Technical Specification code: MAT-I&I-TD-2021-0058-GIN
Version no.03 dated 19/10/2021

Subject: **GSTZ111 -** Global Infrastructure and Networks Global Standard - Power Supply Station (PSS) for HV/MV Substation

Application Areas
Perimeter: *Global*
Staff Function: -
Service Function: -
Business Line: *Infrastructure & Networks*

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THE HEAD OF TECHNOLOGY DEVELOPMENT
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1. DOCUMENT AIMS AND APPLICATION AREA

This document defines the characteristics of the Power Supply Station (PSS) for auxiliary DC power source in the HV/MV Substation according by Global Policy n°49.

1.1 RELATED ORGANIZATIONAL DOCUMENTS TO BE IMPLEMENTED AT COUNTRY LEVEL

This document applies to both Enel Global Infrastructure and Networks Srl Company and to Infrastructure and Networks Business Line perimeter when each Company does not have to issue further documents.

2. DOCUMENT VERSION MANAGEMENT

Version	Date	Main changes description
3	[19/10/2021]	Issuing of Global Infrastructure and Networks Global Standard –Power Supply Station (PSS) for HV/MV Substation List of revisions: - Added circuit breaker IC3 instead of switch-disconnector (on the battery branch) - Updated type test and acceptance list (e.g. correct DSU operation, test with external batteries) - Added “discharge inverter” (e.g. electronic load instead of resistance) - Added RIO to manage PSS alarms

3. UNITS IN CHARGE OF THE DOCUMENT

Responsible for drawing up the document:

- Global Infrastructure and Networks: Innovation and Industrialization/ Technology Development

Responsible for authorizing the document:

- Global Infrastructure and Networks: Head of Technology Development unit;
- Global Infrastructure and Networks: Head of Health, Safety, Environment and Quality unit;

4. REFERENCES

- Enel Group Code of Ethics;
- The Enel Group Zero Corruption Tolerance (ZCT) Plan;
- Organizational and management model as per Italian Legislative Decree no. 231/2001 or equivalent documents adopted in the Countries;
- Enel Human Rights Policy;
- Stop Work Policy;

- Enel Global Compliance Program (EGCP);
- Global Infrastructure and Networks RACI Handbook;
- Integrated Policy of Quality, Health and Safety, Environment and anti-Bribery;
- Policy 49: Global Infrastructure and Networks HV/MV Substation Design Technical Criteria
- ISO 9001:2015 - Quality Management System - Requirements;
- ISO 14001:2015 - Environmental Management System - Requirements and user guide;
- ISO 45001:2018 - Occupational Health and Safety Management System - Requirements and user guide;
- ISO 50001:2018 - Energy management systems - Requirements with guidance for use;
- ISO 37001:2016 - Anti-bribery Management System - Requirements with guidance for use.
- IEC 62485-2 Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries
- IEC 60068-2-1 Environmental testing - Part 2-1: Tests - Test A: Cold
- IEC 60068-2-14 Environmental testing - Part 2-14: Tests - Test N: Change of temperature
- IEC 60068-2-2 Environmental testing - Part 2-2: Tests - Test B: Dry heat
- IEC 60068-2-30 Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
- IEC 60068-2-78 Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state
- IEC 60068-3-1 Environmental testing - Part 3-1: Supporting documentation and guidance - Cold and dry heat tests
- IEC 60068-3-4 Environmental testing - Part 3-4: Supporting documentation and guidance - Damp heat tests
- IEC 60146-1-1 Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements
- IEC 60146-1-3 Semiconductor convertors - General requirements and line commutated convertors - Part 1-3: Transformers and reactors

- IEC 60204-1 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- IEC 60255-27 Measuring relays and protection equipment - Part 27: Product safety requirements
- IEC 60255-5 Electrical Relays - Part 5: Insulation coordination for measuring relays and protection equipment - Requirements and tests
- IEC 60309-1 Plugs, socket-outlets and couplers for industrial purposes - Part 1: General requirements
- IEC 60309-2 Plugs, socket-outlets and couplers for industrial purposes - Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories
- IEC 60384-1 Fixed capacitors for use in electronic equipment - Part 1: Generic specification
- IEC 60384-4 Fixed capacitors for use in electronic equipment - Part 14: Sectional specification - Fixed capacitors for electromagnetic interference suppression and connection to the supply mains
- IEC 60529 Degrees of protection provided by enclosures (IP Code)
- IEC 60896 Stationary lead-acid batteries
- IEC 60947-1 Low-voltage switchgear and control gear - Part 1: General rules
- IEC 60947-2 Low-voltage switchgear and control gear - Part 2: Circuit-breakers
- IEC 60947-3 Low-voltage switchgear and control gear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
- IEC 60947-4-1 Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
- IEC 60950-1 Information technology equipment - Safety - Part 1: General requirements
- IEC 61000-4 Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
- IEC 61010-1 Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements
- IEC 61204-6 Low-voltage power supplies, DC output - Part 6: Requirements for low-voltage power supplies of assessed performance

- IEC 61204-7 Low-voltage switch mode power supplies - Part 7: Safety requirements
- IEC 61810-1 Electromechanical elementary relays - Part 1: General and safety requirements
- IEC 61810-2 Electromechanical elementary relays - Part 2: Reliability
- IEC 61810-7 Electromechanical elementary relays - Part 7: Test and measurement procedures
- IEC 62477-1 Safety requirements for power electronic converter systems and equipment - Part 1
- 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 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 61000-4-11 Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests
- IEC 61000-4-12 Electromagnetic Compatibility (EMC) - Part 4-12: Testing and measurement techniques - Ring wave 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 0 Hz to 150 kHz

- IEC 61000-4-29 Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on DC input power port immunity tests
- IEC 61000-6-5 Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment
- IEC 62271-207 High-voltage switchgear and controlgear - Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV
- IEC TS 60815-1 Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles
- ISO 2081 Metallic and other inorganic coatings - Electroplated coatings of zinc with supplementary treatments on iron or steel
- GSTX905 Cyber security requirements for the Hybrid Energy Station for MV/LV Substation
- GSGC002: Technical Conformity Assessment (TCA);
- GSTX001 Quality Control Activities – Contractual requirements for Automatic Test Systems (ATS).
- NR-10 Segurança em instalações e serviços em eletricidade
- NBR-5410 Instalações Elétricas de Baixa Tensão
- NSR-10 Reglamento colombiano de construcción sismo resistente
- ETGI-1020 Especificaciones técnicas generales - Requisitos de diseño sísmico para equipo eléctrico
- EN 55011 Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
- EN 50178 Electronic equipment for use in power installations
- RETIE Reglamento técnico de instalaciones eléctricas

5. ORGANIZATIONAL PROCESS POSITION IN THE PROCESS TAXONOMY

Value Chain /Process Area: Networks Management

Macro process: Materials management

Process: Network components standardization

6. DEFINITIONS AND ACRONYMS

Acronym and Key words	Description
Alternating Current (AC)	Pertaining to alternating electric quantities such as voltage or current, to devices operated with these, or to quantities associated with these devices.
Distribution, supervision and communication unit (DSU)	Electronic equipment able to manage the Power Supply Station
Electromagnetic Compatibility (EMC)	Ability of electronic equipment not to cause or react to electromagnetic interference from other electronic equipment.
Global Standard (GS)	Enel Group Technical Specification
Nominal Voltage (Vn)	Nominal Voltage for circuit breaker or auxiliary equipments
Valve Regulated Lead-Acid battery (VRLA)	A type of lead–acid battery characterized by a limited amount of electrolyte (“starved” electrolyte) absorbed in a plate separator or formed into a gel

7. DESCRIPTION

7.1 LIST OF COMPONENTS, PRODUCT FAMILY OR SOLUTIONS TO WHICH THE GS APPLIES

The PSS described in this GS is a product of the family provided in **Table 1**.

Table 1 – GSTZ11X product family and description		
GSTZ11X type	**Product family code**	**Description**
GSTZ111	GSTZ11X	Power Supply Station (PSS) for auxiliary DC power source
GSTZ112	GSTZ11X	Power switchgear and controlgear assembly (PSC) for auxiliary DC and AC power source

7.2 APPLICATION FIELDS

This document standardizes the functional, construction and testing requirements of the Power Supply Station (PSS) for auxiliary DC power source in the HV/MV Switching Substation (in according by Global Policy 49).

The auxiliary DC1 and DC2 power source feed the protection devices, breakers, RTU and other critical devices in the substation, for that reason it must be redundant to assure the adequate reliability. The PSS assures a reliable supply to auxiliary equipment and consists in batteries charger, distribution system, switching and protective devices and additional monitoring equipment. Redundancy is guaranteed through two rectifiers (RD1 and RD2) and two converters (CV1 and CV2) which can operate simultaneously or alternately.

This PSS can work in conjunction with the Power Switchgear and Controlgear assembly (PSC) defined in the GSTZ112. For the electrical diagrams, refer to GSTZ111_A1 and GSTZ112_A1.

Security by design is mandatory for any devices developed to be installed in the ENEL premises. The requirements from GSTX905 must be adopted.

7.3 MAIN REQUIREMENTS

The PSS must fed the auxiliary services of the HV/MV substation and is divided into the following types:

Table 2 - GSTZ111 Type

Type	Vnac	frequency	DC1 level	DC2 level
GSTZ111-A1	400/230Vac ± 20%	50 Hz ± 5%	110Vdc ±20%	24Vdc ±20%
GSTZ111-A2			125Vdc ±20%	
GSTZ111-A3				48Vdc +10%/-20%
GSTZ111-B1	380/220Vac ± 20%			48Vdc ±20%
GSTZ111-C1	380/220Vac ± 20%	60 Hz ± 5%		
GSTZ111-C2	220/127Vac ± 20%			
GSTZ111-C3	208/120Vac ± 20%			

The sign plate must be written in the local language of the destination Countries (chapter 7.5.2).

