply voltage.
8.7 LV POWER CABLES

8.7.1 Low voltage power cables shall be compliant with specifications in clause 3.7.

8.7.2 All low voltage cables shall meet the requirements of IEC 60502 and shall be type tested to the requirements of this standard.

8.7.3 All LV power cables shall meet the following basic ratings:

8.7.3.1 Rated operational voltage Ue: 433VAC

8.7.3.2 Rated insulation voltage: 1000VAC

8.7.3.3 Rated impulse withstands voltage Uimp: 12KV

8.7.4 All low voltage power cables shall be sized and installed as per latest BS 7671 (IET Wiring Regulations) requirements for industrial installations and other relevant IEC standards. Voltage drop above 5% shall not be allowed.

8.7.5 For LV switchboard feeder cables the minimum current ratings are given in clause 2.7, the cables shall be appropriately rated to above 120% of rated feeder/incomer load.

8.8 INSPECTION AND TESTING

8.8.1 Type tests

8.8.1.1 Type tests shall be carried out by a laboratory accredited by National Standards Testing Authority, NSTA of a western European (EU) country, USA or Canada.

8.8.1.2 Type tests reports/certificate shall be submitted during design stage for the following tests:

(a) In accordance to IEC61439

(i) Verification of temperature rise limits by test

• Maximum temperature-rise with fully loaded compartments shall not exceed the values indicated in the standard

(ii) Verification of dielectric properties by test

• Test Voltage for main circuits shall be 3500V a.c. r.m.s.
• Test voltage for auxiliary circuits shall be 1500V a.c. r.m.s
• Test voltage for the Impulse voltage withstand test shall be 8kV 1.2/50_s

(iii) Verification of the short-circuit withstand strength by test as follows:
• For Bus bars phase conductors with:
  — Rated currents up to 1000A: 50kArms 1s
  — Rated current 1250A: 65kArms 1s
  — Rated currents 1600A up to 4000A: 80kArms 1s

• Test current for impulse withstand current Ipk for shall be at least, For Bus bar phase conductors with:
  — Rated currents up to 1000A: 105kApk
  — Rated current 1250A: 143kApk
  — Rated currents 1600A up to 4000A: 176kApk

• During the tests for short-circuit withstand strength, it shall be verified:
  — That Bus bar-compartment doors and covers remained closed during the test,
  — That full arc containment is achieved.

(iv) Verification of the effective connection between the exposed conductive parts of the assembly and the protective circuit by inspection or resistance measurement

(v) Verification of the short-circuit withstand strength of the protective circuit by test

(vi) Verification of clearances and creep age distances by test

• It shall be verified that clearance and creepage distances are in accordance limits provided in the standard, considering a pollution degree 3.

• Minimum values for creepage and clearances combinations shall be used when dielectric properties are tested.

• Withdrawable assemblies, shall additionally endure dielectric tests in their “test” and “disconnected” positions.

(vii) Verification of mechanical operations by tests

• A minimum of 50 mechanical operations shall be made on the mechanical functions of individual components and groups after installation into the assembly. At the same time, the operation of the functions of coupled & interlocking devices and mechanisms shall be checked.

• After the testing is complete the apparatus, interlocks, etc., shall operate properly and practically the same as before the test.
(b) Verification of the degree of protection as per IEC 60529
(c) Arc resistance and protection as per IEC TR 61641
(d) Tests on circuit breakers and contactors as per IEC60497
   (i) Mechanical endurance test
   (ii) Temperature rise test.
   (iii) Impulse voltage test
   (iv) Interrupting Capacity test
(e) Type Tests on Current and voltage Transformers as per IEC 61869

8.8.2 Factory Tests

8.8.2.1 Tests given in this clause are not comprehensive and only highlight the minimum required tests. The contractor shall prepare detailed test plans as per clause 1.9.3.3 of specifications, covering all detailed tests necessary as per requirements of IEC 61439, IEC 60947 and IEC 60529.

8.8.2.2 Factory tests shall be witnessed by client engineers

8.8.2.3 The following checks/tests as per Requirement of the IEC 61439 will be carried out in presence of client engineers
   (a) Checking of protective measures & electrical circuits
   (b) Mechanical operations tests
   (c) Checking Internal electrical circuits and connections, terminals for external conductors
   (d) Dielectric properties
      (i) Test Voltage for main circuits shall be 3500V a.c. r.m.s.
      (ii) Test voltage for auxiliary circuits shall be 1500V a.c. r.m.s
      (iii) Test voltage for the Impulse voltage withstand test shall be 8kV 1.2/50_s
      (iv) Withdrawable assemblies, shall additionally endure dielectric tests in their “test” and “disconnected” positions.

8.8.2.4 Tests on all circuit breakers and contactors rated above 160A as per IEC60497
   (a) Operation test.
   (b) Dielectric tests: High Voltage test, dry. 3kV Power Frequency Voltage test and on controls and auxiliary circuits.
   (c) DC resistance measurement of main circuit.

