

ADNOC GROUP PROJECTS AND ENGINEERING

ECMS (ELECTRICAL CONTROL AND MONITORING SYSTEM) SPECIFICATION

Specification

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GROUP PROJECTS & ENGINEERING / PT&CS DIRECTORATE

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REVISION HISTORY

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Group Projects & Engineering is the owner of this Specification and responsible for its custody, maintenance and periodic update.

In addition, Group Projects & Engineering is responsible for communication and distribution of any changes to this Specification and its version control.

This specification will be reviewed and updated in case of any changes affecting the activities described in this specification.

INTER-RELATIONSHIPS AND STAKEHOLDERS

- a. The following are inter-relationships for implementation of this Specification:
 - i. ADNOC Upstream and ADNOC Downstream Directorates; and
 - ii. ADNOC Onshore, ADNOC Offshore, ADNOC Sour Gas, ADNOC Gas Processing, ADNOC LNG, ADNOC Refining, Fertil, Borouge, Al Dhafra Petroleum, Al Yasat.
- b. The following are stakeholders for the purpose of this Specification:
 - i. ADNOC PT&CS Directorate.
- c. This Specification has been approved by the ADNOC PT&CS is to be implemented by each ADNOC Group company included above subject to and in accordance with their Delegation of Authority and other governance-related processes in order to ensure compliance.
- d. Each ADNOC Group company must establish/nominate a Technical Authority responsible for compliance with this Specification.

DEFINITIONS

“**ADNOC**” means Abu Dhabi National Oil Company.

“**ADNOC Group**” means ADNOC together with each company in which ADNOC, directly or indirectly, controls fifty percent (50%) or more of the share capital.

“**Approving Authority**” means the decision-making body or employee with the required authority to approve Policies & Procedures or any changes to it.

“**Business Line Directorates**” or “**BLD**” means a directorate of ADNOC which is responsible for one or more Group Companies reporting to, or operating within the same line of business as, such directorate.

“**Business Support Directorates and Functions**” or “**Non- BLD**” means all the ADNOC functions and the remaining directorates, which are not ADNOC Business Line Directorates.

“**CEO**” means chief executive officer.

“**Group Company**” means any company within the ADNOC Group other than ADNOC.

“**Specification**” means this ECMS (Electrical Control and Monitoring System) Specification.

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1 GENERAL

1.1 Introduction

This specification covers the implementation of control and monitoring of the electrical distribution system from remote centralised locations, including the following functions.

- a. Power management.
- b. Load shedding.
- c. Fault monitoring.
- d. Power quality monitoring and analysis.

1.2 Purpose

The purpose of this specification is to specify the minimum requirements of the design, performance, materials, manufacturing, inspection, testing, documentation and preparation for shipment of the Electrical Control and Monitoring System (ECMS).

For project and site-specific additional requirements, refer to supplementary requirements stated in respective project's Purchase Requisition documentation.

1.3 Definitions and Abbreviations

The following defined terms are used throughout this Specification:

'[PSR]' indicates a mandatory Process Safety Requirement.

"COMPANY" means ADNOC, ADNOC Group or an ADNOC Group Company, and includes any agent or consultant authorised to act for, and on behalf of the COMPANY.

"CONTRACTOR" means the parties that carry out all or part of the design, engineering, procurement, construction, commissioning or management for ADNOC projects. CONTRACTOR includes its approved MANUFACTURER(s), SUPPLIER(s), SUB-SUPPLIER(s) and SUB-CONTRACTOR(s).

"MANUFACTURER" means the Original Equipment Manufacturer (OEM) or MANUFACTURER of one or more of the component(s) which make up a sub-assembly or item of equipment assembled by the main SUPPLIER or his nominated SUB-SUPPLIER.

'may' means a permitted option.

'shall' indicates mandatory requirements.

'should' means a recommendation.

"SUB-CONTRACTOR" means any party engaged by the CONTRACTOR to undertake any assigned work on their behalf. COMPANY maintains the right to review all proposed SUB-CONTRACTORS; this right does not relieve the CONTRACTOR of their obligations under the Contract, nor does it create any contractual relationship between COMPANY and the SUB-CONTRACTOR.

"SUPPLIER" means the party entering into a Contract with COMPANY to provide the materials, equipment, supporting technical documents and/or drawings, guarantees, warranties and/or agreed services in accordance with the requirements of the purchase order and relevant specification(s). The term SUPPLIER includes any legally appointed successors and/or nominated representatives of the SUPPLIER.

“**SUB-SUPPLIER**” means the sub-contracted SUPPLIER of equipment sub-components software and/or support services relating to the equipment / package, or part thereof, to be provided by the SUPPLIER. COMPANY maintains the right to review all proposed SUB-SUPPLIERS, but this right does not relieve the SUPPLIER of their obligations under the Contract, nor does it create any contractual relationship between COMPANY and any individual SUB-SUPPLIER.

“**LATER**” means ‘The document is not available yet. Each ADNOC COMPANY shall use their own relevant document’.

The abbreviations used throughout this specification are shown in Table 1.1.

Table 1.1 List of Abbreviations

Abbreviations	
AC	Alternating Current
ANSI	American National Standards Institute
API	Application Programming Interface
ASD	Adjustable Speed Drive
ATS	Automatic Transfer Scheme
AVR	Automatic Voltage Regulator
BCU	Bay Control Unit
BEDD	Basic Engineering Design Data
BS	British Standard
CB	Circuit Breaker
COM	Component Object Model
CPU	Central Processing Unit
DACM	Data Acquisition and Control Module
DC	Direct Current
DFDS	Design Functional Specification
ECMS	Electrical Control and Monitoring System
EDG	Emergency Diesel Generator
EEMUA	Engineering Equipment and Materials Users Association
EIU	Equipment Interface Unit
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Magnetic Interference
EWS	Engineering Workstation
FAT	Factory Acceptance Test
GIS	Gas Insulated Switchgear
GOOSE	Generic Object-Oriented Substation Events

Abbreviations	
GPS	Global Position System
GUI	Graphical User Interface
HMI	Human Machine Interface
HV	High Voltage (>1000V)
HVAC	Heating Ventilation and Air Conditioning
ICD	IED Capability Description
ICSS	Integrated Control and Safety System
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IHT	In-House Test
I/O	Input /Output
IP	Ingress Protection
IS	Intrinsically Safe
ISO	International Organisation for Standardisation
ITU-T	International Telecommunication Union (ITU-T)
ITP	Inspection and Test Plan
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LNG	Liquified Natural Gas
LV	Low Voltage ($\leq 1000V$)
MCB	Miniature Circuit Breaker
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
OEM	Original Equipment Manufacturer
OLTC	On Load Tap Changer
OPC	Open Platform Communication
OS	Operating System
OSI	Open Systems Interconnect
PC	Personal Computer
PCB	Printed Circuit Board
PE	Protective Earth
PLC	Programmable Logic Controller
PQM	Power Quality Monitoring
PSR	Process Safety Requirement
PVC	Poly Vinyl Chloride

Abbreviations	
RAID	Redundant Array of Independent Disks
RCCB	Residual Current Circuit Breaker
SAT	Site Acceptance Test
SCD	Substation Configurable Description
SIT	Site Integrated Test
SLD	Single Line Diagram
SQL	Structured Query Language
TCP/IP	Transmission Control Protocol / Internet Protocol
TFT	Thin Film Transistor
UAE	United Arab Emirates
UCP	Unit Control Panel
UPS	Uninterruptible Power Supply
VT	Voltage Transformer

SECTION A - GENERAL

2 REFERENCE DOCUMENTS

2.1 International Codes and Standards

The following Codes and Standards shall form a part of this specification. When an edition date is not indicated for a Code or Standard, the latest edition in force at the time of the contract award shall apply.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C-37.2	Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.
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INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60038	IEC standard voltages.
IEC 60073	Basic safety principles for man machine interface, marking and identification - Coding principles for indicators and actuators.
IEC 60079-10-1	Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres.
IEC 60085	Electrical insulation - Thermal evaluation and designation.
IEC 60146	Semiconductor Converters - All Parts.
IEC 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements.
IEC 60255-1	Measuring relays and protection equipment - Part 1: Common requirements.
IEC/IEEE 60255-118-1	Measuring relays and protection equipment - Part 118-1: Synchrophasor for power systems - Measurements.
IEC 60269	Low Voltage Fuses - All parts.
IEC 60300-1	Dependability Management - Part 1: Guidance for management and application.
IEC 60304	Standard colours for insulation for low frequency cables and wires.
IEC 60332	Tests on electric and optical fibre cables under fire conditions - All parts.
IEC 60417-DB	Graphical symbols for use on equipment - ***Includes access to ISO 7000 Database***.
IEC 60445	Basic and safety principles for man machine interface, marking and identifications - Identification of equipment terminals and conductor terminations.

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60529	Degrees of protection provided by enclosures (IP Code).
IEC 60546	Controller with analogue signals for use in industrial control systems - All parts.
IEC 60617-DB	Graphical symbols for diagram (Database Snapshot).
IEC 60654	Operating conditions for industrial process measurement and control equipment - All parts.
IEC 60688	Electrical measuring transducers for converting A.C. and D.C. electrical quantities to analogue or digital signals.
IEC 60706-2	Maintainability of Equipment - Part 2: Maintainability requirements and studies during the design and development phase.
IEC 60748	Semiconductor devices - All parts.
IEC 60754-1	Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content.
IEC 60793	Optical fibres - All parts.
IEC 60794	Optical fibre cables - All parts.
IEC 60870	Telecontrol equipment and systems - All parts.
IEC 61000	Electromagnetic compatibility (EMC) - All parts.
IEC 61034-2	Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements.
IEC 61131	Programmable Controller - All parts.
IEC 61140	Protection against electric shock – Common aspects for installations and equipment.
IEC 61850	Communication networks and systems for power utility automation (excluding parts 7-410 and 7-420).
IEC 61869-2	Instrument transformers - Part 2: Additional requirements for current transformers.
IEC 61869-3	Instrument transformers - Part 3. Additional requirements for inductive voltage transformers.
IEC 61188-5	Printed boards and Printed board assembly - Design and use - Part 5 (all)
IEC 62351	Power systems management and associated information exchange – Data and communications security - All parts.
IEC 62381	Automation systems in the process industry – Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT).
IEC 62402	Obsolescence Management.
IEC 62439	Industrial Communication Networks - High availability automation networks - All parts.

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 62443 Security for industrial automation and control systems - All parts.

INTERNATIONAL ORGANISATION FOR STANDARDISATION (ISO)

ISO 12944-2 Paints and varnishes. Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments.

ISO 12944-5 Paints and varnishes - Corrosion protection of steel structures by protective paint systems, Part 5: Protective paint systems.

INTERNATIONAL TELECOMMUNICATION UNION (ITU-T)

ITU.T.G.651.1 Characteristics of a 50/125 μ m multimode graded index optical fibre cable for the optical access network.

ITU.T.G.652 Characteristics of a single-mode optical fibre and cable.

ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION (EEMUA)

EEMUA 140 Noise Procedure Specification.

BRITISH STANDARDS (BS)

BS 6231 Electrical cables - Single core PVC insulated flexible cables of rated voltage 600/1000 V for switchgear and control gear wiring.

2.2 ADNOC Specifications

Where a document is not available, each ADNOC COMPANY shall use their own relevant document.

AGES-SP-01-003 Structural Design Basis - On Shore Specification.

AGES-SP-04-006 Instrument and Control Cable Specification.

AGES-SP-07-004 Painting and Coating Specification.

LATER OT / Cyber Security Standard.

LATER Basic Engineering Design Data (BEDD).

LATER Tagging and Numbering Procedure.

2.3 Standard Drawings

LATER

2.4 Other References

LATER

3 DOCUMENT PRECEDENCE

The specifications and codes referred to in this specification shall, unless stated otherwise, be the latest approved issue at the time of contract award.

It shall be the CONTRACTOR's responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards.

The CONTRACTOR shall notify the COMPANY of any apparent conflict between this specification, the related data sheets, the Codes and Standards and any other specifications noted herein.

Resolution and/or interpretation precedence shall be obtained from the COMPANY in writing before proceeding with the design/manufacture.

In case of conflict, the order of document precedence shall be:

- a. UAE Statutory requirements.
- b. ADNOC HSE Standards.
- c. Equipment datasheets and drawings.
- d. Project Specifications and standard drawings.
- e. Company Specifications.
- f. National / International Standards.

4 SPECIFICATION DEVIATION / CONCESSION CONTROL

Deviations from this specification are only acceptable where the SUPPLIER has listed in his quotation the requirements he cannot, or does not wish to comply with, and the COMPANY / CONTRACTOR has accepted in writing the deviations before the order is placed.

In the absence of a list of deviations, it will be assumed that the SUPPLIER complies fully with this specification.

Any technical deviations to the Purchase Order and its attachments including, but not limited to, the Data Sheets and Narrative Specifications shall be sought by the SUPPLIER only through Concession Request Format. Concession requests require CONTRACTOR's and COMPANY's review / approval, prior to the proposed technical changes being implemented. Technical changes implemented prior to COMPANY approval are subject to rejection.

5 DESIGN CONSIDERATIONS / MINIMUM DESIGN REQUIREMENTS

5.1 Design Basis

The ECMS shall be:

- a. A modern well proven microprocessor-based system.
- b. Built with distributed intelligence as an automated real-time process engine for data acquisition, processing, transmission, storage and archiving, graphical presentation and display.

- c. Of a reliable design with 30-year design life operating under the specified conditions. The SUPPLIER shall advise the lifetime of any components that might not achieve the design life.
- d. Of modular design to facilitate easy maintenance, fault diagnosis, and repair. All components shall be of the highest attainable attributes for uniformity, interoperability and inter-changeability.
- e. Based on open systems allowing upgrades without any disruption to lower level controls. The SUPPLIER shall ensure that all versions of software and hardware are backwards compatible.
- f. Configured in a manner that its non-availability shall not affect the normal operation of the power generation and electrical distribution system.

5.2 Obsolescence

The SUPPLIER shall submit a statement along with the bid, in accordance with IEC 62402, on any planned or predicted obsolescence of equipment or components over the design life and advise what provisions are made to allow ease of future upgrading of any equipment purchased.

5.3 Cyber Security

Cyber security shall meet the following requirements:

- a. A role-based access control shall be incorporated.
- b. Cyber security for the products and external interface shall comply with IEC 62443 series of standards as applicable.
- c. Communication protocols shall comply with IEC 62351.
- d. SUPPLIER shall provide firewall and malware protection in line with COMPANY corporate cyber security policy.

