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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, comissioning 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-002 - SPECIFICATION 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 - FUNCIONAL 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] TECHNICAL SPECIFICATION FOR TURBOGENERATOR PACKAGE

[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] PIPING AND INSTRUMENT DIAGRAM GENERAL NOTES

[25] I-ET-3010.00-5265-773-P4X-001 – UNINTERRUPTIBLE POWER SUPPLY FOR OFFSHORE UNITS

[26] HULL WLAN SYSTEM

[27] AUTOMATION NETWORK DESCRIPTION

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

3. ELECTRICAL SYSTEM AUTOMATION

3.1. SCOPE OF SUPPLY

3.1.1. All hardware, cables, cable trays, supports, junction boxes, softwares, 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, softwares, licenses, services, accessories, configurations, development of communication drives 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, softwares, licenses, services, accessories, configurations, development of communication drives 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.

3.2. GENERAL REQUIREMENTS

3.2.1. Hardware and Software of Electrical Automation System 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;
- Topside and Hull Operation, control and monitoring of the Electrical Automation System Operation from Topside Operational Portable Devices;
- Hull Operation, control and monitoring from Electrical Automation System Operation from Hull Operational Portable Devices;
- Topside and Hull Operation, control and monitoring from Remote Onshore Operational Center through remote access to the Electrical Automation System Operational Workstations;
- The Electrical Automation System 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.
- Parameterization, adjusting and configuration of all electric equipment connected to the Electrical System Automation networks from Topside Electrical Automation System Maintenance Workstations.
- Parameterization, adjusting and configuration of all electric equipment connected to the Electrical System Automation networks from Hull Electrical Automation System 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 Automation System Maintenance Workstations.
- Parameterization, adjusting and configuration of Real Time Data Servers from Remote Onshore Operational Center through remote access to the Electrical Automation System Real Time Data Servers.

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

3.2.3. The interconnection between automation equipment inside of a panel, such as IED's, switches or CPU, shall be Shielded Twisted Pair (STP) CAT 5e.

3.2.4. The interconnection between different panels or equipment shall be made through CAT 6 cables, except when the distance between equipment exceeds 100 meters according IEC 11801 or the cable crosses outdoor area. In these cases, optic fiber shall be used.

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

3.2.6. 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.

3.2.7. 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.

3.3. **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-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

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

3.3.3. All panels and enclosures for Electrical Automation System 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 automation system 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. The optical fiber cables shall comply with temperature requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS and for other technical characteristics shall comply with I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

3.3.8. 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.

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

3.3.10. The external removable solid-state drives of the Electrical System Automation RTDSs shall be used to log all information from supervisory system, being a mirror of the Electrical System Automation RTDSs internal disks with RAID1 configuration.

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

3.3.12. 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 immediately replaces the primary system.

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 supplied Microsoft® Office Software at its latest version for all computers.

3.5. COMMUNICATION REQUIREMENTS

3.5.1. Network communication among Electrical Automation System 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 Automation System components and electric equipment shall communicate in the defined protocol without use of gateways or converters.

3.5.3. All Electrical Automation System 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 Automation System Ethernet networks shall be as follow: Fast Ethernet (IEEE 802.3), 100Mbps minimum, full duplex. All electrical equipment that uses Ethernet shall communicate in the respective network with this transfer rate.

3.5.6. Each Electrical Automation System Ethernet network, for example the Topside/Hull IEC 61850 Fast Ethernet Network, shall not be connected to any other network, for example the Topside/Hull Multipurpose Fast Ethernet Network. The Electrical Automation System networks shall be independent and physically separated from all other existent networks on the platform and with security mechanism in order to prevent external attacks and data losses. Networks interconnection shall exist only when specified in the document I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

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

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

3.5.7.2. Topside and Hull MCC Fast Ethernet Networks to interconnect the MCC IEDs in MODBUS TCP. 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;

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

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

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

3.5.7.6. Topside and Hull A&C Interface Fast Ethernet Networks in order to interconnect Electrical System Automation Equipment to the Topside and Hull Packaged Systems Network from A&C.

3.5.7.7. 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).

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

3.5.8.1. Connection to A&C controllers shall be made through the Electrical Automation System Controllers by peer-to-peer connection. The controllers will acquire data from the Electrical Automation System 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 using dedicated network cards for each connection.