8.8.2.5 Tests on air circuit breakers as per IEC60497
   (a) Operation test.
(b) Dielectric tests: High Voltage test, dry. 3kV Power Frequency Voltage test and on controls and auxiliary circuits.
(c) DC resistance measurement of main circuit.
(d) Timing tests
(e) Charging motor checks and test

8.8.2.6 Approved designs verification and Functional testing of the fully assembled switchboards

(a) Dimensional Checks
(b) Operation tests on all withdrawable units
(c) Functional tests on all feeder and incomer circuits
(d) Approved designs verification
(e) Multifunction meters’ and panel indication meters’ accuracy checks

8.8.2.7 Communication interface checks and verification as per the approved designs

8.8.2.8 Verification of results for the following routine tests carried out on CT and VT

(a) Polarity Test and Verification of terminal markings
(b) Ratio and phase angle error test (accuracy class composite error test)
(c) Power frequency Tests on Primary and secondary windings

Where deemed necessary repeat of the above routine tests for sampled CT and VT’s

8.8.2.9 Verification of calibration certificates for all instruments and meters and where deemed necessary repeat of calibration checks for sampled instruments and meters

8.8.2.10 The contractor shall provide a test protocol to the client for approval prior to the factory test. This shall contain detailed procedure of all the tests to be carried during the factory tests.

8.8.3 **Site Tests**

8.8.3.1 Tests given in this clause are not comprehensive and only highlight the basic required tests. The contractor shall prepare test plans as per clause 1.10.3 of specifications, covering all detailed tests necessary for commissioning of the switch boards and associated equipment

8.8.3.2 The following minimum tests will be carried out during commissioning:

(a) Primary injection to confirm the CT secondary circuits are correctly connected to the relays, meters, instruments etc.
(b) Wiring verification
(c) Circuit breakers and plug in modules operation checks
(d) ACB’s timing and DC resistance tests
(e) Dielectric tests/checks
8.8.3.3 MCCB and ACB’s
  (a) programming/setting
  (b) Charging-manual/electrical
  (c) Racking
  (d) Protection trip
  (e) Open/close (manual/auto)

8.8.3.4 Panel Meters
  (a) configuring/programming
  (b) Accuracy checks/verification
  (c) Scheme checks (via primary injection)

8.8.3.5 IED’S/PLC if used
  (a) Wiring checks
  (b) Functional checks
  (c) Logic/sequence checks
  (d) Communication tests/checks

8.8.3.6 Communication/SCADA interface checks as per approved design and software applications

8.8.3.7 Annunciator/Indications/alarms; all indications to be tested and confirmed through initiation from the process.

8.8.3.8 Interlock tests/verification
  (a) Incomer Changeover mechanical and electrical interlocks
  (b) Withdrawable modules mechanical operation interlocks
  (c) Air circuit breakers positioning mechanism mechanical interlocks

8.8.3.9 Incomer Changeover checks

8.8.3.10 Function tests for all feeder, incomer and bus coupler circuits to operate as per approved design

8.9 TRAINING
Training shall at minimum cover the following:

8.9.1.1 Practical training on Design, configuration/programming, installation and commissioning
  (a) Detailed training on LV circuit breakers internal operations including
     (i) Operating mechanisms
     (ii) Electromagnetic coils
     (iii) Arc quenching devices and mechanisms
     (iv) Practical dis-assembly and reassembly
(b) Setting and configuring circuit breaker trip units:
   (i) read and analyse tripping curves
   (ii) setting of TM thermal-magnetic trip units
   (iii) setting and configuring of ETU’s

(c) Programming/configuring of PLC’s or if they are used in the project
   (i) Memory/register configuration
   (ii) Communications configuration
   (iii) Logic creation/programming in IEC61131-3
   (iv) Wiring and terminations
   (v) Testing and commissioning

(d) Detailed practical training Setting and configuration including communication set up and register mapping of
   (i) Automatic transfer controllers switches
   (ii) Digital panel multifunction meters
   (iii) Digital AC voltmeters & ammeter
   (iv) Serial device server
   (v) Digital current transducer

8.9.1.2 Commissioning of LV systems from first principles.
   (a) Primary injection testing
   (b) Dielectric tests
   (c) Operation tests

8.9.1.3 Operation and Maintenance
   (a) Withdrawable circuit breakers and withdrawable plug in modules operations such as racking in and out. Detailed practical training on use of the special switchgear tools provided
   (b) All other switchgear operations depending on switchboards and switchgear installed
   (c) Routine system checks and testing procedures.
      (i) This will include practical training on preventive maintenance testing of all LV switchgear components i.e. circuit breakers, earth switches, instrument transformers metering and control devices, etc.
      (ii) Detailed procedures complete with check lists for quarterly semi-annual, annual, triennial/quadrennial etc. checks and tests to be provided.
   (d) Routine/preventive mechanical maintenance procedures such as greasing of moving parts of withdrawable components etc.
(e) Practical training on replacement of faulty switchboard parts and switchgear equipment.

(f) Detailed practical training on removing switchboard covers and reassembly after replacement of failed switchboard parts such as bus bars, arc barriers, earth switches, cable terminals etc.

(g) Repair and parts replacement of withdrawable plug in modules

(h) Detailed practical training on repair and internal parts replacement of air circuit breakers and moulded case circuit breakers. To cover
   (i) Trouble shooting
   (ii) Dis assembly and re assembly
   (iii) Identifying failed parts
   (iv) Testing after repair

(i) Any other training on operation and maintenance of the LV switchgear equipment provided

8.9.2 Detailed training on SCADA interfacing shall be carried out it shall encompass:

(a) Contractor shall carry out all software configurations together with client engineers. At least two client engineers shall be attached to the contractor for the whole duration of SCADA interface system development and configuration.

(b) Carrying out development and configuration of various OPC & Modbus applications with client engineers.

(c) Client engineers will carry out development and configuration of various OPC & Modbus applications/devices for some switchboards under supervision and directions of the contractor engineers

(d) Detailed class room training on use of the interface software configuration manager provided.

(e) Training aids including a software trainer, video’s and printed materials shall be availed
## 9 Existing Equipment Drawings & Specifications

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