5.4 Environmental / Site Data

Unless otherwise stated, the ECMS equipment shall be suitable for installation in an indoor location.

5.4.1 Outdoor Conditions

Unless stated otherwise, the following site environmental data for outdoor conditions shall be used:

- a. Without protective shelter, exposed to direct sunlight and solar gain of up to 1006 W/m², temperatures of up to 85 °C.
- b. Altitude: <1000 m above sea level.
- c. Wind velocity for design: Refer to AGES-SP-01-003.
- d. Environment corrosivity: Saliferous, sulphurous and dusty environment in conformance with ISO 12944 parts 2 and 5 classes as below:
 - i. C5-I for onshore facilities less than 50 km from the coast.
 - ii. C3-I for onshore facilities greater than 50 km from the coast.
 - iii. C5-M for offshore facilities.

- e. Rainfall: Extremely rare, but flash flooding may occur. Measurable rainfall usually occurs in an average of about 10 days per year with a rainfall intensity of 10 mm for 15 minutes. The rainfall is confined to winter and transitional months only.
- f. Relative humidity:
 - i. Maximum: 97 % at 43 °C.
 - ii. Average: 60 % at 54 °C.
- g. Ambient air temperature and humidity shall be as stated in Table 5.1 below.

Table 5.1 Outdoor Ambient Air Temperature and Humidity

	Max ambient temp. (°C)	Hottest monthly average temp. (°C)	Annual average temp. (°C)	Min temp. (°C)	Max relative humidity
Onshore	54	44	34	> 5	97 % at 43 °C
Offshore	48	38	28	> 5	97 % at 43 °C

5.4.2 Indoor Conditions

Unless stated otherwise, the following site environmental data for indoor conditions shall be used:

Table 5.2 Indoor Ambient Air Temperature and Humidity

	Max ambient temp. (°C)	Hottest monthly average temp. (°C)	Annual average temp. (°C)	Min temp. (°C)	Max relative humidity
Onshore and offshore with HVAC	40	30	20	> 5	90 %
Onshore and offshore without HVAC for 8 hours	45	35	NA	NA	90 %

5.5 Area Classification (PSR)

Area classification requirements are as follows:

- a. The ECMS shall be suitable for installation in a non-hazardous area as defined in IEC 60079-10-1, Section 3.3.2.
- b. Where it is necessary to install ECMS equipment in a hazardous area, it shall be installed in a pressurised enclosure or in enclosures certified for Zone 1 and Zone 2 as applicable with

gas group IIB and temperature class T3 as a minimum. The minimum level of protection shall be as below.

- i. Control panels: Ex 'db eb'.
- ii. Electrical and isolation components: Ex 'db'.
- iii. Cable termination compartment: Ex 'eb'.

5.6 Electromagnetic Compatibility

Requirements for electromagnetic compatibility are as follows:

- a. ECMS equipment shall comply with the emission requirements as defined by IEC 61000-6-4. Any electromagnetic disturbance generated by ECMS equipment shall not exceed a level which would affect the correct operation of both radio and telecommunication equipment.
- b. The ECMS system shall comply with the immunity requirements as specified in IEC 61000-6-2 and IEC 61000-6-5. The performance criterion in accordance with IEC 61000-6-2 shall be 'A'. The ECMS equipment shall have an adequate level of intrinsic immunity to external electromagnetic disturbance to enable it to operate as intended.
- c. The performance of ECMS equipment shall not be affected or in any way degraded using portable radio transmitters/receivers.

5.7 Reliability

Reliability requirements are as follows:

- a. The ECMS including components shall have a Mean Time Between Failure (MTBF) of not less than 150,000 hours.
- b. The design of the ECMS shall be modular with plug-in components such that the MTTR is minimised.
- c. The SUPPLIER shall provide MTBF calculation of the proposed system and the estimated MTTR figures for all components with the bid.

SECTION B – TECHNICAL REQUIREMENTS

6 FUNCTIONAL REQUIREMENTS

6.1 Electrical System

The ECMS shall include the facility to control and monitor the electrical system including:

- a. Circuit breaker control
 - i. Circuit breaker and disconnect switch control.
 - ii. **Manual Initiation** of automatic bus transfer sequence.
 - iii. Resetting of electrical trip lockout relays.
- b. Display of generation and distribution single line diagram and individual feeder mimic diagrams with status indication on the HMI for:
 - i. HV switchgear.
 - ii. LV switchgear.
 - iii. DC UPS.
 - iv. AC UPS.
 - v. Main generator sets including excitation system.
 - vi. EDG sets.
 - vii. Power transformers including OLTC.
 - viii. Distribution transformers.
 - ix. HV and LV Motors, ASDs, Soft Starters.
 - x. Capacitor banks.
 - xi. Distribution boards.
 - xii. Thyristor controlled process heater panels.
- c. Measurement of analogue values and on screen displays including:
 - i. Line voltage and phase voltage.
 - ii. Current.
 - iii. Frequency.
 - iv. Power factor.
 - v. Active power, reactive power, and kWh.
 - vi. Tap changer position.
 - vii. Transformer winding / oil temperature with graphical representation / trend curves and energy calculation.

- d. Alarm annunciation.

For typical control and indication requirements for the various types of electrical equipment forming part of the electrical distribution system refer to Appendix A2. I/O Schedule. Each project shall review and amend this schedule depending on the project requirements. All I/O schedules are subject to COMPANY approval.

6.2 IED Protection Relay Setting and Parameters

The ECMS shall include the functionality to input settings and interrogate the IED protection relays.

6.3 Power Management

6.3.1 Generator Control

When the generator control panel is set to remote mode of operation, the following controls shall be available from the ECMS:

- a. **Start/Stop Command.**

The operator shall be able to initiate a generator start or stop sequence from the ECMS.

- b. **Synchronising**

ECMS shall have the following synchronising controls:

- i. The operator shall be able to select the generator which needs to be synchronised.
- ii. **Manual/Auto synchronisation selection.**
 - 1. When selected auto, the operator shall be able to initiate an auto synchronisation sequence from the ECMS. Auto synchroniser, AVR and governor controls will be located in the generator control panel.
 - 2. For manual synchronising the ECMS shall include a synchroscope. When selected manual, the operator shall raise and lower the generator voltage and frequency from the ECMS, and initiate circuit breaker closing command when the synchroscope indicates the supplies in synchronism or dead bus.
- iii. Facilities shall be included for synchronisation across each generator circuit breaker, selected bus ties and interconnectors. Synch-check relays shall be provided by the switchboard SUPPLIER.

- c. Load sharing

- i. The ECMS shall have the facility for automatic voltage and frequency control.
- ii. The ECMS shall be capable of automatic load sharing among generators to achieve maximum overall efficiency for the entire electrical system. The ECMS shall include the facility to bias the generator loading **considering fuel consumption** and other parameters thus optimising the loading of the machines.
- iii. **On ECMS failure, the system shall revert to controls from the generator control panel, sharing load at the last set point, thus retaining a stable system.**

6.3.2 Operating Modes

- a. The ECMS shall include the facility to select the following operating modes for each generator:
 - i. Droop mode.
 - ii. Isochronous mode.
- b. The ECMS shall be capable of the following control:
 - i. Base Generator Control
 1. The largest generator operating shall be selected as the base generator. The base generator shall be set to isochronous mode to regulate the system frequency.
 2. The ECMS shall be capable of issuing the necessary commands to regulate the output of the other generators operating in droop mode.
 - ii. Power Group Frequency Control
 1. ECMS shall maintain the steady state frequency for a power group at a frequency demand set point by adjusting the governor set points of each generator.
 - iii. Power Group Voltage Control.
 1. ECMS shall maintain the steady state voltage for a power group at a voltage demand set point by adjusting AVR set points of each generator.
 - iv. Generator Power Control
 1. ECMS shall calculate a target MW value for each generator and shall attempt to maintain this value by adjusting the governor set points.
 2. The target MW value shall be calculated to share load evenly between interconnected generators.
 - v. Generator Reactive Power Control
 1. ECMS shall calculate a target MVar value for each generator and shall attempt to maintain this value by adjusting AVR set points.
 2. The target MVar value shall be calculated to share reactive load evenly between generators operating in parallel.
 3. Power Factor Control: ECMS shall be capable of controlling the system power factor by adjusting the AVR set points of each generator.

6.4 Power Import and Export Control

- a. The ECMS shall include the capability of active and reactive load sharing between the on-plot generation and the grid connection.
- b. The ECMS shall continuously monitor the power imported or exported from the grid and alarm if the power level is above a pre-set value for a pre-set period time. All values shall be configurable via the HMI workstations.

6.5 Load Shedding

- a. Load Shedding shall be capable of tripping load feeders to avert cascade failure of the generation system. Load shedding can occur due to the following reasons:
 - i. Sudden loss of a generator.
 - ii. Sudden loss of a selected bus-tie.
 - iii. Gradual increase in load leading to a generation overload.
 - iv. System under frequency.
 - v. Rate of change of frequency.
- b. The ECMS shall continuously monitor the available power generation and the system load. The generation capability shall be calculated considering the ability of the generators to accept step changes without exceeding their stability, voltage and frequency limits in the system.
- c. Following a load shed event there shall be a time delay to allow the electrical system to stabilise. If an overload still exists further loads shall be shed as per the load shedding priority table.

6.5.1 Load Shedding Priorities

- a. The sequence of load shedding shall be defined by a shedding priority table. The first load to be shed shall be at the top and the last at the bottom. The order shall be configurable via the HMI workstations.
- b. The load shedding priority table shall be dynamically updated based on the circuit breaker open / close status.
- c. The load shedding system shall be capable of handling all possible sub-networks of the electrical system. When the power system is split into separate sub-networks and an overload occurs within one sub-network, the ECMS shall shed loads on the overloaded sub-network only.
- d. The load shedding priority table shall be stored in a non-volatile memory within ECMS.

6.5.2 Load Shedding Signals

- a. The MW values of all sheddable loads shall be monitored. If communication is lost the load shedding system shall use the last measured load. If no measured load is available, the load shedding system shall default to a user-defined pre-set value.
- b. During a load shedding sequence, the ECMS shall not attempt to trip a feeder more than once. If the feeder circuit breaker fails to open or circuit breaker open status feedback is not received within pre-set time, the load shedding system shall initiate tripping of the next set of load feeders in the priority table.
- c. Once a trip signal has been issued, the feeder shall not be available for further load shedding commands until the shed status is accepted via the HMI workstation.
- d. Load shedding commands shall be initiated within **70 ms** to ensure total time taken, including circuit breaker opening time, is less than **200 ms**. The time of 70 ms shall be considered from the **occurrence of the event that causes disturbance in the electrical system requiring load shedding to the signal reaching the corresponding feeder trip circuits to cause load shedding**.
- e. Load shedding commands shall be transmitted using IEC 61850 GOOSE messaging.

- f. All load shed signals shall be capable of being tested without activation of the final elements.

6.5.3 Spinning Reserve

- a. The ECMS shall continuously monitor and display the spinning reserve for each group of interconnected generators.
- b. To account for operation restrictions the operator shall have the facility to input the available maximum power for each of the generators. This shall be displayed on the HMI clearly indicating the value as 'user defined'.

6.5.4 Fast Acting Load Shedding

- a. Fast acting load shedding shall be provided to mitigate the possibility of cascade tripping of generators upon loss of supply from one or more generators or the grid connection.
- b. The following actions shall cause the fast acting load shedding:
 - i. Any of the generator circuit breakers opening.
 - ii. Any of the generator fault inputs becoming true.
 - iii. Any of the selected bus-tie circuit breakers opening or fault in interconnecting cable (where applicable).
- c. The ECMS shall continuously monitor the power group capability. Once a circuit breaker opens or a fault input becomes true, the new power group capability shall be compared with the pre-disturbance power group load. If there is a capability shortfall, the ECMS shall trip sufficient loads to remove the overload.
- d. When a bus-tie or interconnecting cable opens or trips on a fault, the system can be split into two separate groups. At the instant of separation, the ECMS shall, if required, shed sufficient load in either group to protect the now isolated generation.

6.5.5 Gradual Overload Load Shedding

- a. Gradual overload load shedding shall be provided as a proactive function to address evolving overload conditions at the generators.
- b. If a power group's load increases above its capability, an integrating counter shall start. The count rate shall be proportional to the magnitude of the overload and shall be calculated as a percentage of the capability of the power group.
 - i. If the overload is maintained for a time such that the integrating counter reaches the preset gradual overload alarm point, then an alarm shall be initiated on the ECMS and output to the ICSS.
 - ii. If the overload is maintained for such a time that the integrating counter reaches the preset gradual overload limit, then shedding shall be initiated and an overload load shedding alarm shall be initiated on the ECMS and output to the ICSS.
 - iii. If the overload is removed at any point, the integrating counter shall be reset to zero.
- c. The ECMS shall include the facility to update the pre-set gradual overload alarm and trip limits via the HMI workstations.

6.5.6 Under Frequency Load Shedding:

- a. The ECMS shall include under frequency load shedding functions.
- b. Load shedding shall be initiated when the power group frequency falls below the pre-set 'Under Frequency Load Shed Level' for the duration of the pre-set 'Under Frequency Load Shed Time'.
- c. A pre-set block of loads shall be shed. This block of loads will be specified in the ECMS as either a number of loads to be shed or a minimum MW value by which the power group load must be reduced, or both.
- d. After the pre-set 'Under Frequency Recovery Time' the frequency shall be compared with the pre-set 'Under Frequency Recovery Level'. If the frequency has not recovered sufficiently, another block of loads shall be shed. This sequence of delay and comparison shall continue until the frequency recovers.
- e. The 'Under Frequency Load Shed Level', 'Under Frequency Load Shed Time', 'Under Frequency Recovery Time' and 'Under Frequency Recovery Level' shall be configurable via the HMI workstations.

6.5.7 Rate of Change of Frequency

- a. The ECMS shall include load shedding based on the rate of change of frequency.
- b. Load shedding shall be initiated when the power group frequency falls at a rate higher than the pre-set 'df/dt level' for the duration of the pre-set 'Rate of Change of Frequency Time'.
- c. A pre-set block of loads shall be shed. This block of loads will be specified in the ECMS as either a number of loads to be shed or a minimum MW value by which the power group load must be reduced, or both.
- d. A further block of loads shall be shed if the system frequency has not recovered sufficiently within a set period of time.
- e. The 'df/dt level', 'Rate of Change of Frequency Time', 'Recovery Time' and 'Under Frequency Recovery Level' shall be configurable via the HMI workstations.