3.5.8.2. Connection to SOS network shall be made through the Topside/Hull A&C Interface Fast Ethernet Networks. The RTDSs will acquire data from the Electrical Automation System Networks using dedicated network cards in the defined protocols and provide the data to SOS network in OPC 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.

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

3.5.9. 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.

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

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

3.5.12. 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.

3.5.13. 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.

3.6. **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, gateways 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”, “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 150kHz 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

4.8.6. 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.

3.13.1. The Alarm Management System shall include self diagnostic check of each component of the Electrical System Automation, including switches, controllers and its individual cards, 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 through the Electrical Automation System Network and to the Electrical System Controllers through discrete I/O.

3.13.2. 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.

3.14. 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. The manufacturer shall furnish at least 04 (four) copies of all documentation.

3.14.3. 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.

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

3.14.5. It shall be supplied with the proposal, in the number of copies defined at PETROBRAS documents, at least the following technical documents:

- Technical specifications, data sheets and brochures comprising: hardware, software, cables, materials and accessories, cables, materials and softwares;
- 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.

3.14.6. There shall be supplied for approval, in the number of copies defined at PETROBRAS documents, 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 Automation System 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.

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

3.14.8. 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;
- Procedures for operation, including warning conditions;
- Technical data in catalogues, brochures, manuals and prospects of all equipment, components, material and software;
- All test reports approved;
- Complete software’s documentation;
- Schedule to replace all equipment/component of Electrical System Automation;
- Softwares 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, 4.1.4.1, 3.6.2, 3.6.3 and 3.6.4;
- Conformance tests certificates according to IEC 61850-10 for equipment working with IEC 61850.

3.14.9. 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.

3.14.10. 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.

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 all electrical automation system equipment as switches, controllers, I/O cards, 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. Electrical System Automation Panel include 2 groups of redundant fast Ethernet switches, according to item 3.5.5. The switches shall have the requirements describe in the item 4.2.

4.1.1.6. These 2 groups of switches shall be arranged and connected in order to constitute, at least, the HMI/OPC Network and Electrical System Automation Controllers Network. The following groups of switches, at minimum, shall be comprised: Electrical System Automation Controllers Switches and HMI/OPC Switches.

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

4.1.1.8. 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 automation system 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 Automation System Controllers shall be constituted of redundant, hot-standby PLCs or DCS System without any common mode fault and with facilities for hot-swap.

4.1.2.4. The Topside Electrical System Automation Controllers hardware shall be able to communicate in protocol IEC 61850 natively, without use of external converters or gateways. For other hardware requirements, see I-ET-3010.00-5520-862-P4X-001 - PROGRAMMABLE LOGIC CONTROLLERS - PLC, considering item 4.1.2.3 above. They shall be updated during Detailed Design according to technology development and shall be presented to PETROBRAS approval.

4.1.2.5. The Topside 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. For other hardware requirements, see I-ET-3010.00-5520-862-P4X-001 - PROGRAMMABLE LOGIC CONTROLLERS - PLC, considering item 4.1.2.3 above.

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

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

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

4.1.3.3. 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 Servers and communication drivers for all equipment to be controlled or monitored in the electrical system.

4.1.3.4. The Topside Electrical System Automation RTDSs shall include an OPC Client compatible with HULL Electrical System Automation RTDSs OPC 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.

4.1.3.5. 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.

4.1.3.6. 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.

4.1.3.7. Electrical Automation System Real Time Data Servers main functions are:

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

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

4.1.4. ELECTRICAL SYSTEM AUTOMATION TIME SERVER

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

4.1.4.2. Electrical Automation System 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.

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

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

4.1.4.5. 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-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

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

4.1.5.1. Electrical System Automation shall include a Wireless Network to be designed according to requirements from the document HULL WLAN SYSTEM.

4.1.5.2. 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.

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

4.2. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION SWITCHES PANEL

4.2.1. The Electrical System Automation Switches Panels are comprised of groups of redundant fast 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 and Electrical System Time Server, PMS, VSDs, SSs and others.