The PSS is made up of individual modules whose technical characteristics are described in the following chapters. The manufacturer, based on his experience and construction technology, can propose technical solutions that combine more than one typology in a PSS, always maintaining the functional specifications foreseen by this document and respecting the voltage levels indicated.

The supplier, based on its technology, can provide its proposal which must be approved by enel.

Type of PSS and consequently values of Vnac, DC1 and DC2 depends from installation site: during the procurement process, the information about the operating conditions will be shared. (chapter 7.5.2).

AC source over range:

a. Continue: 1.2Vn;

b. Transient [1s]: 2Vn.

The values refer to the maximum rated voltage applicable in AC. The maximum applicable rated value means Vac + 20% in continue mode and Vac + 50% in transient mode.

The PSS configuration is in a rack, containing:

a. two AC/DC1 rectifiers (RD1, RD2);
b. one voltage regulator DC1/DC1 (REG1);
c. two DC1/DC2 converters (CV1, CV2);
d. a distribution, supervision and communication unit (DSU);
e. synoptic monitor of the PSS
f. two temperature probes that detect the ambient temperature (probe n°1) and the temperature of the batteries (probe n°2);
g. one external electronic load for diagnostic discharge (external to the rack).

Figure ***1*** shows the functional diagram and Figure 2 shows the illustrative diagram of the auxiliary services power system.

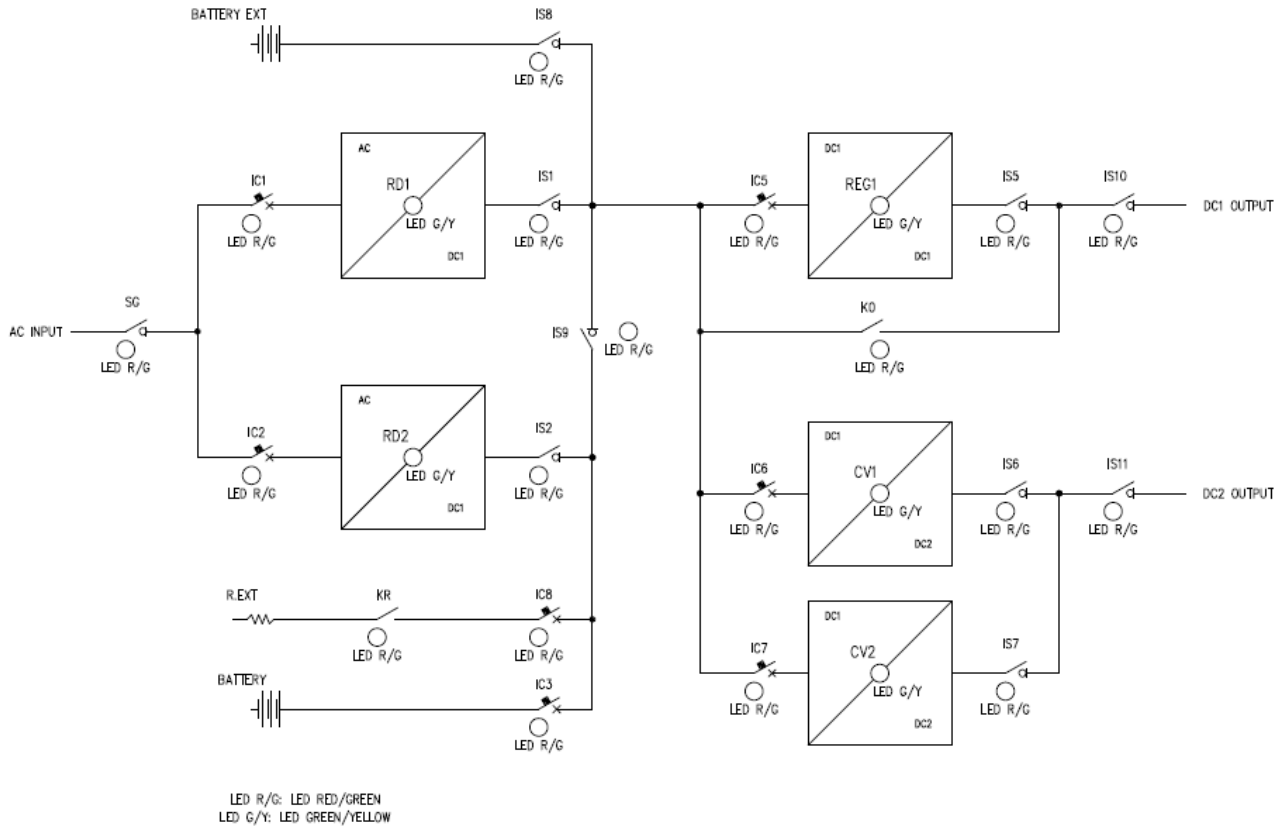

Figure 1 - Functional diagram

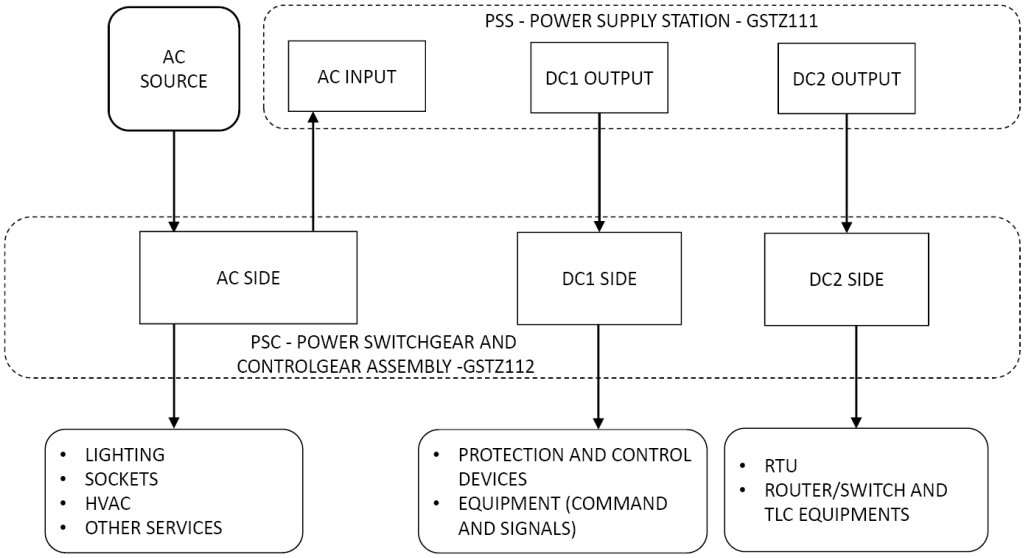

Figure 2 – Illustrative Diagram (example)

The DC1 auxiliary services are powered by two rectifiers (RD1 and RD2) in parallel.

The two AC/DC1 rectifiers must have identical characteristics and must operate:

a. contemporaneously with an automatic load distribution, so each rectifier is loaded with half of the total load required on the DC1 side, the maximum allowed difference between the two loads is 10%;

b. alternatively: one in operation and the second in hot stand-by, that means without serving any load, but able to serve the full load in 80ms after the failure of the first one.

However each rectifier has the ability to manage the entire load on its own, in the event of a failure of its twin.

The supplier must guarantee automatic recovery without the intervention of personnel on site for a possible temporary blockage of the RD1 and RD2 rectifiers for external causes and not due to breakage of internal components of the rectifiers.

The supplier, based on its technology, can provide its proposal which must be approved by Enel.

Between the two rectifiers and the DC1 loads is interposed an automatic voltage regulator (REG1), which regulates and stabilizes the output voltage when the rectifiers during the maintenance or recharging charge phase are brought at a supply voltage higher than the nominal one.

The DC1/DC2 converters (CV1, CV2) are powered by the DC1 power supply provided by the rectifiers and battery pack.

The supplier must guarantee automatic recovery without the intervention of personnel on site for a possible temporary blockage of the CV1 and CV2 converters for external causes and not due to breakage of internal components of the converters. Each proposed solution must be assessed and approved by Enel.

The PSS must be able to start and operate correctly even without a battery or with the battery completely discharge (in this condition it must be able to recharge the batteries).

The PSS work correctly with an intermediate connection of the battery which is connected to the voltage regulator output through a power diode. In the event of a voltage regulator failure, the connection avoids interrupting the DC1 power supply during the automatic bypass operation (by-pass via K0) of the voltage

regulator. The intermediate connection must be derived from the negative pole of the battery pack so as to obtain a voltage higher than 85% of DC1 (for example for DC1 level at 110Vdc, with a VRLA battery consisting in n°9 monoblocks of 12V each, the intermediate connection must be taken from the negative pole of the eighth monoblock). The supplier must guarantee that the bypass K0 intervenes in the basic time of 500ms.

The supplier, based on its technology, can provide its proposal which must be approved by Enel.

The operation of the PSS must be supervised and managed by a microprocessor that makes the diagnosis of the AC/DC1 rectifiers, for the voltage regulator DC1/DC1, for DC1/DC2 converters and the batteries pack as well as of the measurements of current, voltage and temperature.

It must be possible to set:

a. the number and the type of elements of the batteries pack
b. the voltage of the single battery element
c. the type of the batteries
d. the battery capacity in Ah: 50Ah, 100Ah, 150Ah, 200Ah, 250Ah, 300Ah and 400Ah.

The batteries pack must be able to supply auxiliary services with the following conditions:

a. Absence of AC power supply to the PSS
b. Rectifiers failure
c. Insertion of transient or starting loads.

All supervision and control circuits including the microprocessors must be located in the distribution, supervision and communication unit (DSU).

7.3.1 Operation and commissioning

As already indicated, the PSS must be installed in HV/MV substations and must guarantee the supply of all the DC services of the substation.

For this reason, the operation of the PSS described in the following chapters must be guaranteed even in the case of non-normal situations, for example failure of part of the internal components or absence of an external network Vnac.

