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INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL ISSUE
A	REVISED WHERE INDICATED
B	REVISED ACCORDING TO DNV LETTER M-AS-RNB/DANISA/P29889-J-247, PAD 0000087/19 AND I-ET-3010.1M-5520-800-P4X-004 - AUTOMATION NETWORK REQUIREMENTS REVISION A.
C	REVISED ACCORDING TO LVC 90% OF BASIC DESIGN
D	REVISED DUE TO CONSISTENCY ANALYSIS
E	REVISED WHERE INDICATED
F	REVISED WHERE INDICATED
G	REVISED WHERE INDICATED
H	REVISED WHERE INDICATED. ITEM 3.3.7 FROM PREVIOUS REVISION WAS REMOVED FROM TEXT.

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	03/09/2019	MAR/19/2020	MAY/25/2020	JUNE/18/2020	JULY/21/2020	FEB/12/2021	MAY/17/2022	SEP/05/2022	DEC/08/2022
DESIGN	ESUP	ESUP	ESUP	ESUP	ESUP	EEI/ESES	EEI/ESES	EEI/ESES	EEI/ESES
EXECUTION	ANDRELB	ANDRELB	ANDRELB	ANDRELB	ANDRELB	KJK9	U4BY	U4BY	U4BY
CHECK	MAFRA	MAFRA	MAFRA	MAFRA	MAFRA	U4BY	CL33	CL33	CL33
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1. OBJECTIVE

1.1. This document presents the general requirements of the Electrical System Automation. Specific requirements for each project, including changes to the requirements presented in this document and the inclusion of new requirements, if any, shall be defined in the Electrical System Descriptive Memorandum of the respective project.

1.2. This specification establishes technical requirements for design, construction, commissioning and tests for the Electrical System Automation.

1.3. This specification describes the interface between the Topside Electrical System equipment and components with the Automation and Control (A&C) System, remote onshore operational center and Telecommunication System of the Unit (indirectly).

1.4. This specification is not intended to describe interfaces between A&C and equipment when these interfaces are not related to Electrical System. For this information, see A&C documentation.

1.5. This technical specification is complemented by the drawing I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

2. REFERENCE DOCUMENTS

Panel design shall comply with requirements of Classification Society, Brazilian Legislation, applicable regulatory rules and standards listed below.

At the design development and for equipment specification, IEC standards shall be used, all on their latest revisions. Exceptionally, where it is clearly justifiable, the ANSI, NEMA, IEEE, VDE and other internationally recognized standards may be used. Their use shall be restricted to specific cases and approved by PETROBRAS.

2.1. PETROBRAS DOCUMENTS

[1] I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM

[2] AUTOMATION AND CONTROL ARCHITECTURE

[3] NETWORK INTERCONNECTION DIAGRAM

[4] I-ET-3010.00-5140-700-P4X-009 - GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS

[5] I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS

[6] I-ET-3010.00-5140-700-P4X-004 - PN-5140001 - POWER MANAGEMENT SYSTEM (PMS) FOR OFFSHORE UNITS

[7] I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS

[8] I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS

[9] I-ET-3010.00-5520-861-P4X-002 - SUPERVISION AND OPERATION SYSTEM - SOS

[10] I-ET-3010.00-5520-862-P4X-001 - PROGRAMMABLE LOGIC CONTROLLERS - PLC

[11] I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS

[12] I-DE-3010.00-5140-741-P4X-001 - FUNCTIONAL UNITS BLOCK DIAGRAMS

[13] I-DE-3010.00-5143-946-P4X-002 - LOW-VOLTAGE SYSTEMS PROTECTION DIAGRAM

[14] I-DE-3010.00-5143-946-P4X-001 - MEDIUM-VOLTAGE SYSTEMS PROTECTION DIAGRAM

[15] I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS

[16] I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS

[17] I-ET-3010.00-5140-772-P4X-001 - MEDIUM-VOLTAGE FREQUENCY CONVERTER FOR OFFSHORE UNITS

[18] I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA

[19] TURBOGENERATOR PACKAGE SPECIFICATION

[20] I-ET-3010.00-5261-700-P4X-001 - EMERGENCY GENERATOR PACKAGE FOR OFFSHORE UNITS

[21] I-ET-3010.00-5262-700-P4X-001 - AUXILIARY GENERATOR PACKAGE FOR OFFSHORE UNITS

[22] I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST

[23] EMERGENCY LOADS LIST

[24] I-DE-3010.00-5140-797-P4X-002 – ELECTRICAL SYSTEM AUTOMATION TYPICAL ACTUATION DIAGRAMS

[25] I-ET-3010.00-1200-321-P4X-001 – TECHNICAL SPECIFICATION FOR CENTRIFUGAL COMPRESSOR DRIVEN BY ELECTRIC MOTOR

[26] HULL WLAN SYSTEM

[27] AUTOMATION NETWORK DESCRIPTION

[28] I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS

[29] ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM

[30] I-ET-3010.00-5520-800-P4X-004 – AUTOMATION NETWORK REQUIREMENTS

[31] I-ET-3010.00-1350-940-P4X-001 – SYSTEMS OPERATION PHILOSOPHY

[32] I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS

[33] I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS

[34] I-ET-3010.00-5140-713-P4X-001 - SPECIFICATION FOR TRANSFORMERS FOR OFFSHORE UNITS

[35] I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS

[36] I-ET-3010.00-5140-772-P4X-002 - SPECIFICATION FOR LOW-VOLTAGE FREQUENCY CONVERTERS, SOFT-STARTERS AND INVERTERS FOR OFFSHORE UNITS

[37] I-ET-3010.00-5140-773-P4X-001 - SPECIFICATION FOR D.C. UPS FOR OFFSHORE UNITS

[38] I-ET-3010.00-5140-773-P4X-002 - SPECIFICATION FOR GENERIC D.C UPS FOR OFFSHORE UNITS

[39] I-ET-3010.00-5140-773-P4X-003 - SPECIFICATION FOR A.C. UPS FOR OFFSHORE UNITS

[40] I-ET-3010.00-5147-332-P4X-001 - TECHNICAL SPECIFICATION FOR TURBOGENERATOR UNIT

2.2. **STANDARDS**

IEEE 802.1D	Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges
IEEE 802.3	Standard for Information Technology - Telecommunication and Information Exchange between Systems - Local and Metropolitan Area Networks - Specific Requirements. Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
IEEE 1613	Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations
IEC 11801	Information technology – Generic Cabling for Customer Premises
IEC 60870-4	Telecontrol Equipment and Systems - Part 4: Performance Requirements
IEC 60068-2-2	Environmental Testing. Part 2-2: Dry Heat
IEC 61000-4-3	Electromagnetic Compatibility (EMC) - Part 4-3: Testing and Measurement Techniques - Radiated, Radio Frequency, Electromagnetic Field Immunity Test
IEC 61000-4-4	Electromagnetic Compatibility (EMC) - Part 4-4: Testing and Measurement Techniques - Electrical Fast Transient/Burst Immunity Test
IEC 61000-4-5	Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge and Immunity Test
IEC 61000-4-6	Electromagnetic Compatibility (EMC) - Part 4-6: Testing and Measurement Techniques - Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields

IEC 61000-4-8	Electromagnetic Compatibility (EMC) - Part 4-8: Testing and Measurement Techniques - Power Frequency Magnetic Field Immunity Test
IEC 61000-4-10	Electromagnetic Compatibility (EMC) - Part 4-10: Testing and Measurement Techniques - Damped Oscillatory Magnetic Field Immunity Test
IEC 61000-4-12	Electromagnetic Compatibility (EMC) - Part 4-12: Testing and Measurement Techniques - Oscillatory Waves Immunity Test
IEC 61000-4-16	Electromagnetic Compatibility (EMC) - Part 4-16: Testing and Measurement Techniques - Test for Immunity to Conducted, Common Mode Disturbances in the Frequency Range 0Hz to 150kHz
IEC 61850	Communication Networks and Systems in Substations (All Parts)
IEC 62439-3	Industrial communication networks – High availability automation networks – Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)
IEC 62381	Automation Systems in the Process Industry - Factory Acceptance Test (FAT), Site Acceptance Test (SAT), and Site Integration Test (SIT)
ISA 18.2	Management of Alarm Systems for Process Industries
EEMUA PUB NO 191	Alarm Systems - A Guide to Design, Management and Procurement
NR-12	Segurança no Trabalho em Máquinas e Equipamentos
NR-10	Segurança em Instalações e Serviços em Eletricidade
NR-37	Segurança e Saúde em Plataformas de Petróleo

3. ELECTRICAL SYSTEM AUTOMATION

3.1. SCOPE OF SUPPLY

3.1.1. All hardware, cables, cable trays, supports, junction boxes, software, licenses, services, accessories, configurations, development of communication drivers and protocols and tests necessary to implement the Electrical System Automation and the interfaces between Electrical System and A&C are included in scope of BIDDER.

3.1.2. All hardware, cables, cable trays, supports, junction boxes, software, licenses, services, accessories, configurations, development of communication drivers and protocols and tests necessary to acquire data from all equipment connected to the Electrical System Automation networks are included in scope of BIDDER.

3.1.3. All hardware, cables, cable trays, supports, junction boxes, software, licenses, services, accessories, configurations, development of communication drivers and protocols and tests necessary to include operation and supervision screens related to the whole databases of Real Time Data Servers are included in scope of BIDDER.

3.1.4. BIDDER shall be responsible for the performance and stability of Electrical System Automation.

3.1.5. BIDDER shall provide the necessary spare parts for the commissioning and pre operation periods.

3.2. GENERAL REQUIREMENTS

3.2.1. Hardware and Software of Electrical System Automation equipment shall assure:

- Operation, control and monitoring from A&C;
- Topside and Hull Electrical System Operation, control and monitoring from Topside Electrical System Automation Operational Workstations;
- Hull Electrical System Operation, control and monitoring from Hull Electrical System Automation Operational Workstation;
- Emergency Electrical System Automation Historian Data Backup through Removable Hot-Swap Solid-State Drive containing updated historian server data located in the Topside Electrical System Automation Operational Workstation to be installed in CCR;
- Topside Operational Portable Devices shall provide Control and supervision of Topside and Hull Electrical System through the panels rooms access points and through the Unit's wireless network. Unit's wireless network shall provide connection to the Electrical System Automation DMZ Servers;
- Hull Operational Portable Devices shall provide control and supervision of Hull Electrical System through the panels rooms access points and through the Unit's wireless network. Unit's wireless network shall provide connection to the Electrical System Automation DMZ Servers;
- Topside and Hull Operation, control and monitoring from Remote Onshore Operational Center through remote access to the Electrical System Automation Operational Workstations;
- Topside and Hull Operation, control and monitoring from Remote Onshore Operational Center HMI and OPC UA Client through its connection to the HMI server installed in the Electrical System Automation DMZ Servers;
- The Electrical System Automation Operational Workstations shall allow multiple users simultaneously in order to enable Remote Access and local operation independently;
- Providing Network Infrastructure for the IEC 61850 interlock and protection functions among the IEDs based in this standard with minimum requirements as described in the item 3.5;
- Exchange all data required by the Power Management System (PMS) according to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST. Electrical System Automation RTDSs shall be capable of reading/write all memory map from PMS OPC UA client/server to provide alarms and event logging among other functions.

- Parameterization, adjusting and configuration of all electric equipment connected to the Electrical System Automation networks from Topside Electrical System Automation Maintenance Workstations.
- Parameterization, adjusting and configuration of all electric equipment connected to the Electrical System Automation networks from Hull Electrical System Automation Maintenance Workstations.
- Parameterization, adjusting and configuration of all electric equipment connected to the Electrical System Automation networks from Remote Onshore Operational Center through remote access to the Electrical System Automation Maintenance Workstations.
- Parameterization, adjusting and configuration of Real Time Data Servers from Remote Onshore Operational Center through remote access to the Electrical System Automation Real Time Data Servers.
- Secure protocols. It shall be avoided protocols that are considered not secure as, for example: HTTP, FTP and TELNET.
- Secure databases. For shared databases the instances shall be segregated with access control for each instance or application.

3.2.2. The Electrical System Automation equipment shall be fed by redundant UPS feeders according with the document EMERGENCY LOADS LIST.

3.2.3. The interconnection between IEDs (MMRs) and switches internal to electric panels (LV or MV switchgears or MV MCCs), including the interconnection between the switches internal to these panels, shall be made through optical fiber cables by using patch cords.

3.2.4. The interconnection between automation equipment inside of a panel, in exception of LV or MV switchgears or MV MCCs, such as IED's (IRs), switches or CPU, shall be through, at least, unshielded Twisted Pair (UTP) CAT6A cables. Provisions shall be taken in order to avoid electromagnetic interference, protecting the system against data and communication losses. Proper shielded cable (STP) shall be considered whenever electromagnetic interference risks to affect the quality of service. These connections shall be through patch panels and cross-connect-interconnection.