4.2.2. These switches shall be arranged and connected in order to constitute, at least, the networks defined in item 3.5.7, in exception of the MODBUS TCP Peer-to-Peer network and switches regarding the HMI/OPC Network and Electrical System Automation Controllers Network which will be located in Topside/Hull Electrical System Automation Panel. The following groups of switches, at minimum, shall be comprised: IEC 61850 Switches, LV MCC Relays Switches, Multipurpose Switches and A&C Interface Switches.

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

4.2.4. The quantity of switches connections shall be designed considering 50% of the total quantity of required connections of each switch (50% connections as spare). In case of failure of one connection point (input/output) or of an entire switch, there shall be easy to promptly move to other connection point or switch.

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

4.2.6. All switches shall me manageable as per item 3.2.5.

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

4.2.8. 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.

4.2.9. The interconnection of each ring network to external ring networks (outside TOPSIDE/HULL Electrical System Automation Switches 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 the active connection.

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

4.3. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION OPERATIONAL WORKSTATION

4.3.1. Electrical System Automation Operational Workstations shall be supplied as industrial microcomputers 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.

4.3.2. USB, memory card and other communication ports shall include cyber security mechanisms in order to be protected against cyber-attacks.

4.3.3. Operating System of Electrical System Automation Operational Workstation: Microsoft ® Windows Professional at its latest version.

4.3.4. 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.

4.3.5. Different access levels protected through different passwords shall be granted for operation and monitoring of Electrical System equipment. Report with discrimination of users' access shall be stored for all operations.

4.3.6. It shall be possible full remote control of electrical system non-motoric loads classified as EA02 and EA03 via Electrical System Operational Workstations.

4.3.7. It shall be possible full remote control of panels incoming and tie circuit-breakers and outgoing feeders for power transformers via Electrical System Operational Workstations. Electrical System interlocks shall prevail.

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

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

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

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

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

4.3.9.4. 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.

4.3.9.5. 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.

4.3.9.6. 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.

4.3.9.7. 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.

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

4.3.9.9. Main generators, auxiliary and emergency specific screens.

4.3.9.10. Alarm, trend graphs and event record screens

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

4.3.9.12. Data available in electrical equipment connected to the Topside/Hull Electrical System Automation Networks shall be monitored by Electrical System Automation Operational Workstations, even if these data are not sent to A&C.

4.3.9.13. All data available in Topside/Hull Electrical System Automation Panel from hardwired signals shall be monitored by Electrical Automation System Operational Workstations.

4.3.9.14. The Electrical System Automation Operational Workstations shall provide monitoring of real-time data, alarm and event for all electrical equipment with remote monitoring.

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

4.3.9.16. The colour code to be used to represent the status of switching devices shall comply with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

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

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

4.4. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION OPERATIONAL PORTABLE DEVICE

4.4.1. The Electrical System Automation Operational Portable Device 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-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.4.2. The Electrical System Automation Operational Portable Device shall be compatible with the Electrical System Automation Wireless Network Access Points.

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

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

4.4.5. Custom screens for portable devices comprising the whole supervision and control required from item 4.3 shall be implemented.

4.4.6. The Electrical System Automation Operational Portable Device shall include a QR Code reader in order to read QR Codes installed in panels to automatically open the documents folder regarding the equipment located in the Electrical System Automation RTDSs.

4.4.7. It shall be supplied all QR codes for the unit together with the Electrical System Automation Operational Portable Device.

4.5. TOPSIDE/HULL ELECTRICAL SYSTEM AUTOMATION MAINTENANCE WORKSTATION

4.5.1. Electrical system Automation Maintenance Workstation shall be supplied as industrial server 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) BlueRay/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.

4.5.2. USB, memory card and other communication ports shall include cyber security mechanisms in order to be protected against cyber-attacks.

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

4.5.4. Operating System of Electrical System Automation Maintenance Workstation: Microsoft ® Windows Professional at its latest version.

4.5.5. Electrical Automation System Maintenance Workstations shall be connected to Electrical Automation System through the networks listed in 3.5.7, in exception of the MODBUS TCP Peer-to-Peer network.

4.5.6. Electrical Automation System 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.

4.5.7. All parameters of electrical system equipment connected to electrical system network shall be stored in the Electrical Automation System 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 Automation System Maintenance Workstation, and shall not cause impacts in operation of other equipment.

