Protection and control device for HV/MV substation – Remote Input / Output module (RIO) for the MFP

This global standard defines the characteristics of Remote Input / Output module (RIO) used with multifunctional feeder protection (MFP) for HV/MV distribution substations a declared fundamental frequency of 50 Hz or 60 Hz.

Countries' I&N	Elaborated by	Collaborations by	Verified by	Approved by
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	Elaborated by	Collaborations by	Verified by	Approved by
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Revision	Data	List of modifications
00	27.07.2018	First draft
01	06.12.2018	First approved edition

INDEX

TABLES

1 ACRONYSM

a. **EMC** Electromagnetic Compatibility

b. **GS** Enel Global standard

c. **IED** Intelligent Electronic Device

d. **MFP** Multifunctional feeder protection

e. **PS** primary substation that is an HV/MV substation or another substation having a primary role in the electricity distribution

f. **RIO** Remote I/O Module of multifunctional feeder protection

g. **RTU** Remote Terminal Unit

h. **TCP** Transmission Control Protocol

i. **TFN** Neutral Forming Transformer

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

The MFP–RIO module described in this GS is a product of GSTP10X series, as shown in Table 1 in GSTP101.

3 NORMATIVE REFERENCES AND BIBLIOGRAPHY

All the references in this GS are intended in the last revision or amendment.

3.1 For all countries

IEC 61850 series	Communication protocols for IED at electrical substation
IEC 60529	Classification of degrees of protection provided by enclosures for electrical equipment
IEC 60255 series	Measuring relays and protection equipment
IEC 61000 series	Electromagnetic compatibility
IEC 60068 series	Environmental testing
IEEE 802.3u	Physical layer and data link layer's media access control of wired Ethernet
IEEE 802.1q	System of VLAN tagging for Ethernet frames
GSCG002	Technical Conformity Assessment
GSTP10X series	Protection and control device for HV/MV substation – Multifunctional feeder protection (MFP)
GSTP901	Cybersecurity requirements for protection and control devices

3.2 For EU countries

EN 55011	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
EN 50160	Voltage characteristics of electricity supplied by public distribution systems.
EU directive 2004/108/CEE	EMC directive
EU directive 2006/95/CEE	Low Voltage directive
EU directive 93/68/CEE	CE marking directive

3.3 For Colombia

NTC-2050	Código eléctrico colombiano
RETIE	Reglamento técnico de instalaciones eléctricas

4 REPLACED STANDARDS

Codification	Country	Title
DMI-9-00016	Italy	Requisiti costruttivi e funzionali del Pannello Multifunzione di Protezione e Controllo per Cabina Primaria
SNC002	Iberia	Relé multifunción posiciones MT
PCM001	Brazil Perù Chile Argentina Colombia	Proteccion de sobrecorriente multifuncion
ET189	Brazil	Relé de Freqüência
PCM002	Brazil Perù Chile Argentina Colombia	Protección para Banco de Condensadores MT
ET111d	Perù	Reles de proteción de falla a tierra para redes de distribución con neutro aislado
ET124c	Perù	Equipos de protección y maniobra de media tensión para interior
PCM007	Brazil Perù Chile Argentina Colombia	Proteccion de sobretension homopolar
DWEC19	Argentina	Relevador de frecuencia con derivada
DWEC20	Argentina	Proteccion de sobrecorriente

Differential and distance protections are included in some replaced standards but are not covered by the MFP.

Some Iberia installations may require the persistence of the local standard.

5 APPLICATION FIELDS

This document standardizes the functional and construction requirements of the Remote I/O modules (RIO) used with multifunctional feeder protection (MFP) in the ENEL's HV/MV distribution substation. This device accomplish to the definition of IED, by according to IEC 61850 series.

The MFP is defined in GSTP101.

The MFP and RIO use the protocols from the IEC 61850 to communicate with the RTU, the communication profiles are defined in the GSTP103 and GSTP104.

The Remote I/O Modules (RIO) is a slave IED of the MFP that monitor the operating status and the faults of both the switching device and any controlled equipment and notify them to the MFP.

The Remote I/O Modules (RIO) allows reducing the required wiring for IEDs constituted by an integrated protection in a controlled system.

The MFP-RIO equipment shall meet the following physical general features:

a. Reduced size

b. Easy installation

c. Strength

Security by design is mandatory for any devices developed to be installed in the ENEL premises. The requirements from GSTP901 must be adopted.

6 BASIC REQUIREMENTS

This chapter present all the basic requirements for the MFP-RIO system.