3.2.5. The interconnection between different panels and equipment shall be done through optical fiber multicables using DIO at each end of the fiber optical cable. Multicables shall have additional spare optical fibers connected to the DIO. Optical patch cords shall be used, inside the panels, between the DIOs and the switch or media converter (GigaEthernet RJ-45 electrical to optical termination). All switches and media converters shall be compatible with switches and media converters of ESA system.

3.2.6. Exceptions to item 3.2.5 shall be submitted to Petrobras approval. In these cases the interconnection between different panels or equipment shall be made through CAT6A cables. Provisions shall be taken in order to avoid electromagnetic interference, protecting the system against data and communication losses. Proper shielded cable (STP) shall be considered whenever electromagnetic interference risks to affect the quality of service. Exceptions to item 3.2.5 shall fulfill all following conditions simultaneously:

3.2.6.1. The distance between panels or equipment does not exceed 100 meters according to IEC 11801;

3.2.6.2. The cable does not cross outdoor area;

3.2.6.3. It is proven that it is not technically possible to use optical fibers.

3.2.7. All network cables (Optical or Metallic), patch cords (Optical or Metallic) and accessories (DIO, patch panels, etc.) shall follow requirements from I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

3.2.8. In addition to 3.2.7, LC connectors are acceptable as recommended by IEC 61850 network engineering guidelines.

3.2.9. In addition to 3.2.7, fiber optic cables with 4 cores are allowed if only one core pair of that cable is used.

3.2.10. Switches and media converters shall follow requirements from I-ET-3010.00-5520-800-P4X-004 – AUTOMATION NETWORK REQUIREMENTS in addition to any other requirements presented in this document.

3.2.11. Cables and patch cords shall be pulled, interconnected, tested and certified according to I-ET-3010.00-5520-800-P4X-004 – AUTOMATION NETWORK REQUIREMENTS.

3.2.12. All switches belonging to the Electrical System Automation Networks shall be manageable switches.

3.2.13. Hull and Topside Maintenance Workstations shall include, each, one license of Network Management Software capable of managing at least, the double of nodes of the respective Topside or Hull network devices.

3.2.14. All equipment related to the Electrical System Automation shall be supplied with its respective management information base (MIB) in order to provide network supervision by using the SNMP version 3 protocol.

3.2.15. The Electrical System Automation shall be supplied as a PLC+SCADA system.

3.2.16. The ESA supervisory system shall have the following performance requirements:

3.2.16.1. Hot standby switchover time between redundant RTDS's and DMZ servers shall not exceed five (05) seconds. During switchover, Supervisory Software shall not be unavailable for more than five (05) seconds.

3.2.16.2. Data reading by the communication drivers shall be executed in configurable time intervals equal to or less than one (01) second.

3.2.16.3. HMI update response time from field inputs: maximum 2 seconds.

3.2.16.4. Operator outputs to field response time, from HMI to output terminal: maximum 2 seconds.

3.2.16.5. Bad quality data indication: maximum 2 seconds.

3.2.16.6. Delay from requesting a screen display to its appearance at the HMI: maximum 3 seconds.

3.2.16.7. Update time for dynamic data in an already open display: maximum 2 seconds.

3.2.16.8. Time delay between operator keyboard input and data display at HMI: 0.1 second.

3.2.16.9. It shall be possible to configure ESA supervisory system (screens and database) without interrupting running applications.

3.3. HARDWARE REQUIREMENTS

3.3.1. All electrical devices, like panels, cards, terminations, controllers, switches, workstations, HMIs, etc., shall be proper for marine industrial installation and for 24 hours operation, 7 days per week, including inclination and vibration requirements defined by Classification Society. The minimum protection degree, tropicalization requirements and ambient temperature requirements shall comply with I-ET-3010.00-5140-700-P4X-009 - GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

3.3.2. All panels shall be proper for indoor installation, floor mounted, with front access for all services, without necessity of rear access.

3.3.3. All panels and enclosures for Electrical System Automation shall be light green (MUNSELL notation 5 G 8/4). Inner components mounting plate and/or inner door/safety barrier of Electrical Panels shall be safety orange (MUNSELL notation 2.5 Y R 6/14).

3.3.4. Dimensions and weight of Electrical System Automation panels and cabinets shall be proper to installation and handling at the installation location.

3.3.5. All interface signals shall be fail-safe, so that any failure in the equipment that generates the signal leads the equipment that receives the signal to safe condition.

3.3.6. All communication devices (switches, controllers, IEDs, etc.) shall be defined as class 1 according to IEEE std 1613 and shall be tested according to this standard.

3.3.7. Only industrial server grade computers shall be used for the Electrical System Automation Real Time Data Servers. Only industrial workstation grade computers shall be used for the Electrical System Automation Operational Workstations and Maintenance Workstations. All other equipment shall be suitable for industrial environment. It shall not be supplied any refurbished or used equipment.

3.3.8. All CPU cabinets shall have internal shock absorbers to protect the internal components from balance movements and vibration.

3.3.9. All computers shall be powered by dual power supplies, each one to be fed by a different UPS.

3.3.10. All hardware shall be of the most recent model at purchase time.

3.4. SOFTWARE REQUIREMENTS

3.4.1. All servers/workstations shall have security mechanisms (firewall, antivirus, etc.), including the applicable security requirements from the document AUTOMATION NETWORK DESCRIPTION.

3.4.2. The supervision and control software shall have built-in facilities to perform alarm acknowledgement from one single workstation to all other workstations. Additional scripts to perform this function shall not be acceptable.

3.4.3. The supervision and control software shall have facilities to implement hot standby function. The standby system shall run applications simultaneously identically to the active system, sharing the same data. Upon a failure of the active system, the hot standby system shall replace the primary system immediately.

3.4.4. The supervision and control software shall have built-in configuration mechanisms to define logic layers of operation, based on definition of users.

3.4.5. The supervision and control software shall be able to ordinate alarms annunciation in most recent and in most priority orders.

3.4.6. All software shall be furnished in their most recent versions at purchase time, accompanied by their corresponding licensing, installation media(s) and manuals, as well as with one year of technical support and maintenance. Demo versions and under development shall not be accepted.

3.4.7. It shall be possible to update and correct software's security vulnerabilities at any operational time. Vendor shall provide information and assistance in case of software discontinuity.

3.4.8. It shall be possible to generate the following logs in order to Operational Team send to SIEM: services status, authentication, scheduling services, network communication, devices connections (external medias), element configuration changes, privileges elevation, accounts manipulation (creation, exclusion) and groups manipulation (creation, exclusion).

3.4.9. It shall be supplied Microsoft® Office Software at its latest version for all computers.

3.4.10. It shall be forbidden the use of Hardcoded passwords (passwords that cannot be changed).

3.5. COMMUNICATION REQUIREMENTS

3.5.1. Network communication among Electrical System Automation Controllers, Real Time Data Servers, Functional units of MCCs Intelligent Relays (IR), Multifunction Microprocessed Relays (MMRs), VSDs (Variable Speed Drives), soft-starters, Power Quality Monitoring Systems (PQMS), ground fault relays and other electrical equipment shall be according with I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

3.5.2. All Electrical System Automation components and electric equipment shall communicate in the defined protocol without use of gateways or converters.

3.5.3. All Electrical System Automation components, including IEDs (IRs and MMRs), Switches, Controllers, VSDs, soft-starters, PQMS, among others, shall be parameterized through the existing Ethernet connection by the standard manufacturer software and by Web Browser (when the device has such functionality) available in the Electrical Automation Maintenance Workstation.

3.5.4. All network equipment shall be capable of communicating in the SNMP protocol for network and network equipment supervision purposes.

3.5.5. The Electrical System Automation Ethernet networks shall be as follow: 100Mbps minimum, full duplex.

3.5.6. Each Electrical System Automation Ethernet network, for example the Topside/Hull IEC 61850 Ethernet Network, shall not be connected to any other network, for example the Topside/Hull Multipurpose Ethernet Network.

3.5.7. The Electrical System Automation networks shall be independent and physically separated from all other existent networks on the Unit and with security mechanism in order to prevent external attacks and data losses.

3.5.8. The Electrical System Automation Ethernet network shall be formed by a group of independent networks which are physically separated from each other according to its functionality. The Electrical System Automation Ethernet networks shall comprise at least the following networks;

3.5.8.1. Topside and Hull IEC 61850 Ethernet Networks dedicated to the IEC 61850 standard based devices.

3.5.8.2. Topside and Hull MCC Ethernet Networks to interconnect the MCC IEDs. The network can be subdivided in more networks if required by protocol limitations of number of devices or bandwidth consumption due to the quantity of IRs to be interconnected;

3.5.8.3. Topside and Hull Multipurpose Ethernet Networks to interconnect other equipment or mixed protocol equipment.

3.5.8.4. Topside and Hull Electrical System Automation Controllers Ethernet Network to interconnect the Electrical System Automation Controller parts when required (Redundant PLCs, Remote I/Os, etc.) and to interconnect this equipment to the RTDSs (Control and Supervision), Maintenance Workstations (engineering and parameterization) and to the PMS (PMS only for Topside Electrical System Automation Controllers);

3.5.8.5. Topside and Hull Ethernet HMI/OPC UA Network in order to interconnect HMI clients and OPC UA clients to the RTDSs. This network also has the purpose of providing communication for control and supervision from Hull RTDSs (OPC UA Server) to Topside RTDSs (OPC UA Client).

3.5.8.6. Topside and Hull A&C Interface Ethernet Networks in order to interconnect Electrical System Automation Equipment to the Topside and Hull Package Units LAN from A&C.

3.5.8.7. MODBUS TCP Peer-to-Peer network among Topside and Hull Electrical System Automation Controllers in order to provide communication for control and supervision from Hull Electrical System Controllers (Server) to Topside Electrical System Automation Controllers (Client).

3.5.9. Interfaces among the Electrical System Automation Ethernet network shall be as follows:

3.5.9.1. Connection to A&C controllers shall be made through the Electrical System Automation Controllers by MODBUS TCP connection. The controllers will acquire data from the Electrical System Automation Networks in the defined protocols and provide the data to A&C network in the protocol defined in I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

3.5.9.2. Connection to SOS network shall be made through the Topside/Hull A&C Interface Ethernet Networks. The RTDSs will acquire data from the Electrical System Automation Networks using dedicated network cards in the defined protocols and provide the data to SOS network in OPC UA using another dedicated network card (A&C IP range) connected to this network as defined in I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

3.5.9.3. The connection related to monitoring and engineering from remote onshore operational center shall be made through the Topside and Hull A&C Interface Ethernet Networks by dedicated network cards from the Topside and Hull Electrical System Automation Operational Workstations, Electrical System Real Time Data Servers and Electrical System Automation Maintenance Workstations as defined in I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

3.5.10. As recommendations of IEC 61850-5, the Logical Nodes shall be used. Use of Generic Process I/O (GGIO) is acceptable only in case of non-existent standard Logical Nodes.

3.5.11. The Topside/Hull Electrical System Automation Controllers shall be able to communicate with all foreseen protocols at the Multipurpose Ethernet Network. The Topside/Hull Electrical System Automation Controllers shall have at least one Communication Card/Interface to be connected to the Multipurpose Ethernet Network for each protocol per redundant equipment.

3.5.12. The Topside/Hull Electrical System Automation RTDSs shall be able to communicate with all foreseen protocols at the Multipurpose Ethernet Network. The Topside/Hull Electrical System Automation RTDSs shall have communication drivers for each protocol per RTDSs.

3.5.13. IEC 61850, CCM Relays and Multipurpose Networks shall have, at least, the following VLANs: VLAN 2 for communication between topside IEDs, VLAN 3 for communication between Hull IEDs and VLAN 1 for communication of the electrical system automation RTDSs, Electrical System Automation Controllers, Time Servers, PMS and Maintenance Workstations with all devices, including IEDs, Switches and other equipment. Communication among Topside and Hull IEDs shall be avoided by the use of the VLANs above in exception of primary and secondary sides of Hull transformers fed from Topside.

3.5.14. The relays for protection of primary and secondary sides of Hull transformers fed from Topside shall be capable of communicating with both VLANs 2 and 3 besides the other applicable VLANs.

3.5.15. The Electrical System Automation Maintenance Workstations shall be allowed to access and collect all oscillography records, data logger files, event records and alarms generated internally to any electrical equipment connected to ESA according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

3.6. NETWORK PERFORMANCE

3.6.1. The total transmission time consists of the sum of individual times of the communication processors and the network transfer time, including waiting times and time used by switches and other devices that are part of the complete network.

3.6.2. The total transmission time for functions like trip, request for interlock, intertrips and logic discrimination between protection functions of MMRs shall be less than or equal to 3ms.

3.6.3. The total transmission time for “close”, “open,” “start”, “stop”, “block”, “unblock”, “release”, etc. shall be less than or equal to 20ms.