The supplier must implement all the necessary actions to allow continuity of the service in the event of an anomaly of one of the components without the manual intervention of personnel on site.

The supplier must provide a "First Start-up Procedure" which describes in detail each action to be performed for the complete commissioning of the PSS; in particular for each action it is necessary to indicate:

a. Initial situation of the action
b. Action to be performed by the operator
c. Effect of the action of the operator (for example LED lighting or display message)
d. Any waiting times between the passage of one action to the next

At the end of the "First Start-up Procedure" the PSS must not present any anomalies and must be able to function correctly on the basis of what is prescribed in this functional specification.

In the event that the First Start-up Procedure is not respected, the PSS must not present hardware failures or breakages of the internal components.

The PSS First Start-up Procedure must be written in local language (see chapter 7.5.2), as well as in the use and maintenance documentation supplied with the PSS, also on a separate plate positioned on the front or inside the PSS itself, in order to facilitate personnel intervention.

Furthermore, in the following cases the PSS must be able to correctly resume operation without any intervention in praise by personnel:

a. Return of the power supply Vnac with batteries in normal state and regularly connected to the PSS
b. Return of the power supply Vnac with inefficient batteries and regularly connected to the PSS.

In the second case, when the service is resumed, the PSS must privilege the DC1 and DC2 services by limiting the supply of current to the batteries (with residual battery voltage >80% of DC1).

The supplier, based on its technology, can provide its proposal which must be approved by Enel.

7.3.2 Operating conditions

Exact conditions depend from installation site, during the procurement process (Par. 7.5.2) the information about the operating conditions will be shared.

The environmental conditions foreseen for the PSS are the following:

Table 3 – PSS reference environmental conditions		
PV-IES type	Operating range	On storage and transport range
Temperature	-25 °C ÷ 70 °C	-40 °C ÷ 80 °C
Humidity	0 % ÷ 95% RH, non condensing	
Atmospheric pressure	860 hPa ÷ 1060 hPa	
Altitude	0 m ÷ 2700 m	
Pollution degree (IEC TS 60815-1)	Very Heavy	
Seismic qualification (IEC 62271-207)	AF5 response spectrum	

With reference to the expected environmental conditions, is admitted:

a. Derating of the power supplied by the PSS components starting from 55 °C up to 70 °C with a linear reduction of the power supplied to reach a value> 50% at 70 °C. The manufacturer must submit a proposal, accompanied by the relative operating diagram which will be approved by Enel. This derating must not be applied to the DSU (Distribution, Supervision and Communication Unit), to the management, control, monitoring and measurement components which must be able to operate correctly for the entire temperature range indicated.
b. No derating is foreseen for temperature ranges below zero.
c. When normal conditions are restored, the PSS must return to normal operation in full power automatically, without personnel intervention.
d. The derating and the achievement of the temperatures that cause its activation must be signaled with a specific alarm (chapter 7.3.8.3)

The operating ranges are applicable at the PSS perimeter, the on storage and transport ranges must be applied at each PSS component.

The design and the characterization of the seismic protection of the PSS must be done using the AF5 response spectrum provided by the IEC 62271-207 usually adopted to qualify the high-voltage switchgear and control gear in seismic prone areas; the PSS must stay fully operative and maintaining the previous operating mode in continuity before, during and after the earthquake.

7.3.3 Environmental requirements

7.3.3.1 Rack

All the equipment that composed the PSS must be mounted on a rack 19” (by according to IEC 60297) with the follow dimensions and characteristic:

a. Height: Industry standard rack cabinet 42U tall; internal rack unit ≥42U
b. Width: 600 mm,
c. Depth: 600 mm;
d. The PSS must guarantee IP3X while maintaining natural ventilation. Cooling grids on the sides are not allowed because the PSS must be mounted next to other protection cabinets. The PSS must have a rubber profile around the perimeter of the side panels, the ceiling and the cabinet door to prevent the entry of dust;
e. IK code resistance to shocks (by according to IEC 62262): IK08;

The rack must be entirely of sheet steel press-folded 20/10 mm thick. The external coating must be made to obtain excellent resistance to wear according to the following cycle:

a. sheet washing;
b. phosphating based on non-crystalline iron salts (amorphous);
c. drying in tunnel at 100 ° C;
d. internal and external painting with electrostatic application of enamel in thermosetting powder with epoxy-polyester binders, RAL 7032 color, total thickness 70 µm.
e. Polymerization in oven at 180 ° C.

The access at the elements of the PSS must be only on the front and no access from the rear side is allowed.

The rack must be supplied complete with a front door; the door must have a maximum opening of 130° (in any case above 90°) and must be equipped with a keyless handle.A document holder for the manufacturer's wiring diagram and user manual must be mounted inside on the front door.

The rack, without sheet metal on the bottom, must have on the base n° 4 holes ø12 for fixing to the floor and n° 4 removable eyebolts on the upper frame. The sides of the cabinets must not have protrusions as the PSS can be mounted side by side with other 19” rack.

The protection against direct contacts of dangerous internal parts during maintenance or updating must be performed; where not possible the supplier must provide for the isolation of all the active parts.

The input of the electric connection cables is in the lower part; due to the connection of cables through the floor, the PSS must have a sealed system that prevents access to the animals.

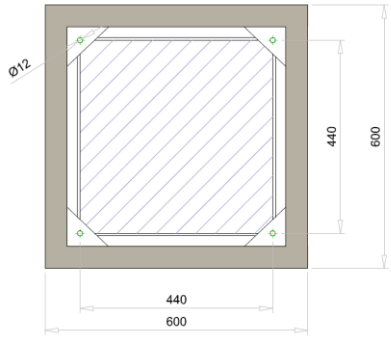

Figure 3 - Holes on the base

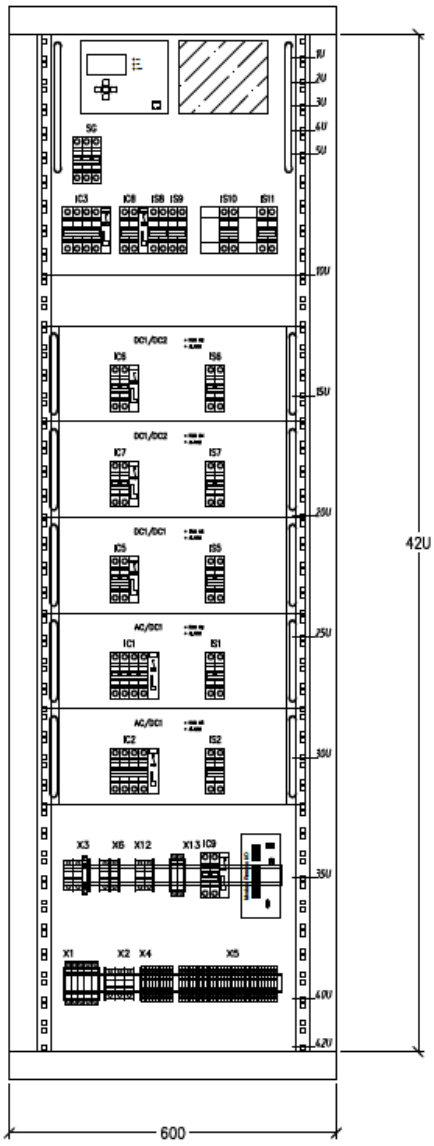

Figure 4 - Rack 19" example layout

The layout is indicative: The supplier, based on its technology, can provide its proposal which must be approved by Enel.

7.3.3.2 Enclosures

Rectifiers, Converters and Distribution and supervision unit must be contained in a separated enclosure, closed on all sides and suitable for mounting on a standard 19" rack frame unit. Each enclosure must be fixed to the 19" rack frame by four screws on the front panel; to facilitate assembly and disassembly operations two aluminum or steel handles must be fitted on the front of the box, in an appropriate position; plastic handles are not allowed.

Ventilation slots are only allowed in the lower and upper part. The heatsinks must be aluminum and preferably placed in the rear part; it is also possible to install dispersing surfaces on the side of the enclosures.

With reference to the rack layout, any solution must be previously approved by Enel and must provide the study of the thermal flows that are established inside and outside the various enclosures.

The enclosures must be galvanized steel according to the ISO 2081 standard with a thickness ≥ 1 mm or of an equivalent material in terms of EMC, mechanical stiffness (metalized plastic is not acceptable) and oxidation protection. The internal and external painting must be performed with electrostatic application of enamel in thermosetting powder with epoxy-polyester binders, RAL 7032 color, and total thickness 70 µm.

The supplier may propose its own technical solution for each type of module (RD, CV, REG, DSU); the technical solution must be previously submitted to the Enel technical evaluation which will approve its use if deemed suitable.

7.3.4 Electrical characteristics

7.3.4.1 Electrical Diagram

The wiring diagram GSTZ111_A1 attached to this GS is only indicative and has the purpose of illustrating the structure of the PSS.

The manufacturer must supply all the equipment and components indicated in this document.

7.3.4.2 Protection against transient overvoltage

The PSS must be installed in HV/MV substations and therefore it is necessary to provide protection against transitory overvoltages.

This protection can be performed through the use of an isolation transformer or an SPD device.

The supplier must propose its own technical solution which must be submitted to Enel's technical evaluation which will approve its use if deemed suitable.

7.3.4.3 Electrical connections

The electrical connections can be positioned both on the front and on the rear side of the boxes: in this case, quick-fit connectors must be chosen due to guarantee a secure electrical connection.

The electrical connections must have the following characteristics:

Table 4 - Characteristics of the electrical connections

Type of circuit	Phase	Section
AC power circuits	L1	≥ 16 mm^2
	L2	≥ 16 mm^2
	L3	≥ 16 mm^2
	N	≥ 16 mm^2
DC1 power circuits	+	≥ 16 mm^2
	-	≥ 16 mm^2
DC2 power circuits	+	≥ 10 mm^2
	-	≥ 10 mm^2
Auxiliary connections		≥ 1,5 mm^2
Ground connections		≥ 4 mm^2
LAN connections		≥ 0,75 mm^2

There must not be overvoltage on the outputs exceeding 5% of the rated voltage when the rectifiers are switched on or off.