6.5.8 Inhibit Motor Starting

- a. Motor start inhibit signals shall be transmitted from the ECMS to both the ICSS and motor IED to prevent the starting of a motor whose pre-set starting power (MW and MVAR) is greater than the available spinning reserve.
- b. Each motor feeder shall be assigned a pre-set MW and MVAR start level, which is configurable via the HMI workstations.
- c. The inhibit shall be in the form of a digital signal which shall represent an opened status of potential free contact in the inhibit condition thus allowing a start in the event of the ECMS being unavailable.
- d. The ECMS shall include a facility for an operator to override 'start inhibit' of an individual motor or a group of motors.

6.6 Transformer On Load Tap Changer / Voltage Regulation

The ECMS shall include the facility to interface with transformer remote tap change control panel. The ECMS shall be capable of:

- a. Selecting the mode of operation - 'Master', 'Follower' or 'independent'.
- b. Adjusting voltage, MVar or power set points.
- c. Manual voltage adjustment via raise/ lower commands.
- d. Display of tap position status and alarm signals.

Refer to Table A2.13 Transformer Remote Tap Changer Control Panel, for a typical I/O schedule.

6.7 Capacitor Banks

Capacitor banks shall be controlled by a standalone power factor controller (supplied by others). The ECMS shall include the facility to interface with the power factor controller for:

- a. Monitoring.
- b. Alarms.
- c. Adjusting target power factor set point.

Refer to Table A2.15 Capacitor Bank Controller, for a typical I/O schedule.

6.8 Emergency Diesel Generator

- a. The ECMS shall have the capability to initiate a start and stop of the emergency diesel generators. The EDG and associated circuit breaker control shall be from the EDG control panel.
- b. As a minimum the following signals shall be monitored:
 - i. Generator circuit breaker position.
 - ii. Essential services switchboard bus tie circuit breaker position.
 - iii. EDG status (tripped, running, stopped).
 - iv. EDG mode selection e.g. test mode.
 - v. Metering: Voltage, current, frequency, kW, kVar and PF.
 - vi. Common alarm.
 - vii. EDG protection functions.

Refer to Table A2.8 Emergency Diesel Generator Circuit, for a typical I/O schedule.

- c. A failure of the ECMS shall not affect the operation of the EDGs.

6.9 Motors

- a. All motors shall be controlled by the ICSS and except for load shedding and the associated start inhibit control of the selected motors, no other control is provided from the ECMS.

- b. The control and status feedback interface between the ICSS and the switchgear shall not be via the ECMS. Control and status feedback signals shall be exchanged by:
 - i. Redundant data communication link between ICSS and switchgear.
 - ii. Hardwired via an interposing relay panel between package UCP and switchgear.
 - iii. Emergency shut down signals shall be hardwired via an interposing relay panel.
- c. The following data, as a minimum, shall be made available to the ECMS:
 - i. Status: Available, tripped, running / stopped.
 - ii. Metering: Current, kW, PF, etc.
 - iii. Alarms.
 - iv. Trends and events.

Refer to Table A2.4. Switchgear - HV Motor and Table A2.5. Switchgear - LV Motor, for typical I/O schedules.

- d. Selected motor data shall be communicated from the ECMS to the ICSS.

6.10 Power Quality Monitoring

- a. The ECMS shall include power quality monitoring (PQM). This shall include:
 - i. Detecting and recording voltage sags and surges.
 - ii. Metering: Voltage, current, frequency, kW, kVAr, energy use and PF.
 - iii. Capturing current and voltage waveforms.
 - iv. Current and voltage harmonics.
- b. The above functions can be implemented either via a separate power monitoring unit installed on each section of the switchgear bus or via multifunction protection relay.

6.11 Fault Monitoring

- a. Multifunction relays and / or dedicated fault relays shall be installed in the switchgear for non-critical feeders.
- b. For critical feeders a separate independent fault recorder with a high sampling rate of minimum 30 kHz shall be provided. The critical feeders include:
 - i. All generator incomers.
 - ii. All incomers and bus section with an operating voltage 33 KV.
 - iii. All incomers, feeders and bus section with an operating voltage greater than 33 kV.
 - iv. Other critical incomers as defined by the individual project.
- c. The fault monitoring shall record the following:
 - i. Three phase currents.
 - ii. Residual current.
 - iii. Event information of switchgear operation before, during, and after system fault incidents.

- iv. Automatic traveling wave fault location functionality, when specified on the data sheet.
 - v. Synchrophasor measurement and transmission as per IEC/IEEE 60255-118-1. Phasor communication shall comply with IEC 61850-90-5.
 - vi. Measurement and recording of harmonics up to the 50th order as per IEC 61000-4-7.
 - vii. Measurement and recording of flicker as per IEC 61000-4-15.
 - viii. Capturing of the system fault data shall be automatically triggered. It shall be possible to trigger an event report through relay logic for an event that is completely unrelated to the operation of the multifunctional relay.
- d. The ECMS shall perform the following fault monitoring functions:
- i. Capture, store, and archive fault and disturbance data and the fault analysis data from the multifunction protection relays, dedicated fault monitoring relays, and digital fault recorders.
 - ii. Obtain time-synchronised real time data and provide historical information of all events, faults, and disturbances.
 - iii. Perform additional fault and transient analysis as necessary.
 - iv. Provide operator access to the fault monitoring and analysis data including configuration of analytic functions via engineering workstations.
 - v. Printout and display of faults and events.
- e. Fault and disturbance event recording shall include the following pre-fault and post fault data:
- i. Power and frequency recording for the supervision of power balance and frequency stability.
 - ii. Mean value recording for registering long-term progression of measured values.
 - iii. Power swing conditions.
 - iv. Under frequency conditions.
 - v. Power quality monitoring as per Section 6.10.
 - vi. Event recording, i.e. switching status, etc.
- f. The ECMS shall compute and record active power, reactive power, power factor and the system frequency during pre-fault, fault, and post-fault periods. With this function it shall be possible to monitor power swing in the power grid network and power balance of individual feeders.
- g. The fault monitoring shall include mathematical analysis features and be able to calculate and compute from the analogue and digital measured values, depending on the configuration as well as display against time of the following:
- i. Positive and negative phase-sequence system voltages.
 - ii. Current and voltage harmonics.
 - iii. Power system frequency.
 - iv. Power supply phase angles.
 - v. Active and reactive power.
 - vi. RMS currents and voltages.

- vii. Power swing.
- viii. Instantaneous value recording of current, voltage, and digital data.
- ix. Transient overvoltages.
- x. Transient recovery voltages and circuit breaker restrike and arcing risks.
- xi. Detection of ferro-resonance condition.
- xii. Fault location.
- xiii. Type, presence, severity and duration of a fault.
- xiv. Operation outside the limits of performance and any malfunctions.
- xv. Cause and possible resolution of a problem.

7 CONTROL PHILOSOPHY AND CONFIGURATION

7.1 General

- a. The ECMS shall be based on a distributed intelligent architecture. Refer to Appendix A1- Typical Block Diagram for an example of the system configuration and interfaces with other systems.
- b. The CONTRACTOR shall develop a suitable system architecture, meeting the project requirements, as applicable based on this block diagram. The system architecture shall be agreed with the COMPANY.
- c. The main electrical equipment such as switchgear and generator control and protection panel shall be equipped with multi-functional IEDs complete with serial link communication interface to the ECMS.

7.2 Control Philosophy

- a. The ECMS shall be configured with four levels of control:
 - i. Level 1 - Local Control
 - 1. Equipment at this level controls and protects part of the electrical system e.g. an IED associated with a feeder BCU.
 - 2. All protection and control functions shall operate independent of the ECMS.
 - ii. Level 2 - Substation Control and Monitoring
 - Equipment at this level:
 - 1. Communicates with local equipment (Level 1) within the substation.
 - 2. Communicates with Central Control and Monitoring (Level 3).
 - 3. Includes monitoring functions to view the overall status of the electrical power generation and distribution system.
 - 4. Includes control functions to enable the operator to remotely operate electrical power generation and distribution system, e.g. open/close selected switchgear circuit breakers, generator controls, load shedding, OLTC controls etc.

5. Includes a data concentration function to gather all information within the substation.
 6. Includes fault monitoring.
- iii. **Level 3 - Central Control and Monitoring**
- Equipment at this level:
1. Communicates with Substation Control and Monitoring (Level 2) Equipment.
 2. Communicates with ADNOC Facility Remote Monitoring (Level 4) Equipment.
 3. Interfaces with external systems e.g. ICSS.
 4. Centrally collects all the information from Level 2 Substations.
 5. Includes monitoring functions to view the overall status of the electrical power generation and distribution system.
 6. Includes control functions to enable the operator to remotely operate electrical power generation and distribution system, e.g. open/close selected switchgear circuit breakers, generator controls, load shedding, OLTC controls etc.
 7. Includes historical data processing.
 8. ECMS system maintenance. e.g. graphic updates.
- iv. **Level 4 - Remote Monitoring**
- Equipment at this level:
1. Communicates with Central Control and Monitoring (Level 3) Equipment.
 2. Includes monitoring functions to view the overall status of the electrical power generation and distribution system.
- b. The ECMS shall be capable of providing control functions from the locations listed above. However, only one control point shall be capable of carrying out control functions at any given time.

7.3 Configuration

The ECMS shall comprise of the following main equipment/components:

- a. Bay Control Unit, IED, and protection relays etc. inside the switchgear protection and control cubicles connected to ethernet switch through fibre optic or ethernet cable parallel redundancy protocol configuration. This shall be supplied as part of the switchgear.
- b. Equipment Interface Units to perform the interface with the primary equipment and to receive hardwired signals from electrical equipment including distribution boards and existing non-intelligent type switchgear units. **The EIU hardware shall be redundant** and fitted with the process interface slot-in modules for digital inputs and outputs and analogue inputs etc.
- c. Data Acquisition and Control Modules complete with **interposing relays**, I/O cards, CPUs and communication processors, as required. DACM shall accept IEC 61850 and other communication protocols, as required, from the switchgear and major electrical equipment e.g. generator control panel, turbine control panel, relay and control panels, OLTC panel, AC and DC UPS, EDG sets, etc. The DACM's shall be a redundant system comprising of a main/standby configuration with automatic fail over logic.

- d. Redundant industrial type controllers for performing each of the required ECMS functions including load shedding and generator control functions.
- e. Redundant industrial type RAID 5 servers, minimum, for performing the required ECMS functions including monitoring, operation, measurement, control, data logging and relay parameterisation for the electrical power generation and distribution system based on inputs received from DACMs/EIUs/ IEDs.
- f. Transient fault recorders with a sampling rate of minimum 30 kHz.
- g. Redundant industrial ethernet switches providing connections to the fibre optic ethernet communications backbone and connections to terminal servers, PLCs, workstations. As a minimum the ethernet switches shall include:
 - i. Output relay for critical failure or error alarming.
 - ii. Enhanced Rapid Spanning Tree Protocol with network fault recovery of less than 5 ms.
 - iii. Loss of link management and diagnostics logging and alarm.
 - iv. Multi-level password control.
- h. Patch panels to facilitate ease of installation and expansion.
- i. HMIs, at various locations, in the form of operator consoles and engineering workstations, shall be of a personal computer-based system, complete with colour monitors, industrial grade CPU, keyboard, trackball, printers, etc.
- j. Appendix A1, Typical Block Diagram, shows an independent device for each critical function e.g. load shedding and generator control. These functions may be realised in common devices provided the system performance requirements are maintained. However, as a minimum, two independent devices shall be provided.

7.4 Redundancy

- a. All ethernet data highways, ethernet switches, CPU's, servers and controllers shall be dual redundant with hot-standby arrangement.
- b. The arrangement of servers and controllers shall be such that in the event of failure of one unit, the second unit shall take over the complete operation in a bumpless fashion and provide both local and remote alarms to indicate unit failure. The sub-assemblies, such as the CPU, hard disks, mass storage systems, communication interfaces etc. of the individual system shall be hot swappable such that the failed sub-assemblies can be replaced online.
- c. The design of the communication interfaces and media shall have the minimum redundancy to achieve the following:
 - i. Outage of one of each pair of duplicated components shall not result in any reduction of functionality.
 - ii. Outage of one communication link shall not affect any other communication link.
- d. The ECMS shall be designed such that failure in any part of the ECMS will not result in the loss of availability of electrical power generation and distribution system and shall not stop operation of any part of the plant.

7.5 System Clocks

- A GPS clock shall be provided for the central control building and in each substation with an antenna, antenna cable, signal amplifiers as required, and related hardware.
- Internal clocks in all devices of the ECMS shall be synchronised.
- The reference time shall also be sent through the ECMS to all IEDs inside switchgear having internal clocks.

8 PERFORMANCE REQUIREMENTS

8.1 Response Times

- The SUPPLIER shall specify the response times of the ECMS under all operational conditions.
- The SUPPLIER shall provide an overview of the preliminary calculated response times in the bid complete with the average CPU loading for each network activity scenario. These response times and average CPU loading shall be guaranteed.
- Unless otherwise specified, the maximum response times shall be as per Table 8.1.
- For determining response times, worst case operating conditions and future expansions up to the ultimate capacity of the installed system, shall be considered.

Table 8.1 Maximum Response Time

Item		Maximum response time
Starting up individual equipment components after a power failure		30 seconds
Starting up the 'central' unit of the ECMS after a power failure	PC-based systems	2 minutes
	Systems based on workstations	10 minutes
Issuing a command in response to the operator's input		1 second
Issue of load shed command		70 milliseconds
Updating information on the screen after change of value		2 seconds
Direct signals (hard wired) or GOOSE		1 second (total loop time)
Indirect signals (communication protocol)		2 seconds (total loop time)
Completion of a newly selected display after call-up		2 seconds

8.2 Integrity

- All failures and discrepancies shall be reported by the ECMS via the HMI, including identification of the problem and the affected function and the hardware.
- After a power supply failure to the ECMS, the ECMS shall restart automatically when power is restored, updating automatically all system information and resuming normal operation without causing trip or other action.

- i. There shall be no loss of memory.
- ii. Loss of power supply shall not result in loss or failure of system or application software.
- c. A continuous back-up data storage facility shall be available.
- d. Internal batteries, if any, shall be monitored and alerted for remaining capacity.
- e. The ECMS shall maintain the status as it was upon failure.
- f. In the event of communication failures between levels of control, the systems concerned shall continue operation and perform their functions as far as the missing information allows.
- g. Systems at a lower level shall always be able to function independently of the higher level.
- h. The ECMS system shall identify and block incorrect commands.
- i. For reasons of verification, measured critical data e.g., voltage, power, frequency at a busbar section, shall be done by several different devices e.g. IEDs.
- j. Critical data such as bus bar voltage and frequency shall be obtained and verified from more than one IED.
- k. No information shall be lost due to overloading of the ECMS.