4.5.8. 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 softwares;
- Software for management and maintenance of LANs and VLANs;
- Configuration software for the Gateway PLC or DCS.

4.5.9. 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.

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

4.5.11. 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, BETUs (Built-in Electronic Trip Units), etc., seeI-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT 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.

5.2. MEDIUM VOLTAGE SWITCHGEARS/MCC AND LOW VOLTAGE SWITCHGEARS

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

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

5.2.3. 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.

5.2.4. The interconnection of the redundant switches to the IEC 61850 Fast Ethernet Network 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 the active connection.

5.2.5. IEDs (MMRs), shall be connected to the switches by using ring topology among the IEDs from the same busbar. One end of the ring topology shall be connected to a different switch which the other end is connected at the same busbar. Alternatively, it is allowed to connect each IED to the switches by using star topology with redundant connections for each relay.

5.2.6. The BETU shall be connected to the switch located in the respective busbar by 1 (one) single connection.

5.2.7. 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.

5.2.8. Switches shall comply with requirements presented item 4.2.

5.2.9. 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.

5.3. 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.

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

5.3.3. There shall not be used any gateway or protocol converter for this communication.

5.3.4. Switches shall comply with requirements presented item 4.2

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

5.3.6. The interconnection of the redundant switches to the MCC Fast Ethernet Network 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 the active connection.

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

5.4. THYRISTOR HEATER PANELS

5.4.1. The ACB of incoming circuits shall be connected to the Multipurpose Fast Ethernet Networks.

5.4.2. MCBs shall have their status monitored by hardwired connections to the Electrical System Automation Controllers.

5.4.3. The outgoing circuits shall have their status monitored by hardwired connections to the Electrical System Automation Controllers.

5.4.4. The outgoing circuits shall have ground fault trip signalling by hardwired connections to the Electrical System Automation Controllers.

5.5. MAIN GENERATORS

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

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

5.5.3. 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 Fast Ethernet (IEC 61850). See I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

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.

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

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

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

5.6.3. The PMS is connected to several networks, in many protocols according to item 5.6.1 and 5.6.2. Detail Design shall define which networks are suitable for the respective signals to be transferred.

5.6.4. Topside Electrical System Automation RTDSs shall include an OPC Client and Server compatible with PMS OPC Client and Server in order to be capable of reading and writing all data from PMS.

5.6.5. 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.

5.6.6. Topside Electrical System Automation Operational Workstations and Operational Portable Devices shall include 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.

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

5.6.8. Topside Electrical System Controllers shall be capable of communicating in the Manufacturer's Standard Ethernet TCP/IP Protocol of the PMS controllers to provide communication with A&C and for any automatic control function.

5.6.9. 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.

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

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

5.7. EMERGENCY AND AUXILIARY GENERATORS

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

5.7.2. The communication between the generators controllers, installed inside Emergency Generator Power and Control Panel (EGCP) and Auxiliary Generator Power and Control Panel (AGCP) and Unit low-voltage panels (MCCs and CDCs) and Electrical System Automation shall be according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

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

5.7.4. Emergency and Auxiliary Generators controller panels shall communicate with Electrical System Automation through the Multipurpose Fast Ethernet TCP/IP network, with protocol defined by equipment manufacturer, for remote supervision and monitoring.

5.8. UPSs, BATTERY CHARGERS (CBs) AND CATHODIC PROTECTION RECTIFIERS

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

5.8.2. The requirements of this item are applicable for UPSs, CBs and their respective batteries and distribution panels.

5.8.3. It is not foreseen to operate UPSs, CBs and cathodic protection rectifiers remotely from Electrical System Workstations or from A&C.

5.8.4. UPSs, CBs, UPS and CB primary distribution panels and cathodic protection rectifiers shall communicate with Electrical System Automation through the Multipurpose Fast Ethernet TCP/IP network, with protocol defined by equipment manufacturers, for remote supervision and monitoring.

5.8.5. Additionally, some hardwired signals are foreseen among UPSs and Battery Chargers and Electrical System Gateways.

5.8.6. Signals to be transferred shall be according with I-LI-3010.00-5140-797-P4X-001

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

5.9.1. 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.

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

5.9.3. 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.