6.1 Interface for local connection and configuration

The module must be equipped with an Ethernet port compliant with the 100 BASE-FX standard on LC connectors standard IEEE802.3u and IEEE802.1q, for the communication with the MFP.

The protocol to be provided for the communication between the MFP panel (Client) and the remote modules (server) is IEC61850 (the communication profiles is defined in GSTP104), in which case the module must become an IED of the BUS process network.

Since the interchangeability (not the only interoperability) between modules and panels must be guaranteed, even between the different manufacturers, no solutions or configurations for the panel-module communication outside or limiting the standard dictated by the protocol in question shall be implemented.

The module must be equipped with an RS232 serial port (null-modem connection cable) through which it must be possible, by an application prepared by the manufacturer, to configure the communication parameters on the Ethernet network, the labeling of the module, as well as to view and locally forcing the status of the inputs and outputs.

6.1.1 SFTP interface

The MFP-RIO module must be able to access uploading/downloading files following SFTP protocol. This service should allow the following services for a user

a. Get CID file

b. Send CID file

c. Get Events text file

d. Update firmware

6.1.2 Synchronization

Its synchronization will be able to be configured via NTP. It will be a main NTP server IP address. The equipment must have a backup NTP server IP address in case of failure of the main IP address.

6.1.3 Sampling and filtering the inputs

The sampling of each digital input will be performed in a frequency equal or greater than 1 KHz (one sample/1ms).

The digital MFP-RIO module inputs will have filtering systems that allow balancing the acquisition speed and the stability threshold against transients and electromagnetic disturbances.

This filtering feature must be user-settable, allowing the configuration of the number of consecutive samples with the same state to stamp a value as “valid”. It must be possible to deactivate this filtering mode.

6.2 Enclosure

The MFP-RIO module must be in boxed version suitable for mounting on DIN rail (Omega type). The MFP-RIO type module must have following maximum dimensions (Figure 1):

a. W = 150mm

b. H = 120mm

c. D = 60mm

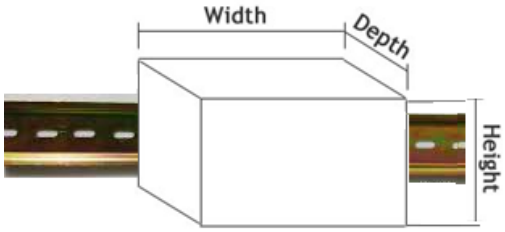

Figure 1 – MFP-RIO dimensions reference

The container must be made of hot-galvanized steel sheet or equivalent material from the point of view of electromagnetic compatibility, of the structure's stiffness and resistance to atmospheric agents (plastic solutions with metallization are excluded).

It must also be guaranteed a degree of IP protection according to IEC 60529 standard same as MFP in the GSTP101.

Different enclosure characteristics may be approved by ENEL during the procurement process (par.9.2.).

6.3 Environmental requirements

The device shall operate accurately in the following conditions:

a.	operating temperature	-10 ÷ 70°C
b.	relative humidity (without condensation or ice)	≤ 95%
c.	atmospheric pressure	86 ÷ 106kPa

6.4 Module power supply

The module will be powered at the auxiliary voltage described in GSTP101. A self-diagnosis function must be provided that constantly checks the general efficiency of the power supply and more generally of the module. Instead, the fault conditions that do not compromise the communication functions must be reported to the MFP panel.

The supply stage must be protected against polarity inversion.

6.5 Module Digital Inputs

The digital inputs must have the same electrical characteristics shown in GSTP101.

6.6 Module Digital Outputs

The digital outputs must have the same electrical characteristics as the digital outputs on the circuit-breaker module card shown in GSTP101, including the electrical continuity monitoring function of the 74TC control circuits shown in GSTP101.

6.7 MFP-RIO Module Pin-Out

In Table 1 the characteristics of the module output pins are shown.