8.3 Accuracy

Unless otherwise specified, the accuracy requirements shall be as per Table 8.2.

Table 8.2 Accuracy Requirements

Item	Requirement
Analogue measurements: inputs/outputs	0.25 % of full-scale accuracy
Analogue measurements: sampling time	1 second
Analogue measurements, presentation	1 % of full-scale accuracy
Time Stamps	1 millisecond accuracy
System time relevant to absolute time	1 millisecond accuracy
Minimum pulse width to be detected	10 millisecond accuracy
Commands (pulse)	0.1 to 50 seconds in steps of 0.1 seconds

9 COMMUNICATION

9.1 General

- a. The ECMS shall communicate over an ethernet fibre optic backbone between each substation and control building via a fault tolerant dual ring with protocol (e.g. rapid spanning tree) to re-establish the link following a break in the ring.
- b. IEDs shall be networked with data highways within each switchgear line-up.

- c. Systems and devices that do not have ethernet ports shall be integrated into the ECMS using RS 485 serial links via data managers or gateways.
- d. The ECMS equipment shall be able to communicate with each other and other systems of the network by means of standard interfaces and protocols.
- e. The communication interface between any elements in ECMS shall be tolerant to electromagnetic impulses and shall be fully protected against any short circuit or similar faults without loss of communication and shall maintain full operation after clearance of such faults.
- f. All communication links shall be monitored in terms of overruns, quality errors and response time-outs. Failure of a communication link shall initiate an operator alarm.
- g. The SUPPLIER shall indicate communication speeds between various ECMS equipment through fibre optic link.

9.2 Applicable Protocols

- a. The ECMS SUPPLIER shall be responsible for coordination required with other equipment SUPPLIERS, whose equipment are to be integrated with the ECMS, to ensure compatibility for satisfactory functioning of the entire system. To achieve this, whatever protocol converters are required to make the ECMS compatible with other equipment shall be provided by the ECMS SUPPLIER. The ECMS SUPPLIER shall ensure there is no loss of data, signals, functionality i.e. time stamping, relay parameterisation, etc by using converters.
- b. The ECMS SUPPLIER shall confirm the communication protocols to be utilised in the data connections to other systems e.g. profibus, profinet, or modbus TCP/IP systems. Other Systems include (but not limited to):
 - i. ICSS.
 - ii. Generation packages (governors, AVR's etc.).
 - iii. Switchgear.
 - iv. ASD driven equipment.
 - v. AC/DC UPS.
 - vi. Capacitor banks.
 - vii. Transformer OLTC.
- c. The ECMS SUPPLIER shall establish the following:
 - i. Data to be exchanged.
 - ii. Protocol and type of messages to be used.
 - iii. Integrity and redundancy of the link to be used.
- d. Communication software shall be designed in accordance with the International Standards Organisation Open Systems Interconnect (OSI) model.
- e. The selection of communication protocols shall be ethernet-based, using the relevant parts of IEC 61850 and IEC 60870.
- f. IEC 61850 protocol shall be used for monitoring, control, interlocking and inter-trip signal communication (e.g. load shed).

- g. OPC systems of communication should be restricted to the HMI functionality for non-critical data.
- h. Status indication of circuit breakers and disconnectors e.g. busbar selection switches, required in time sensitive ECMS control functions shall be communicated instantaneously i.e., **hardwired or via GOOSE protocol**.
- i. GOOSE protocol response time should be **Type 1 as per IEC 61850-5**.
- j. IEC 61850-9-2 process bus protocol may be used only for metering and control and not for protection and interlocking.

9.2.1 Existing Facilities

- a. All existing facilities, if any, which the ECMS shall interface and communicate are specified in the requisition.
- b. The SUPPLIER shall review the existing facilities and advise any upgrade or additional equipment required to successfully integrate the existing facility into the ECMS.

9.3 Software

9.3.1 General

- a. The ECMS shall be based on standard firmware and software, which has already been implemented in previous systems.
- b. Software tools shall be provided to customise the ECMS to complete settings, to create displays, to define event and alarm text, etc.
- c. The use of software tools shall require no knowledge in programming languages or system source code.

9.3.2 Operating System

- a. The SUPPLIER shall provide detailed information about software used in the ECMS.
- b. The Operating System (OS) including all service packs shall be a version that is currently supported by the OS SUPPLIER and have been verified by the ECMS SUPPLIER for application software compatibility.
- c. The OS shall be standard off-the-shelf software. It shall not be modified for implementing any functionality and shall be upgradeable with future extension capability.
- d. The OS shall support multi-tasking and shall not require a restart if an application crashes.

9.3.3 Configuration Software

- a. Configuration software shall be provided to enable the user to configure, set up and modify the data acquisition, data processing and database system components to suit the requirements of specific application functions.
- b. This shall include facilities to perform programmable logic functions and automatic control functions such as voltage control, transformer tap change control etc.

- c. This software application shall also include the ability to execute automated sequences initiated either manually by a single command from the operator interface or automatically by a set of conditions at the station, as defined by the logic algorithms.
- d. Where data is required to be imported from other systems to build displays or to fill the database, the format required for this data exchange shall be an industry standard e.g. ICD/SCD files, Microsoft COM (Component Object Model) or API user interface.
- e. Interfaces to relational databases shall comply with the Structured Query Language (SQL) standard.

9.3.4 Application Software

Application software shall be provided to perform the functions and features as described in specification. This includes HMI display creation and modification, report generation and modification, database management, file back-up and network administration.

9.3.5 Proprietary Software

Proprietary OEM software required for configuring, programming and setting IEDs in the electrical distribution system shall be provided.

9.3.6 Diagnostic Software

The system shall incorporate self-diagnostics software for both hardware and software. Diagnostics shall provide an effective way of reducing system downtime, assist to localise the malfunctioning device and diagnose the fault.

9.3.7 Licenses

- a. All software supplied as part of the ECMS, whether new, updates, or extensions, shall be licensed to the COMPANY.
- b. Copies of each software shall be handed over to the COMPANY.
- c. The latest release of software shall be supplied and tested at the Factory Acceptance Test.

9.4 Capacity, Scalability and Expandability

9.4.1 Capacity

- a. The SUPPLIER shall determine the number of I/O per location based on the project I/O Schedule. Refer to Appendix A2 for a typical I/O Schedule.
- b. The SUPPLIER shall determine the:
 - i. Buffer capacity to cope with abnormal operating conditions e.g. major power system event and system communication fault.
 - ii. Number of data that can be handled in a limited time without disturbing critical functions that have to deliver their results within a predefined time i.e. during a fault in the electrical system.
 - iii. Maximum number of I/O that can be handled including spare capacity.

9.4.2 Scalability and Expandability

The ECMS scalability and expansion requirements specified shall be met while also meeting the performance requirements.

- a. System loading/usage: CPU loading, memory usage of servers, clients and controllers shall not exceed 60 %. The remaining 40 % shall be reserved for future use.
- b. Hardwired I/O points: The system shall have the capacity for the I/O points specified, plus 20 % spare of each type I/O used in each cabinet location. Each I/O rack shall include prewired terminal strips for the spare capacity.
- c. Communication network node expansion capability: The system shall have the capacity for the ethernet ports required, plus a minimum of two unused spare ports for each switch. The communication network nodes shall include an expansion capability of 25 %.
- d. Hardware expansion capability (slots): All hardware supplied with expansion slots shall have an expansion capability of 25 %, with a minimum of two spare slots.

10 OPERATOR INTERFACE AND ASSET MANAGEMENT

10.1 HMI Workstation Interface

10.1.1 The operator interface shall be from the HMI workstations located in the following locations:

- a. Central control building.
- b. Local control rooms or substations.
- c. ADNOC remote monitoring facilities.

10.1.2 Each HMI workstation shall include a Graphical User Interface (GUI) displaying the following information:

- a. Electrical single line diagrams showing an overview of the electrical distribution system with drill down capabilities to the level showing individual switchgear.
- b. Detailed view of individual bays or circuits.
- c. Control status (circuit breakers, disconnect switches, etc.).
- d. Object status (relays, meters, circuit breakers, ATS scheme etc).
- e. Tabular display of measurements from meters and relays.
- f. Generator overviews including tabular display of MW, MVar loadings and spinning reserve.
- g. Load shedding priority table, status and start inhibits.
- h. Alarm status (Alarm status shall display on every screen display page with one step navigation to alarm summary page).
- i. Sequence of event log.
- j. Daily/Monthly reports.
- k. Trend information.
- l. Recorded transients from relays.

- m. Protection relay interface.
- n. Overview and detail of ECMS information, including connected devices and communications status of protection relay interface.

10.2 Presentation

- a. English language and SI units shall be used for all displays.
- b. Graphical symbols shall be in accordance with IEC 60617-DB and other relevant IEC standards.
- c. Colour coding shall be used to distinguish system voltages, status, alarms, etc. The colours for the different voltage levels shall be in accordance with Table 10.1.

Table 10.1 Voltage Level Colours

Voltage	Colour
220 kV	Red
132 kV	Red orange
33 kV	Orange
11 kV	Yellow orange
6.6 kV	Yellow
3.3 kV	Yellow green
690 V	Green
415 V	Blue

- d. Colours shall reflect the equipment energised/de-energised condition, e.g. greyed out for de-energised.
- e. The single line diagram bus bar line weight shown on the HMI screens shall be different for each of the voltage levels and progressively increase corresponding to the increase bus bar voltage.
- f. All graphic display configurations shall be approved by the COMPANY.

10.3 Monitoring of Values

- a. All data including status, events, and measurements received or generated within the ECMS shall be monitored for the following:
 - i. Exceeding minimum or maximum thresholds.
 - ii. Status change.
 - iii. Exceeding maximum transition time.
- b. The monitored data shall be reported to the operator on the HMI Workstations.
- c. Whenever events occur, initiation of one or more of the following actions shall be possible:
 - i. Providing an audible signal.

- ii. Starting a specific program.
- iii. Generating a message.
- iv. Logging.

10.4 Operation

- a. The ECMS operator actions shall be related to the graphical display by means of face plates. The face plate shall contain the 'push buttons' to execute commands.
- b. All command actions on the HMI shall be subject to a two-step process:
 - i. Command Selection
 - 1. It shall be possible to interrupt a selection at any time.
 - 2. A selection shall automatically be interrupted if the given command is not the correct one.
 - ii. Command Execution (confirmation step)
 - 1. The execution command shall be given within a pre-defined adjustable time period after the selection has been made.
- c. All operator actions shall be reported and recorded by the ECMS system.
- d. The ECMS shall determine the circuit breaker close permissive based on the interlocking logic.
- e. If a command is blocked or is not executed, this shall immediately be shown to the operator via the HMI and recorded.

10.5 System Access Control

- a. The ECMS functionality shall be protected by a system wide security system. Access and control privileges are required to perform system functions e.g. control of electrical distribution breakers, change parameters, upload relay settings etc.
- b. All operators shall be required to login with a unique password which will allow levels of access and control privileges.
- c. All passwords shall comply with the COMPANY OT/Cyber Security Standard, document number **LATER.**
- d. Unless otherwise specified, the levels of access and control privileges shall be implemented in accordance with Table 10.2.

Table 10.2 Levels of Access and Control Privileges

Level	Category	Access and Control Privileges
1	View Only	The maintenance engineer or operator shall be able to display the single line diagram, view the set parameters and actual data but shall not be permitted to control any circuit breaker, acknowledge any alarm message nor access the software configuration tool.
2	Control	All rights are granted as Level 1 with the addition of the ability to control electrical distribution breakers and acknowledge alarm messages.
3	Configuration	All rights are granted as Level 1 along with the ability to access the software configuration tool and configure modifications e.g. modify graphics on HMI displays, create tagged equipment etc.
4	Engineering	All rights are granted as Level 1, 2 and 3 along with addition of conducting all engineering activities including reset of electrical trip lockout relays, reset of motor inhibit starts, changing parameters, upload relay settings etc
5	System Administration	All rights are granted including adding new users and modifying user access level.

10.6 Alarm Management

Requirements for alarm management are as follows:

- a. Alarm Signalling
 - i. The alarms will be audio-visual type and shall be displayed on any HMI screen.
 - ii. The alarm signal shall include a pop-up element to provide instant access to an alarm summary screen.
- b. Alarm Priority System
 - i. A priority number shall be assigned to each alarm.
 - ii. During a system avalanche when many alarms are generated, the ECMS shall be able to reduce the amount of alarms presented to the operator.
 - iii. Alarms shall be shown to the operator in descending order of priority.
- c. Alarm Display
 - i. Alarm events shall be displayed and shall be acknowledged by the operator.
 - ii. The ECMS shall provide several alarm lists to the operator with specific filters such as active alarms, unacknowledged alarms and all alarms.
 - iii. The ECMS shall prioritise and segregate alarms into High-Level and Low-Level categories.
 - iv. Alarm level designation shall be defined by the CONTRACTOR and approved by the COMPANY.
- d. Prevention of Alarm System Overload
 - i. System disruptions that produce multiple recordable alarms shall not overload the network.

e. Maintenance and Diagnostic

- i. Maintenance and diagnostic related information, including running hours, breaker maintenance due alarm, diagnostic help from the menu for disturbance in the power distribution system, current and historical alarm summaries, historical trending of individual motors and feeders shall also be available to the operator.

10.7 Data Logging

- a. The ECMS shall detect and record events and alarms, including logging from metering, protective relays, other external devices, data from online condition monitoring and trends etc.
- b. The ECMS shall log significant events such as changes of status signal states, changes of alarm states, operator actions, engineering modifications, and user log-on/log-off.
- c. All events, including status changes, shall be displayed, recorded, and sorted in chronological order.
- d. Events shall be time stamped with a resolution of 1 ms. The time stamp shall be established at:
 - i. Each of the IEDs inside the switchgear.
 - ii. For hardwired points, the time stamp may be established at the ECMS I/O point.

10.8 Historical Data Server

- a. Redundant historical data servers shall be provided in the control building.
- b. The historical data servers shall provide archiving and retrieval services for a minimum of two years of plant data.
- c. The ECMS shall include the facility to archive historical data to removable media for long-term data storage. In addition, it shall be possible to retrieve, and display data stored on removable media.