7.3.4.4 Contactors

The contactors to be used are electromagnetic type, category DC1, have a nominal voltage of AC as indicated in Table 2 and nominal currents of use:

- KR 32A Normally open (NO)

- K0 100A Normally closed (NC)

The supplier, based on its technology, can provide its proposal which must be approved by Enel.

7.3.4.5 Circuit Breaker and switch-disconnector

The circuit-breakers must comply with the IEC 60947-1, IEC 60947-2 standards, for use in alternating current for IC1 and IC2 and for use in direct current for all the others.

The switch-disconnectors must comply with the IEC 60947-3 standard, for non-automatic direct current applications.

On the basis of its evaluations and the executive project, the manufacturer must verify the most suitable characteristics of the components to be used and submit the solution to Enel that will decide on the admissibility. In any case, the manufacturer must provide for the use of switches and disconnectors to guarantee protection intervention and an untimely non-intervention on the energy transients.

Table 5 – Circuit breaker (IC) and switches (IS)

Acronym	Description	Aux contact	Vn	In	Caract.	Poles	Icn	Icu
			[V]	[A]			[Ka]	[Ka]
IC1	Input Rectifier 1	X	400	25	Z	3P	10	10
IC2	Input Rectifier 2	X	400	25	Z	3P	10	10
IC3*	Battery	X	400	100		3P	10	10
IC5	Input voltage regulator	X	400	63	Z	2P	10	10
IC6	Input Converter 1	X	400	10	Z	2P	10	10
IC7	Input Converter 2	X	400	10	Z	2P	10	10
IC8	Electronic load (discharge)	X	400	25	C	2P	10	10
SG	General	X	400	63		3P		
IS1	Output Rectifier 1	X	400	63		2P		
IS2	Output Rectifier 2	X	400	63		2P		
IS5	Output voltage regulator	X	400	63	(*)	2P		
IS6	Output Converter 1	X	400	32		2P		
IS7	Output Converter 2	X	400	32		2P		
IS8	Ext. battery	X	400	100		2P		
IS9	equalization charge switch	X	400	100		2P		
IS10	Output DC1	X	400	63	(*)	2P		
IS11	Output DC1	X	400	32	(*)	2P		

In particular, the IS5, IS10 and IS11 disconnectors must be of the key lock type. To carry out the disconnector operation, the respective key must be activated. A sign with the following warning must be mounted at each disconnector: "Warning - opening this disconnector causes the switch off of the protection circuits". The sign plate must be written in the local language of the destination Countries.

7.3.4.6 *Terminal Boards*

The terminal board must be mounted in an accessible position and must be easily identified.

The sequence of the terminal boards is not mandatory and it is possible to use clamps screw-type, spring-type or push in-type, according to the indications of each Country.

For the terminal block composition please refer to GSTZ111_A1: Electrical Diagrams for the Power Supply Station (PSS) for HV/MV Substation.

7.3.5 Rectifier requirements AC/DC1

The PSS is equipped with two AC/DC1 rectifiers. The PSS must automatically recognize the number and the presence or absence of the rectifiers; from the PC or from the synoptic, it will however be necessary to confirm the number of installed rectifiers. The PSS must also be able to operate without one of the two rectifier modules on board.

The technical characteristics of each rectifier AC/DC1 are in Table 6.

AC input and DC1 output depends from installation site: during the procurement process, the information about the operating conditions will be shared. (Par. 7.5.2).

Table 6 – Rectifier AC/DC1		
AC INPUT		
Description	Symbol	Value
Nominal Voltage	Vnac	Table 2
Total Harmonic Distortion (current)	THDi	< 3%
Power factor at maximum load	cosφ	> 0,99
Inrush current		≤ 2 In
Protection		Varistor, V_{AC} out of range (block with automatic reset)
DC1 OUTPUT		
Description	Symbol	Value
Nominal Voltage	$Vndc_1$	Table 2
Nominal Current	$Indc_1$	50 A
Permanent overload		105 %
Stating regulation		≤ 0,5 %
Dynamic regulation		≤ 5 %
Polarity grounded		floating: both poles isolated
Ripple		≤ 20 mV ≤ 2 mV psophometric (CCITT-A)
Yeld	η	≥ 0,75 with load 25% ≥ 0,85 with load 100%
Protection		Overvoltage, Under voltage, Overload, Over temperature, output power limitation
Cooling		Air natural

The manufacturer must provide physical protection devices against polarity reversal on the battery connections and to the DC1 outputs.

The supplier, based on its technology, can provide its proposal which must be approved by Enel.

The two AC/DC1 rectifiers must have identical characteristics and must operate:

a. contemporaneously with an automatic load distribution, so each rectifier is loaded with half of the total load required on the DC1 side, the maximum allowed difference between the two loads is 10%;

b. alternatively: one in operation and the second in hot stand-by, that means without serving any load, but able to serve the full load in 80ms after the failure of the first one.

The choice between the two above modes must be made by the user through the DSU (par. 7.3.8), the default is the contemporaneously mode.

In case of alternative mode, the two rectifiers must be programmed to switch automatically every week in order to assure the same operational time for both; during the switching procedure, the output voltage quality and any other performances must remain inside the limits requested in this GS.

The supplier must propose an executive design to Enel that will decide about the admissibility.

In case of failure of the control logic, the rectifier must in any case guarantee the maintenance charge with current limitation and maximum voltage control.

In the event of a short-circuit at the output terminals, each rectifier must limit the current supplied at its nominal value and must automatically reset when the short circuit is removed.

The two rectifiers must be able to access at the measurements of the two temperature probes that detect the ambient temperature (probe n°1), and the temperature of the battery (probe n°2).

Each rectifier must be controlled by the microprocessor to manage the various operating modes and redundancy in case of failure.

Each rectifier must be able to monitor measure and transmit the following electrical quantities to the DSU:

a. AC input voltage (Vnac);

b. AC input current (Inac);

c. DC1 output voltage (Vndc1);

d. DC1 output current (Indc1).

On the front of the DSU must be mounted two LEDs for signaling:

a. Run OK (Green LED);

b. Rectifier Alarm (Red LED).

c. Each rectifier must be provided with output blocking diodes. The supplier can propose an alternative solution to diodes, subject to the approval of ENEL, to make available the measurement points upstream and downstream of the rectifier.

7.3.6 Converter requirements DC1/DC2

The PSS is equipped with two DC1/DC2 converters. The PSS must automatically recognize the number and the presence or absence of the converters; from the PC or from the synoptic, it will however be necessary to confirm the number of installed converters. The PSS must also be able to operate without one of the two converters modules on board.

The converter must be of the switching type, with galvanic insulation between input and output and possess the technical characteristics shown in Table 7.

DC1 input and DC2 output depends from installation site: during the procurement process, the information about the operating conditions will be shared. (Par. 7.5.2).

Table 7 – Converter DC1/DC2		
DC1 INPUT		
Description	Symbol	Value
Nominal Voltage	Vndc1	Table 2
Inrush current		≤ 2 In
Protection		Varistor V_{DC1} out of range (block with automatic reset)
DC2 OUTPUT		
Description	Symbol	Value
Nominal Voltage	$Vndc_2$	Table 2
Nominal Current	$Indc_2$	25 A
Permanent overload		105 %
Stating regulation		≤ 0,5 %
Dynamic regulation		≤ 5 %
Polarity grounded		Positive grounded
Ripple		≤ 20 mV ≤ 2 mV psophometric (CCITT-A)
Yeld	η	≥ 0,75 with load 25% ≥ 0,85 with load 100%
Protection		Overvoltage, Under voltage, Overload, Over temperature, output power limitation
Cooling		Air natural

The supplier, based on its technology, can provide its proposal which must be approved by Enel.

The two DC1/DC2 converters must have identical characteristics and must operate:

a. contemporaneously with an automatic load distribution, so each rectifier is loaded with half of the total load required on the DC2 side, the maximum allowed difference between the two loads is 10%;

b. alternatively: one in operation and the second in hot stand-by, that means without serving any load, but able to serve the full load in 80ms after the failure of the first one.

The choice between the two above modes must be made by the user through the DSU (par. 7.3.8), the default is the alternative mode.

In case of alternative mode, the two converters must be programmed to switch automatically every week in order to assure the same operational time for both; during the switching procedure, the output voltage quality and any other performances must remain inside the limits requested in this GS.

The supplier must propose an executive design to Enel that will decide about the admissibility.

In the event of a short-circuit at the output terminals, each converter must limit the current supplied at its nominal value and must automatically reset when the short circuit is removed.

Each converter must be controlled by the microprocessor to manage the various operating modes and redundancy in case of failure.

Each converter must be able to monitor measure and transmit the following electrical quantities to the DSU:

a. DC1 input voltage (Vndc1);

b. DC2 output voltage (Vndc2);

c. DC2 output current (Indc2).

On the front of the DSU must be mounted two LEDs for signaling:

a. Run OK (Green LED);

b. Rectifier Alarm (Red LED).

Each converter must be provided with output blocking diodes. The supplier can propose an alternative solution to diodes, subject to the approval of ENEL, to make available the measurement points upstream and downstream of the converter.

7.3.7 Voltage regulator DC1/DC1

The voltage regulator must be of the switching type and possess the technical characteristics in Table 8.

DC1 input and DC1 output depends from installation site: during the procurement process, the information about the operating conditions will be shared. (Par. 7.5.2).