3.6.4. The total transmission time for less critical messages shall be less than 100ms.

3.6.5. These times are minimal requirements, and may be revised by Detailed Design, according to stability studies, for data that affect the stability of the electrical system (data related to load sharing, shedding, synchronization, etc.).

3.7. SYSTEM RELIABILITY

3.7.1. A failure of any component shall not result in an undetected loss of functions nor multiple and cascading component failures. There shall be no single point of failure that would cause the electrical system to be inoperable.

3.7.2. For redundant communication elements, there shall be no single failure mode that would disable both redundant elements.

3.7.3. A failure in the automation system shall not disable any available local metering and local control function of the electrical system.

3.7.4. The reliability class severity shall be R3 according to IEC 60870-4.

3.8. SYSTEM AVAILABILITY

3.8.1. Increasing error rates shall not cause a sudden system outage, but result in graceful degradation.

3.8.2. The availability class severity shall be A3 according to IEC 60870-4.

3.9. SYSTEM MAINTAINABILITY

3.9.1. The maintainability class severity shall be M4 according to IEC 60870-4.

3.9.2. The repair time class shall be RT4 according to IEC 60870-4.

3.9.3. BIDDER shall provide a list of test equipment and quantities of replacement parts deemed necessary for the maintainability class above.

3.10. DATA INTEGRITY

3.10.1. The data integrity class shall be I3 according to IEC 60870-4.

3.11. ELECTROMAGNETIC COMPATIBILITY (EMC)

3.11.1. Regarding induced disturbances, all electrical automation equipment shall meet IEC 61000-4-6 class 3.

3.11.2. Regarding surges, all electrical automation equipment shall meet IEC 61000-4-5 class 4 with wave forms 1.2/50µs and 10/700µs and peaks up to 4kV.

3.11.3. Regarding oscillatory waves, all electrical automation equipment shall meet IEC 61000-4-12 class 3 and common mode disturbances up to 150 kHz as per IEC 61000-4-16 level 4. Data communications and signal circuits shall be tested only in common mode, but at the same surge magnitude as specified for transverse mode tests, according to IEC 61850-3.

3.11.4. Regarding fast transients, all electrical automation equipment shall meet IEC 61000-4-4 class 4, or above. In addition, power supply circuits shall be tested with transverse mode applied voltages, according to IEC 61850-3.

3.11.5. Regarding electromagnetic disturbances, all electrical automation equipment shall meet IEC 61000-4-3 class 3.

3.11.6. Regarding damped oscillatory magnetic, all electrical automation equipment shall meet IEC 61000-4-10 level 5.

3.11.7. Regarding power frequency magnetic field, all electrical automation equipment shall meet IEC 61000-4-8 level 5 for continuous and short duration fields.

3.11.8. All electrical automation equipment shall operate correctly in the presence of a power frequency voltage in accordance with table 1 of IEC 61850-3.

3.12. BASE TIME REQUIREMENTS

3.12.1. MMR synchronization for control and protection events shall comply with time performance class T1 (accuracy ±1ms) according to IEC 61850-5.

3.13. ALARM AND EVENTS MANAGEMENT SYSTEM

3.13.1. The Alarm Management System shall achieve the following goals:

- Maximum of 100 (one hundred) alarms during 10 minutes under abnormal condition;

- Alarm rate greater than 30 (thirty) alarms/hour during, at maximum, 5% of the day.

3.13.2. The Alarm Management System shall include self-diagnostic check of each component of the Electrical System Automation, including switches, controllers and its individual cards/interfaces, servers, workstations, time servers, I/O racks, communication modules, among others, generating UAM and UAS alarm signals to the Electrical System Automation Real Time Data Servers.

3.13.3. An Alarm Management System shall be configured and implemented based on ISA 18.2 and on Guide EEMUA PUB NO 191, separating alarms to operators according to the priority levels and with recommended actions related to each alarm.

3.13.4. All alarms and events signals available in the equipment's memory map of equipment marked with note 19 in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST shall be recorded and displayed in the ESA Operational Workstations screens.

3.14. DOCUMENTATION

3.14.1. Manufacturer's documentation is an integral part of the order, which shall not be considered complete until the full documentation has been delivered as required in the purchase requisition.

3.14.2. All reference manuals and reports, shall be provide, in at least, two copies in English language and two copies in Brazilian Portuguese language and comply with NR-12 requirements.

3.14.3. Complete documentation of the system, covering all devices and services, shall be supplied with the proposal, for approval, and for final acceptance.

3.14.4. It shall be supplied with the proposal at least the following technical documents:

- Technical specifications, data sheets and brochures comprising: hardware, software, cables, materials and accessories, cables, materials and software;
- Electrical System Automation Preliminary architecture with all Electrical System Automation devices;
- Material list, equipment list, spare part list, power consumption list, weight list and panel layout, system layout, etc. for all Electrical System Automation equipment and installation;
- Complete description of services, training courses, tests, etc.;
- Deviation list related to this Technical Specification, including reason for deviation, alternative proposals and impacts in performance and cost;
- Dimensional drawings of frontal and lateral views and transversal section of the panels;
- List of applicable standards for design, fabrication and tests;
- Data sheet filled out and signed by the manufacturer.

3.14.5. There shall be supplied for approval at least the following technical documents:

- Dimensional drawings with views, cross sections and gravity center;
- Details of transportation, assembling and grounding;
- Details of cable entries and free space for installation;
- Control and wiring (interconnection) functional schemes indicating all the terminal blocks, including those necessary for interconnection to other equipment not supplied by the Manufacturer, showing clearly the identified terminals;
- Complete list of all Electrical System Automation equipment/components indicating, at least, the TAG, part number, description, the quantity and manufacturer's complete codification;
- Electrical System Automation architecture with all devices;
- Technical specifications comprising: hardware, software, cables, materials and accessories;
- Warranty certificate and declaration of availability of spare parts for 10 (ten) years;
- Data sheets and drawings for all equipment;
- All HMI screens developed for the supervision and control of the Electrical System Automation Operational Workstations
- Installation drawings including general arrangement, electrical diagrams, wiring diagrams, cable list, material list, electrical certificates and equipment list;
- List of all alarms and events of electrical system classified by criticality;
- Factory and Site test procedures;
- Communication List from Electrical System Automation Controllers and RTDSs to electrical equipment;
- Electrical System Automation Controllers MEMORY MAP;
- Electrical System Automation RTDSs MEMORY MAP.
- ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST revised and complemented, including all signals exchanged between Electrical System equipment, Electrical System Automation, Packages, A&C, TGCPs and PMS.
- Instructions regarding necessary configuration to be implemented in Firewalls in order to provide all required functionalities to the Electrical System Automation DMZ Servers.
- Instructions regarding necessary configuration to be implemented in each ESA equipment.
- Network hook up considering typical details for DIOs, Patch Panels, fiber arrangement, equipment fixation, cable termination and other installation details according to requirements of I-ET-3010.00-5520-800-P4X-004 – AUTOMATION NETWORK REQUIREMENTS.

- Network maps with port distribution for Patch Panels and DIO informing, at least, port, cable tag, from/to (equipment with description) and reference drawing.

3.14.6. The Electrical System Automation operation, installation and maintenance manual shall be sent for approval before factory acceptance test.

3.14.7. The Electrical System Automation operation, installation and maintenance manual shall contain, at least, the following information:

- All approved document filled out “as purchased” and/or "as built";
- The Electrical System Automation storage procedures, as well as any other spare part elements;
- Procedures for transportation and assembling;
- Rules and standards used as references to the design and construction;
- Technical data in catalogues, brochures, manuals and prospects of all equipment, components, material and software with detailed description of the equipment and accessories;
- Procedures for operation, including warning conditions as, for example, risks arisen from changes or bypass of protections and security devices and risks from uses different of those foreseen by the design;
- Procedures to be adopted in case of emergency conditions;
- Indication of the lifespan of equipment and components;
- All test reports approved;
- Complete software’s documentation;
- Schedule to replace all equipment/component of Electrical System Automation;
- Software documentation (installation, operation, configuration, licenses, etc.);
- List of necessary tools for maintenance of equipment;
- Programming tools, system reports, system diagnosis, etc.;
- Training course program and services schedule;
- Complete codes of all programs related to Electrical System Automation, including comments;
- Complete project file for the HMI screens development;
- Complete documentation of network addresses and protocols;
- Network cable list, including cable TAGs, and network interconnection diagrams including interconnection ports of devices for all network cables regarding the Electrical System Automation and its interfaces;
- Switches and other network components parameterization reports;
- Network configuration report from the Network Management Software supplied with the Electrical System Automation Maintenance Workstation;

- Foreseen MTTR (Mean Time to Repair) for each equipment;
- Technical reports with performance requirements, including check of items 3.7.4, 3.8.2 and 3.9.2;
- Test reports complying with items 3.10.1, 3.11, 3.12.1, 4.1.5.1, 3.6.2, 3.6.3 and 3.6.4;
- Conformance tests certificates according to IEC 61850-10 for equipment working with IEC 61850.

3.14.8. Manufacturer is obliged to deliver the documentation together with, or before delivery of the equipment in order to allow proper checking before final acceptance of the equipment.

3.14.9. After complete installation, site test and commission, “as built” versions for all documents listed in items above shall be supplied. The Electrical System Automation operation, installation and maintenance manual shall be complemented with the following documents:

- Configuration files related to MMRs, according to IEC 61850-6;
- Configuration files related to IRs;
- IED Capability Description (.ICD) files for all MMRs;
- System Configuration Description (.SCD) files related to the whole electrical system;
- Electrical System Controllers programs;
- Switches configuration files;
- HMI configurations files;
- HMI screens backups;
- Workstations backups;
- Portable Devices backups;
- All other Electrical System Automation equipment configuration files or backups.

4. ELECTRICAL SYSTEM AUTOMATION MAIN COMPONENTS

4.1. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION PANEL

4.1.1. GENERAL REQUIREMENTS

4.1.1.1. The Electrical System Automation Panel shall include Electrical System Automation equipment such as switches, controllers, I/O cards/interfaces, servers, terminations. It shall be acceptable segregation for these equipment in separate cabinets.

4.1.1.2. The Electrical System Automation Panel shall have spare input and output points and nodes according to requirements for A&C controllers.

4.1.1.3. All output contacts shall be sized for the making and breaking capacity required by the respective loads. The use of interposing relays shall be limited to multiplication of contacts and for cases where the output contact has no capacity to switch the load. These cases shall be submitted to PETROBRAS approval.

4.1.1.4. The control voltage for interposing relays (when approved) shall be the same control voltage of the respective functional units.

4.1.1.5. There shall be as many individual switches as necessary for each network, keeping the redundancy requirement.

4.1.1.6. The Electrical System Automation Panel and its components shall be fed by redundant UPS feeders.

4.1.2. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION CONTROLLERS

4.1.2.1. The Electrical System Automation Controllers shall establish the connection to A&C controllers in order to provide control and monitoring data among equipment of Electrical System Automation and A&C equipment, converting protocols, without impacting in the Electrical System Automation performance.

4.1.2.2. The Hull Electrical System Automation Controllers (Server) shall establish the connection to Topside Electrical System Automation Controllers (Client) in order to provide control and monitoring data from Hull equipment to Topside Electrical System Controllers in parallel to Hull A&C controllers. This connection shall be used to supply control of the Hull equipment to Topside A&C controllers.

4.1.2.3. Electrical System Automation Controllers shall be constituted of redundant, hot-standby PLCs. PLCs shall not present any common mode fault and shall have facilities for hot-swap.

4.1.2.4. The Electrical System Automation Controllers hardware shall be able to communicate in the IEC 61850 standard natively, without use of external converters or gateways.

4.1.2.5. The Electrical System Automation Controllers hardware shall be able to communicate in all other Ethernet protocols defined in the I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM natively, without use of external converters or gateways.

4.1.2.6. The Electrical System Automation Controllers shall include as many communication cards/interfaces as necessary in order to communicate with all Electric Equipment.

4.1.2.7. The Electrical System Automation Controllers shall have at least 1 (one) communication card/interface per redundant controller for each protocol to be connected to the Multipurpose Ethernet Network.

4.1.2.8. The Electrical System Automation Controllers shall support as many simultaneous client connections as necessary in order to provide all functionalities.

4.1.2.9. Scan time of Electrical System Automation Controllers shall be such as to perform any function in less than 200ms.

4.1.2.10. The Electrical System Automation Controllers hardware requirements shall follow requirements from I-ET-3010.00-5520-862-P4X-001 - PROGRAMMABLE LOGIC CONTROLLERS - PLC.

4.1.2.11. The hardware requirements shall be updated during Detailed Design according to technology development and shall be presented to PETROBRAS approval.

4.1.2.12. Each Electrical System Automation Controller shall have an individual circuit-breaker. If each Electrical System Automation Controller is comprised by more than one controller rack, each rack shall have and individual circuit-breaker.