10.9 Reports

- a. Information shall be printed at the request of an operator on the control building colour laser printers. The types of report shall include the following as a minimum:
 - i. Alarm reports.
 - ii. Status reports.
 - iii. Daily logs (events, operator actions, etc.).
 - iv. Periodic reports.
 - v. Single line diagrams with status (HMI graphics screen shots).
 - vi. Trend information.
 - vii. Measurements.
 - viii. Power and energy consumption reports for each substation, process unit and non-process buildings.
- b. The format of all reports shall be approved by the COMPANY.
- c. The facility shall be included to save all printed reports as files for later use. Native file format shall be approved by the COMPANY

10.10 **Asset Management**

- a. The ECMS shall include the provision to add an asset management module.
- b. The asset management module shall include the facility to analyse data, predict and report the maintenance intervals of electrical equipment.

10.11 **System Support Functions**

- a. A dedicated engineering workstation (EWS) shall be provided for software maintenance, configuration work, demonstration and training purposes.
- b. The engineering workstation shall have the same configuration and functionality as the control room operator workstations, except the capability to control or operate the electrical distribution system shall be disabled.
- c. The engineering workstation shall be used for the following purposes:
 - i. Program entry, amendment and testing.
 - ii. Configuration work.
 - iii. Setting of parameters.
 - iv. Fault tracing (trouble shooting/diagnostics).
 - v. Update of graphics.
 - vi. Training simulation.
 - vii. Commissioning.
 - viii. Changing peripheral parameters.
 - ix. Security management.
 - x. Software installation/update.
 - xi. System performance review/reporting.
- d. In case of EWS failure, it shall be possible to assign any of the HMI workstations in the control building to an EWS mode of operation. Any workstation assigned to EWS mode of operation shall automatically be inhibited from the control and operation of the electrical distribution system.

11 **HMI WORKSTATIONS AND ACCESSORIES**

11.1 **HMI Workstations**

Unless otherwise specified, all workstations shall be high-end 64 bit with full graphic display complete with the required hard disk space, keyboard, trackball and networking facilities.

- a. Control Room HMI Workstations
 - i. Two main HMI workstations shall be provided in Central Control Room.
 - ii. Each workstation shall be a console type assembly with dual display monitors sized as minimum 24 inch.

- iii. The workstations shall be provided with the required provision to operate either of the workstations from a single trackball and a single keyboard.
- b. Central Control building – Rack Room and Engineering Room
 - i. Both the Rack Room and Engineering Room shall contain a single HMI workstation, console type assembly with dual display monitors sized as minimum 24 inch.
- c. Local Substation HMI Workstations. HMI workstations shall be provided in local substations as follows:
 - i. Substation with one or two LV Switchboards. The ECMS cabinet shall include the facility to connect an engineering laptop. The SUPPLIER shall provide an engineering laptop complete with all software and leads. This engineering laptop maybe used in more than one substation.
 - ii. Substation with one HV switchboard or several LV Switchboards. The local substation shall contain a single HMI workstation, panel mounted with a touch screen display monitor. Minimum Monitor screen size 24 inch.
 - iii. Substation with Main Power Generation switchboard or multiple HV switchboards. The local substation shall contain a single HMI workstation, console type assembly with dual display monitors sized as minimum 24 inch.

11.2 Monitors

HMI workstation monitors shall be TFT colour LCD with a 16:9 aspect ratio.

11.3 Cursor Control

Unless otherwise specified, HMI workstation cursor controlling device shall be a trackball.

11.4 Keyboard

- a. Each HMI workstation shall have a spill proof keyboard.
- b. Touch screen monitors shall have on screen keyboard in addition to a hardware keyboard.

11.5 Touch Screen Monitors

Cabinets with touch screen monitors shall have provisions for using hardware keyboard and trackball with the door closed.

11.6 Printers

- a. All HMI workstations shall have access to two central network high speed A3/A4 colour laser printers for reports, printing screen displays, etc.
- b. The printers shall be provided and located in the central control building and be connected to the ethernet network.
- c. The printers shall have multiple paper trays.

12 **HARDWARE AND ACCESSORIES**

12.1 **Cabinet Requirements**

Cabinet requirements are specified in Appendix A3.

12.2 **Cabling Requirements**

- a. Unless specified otherwise, cables external to the ECMS cabinets or suite of cabinets such as the main fibre optic ring and connections to the third-party supplied equipment e.g. switchgear, are excluded from the ECMS SUPPLIER's scope.
- b. The EPC CONTRACTOR shall provide the external cables and coordinate with the ECMS SUPPLIER and third-party equipment SUPPLIER's to ensure the correct specification of external cables.
- c. All cables within the ECMS cabinets or suite of cabinets including all patch cords shall be provided by the ECMS SUPPLIER.
- d. The ECMS SUPPLIER shall provide all leads, including power cords, HMI cords, ethernet patch cords etc for all workstations, monitors and printers supplied.

12.3 **Fibre Optic Cables**

- a. Optical fibres and connectors shall be standard and shall meet the requirement of IEC 60793 amended by:
 - i. ITU.T G.651.1 for multimode graded index fibres.
 - ii. ITU.T G.652 for single mode fibres.
- b. Fibre optic cables shall be designed and manufactured in accordance with IEC 60794.
- c. Fibre optic cables shall be colour coded as specified in IEC 60304.
- d. The colouring including marking shall be unambiguous. It shall be possible to identify all the optical fibres within a 300 mm length of optical cable core, provided that each loose tube is coded. The colouring shall be permanent.
- e. The fibre type shall be suitable for the distance and the protocol used.
- f. The SUPPLIER shall advise the minimum performance requirements of the fibre optic connections that are not within their scope of supply.
- g. In order to minimise signal attenuation, splices shall not be used. Connectors shall only be used to connect equipment in patch panels. All cables shall have minimum 100% spare capacity.

12.4 **Inputs and Outputs**

All I/O circuits shall be powered from respective ECMS cabinet and shall be:

- a. Galvanically separated from other I/O and from the earth.
- b. Able to withstand short circuits.
- c. Able to be connected to inductive loads.

13 POWER SUPPLY

- a. Unless specified otherwise, the ECMS equipment shall be suitable for operating on the following external power supply:
 - i. 240V AC UPS ($\pm 5\%$), 1 phase, 50Hz ($\pm 2\%$) supply. The power supply shall be dual redundant to each cabinet.
 - ii. 240V AC non-UPS ($\pm 5\%$), 1 phase, 50Hz ($\pm 2\%$) supply for anti-condensation heaters, cabinet sockets and illumination. The power supply shall be a single feeder with a failure alarm.
- b. Each cabinet shall be equipped with a static transfer switch for the synchronised changeover of the incoming redundant power supplies. The static transfer switch shall alarm in case of failure of one of the incoming power supplies.
- c. If the ECMS equipment requires a power supply at any other voltage level, then the SUPPLIER shall derive the same internally by providing 100 % redundant power supply units.
- d. The SUPPLIER shall submit both UPS and non-UPS power requirements for each item of equipment with the bid.

14 NOISE LIMITS

The SUPPLIER shall ensure that the audible noise level generated by ECMS equipment shall not exceed 50 dB (A) one metre from the equipment.

15 ICSS INTERFACE

- a. The ECMS shall have redundant communication links to the ICSS. An OPC server shall be used if the ICSS cannot handle the interface natively.
- b. Control of process related loads such as motors and heaters shall be directly from the ICSS. Only selected monitoring functions of these process related loads shall be communicated from ECMS to ICSS.
- c. The ICSS shall receive sufficient data to have the electrical system configuration, status, and critical alarms displayed. A watchdog shall be used to verify communication, and alarm on loss of communication.
- d. ICSS shall not have any control of the electrical distribution system.

SECTION C – OTHER REQUIREMENTS

16 DETAILS OF SCOPE SUPPLY

The scope of supply of shall include:

- a. Detailed design.
- b. Supply of materials.
- c. Factory and site inspection and testing.
- d. Documentation including certification.
- e. Installation, commissioning and start-up assistance; where specified in the requisition.
- f. Spare parts for 2 years operation.

Refer to the project requisition document for detailed requirements.

17 QUALITY CONTROL AND ASSURANCE

Equipment shall only be purchased from SUPPLIERS approved by ADNOC Category Management. This approval indicates that the SUPPLIER has an approved quality management system and a proven track record in supply of this equipment type.

18 SUB-CONTRACTORS, SUB-SUPPLERS

The SUPPLIER shall assume unit responsibility and overall guarantee for the equipment package and associated equipment.

The SUPPLIER shall transmit all relevant purchase order documents including specifications to his SUB-SUPPLIERS and SUBCONTRACTORS.

It is the SUPPLIER's responsibility to enforce all purchase order and specification requirements on his SUB-SUPPLIERS and SUBCONTRACTORS.

The SUPPLIER shall submit all relevant SUB-SUPPLIER and SUBCONTRACTOR drawings and engineering data to the CONTRACTOR.

The SUPPLIER shall obtain and transmit all SUB-SUPPLIER and SUBCONTRACTOR's warranties to the CONTRACTOR/COMPANY, in addition to the system warranty.

19 MATERIAL CERTIFICATION

Not applicable.

20 INSPECTION AND TESTING REQUIREMENTS

20.1 General

- a. Before leaving the SUPPLIER's works, each item of equipment shall be inspected and tested in accordance with this specification.
- b. The SUPPLIER shall provide an ITP at least 8 weeks' notice prior to the testing date.

- c. The ITP shall be submitted for review and acceptance by the COMPANY and include Witness and Hold points in the programme for SUPPLIER, CONTRACTOR, and COMPANY.
- d. The COMPANY/CONTRACTOR or his nominee will inspect the equipment and witness the required tests indicated in the Requisition at the time the equipment is offered for final inspection.
- e. A detailed test procedure of factory tests shall be submitted at least 3 months in advance of any testing, detailing the proposed inspection, testing and witness testing programme throughout the design and build of the equipment.
- f. Test certificates for the ECMS shall be submitted prior to delivery for approval.

20.2 Test Reports

- a. Test reports including comprehensive checklists (covering hardware, I/O, software, and applications) shall be submitted to COMPANY.
- b. The SUPPLIER shall compile the records of all inspections and tests including routine tests and special tests in one document and shall submit as part of technical documentation.

20.3 Type Tests

- a. SUPPLIER shall submit the type test certificates for each item of equipment for test as required in the applicable IEC standards.
- b. Type test certificates shall be submitted with the bid.
- c. Test certificates shall be from an internationally recognised, independent testing authority, and shall be subject to COMPANY acceptance.

20.4 Factory Acceptance Test (FAT)

20.4.1 General Requirements

- a. Maximum testing of all the equipment shall be carried out at the SUPPLIER's works in order to save time and cost for onsite testing.
- b. Inspection and testing fall into the following subdivisions:
 - i. System Staging and In-House Test (IHT).
 - ii. Third Party Equipment Communication Test.
 - iii. Software and Database Test.
 - iv. Hardware Inspection.
 - v. Functional Test.
 - vi. Integrated System Test.
 - vii. System Performance Test.
 - viii. Soak Test.
 - ix. Unstructured Tests.

20.4.2 System Staging and In-House Test (IHT)

- a. The SUPPLIER shall assemble and interconnect all cabinets, workstations, components, and sub-assemblies in one area.
- b. The SUPPLIER shall carry out a full and exhaustive “in house” test (IHT) prior to submitting the system for FAT. Each test shall be fully documented and recorded with check signatures. IHT documentation shall be available for review before the start of FAT.
- c. The SUPPLIER shall maintain a detailed logbook, reinforced by the system printouts, etc. covering the following areas:
 - i. Material deficiencies.
 - ii. System activity.
 - iii. System problems and resolutions.
 - iv. System testing.
 - v. System hardware inspection and tests shall include:
 1. Equipment inventory.
 2. Visual inspection of all components.
 3. Continuity check of wiring, cross wiring and interconnecting system cables.
 4. AC and DC power checks.
 5. Operation of redundant devices.
 6. Diagnostic checks of all devices.
 7. Operation of communication networks.
 8. Operation of serial links.
 9. Immunity to EMI.
- d. The SUPPLIER shall update all devices to the agreed firmware and software version before testing.
- e. The SUPPLIER shall complete the system software tests, including but not limited to:
 - i. Loading and verifying all databases.
 - ii. Run standard diagnostic tests for system functions, security performance etc.
 - iii. Monitor communication errors.
 - iv. Applications, graphics, reports.
 - v. Highway and processor loading tests.

20.4.3 Third-Party Equipment Communication Test

- a. Prior to the Integrated Systems Test, the SUPPLIER shall ensure that all third-party communications shall operate successfully as specified.
- b. The SUPPLIER shall coordinate through CONTRACTOR with other third-party SUPPLIER's to arrange communication tests at an agreed location to prove system-to-system communications.

20.4.4 Software and Database Test.

- a. The SUPPLIER shall perform a separate software and database test. This test shall be conducted prior to performing the Integrated System Test and shall include tests to verify the following:
 - i. All operator functions.
 - ii. Monitor displays and real-time data.
 - iii. Manual and automatic operation.
 - iv. IED configurations.
 - v. Point/signal configurations.
 - vi. Signal assignments.
 - vii. Faceplate layout and text.
 - viii. Faceplate parameters.
 - ix. Alarm configurations (avalanche condition).
 - x. Application programs.
 - xi. Reports.
- b. All display screens shall be checked for content, format and dynamic indications.
- c. Tests shall be made by simulating an input, reading displays, and verifying outputs at the simulator. Control function testing shall be conducted with one switchgear IED of each type.
 - i. Three-point accuracy (0 %, 50 %, and 100 %).
 - ii. Correct function of each algorithm.
 - iii. Control action.
 - iv. Alarm limits.
 - v. Alarm action.
 - vi. Scaling.
 - vii. Data logging.

20.4.5 Hardware Inspection

- a. A hardware inspection shall be completed. This shall include, but not limited to:
 - i. Correct standards of workmanship and quality.
 - ii. Correct identification labels, cabling, tagging, housing and mounting arrangement, including:
 - 1. Completeness of the data on the equipment nameplates.
 - 2. Visual examination (appearance, finish, paint work, wiring etc.).
 - 3. Dimensional check.
 - 4. Degree of ingress protection of the enclosures.
 - 5. Caution, danger, instruction labels.

6. Correct wiring of auxiliary devices.
 7. Suitability of clamping, earthing and terminating arrangement.
 8. Suitability of lifting lugs.
 9. Correct labeling of functional units and auxiliary devices.
- iii. Adequate accessibility.
 - iv. Compliance with this specification and reviewed SUPPLIER drawings.