Table 8 – Voltage regulator DC1/DC1		
DC1 INPUT		
Description	Symbol	Value
Nominal Voltage	Vndc1	Table 2
Adjustment range	$\Delta Vndc_1$	±20%
Inrush current		≤ 2 In
Protection		Varistor V_{DC1} out of range (block with automatic reset)
DC1 OUTPUT		
Description	Symbol	Value
Nominal Voltage	$Vndc_1$	Table 2
Adjustment range	$\Delta Vndc_1$	±5%
Nominal Current	$Indc_1$	50 A
Permanent overload		105 %
Stating regulation		≤ 0,5 %
Dynamic regulation		≤ 5 %
Polarity grounded		floating: both poles isolated
Ripple		≤ 20 mV ≤ 2 mV psophometric (CCITT-A)
Yeld	η	≥ 0,75 with load 25%
		≥ 0,95 with load 100%
Protection		Overvoltage, Under voltage, Overload, Over temperature, output power limitation
Cooling		Air natural

The supplier, based on its technology, can provide its proposal which must be approved by Enel.

In the event of a short-circuit at the output terminals, the Voltage regulator must limit the current supplied at its nominal value and must automatically reset when the short circuit is removed.

The voltage regulator DC1/DC1 must be controlled by the microprocessor to manage the operating mode.

The voltage regulator DC1/DC1 must be able to monitor measure and transmit the following electrical quantities to the DSU:

a. DC1 input voltage (Vndc1);

b. DC1 output voltage (Vndc1);

c. DC1 output current (Indc1).

On the front of the DSU must be mounted two LEDs for signaling:

a. Run OK (Green LED);

b. Rectifier Alarm (Red LED).

The voltage regulator must be provided with output blocking diodes. The supplier can propose an alternative solution to diodes, subject to the approval of ENEL, to make available the measurement points upstream and downstream of the voltage regulator.

7.3.8 Distribution, Supervision and Communication Unit (DSU)

The distribution, supervision and communication unit must have two power sources, the first directly from the AC network, the second one from the DC1 bus.

This DSU must guarantee the following functions:

a. Monitoring the AC power supply;

b. Monitoring the power supply of DC1 ;

c. Monitoring the power supply of DC2;

d. Maintenance charge of the battery;

e. Recharge of the battery;

f. Monitor battery status (diagnostics);

g. Protection of the maximum and minimum AC voltage (ref. Table 9);

h. Protection of the maximum and minimum DC1 voltage (ref. Table 9);

i. Protection of the maximum and minimum DC2 voltage (ref. Table 9);

j. Protection of the DC1 polarity earth (ref. Table 9);

k. Supervision and control of the PSS;

l. Alarm management of rectifiers RD1/RD2, converter CV1/CV2 and voltage regulator REG1;

m. Position of circuit breaker signed with IC* (see able 5) with auxiliary contact;

n. Voltage and current measurements as indicated in the previous chapters;

o. Voltage measurement of batteries pack;

p. Temperature measurement of battery and ambient;

q. Management and alarm reporting;

r. Output relay command;

s. Storage of fault / fault events;

t. Storage of periodic battery discharge data.

Any update, reset or modification of the parameters must not cause the PSS to switch off.

On the front of the DSU must be mounted:

a. Graphic LCD display with a resolution of four rows (as minimum). An energy saving function with configurable parameters must be provided. The expected service life of the display must be at least 10^5 h. Through the graphic display it will be possible, through the navigation buttons, to display all the information regarding measurements, alarms status of rectifiers, converters, voltage regulator and position of the circuit breaker in the able 5.

b. Navigation-selection buttons or rotary selector / confirmation, which allow the operator full access to the functions. They must be compliant with IK01 mechanical strength. The setting/configuration of the PSS must only be possible via software application running on a PC connected to the PSS.

As an alternative to the display and controls, it will be possible to use a touchscreen with a size of not less than 7 ". Through the touchscreen it must be possible to perform any measurement, functionality check, alarms and setup consultation provided in the document

c. Button for Alarm Rest

d. Button for Test Led

e. Button for recharge operating mode (Par. 7.3.10.2)

f. Button for discharge battery (Par. 7.3.8.4)

When any of the buttons is pressed, except for the Alarm Reset, a confirmation message must appear on the display, only after confirmation by the operator must start the selected operation.

g. Ethernet 100 BASE-TX with an RJ45 connector (independently addressable at the MAC level) to facilitate the local configuration, including all the FW updates (Par. 7.3.8.1)

h. Ethernet 100 BASE-FX with a LC connector (independently addressable at the MAC level) available for remote connection to the substation LAN.

i. Three LEDs for signaling:

- Run OK (Green LED)
- PSS Alarm (Red LED)
- Battery Alarm (Red LED)

j. Two aluminum or steel handles

The PSS must have the following protection functions:

Table 9 – Protections

Type	Vn	Range	Delay Time	Default Settings
IEEE 59 (59-AC)	Table 2	(1÷1,4)Vn step 0,1Vn	(0,05÷5)s step 0,05s	1,2Vn / 1s
IEEE 27 (27-AC)	Table 2	(0,7÷1)Vn step 0,1Vn	(0,05÷5)s step 0,05s	0,8Vn / 1s
IEEE 59 (59-DC1) RD1/RD2	Table 2	(1÷1,4)Vn step 0,05Vn	(0,05÷5)s step 0,05s	1,1Vn / 1s
IEEE 27 (27-DC1) RD1/RD2	Table 2	(0,7÷1)Vn step 0,05Vn	(0,05÷5)s step 0,05s	0,9Vn / 1s
IEEE 59 (59-DC1) REG1	Table 2	(1÷1,4)Vn step 0,05Vn	(0,05÷5)s step 0,05s	1,1Vn / 1s
IEEE 27 (27-DC1) REG1	Table 2	(0,7÷1)Vn step 0,05Vn	(0,05÷5)s step 0,05s	0,9Vn / 1s
IEEE 59 (59-DC2)	Table 2	(1÷1,4)Vn step 0,05Vn	(0,05÷5)s step 0,05s	1,1Vn / 1s

IEEE 27 (27-DC2)	Table 2	(0,7÷1)Vn step 0,05Vn	(0,05÷5)s step 0,05s	0,9Vn / 1s
IEEE 64 (64-DC1) On DC1 output bus	Table 2	(10-400kΩ) step di 5kΩ	(0,05÷5)s step 0,05s	180 kΩ / 1 s

Each functions are enabled by default; it must be able to be excluded from software configuration.

7.3.8.1 Interface for Local Connection and Configuration

The PSS must have an Ethernet 100 BASE-TX with an RJ45 connector on the front to facilitate the local configuration, including all the FW updates of the boards (for all components of the PSS). The local maintenance interface is Ethernet native so serial/Ethernet adapters/ converters are not allowed.

The PSS must have a second Ethernet 100 BASE-FX with a LC connector available for connection to the substation LAN.

The software application must be compatible with the operating system homologated in ENEL at the procurement time (Par. 7.5.2).

The software must not require user license and must have two level passwords: one for visualization and one for configuration.

7.3.8.2 Requirements for the Communication

The communication unit must natively support both Internet Protocol IPV4 and IPV6.

The PSS must have, at the same time but on different Ethernet interfaces:

a. A static IP address (192.168.1.1) for local connection, not associated with any gateway;

b. An additional IP address that can be configured as static

Therefore, the operator (with the local configuration SW) has to configure the following fields:

a. PSS IP address, if static,

b. Subnet mask,

c. Default gateway.

The following services must be available:

a. WEB server,

b. NTP client,

c. SSH server,

d. SNMP server,

e. SFTP server

The Ethernet 100 BASE-FX to the LAN substation can be used for the following communication protocols:

a. Slave DNP 3.0 TCP

b. Slave modbus TCP

c. prepared for IEC 61850 Server.

For DNP 3.0 TCP and modbus TCP protocols it must be possible to configure the basic link parameters and all the signals, states, measurements and alarms of the PSS.

7.3.8.3 Alarms and Signals

The DSU must control the operation of the PSS, manage the synoptic, manage the alarms and HW redundancies in order to ensure the operation of the PSS in the event of failure of one of the component modules.

A register with non-volatile memory must be provided for storing at least 500 sequences of events. The stored events must be visible on the display, exported to a PC, and saved in txt or cvs format.

The file structure must be implemented as follows:

a. name event_hour: minutes: seconds_day. month. year

The procedure that the DSU must perform to report an anomaly is always the following:

a. Command the respective signaling relay (if enabled);

b. Turn on the LED on the synoptic relating to the faulty module;

c. Turn on the general fault LED;

d. Display the faulty component on the synoptic monitor and, if available, also show the type of fault.

In order to check the efficiency of the K0 contactor, the relay must be released verifying that the input and output voltages are the same and that the two rectifiers are put in the maintenance charge operating mode, (if the rectifiers are in recharge operating mode, this will be interrupted to perform the check and then resumed without resetting the charging time). After verification the contactor must return to be excited, with the opening of the contacts.

When the battery discharge is carried out on the electronic load, the two rectifiers must be brought into voltage limitation. In the event of faults, the discharge must be interrupted immediately and the rectifiers must start up again at the rated voltage.

Rectifiers fault:

a. If the fault does not lead to short circuit, the microprocessor will activate the anomaly signaling procedure without further actions.

b. In the event of a short circuit, circuit breaker IC1 (or IC2) opens automatically, with passage of the load on the healthy rectifier. The microprocessor recognizing the event will activate the anomaly signaling procedure.

Voltage Regulator fault:

a. The temperature of REG1, the voltages and the currents in input and output of the REG1 and the status of circuit-breaker IC5 must be monitored; if a fault condition is identified, the DSU must command the opening of the IC5 circuit breaker and the closure of the bypass by means of the K0 contactor;

b. In case of activation of the bypass, the recharging state must be disabled and the rectifiers will lead to maintenance charge operating mode;

c. The K0 must be managed in “Continuously excited” mode keeping the power contact open in this state. If the coil is not energized, the automatic contact closure and then the voltage regulator bypass will occur;

d. In the event of a short circuit on the voltage regulator, switch IC5 open automatically and the DSU will command the closure of K0.

