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DESIGN	ESUP	EEI	ESUP	ESUP	ESUP	EEI	EEI	EEI	EEI	
EXECUTION	JOAOCASTRO	UR7U	JOAOCASTR	JOAOCASTR	JOAOCASTR	UR7U	UR7U	UR7U	UR7U	
CHECK	MARCELO BP	CTLX	WVERLY	WVERLY	PFERRAZ	BD36	U5AL	U4RH	CTLX	
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1. GENERAL

1.1. Objective

- 1.1.1. This specification together with the references listed in item 1.3 establish the criteria, requirements and guidance for definition of protection of Electrical System, for the execution of the Electrical Protection Coordination Study and for the specification of the protective devices.
- 1.1.2. This specification defines protection for the electrical equipment. For generators prime movers and for motors driven machines specific protections refer to the applicable Petrobras Technical Specifications and manufacturers recommendations.
- 1.1.3. This technical specification defines protection criteria for 480V and above. For lower voltage levels, the protection settings shall be defined in the detailed design with Petrobras approval.

1.2. Applicable Standards

- 1.2.1. The Electrical Protection shall comply, but not restricted only, with the requirements of Classification Society and the standards and practices listed below, in their latest revision:

IEEE 242 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

IEEE C37.2 Electrical Power System Device Function Numbers, Acronyms, and Contact Designation

IEEE C37.91 Guide for Protective Relay Applications to Power Transformers

IEEE C37.96 Guide for AC Motor Protection

IEEE C37.102 Guide for AC Generator Protection

IEEE 141 Recommended Practice for Electric Power Distribution for Industrial Plants

IEC 61892-2 Mobile and fixed offshore units – Electrical installations – Part 2: System Design


IEC 60034-1 Rotating Electrical Machines – Part1: Rating and performance


IEC 60255 Measuring Relays and Protection Equipment – All parts

NR-10 Segurança em Instalações e Serviços em Eletricidade

1.3. Reference documents

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

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<p>[2] I-DE-3010.00-5143-946-P4X-002 - LOW-VOLTAGE SYSTEMS PROTECTION DIAGRAM</p> <p>[3] I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS</p> <p>[4] I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS</p> <p>[5] I-ET-3010.00-5147-711-P4X-001 - MAIN GENERATOR FOR OFFSHORE UNITS</p> <p>[6] I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM</p> <p>[7] I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE</p> <p>[8] I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS</p> <p>[9] I-ET-3010.00-5140-712-P4X-002 - MEDIUM-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS</p> <p>[10] I-ET-3010.00-5261-700-P4X-001 - EMERGENCY GENERATOR PACKAGE FOR OFFSHORE UNITS</p> <p>[11] I-ET-3010.00-5262-700-P4X-001 - AUXILIARY GENERATOR PACKAGE FOR OFFSHORE UNITS</p> <p>[12] I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS</p> <p>[13] I-ET-3010.00-5140-712-P4X-001 - LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS</p> <p>[14] I-DE-3010.00-5140-741-P4X-001 - FUNCTIONAL UNITS BLOCK DIAGRAMS</p> <p>[15] I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS</p> <p>[16] I-ET-3010.00-5140-772-P4X-001 - MEDIUM-VOLTAGE FREQUENCY CONVERTER FOR OFFSHORE UNITS</p> <p>[17] I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST</p> <p>[18] I-ET-3010.00-5262-700-P4X-002 - HULL GENERATOR PACKAGE FOR OFFSHORE UNITS</p> <p>[19] I-ET-3010.00-5140-773-P4X-001 - SPECIFICATION FOR D.C. UPS FOR OFFSHORE UNITS</p> <p>[20] I-ET-3010.00-5140-773-P4X-002 - SPECIFICATION FOR GENERIC D.C. UPS FOR OFFSHORE UNITS</p> <p>[21] I-ET-3010.00-5140-773-P4X-003 - SPECIFICATION FOR A.C. UPS FOR OFFSHORE UNITS</p>			