Table 1 – Pin-Out Remote Module				
Type	Clamps	Terminal	Function	Voltage
MMP Connector – 2 poles – pitch 5.08				
Power Supply	MMP	1	Power supply	+MFP Vaux
Power Supply	MMP	2	Power supply	-MFP Vaux
MMI Connector – 13 poles – pitch 3.81				
Dig-IN	MMI	1	Programmable	+MFP Vaux
Dig-IN	MMI	2	Programmable	+MFP Vaux
Dig-IN	MMI	3	Programmable	+MFP Vaux
Dig-IN	MMI	4	Programmable	+MFP Vaux
Dig-IN	MMI	5	Programmable	+MFP Vaux
Dig-IN	MMI	6	Programmable	+MFP Vaux
Dig-IN	MMI	7	Programmable	+MFP Vaux
Dig-IN	MMI	8	Programmable	+MFP Vaux
Dig-IN	MMI	9	Programmable	+MFP Vaux
Dig-IN	MMI	10	Programmable	+MFP Vaux
Dig-IN	MMI	11	Programmable	+MFP Vaux
Dig-IN	MMI	12	Programmable	+MFP Vaux
Dig-IN	MMI	13	Common	-MFP Vaux
MMO Connector – 6 poles – pitch 3.81				
Polarization Dig-OUT	MMO	1	Common	+MFP Vaux
Dig-OUT 1	MMO	2	Programmable NO	+MFP Vaux
	MMO	3	Programmable NC	+MFP Vaux
Polarization Dig-OUT	MMO	4	Common	+MFP Vaux
Dig-OUT 2	MMO	5	Programmable NO	+MFP Vaux
	MMO	6	Programmable NC	+MFP Vaux

In the above table, NO is used for Normally Open, instead NC for Normally Closed.

6.8 Electrical safety

The insulation characteristics must comply with the electrical safety standards shown in GSTP101.

6.9 EMC

The remote module must comply the same EMC requirements as the multifunctional feeder protection (MFP) in GSTP101.

6.10 Electrical Diagrams

For the electrical diagrams, please refer to GSTX102 Electrical Diagrams for Protection and control device for HV / MV substation – Remote Input / Output module (RIO) for the MFP.

7 EXTENDED REQUIREMENTS

The requirements from this chapter must be respected just if expressly requested during the procurement process par. 9.2.

7.1 RIO MODBUS enhancement

The MODBUS (TCP/IP) protocols must be provided for the communication between the MFP panel (Client) and the remote modules (server), in addition to IEC 61850.

7.1.1 Default configuration for MFP-RIO I/O

The MFP panel interfaces with the field through one or two (only for TFN application) remote I/O modules whose default functions are defined in Table 2 and Table 3.

The functions assigned to the inputs and outputs of the modules must be configurable with programmable logic, both for current applications on MODBUS TCP / IP and on the IEC61850 protocol.

Table 2 – Pin-Out Remote Module N°1 (general application)

				MODBUS Parameters				
		Bay	Function			Address Hi (HEX)	Address Low (HEX)	Format
Dig-IN	Module MODBUS TCP/IP 52MT	52 LMT 52 RIF 52 TFN 52 KMT 52 AT	Closed earth switch (89TccX)	(1X)	10000	0	0	1bit
			Open earth switch (89TcaX)	(1X)	10001	0	1	1bit
			Switch 52MT on	(1X)	10002	0	2	1bit
			Switch 52MT sectioned	(1X)	10003	0	3	1bit
			Block CH – port for return voltage (BLP)	(1X)	10004	0	4	1bit
			No voltage switch 52MT (27X)	(1X)	10005	0	5	1bit
			Release of the spring charging motor switch (6L)	(1X)	10006	0	6	1bit
			Springs weak (X33)	(1X)	10007	0	7	1bit
			63G All.	(1X)	10008	0	8	1bit
			63G SC.	(1X)	10009	0	9	1bit
			S27	(1X)	10010	0	10	1bit
				(1X)	10011	0	11	1bit
Dig-OUT				(2X)	20000	0	0	1bit
				(2X)	20001	0	1	1bit

		Table 3 – Pin-Out Remote Module N°2 (TFN application)						
				MODBUS Parameters				
		Site	Function			Address Hi (HEX)	Address Low (HEX)	Format
Dig-IN	Module MODBUS TCP/IP B;	TFN Mobile Coil	26 All. Series/Parallel Resistors	(1X)	10000	0	0	1bit
			26 All. Fixed Coil/Mobile Coil	(1X)	10001	0	1	1bit
			97 All. Fixed Coil/Mobile Coil	(1X)	10002	0	2	1bit
			99 All. Fixed Coil/Mobile Coil	(1X)	10003	0	3	1bit
			Anomalies heaters coil mobile/trip ATV	(1X)	10004	0	4	1bit
			26 Sc. Series/Parallel Resistors	(1X)	10005	0	5	1bit
			Serious Coil Alarm	(1X)	10006	0	6	1bit
			26 All. TFN	(1X)	10007	0	7	1bit
			97 All. TFN	(1X)	10008	0	8	1bit
			26 Sc. TFN	(1X)	10009	0	9	1bit
			97 Sc. TFN	(1X)	10010	0	10	1bit
			No voltage bay TFN (27X)	(1X)	10011	0	11	1bit
Dig-OUT				(2X)	20000	0	0	1bit
				(2X)	20001	0	1	1bit

7.1.2 Wiring Requirements

Three connector terminal blocks are required for electrical connections; as well as an M5 terminal that allows ground connection of the module.