Converters fault

a. If the fault does not lead to short circuits, the microprocessor will activate the anomaly signaling procedure without further actions.

b. In the event of a short circuit, circuit breaker IC6 (or IC7) opens automatically, with passage of the load on the healthy converter. The microprocessor recognizing the event will activate the anomaly signaling procedure.

All alarm and blocking thresholds of components not relevant to this operating condition must be automatically excluded. When the normal operating conditions return with the closing operation of IS9, the station must restore all supervision of the station, open the by-pass K0 and resume normal operation.

The station must have dry contacts connected to a dedicated terminal board (X5) with the following characteristics (Vn = 110/125VDC; L / R = 40ms; 0.5A)

Table 10 – Alarms and signals

Relay	Description	Causes of anomalies
K1.1	AC side PSS alarm	- Lack of power supply or fault of logic control - Phase-to-phase overvoltage protection function IEEE 59 (59-AC) - Phase-to-phase under voltage protection function IEEE 27 (27-AC) - Opening of IC1 circuit breaker - Opening of IC2 circuit breaker
K2.1	DC side PSS alarm	- Fault of rectifiers, converters and voltage regulator - Fault of distribution, supervision and control unit (DSU) - Opening of IC5 circuit breaker - Opening of IC6 circuit breaker - Opening of IC7 circuit breaker - Intervention of the bypass contactor K0 - DC1 overvoltage protection function IEEE 59 (59-DC1) - DC1 under voltage protection function IEEE 27 (27-DC1) - DC2 overvoltage protection function IEEE 59 (59-DC1) - DC2 under voltage protection function IEEE 27 (27-DC2) - Intervention of a protection indicated in Table 6 (AC Input and DC Output) - Intervention of a protection indicated in Table 7 (DC1 Input and DC2 Output) - Intervention of a protection indicated in Table 8 (DC1 Input and DC1 Output) - Max DC Voltage in recharging mode - Min or Max DC Voltage in maintenance charge mode - Max time of charging - Lack of power supply or fault of logic control - Derating
K3.1	Battery Alarm	- Alarm of battery - Battery in discharge (The signal must be inhibited during the periodic checks carried out by the station to check, for example, the "battery interrupted" condition or during the diagnostic discharge) - Minimum battery capacity - Low DC Battery - Over temperature battery pack - Increase resistance of the battery pack
K4.1	Battery Interrupted	- Battery interrupted (Par.7.3.8.4) - Opening of IC3 circuit breaker
K5.1	DC1 polarity Earth	- DC1 polarity Earth function IEEE 64-DC1
K1.2	Alarm of rectifier 1	- Fault of rectifier RD1 - Phase-to-phase overvoltage protection function IEEE 59 (59-AC) - DC1 overvoltage protection function IEEE 59 (59-DC1) of RD1 - DC1 under voltage protection function IEEE 27 (27-DC1) of RD1 - Opening of IC1 circuit breaker

K2.2	Alarm of rectifier 2	- Fault of rectifier RD2 - Phase-to-phase overvoltage protection function IEEE 59 (59-AC) - DC1 overvoltage protection function IEEE 59 (59-DC1) of RD2 - DC1 under voltage protection function IEEE 27 (27-DC1) of RD2 - Opening of IC2 circuit breaker
K3.2	Alarm of voltage regulator	- Fault of voltage regulator REG1 - DC1 overvoltage protection function IEEE 59 (59-DC1) of REG1 - DC1 under voltage protection function IEEE 27 (27-DC1) of REG1 - Opening of IC5 circuit breaker - Intervention of the bypass contactor K0
K4.2	Alarm of DC1/DC2 converter 1	- Fault of converter DC1/DC2 CV1 - DC2 overvoltage protection function IEEE 59 (59-DC2) of CV1 - DC2 under voltage protection function IEEE 27 (27-DC2) of CV1 - Opening of IC6 circuit breaker
K5.2	Alarm of DC1/DC2 converter 2	- Fault of converter DC1/DC2 CV2 - DC2 overvoltage protection function IEEE 59 (59-DC2) of CV2 - DC2 under voltage protection function IEEE 27 (27-DC2) of CV2 - Opening of IC7 circuit breaker
K6.2	Battery interrupted	- Battery interrupted (Par.7.3.8.4) - Opening of IC3 circuit breaker
K7.2	Maintenance battery	- battery anomaly - Low DC Battery - Over temperature battery pack - Increase resistance of the battery pack
K8.2	Battery in discharge	- Battery in discharge (The signal must be inhibited during the periodic checks carried out by the station to check, for example, the "battery interrupted" condition or during the diagnostic discharge) ref. Figure 5
K9.2	Minimum battery capacity	- Minimum battery capacity
K10.2	No Power Supply	- Phase-to-phase under voltage protection function IEEE 27 (27-AC)
K11.2	Derating	- Intervention of the derarting procedure following high temperature
K12.2	Available	-
K1.3	PSS in recharge mode	- PSS in recharge mode (chapter 7.3.10.2)
K2.3	PSS in recharge mode	- PSS in recharge mode (chapter 7.3.10.2)

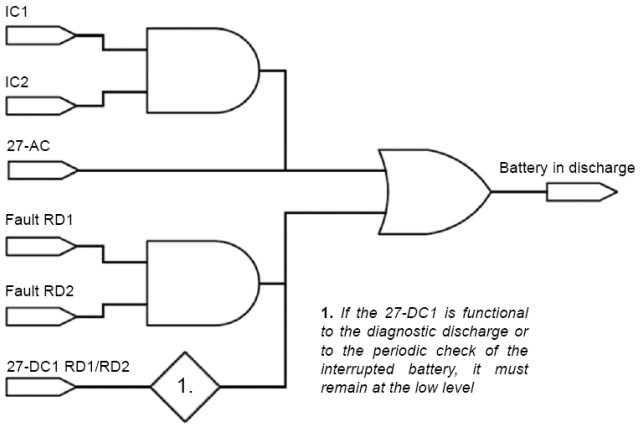

Figure 5 - battery in discharge

In presence of anomaly, it must be possible via PC to disable the alarm, even if the fault is not repaired.

This eventuality is necessary to avoid that a second alarm of the same type is not reported.

For example, in case of failure of the rectifier RD1 and the replacement is not immediately possible, the PSS can continue to operate with relative alarm disabled. In this way, the next alarm of the RD2 is visible again.

All the alarms indicated in **Table 10** will be managed by the RIO device.

The RIO (included in the supply) must have the characteristics indicated in the technical specification GSTP102. The electrical connection between RIO and the PSS are indicated in the GSTZ111_A1.

7.3.8.4 Enabling for external battery

With PC or panel control it must be possible to enable the station to accept power from the external battery. In this case, after the opening operation of IS9, the DSU must ignore any signals and alarms coming from the battery and rectifiers, must continue to manage the DC1/DC2 converters and close the by-pass K0 by deactivating the voltage regulator.

With I0S9 open, the station will continue to operate with the RD1 at rated voltage and current, the RD2 will instead be used to carry out maintenance operations on the battery pack.

7.3.8.5 Battery management

The state of charge of the battery must be entirely managed by microprocessor.

The battery management must follow the requirement from the IEC 60896-21 and the IEC 60896-22.

The power supply station must provide a diagnosis of the charge and efficiency status of the battery pack.

The supplier must propose an implementation of the requested function to Enel that will decide about the admissibility.

The battery management function must provide the acquisition of the measures listed below for different conditions and operating modes.

Table 11 – Measurements		
measurement	measurement frequency	saving frequency

Voltage of battery pack	15 s	1 h (average value)
Intermediate measurement	15 s	1 h (average value)
Charging current of battery	15 s	60 s (if ≥4 A)
Battery temperature	120 s	240 s
Ambient temperature	900 s	24 h (max and min)

The selection of the state of charge of the battery must be implemented according to the following logic:

a. The maintenance status is the initial setup of the PSS. Depending on the current absorbed by the battery, the DSU determines the possible change of state from maintenance to recharge;

b. The current that determines the passage from maintenance to recharge must be able to be set in the range 0.02-0.08 C_{10} (step of 0.01) with default equal to 0.04 C_{10};

c. During the recharging phases the PSS must be able to measure the recharge time and the current that has been absorbed by the battery in order to estimate the Ah supplied to the battery and the state of charge of the battery;

d. The transition from the recharging state to the maintenance state must be set in the range of 0.01-0.04 C_{10} (step of 0.01) with a default of 0.03 C_{10}.

e. the control logic must also be able to estimate the percentage of battery self-discharge and the influence of ambient temperature on the latter.

By using a Discharge electronic load (which can be inserted through the contactor KR), it will be possible to carry out a test download to diagnose the charge state of the battery pack and to allow an adequate ion exchange between the battery plates necessary to maintain efficient the battery.

The percentage of discharge and the interval of the test must be configurable by PC

Table 12 – Discharge Battery mode

Value	setting	default
% discharge	10-30%	15%
Interval time	30-180 days	90 days

During the discharge must be acquired the measurement indicated:

Table 13 – measurements

measurement	measurement frequency	saving frequency
Voltage of battery pack	30 s	60 s (average value)
Intermediate measurement	15 s	60 s (average value)
Charging current of battery	15 s	60 s (average value)

Battery temperature	60 s	60 s

In case of anomaly, the discharge must be interrupted and the battery maintenance alarm will be generated.

It also possible using the loads of the HV/MV substation, to carry out a diagnostic discharge.

The discharge on the load must last from 15 ÷ 45 minutes, the interval between two discharges must be 1 ÷ 30 days. The default value must be set to 30 minutes with a time interval between two downloads equal to 15 days.

During the discharge on load must be acquired the measurement indicated in Table 13.

The diagnostic function must periodically check:

a. Battery efficiency by diagnosing the condition of interruption of the battery pack. This type of fault must be recognized according to the voltage and current measurements performed;

b. The state of charge of the battery

c. The absence of anomalies

It must be possible to discharge the battery with a manual command (button in front of DSU).