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- [22] I-ET-3010.00-5111-712-P4X-001 - SUBMERSIBLE INDUCTION MOTORS FOR SEA WATER LIFT PUMPS FOR OFFSHORE UNITS
- [23] I-ET-3010.00-5140-775-P4X-001 - REQUIREMENTS FOR ELECTRICAL GENERATION EXCITATION SYSTEM FOR OFFSHORE UNITS
- [24] I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS
- [25] I-ET-3010.00-5140-700-P4X-009 - GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
- [26] I-ET-3010.00-5140-713-P4X-001 - SPECIFICATION FOR TRANSFORMERS FOR OFFSHORE UNITS
- [27] I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS
- [28] I-ET-3010.00-5140-772-P4X-002 - SPECIFICATION FOR LOW-VOLTAGE FREQUENCY CONVERTERS, SOFTSTARTERS AND INVERTERS FOR OFFSHORE UNITS

2. TERMS AND DEFINITIONS

- MCCB – Molded Case Circuit-Breaker;
- MCC – Motor Control Center;
- AVR – Automatic Voltage Regulator;
- CT – Current Transformer;
- VT – Voltage Transformer;
- RTD – Temperature Sensor;
- CB – Circuit-Breaker;
- MMR – Microprocessor-Based Multifunction Protection Relays;
- MGCP – Main Generator Control Panel;
- Isc min – Minimum Short-circuit Current;
- VSD – Variable Speed Driver;
- AGCP – Auxiliary Generator Control Panel;
- EGCP – Emergency Generator Control Panel;
- STD – Short Time Delay Protection Curve;
- LTD – Long Time Delay Protection Curve;
- AR1 and AR2 - For Main Switchgear tie CB it is considered two MMRs hereafter denominated AR1 in bar B and AR2 in bar A. For three 13.8kV busbar configuration there are one relay for each busbar TIE.

Table 1 – Terminology adopted

Terminology	Description
ANSI 24	Over-excitation V/Hz
ANSI 25	Synchronism Check
ANSI 27	Undervoltage
ANSI 32	Reverse Power
ANSI 37	Undercurrent or Underpower
37F-1	Field undercurrent limiter

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Terminology	Description
ANSI 38	High Temperature - bearings
ANSI 39	Vibration
ANSI 40	Field Loss
ANSI 46	Current Unbalance
ANSI 47	Phase-Sequence
ANSI 48	Locked Rotor
ANSI 49	Thermal Image (by Current Sensors)
ANSI 49 RTD	High Temperature (by Temperature Sensors)
ANSI 50	Overcurrent Instantaneous/Definite Time
50/STD	Definite Time Overcurrent / Short time delay
51/LTD	Inverse time Overcurrent / Long time delay
68-1	Logical Selectivity, send a blocking signal to upstream relay
68-2	Logical Selectivity, trip the CB unless receives a blocking signal from downstream relays
ANSI 50BF	Breaker failure
ANSI 50GS	Ground Fault (core balanced CT)
ANSI 51	Inverse time Overcurrent
ANSI 51LR	Rotor Jam
ANSI 51V	Overcurrent with Voltage Restrained
51F	Field overcurrent
51F-1	Field overcurrent limiter
ANSI 58	Rotating Diode Bridge Failure
ANSI 59	Overvoltage
ANSI 59N	Ground Fault (Calculated Neutral Overvoltage)
ANSI 59G	Ground Fault (Neutral Overvoltage)
59F	Field overvoltage
ANSI 60	Voltage Unbalance – VT fuse supervision
ANSI 63	Underpressure
63A	Compressed Air Underpressure
63Q	Lube Oil Underpressure
ANSI 64F	Field Ground Fault
ANSI 64G	Stator Winding Ground Fault
ANSI 66	Starts/Hour & Time Between Starts
ANSI 67	Directional Overcurrent
67F	Directional Overcurrent Forward
67R	Directional Overcurrent Reverse
67N	Directional ground fault overcurrent
ANSI 81 (U)	Underfrequency
ANSI 81 (O)	Overfrequency
ANSI 86	Lockout Relay
ANSI 86-1	Generator Breaker Lockout Relay
ANSI 86-2	Turbine, Field & Generator Breaker Lockout Relay
ANSI 87M	Motor Differential Current – Self-balanced CT
ANSI 87	Differential Protection

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3. LOGICAL SELECTIVITY

- 3.1.1. To reduce the trip time between adjacent circuit-breakers (including back-feeds in different switchgears) the use of logical selectivity shall be considered during the Protection and Coordination Study.
- 3.1.2. For network and communication requirements between MMRs refer to I-ET-3010.00-5140-797-P4X-001 and I-DE-3010.00-5140-797-P4X-001.
- 3.1.3. In order to detail the logical selectivity scheme the following terminology is adopted in this document:
- The pickup of the overcurrent element (hereafter denominated XX/68-1) will generate a blocking signal to the upstream relay (GOOSE, IEC 61850).
 - The overcurrent element (hereafter denominated XX/68-2) of the switchgear's tie or incomer circuit-breaker, will trip within a specified time delay, unless it receives a blocking signal from downstream relay.