20.4.6 Functional Tests

The SUPPLIER shall, as a minimum, include the following functional tests:

- a. System Security. The overall system security shall be verified by failing the communications paths, cables, and power to verify the proper system operation under each condition. System security testing shall also include alarming and system diagnostics.
- b. Network communications. Network communications shall be tested from each master to each slave and from master to master. The communications test shall verify all possible communication paths, including primary and redundant networks and cables. Appropriate error conditions shall be forced to ensure communication path switching upon failure.
- c. Hardwired I/O Points. Test panels shall be used to verify specified operation of each digital and analogue hardwired I/O point.
- d. Miscellaneous
 - i. Access and control privileges shall be tested for correct operation.
 - ii. Software loading, reloading, and operating procedures for each workstation shall be demonstrated.
 - iii. Printer functions and trend recording shall be verified.

20.4.7 Integrated System Test

- a. An integrated system test shall be performed to:
 - i. Prove communication interfaces with ECMS third-party subsystems.
 - ii. Test 100 % ECMS operability and functionality with all third-party systems connected.
- b. Testing shall be carried out at the staging location using all ECMS hardware, project configured software databases, one switchgear IED of each type and other components. The setup shall reflect the actual system configuration on site.
- c. Use of simulators, where required, shall be subject to COMPANY approval.

20.4.8 System Performance Test

- a. The SUPPLIER shall develop a test procedure and acceptance criterion for an integrated system performance test. The system performance test shall include response time simulation.

- b. The test shall be carried out at:
 - i. Normal load with simulated I/O cycling and all software applications running.
 - ii. Upset load with increased rate of change of analogue values and alarm bursts and all software applications running.

20.4.9 Soak Test

- a. The SUPPLIER shall complete a soak test for a period of at least two weeks, 24 hours per day at operating temperature to minimise the possibility of process shutdowns caused by failures. During this period, the temperature and humidity shall be monitored in selected cabinets.
- b. The SUPPLIER shall agree with the COMPANY the environmental conditions under which the soak test is to take place in accordance with the project requirements.
- c. The SUPPLIER shall maintain a record of all components, with serial numbers, that failed during the soak test. This record shall include the length of time that the failed component was running prior to its failure.

20.4.10 Unstructured Tests

The SUPPLIER shall include a 48-hour period of unstructured testing, during which the COMPANY shall be at liberty to instruct the CONTRACTOR/SUPPLIER to carry out such additional tests as may be required to test the reliability and robustness of the system.

20.5 Site Acceptance Test (SAT)

- a. The SUPPLIER shall develop a test procedure and acceptance criterion for a site acceptance test.
- b. This site acceptance test shall demonstrate that the overall design of the ECMS meets the functional and performance requirements of this specification in the field, using the actual communications network and including equipment supplied by others, to which the system is designed to interface.
- c. The site acceptance test, as a minimum, shall include:
 - i. A post-installation inspection and software module testing to verify installation and communication of SUPPLIER's equipment.
 - ii. A repeat of a portion of tests performed at the FAT, as necessary, to confirm correct ECMS functionality and operation.
 - iii. An EMC test to verify compliance.
 - iv. A Reliability Test. This test shall be performed for a period of 2200 hours. During the last 200 hours of this test no failures or switchovers (in hot-standby redundant systems) are allowed. The system is regarded to be down if functions that are essential to monitor and control all or part of the electrical system cannot be used.

21 SPARE PARTS

- a. The SUPPLIER shall propose:
 - i. A list of commissioning spare parts.
 - ii. A list of 2 years operation spare parts.

- iii. A list of special tools required for erection, commissioning and maintenance.
- b. Special tools required for erection, commissioning and maintenance shall be shipped together with the ECMS equipment.
- c. Each spare part shall be separately packed and clearly identified for storage management.

22 PAINTING, PRESERVATION AND SHIPMENT

22.1 Painting

- a. Surface preparation and painting of the ECMS cabinets shall be in accordance with the COMPANY standard, AGES-SP-07-004 Painting and Coating Specification.
- b. Alternatively, SUPPLIER may propose the standard for enhanced protection against corrosion in outdoor climates. The paint system applied shall provide adequate protection against the adverse effects of the climatic conditions specified. Full details of SUPPLIER's painting specification shall be provided with the bid for COMPANY approval.
- c. The ECMS Cabinets shall be fully tropicalised.
- d. The ECMS cabinet colour shade shall be in accordance with the COMPANY standard, AGES-SP-07-004 Painting and Coating Specification, equipment type 'switchboard'.

22.2 Shipment

SUPPLIER's standard packing shall be acceptable unless otherwise stated in the COMPANY's preservation and export packing procedure. Installation of impact recorders on individual packing boxes and containers shall be included.

23 COMMISSIONING

The requirements of commissioning shall be included in the requisition document.

24 TRAINING

- a. The SUPPLIER shall arrange training for COMPANY personnel. The training course, as a minimum, shall include:
 - i. System configuration.
 - ii. ECMS functions and operation.
 - iii. System administration.
 - iv. Maintenance and trouble shooting.
- b. The training shall be customised to the actual ECMS equipment and software supplied and include aspects of both classroom training and 'hands on' practical training.
- c. The SUPPLIER shall prepare a comprehensive training manual and organise the training programme. Part of the training shall be delivered at the SUPPLIER's premises and part shall be delivered at site during the commissioning phase.
- d. All training shall be conducted in English language.

25 DOCUMENTATION / MANUFACTURER DATA RECORDS

25.1 General

- a. SUPPLIER shall submit the type and number of drawings and documentation for CONTRACTOR's authorisation or information as listed in the Material Requisitions and Purchase Orders.
- b. Schedule of documents and data submittal shall be as agreed in the Purchase Order.
- c. Comments made by CONTRACTOR on drawing submittal shall not relieve the SUPPLIER of any responsibility in meeting the requirements of the specifications. Such comments shall not be construed as permission to deviate from requirements of the Purchase Order unless specific and mutual agreement is reached and confirmed in writing.
- d. Each drawing shall be provided with a block in the bottom right-hand corner incorporating the following information:
 - i. Official trade name of the SUPPLIER.
 - ii. SUPPLIER's drawing number.
 - iii. Drawing title giving the description of contents whereby the drawing can be identified.
 - iv. A symbol or letter indicating the latest issue or revision.
 - v. Purchase order number and item tag numbers.
- e. Revisions:
 - i. Document and drawing revisions shall be identified with symbols adjacent to the alterations.
 - ii. A brief description of each revision shall be given in tabular form.
 - iii. If applicable, the authority and date of the revision shall be listed. The term "Latest Revision" shall not be used.
- f. All documents shall show the relevant order number, item tag numbers and SUPPLIER's references and shall be distributed as specified in the purchase order documents.
- g. Graphic symbols for electrical diagrams shall be according to IEC 60617-DB. Device code numbers shall be as per ANSI C-37.2.
- h. All documents and drawings shall be in English.
- i. Installation, operating and maintenance manuals shall be arranged as follows:
 - i. The front cover, spine and inside page shall state the purchase order number and SUPPLIER's reference number.
 - ii. The inside front page shall carry an index listing the contents of each section of the manual.
 - iii. Individual sections shall be completed and shall refer to the equipment actually supplied.
 - iv. Published data shall also be included, including published data for bought-in items.
 - v. Full detail for installation setting up shall be included.
 - vi. Recommended test data shall be stated, covering initial and regular testing, i.e. values for high voltage, AC or DC. etc. will be given.

- vii. Items requiring regular inspection, checking, testing and maintenance shall be listed, and the time scale clearly indicated.
- viii. Important items shall be cross referenced to other part of the manual as necessary.
- ix. Fault finding chapter shall be included.
- x. As built panel wiring diagram.
- xi. Parts and equipment list.

25.2 Deliverables

Unless otherwise stated in the inquiry/order documents, the SUPPLIER shall at least supply the documents as listed in Table 25.1. The language used shall be English.

Table 25.1 Deliverables

With Bid:	
a.	Project specific technical description of the system offered.
b.	Scope of supply for hardware and software with make, type, and country of manufacture.
c.	A system architecture block diagram of the complete system showing all the hardware, communication links, and scope of supply boundaries.
d.	List of protocols to be implemented.
e.	Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) for the equipment.
f.	Preliminary dimensions and weights of panels.
g.	Power supply requirements and heat loads.
h.	Colour views showing detail of typical screens of each type to be included on HMI screen displays.
i.	FAT procedures (Typical).
j.	SAT procedures and quotation (Typical).
k.	List of recommended spares.
l.	Scope of services.
m.	Nearest service centre details.
n.	Commissioning procedures and quotation.
o.	Start-up procedures and quotation.
p.	List of training with descriptions.
q.	EMC Plan.
r.	Preliminary capacity study. Refer to Section 8.1.
After placement of order:	
a.	Detail Functional Design Specification (DFDS).
b.	Listing of user specific settings and parameters.
c.	Complete I/O List (Table of data exchange).

After placement of order:	
d.	Bill of materials.
e.	Hardware drawings, including internal component details, panel layouts with dimensions and weights, schematic and wiring diagrams, power supplies, and heat loads.
f.	Termination drawings and diagrams.
g.	Cable specifications and cable schedule.
h.	Earthing arrangement and recommendations.
i.	EMC Plan.
j.	Functional block diagrams and logic diagrams.
k.	Displays and hierarchy of displays.
l.	Catalogues and Technical Brochures.
m.	Test Certificates.
n.	Factory Acceptance Test and Site Acceptance Test plan and forms.
o.	Recommended spare parts lists (commissioning and 2 years' operation).
p.	List special tools, devices and test equipment.
q.	Configuration software – softcopy.
r.	Software licenses.
s.	Certificates of conformity for communication.
t.	User manual for all the software that forms part of ECMS.
u.	Operating manuals incorporating installation, commissioning, operating and maintenance instructions and fault-finding procedures.
v.	Maintenance Manual for all ECMS components.
w.	Training Manual for ECMS Operation and Maintenance.
x.	FAT Report and Site Test Reports.
y.	Adequacy/Capacity study. This study shall confirm the selection of CPUs, the network design and memory capacity is in accordance with this specification.

26 GUARANTEES AND WARRANTY

The requirements of guarantees and warranty shall be included in the requisition document.

SECTION D – STANDARD DRAWINGS & DATASHEETS

27 DATASHEET TEMPLATES

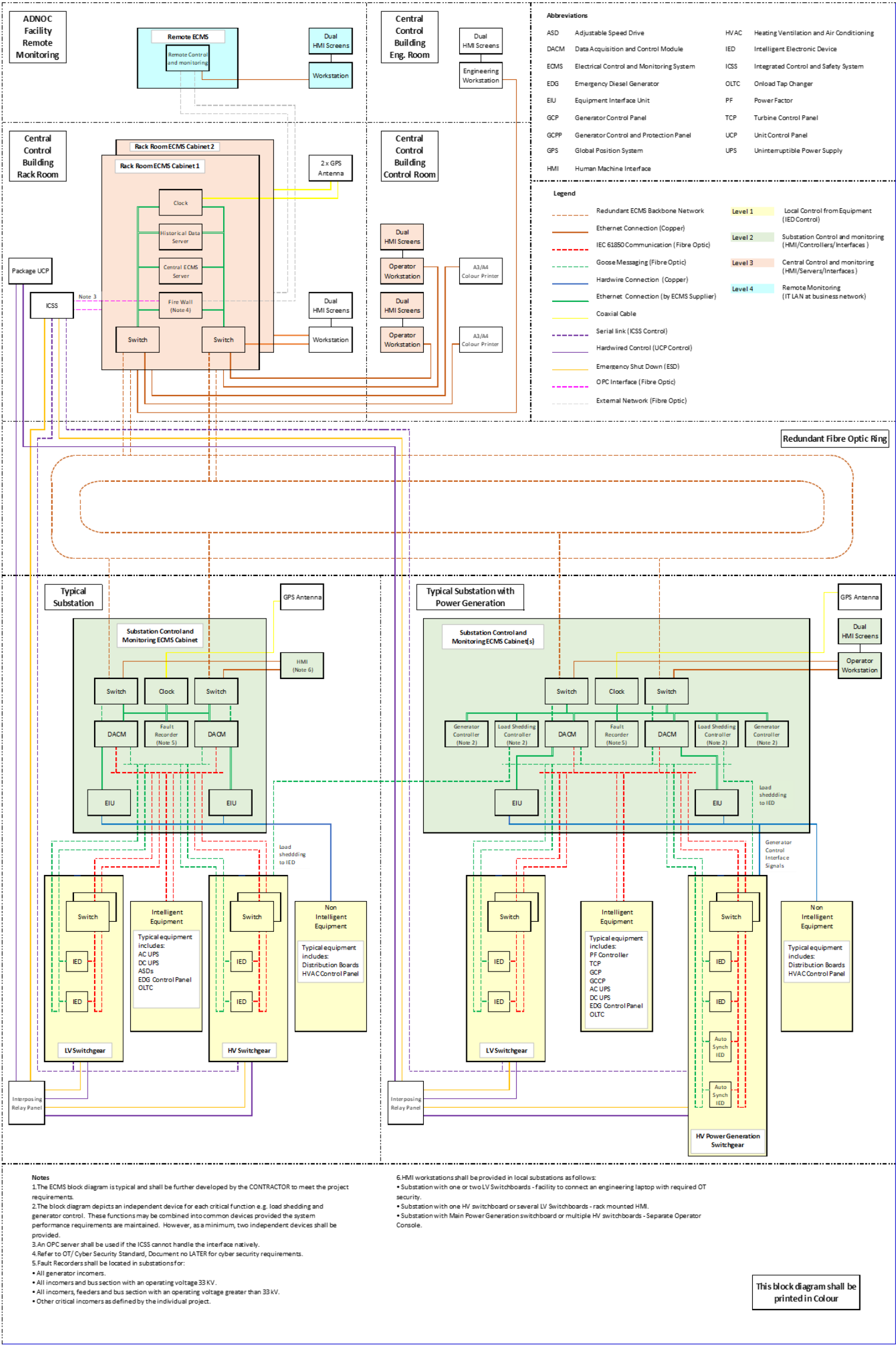
LATER.

28 STANDARD DRAWINGS

Not Applicable.

SECTION E - APPENDICES

APPENDIX A1. BLOCK DIAGRAM ELECTRICAL CONTROL AND MONITORING SYSTEM



APPENDIX A2. I/O SCHEDULE

A2.1. Scope

This Appendix specifies the typical requirements for the ECMS control and indication for the various types of electrical equipment forming part of the electrical distribution system.