5.9.4. 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.

5.9.5. 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.

5.9.6. 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.

5.9.7. 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. OTHER ELECTRICAL EQUIPMENT

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

5.10.2. VSDs or SSs to drive Turbogenerators auxiliary loads, if any, may not be connected to the Electrical System Automation Networks.

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

5.10.4. Power transformers with winding overload alarm and high temperature in windings alarm shall have the signals sent the respective IED (primary, secondary, tertiary IED).

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

6. INTERFACE BETWEEN ELECTRICAL AUTOMATION SYSTEM 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 automation system 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 and furnished with devices capable to communicate with the A&C through network. These devices could be IED's, VSD's, MMR's, IR's, etc. Shutdown signal shall be hardwired.
- EA02: Functional Unit monitored by Process Controllers, by Fire & Gas Controllers. Field pushbutton (start signal) 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 pushbutton (start signal) from A&C shall be received by network. Shutdown signal shall be hardwired.

- EA04: Package Functional Unit or Functional Units controlled by the Packages. These units shall communicate with the Package controllers (installed in Packages control panels) through hardwired signals. These functional units do not have interface signals with Process Controllers. 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 PIPING AND INSTRUMENT DIAGRAM GENERAL NOTES.

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:

- PIPING AND INSTRUMENT DIAGRAM GENERAL NOTES
- 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 during detailed design, the functional unit shall be classified as non-motor EA03 and the VSD shall keep the previous functional unit classification.

6.1.7.3. Some loads, despite not classified as Packages by A&C, may have small control panels included in their scope of supply to control the main or the auxiliary loads, according to supplier standard. In these cases, these small control panels may not be installed in AEPR. For these cases, if the control panel is a power & control panel and is the responsible to drive the loads, it shall be classified as non-motor EA03. If the control panel is used only 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 stamped.

6.1.10. OPC 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. The network communication among EA01 functional units and A&C shall be through Electrical System Automation as follows:

6.2.1.1.1. 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.

6.2.1.1.2. Signals used only for monitoring purposes shall be read from electric equipment and sent through the Electrical System Automation RTDSs.

6.2.1.1.3. VSDs Set point shall be hardwired.

6.2.1.2. The network communication protocol among all EA01 functional units and the Electrical System Automation RTDSs and Electrical Automation System 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.

6.2.1.3. Normal loads functional units shall receive hardwired ESD (Emergency Shutdown) signals from Shutdown Controllers or from Fire & Gas Controllers.

6.2.1.4. Essential loads functional units shall not receive any kind of ESD (Emergency Shutdown) signals from A&C. Exception for air compressors (to avoid contamination of compressed air, in case of confirmed gas detection in air compressors vicinity), Emergency Generator Power and Control Panel (EGCP) (to inhibit generator start, in case of confirmed gas detection in Emergency Generator Room) and all HVAC loads (to allow isolation of ignition sources in case of confirmed gas detection in the rooms served by the HVAC loads).

6.2.1.5. 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 Automation System 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. The network communication among EA02 functional units and A&C shall be through Electrical System Automation RTDSs for monitoring from A&C and remote control (non-motor loads) and monitoring from Electrical System Operational Workstations.

6.3.1.2. Field pushbutton (start) and Set point (applicable for VSDs) shall be transferred from A&C to electric equipment through Electrical System Automation Controllers.

6.3.1.3. The network communication protocol among all EA02 functional units and the Electrical Automation System 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.

6.3.1.4. Functional Units shall receive ESD signals shall be according items 6.2.1.3 and 6.2.1.4.

6.3.1.5. 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 Automation System 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 manual control (start) and Set point (applicable for VSDs EA02 and EA03) shall be transferred from A&C to electric equipment through Electrical System Automation Controllers.

6.4.1.4. Functional Units shall receive ESD signals shall be according items 6.2.1.3 and 6.2.1.4.

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

6.4.2. Interface of functional units type EA03 with Electrical Automation System 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, for loads that are not essential loads (See item for 6.2.1.4 exceptions).

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 are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.5.1.7. “START” signals from Package push-buttons connected to normal EA04 functional units shall turn on the respective loads if there is no ESD signal from A&C.

6.5.1.8. “STOP” signals from Package push-buttons connected to normal EA04 functional units shall always turn off the respective load.