4.1.2.13. Topside Electrical System Controllers shall be capable of communicating in the Manufacturer's Standard Ethernet TCP/IP Protocol of the PMS controllers.

4.1.3. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION REAL TIME DATA SERVERS

4.1.3.1. The Electrical System Automation Real Time Data Servers (RTDSs) shall be supplied as industrial server grade computers for use in offshore environmental conditions with at least 8 (eight) Gigabit Ethernet network interface cards. Processor type, internal drive space and memory shall be according to the use of the necessary software in its maximum performance configuration. The use of extra network interface cards shall be evaluated during detail engineering design phase depending on the number of networks to be connected and supervisory software redundancy strategy. No mechanical drives are allowed (as hard disks), only solid-state drives.

4.1.3.2. All servers shall operate with processor loading and memory usage below 40% under normal operation and with no more than 70% when under system stress, such as during alarm storm, simultaneous accesses from all clients or a high amounts of alarm acknowledgment ("ACK ALL").

4.1.3.3. The Electrical System Automation RTDSs shall be installed in server 19" racks, properly housed inside the Electrical System Automation Panel.

4.1.3.4. The Electrical System Automation Real Time Data Servers (RTDSs) shall include specific software for Operation, Monitoring and Historian of the electrical system equipment and components, including HMI servers, Historian Servers, OPC UA Servers and communication drivers for all equipment to be controlled or monitored in the electrical system.

4.1.3.5. The Topside Electrical System Automation RTDSs shall include an OPC UA Client compatible with HULL Electrical System Automation RTDSs OPC UA Server in order to be able to read and write all data available. This communication shall be used to provide control and monitoring from Hull equipment to Topside Electrical System Automation Operational Workstation and Topside Electrical System Automation Operational Portable Devices.

4.1.3.6. Topside/Hull Electrical System Automation RTDSs shall include OPC UA Clients and Servers compatible with PMS (Topside RTDS), TGCP (Topside RTDS) and HGCP (Hull RTDS) OPC UA Clients and Servers in order to be capable of reading and writing all data.

4.1.3.7. Topside Electrical System Automation RTDSs shall be able to integrate PMS database in Topside Electrical System Automation RTDSs database in order to supply PMS supervision and control to Topside Electrical System Automation Operational Workstations and Operational Portable Devices.

4.1.3.8. Topside/Hull Electrical System Automation RTDSs shall be able to integrate TGCP (Topside RTDS) and HGCP (Hull RTDS) database in the respective database in order to supply TGCP and HGCP supervision to Topside/Hull Electrical System Automation Operational Workstations and Operational Portable Devices.

4.1.3.9. The Topside Electrical System Automation RTDSs HMI server software, Topside Electrical System Automation Operational Workstation and Portable devices shall include Hull custom screens, in addition to Topside related equipment screens, in order to provide Hull control and monitoring developed in the same HMI software used for Topside control and monitoring. It shall not be accepted the development of Topside and Hull screens in the Topside Electrical System Automation RTDSs by using different HMI software for this requirement.

4.1.3.10. The Electrical System Automation RTDSs shall be connected to Electrical Automation Networks according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

4.1.3.11. Electrical System Automation RTDSs main functions are:

- Real-time communication in order to read/write data from/to all Electrical System Automation Equipment and A&C (OPC UA Client/Server);
- Historical alarms, trends and events collection and archiving;
- Providing HMI function for Electrical System Operational Workstations for control, monitoring and historian purposes.

4.1.3.12. The Electrical System Automation Real Time Data Servers shall have mirrored solid state drives, as a minimum requirement (RAID1 configuration).

4.1.4. ELECTRICAL SYSTEM AUTOMATION DMZ SERVERS

4.1.4.1. It shall be provided the Electrical System Automation DMZ Servers, which will obtain supervision and historian data from the Electrical System Automation RTDSs installed in the Electrical System Automation Panels.

4.1.4.2. All servers shall operate with processor loading and memory usage below 40% under normal operation and with no more than 70% when under system stress, such as during alarm storm, simultaneous accesses from all clients or a high amounts of alarm acknowledgment (“ACK ALL”).

4.1.4.3. Hardware requirements shall be equal to the requirements for the Electrical System Automation RTDSs, in exception of the number of network ports which shall be that exactly the number of connection to the firewall.

4.1.4.4. Electrical System Automation DMZ Servers shall provide supervision and control to Onshore Operational Center Electrical System Operational Workstation HMI client and to Portable Operational Devices HMI client connected to the Unit wireless network.

4.1.4.5. Remote access to ESA equipment from DMZ shall be allowed only if the following requirements are complied with:

- Strong authentication (double factor minimum) shall be used;
- Beginning and Ending logs shall be recorded for every session and all connection shall have user and device identification of access destination;

4.1.4.6. Electrical System Automation DMZ Servers shall provide data to the A&C PI Server through a PI Collector Software.

4.1.4.7. Software installed in the Electrical System Automation DMZ Servers shall include, at least, the HMI software Client/Server, OPC UA Client/Server, Historian Software Client/Server and PI collector software.

4.1.4.8. It shall be supplied any other additional software necessary in order provide all functionalities required to the Electrical System Automation DMZ Servers.

4.1.4.9. All data of the Electrical System Automation DMZ Servers shall be obtained from the Electrical System Automation RTDS through the Firewall connection, not being allowed to communicate directly with other Electrical System Automation equipment or network. Direct connection of the Electrical System Automation DMZ Servers to the Electrical System Automation Networks shall not exist. For details about Firewall interconnection see the document NETWORK INTERCONNECTION DIAGRAM.

4.1.4.10. It shall be provided mechanical protection with lock against any unauthorized access to the Electrical System DMZ Servers and to its network connections (i.e. a cage comprising the DMZ servers and related F.O. Patch Panels within the panel).

4.1.4.11. Network and firewall security rules and mechanisms shall be implemented by Telecom in order to provide cybersecurity to the system.

4.1.5. ELECTRICAL SYSTEM AUTOMATION TIME SERVER

4.1.5.1. The Electrical System Automation Time Servers shall carry out the base time synchronization among Electrical System Automation equipment and all equipment connected to the Electrical System Automation Networks using SNTP (Simple Network Time Protocol) technology.

4.1.5.2. Electrical System Automation Time Server shall be composed by as many time servers and antennas as necessary, to interconnect all equipment according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

4.1.5.3. The Electrical System Automation Time Server must be capable of supplying time synchronization for segregated networks simultaneously in order to synchronize each Electrical System Automation Network and A&C Network.

4.1.5.4. Each redundant Time Server shall have its own antenna and related accessories.

4.1.5.5. GPS antennas and accessories to be installed in external area shall follow the hazardous area requirements for equipment that shall be kept operating during emergency shutdown ESD-3P and ESD-3T of I-ET-3010.00-5140-700-P4X-009 - GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.1.6. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION WIRELESS NETWORK ACCESS POINT

4.1.6.1. Electrical System Automation shall include a Wireless Network to be designed according to requirements from HULL WLAN SYSTEM documentation.

4.1.6.2. Main hardware components comprising the Electrical System Automation Wireless Network Access Point, for example the Wireless Controller, shall be installed in the Electrical System Automation Panel.

4.1.6.3. Each room containing CDCs or MCCs in the unit shall have Wireless Network Access Points to provide connection to the Ethernet HMI/OPC UA Network.

4.1.6.4. The function of this Wireless Network shall be to provide communication among Topside/Hull Electrical System Automation Operational Portable Devices and Electrical System Automation RTDSs for supervision and control from portable devices.

4.1.7. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION SWITCHES

4.1.7.1. The Electrical System Automation Switches shall be comprised of groups of redundant Ethernet switches, according to item 3.5.5, and shall be used to control data transference among the IEDs, Electrical System Automation Real Time Data Servers, Electrical System Maintenance Workstation, Electrical System Controllers, Electrical System Time Server, PMS, VSDs, SSs, and others. There shall be also a group of redundant switches intended to provide interconnection between the Electrical System Automation Maintenance Workstations, Electrical System Automation Operational Workstations, Electrical System Automation RTDSs, PMS and A&C Package Units Lan.

4.1.7.2. These switches shall be arranged and connected in order to constitute, at least, the networks defined in item 3.5.8.

4.1.7.3. There shall be as many individual switches as necessary for each network, keeping the redundancy requirement.

4.1.7.4. The quantity of switches connections shall be designed considering 20% of the total quantity of required connections of each switch (20% connections as spare).

4.1.7.5. All switches shall allow Ethernet (IEEE 802.3) ports to communicate simultaneously with more than one VLAN.

4.1.7.6. All switches shall me manageable as per item 3.2.12.

4.1.7.7. Switches connecting equipment according to standard IEC 61850 shall be certified for this network protocol.

4.1.7.8. The switches belonging to the same redundant group of switches shall be interconnected in ring topology by using the MRP protocol. The final quantities of switches shall be evaluated during detail design.

4.1.7.9. The interconnection of each ring network to external ring networks (outside TOPSIDE/HULL Electrical System Automation Panel) shall be made through 2 connections. One connection remains active and the other one remains in standby. When the active connection is lost, the standby connection shall be automatically switched to active connection.

4.1.7.10. The Electrical System Automation Switches shall be fed by redundant UPS feeders.

4.1.7.11. Electrical System Topside/Hull A&C Interface Switches shall be from the same manufacturer as the ones from the Package Unit LAN main ring.

4.2. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION OPERATIONAL WORKSTATION

4.2.1. Electrical System Automation Operational Workstations shall be supplied as industrial workstation for use in offshore environmental conditions with 1 (one) 32" LED video monitors each (5 ms or less refresh time), wired ABNT2 keyboard and wired optical mouse and 2 (two) Ethernet network interface card. Processor type, internal drives space and memory shall be according to the use of the necessary software in its maximum performance configuration. No mechanical drives are allowed (as hard disks), only solid-state drives.

4.2.2. USB, memory card and other communication ports shall be normally blocked to be protected against cyber-attacks. The block shall be controlled by Antivirus Software and shall be predicted disabling to allow system maintenance or emergency recuperation.

4.2.3. Operating System of Electrical System Automation Operational Workstation: Microsoft ® Windows Professional at its latest version preferably at 64 bits version. It shall be possible to update the operating system. Vendor shall supply active support for operating system.

4.2.4. Electrical System operational Workstations main functions are:

- Visualization of real-time and historical condition, alarms, trend graphs and events of electrical system equipment;

- Actuate in electrical equipment, including the change of equipment status, control variables and execution of operational and maintenance overrides commands;
- Act as an interface for remote onshore operation of the electrical system through remote desktop.

4.2.5. Different access levels protected through different passwords shall be granted for operation and monitoring of Electrical System equipment. Historical report with discrimination of users' access and actions, such as commands, shall be stored for all operations.

4.2.6. The Electrical System Automation Operational Workstations shall be fed by redundant UPS feeders.

4.2.7. Electrical system screens on Topside/Hull Electrical System Automation Operational Workstations:

4.2.7.1. An adequate number of dynamic high-resolution full-graphic screens and windows shall be prepared by BIDDER showing the real state of electrical equipment.

4.2.7.2. The remote operating and monitoring of all the electrical equipment shall be, at least, according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.2.7.3. General One line diagram screen showing the real state of all generators (main generators, hull generators, auxiliary generators, and emergency generators), transformers, distribution panels and MCC panels for the Topside Electrical System Automation Operational Workstations.

4.2.7.4. One-line diagrams screens for each CDC and MCC panels showing the real state of bus bars, generators (if any), circuit-breakers, feeders, VSDs, soft-starters, motor and non-motor loads.

4.2.7.5. Specific system screens shall be provided to allow remote operation of transformers, incoming circuit-breakers and tie circuit-breakers of switchgears and MCCs. The electrical interlocks that control the operation of these circuit-breakers, as shown on PETROBRAS documents, shall prevail.

4.2.7.6. Specific screens showing the logic diagram from main logic variables of each IED, including ready to start, start and stop logics with the related inputs and outputs. These screens will have the purpose of showing the real state of logic variables to troubleshooting. It shall be included internal variables to the relay in order to provide this functionality in addition to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.2.7.7. Communication and diagnostics status screens showing real state of IEDs, controllers, switches, PLCs, IRs, network cables. It shall be included specific signals to this functionality in addition to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.2.7.8. UPS, cathodic protection, VSDs and battery charger screens.

4.2.7.9. Auxiliary and emergency generators specific screens.

4.2.7.10. Custom screens for supervision and control of the PMS developed using the database (memory map) replicated/integrated from PMS in addition to the other screens.

4.2.7.11. Custom screens for supervision of the TGCP and HGCP developed using the database (memory map) replicated/integrated from TGCP and HGCP in addition to the other screens.