A2.2. Switchgear – Incomer

Table A2.1 Switchgear – Incomer Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Circuit breaker open / close action	X			
2	Circuit breaker open / close status		X		
3	Isolator connected / isolated / Earthed action	X			Applicable to GIS only
4	Isolator connected / isolated / Earthed status		X		Applicable to GIS only
5	Earth switch open/close status		X		Applicable to HV switchgear only
6	Circuit breaker in service position		X		
7	Circuit breaker selector switch Local / off/ remote status		X		
8	Circuit breaker spring charged / Discharged status		X		
9	Trip circuit supervision alarm		X		
10	Circuit breaker tripped / lockout relay Operated		X		
11	IED fault/ loss of communication		X		
12	IED alarm function (as per Protection and Metering SLDs)		X		
13	IED trip function (as per Protection and Metering SLDs)		X		
14	Synch check permissive to close		X		
15	Inter trip operated		X		
16	Lockout relay reset	X			Password protected
17	VT MCB tripped		X		
18	VT Primary Fuse blown		X		
19	DC supply loss alarm		X		Control supply healthy
20	AC supply loss alarm		X		
21	CB chamber gas density monitoring		X		Applicable to GIS only

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
22	Busbar chamber gas density monitoring		X		Applicable to GIS only
23	Number of circuit breaker operations		X		
24	Event recording		X		
25	Fault record		X		
26	IED settings	X*			ECMS to include the facility to view all settings and upload new settings
27	Voltage			X	
28	Current			X	
29	Power MW			X	
30	Power MVar			X	
31	Power MVA			X	
32	Power factor			X	
33	Frequency			X	

A2.3. Switchgear - Bus Tie

Table A2.2 Switchgear – Bus Tie Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Circuit breaker open / close action	X			
2	Circuit breaker open / close status		X		
3	Disconnecter bus A open / close / earth action	X			Applicable to GIS only
4	Disconnecter bus A open / close / earth status		X		Applicable to GIS only
5	Disconnecter bus B open / close / earth action	X			Applicable to GIS only
6	Disconnecter bus B open / close / earth status		X		Applicable to GIS only
7	Earth switch open / close status		X		Applicable to HV switchgear only
8	Circuit breaker in service position		X		
9	Circuit breaker selector switch local / off / remote status		X		

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
10	Circuit breaker spring charged / discharged status		X		
11	Trip circuit supervision alarm		X		
12	Circuit breaker tripped / lockout relay Operated		X		
13	IED fault / loss of communication		X		
14	IED trip function (as per Protection and Metering SLDs)		X		
15	Synch check permissive to close		X		
16	Synch check error		X		
17	Lockout relay reset	X			Password protected
18	Bus A VT MCB tripped		X		
19	Bus A VT Primary Fuse blown		X		Applicable to HV switchgear only
20	Bus B VT MCB tripped		X		
21	Bus B VT Primary Fuse blown		X		Applicable to HV switchgear only
22	DC supply loss alarm		X		Control supply healthy
23	AC supply loss alarm		X		
24	CB chamber gas density monitoring		X		Applicable to GIS only
25	Busbar chamber gas density monitoring		X		Applicable to GIS only
26	Number of circuit breaker operations		X		
27	Event recording		X		
28	Fault record		X		
29	IED settings	X*			ECMS to include the facility to view all settings and upload new settings
30	Voltage			X	
31	Current			X	
32	Initiate automatic transfer	X			Applicable to switchgear with auto transfer system
33	Auto transfer failure		X		
34	Condition monitoring			X	Interface with switchgear Data Analysers

A2.4. Switchgear - HV Feeder

Table A2.3 Switchgear – HV Feeder Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Circuit breaker open / close action	X			
2	Circuit breaker open / close status		X		
3	Isolator connected / isolated / earthed action	X			Applicable to GIS only
4	Isolator connected / isolated / earthed status		X		Applicable to GIS only
5	Earth switch open/close status		X		
6	Circuit breaker in service position		X		
7	Circuit breaker selector switch local / off / remote status		X		
8	Circuit breaker spring charged / discharged status		X		
9	Trip circuit supervision alarm		X		
10	Circuit breaker tripped / lockout relay Operated		X		
11	IED fault / loss of communication		X		
12	IED alarm function (as per Protection and Metering SLDs)		X		
13	IED trip function (as per Protection and Metering SLDs)		X		
14	Inter trip operated		X		Applicable when feeding a downstream switchboard either via transformer or a direct feed
15	Lockout relay reset	X			Password protected
16	DC supply loss alarm		X		Control supply healthy
17	AC supply loss alarm		X		
18	CB chamber gas density monitoring		X		Applicable to GIS only
19	Busbar chamber gas density monitoring		X		Applicable to GIS only
20	Number of circuit breaker operations		X		
21	Event recording		X		
22	Fault record		X		
23	IED settings	X*			ECMS to include the facility to view all settings and upload new settings

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
24	Voltage			X	
25	Current			X	
26	Power MW			X	
27	Power MVA			X	
28	Power MVAR			X	
29	Power factor			X	
30	Load shed	X			Load shedding requirements to be defined for each project considering the plant operation.

A2.5. Switchgear - HV Motor

Table A2.4 Switchgear – HV Motor Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Motor available to start		X		
2	Motor running / stopped status		X		
3	Motor tripped		X		
4	Emergency stop activated		X		
5	Circuit breaker open / close status		X		
6	Earth switch open / close status		X		
7	Circuit breaker in service position		X		
8	Circuit breaker selector switch auto / manual status		X		
9	Circuit breaker spring charged / discharged status		X		
10	Trip circuit supervision alarm		X		
11	Circuit breaker tripped / lockout relay Operated		X		
12	IED fault / loss of communication		X		
13	IED alarm function (as per Protection and Metering SLDs)		X		
14	IED trip function (as per Protection and Metering SLDs)		X		

Item No	Source of Signal	Control	Alarm/ Status	Measure ment	Remarks
15	Lockout relay reset	X			Password protected
16	DC supply loss alarm		X		Control supply healthy
17	AC supply loss alarm		X		
18	Number of circuit breaker operations		X		
19	Event recording		X		
20	Fault record		X		
21	IED settings	X*			ECMS to include the facility to view all settings and upload new settings
22	Current			X	
23	Power kW			X	
24	Running hours			X	
25	Power factor			X	
26	Time before reset of thermal trip			X	
27	Partial discharge monitoring			X	For motors with input voltage 6.6kV and above
28	Air temperature high		X		For air-to-air cooled motors only
29	Water temperature high		X		For air-to-water cooled motors only
30	Leak detection		X		
31	Winding temperature			X	
32	Bearing Temperature high		X		From motor condition monitoring system
33	Vibration monitoring high		X		
34	Load shed	X			Load shedding and inhibit start requirements to be defined for each project considering the plant operation.
35	Inhibit start	X			

A2.6. Switchgear - LV Motor

Table A2.5 Switchgear – LV Motor Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Motor available to start		X		
2	Motor running / stopped status		X		
3	Motor tripped		X		
4	Emergency stop activated		X		
5	IED fault / loss of communication		X		
6	IED alarm function (as per Protection and Metering SLDs)		X		
7	IED trip function (as per Protection and Metering SLDs)		X		
8	Fault record		X		
9	IED settings	X*			ECMS to include the facility to view all settings and upload new settings
10	Current			X	
11	Power kW			X	
12	Running hours			X	
13	Power factor			X	

A2.7. LV Switchgear - Distribution Board Feeders

Table A2.6 LV Switchgear – Distribution Board Feeders Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	MCCB on-off status		X		
2	MCCB tripped		X		
3	Line current			X	
4	Power (kW)			X	

A2.8. Gas Turbine Generator Circuit

Table A2.7 Gas Turbine Generator Circuit Control and Indication

Item No	Source of Signal	Control	Alarm/ Status	Measure ment	Remarks
1	Generator control panel local / remote Status		X		
2	Initiate generator start / stop action	X			
3	Generator incomplete start sequence		X		
4	Generator running / stopped / tripped Status		X		
5	Initiate automatic synchronisation	X			
6	Automatic synchronisation failure		X		
7	Operating mode select droop / isochronous	X			
8	Operating mode status droop / isochronous		X		
9	Voltage raise / lower action	X			
10	Frequency raise / lower action	X			
11	Modify MW set point	X			
12	Exciter failure		X		
13	Circuit breaker open / close status		X		
14	Isolator connected / isolated / earthed action	X			Applicable to GIS only
15	Isolator connected / isolated / earthed status		X		Applicable to GIS only
16	Earth switch open / close status		X		
17	Circuit breaker in service position		X		
18	Circuit breaker selector switch local / off / remote status		X		
19	Circuit breaker spring charged / discharged status		X		
20	Trip circuit supervision alarm		X		
21	Circuit breaker tripped / lockout relay Operated		X		
22	IED fault / loss of communication		X		
23	IED alarm function (as per Protection and Metering SLDs)		X		
24	IED trip function (as per Protection and Metering SLDs)		X		
25	Synch check permissive to close		X		

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
26	Synch check error		X		
27	Lockout relay reset	X			Password protected
28	VT MCB tripped		X		
29	VT Primary Fuse blown		X		
30	DC supply loss alarm		X		Control supply healthy
31	AC supply loss alarm		X		
32	CB chamber gas density monitoring		X		Applicable to GIS only
33	Busbar chamber gas density monitoring		X		Applicable to GIS only
34	Number of circuit breaker operations		X		
35	Event recording		X		
36	Fault record		X		
37	IED settings	X*			ECMS to include the facility to view all settings and upload new settings
38	Generator capability diagram			X	
39	Voltage			X	
40	Current			X	
41	Power MW			X	
42	Power MVA			X	
43	Power MVA			X	
44	Power factor			X	
45	Frequency			X	
46	Gas turbine air inlet temperature			X	
47	Lube oil temperature high		X		
48	Lube oil reserve oil level-low		X		
49	Low fuel supply pressure		X		
50	Exhaust over temperature		X		
51	Control signal failure		X		
52	Control system actuator failure		X		
53	Governor failure		X		
54	Enclosure vent fan failure		X		
55	Turbine common group fault		X		
56	Turbine start failure		X		
57	Turbine overspeed		X		

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
58	Turbine outlet temperature high		X		
59	Turbine oil level low		X		
60	GTG ready for operation		X		
61	Generator / turbine speed			X	
62	Generator temperature			X	
63	Generator running hours			X	
64	Exciter voltage			X	
65	Vibration high		X		
66	NER neutral current			X	
67	NER high temperature alarm		X		Where available
68	NER common fault		X		

A2.9. Emergency Diesel Generator Circuit

Table A2.8 Emergency Diesel Generator Circuit Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	EDG mode auto / test status		X		
2	Initiate generator start / stop action	X			
3	Generator running / stopped / tripped Status		X		
4	Circuit breaker open / close status		X		
5	Earth switch open / close status		X		Applicable to HV switchgear only
6	Circuit breaker in service position		X		
7	Circuit breaker selector switch local / off / remote status		X		
8	Circuit breaker spring charged / discharged status		X		
9	Trip circuit supervision alarm		X		
10	Circuit breaker tripped/ lockout relay Operated		X		
11	IED fault / loss of communication		X		
12	IED alarm function (as per Protection and Metering SLDs)		X		
13	IED trip function (as per Protection and Metering SLDs)		X		

Item No	Source of Signal	Control	Alarm/ Status	Measure ment	Remarks
14	Synch check permissive to close		X		
15	Synch Check error		X		
16	Lockout relay reset	X			Password protected
17	VT MCB tripped		X		
18	VT Primary Fuse blown		X		
19	DC supply loss alarm		X		
20	AC supply loss alarm		X		
21	Number of circuit breaker operations		X		
22	Event recording		X		
23	Fault record		X		
24	IED settings	X*			ECMS to include the facility to view all settings and upload new settings
25	Voltage			X	
26	Current			X	
27	Power kW			X	
28	Power kVAr			X	
29	Power factor			X	
30	Frequency			X	
31	Generator temperature			X	
32	Generator running hours			X	
33	Exciter voltage			X	
34	Engine common fault		X		
35	Engine start failure		X		
36	Engine over speed		X		
37	Engine jacket outlet temperature high		X		
38	Fuel level low		X		
39	Engine oil pressure low		X		
40	Engine oil level low		X		
41	Starting battery voltage low		X		
42	Charger failure		X		
43	Common alarm		X		

A2.10. AC UPS

Table A2.9 AC UPS Control and Indication

Item No	Source of Signal	Control	Alarm/ Status	Measure ment	Remarks
1	Mains input failed		X		
2	Bypass supply failed		X		
3	Rectifier input voltage per phase			X	
4	Rectifier input current per phase			X	
5	Bypass voltage per phase			X	
6	Bypass input current			X	
7	Battery autonomy time remaining			X	
8	Rectifier / charger output voltage			X	
9	Rectifier / charger output current			X	
10	UPS output voltage per phase			X	
11	UPS output current per phase			X	
12	UPS output frequency			X	
13	Bypass output frequency			X	
14	Battery Current			X	
15	UPS fault alarm		X		
16	Rectifier input out of tolerance		X		
17	Bypass voltage out of tolerance		X		
18	Rectifier failure		X		
19	DC overvoltage		X		
20	DC undervoltage		X		
21	Load on battery		X		
22	Battery discharged		X		
23	Battery CB open		X		
24	Inverter failure		X		
25	Inverter / static bypass overload		X		
26	Inverter output voltage deviation		X		
27	Inverter / bypass not synchronised		X		
28	Static switch blocked		X		
29	Individual fan failure		X		
30	Enclosure temperature high		X		
31	Load on maintenance bypass		X		

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
32	Load feeders open or tripped common alarm		X		
33	Battery overvoltage		X		
34	Battery under voltage		X		
35	AC earth fault		X		
36	DC earth fault		X		
37	Rectifier ON/OFF		X		
38	Inverter ON/OFF		X		
39	Load on Inverter		X		
40	Load on Bypass		X		
41	Battery on Boost mode		X		

A2.11. DC UPS

Table A2.10 DC UPS Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Mains input failed		X		
2	Rectifier / charger input voltage per phase			X	
3	Rectifier / charger input current per phase			X	
4	Rectifier / charger output voltage			X	
5	Rectifier / charger output current			X	
6	Battery current			X	
7	Rectifier / charger trouble alarm		X		
8	Rectifier / charger input out of Tolerance		X		
9	Rectifier failure		X		
10	DC overvoltage		X		
11	DC undervoltage		X		
12	Load on battery		X		
13	Battery discharged		X		
14	Battery CB open		X		
15	Load feeders open or tripped		X		
16	DC earth fault		X		