7.2 RIO RJ45 enhancement

In addition to the LC connectors, the module must be equipped with an Ethernet port compliant with the RJ45 connectors for the communication with the MFP. These two ports (RJ45 and LC) must be in switch mode.

Also the RS232 serial port may be replaced by an RJ45 connectors with analogous functions.

7.3 RIO HW enhancement

7.3.1 Visual indicators

The inclusion of any kind of display will be rejected. Visual indications must be reduced to the following LEDs:

a. LED “Power”: to indicate the status of power supply

b. A LED to indicate device status (self-diagnosis):

- This LED keeps green if no problem is detected.
- This LED turns red, or turns off, when an internal hardware fault is detected.

c. Communication LEDs:

- LEDs to indicate transmission and reception (connection to IED/protection)

d. LED of each input and output:

- RIO module must have LEDs to indicate the state of each input and output.

7.3.2 MFP-RIO Module Pin-Out

In Table 4 the characteristics of the extended module output pins are shown.

Table 4 – Extended Pin-Out Remote Module

Type	Clamps	Terminal	Function	Voltage
MMP Connector – 2 poles – pitch 5.08				
Power Supply	MMP	1	Power supply	+MFP Vaux
Power Supply	MMP	2	Power supply	-MFP Vaux
MMI Connector – 14 poles – pitch 3.81				
Dig-IN	MMI	1	Programmable	+MFP Vaux
Dig-IN	MMI	2	Programmable	+MFP Vaux
Dig-IN	MMI	3	Programmable	+MFP Vaux
Dig-IN	MMI	4	Programmable	+MFP Vaux
Dig-IN	MMI	5	Programmable	+MFP Vaux
Dig-IN	MMI	6	Programmable	+MFP Vaux
Dig-IN	MMI	7	Programmable	+MFP Vaux
Dig-IN	MMI	8	Programmable	+MFP Vaux
Dig-IN	MMI	9	Programmable	+MFP Vaux
Dig-IN	MMI	10	Programmable	+MFP Vaux
Dig-IN	MMI	11	Programmable	+MFP Vaux
Dig-IN	MMI	12	Programmable	+MFP Vaux
Dig-IN	MMI	13	Programmable	+MFP Vaux
Dig-IN	MMI	14	Programmable	-MFP Vaux
MMO Connector – 12 poles – pitch 3.81				
Polarization Dig-OUT	MMO	1	Common	+MFP Vaux
Dig-OUT 1	MMO	2	Programmable NO	+MFP Vaux
	MMO	3	Programmable NC	+MFP Vaux
Polarization Dig-OUT	MMO	4	Common	+MFP Vaux
Dig-OUT 2	MMO	5	Programmable NO	+MFP Vaux
	MMO	6	Programmable NC	+MFP Vaux
Polarization Dig-OUT	MMO	7	Common	+MFP Vaux
Dig-OUT 3	MMO	8	Programmable NO	+MFP Vaux
	MMO	9	Programmable NC	+MFP Vaux
Polarization Dig-OUT	MMO	10	Common	+MFP Vaux
Dig-OUT 4	MMO	11	Programmable NO	+MFP Vaux
	MMO	12	Programmable NC	+MFP Vaux

7.4 RIO SW enhancement

7.4.1 GOOSE message sent by the MFP-RIO module

The GOOSE messages sent by the MFP-RIO module will have the following information, to set in the device:

a. Destination address GOOSE: 01-0C-CD-01-XX-YY

b. VLAN-PRIORITY

c. VLAN-ID

d. Control Block Reference

e. Time Allowed to Live (msec)

f. (T0): It is considered that the default repetition time must be 2000 ms, when there is no change (it is a GOOSE setting).

g. Dataset Reference:

h. GOOSEID

If no GOOSE message is received within a three seconds period, all its signals will be set to zero and after that, the subscription will be deactivated until the GOOSE is available again.

The general criterion for sending data will consist in sending two variables, first its state and second its quality.

Any change in the state or the quality of a signal will cause the sending of a new GOOSE.

There are two types of data to be sent by the MFP-RIO module:

i. Its internal state.

j. The state of its inputs and outputs.