6.5.2. Interface of functional units type EA04 with Electrical Automation System 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. All signals among A&C and TGCPs (through Electrical System Automation Controllers), not defined as hardwired in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST, shall be through network using manufacturer standard Ethernet Network protocol.

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

6.6.4. Interface of Main Generators with Electrical Automation System shall include all A&C signals, besides the signals to be exchanged are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.7. INTERFACES OF PMS WITH A&C

6.7.1. 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. All signals between A&C and PMS, not defined as hardwired in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST shall be through network communication according to item 5.6.1.

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

6.7.3. The ESD signal from the Shutdown Controllers shall be hardwired to PMS.

6.7.4. Interface of PMS with Electrical Automation System shall include all A&C signals, besides the signals to be exchanged are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

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

6.8.1. The communication between the generators controllers shall be through the Multipurpose Fast Ethernet Network.

6.8.2. Signals to A&C shall be transferred by using the Electrical System Automation Controllers.

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

6.8.4. ESD signals are foreseen from A&C to generators control panels. For Emergency Generator, this signal is only for confirmed gas detection in Emergency Generator Room air intake, to inhibit start.

6.8.5. The signals to be transferred between the generators package and Electrical Automation include all signals transferred to A&C, besides the signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.9. INTERFACES OF UPSs, CBs AND CATHODIC PROTECTION RECTIFIERS WITH A&C

6.9.1. Battery chargers and UPSs shall receive signals from A&C to inhibit battery charge, according to safety requirements.

6.9.2. Signal required to be sent to A&C from these equipment shall be sent through Electrical System Automation Controller, which will read the information from the equipment through the Multipurpose Fast Ethernet Network.

6.9.3. The signals foreseen to be transferred between UPSs, CBs and their distribution panels to A&C are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

6.9.4. UPSs and CBs fed from essential MCCs or essential CDCs and classified as essential loads shall not be tripped by ESD signals.

6.9.5. The signals to be transferred between the UPSs, CBs and their distribution panels and Electrical Automation include all signals transferred to A&C, besides the signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

7. INTERFACE OF ELECTRICAL AUTOMATION SYSTEM BETWEEN HULL AND TOPSIDE

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

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

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

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

7.1.8. 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 dedicated MODBUS TCP Peer-to-Peer connection.

7.1.9. The Topside Electrical System Automation Controllers shall be capable of reading and writing, acting as a Client, of all data available from the Hull Electrical System Automation Controllers by using the dedicated MODBUS TCP Peer-to-Peer 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.

7.1.10. 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 AUTOMATION SYSTEM AND REMOTE ONSHORE OPERATION CENTER

8.1. GENERAL

8.1.1. Electrical System Automation data will be available to A&C Packaged System Servers from Electrical system Automation RTDSs OPC server though A&C Interface Fast Ethernet Network.

8.1.2. Electrical System Automation Operational Workstation will be accessed through remote desktop connection from A&C Packaged System Network.

8.1.3. Electrical System Automation Maintenance Workstation will be accessed through remote desktop connection from A&C Packaged System Network.

8.1.4. There shall be provided one additional Electrical System Automation RTDSs, which will share data with the Electrical System Automation RTDSs installed in the Electrical System Automation Panels, including the OPC Server, HMI server, Historian Server and PI collector software to be installed in the DMZ using Telecom facilities.

8.2. MONITORING SIGNALS

8.2.1. All signals from I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST shall be transferred to PI Systems.

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 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, SAT and SIT 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 CONTROLERS
- ELECTRICAL SYSTEM AUTOMATION OPERATIONAL WORKSTATION
- 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 PANEL
- HULL ELECTRICAL SYSTEM AUTOMATION SWITCHES PANEL
- TOPSIDE ELECTRICAL SYSTEM AUTOMATION SWITCHES
- HULL ELECTRICAL SYSTEM AUTOMATION SWITCHES
- 2 MMRs RELAYS OF EACH MANUFACTURER REPRESENTING LOADS
- 1 MMR RELAY REPRESENTING GENERATOR
- 2 MMRs RELAYS REPRESENTING INCOMING AND TIE