Note: XX/68-1 or XX/68-2 stands for the protection function operating in the logical selectivity scheme. For example, 50/68-1 in case of definite time overcurrent function sending a blocking signal, or 67/68-2 in case of directional overcurrent function waiting for blocking signal.


4. BREAKER FAILURE (ANSI 50BF)

- 4.1.1. If the fault current persists after the MMR trip signal of an outgoing circuit-breaker, the 50BF function shall issue an IEC 61850 GOOSE signal to trip the tie, back-feeders and incomer circuit-breaker (Transformer's secondary/tertiary where applicable) located on the same semi-bar of the faulted circuit-breaker.
- 4.1.2. For generators incoming circuit-breakers, the 50BF function shall shutdown also the prime mover and field circuit.
- 4.1.3. In order to avoid the trip of others CB during the test of one outgoing functional unit, its 50BF function shall be active only when the circuit-breaker is in inserted position.

5. MAIN EQUIPMENT PROTECTION CRITERIA

5.1. Main Generator / Hull Generator

- 5.1.1. Unless otherwise specified in the Petrobras Documentation, the generator auxiliary components and MMR shall be supplied with necessary sensors and devices to comply with at least the protection functions indicated in protection settings table (Annex I) of this Technical Specification and I-DE-3010.00-5143-946-P4X-001.
- 5.1.2. The Microprocessor-Based Multifunction protection Relay (MMR) adopted shall be a model specific for generator protection purposes.

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5.1.3. Generator manufacturer shall inform the required settings for the protection functions listed in protection settings table (Annex I).

5.1.4. The Generator Control Panel shall be equipped with two lockout relays 86-1 (for generator CB trip) and 86-2 (for prime mover and AVR trip), refer to I-ET-3010.00-5140-700-P4X-002 for lockout relay specifications.

5.2. Medium-Voltage Switchgear and Motor Control Center

5.2.1. The panels shall be equipped with one selector switch with the positions “Operação / Manutenção” (Operation / Maintenance). When this selector is in “Manutenção” position, the instantaneous overcurrent function (50) of incomer and tie MMRs shall be activated, overriding protection coordination and minimizing the damage in case of internal faults.

5.2.2. For more details about the “Operação / Manutenção” selector switch refer to I-ET-3010.00-5140-741-P4X-002.

5.2.3. The minimum protection functions for the medium-voltage panels MMR shall be according to protection settings table (Annex I) and I-DE-3010.00-5143-946-P4X-001.

5.2.4. For Medium-Voltage Switchgear and MCC Arc Monitoring Relay refer to I-ET-3010.00-5140-741-P4X-002 and I-DE-3010.00-5143-946-P4X-001.

5.2.5. For functional units equipped with power contactor and fuse, blown fuse shall trip main contactor and inhibit closing. Blown fuse shall be signalled in MMR.

5.2.6. For the protection function 67 the native functions of the MMR shall be used. A solution through programming logic is not acceptable.

5.2.7. For two busbar configuration on Main Switchgear 13.8kV (switchgear connected to Main Generation), the Tie CB overcurrent protection shall have 2 (two) directional elements (function 67) connected to two sets of CTs, each one installed in one side of tie circuit-breaker, in order to make it possible to detect separately faults in busbars and in tie circuit-breaker.

5.2.8. For three busbar configuration on Main Switchgear 13.8kV (switchgear connected to Main Generation), the Tie CB overcurrent protection shall have 3 (three) directional elements (function 67) connected to three sets of CTs.

5.2.9. Refer to figure 1 and figure 2 below for the 13.8kV tie CTs arrangement and 67 functions directions definitions for 13.8kV busbar configuration.