The following table presents the structure of the message body including its data and its possible values:

Table 5 – Message body (message sent by the RIO)				
General state of the RIO	STATE	BOOLEAN:	TRUE/FALSE	TRUE- correct RIO state FALSE- alarm RIO state
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 1	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 2	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 3	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 4	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 5	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 6	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 7	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 8	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 9	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 10	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 11	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 12	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850

INPUT 13	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
INPUT 14	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated input FALSE- Disabled input
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
OUTPUT 1	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
OUTPUT 2	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
OUTPUT 3	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
OUTPUT 4	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850

Each RIO module will send a GOOSE message with its internal state and the state of its inputs and outputs.

Activation and deactivation of the MFP-RIO digital outputs will be done by subscription to GOOSE messages sent by the IED of the system subscribed to a particular MFP-RIO.

When a signal from a GOOSE message arrives with a bad quality, it will be rejected and treated as if the signal was turned off, regardless of the state of arrival.

The structure of the message body must be the following:

Table 6 – Output activations

OUTPUT 1	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
OUTPUT 2	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
OUTPUT 3	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850
OUTPUT 4	STATE	BOOLEAN:	TRUE/FALSE	TRUE- Activated output FALSE- Disabled output
	QUALITY	BITSTRING:	0000000000000000	Quality defined in IEC 61850

7.4.2 PLC function

The PLC logic (16 variables) presented in Figure 2 must be available.

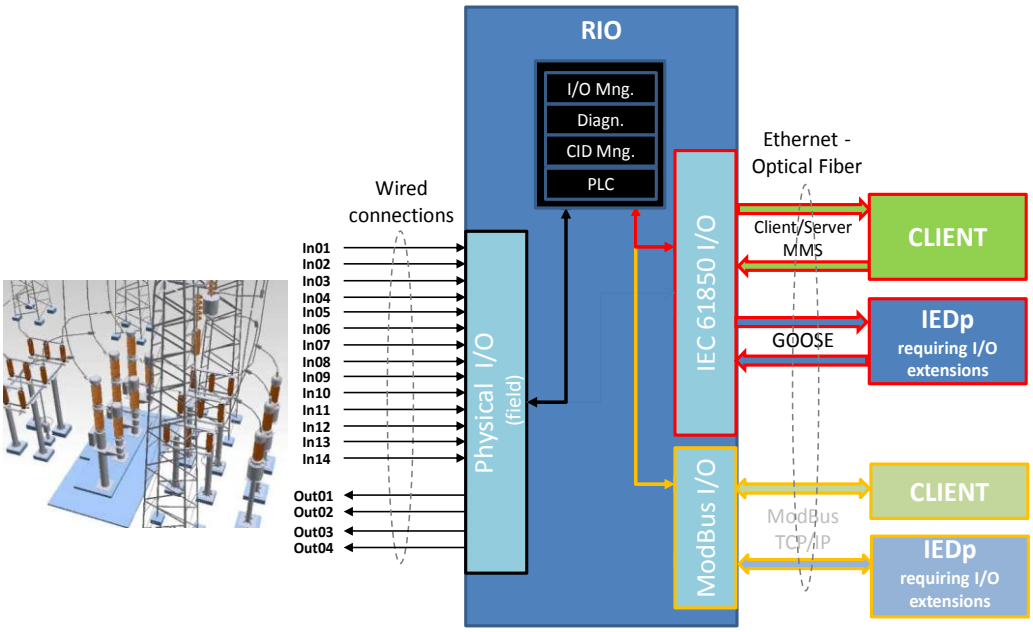

Figure 2 – RIO connectivity, functions and communication

8 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.

8.1 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.

8.1.1 TCA documents

The ENEL technical organization unit in charge of the Technical Conformity Assessment of the MFP-RIO 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)

d. The supplier shall provide the TCA Dossier on digital support.

8.1.2 Quality

During the TCA, the supplier shall provide the technical documentation listed in ENEL Quality Specification for Electronic Assemblies.

8.1.3 Safety warnings on Plate

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

8.1.4 Tests required to complete the TCA

This process consists of the following tests cases:

a. static accuracy/precision tests;

b. real-world tests cases (in COMTRADE format, supplied by ENEL);

c. approximately 300 laboratory tests cases.

The manufacturer must have a valid and product specific homologation before he may supply devices to ENEL. In compliance with this technical specification, the manufacturer must satisfactorily pass, within a maximum period of 6 months after contract award, all the tests described in the following sections.

Once these tests have been successfully completed, an approved manufacturer's MFP-RIO 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 devices 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.

8.1.5 Type test list

a. Visual examination and control of geometric characteristics,

b. Out of range power supply tests,

c. Electromagnetic compatibility tests,

d. Mechanical compatibility tests,

e. Climate compatibility tests,

f. Thermal behavior r tests

g. Performance test

h. Functional final test.