4.2.7.12. Alarm, trend graphs and event record screens

4.2.7.13. Topside Electrical System Automation Operational Workstation shall have custom designed screens for operation and supervision related to Hull Electrical System.

4.2.7.14. The color code and guide for equipment symbology and status of equipment shall comply with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.2.7.15. The monitoring software shall allow generation of reports and visualization of real-time and historical trend graphs.

4.2.7.16. The specific functional units screens shall include breaker, contactor or Short-Circuit Peak Current Limiting Devices operation counters.

4.2.7.17. Monitoring summary screen of electrical system variables (status and analog values) from equipment that are related to system integrity such as:

- AC UPS;
- DC UPS;
- Emergency Lighting Battery Charger;
- Control Voltage related alarm for MCC, Switchgears, ESA panels, among other electrical system equipment fed by UPS systems;
- 220 V Emergency and Essential distribution panels;
- Emergency and Auxiliary generators.

4.2.8. One Topside Electrical System Automation Operational Workstation shall be installed in CCR.

4.2.9. The Topside Electrical System Automation Operational Workstation to be installed in CCR shall include a Historian Server redundant to the servers installed in Electrical System Automation RTDSs. The Historical data shall be available in the Removable Hot-Swap Solid-State Drive.

4.3. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION OPERATIONAL PORTABLE DEVICE

4.3.1. The Electrical System Automation Operational Portable Device shall be certified for hazardous areas Zone 1 Group IIC temperature T3.

4.3.2. The Electrical System Automation Operational Portable Device shall be compatible with the Electrical System Automation Wireless Network Access Points and with Hull WLAN system.

4.3.3. The Electrical System Automation Operational Portable Device shall have at least 8 (eight) inches screen to be operated with protection gloves.

4.3.4. The Electrical System Automation Operational Portable Device shall include HMI APP clients compatible to the RTDSs HMI server.

4.3.5. Different access levels protected through different passwords shall be granted for operation and monitoring of Electrical System equipment. Historical report with discrimination of users' access and actions, such as commands, shall be stored for all operations. Access levels shall be equal to the ones of ESA Operational Workstations.

4.3.6. Custom screens for portable devices comprising the whole supervision and control required from item 4.2 shall be implemented.

4.3.7. The Electrical System Automation Operational Portable Device shall include a QR Code reader in order to read QR Codes from electrical equipment.

4.4. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION MAINTENANCE WORKSTATION

4.4.1. Electrical system Automation Maintenance Workstation shall be supplied as industrial workstation for use in offshore environmental conditions, one 32" video monitor, wired ABNT2 keyboard and optical mouse and at least 8 (eight) Ethernet network interface cards with support to IEEE 802.3an, 1 (one) Blue Ray/DVD/CD recorder, and USB interface. Processor type, internal drive space and memory shall be according to the use of the necessary software in its maximum performance configuration. No mechanical drives are allowed (as hard disks), only solid-state drives.

4.4.2. USB, memory card and other communication ports shall be normally blocked to be protected against cyber-attacks. The block shall be controlled by Antivirus Software and shall be predicted disabling to allow system maintenance or emergency recuperation.

4.4.3. Electrical System Automation Maintenance Workstation shall have mirrored internal drives (RAID 1 configuration).

4.4.4. Operating System of Electrical System Automation Maintenance Workstation: Microsoft ® Windows Professional at its latest version preferably at 64 bits version. It shall be possible to update the operating system. Vendor shall supply active support for operating system.

4.4.5. Electrical System Automation Maintenance Workstations shall be connected to all Electrical System Automation through the networks listed in 3.5.8, in exception of the MODBUS TCP Peer-to-Peer network.

4.4.6. Electrical System Automation Maintenance Workstations main functions are:

- Online adjusting, configuration, parameterization, download and upload of all data of electrical equipment connected to the network;
- Online test of electrical equipment connected to the network.

4.4.7. All parameters of electrical system equipment connected to electrical system networks shall be stored in the Electrical System Automation Maintenance Workstations. In case of fault and replacement of equipment the parameterization of the new equipment shall be made online, through the network, using the data stored in the Electrical System Automation Maintenance Workstation, and shall not cause impacts in operation of other equipment.

4.4.8. At least the following additional modules of software shall be provided for the Electrical System Workstation besides the general software requirements:

- IEDs parameterization, test and communication software;
- Software for parameterization, tests, monitoring and communication for the various devices connected to the Electrical System Automation Networks such as VSDs, AVR, GPS, switches, MV and LV generator controllers, soft-starters, IMDs, PQMS, UPS and Battery-Chargers, among others.
- Software for management and maintenance of LANs and VLANs;
- Configuration software for the Electrical System Controllers.

4.4.9. The Electrical System Workstations shall have a portable flash drive with security mechanisms to prevent unauthorized data access (size shall be defined during Detailed Design). The minimum capacity of store shall be 30 days of historical data collection and register.

4.4.10. Different access levels protected through different passwords shall be granted for adjusting, configuration, parameterization, download and upload (including remote access). Report with discrimination of users' access shall be stored for all operations.

4.4.11. The Electrical System Automation Operational shall be fed by redundant UPS feeders.

5. AUTOMATION OF ELECTRICAL EQUIPMENT

5.1. GENERAL

5.1.1. For information about requirements of IEDs (Intelligent Relays - IRs and Multifunction Microprocessed Relays - MMRs), Variable Speed Drives (VSDs), soft-starters, ground fault relays, etc., see I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS, I-ET-3010.00-5140-713-P4X-001 - SPECIFICATION FOR TRANSFORMERS FOR OFFSHORE UNITS, I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS, I-ET-3010.00-5140-772-P4X-002 - SPECIFICATION FOR LOW-VOLTAGE FREQUENCY CONVERTERS, SOFT-STARTERS AND INVERTERS FOR OFFSHORE UNITS, I-ET-3010.00-5140-773-P4X-001 - SPECIFICATION FOR D.C. UPS FOR OFFSHORE UNITS, I-ET-3010.00-5140-773-P4X-002 - SPECIFICATION FOR GENERIC D.C UPS FOR OFFSHORE UNITS, I-ET-3010.00-5140-773-P4X-003 - SPECIFICATION FOR A.C. UPS FOR

OFFSHORE UNITS, I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS, I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS and specific equipment specifications.

5.1.2. All electric equipment, such as the Electrical System Automation Controllers, VSDs, PMS, etc., which receive 4-20 mA analog signals shall include galvanic insulators, in exception of 4-20 mA signals received from A&C Remote IO panels.

5.1.3. The electric equipment shall have operation mode classifications presented in to I-ET-3010.00-1350-940-P4X-001 – SYSTEMS OPERATION PHILOSOPHY as follows:

5.1.3.1. MV switchgears and MCCs: Incomers (excluding generator incoming functional units), tie (excluding switchgears with generation in which tie functional units will be controlled by PMS), feeders, backfeeders and power transformers shall be MOP 8. Other loads, such as CSS or PCP controlled motors, shall be according to the related system MOP;

5.1.3.2. LV switchgears and MCCs: Incomers (excluding generator incoming functional units), tie, feeders, backfeeders and power transformers shall be MOP 8. Other loads, such as CSS or PCP controlled motors, shall be classified according to the related system MOP;

5.1.3.3. Package LV MCCs: these panels shall be MOP 9;

5.1.3.4. VSD and soft-starters: equipment shall be classified according to the related system MOP;

5.1.3.5. Thyristor heater panels: panels belonging to PACKAGES shall be according to the related system MOP. Otherwise incomer and tie circuit-breakers shall be MOP 8 and outgoing circuits shall be according to the related system MOP;

5.1.3.6. PMS: the equipment shall be MOP 8;

5.1.3.7. Main Generators and Hull generators: equipment and its incoming functional unit shall follow the MOP according to equipment documentation;

5.1.3.8. Emergency and Auxiliary generators: equipment shall be MOP 9;

5.1.3.9. UPSs, Battery Chargers and Cathodic Protection Rectifiers: equipment shall be MOP 9;

5.1.3.10. SHORT-CIRCUIT PEAK CURRENT LIMITING DEVICE (LIMITER): the Limiter shall be MOP 8;

5.1.3.11. Primary low voltage distribution power panels (up to 240 Vac or Vdc): these panels shall be MOP 9;

5.1.3.12. Emergency and Essential Secondary low voltage distribution power panels (up to 240 Vac or Vdc): these panels shall be MOP 9.

5.2. MEDIUM VOLTAGE SWITCHGEARS/MCC AND LOW VOLTAGE SWITCHGEARS

5.2.1. All functional units shall have IEDs (MMRs) connected full duplex to switches internal to the panels by using IEC 61850.

5.2.2. The same internal Ethernet connection from IEDs to panel switches shall be used for both supervision and control and engineering/maintenance functions.

5.2.3. IEDs shall allow simultaneous clients for control and supervision from Electrical System Automation Controllers, Electrical System Automation RTDSs, PMS and engineering/parameterization from Electrical System Automation Maintenance Workstation.

5.2.4. It shall not be used any gateway or protocol converter.

5.2.5. There shall be a group of redundant switches for each busbar connected in ring network by using the MRP protocol.

5.2.6. Switches shall be installed in control cabinets of the panels and shall be distributed among the columns in order to provide better arrangement and avoid excessive quantities of cables in one control cabinet.

5.2.7. The interconnection of the redundant switches to the IEC 61850 Ethernet Network shall be made through 2 connections, each one from a different redundant switch. One connection remains active and the other one remains in standby. When the active connection is lost, the standby connection shall be automatically switched to the active connection.

5.2.8. IEDs (MMRs), shall be connected to the switches by using star topology with redundant connections for each relay.

5.2.9. The implementation of logic selectivity schemes, trip events and other protection interlocks among MMRs shall use Generic Object Oriented Substation Event (GOOSE), as defined in IEC 61850.

5.2.10. Communication among Electrical System Automation and IEDs shall be through MMS messages.

5.2.11. Switches shall comply with requirements presented item 4.1.7.

5.2.12. Temporary parallelism between incoming circuits shall be made through the communication among incoming and tie MMRs by using GOOSE signals. Details of temporary parallelism requirements can be found in I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS and I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS.

5.2.13. Spare functional units shall have all functionalities regarding supervision and control implemented considering its classification according to control mode. Spare functional units shall be represented and shall be fully operational in Electrical System Automation Operational Workstation and Electrical System Automation Operational Portable Devices. All interface signals shall be foreseen in the memory map.

5.2.14. MMRs shall be synchronized with ESA Time Server through SNTP.

5.2.15. Communication failure of any IED (MMR) in essential switchgear shall not block closing any essential load, tie or emergency generator circuit-breaker. Interlocks in essential switchgear foreseen in ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM shall be maintained and shall allow safe closing of the circuit-breakers in this condition.

5.2.16. Communication failure of IEDs (MMRs) shall not automatically open circuit-breakers or main contactors.

5.2.17. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.8 and 3.2.9.

5.2.18. Temperature Monitoring Devices shall be connected to ESA Networks to provide monitoring at ESA. These devices shall be connected to the existing IEC 61850 networks inside panels. Alternatively, these devices can be connected to ESA Multipurpose Networks if there is any limitation to communicate using the Temperature Monitoring System communication protocol through IEC 61850 network infrastructure.

5.3. LOW VOLTAGE MCC

5.3.1. All functional units shall have IEDs (IRs) connected full duplex to switches internal to the panels by using MODBUS TCP, Ethernet/IP or Profinet protocol.

5.3.2. The same internal Ethernet connection from IEDs to panel switches shall be used for both supervision and control and engineering/maintenance functions.

5.3.3. IRs shall allow simultaneous clients for control and supervision from Electrical System Automation Controllers, Electrical System Automation RTDSs and engineering/parameterization from Electrical System Automation Maintenance Workstation.

5.3.4. It shall not be used any gateway or protocol converter.

5.3.5. Switches shall comply with requirements presented item 4.1.7

5.3.6. There shall be a group of redundant switches connected in ring network by using the MRP protocol installed in the control cabinet of MCCs.

5.3.7. The interconnection of the redundant switches to the MCC Ethernet Network shall be made through 2 connections, each one from a different redundant switch. One connection remains active and the other one remains in standby. When the active connection is lost, the standby connection shall be automatically switched to the active connection.

5.3.8. Provisions shall be made to avoid starting of incorrect load when panels' drawers or IRs are moved from one position to other.

5.3.9. Spare functional units shall have all functionalities regarding supervision and control implemented considering its classification according to control mode. Spare functional units shall be represented and shall be fully operational in Electrical System Automation Operational Workstation and Electrical System Automation Operational Portable Devices. All interface signals shall be foreseen in the memory map.

5.3.10. IRs shall be synchronized with ESA Time Server through SNTP.

5.3.11. Communication failure of IEDs (IRs) in essential panels shall not block operating essential loads.

5.3.12. Communication failure of IEDs (IRs) shall not automatically open circuit-breakers or main contactors.

5.3.13. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.3.14. Internal network architecture for interconnection of IRs to switches internal to the MCC shall be according to panel manufacturer standards.