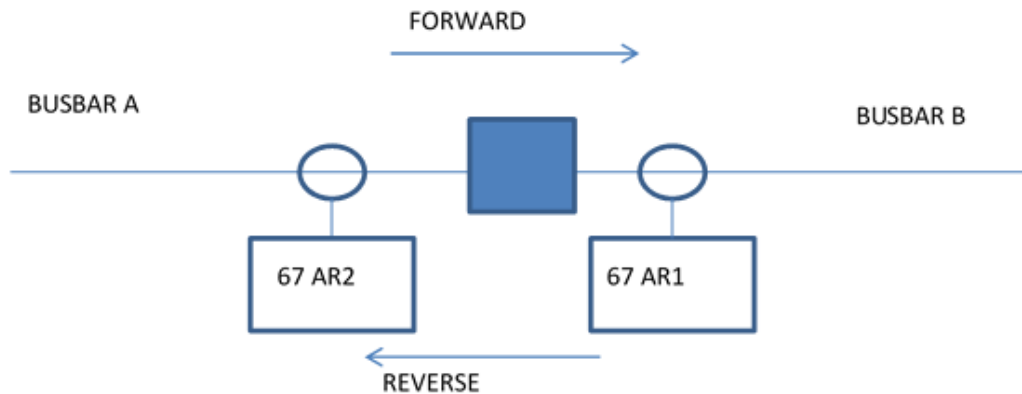


Figure 1 – Two 13.8kV busbar configuration - Tie Relay Arrangement

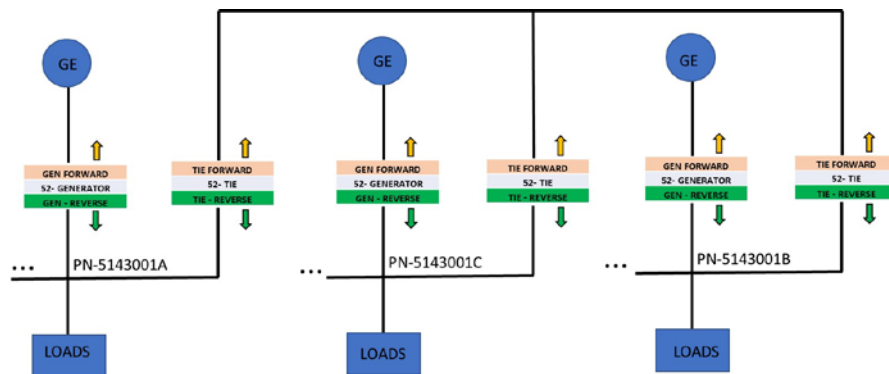


Figure 2 – Three 13.8kV busbar configuration - Tie Relay Arrangement


5.2.10. For electrical topology see project Key one-line diagram.

5.3. Medium Voltage Motors

- 5.3.1. Unless otherwise specified in the Petrobras Documentation, the motors, auxiliary components and MMRs shall be supplied with necessary sensors and devices to comply with at least the protection functions indicated in protection settings table (Annex I) of this technical specification and I-DE-3010.00-5143-946-P4X-001.
- 5.3.2. Motor manufacturer shall inform in Motor Data Sheet the adjustment settings for the protection functions listed in protection settings table (Annex I).
- 5.3.3. The Microprocessor-Based Multifunction protection Relay (MMR) adopted shall be a model specific for motor protection purposes.

5.4. Emergency Generator

- 5.4.1. Unless otherwise specified in the Petrobras Documentation, the generator auxiliary components and MMR shall be supplied with necessary sensors and devices to comply with at least the protection functions indicated in protection settings table (Annex I) of this Technical Specification and I-ET-3010.00-5261-700-P4X-001.

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5.4.2. The Microprocessor-Based Multifunction protection Relay (MMR) adopted shall be a model specific for generator protection purposes.

5.4.3. Generator manufacturer shall inform/validate the protection settings listed in protection settings table (Annex I). Emergency Generator protection shall be simple in order to avoid undesired trip and unavailability of electrical essential loads. The protective functions shall be limited to definitions of this Technical Specification and Classification Society requirements

5.5. Auxiliary Generator

5.5.1. Unless otherwise specified in the Petrobras Documentation, the generator auxiliary components and MMR shall be supplied with necessary sensors and devices to comply with at least the protection functions indicated in protection settings table (Annex I) of this Technical Specification and I-ET-3010.00-5262-700-P4X-001.