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.

8.1.6 Type test levels

The test level for each requested environmental compatibility test and the relevant standard, where applicable, is shown in. Table 7.

Table 7 – Tests Levels

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 a.c.	IEC 60255-27
	Insulation resistance	≥100 MΩ a 500 V d.c.	IEC 60255-27
	Electrostatic discharges	Contact discharge level 3 Air discharge level 3	IEC 61000-4-2 IEC 60255-26
	Ring wave	Test level 3	IEC 61000-4-12
	Damped oscillatory wave	Test level 3	IEC 61000-4-18 IEC 60255-26
	Electrical fast transient/burst	Test level 4	IEC 61000-4-4 IEC 60255-26
	Voltage surges 1.2/50ms – Current surges 8/20ms	Test level 3	IEC 61000-4-5 IEC 61000-4-5/A1
	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 IEC 60255-26
	Radiated, radio-frequency, electromagnetic field from digital radio telephones		Test level 3	
	Short interruptions on d.c. input power port		level 0% t = 0,05 s	IEC 61000-4-29
	Voltage dips on d.c. input power port		level 50% t = 0,1 s	
	Voltage variations on d.c. input power port		Un ± 20%; t = 10 s	
	Power frequency voltage		Test level 3	IEC 61000-4-16 IEC 60255-26
	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 IEC 60255-26
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 hours	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

8.1.7 Acceptance tests

The acceptance tests are those indicated in Par. 8.1.5. clause a, b and g.

The acceptance tests must be carried out using specifically designed and automated test equipment (SCA). Each device must be accompanied by a report stating that all SCA tests have been concluded successfully.

8.1.8 Visual inspections

It is mandatory to verify the absence of visible manufacturing defects, the highest build-quality and precision of manufacture, the compliance of the enclosure dimensions with those indicated in the present specification, as well as the required degree of IP protection.

8.1.9 Out of range power supply tests

It shall be verified that RIO module is inhibited by feeding the device with the values of the supply voltage that don't provide the proper function.

8.1.10 Immunity tests (electromagnetic compatibillity)

The objective of the tests is to verify the correct functioning of RIO module subject to the application of various electromagnetic disturbances.

The interferences shall be applied on the terminal board, with reference to digital inputs.

The procedure for verifying the correct functioning of RIO module during these tests shall be agreed with ENEL.

8.1.11 Thermal behaviour tests

It shall be revealed the thermal map of RIO module feeding with maximum values of the nominal range; the test shall be performed under the following normal environmental conditions:

a. temperature: -10 ÷ 70 °C

b. atmospheric pressure: 86 ÷ 106 kPa

c. relative humidity: 45 ÷ 75%

The values of over temperature, collected near the individual component, shall be used for verifying that, at the highest temperature of the expected operation, the maximum permissible temperature of functioning for the same components is not exceeded.

Moreover, the thermal map shall be used for the definition of thermal time constant in view of the temperature variation test.

8.1.12 Mechanics compatibility tests

The tests and are divided in:

a. immunity tests to sinusoidal type vibrations (working device)

b. resistance tests to transport and handling stresses (non working device)

The requirements to apply are the following:

c. immunity to sinusoidal vibrations V.H.3

d. resistance to transport and handling stresses test type broadband random vibrations

The procedures for verifying the correct operation of RIO module during these tests shall be agreed with ENEL.

8.1.13 Climatic tests

The referring levels of the single group of tests are indicated in the Table 7.

The procedures for verifying the correct operation of RIO module during these tests shall be agreed with ENEL

8.1.14 Performance system

Performance system must be tested getting times acceptable for control and protection system.

The figure below represents an example of test environment to get minimum time for required performance.

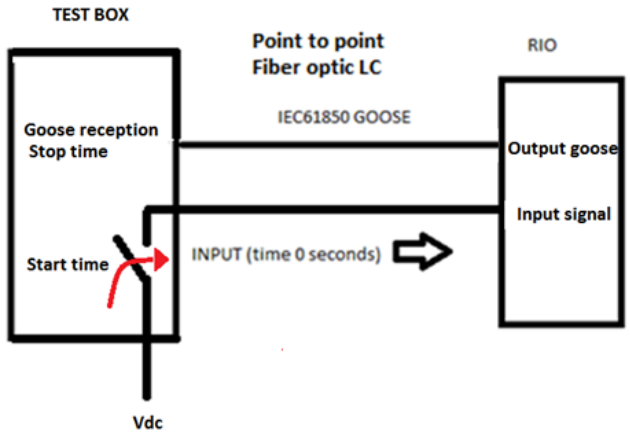

Figure 3 – Performance System

A test document will be issued. Time performance must be less o equal to 20 ms. This time must not be higher in any case.