Both during the discharge on the electronic load and on the loads, the intervention and the minimum voltage alarm of the battery must be inhibited for a time sufficient to extinguish any transient settling of the voltage supplied by the battery. This time must be set by default to 5 s. In addition, the battery temperature must be observed. An alarm should be generated for the maximum battery temperature if the threshold value is exceeded.

The default values for the Max Battery Temperature alarm are:

Table 14 – temperature monitor

Value	setting	default
Discharge	30-70 °C (step 1°C)	35 °C
Recharge	30-70 °C (step 1°C)	40 °C

At the end of the discharge, the PSS must return to normal service. If during the discharge there is an anomaly the PSS must return to the normal service.

The continuity in battery internal/external connection must be monitored by measuring:

d. the current supplied by the battery;

e. the voltage between the positive and negative poles and an intermediate measurements each element named “G1÷Gn”.

Some continuity interruption in the batteries connection may not be detected if the current from the batteries is too small; in order to detect such situations a possible procedure is:

f. regulate the output voltage of the acting rectifiers to DC1 -8%;

g. it is expected that the batteries voltages is more of DC1-8%, so the batteries will start to feed the load;

h. if possible continuity interruption will rise (because of the current), they will be detected and the converter will be ready to feed the loads;

i. in case of problem detection alarms and warnings must be generated and treated (par. 7.3.8);

j. in any case, after this procedure the voltage from converters must return to nominal values.

Alternative procedures may be proposed by the supplier and they will be approved by Enel.

All data and measurement values useful for diagnostic purposes must be memorized with the day and time associated.

This processing will provide, for example:

a. the trend of capacity;

b. Total voltage and voltage of elements;

c. Temperature of the elements;

d. Maintenance charge operating mode current.

The value of the battery capacity after the checks must be memorized and compared with the data previously recorded or with those declared by the battery manufacturers.

The supplier must propose an implementation function to Enel that will decide about the admissibility.

7.3.9 Synoptic monitor of the PSS

For synoptic panel refer to

*Figure **1***; on the front of the PSS there must be a panel on which a synoptic diagram which must contain a screen printing of the circuits composing the station, on each component there must be a multicolour LED which must present the following modes:

- green: normal operation / Run OK
- yellow/orange: alarm or threshold exceeded

The intervention of the switches in the various positions must be indicated on the synoptic panel.

The status of the switching devices (circuit breakers and disconnectors), must be signaled with the following convention:

Table 15 – LED color

CB and switch position	Argentina, Colombia, Iberia, Italy, Peru, Romania	Brazil, Chile
Open	red	green
Close	green	red

The manufacturer can provide the setup of the color of the LEDs in the previous table through the software. During the procurement process (Par. 7.5.2) the information about the Synoptic monitor will be shared.

The status of the two contactors (KR and K0) must be signaled with the following convention:

- red: closed
- green: open

Under normal operating conditions the display must show the message "Normal operation" followed by date and time.

7.3.10 Operating modes

The output voltage values for the different operating modes must be programmable in the indicated ranges and show the default values provided for VRLA batteries type.

The batteries are solidly connected to the PSS.

The numbers of elements that compose the battery pack depending from DC1 level and normally are:

- for DC1 level 110Vdc: 54 elements VRLA or Stationery Vented Lead Acid battery (SVLA)
- for DC1 level 125Vdc: 62 elements VRLA or Stationery Vented Lead Acid battery (SVLA)

The PSS will therefore have to be suitable for the management of all the batteries, considering the number of elements of the battery pack, the voltage of the single battery element and the battery capacity. Enel GS (if available) or local standard subordinately should be used to purchase these batteries that have normally an own specification process, this GS recall the main characteristics only for interoperability needs.

7.3.10.1 *"Maintenance charge" operating mode*

The PSS can remain in this state for an indefinite time according to what is established by the control logic.

The voltage to be applied at the batteries will be determined according to the type and temperature of the battery pack.

7.3.10.2 "Recharge" operating mode

The recharge is carried out in two phases:

a. First phase with constant current and increasing voltage.

b. Second phase at constant voltage and decreasing current

The charging curve must be able to be programmed differently from the default parameters shown above by a PC.

The duration of the charge must not exceed 12 hours.

It must be possible to charge the battery with a manual command (button in front of the panel) or by PC.

During the recharge operating mode the voltage regulator DC1/DC1 must work correctly, respecting the provisions in the Table 8, regardless of the type of battery.

During the charging mode, the PSS must activate two dry output exchange contacts as indicated in Table 10 and in the wiring diagram GSTZ111_A1. At the end of the charging mode, the relays must return to the normal state. The supplier, based on its technology, can provide its proposal which must be approved by Enel.

7.3.10.3 Equalization charge operating mode

It must be possible to perform the equalization charge of the battery, at constant voltage, only by PC command.

The transition to the equalization charge must be interlocked with the state of opening of the switch IS9.

In this case the rectifier RD1 will supply the auxiliary services, while the rectifier RD2 which with the opening of IS9 becomes in fact separate from the system, will carry out the equalizing charge on the battery. During the equalization charge and in general with the IS9 switch open, the station must in any case be connected to a mobile battery assembly with appropriate technical characteristics.

The supplier must propose an executive solution for the equalization charge operating mode to Enel, which will decide on admissibility.

7.3.11 Discharge Inverter

The electronic load, an Inverter, must be connected on the DC side to the batteries, and on the AC side to the gird, with adequate synchronization with the grid frequency. It must be installed in MV switchgear room of the HV/MV substation and will be used to carry out the periodic discharge of the battery.

The characteristics are:

a. DC current 25A

b. VDC 140 ÷ 95

c. IP degree (by according to IEC 60529): IP3X.

The electronic load (e.g Inverter) and all the accessories for its assembly must be included in the supply of the PSS.

The supplier must propose a solution to Enel that will decide about the admissibility.

7.3.12 Safety considerations

With reference to safety issues, when applicable, the provision from IEC 62485 series, IEC 61010-1, IEC 61508 series, IEC 62061 and IEC 62477 series must be respected. The candidate must also respect any additional safety requirement from other applicable standards recalled in this GS or from standard/law in force in the installation field.

7.4 TESTING AND CERTIFICATIONS

All the requirements from this chapter must be respected. ENEL has the right to ask a prototype for any kind of verification testing. These tests must be performed in the provider factory or third party laboratories (by according to ENEL or relevant standards provision), with no cost participation by ENEL.

The PSS will be subjected to an ENEL Technical Conformity Assessment (TCA) process, by according to GSCG002 that is intended to verify if the supplied device meets regulatory standards and specifications.

7.4.1 Overview Technical Conformity Assessment (TCA) Process

The information of this paragraph are only indicative and may change by according with ENEL TCA management; final TCA organization will be discussed during the TCA kick off meeting.

7.4.1.1 TCA documents

The ENEL technical organization unit in charge of the Technical Conformity Assessment of the PSS will supervise the technical documentation and the execution of the tests required to receive the “Statement of Conformity”, according to GSCG002 prescriptions.

All the technical documentation required during that process shall be in English or in the local language of ENEL technical organization unit in charge of the TCA.

The TCA documents that shall be delivered include:

a. Type A documentation (Not confidential documents used for product manufacturing and management from which it is possible to verify the product conformity to all technical specification requirements, directly or indirectly).

b. Type B documentation (Confidential documents used for product manufacturing and management where all product project details are described, in order to uniquely identify the product object of the TCA). This type of documentation must be delivered only to the ENEL technical organization unit in charge of the TCA

c. TCA dossier (Set of final documents delivered by the Supplier for the TCA) on digital support.

7.4.1.2 Quality

During the TCA, the supplier shall provide the technical documentation listed in ENEL Quality Specification for Electronic Assemblies during the procurement process (Par. 7.5.2) more information will be shared.

7.4.1.3 Safety warnings on Plate

The safety warnings required in the plate of the PSS and its components must be written in the local language of the destination Countries.

7.4.1.4 Tests required to complete the TCA

The manufacturer must have a valid and product specific homologation before he may supply PSSs to ENEL. In compliance with this technical specification, the manufacturer must satisfactorily pass all the type tests described in the following sections.

Once these tests have been successfully completed, an approved manufacturer's PSS will be subject to ad-hoc reception tests.

In addition, ENEL reserves the right to request the repetition of the type tests at any time to ensure that the PSS continue to meet the standards achieved by the initial testing and certification programs at the time the contact was awarded.

Type tests will be carried out in Official Laboratories or Laboratories recognized by ENEL, or in the workshops of the manufacturer. ENEL reserves the right to attend any or all of these tests and must be kept informed of the manufacturer's testing programs, schedules and result.

The manufacturer will bear the cost for type tests and for pilot installation tests.

7.4.1.5 Type test list

a. Visual examination and control of geometric characteristics, It is mandatory to verify the absence of visible manufacturing defects, the highest build-quality and precision of manufacture, the compliance of the rack/box dimensions with those indicated in the present specification;

b. Verification of all functions,

c. Insulation tests,

d. Electromagnetic compatibility tests (ref. to par.7.4.1.5),

e. Mechanical compatibility tests (ref. Table 16),

f. Environmental compatibility tests (ref. Table 16),

g. Correct operation of the DSU equipment and functionalities;

h. Selectivity test between IC3 and the other switches: operation of the PSS with K0 closed, rectifiers and regulator out of order; connection of a circuit breaker in series (with the same characteristics of the circuit breakers mounted on the PSC) and implementation of a short circuit on the VDC1 output. The correct selectivity between the circuit breakers must be verified.
i. Thermic operating tests:

The over temperature measurements must be carried out under thermic regime conditions with reference to the ambient temperature of 30° C and with the station in operation for at least 60 minutes.