5.3.15. Temperature Monitoring Devices, when installed in MCCs, shall be connected to ESA Networks to provide monitoring at ESA. These devices shall be connected to the existing MCC Ethernet Networks inside panels. Alternatively, these devices can be connected to ESA Multipurpose Networks if there is any limitation to communicate using the Temperature Monitoring System communication protocol through MCC Ethernet network infrastructure.

5.4. THYRISTOR HEATER PANELS

5.4.1. Thyristor Heater Panels shall communicate with Electrical System Network through Topside Electrical System Automation Panel, using the Multipurpose Ethernet Network (see I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM).

5.4.2. Signals to be transferred shall, at minimum, be according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.4.3. IEDs shall be synchronized with ESA Time Server through SNTP.

5.4.4. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.5. MAIN GENERATORS

5.5.1. Turbogenerator Control Panel (TGCP) shall communicate with Electrical System Automation Panel through Topside Electrical System Automation Panel, using the Multipurpose Ethernet Network (see I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM).

5.5.2. The multipurpose Ethernet network shall be used to communicate with the TGCP AVR, Controllers and OPC UA server in their respective protocols.

5.5.3. A TGCP OPC UA server shall be supplied in order to allow reading all TGCP available supervision data.

5.5.4. Signals to be transferred shall, at minimum, be according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.5.5. Turbogenerator Control Panel (TGCP) shall communicate with PMS directly through the HSDN PMS/TGCP NETWORK (see I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM).

5.5.6. TGCP data shall be available to A&C through Topside Electrical System Automation by using network communication, according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.5.7. The MMRs installed inside TGCPs and responsible for the protection of the Main Generators shall communicate with Electrical System Network through IEC 61850 Electrical System Automation Switch, using Ethernet (IEC 61850). See I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.5.8. All alarms and events signals available in the TGCP memory map shall be recorded in RTDS HMI and Historian servers and displayed in the ESA Operational Workstations screens.

5.5.9. All Ethernet Network Connections shall be redundant.

5.5.10. IEDs, OPC UA Server, AVR, Controllers and other components shall be synchronized with ESA Time Server through SNTP.

5.5.11. TGCP shall not internally interconnect the networks which it is connected to.

5.5.12. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.6. HULL GENERATORS

5.6.1. Hull Generator Control Panel (HGCP) shall communicate with Electrical System Network through Topside Electrical System Automation Panel, using the Multipurpose Ethernet Network (see I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM).

5.6.2. The multipurpose Ethernet network shall be used to communicate with the HGCP AVR, Controllers and OPC UA server in their respective protocols.

5.6.3. A HGCP OPC UA server shall be supplied in order to allow reading all HGCP available supervision data.

5.6.4. Hull Generator Control Panel (HGCP) shall communicate with PMS directly through the HSDN PMS/HGCP NETWORK (see I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM).

5.6.5. Topside Electrical System Automation Controllers shall mirror HGCPs data available to A&C, via network communication, according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.6.6. The MMRs installed inside HGCPs and responsible for the protection of the Hull Generators shall communicate with Electrical System Network through IEC 61850 Electrical System Automation Switch, using Ethernet (IEC 61850). See I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.6.7. Signals to be transferred shall, at minimum, be according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.6.8. All alarms and events signals available in the HGCP memory map shall be recorded in RTDS HMI and Historian servers and displayed in the ESA Operational Workstations screens.

5.6.9. All Ethernet Network Connections shall be redundant.

5.6.10. IEDs, OPC UA Server, AVR, Controllers and other components shall be synchronized with ESA Time Server through SNTP.

5.6.11. HGCP shall not internally interconnect the networks which it is connected to.

5.6.12. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.7. POWER MANAGEMENT SYSTEM (PMS) - PN-5140001

5.7.1. PMS shall communicate with Electrical System Automation according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.7.2. PMS shall communicate with TGCP according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and according to 5.5.

5.7.3. PMS shall communicate with HGCP according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and according to 5.6.

5.7.4. The PMS is connected to several networks, in many protocols according to item 5.7.1. Detail Design shall define which networks are suitable for the respective signals to be transferred.

5.7.4.1. Signals regarding control functions between PMS and ESA shall be exchanged through Controllers.

5.7.4.2. Signals regarding general supervision, events and alarms between PMS and ESA shall be exchanged through OPC UA.

5.7.4.3. Network signals between PMS and IEDs shall be exchanged using IEC-61850 standard.

5.7.4.3.1. PMS shall communicate with IEDs through MMS messages unless GOOSE messages are required by I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST or by specific applications defined in detailed design.

5.7.5. PMS HMI shall allow Remote Desktop connection through the A&C Interface Ethernet Network connection in A&C IP range.

5.7.6. The operation of PMS and the interfaces between PMS and other electrical equipment and the signal to be transferred are defined in I-ET-3010.00-5140-700-P4X-004 - PN-5140001 - POWER MANAGEMENT SYSTEM (PMS) FOR OFFSHORE UNITS.

5.7.7. Signals to be transferred shall, at minimum, be according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.7.8. All alarms and events signals available in the PMS memory map shall be recorded in RTDS HMI and Historian servers and displayed in the ESA Operational Workstations screens.

5.7.9. PMS shall not internally interconnect the networks which it is connected to.

5.7.10. Ethernet Network Connections shall be redundant.

5.7.11. PMS shall include an OPC UA server which shall allow ESA RTDSs to integrate PMS database to ESA database, including reading and writing data, in order to supply supervision and control to Electrical System Automation.

5.7.12. OPC UA Server, Controllers, HMI and other components shall be synchronized with ESA Time Server through SNTP.

5.7.13. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.8. EMERGENCY AND AUXILIARY GENERATORS

5.8.1. The communication among internal components and equipment of the packages will be responsibility of the Packagers.

5.8.2. Generators controllers and AVRs shall communicate with Electrical System Automation according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM for remote supervision, monitoring and parameterization.

5.8.3. Signals to be transferred shall be according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.8.4. All alarms and events signals available in the EGCP and AGCP(s) memory map shall be recorded in RTDS HMI and Historian servers and displayed in the ESA Operational Workstations screens.

5.8.5. EGCP and AGCP IEDs shall communicate with Electrical System Automation through the IEC 61850 Ethernet network.

5.8.6. Ethernet Network Connections shall be redundant.

5.8.7. IEDs, controllers, AVR and other components shall be synchronized with ESA Time Server through SNTP.

5.8.8. EGCP and AGCP(s) shall not internally interconnect the networks which it is connected to.

5.8.9. Communication failure of generator controller, AVR or IED with Electrical System Automation or of IEDs from essential switchgear with Electrical System Automation shall not block manual or automatic starting and operating the Emergency Generator, Auxiliary Generator(s) or its circuit-breakers.

5.8.10. Communication failure of generator controller, AVR or IED with Electrical System Automation shall not automatically open Emergency Generator or Auxiliary Generator(s) incoming circuit-breakers.

5.8.11. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.9. UPSs, BATTERY CHARGERS AND CATHODIC PROTECTION RECTIFIERS

5.9.1. The requirements of this item are not applicable for UPSs and Battery Chargers included in Emergency Generator, Auxiliary Generator, Main Generator, Gas Compressors and Fire Fighting Pumps packages. In these cases, the UPSs and CBs, if any, shall be controlled and supervised by Package controllers.

5.9.2. The requirements of this item are applicable for UPSs, Battery Chargers, Battery Chargers for D.C. UPS Systems and their respective batteries and distribution panels.

5.9.3. It is not foreseen to operate UPSs, Battery Chargers, Battery Chargers for D.C. UPS Systems and cathodic protection rectifiers remotely from Electrical System Workstations or from A&C.

5.9.4. UPSs, Cathodic Protection Rectifiers, Battery Chargers, Battery Chargers for D.C. UPS Systems and their primary distribution panels shall communicate with Electrical System Automation through the Multipurpose Ethernet TCP/IP network, with protocol defined by equipment manufacturers, for remote supervision and monitoring.

5.9.5. Signals to be transferred shall be, at least, according with I-LI-3010.00-5140-797-P4X-001.

5.9.6. All alarms and events signals available in the UPSs and BATTERY CHARGERS memory map shall be recorded in RTDS HMI and Historian servers and displayed in the ESA Operational Workstations screens.

5.9.7. Alarm signals related to UPS and Battery Charger for D.C. Ups Systems shall have high priority in the Electrical System Automation Operational Workstations and Electrical System Automation Operational Portable Devices.

5.9.8. UPSs, Battery Chargers, Battery Chargers for D.C. UPS Systems and cathodic protection rectifiers and their distribution panels IEDs shall be synchronized with ESA Time Server through SNTP.

5.9.9. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.10. SHORT-CIRCUIT PEAK CURRENT LIMITING DEVICE (LIMITER)

5.10.1. The communication between the Short-Circuit Peak Limiting Device (Limiter) and the Electrical System Automation shall be according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.10.2. Signals to be transferred shall be, at least, according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.10.3. Topside Electrical System Automation Controllers shall carry out a control interlocking function to inhibit Limiter operation for operational scenarios when the expected short-circuit peak current in the panel where the Limiter is installed is lower than the rated short-circuit withstand peak current of this panel. For interlock details, see ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM.

5.10.4. For this function, Topside Electrical System Controllers shall calculate the sum of short-circuit current contribution of each operating generator and operating load. There shall be available a security margin to be set by the operator, which will decrease the rated short-circuit withstand peak current of this panel by this margin.

5.10.5. Short-circuit probability in the panels are higher during switching operation (starting of motors, generators or transformers). For generators, to decide which generators contribute for short-circuits, besides the position of circuit-breakers (open/closed), this interlock shall consider the existence of voltage at generator side. If the generator circuit-breaker is open, but there is voltage at generator side, it means that the turbine is running and the generator is excited. In case of closing of the circuit-breaker of this generator, if one short-circuit occurs, this generator will contribute for the peak current. Therefore it shall be considered “in operation” to decide the inhibition of Limiter.

5.10.6. This interlock shall be fail-safe, being Limiter active the safe condition. Failure in controllers, contacts, control cables, communication devices used, etc. shall keep the Limiter active.

5.10.7. It shall not be included in this interlock the inhibition of Limiter for events of motor starting or transformer inrush, since the motor to be started or the transformer to be energized can be in failure condition. To avoid misoperation during these events, it is required di/dt analysis for the Limiter (to differentiate starting and in-rush currents from short-circuit currents). See I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS.

5.10.8. Limiter IED shall be synchronized with ESA Time Server through SNTP.

5.10.9. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

5.11. OTHER ELECTRICAL EQUIPMENT

5.11.1. Electrical equipment that is capable to communicate via network (VSDs, soft-starters, Medium-Voltage Transformers and others) shall be connected according with I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

5.11.2. If an equipment is capable to communicate with the same protocol for low-voltage MCCs Ethernet Network it may be connected to this network.

5.11.3. Power transformers with winding overload alarm and trip and high temperature in windings alarm and trip shall have both hardwired alarm and trip signals sent to the respective IED (primary, secondary, tertiary IED) besides the signals sent through network.

5.11.4. Signals to be transferred shall be according with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.11.5. The Ethernet connections of equipment shall be used for supervision, control and engineering/maintenance functions.

5.11.6. VSDs and soft-starters shall allow simultaneous clients for control and supervision from Electrical System Automation Controllers, Electrical System Automation RTDSs and engineering/parameterization from Electrical System Automation Maintenance Workstation.

5.11.7. It shall not be used any gateway or protocol converter for the VSD or soft-starter communication.

5.11.8. VSD, soft-starter and other equipment shall be synchronized with ESA Time Server through SNTP.

5.11.9. Internal and external network connections shall be made following requirements from items 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.10 and 3.2.11.

6. INTERFACE BETWEEN ELECTRICAL SYSTEM AUTOMATION AND PROCESS AUTOMATION (A&C)

6.1. GENERAL CRITERIA FOR INTERFACE WITH A&C

6.1.1. There are two controllers for process equipment in A&C, one for Topside systems, called PCS (Process Control System) and other for Hull systems, called HCS (Hull Control System). This technical specification will use the term “Process Controllers” meaning both controllers. The loads shall be connected to the controller related to the system where the load is installed.

6.1.2. There are two controllers for shutdown in A&C, one for Topside systems, called PSD (Process Shutdown System) and other for Hull systems, called HSD (Hull Shutdown System). This technical specification will use the term “Shutdown Controllers” meaning both controllers. The loads shall be connected to the controller related to the system where the load is installed.

6.1.3. There are two controllers for HVAC (Heating, Ventilation and Air Conditioning) loads and for fire and gas detection systems in A&C, one for Topside systems, called FGS (Fire & Gas System - Topsides) and other for Hull systems, called HFGS (Fire & Gas System - Hull). This technical specification will use the term "Fire & Gas Controllers" meaning both controllers. The loads shall be connected to the controller related to the system where the load is installed.