The same behavior is required in reverse mode:

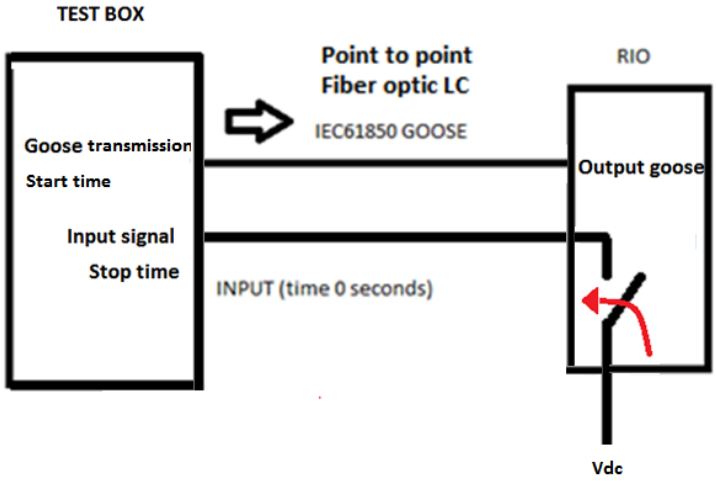

Figure 4 – Performance System (reverse mode)

The same requirement must be required within a LAN connection through switch, shared with other equipments that are using IEC61850 or other protocols. The same tests and the same time performance must be obtained, despite the traffic generated.

Traffic generator consists of 3 RIO modules connected to the LAN, with a continuous change of 1 input signal every 15 ms in everyone.

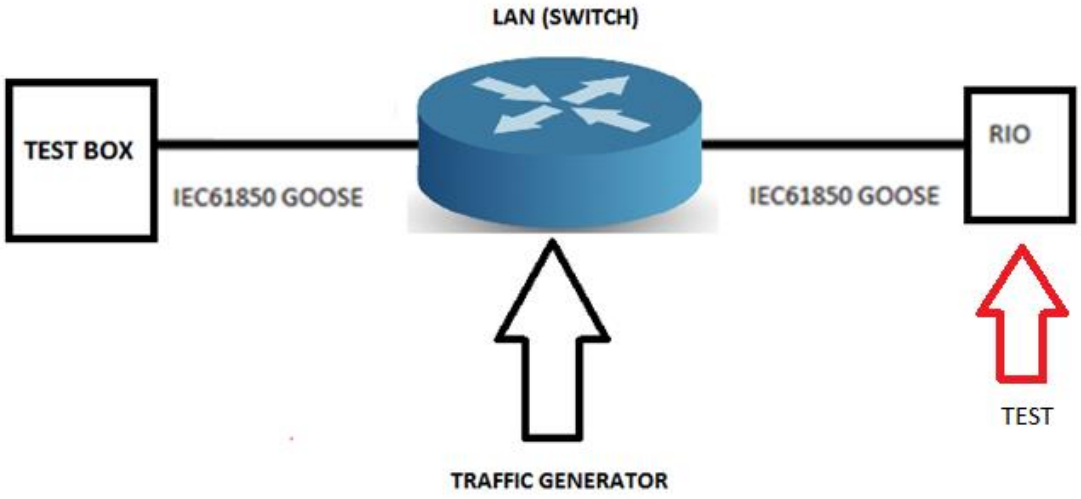

Figure 5 – Performance System (traffic generator)

The same behavior is required within a RIO LAN connection. The RIO module won't have any more connections. The same tests and the same time performance must be obtained.

The RIO LAN will have a continuous change of 1 input signal every 15 ms.