5.5.2. The Microprocessor-Based Multifunction protection Relay (MMR) adopted shall be a model specific for generator protection purposes.

5.5.3. Generator manufacturer shall inform/validate the protection settings listed in protection settings table (Annex I).

5.6. Low-Voltage Switchgear

5.6.1. The panels shall be equipped with selectors switches with the positions “Operação / Manutenção” (Operation / Maintenance). When this selector is in “Manutenção” position, the instantaneous overcurrent function (50) of incomer and tie MMRs shall be activated, overriding protection coordination and minimizing the damage in case of internal faults.

5.6.2. Each output feeders to MCC shall be equipped with a selector switch “Operação / Manutenção” (Operation / Maintenance) according to protection settings table (Annex I).


5.6.3. For more details about the “Operação / Manutenção” selector switch refer to I-ET-3010.00-5140-741-P4X-001.

5.6.4. The minimum protection functions for the low-voltage panels MMR shall be according to protection settings table (Annex I) tables and I-DE-3010.00-5143-946-P4X-002.

5.6.5. For high impedance grounded low-voltage systems, ground fault protection shall be implemented by 50GS function devices (Core balanced CT) installed in all outgoing circuits. Refer to I-ET-3010.00-5140-741-P4X-001.

5.6.6. For low-voltage ungrounded systems, ground fault protection shall be provided by isolation monitoring devices as per I-ET-3010.00-5140-741-P4X-001.

5.6.7. For low-voltage switchgear Arc Monitoring Relays refer to I-ET-3010.00-5140-741-P4X-001 and I-DE-3010.00-5143-946-P4X-002.

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5.6.8. For the Essential Switchgear, if the Emergency Generator active power demand reaches 85% there shall be an alarm in ESA (Electrical System Automation).

5.6.9. For the Essential Switchgear, if the Emergency Generator active power demand reaches 90% the Essential Switchgear back-feeds circuits shall be tripped.

5.6.10. For the hull switchgears' directional function (67) the following definitions were adopted in this document:

TIE – Forward direction from bar A to fault on bar B (67F)

Reverse direction from bar B to fault on bar A (67R)

BACK FEED – Forward direction from the busbar to fault on line (67F)

Reverse direction from line to fault on busbar (67R)

5.7. Low-Voltage Induction Motor

5.7.1. Unless otherwise specified in the Petrobras Documentation, the motors, auxiliary components and MMRs (switchgear) or intelligent relay (MCC) shall be supplied with necessary sensors and devices to comply with at least the protection functions indicated in protection settings table (Annex I) of this technical specification and I-DE-3010.00-5143-946-P4X-002.

5.7.2. The Microprocessor-Based Multifunction protection Relay (MMR) or intelligent relay adopted shall be a model specific for motor protection purposes.

5.7.3. Motor manufacturer shall inform in Motor Data Sheet the adjustment settings for the protection functions listed in protection settings table (Annex I).

5.8. Low-Voltage Soft-Starter Feeder


5.8.1. The MMR (switchgear) or intelligent relay (MCC) adopted shall be specific for motor protection, the settings shall be according to the protection settings table (Annex I). In the MCC adjustments, consider the soft-starter as motor load.

5.8.2. The 48 function shall be disabled to not interfere with soft-start initial current ramp.

5.8.3. Trip time for motors with protection Ex e (increased safety) shall be shorter than t_E according to IEC 60079-7 for Group IIA, Class T3 (200°C).

5.8.4. CANCELED

5.8.5. These settings refer to the MMR (switchgear) or intelligent relay (MCC) protecting the soft-start output feeder, the soft-start internal protection functions are not discussed in this document and shall be implemented by the manufacturer/package integrator.

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6. PROTECTION SETTINGS TABLES

- 6.1.1. The Annex I below presents the basic criteria that shall be considered for the Electrical Protection Coordination and Selectivity Study.
- 6.1.2. During the development of the referred study the time current plots shall be used to validate and, if necessary, adjust the settings described below in order to achieve proper coordination between the protection devices.