6.1.4. In order to standardize the communication interface among Unit electrical panels, Electrical System Automation and the A&C, four main different types of functional units for output loads, circuit-breakers and devices were foreseen, according to the following:

- EA01: Functional Unit controlled by Process Controllers or by Fire & Gas Controllers. Field Start push-button from A&C shall be received by network. Shutdown signal shall be hardwired.
- EA02: Functional Unit monitored by Process Controllers or by Fire & Gas Controllers. Field Start push-button from A&C shall be received by network. Shutdown signal shall be hardwired.
- EA03: Functional Unit neither controlled (nor monitored) by Process Controllers, nor by Fire & Gas Controllers, nor by Package controllers. Field Start push-button from A&C shall be received by network. Shutdown signal shall be hardwired.
- EA04: Functional Units controlled by the Packages. These units shall communicate with the Package controllers (installed in Packages control panels) through hardwired signals. Shutdown signal shall be hardwired.

6.1.5. Functional units may be motor or non-motor types.

6.1.6. For actuation modes and command sources, see I-DE-3010.00-5140-797-P4X-002 – ELECTRICAL SYSTEM AUTOMATION TYPICAL ACTUATION DIAGRAMS

6.1.7. Criteria to classification of Functional Units EA01, EA02, EA03 and EA04

6.1.7.1. To evaluate the classification of each functional unit it shall be considered the following items:

- I-DE-3010.00-5140-797-P4X-002 – ELECTRICAL SYSTEM AUTOMATION TYPICAL ACTUATION DIAGRAMS
- I-ET-3010.00-1350-940-P4X-001 – SYSTEMS OPERATION PHILOSOPHY
- P&ID where the load is presented.
- Type of package of the load.
- Service carried out by the load.
- Type of automation foreseen to the load.

6.1.7.2. In case the starting method of any load is changed from direct on-line to VSD or soft-starter during detailed design, the functional unit shall be classified as non-motor EA02 (previous EA01 or EA02 motor) or non-motor EA03 (previous EA03 or EA04 motor) and the VSD or soft-starter shall keep the previous functional unit classification.

6.1.7.3. Some loads or Packages may have small control panels included in their scope of supply to control the main or the auxiliary loads, according to supplier standard. In some cases, these small control panels may not be installed in AEPR. In any case, if the control panel is a power and control panel and is the responsible to drive the loads, it shall be classified as non-motor EA03. If the control panel is used for control and use CDCs or MCCs functional units to drive loads, each functional unit controlled by the control panel shall be classified as EA04. In case these panels are added during Detailed Design, these loads shall be reclassified accordingly.

6.1.7.4. Any auxiliary load included in Detailed Design for EA01 and for EA02 loads, shall be classified with the same classification of the main load.

6.1.7.5. The document I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS present the initial load classification.

6.1.7.6. This classification refers only to the interface between the Electrical System and A&C. For additional information about the functional units, see I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS and I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS.

6.1.8. Actuation of ESD signals from A&C controllers or failure in cables among remote I/O panels of these controllers and electrical system equipment shall force electrical equipment to safe condition.

6.1.9. All data sent to A&C shall have time stamp.

6.1.10. OPC UA Servers shall be provided for both Hull and Topside Electrical System Automation RTDSs in order to permit the A&C hull packaged systems server to read all available data.

6.2. FUNCTIONAL UNITS TYPE EA01

6.2.1. Interface of functional units type EA01 with A&C

6.2.1.1. A&C interface signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST and other additional signals used for automation and control are considered critical and shall be read/written from/to electric equipment and sent to A&C through Electrical System Automation Controllers.

6.2.1.2. Additional signals used only for monitoring purposes shall be read from electric equipment and sent to A&C through the Electrical System Automation RTDSs.

6.2.1.3. Field start push-button signal shall be transferred from A&C to electric equipment through Electrical System Automation Controllers.

6.2.1.4. VSDs Set point shall be hardwired.

6.2.1.5. The network communication protocol among all EA01 functional units and the Electrical System Automation RTDSs and Electrical System Automation Controllers shall be according to the network which it is connected according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

6.2.1.6. Functional units shall receive hardwired ESD (Emergency Shutdown) signals from Shutdown Controllers or from Fire & Gas Controllers according to the ESD Criteria for Electrical Loads from I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

6.2.1.7. The signals foreseen to be transferred among EA01 functional units and A&C are listed on I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.2.2. Interface of functional units type EA01 with Electrical System Automation shall include all A&C monitoring signals, besides all other signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.3. FUNCTIONAL UNITS TYPE EA02

6.3.1. Interface of functional units type EA02 with A&C:

6.3.1.1. A&C interface signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST shall be read/written from/to electric equipment and sent to A&C through Electrical System Automation Controllers.

6.3.1.2. Additional signals used only for monitoring purposes shall be read from electric equipment and sent to A&C through the Electrical System Automation RTDSs.

6.3.1.3. Field start push-button signal and Set point (applicable for VSDs) shall be transferred from A&C to electric equipment through Electrical System Automation Controllers.

6.3.1.4. The network communication protocol among all EA02 functional units and the Electrical System Automation RTDSs and Electrical System Automation Controllers shall be according to the network which it is connected according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

6.3.1.5. Functional Units shall receive ESD signals according to items 6.2.1.6.

6.3.1.6. The signals foreseen to be transferred among EA02 functional units and A&C are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.3.2. Interface of functional units type EA02 with Electrical System Automation shall include all A&C monitoring signals, besides all other signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.4. FUNCTIONAL UNITS TYPE EA03

6.4.1. Interface of functional units type EA03 with A&C:

6.4.1.1. There are no signals transferred from EA03 functional units to A&C.

6.4.1.2. The network communication among EA03 functional units and Electrical System Automation shall be through Electrical System Automation RTDSs for remote control and monitoring from Electrical System Operational Workstations.

6.4.1.3. Field start push-button signal and Set point (applicable for VSDs) shall be transferred from A&C to electric equipment through Electrical System Automation Controllers.

6.4.1.4. Functional Units shall receive ESD signals according to items 6.2.1.6.

6.4.2. Interface of functional units type EA03 with Electrical System Automation shall use the protocol of the network which the functional unit is connected according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM to establish communication with the Electrical System Automation RTDSs and Electrical System Automation Controllers. The signals to be exchanged are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.5. FUNCTIONAL UNITS TYPE EA04

6.5.1. Interface of functional units type EA04 with A&C

6.5.1.1. The communication among the Package Control Panels and A&C shall be according to A&C documentation.

6.5.1.2. The communication among the Packages internal components and equipment shall be responsibility of the Packager.

6.5.1.3. The communication between the Package controllers (installed inside Package Control Panel) and EA04 functional units shall be hardwired.

6.5.1.4. The only signal to be transferred from A&C to EA04 functional units is a hardwired ESD signal according to the ESD criteria from 6.2.1.6.

6.5.1.5. There are no signals transferred from EA04 functional units to A&C. Any communication signal required about these loads from A&C (except ESD signal) shall be sent by Package Control Panel and not by functional units of MCCs or CDCs. For communication signals between Package Control Panels and A&C, see A&C documentation.

6.5.1.6. The signals foreseen to be transferred among Package controllers and EA04 functional units shall be, at least, the signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.5.2. Interface of functional units type EA04 with Electrical System Automation shall use the protocol of the network which the functional unit is connected according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM to establish communication with the Electrical System Automation RTDSs and Electrical System Automation Controllers. The signals to be exchanged are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.6. INTERFACES OF MAIN GENERATORS WITH A&C

6.6.1. The signals to be transferred among A&C and TGCPs (through Electrical System Automation Controllers) are defined in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.6.2. The ESD signal from the Shutdown Controllers shall be hardwired to TGCPs.

6.6.3. OPC UA data replicated by ESA from TGCP OPC UA Server shall be available to A&C.

6.7. INTERFACES OF HULL GENERATORS WITH A&C

6.7.1. The signals to be transferred among A&C and HGCPs (through Electrical System Automation Controllers) are defined in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.7.2. The ESD signal from the Shutdown Controllers shall be hardwired to HGCPs.

6.7.3. OPC UA data replicated by ESA from HGCP OPC UA Server shall be available to A&C.

6.8. INTERFACES OF PMS WITH A&C

6.8.1. The signals to be transferred between A&C and PMS (through Electrical System Automation Controllers) are defined in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.8.2. All control signals exchanged with A&C controllers shall be transferred through Electrical System Automation Controllers.

6.8.3. The ESD signal from the PSD Controllers shall be hardwired to PMS.

6.8.4. OPC UA data replicated by ESA from PMS OPC UA Server shall be available to A&C.

6.9. INTERFACES OF EMERGENCY AND AUXILIARY GENERATORS WITH A&C

6.9.1. Signals to be transferred to A&C are presented in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.9.2. ESD signals from A&C shall be according to the ESD Criteria for Electrical Loads from I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

6.10. INTERFACES OF UPSs, BATTERY CHARGERS AND CATHODIC PROTECTION RECTIFIERS WITH A&C

6.10.1. UPSs, Battery Chargers, Battery Chargers for D.C. UPS Systems shall receive signals from A&C to inhibit battery charge, according to safety requirements.

6.10.2. The signals foreseen to be transferred between UPSs, Battery Chargers, Battery Chargers for D.C. UPS Systems and their distribution panels to A&C are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

7. INTERFACE OF ELECTRICAL SYSTEM AUTOMATION BETWEEN HULL AND TOPSIDE

7.1.1. The interconnection between Topside and Hull Ethernet HMI/OPC UA Networks shall be made through Topside and Hull HMI/OPC UA Switches by using redundant full duplex optic fiber.

7.1.2. Hull Electrical System Automation RTDSs shall include an OPC UA server in order to allow the Topside Electrical System Automation RTDSs to read and write all data from its database by using the OPC UA connection among Topside and Hull HMI/OPC UA switches.

7.1.3. The Hull Electrical System Automation RTDSs Shall have one dedicate network card to be configured with Topside Ethernet HMI/OPC UA Network IP range in order to provide communication among Hull Electrical System Automation RTDSs OPC UA Server with Topside Electrical System Automation RTDSs OPC UA Client.

7.1.4. Topside Electrical System Automation RTDSs shall include an OPC UA Client and an OPC UA Server. The OPC UA Client shall be compatible with Hull OPC UA Server in order to be capable of reading and writing all data by using the OPC UA connection among Topside and Hull HMI/OPC UA Switches.

7.1.5. Topside Electrical System Automation RTDSs shall be able to integrate Topside and Hull RTDSs databases in order to supply Hull supervision and control to Topside Electrical System Automation Operational Workstations and Operational Portable Devices.

7.1.6. The Topside Electrical System Automation Controllers (MODBUS TCP Client) shall be connected to the Hull Electrical System Automation Controller (MODBUS TCP Server) through redundant MODBUS TCP Peer-to-Peer connection.

7.1.7. Hull Electrical System Automation Controllers shall be capable of receiving commands and exchange the same data (memory map), acting as a Server, among A&C Controllers and Topside Electrical System Automation Controllers in parallel by using the respective MODBUS TCP connection.

7.1.8. The Topside Electrical System Automation Controllers shall be capable of reading and writing, acting as a Client, all data available from the Hull Electrical System Automation Controllers by using the dedicated MODBUS TCP connection and shall be able to integrate the Hull Electrical System Automation Controllers database in its memory map in order to supply supervision and control from hull equipment to Topside PCS, PSD and FGS controllers from A&C systems and to Topside Electrical System Automation.

7.1.9. Hull Electrical System Automation Controllers shall be capable of exchange the same data (memory map), acting as a server, among Hull Electrical System Automation RTDSs and Topside Electrical System Automation Controllers in parallel by using the respective connections.

7.1.10. Topside Operational Workstations and Operational Portable Devices shall include custom screens developed by using the database (memory map) replicated/integrated from Hull equipment in addition to the Topside equipment database.

8. INTERFACE BETWEEN ELECTRICAL SYSTEM AUTOMATION AND REMOTE ONSHORE OPERATION CENTER

8.1. GENERAL

8.1.1. Electrical System Automation data shall be available to A&C Packaged System Servers from Electrical system Automation RTDSs OPC UA server through A&C Interface Ethernet Network.

8.1.2. Electrical System Automation real time data shall be available to onshore OPC UA Clients from Electrical system Automation DMZ Servers OPC UA server through the Firewall. For details about Firewall interconnection see the document NETWORK INTERCONNECTION DIAGRAM.

8.1.3. Electrical System Automation Historian data shall be available to onshore Historian Clients from Electrical system Automation DMZ Servers Historian server through the Firewall. For details about Firewall interconnection see the document NETWORK INTERCONNECTION DIAGRAM.