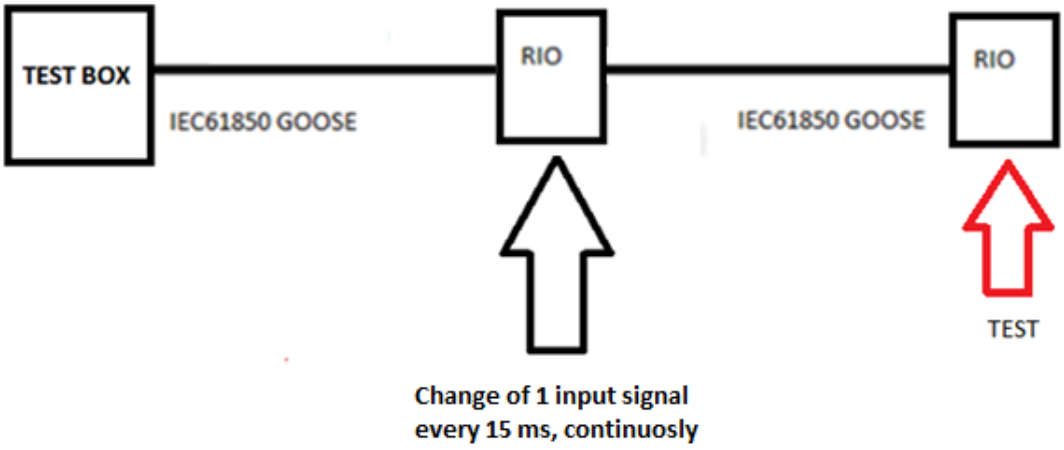

Figure 6 – Performance System (RO LAN)

8.1.15 Functional final test

In order to check that RIO module operates regularly after the execution of all the prescribed type tests, they shall be repeated, with the characteristics of the acceptance tests, those indicated in Par. 8.1.5. clause a, b and g.

8.2 Pilot installation tests

In a substation chosen by ENEL will be installed one RIO garanted by the manufacturer in order to evaluate its behavior and stability in a real environment.

The manufacturer will configure the device and will collaborate in the commissioning with all the necessary modifications to enable all the required functionalities and completely integrate the RIO in the substation.

8.3 Individual tests

These tests will consist of the visual checking of:

a. Terminal blocks for the power supply, Digital Inputs and Outputs, Current and Voltage Inputs, communication ports/channels, etc.. For these tests it will be necessary to provide:
   a) Photo(s) of the front panel of the device,
   b) Photo(s) of the rear of the device.

b. Identification label with the characteristics of the device (including complete model and firmware version).

The device will also be powered on to verify (via its keyboard/display) that the information about its identifying characteristics match those registered in the homologation process.

8.4 Certifications and self-certifications

About the compliance of all the requirements/standards recalled in this GS, a certificate or selfcertificate 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).

9 MISCELLANEOUS

This chapter include further requirements, recommendations and additional information.

9.1 Required documentation

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

a. RIO data sheet with snapshots;

b. installation, operation and maintenance manuals, with instructions on the installation and interfacing procedures;

c. administrator's manual, for proper integration of RIO into communication and IT networks (this document should describe any network service the RIO is supplying);

d. list of pre-installation checks to ensure that the components have been delivered correctly;

e. quick installation and set-up guide;

f. installation and one-wire diagrams (also in DWG/DXF formats);

g. all software need to RIO operation;

h. parts list;

i. required but not included parts list;

j. recommended Tool List;

k. electrical schematics;

l. mechanical drawings;

m. spare parts list;

n. maintenance procedures;

o. troubleshooting guide;

p. component specification literature.

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

9.2 Clarification during procurement process

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

a. Choice about the enclosure (par. 6.2);

b. Extended requirement included (chap. 7);

c. Language for embedded sw and documentations;

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

9.3 Procurement management

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

Within 30 days of receiving the present specification, the manufacturer must send the following documentation, in English, along with the technical proposal:

a. Dimensions and weight of the RIO,

b. General description of functions, functional schema, wiring diagrams, power consumption requirements, errors limit, etc. The description must also include the algorithms used for the treating and filtering signals and the number of samples per cycle,

c. Photos or detailed drawings of the RIO,

d. Lists of references,

e. Exceptions to this specification,

f. Instructions for the installation, adjustment and commissioning of the RIO,

g. Examples of adjustment and configuration,

h. Instructions for checking and maintenance.

If the manufacturer fails to provide any or all of the above information within 30 days of receipt of this specification, he will be disqualified as supplier, for ENEL, of the product standardized in this Technical Specification.

9.4 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.

9.4.1 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. 8.1.7).

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.

The reception will be deemed as completed once the reception tests have been carried out and the material has been delivered with the associated tests protocols. The tests are the ones mentioned in Par.8.3 and will be performed before any order is delivered; the associated testing protocols will be presented to ENEL for approval. The results obtained in these individual tests must be indicated in a report; every device must be accompanied by this report.

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.

9.4.2 Warranty

The manufacturer will commit to providing a guarantee of the IEDs for a minimum period of 24 months, which will commence immediately following a successful reception; final procurement approach will be issued by entrusted ENEL units.

The guarantee will be legally binding for any device/component faults and/or defects that occur within the guarantee period: accordingly, the devices 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.