The operating conditions of the rectifier must be the following:

a. Power supply: refer to Table 2
b. Output DC1: refer to Table 2
c. Output DC2: 24VDC 50A

The over temperature values measured at the thermic regime must be the following:

a. Core and winding transformers and inductances <65 ° C
b. Various components according to the limits guaranteed by the manufacturers
c. Environment inside the rack <45 ° C

The temperature inside the rack must be measured at 15 cm below the rack cover.

a. Stabilization limits tests:

The test of the stabilization limits must be carried out on the DC1 output with a load between 0 and 100%. The test must be performed without battery.

a. Noise level tests:

It must be verified that the noise level at a distance of 1 meter must be <60 dB.

a. Short Circuit tests:

The short-circuit test must be performed with the power supply station supplied in the reference conditions without battery.

The following short circuits must be performed:

a. downstream of RD1 and RD2
b. downstream of CV1 and CV2
c. downstream of REG1

The test is considered surpassed if no damage to any component occurs and the PSS resumes normal service.

a. Testing of the auxiliary control relays (making and breaking capacity) and signaling,
b. Power supply interruptions,
c. Influence of auxiliary voltage value,
d. Final verification of the PSS operation.

The supplier must retain all the documentation proving the successful results of the type tests and all data must be made available to ENEL in real time.

At ENEL's discretion, these tests may be completely or partially repeated during the lifetime of the contract as continuing evidence of type conformity.

7.4.1.6 Acceptance tests

Acceptance tests can be performed using specially designed automatic test systems (ATS). Each PSS must be accompanied by a report stating that all tests have been successfully completed.

The acceptance tests are those indicated in Par.7.4.1.5 Clause a, b, c and d; in particular, the following tests are scheduled:

a. Visual examination and control of geometric characteristics as indicated in the chapter 7.3.3.1;
b. Check the electrical connections and the composition of terminal blocks (7.3.4.2);
c. Check for signs of internal / external damage;
d. Check the “First start-up procedure” indicated by the supplier;
e. Test of the correspondence between switch position and LED signals;
f. Compliance of circuit breakers/components with the GS and manufacturer's documentation;
g. Regular indication of components;
h. Presence of all the advertising plates provided and the user manual in the local language
i. Switching on the PSS with the power supply;
j. Switching on the PSS with efficient battery (without Vnac power supply);
k. Data setting on the control panel;
l. Start-up of RD1 and RD2 rectifiers
m. Start-up of CV1 and CV2 converters
n. Start-up of REG1 converter
o. Test of the operating logic of the Rd1 and RD2 rectifiers and of the CV1 and CV2 converters (alternative or in parallel)
p. Measurement of electrical input / output quantities on all components (RD1, RD2, CV1, CV2, REG1);
q. Current limitation test supplied by the rectifiers and converters;
r. Discharge operation and mains power recovery;
s. Limitation test of the battery charge current value;
t. Thermal probe test;
u. Test of the stabilization limits RD1, RD2, CV1, CV2;
v. Measurement of the AC component on DC1 and AC component on DC2 on RD1, RD2, CV1, CV2 and REG1;
w. Positive ground polarity for DC2;
x. Check the protections provided and tests on their operation (Table 9);
y. Check signals on Kx.1 and Kx.2 boards;
z. Test of synoptic and display alarm signals;
aa. Check closing of alarm contacts on terminal block;
bb. Cause failure in the DSU and check the operation and performance of the PSS
cc. Test of switching and tripping times K0 following REG1 failure with measurement of input and output voltages before and after closing the by-pass;
dd. Function test following Vnac failure with charged batteries connected;
ee. Function test following Vnac failure with connected non-efficient batteries;
ff. There must not be overvoltage on the outputs exceeding 5% of the rated voltage when the rectifiers are switched on or off.
gg. Equipment energization test to check circuit-breaker features.
hh. Test correct operation of the PSS when an external battery is connected (according to par.7.3.8.4)

7.4.1.7 Type test levels

The test level for each requested environmental compatibility test and the relevant standard, where applicable, is shown in Table 16.

Furthermore the PSS must comply with the EMC standards EN 55011 and IEC 61000-6-5.

Table 16 - Tests Level

Type	Description	Test Level/Note	Standard
Insulation and EMC	Impulse withstand voltage	Overvoltage category IV	IEC 60664-1
	Dielectric strength	Test Voltage = 2 kV for the circuits in AC.	IEC 60255-27
	Insulation resistance	≥100 MΩ a 500 V_{DC}	IEC 60255-27
	Electrostatic discharges	Contact discharge level 3 Air discharge level 3	IEC 61000-4-2
	Ring wave	Test level 3	IEC 61000-4-12
	Damped oscillatory wave	Test level 3	IEC 61000-4-18
	Electrical fast transient/burst	Test level 4	IEC 61000-4-4
	Voltage surges 1.2/50 µs – Current surges 8/20 µs	Test level 3	IEC 61000-4-5
	Power frequency Magnetic field	Test level 5	IEC 61000-4-8
	Damped oscillatory magnetic field	Test level 5	IEC 61000-4-10
	Radiated, radio-frequency, electromagnetic field	Test level 3	IEC 61000-4-3
	Radiated, radio-frequency, electromagnetic field from digital radio telephones	Test level 3	
	Short interruptions on DC input power port	level 0% t = 0,05 s	IEC 61000-4-29
	Voltage dips on DC input power port	level 50% t = 0,1 s	
	Voltage variations on DC input power port	Un ± 20%; t = 10 s	
	Power frequency voltage	Test level 3	IEC 61000-4-16

	Conducted disturbances in the frequency range 0 Hz to 150 kHz		Test level 3	
	Conducted disturbances, induced by radio-frequency fields		Test level 3	IEC 61000-4-6
Environment	Non powered equipment	Dry heat	(+70 ± 2)°C; duration 16 hour	IEC 60068-2-2
		Damp heat	(40±2)°C; (93±3)% RH; duration 4 days	IEC 60068-2-78
		Cold	(-25 ± 3)°C; duration 16 hour	IEC 60068-2-1
		Change of temperature	TA = -25°C; TB =70°C; duration 3 hour + 3 hour	IEC 60068-2-14
	Powered equipment	Dry heat	(+70 ± 2)°C; duration 16 h	IEC 60068-2-2
		Damp heat	(40±2)°C; (93±3)% RH; duration 4 days	IEC 60068-2-78
		Cold	(-25 ± 3)°C; duration 16 hour	IEC 60068-2-1
		Change of temperature	TA = -25°C; TB =70°C; duration 3 hour + 3 hour	IEC 60068-2-14
Mechanical	Vibration immunity		Inf. limit 10 Hz Sup. limit 500 Hz Acceleration 10 m/s^2 Displacement amplitude 0,075 mm	IEC 60068-2-6
	Broadband random Vibrations			IEC 60068-2-64

7.4.2 Certifications and self-certifications

About the compliance of all the requirements/standards recalled in this GS, a certificate or self-certificate must be provided.

Regional laws or standards may requires additional certifications or self-certifications.

Certifications and self-certifications must be made according to the relevant standards or laws (including the template format).

7.5 MISCELLANEOUS

This chapter include further requirements, recommendations, and additional information.

7.5.1 Required documentation

The following documents (in pdf format) must be provided in local language:

a. PSS data sheet with layout and weight;
b. First Start-up procedure;
c. Installation, operation and maintenance manuals, with instructions on the installation and interfacing procedures;
d. List of pre-installation checks to ensure that the components have been delivered correctly;
e. Maintenance procedures;
f. Troubleshooting guide;
g. Quick installation and set-up guide;
h. Software need to operation;
i. Parts list;
j. Required but not included parts list;
k. Spare parts list;
l. Recommended Tool List;
m. One-wire diagrams (also in DWG/DXF formats);
n. Electrical diagrams (also in DWG/DXF formats);
o. Mechanical diagrams (also in DWG/DXF formats);
p. Component specification literature;
q. General description of functions, functional schema, wiring diagrams, power consumption requirements, etc.,
r. Detailed diagrams of the PSS,
s. Lists of references,
t. Exceptions to this specification,
u. Instructions for the installation, adjustment and commissioning of the PSS,
v. Examples of adjustment and configuration,
w. Instructions for checking and maintenance.

These documents must be made according to IEC 61010-1 and they must be approved by ENEL.

7.5.2 Clarification during procurement process

By summarizing, during the procurement process the following clarification will be provided to the supplier:

a. Type, Vnac, DC1 and DC2 level (Table 2)
b. Enviromental conditions (Table 3)

c. Language for embedded sw, documentations and labels;

d. Information about operating system homologated in ENEL (par. 7.3.8.1);

e. Details about unique serial identifier, serial code and other labeling.

7.5.3 Receipt of material

The information of this paragraph are only indicative and may change by according with ENEL product management; final procurement approach will be issued by entrusted ENEL units.

7.5.3.1 Reception tests

Part of the process of accepting delivery of a manufacturer's devices will include the proof of having successfully passed previously performed acceptance tests (Par.7.4.1.6).

Then, the reception tests will be carried out in Official Laboratories or Laboratories accredited by ENEL, or in the workshops of the manufacturer. ENEL reserves the right to attend any or all of these tests and must be kept informed of the manufacturer's testing programs, schedules and results. If the assistance of an ENEL representative is not available, the provisional reception procedure will be conducted when tests protocols are received.

In the event the documentation has undergone modifications with reference to the actual devices delivered, the manufacturer must provide the updated documentation before the reception procedure will be deemed to have been completed.

7.5.3.2 Warranty

The manufacturer will commit to providing a guarantee of the PSS for a minimum period of 24 months, which will commence immediately following a successful reception.

The guarantee will be legally binding for any device/component faults and/or defects that occur within the guarantee period: accordingly, the PSS and/or components will be replaced. Further, the manufacturer will undertake to continue, free of charge, the software and firmware development and provide the updates to ENEL for the lifetime of the devices.

If during the contract term the manufacturer fails to address in a prompt and timely manner any functional anomalies or defects in the device behavior or manufacture (hardware or firmware).

ENEL reserves the right to block the necessary positions on the contract, staged payments and/or alter the payment schedules as necessary until the anomalies have been resolved to the complete satisfaction of ENEL.