8.1.4. Electrical System Automation Operational Workstation shall be accessed through remote desktop connection from A&C Packaged System Network for remote control and supervision.

8.1.5. Electrical System Automation Maintenance Workstation shall be accessed through remote desktop connection from A&C Packaged System Network for remote parameterization, configuration and adjustments of equipment connected to Electrical System Automation Networks.

8.1.6. It shall be supplied two HMI client software and its licenses to be used in the Remote Onshore Operational Center Operational Workstation with same requirements as the Electrical System Automation Operational Workstation. This Operational Workstation shall be connected through the Firewall to the Electrical System Automation DMZ Servers for control and supervision purposes. For details about Firewall interconnection see the document NETWORK INTERCONNECTION DIAGRAM.

8.2. MONITORING SIGNALS

8.2.1. At least all monitoring signals from I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST shall be transferred to PI Systems through the Electrical System Automation DMZ Servers.

9. TESTING

9.1. GENERAL

9.1.1. BIDDER shall be responsible for performing all the acceptance tests (FAT, SAT and SIT) as defined at IEC 62381 standard.

9.1.2. BIDDER shall be responsible for providing facilities, personnel, material, necessary equipment and instruments for all the tests, independent of the place where they are carried out, until the final commissioning and acceptance of the unit by PETROBRAS.

9.1.3. BIDDER shall submit to PETROBRAS, for approval, detailed FAT and SAT programs.

9.2. FACTORY ACCEPTANCE TESTS

9.2.1. BIDDER shall be responsible for performing all factory acceptance tests of Electrical System Automation with the following minimum hardware and software:

- ELECTRICAL SYSTEM AUTOMATION PANEL
- ELECTRICAL SYSTEM AUTOMATION CONTROLLERS
- ELECTRICAL SYSTEM AUTOMATION OPERATIONAL WORKSTATION
- ELECTRICAL SYSTEM AUTOMATION MAINTENANCE WORKSTATION
- ELECTRICAL SYSTEM AUTOMATION REAL TIME DATA SERVER
- ELECTRICAL SYSTEM AUTOMATION TIME SERVER

- TOPSIDE ELECTRICAL SYSTEM AUTOMATION SWITCHES
- HULL ELECTRICAL SYSTEM AUTOMATION SWITCHES
- 2 MMRs RELAYS OF EACH MANUFACTURER REPRESENTING CDC AND MV MCC LOADS
- 1 MMR RELAY REPRESENTING GENERATOR
- 2 MMRs RELAYS REPRESENTING INCOMING AND TIE
- 2 IRs RELAYS REPRESENTING LV MCC LOADS
- PORTABLE DEVICES
- ELECTRICAL SYSTEM AUTOMATION DMZ SERVERS

9.2.2. At least the following tests shall be performed at Factory (FAT), prior to delivery:

Table 1 - Minimum Tests List

General and Hardware Tests
Documentation check
Mechanical inspection check;
Material List inventory check
Protection degree (IP)
Marking, identification and safety warnings check
Dimensions check
Grounding check
Hardware inventory check
Verification of painting (color, thickness and adhesion)
Wiring and termination inspection;
General system functions including hardware redundancy and diagnostic check;
General turn off, turn on and reset check
Controller, switch, PLC, GPS, workstations, wireless network access point devices, portable devices, servers and relays turn off/turn on checks (Automatic initialization)
EMC tests according with IEC series 61000 standards.
ESA network model assembled
ESA Supervisory System Maximum Response Time tests (see item 3.2.16)
ESA Controllers Maximum Response Time tests (see item 4.1.2.9)
IEC 61850 messages Maximum Total Transmission Time tests (see item 3.6)
Communication Tests
Cards arrangement check
ESA network devices communication at screens and LED indicators
Primary and secondary controllers transference check
Cards removing check
Hot swap HD extraction and insertion test
Switches interconnection cables removing check
Interlocks (including GOOSE and MMS typical messages, scenarios with backfeed operation and generators synchronizing);
Wireless network communication test

Software Tests
Software inventory check
Software license inventory check
Check all ESA software installed at equipment and at maintenance workstation
Check all IEDs, MMRs, IRs, VSDs, soft-starters, UPS, battery chargers, AVR, MV and LV generators controllers, PQMS, software installed at maintenance workstation
Back up software installation verifying
Operation and supervision screens running and fully operational
Color code check with all electrical equipment animated
Screens navigation check
Verification of data, time, company identification, Unit , etc. at screens
User access and change profile check
Functional Tests
Check of operation and supervision configuration software
Check of IEC 61850 network configuration software
Check all ESA network devices software running at maintenance workstation
Check all VSD, soft-starter, generators, battery chargers, AVR, MV and LV generators controllers, PQMS and UPS software running at maintenance workstation
Check IED, MMRs and IRs network devices software running at maintenance workstation
Check of time stamp during event of overcurrent or low voltage trigger in 0%, 50% and 80% network loading.
Check of logical selectivity and 50BF between relays in 0%, 50% and 80% network loading.
Operation, monitoring and supervision screens check in 0%, 50% and 80% network loading.
EA01, EA02, EA03 and EA04 drawers, UPS, battery chargers, VSDs and soft-starters typical check
MV and LV Generators, CDCs and MCCs screens typical check
Others HMI screens typical check
Start/stop total time check.
Interface with A&C check.
Interface with Packages, PMS, main generator among others check
Alarms and event record check
Check busbar, loads, sources and Tie measurements (voltage, frequency, current, power, control voltage, among others);
Check at HMI commands, status and measurement at HMI of Motor loads, nom motor loads, VSDs, soft-starters, circuit-breakers, contactors, transformers, generators, busbars, UPS, and panels, among others;
Check of interlocks (including GOOSE and MMS typical messages according with IEC 61850, scenarios with backfeed operation and generators synchronizing);
Protection check (interface among IEDs and HMI).
Trends check
Note: 1 - Tests involving HMI shall be carried out in all workstations and portable devices

9.3. SITE ACCEPTANCE TESTS

9.3.1. After the installation of the system at the site, at least the following tests (SAT) shall be provided in order to assure that the equipment is correctly installed:

Table 2 - SITE ACCEPTANCE TESTS

ESA documents updated in the last revision
Mechanical inspection check;
Marking, identification and safety warnings check
Grounding check
Hardware inventory check
Wiring and termination inspection;
General system functions including hardware redundancy and diagnostic check;
General turn off, turn on and reset check
Controller, switch, PLC, GPS, workstations, wireless network access point devices, portable devices, servers and relays turn off/turn on checks (Automatic initialization)
ESA network completely assembled
ESA wireless network completely assembled
ESA Supervisory System Maximum Response Time tests (see item 3.2.16)
ESA Controllers Maximum Response Time tests (see item 4.1.2.9)
IEC 61850 messages Maximum Total Transmission Time tests (see item 3.6)
Communication Tests
Optical fibers conectorizing certification
Network certification
IP address of all ESA devices check
List of all ESA devices IP address
List of all ESA devices VLAN
All ESA devices assembled, interconnected and identified
Cards arrangement check
ESA network devices communication at screens and LED indicators
Primary and secondary controllers transference check
Cards removing check
Hot swap HD extraction and insertion test
Switches interconnection cables removing check
Check of interlocks (including GOOSE and MMS typical messages according with IEC 61850, scenarios with backfeed operation and generators synchronizing);
Check of time stamp during overcurrent or low voltage trigger in 0%, 50% and 80% network loading in IEC 61850 network.
Check of logical selectivity and 50 BF between relays in 0%, 50% and 80% network loading in IEC 61850 network.
Operation, monitoring and supervision screens check in 0%, 50% and 80% network loading in each ESA network.
Wireless network communication test
Software Tests
Software license inventory check
Check all ESA software installed at equipment and at maintenance workstation

Check at maintenance workstation adjusting, parameterization and configuration changes of all ESA equipment using software.
Check all IEDs, MMRs, IRs, VSDs, soft-starters, UPS, battery chargers, AVR, MV and LV generators controllers, PQMS software installed at maintenance workstation
Check at maintenance workstation adjusting, parameterization and configuration changes of all IEDs, MMRs, IRs, VSDs, soft-starters, UPS, battery chargers, AVR, MV and LV generators controllers, and PQMS using software
Back up software installation verification
Operation and supervision screens running and fully operational
Color code check with all electrical equipment animated
Screens navigation check
Verification of data, time, company identification, Unit , etc. at screens
User access and change profile check
Functional tests
Interface with A&C check
Interface with Packages, PMS, Main Generator, UPS, VSDs, soft-starters, CDCs, MCCs, EGCP, AGCP, HGCP, Cathodic Protection Rectifiers, Battery-Chargers, Low-Voltage primary and secondary (up to 240 Vac and Vdc) distribution panels, among others check.
Check all EA01, EA02, EA03 and EA04 drawers, UPS, PMS, VSDs and soft-starters screens
Check all MV and LV generators, CDCs and MCCs screens
Check others HMI screens
Start/stop total time check.
Alarms and event record check
Check busbar, loads, sources and Tie measurements (voltage, frequency, current, power, control voltage, among others);
Check at HMI commands, status and measurement at HMI of Motor loads, non-motor loads, VSDs, soft-starters, circuit-breakers, contactors, transformers, generators, busbars, UPS, and panels, among others;
Protection check (interface among all IEDs and HMI).
Trends check
Note: 1 - Tests involving HMI shall be carried out in all workstations and portable devices

10.TRAINING

10.1. GENERAL

10.1.1. Vendor shall furnish trainings level 1 and level 2.

10.2. TRAINING LEVEL 1

10.2.1. Electrical System Automation training Level 1 shall be done at factory installation.

10.2.2. This training shall be offered for 5 (five) Petrobras' personnel among Engineers and Technicians.

10.2.3. This course shall be complete in Electrical System Automation technology, operation and maintenance including theory and field.

10.3. TRAINING LEVEL 2

10.3.1. Electrical System Automation training level 2 shall be done in Brazil in Portuguese language.

10.3.2. This training shall be offered for 15 (fifteen) Petrobras' personnel among Engineers and Technicians.

10.3.3. This course shall be complete in Electrical System Automation technology, operation and maintenance including theory and field.

11.ABBREVIATIONS

A&C	Automation and Control System
AEPR	Automation and Electrical Panels Room
AGCP	Auxiliary Generator Power and Control Panel
AVR	Automatic Voltage Regulator
BETU	Built-in Electronic Trip Unit (type of IED)
CB	Battery Charger
CCR	Central Control Room
CDC	Load Center Switchgear
CGA	Automation Overall Contract
CSV	Comma-Separated Value
DMZ	Demilitarized Zone
DIO	Fiber Optic Patch Panel
EA01 to EA04	Electric Actuation Type 01 to Electric Actuation Type 04
EEMUA	Engineering Equipment and Materials Users Association
EGCP	Emergency Generator Power and Control Panel
EMC	Electromagnetic Compatibility
ESA	Electrical System Automation
ESD	Emergency Shutdown
F.O.	Fiber Optic
FGS	Fire & Gas System - Topsides
FPSO	Floating, Production, Storage and Offloading Unit
GGIO	Generic process I/O
GOOSE	Generic Object Oriented Substation Event (as defined in IEC 61850)
GPS	Global Positioning System
HCS	Hull Control System
HFGS	Fire & Gas System – Hull
HGCP	Hull Generator Control Panel
HMI	Human-Machine Interface (current designation for MMI)
HSD	Hull Shutdown System
HSDN	High-Speed Deterministic Network
HVAC	Heating, Ventilation and Air Conditioning
HW	Hardwired
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device (as defined in IEC TR 61850)
IMD	Insulation Monitoring Device
IR	Intelligent Relay (type of IED)
ISA	International Society of Automation
LAN	Local Area Network
LV	Low-Voltage (≤ 1kV)
MCC	Motor Control Center
MMI	Man-Machine Interface
MMR	Microprocessor-based Multifunction Relays (type of IED)
MMS	Manufacturing Message Specification (as defined in IEC 61850)
MOP	Operational Mode
MRP	Media Redundancy Protocol
MTTR	Mean Time to Repair

MV	Medium Voltage (> 1kV)
OLE	Object Linking and Embedding
OPC UA	OLE for Process Control Unified Architecture
PCP	Package Control Panel
PCS	Process Control System
PI	Plant Information® software from Osisoft
PLC	Programmable Logic Controller
PMS	Power Management System
PQMS	Power Quality Monitoring System
PSD	Process Shutdown System
RTDS	Real Time Data Server
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SIEM	Security Information and Event Management
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol
SOS	Supervision and Operation System
SQL	Structured Query Language
SS	Soft-starter
TCP/IP	Transmission Control Protocol / Internet Protocol
TGCP	Turbogenerator Control Panel
UAM	Unit Alarm Malfunction
UAS	Unit Alarm Shutdown
UPS	Uninterruptible Power Supply
VLAN	Virtual Local Area Network
VSD	Variable Speed Drive