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
17	Enclosure temperature high		X		
18	Cubicle fan failure		X		
19	AC input undervoltage alarm and trip		X		
20	Battery overvoltage		X		
21	Battery under voltage		X		
22	Common alarm		X		
23	Charger on/off		X		
24	MCCB on/off		X		
25	Battery on boost mode		X		
26	Mains on/off		X		

A2.12. Adjustable Speed Drive System

Table A2.11 ASD Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	AC mains ON		X		
2	Rectifier output ON		X		
3	Motor running / stopped status		X		
4	Motor zero speed		X		
5	Motor over speed		X		
6	ASD system fault		X		
7	Transformer common alarm		X		Applicable to ASD's with a HV supply
8	Motor common alarm		X		
9	Harmonic filter common alarm		X		
10	ASD common alarm		X		
11	Auxiliaries common alarm		X		
12	Input AC voltage			X	
13	Input AC Current			X	
14	Input AC frequency			X	
15	Input Power			X	
16	Output voltage			X	
17	Output current			X	
18	Output frequency			X	

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
19	Output Power			X	
20	Motor thermal state			X	
21	Drive thermal state			X	
22	Motor speed			X	
23	Motor energy meter			X	
24	DC Link voltage			X	
25	Hour Run			X	
26	Speed reference signal			X	
27	Loss of speed reference signal		X		
28	Loss of cooling airflow		X		Air cooled ASDs only
29	Loss of cabinet cooling fan		X		
30	Loss of a cooling water pump		X		Water cooled ASDs only
31	Loss of an air cooler		X		Water cooled ASDs only
32	High water conductivity		X		Water cooled ASDs only
33	Low cooling water flow		X		Water cooled ASDs only
34	Pre-charge circuit - common alarm		X		
35	Trip circuit supervision alarm		X		
36	IED fault / loss of communication		X		
37	IED alarm functions (as per Protection and Metering SLDs)		X		
38	IED trip functions (as per Protection and Metering SLDs)		X		
39	Fault record - Status		X		
40	IED settings - Control*	X*			ECMS to include the facility to view all settings and upload new settings
41	Condition monitoring - measurement			X	

A2.13. Soft Starters

Where applicable, Table A2.11 may be used as a basis for typical control and indication signals for electronic soft start systems.

A2.14. Transformers

Table A2.12 Transformer Control and Indication

Item No	Source of Signal	Control	Alarm/ Status	Measure ment	Remarks
1	Top liquid temperature			X	
2	Winding temperature			X	
3	Ambient temperature			X	
4	Liquid level			X	
5	Tank pressure.			X	
6	Dissolved Gas Analysis (DGA) monitors			X	Applicable to liquid transformers rated 10MVA and above
7	Partial Discharge (PD)			X	Applicable to transformers 6.6 kV and above
8	Transformer Buchholz alarm		X		
9	Transformer Buchholz trip		X		
10	Transformer winding temperature alarm		X		
11	Transformer winding temperature trip		X		
12	Transformer liquid temperature Alarm		X		
13	Transformer liquid temperature trip		X		
14	Transformer tank low liquid level Alarm		X		
15	Transformer tank high liquid level Alarm		X		
Note 1: The above I/Os are for both dry type and liquid filled transformers as applicable. Note 2: All transformer signals shall be routed via switchgear.					

A2.15. Transformer OLTC / Voltage Regulation

Table A2.13 Transformer Remote Tap Changer Control Panel Control and Indication

Item No	Source of Signal	Control	Alarm/ Status	Measure ment	Remarks
1	Master / follower / independent - Action	X			
2	Master / follower / independent - Status		X		
3	RTCCP / Off / ECMS control status		X		
4	Raise / lower tap position	X			
5	Tap change in progress		X		
6	Failure to complete tap change		X		
7	Tap position indication			X	
8	Tap changer fault alarm		X		
9	AVR control mode - automatic / manual status		X		
10	Winding temperature			X	
11	Oil temperature			X	
12	OLTC overpressure trip		X		
13	OLTC Buchholz alarm		X		
14	OLTC Buchholz Trip		X		
15	OLTC Low oil level Alarm		X		
16	OLTC high oil level Alarm		X		
17	OLTC set point control	X			
18	OLTC set point status		X		
19	Common alarm		X		
20	Common tripped		X		

A2.16. Transformer - Force Cooled

Table A2.14 Transformer - Force Cooled Control and Indication

Item No	Source of Signal	Control	Alarm/ Status	Measure ment	Remarks
1	Fan control manual / auto status	X	X		
2	Fan start / stop control	X			
3	Fan group running status		X		
4	Fan group fault		X		
5	Oil Pump control manual / auto status	X	X		
6	Oil Pump A start / stop control	X			
7	Oil Pump B start / stop control	X			
8	Oil Pump A Running Status		X		
9	Oil Pump B Running Status		X		
10	Oil Pump A fault		X		
11	Oil Pump B fault		X		

A2.17. Capacitor Bank Controller

Table A2.15 Capacitor Bank Controller Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Controller auto / manual mode status		X		
2	Target power factor set point	X			
3	Measured power factor			X	
4	Voltage			X	
5	Current			X	
6	Power MW			X	
7	Power MVA			X	
8	Power MVA			X	
9	Harmonic Distortion			X	
10	Number of capacitor bank stages Energised		X		
11	Low power factor		X		
12	Hunting		X		
13	Overvoltage		X		
14	Overtemperature		X		
15	Low capacitor output		X		
16	Power supply failure		X		
17	Common alarm		X		

A2.18. Distribution Board

Table A2.16 Distribution Board Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Incoming MCCB open / closed status		X		
2	Incoming MCCB tripped		X		
3	Common alarm		X		

A2.19. Transformer Rectifier

Table A2.17 Transformer Rectifier Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	DC voltage			X	
2	DC current			X	
3	Potential to earth			X	
4	Common alarm		X		

A2.20. Thyristor Control Panel

Table A2.18 Thyristor Control Panel Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	Incoming voltage			X	
2	Output current			X	
3	Thyristor over temperature alarm		X		
4	Thyristor over temperature trip		X		
5	Heater element over temperature alarm		X		
6	Heater element over temperature trip		X		
7	Shorted thyristor detection and trip		X		
8	Earth fault trip		X		
9	Cabinet fan failure alarm		X		
10	Common alarm		X		

A2.21. HVAC System

Table A2.19 HVAC Control and Indication

Item No	Source of Signal	Control	Alarm/Status	Measurement	Remarks
1	HVAC running		X		
2	HVAC tripped		X		
3	HVAC system failure		X		
4	Common group fault		X		

APPENDIX A3. ECMS CABINET REQUIREMENTS

A3.1. Scope

This Appendix specifies the minimum requirements for the ECMS cabinet enclosures and components, anti-condensation heaters, wiring, earthing, identification labels and markings, colour coding etc.

A3.2. Normative References:

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60204-1	Safety of Machinery - Electrical Equipment of Machines - Part 1: General requirements.
IEC 60332	Tests on electric and optical fibre cables under fire conditions - All parts.
IEC 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals, conductor terminations and conductors.
IEC 60754-1	Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content.
IEC 61034-2	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements.
IEC 61439-1	Low Voltage Switchgear and Control gear Assemblies - Part 1: General rules.
IEC 61439-2	Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies.

In addition, the ECMS cabinet enclosures and components shall comply with the relevant IEC standards.

A3.3. Enclosure

a. The ECMS cabinets shall be/have:

- i. Fabricated sheet steel.
- ii. Suitable for rack mounted equipment.
- iii. Floor mounted, rigid, self-supporting with a 100 mm plinth.
- iv. A maximum height of 2,100 mm.
- v. A maximum door dimension of 2,000 mm high by 800 mm wide.
- vi. Detachable front and rear lockable doors.
- vii. A degree of ingress protection not less than **IP 31** in accordance with IEC 60529 and IP 2X with the door open. The floor shall not be considered as forming a part of the enclosure.
- viii. Naturally ventilated. Forced ventilation is subject to COMPANY approval. Where forced ventilation is used:
 1. Fans shall be redundant and be provided with replaceable filters.

2. Fans shall be internally fed from the UPS distribution bus.
3. Replacement of fans shall be possible without shutting down the cabinet.
4. A fan failure alarm shall be provided
- ix. Suitable for top and bottom cable entry, unless specified otherwise.
- x. Provided with LED type panel light, operated by a door switch, unless specified otherwise.
- xi. Provided with a socket outlet for laptop connection. Socket circuit shall be equipped with a 30 mA RCCB.
- xii. Equipped with an anti-condensation heater.
- b. Enclosures and doors shall be fabricated of heavy gauge steel of minimum thickness of 2 mm with structural reinforcing members as 3 mm minimum. All enclosures shall be provided with removable lifting lugs, located to ensure the enclosure can be lifted without distortion.
- c. Door mounted metering, protection, and indication components shall be flush mounted.
- d. All door openings shall be provided with gaskets and doors shall open at least 120° with provision for door stay.

A3.4. Wiring and Termination

- a. For the instrument and control cables, wiring, and termination requirements, refer to AGES-SP-04-006.
- b. Wire Conductor material shall be stranded copper.
- c. Minimum conductor size shall be as below.
 - i. Power circuit: 2.5 mm².
 - ii. Control circuit: 1.0 mm².
 - iii. Data communication: Unless otherwise specified the minimum conductor size for data communication shall be as per Table 5 of IEC 60204-1.
- d. Wire insulation shall be:
 - i. 450 / 750 V grade for power circuits.
 - ii. 250 V grade for instruments and controls.
- e. Wiring, including accessories and trunking shall be as below:
 - i. Flame retardant complying with IEC 60332 series standards.
 - ii. Where specified, these shall be low smoke and halogen free complying with the following requirements.
 1. Minimum light transmission value of 60 %, conforming to IEC 61034-2.
 2. Maximum halogen gas emission of 0.5 %, when tested in accordance with IEC 60754-1.
- f. Cables shall be run in trunking. Separate trunking shall be provided within the panel for CONTRACTOR wiring to be completed at site, where terminal blocks are not mounted adjacent to incoming cable entry.

- g. Trunking fill shall be limited to maximum 70 %.
- h. Gland plates shall be undrilled metallic compatible with cable armour and panel material.
- i. Terminals and lugs shall be one of the following:
 - i. Crimped bootlace type lugs.
 - ii. Crimped ring type copper lugs.
 - iii. Screw-less push-in type terminals subject to COMPANY approval.
- j. Wires shall be identified at terminating points using printed heat-shrink sleeves.
- k. 20% spare terminals shall be provided in each section of terminal blocks for future use.
- l. All spare I/O contacts of protection and auxiliary relays shall be wired to terminal blocks and numbered as per SUPPLIER documentation.
- m. Unless the access to live terminals is prevented by interlocking (or otherwise), terminal and lugs at voltage above 110 V shall be shrouded.
- n. Terminal Arrangement and Segregation:
 - i. Knife edge disconnect terminals shall be used to connect all external signal cables.
 - ii. Terminal blocks shall be grouped into separate terminals for internal and external connections.
 - iii. Terminals carrying different voltages shall be segregated.
 - iv. Only one conductor shall be terminated in one side of a terminal.

A3.5. System Components

- a. Where applicable, PCB and/or equipment frames shall be easily removable and indicate their status (failure, functioning etc.) to facilitate fault diagnosis.
- b. I/O boards shall be plug in type and shall be provided with status LEDs for every input and output.
- c. Changing I/O boards shall be possible without switching off the power of the equipment concerned. These shall be hot swappable.

A3.6. Colour Coding and Marking

- a. The colour and marking of actuators (push buttons) shall be in accordance with IEC 60204-1.
- b. The following colour code shall be used:
 - i. Status signal light:
 - 1. On/closed: RED.
 - 2. Off/Open: GREEN.
 - 3. Fault/Trip: YELLOW.
 - 4. Voltage presence: WHITE.
 - 5. Anti-con heater 'on': WHITE.
 - ii. Non-illuminated push button:

1. On/Close/Start: GREEN.
 2. Off/Open/Stop: RED.
 3. Emergency Stop: RED.
 4. Lamp test: BLACK.
 5. Reset: BLUE (if any).
- c. Conductors and terminals shall be in compliance with the IEC 60445.

A3.7. Earthing and Bonding

- a. A separate earth bar shall be provided within the panel for termination of all earth wires.
- b. The earth bar shall be insulated from the back-plate but connected by one earthing conductor to the back-plate. Unless otherwise specified, this bus bar shall have a minimum cross-sectional area in accordance with clause 8.2.2 of IEC 60204-1.
- c. Earthing bus bars and conductors shall be hard-drawn, high-conductivity copper.
- d. A means of earthing the incoming cable glands and the enclosure to this central earthing point shall also be provided.
- e. An earth stud shall be provided on all doors, with earthing straps across hinges.
- f. Panels containing instrument circuits requiring instrument reference earth shall be equipped with a separate instrument earth bar insulated from the enclosure protective earth.
- g. A separate IS earth bar, insulated from both the PE and the instrument earth bar, shall be provided for non-galvanic IS components located in the panel.

A3.8. Labels and Identification

- a. Equipment and components shall be tagged as per the ADNOC tagging and numbering procedure, document reference LATER.
- b. Each equipment and component shall be labelled as per the general arrangement drawings.
- c. Warning labels shall be provided with white characters on a red background for the following.
 - i. Terminals remaining live when a function is isolated.
 - ii. Terminals associated with an external source of supply.
- d. Labels shall be laminated, engraved Traffolyte with black letters on a white background. The text shall be in English language.

A3.9. Anti-Condensation Heater:

- a. Each cabinet shall be equipped with an anti-condensation heater.
- b. The capacity of heaters shall be sufficient to prevent the formation of possible condensation under the service conditions.
- c. Anti-condensation heaters shall:
 - i. Have IP 2X protection.

- ii. Be fitted with a guard.
- d. Anti-condensation heaters shall be controlled by hygrostats.
- e. The heater shall be energised from an external power source at 240V AC, single phase and neutral.
- f. Each heater circuit shall be provided with a manually controlled cut off switch mounted in the cabinet.
- g. Each heater circuit shall be supplied from a residual current circuit breaker (RCCB) equipped with the following:
 - i. 30 mA earth leakage protection.
 - ii. Auxiliary contacts for 'tripped' and status indication.
 - iii. Padlocking facility.
- h. 'Heater circuit live' indication shall be provided by means of white colour LED or lamp.