9.2.2. At least the following tests shall be performed at Factory (FAT), where applicable, 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 (colour, thickness and adhesion)
Wiring and termination inspection;
General system functions including hardware redundancy and diagnostic check;
General turn of , turn on and reset check
Controller, switch, PLC, GPS, servers and relays turn of and turn on checks
EMC tests according with IEC series 61000 standards.
ESA network model assembled
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);
Software Tests
Softwares license inventory check
Check all ESA softwares installed
Check all IEDs, MMRs, IRs, VSDs, Soft Starters, UPS softwares installed
Back up softwares installation verifying
Operation and supervision screens running and fully operational
Color code check
Screens navigation check
Verification of data, time, company identification, platform , etc. at screens
User and access profile check
Functional Tests
Check of operation and supervision configuration software at local and remote workstations
Check of IEC 61850 network configuration software at local and remote workstations
Check all ESA network devices software running at local and remote workstations
Check all VSD, soft starter, generators and UPS software running at local and remote workstations
Check IED, MMRs and IRs network devices software running at local and remote workstations
User profile change check

Check of time stamp during overcurrent or low voltage trigger in 0%, 50% and 80% network loading.
Check of logical selectivity 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, VSDs and soft starters typical check
Generators, CDCs and MCCs screens typical check
Others HMI screens typical check
Circuit breaker failure (50 BF)
Start/stop total time check.
Interface with A&C check.
Interface with Packages, PMS, among others check
Alarms and event record check
Check at HMI 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

9.3. SITE INTEGRATION ACCEPTANCE TESTS

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

Table 2 - SITE INTEGRATION 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 of , turn on and reset check
Controller, switch, PLC, GPS, servers and relays turn of and turn on checks
ESA network completely assembled
Communication Tests
Optical fibers conectorizing certification
Network certification
Internet protocol 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
Interlocks (including GOOSE and MMS typical messages, scenarios with backfeed operation and generators synchronizing);
Software Tests
Softwares license inventory check
Check all ESA softwares installed
Check all IEDs, MMRs, Irs, VSDs, Soft Starters, UPS softwares installed
Back up softwares installation verifying
Operation and supervision screens running and fully operational
Color code check
Screens navigation check
Verification of data, time, company identification, platform , etc at screens
User and access profile check
Functional tests
Check of operation and supervision configuration software at local and remote workstations
Check of IEC 61850 network configuration software at local and remote workstations
Check all ESA network devices software running at local and remote workstations
Check all VSD, soft start, generators and UPS software running at local and remote workstations
Check IED, MMRs and IRs network devices software running at local and remote workstations
User profile change check
Check of time stamp during overcurrent or low voltage trigger in 0%, 50% and 80% network loading.
Check of logical selectivity between relays in 0%, 50% and 80% network loading.
Operation, monitoring and supervision screens check in 0%, 50% and 80% network loading.
Check all EA01, EA02, EA03 and EA04 drawers, UPS, VSDs and soft starters
Check all generators, CDCs and MCCs screens
Check others HMI screens
Circuit breakerfailure (50 BF)
Start/stop total time check.
Interface with A&C check
Interface with Packages, PMS, among others check
Alarms and event record check
Check at HMI 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

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
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
DCS	Distributed Control System
EA01 to EA04	Electric Actuation Type 01 to Electric Actuation Type 04
EGCP	Emergency Generator Power and Control Panel
EMC	Electromagnetic Compatibility
ESD	Emergency Shutdown
FGS	Fire & Gas System - Topsides
FPSO	Floating, Production, Storage and Offloading Unit
GOOSE	Generic Object Oriented Substation Event (as defined in IEC 61850)
HCS	Hull Control System
HFGS	Fire & Gas System - Hull
HMI	Human-Machine Interface (current designation for MMI)
HSD	Hull Shutdown System
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)
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	Machinery Monitoring System
MTTR	Mean Time to Repair
MV	Medium Voltage (> 1kV)
OLE	Object Linking and Embedding
OPC	OLE for Process Control
PCS	Process Control System
PLC	Programmable Logic Controller
PMS	Power Management System
PQMS	Power Quality Monitoring System
PSD	Process Shutdown System
RTU	Remote Terminal Unit
SOS	Supervision and Operation System
SQL	Structured Query Language
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