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THE HEAD OF GRID DIGITALIZATION

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1. DOCUMENT VERSION MANAGEMENT

Version	Date	Main changes description
1	[26/07/2019]	Issuing of Global Infrastructure and Networks Global Standard Protection and control devices for MV substation – RGDM control unit
2	[15/09/2022]	Issuing of Global Energy Transition Standard for Protection and control devices for MV substation – RGDM Control unit List of main changes: • Clarification about Analog Inputs (Impedence, anti-aliasing filter, etc..); the measurement Input used for Synchronism and RGDAT compatibility sensor. • Eliminated reference to Serial communication ports (RS232,RS485); • Eliminated basic vs extended configuration modes; • Clarifiction about protection functions: ANSI curves, protection 46,ES59B,RLS; • Eliminated connection cable related to MI terminal boards.

2. GRIDSPERTISE UNITS IN CHARGE OF THE DOCUMENT

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3. REFERENCES

- IEC 61850 series: Communication networks and systems for power utility automation
- IEC 60255 series: Measuring relays and protection equipment
- IEC 60529: Degrees of protection provided by enclosures (IP Code)

- IEC 62262: Degrees of Protection Provided by Enclosures for Electrical Equipment Against External Mechanical Impacts (IK Code)
- IEC 62689: Current and voltage sensors or detectors, to be used for fault passage indication purposes
- IEC 61869-10: Additional Requirements for low-power passive current transformers
- IEC61869-11: Additional Requirements for low-power passive voltage transformers
- IEC 61000-4-2: Electromagnetic compatibility (EMC) Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
- 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 61000-4-8: Electromagnetic compatibility (EMC) Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test
- IEC 61000-4-10: Electromagnetic compatibility (EMC) Part 4-10: Testing and measurement techniques - Damped oscillatory magnetic field immunity test
- IEC 61000-4-12: Electromagnetic compatibility (EMC) Part 4-12: Testing and measurement techniques - 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 61000-4-17: Electromagnetic compatibility (EMC) Ripple on d.c. input power port immunity test
- IEC 61000-4-29: Electromagnetic compatibility (EMC) Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests

- GETP013: Protection and control devices for HV/MV substation – Communication profile according to IEC61850 for the RGDM
- GETP011-A1: RGDM IPR functonalities
- GSTR002: Remote Terminal Unit for MV/LV substation – UP2020 Lite
- GSTC005: Technical characteristics of Ipits for RGDM/RGDAT
- GSCM004: MV RMU
- GSCC012: Smart Termination specification
- GSTP901: Cyber security requirements for protection and control devices

4. DEFINITIONS AND ACRONYMS

Acronym and Key words	Description
ARF	Automatic reclosing function
CID	Configured IED Description
CT	Current Transformer
CT-VT	Current and Voltage Transformer
DER	Distributed Energy Resources
DG	Distributed Generation
DSU	Distribution Substation Unit
E_{rn}	Rated Residual Voltage
FdP	Protection Function
FFT	Fast Fourier Transform
FRT	Timed Re-closing Function
FSL	Logic Selectivity Function
GOOSE	Generic Object Oriented Substation Events
ICD	IED Capability Description (XML file)
MV RMU	Standardized Circuit Breaker for MV/LV substations
IDC	Interoperability Device with the Customer
IDC_DER	IDC (functions) related to the DER resources
IDC_PROT I	IDC (functions) related to the DER plant Protections
IED	Intelligent Electronic Device
MMS	Manufacturing Message Specification
MV	Medium Voltage
OdM	Device for changing the electric connections (e.g. switch, breaker)
PG	General Protection
PI	Interface Protection

5. DESCRIPTION

5.1 List of components, product family or solutions to which the gs applies

The RGDM described in this technical specification can be classified to several products provided in **Table 1**.

Table 1 – GETP01X product family and description

GETP01X type	Product family code	Description
GETP011- RGDM	GETP01X	Protection and control device for MV substation – RGDM control unit.
GETP011-A1	GETP01X	Protection and control device for MV substation – RGDM IPR functonalities
GETP013	GETP01X	Protection and control device for MV substation – Communication profile according to the IEC 61850 for the RGDM control unit.

5.2 Application Fields

This document standardizes the functional, construction and testing requirements for the RGDM control unit used for protection and control in MV substation.

The RGDM is a device designed to be installed in the medium voltage compartment, with an SF6 or air isolated switch, air isolated line and earth disconnecting switch, situated in remote controlled secondary substations, for protection, measurement, remote control and monitoring.

Particularly the RGDM purposes are:

- detecting any multi-phase and single-phase faults to earth, irrespective of how the MV neutral operates;
- voltage detection on the line;
- measuring the currents, voltages, active and reactive power on the MV line;
- dealing with faults when required, or using a remote control from UP, and opening and closing the MV RMU (according to GSCM004);
- interfacing with generators in the MV network, in order to coordinate voltage regulation along the line, and the remote disconnection signals (by according to GETP011-A1);

The RGDM will be able to implement functionalities compliant to the requirements defined in IEC 62689; therefore, it is considered as a Distribution Substation Unit (DSU).

The device is connected to three integrated phase current/voltage sensors (CT-VT), according to GSCT005.

The device has an evolved communication interface, by means of which it is able to exchange information in accordance with the suite of protocols provided by the IEC 61850 standard. The communication profile is defined in GETP013 and is compliant with IEC61850 1st Edition. The product is intended to migrate with easiness to IEC61850 2nd Edition when GridSpertise will decide for this migration to apply.

In order to guarantee full compatibility in the secondary plants, the RGDM is always equipped with a double interface, able to dialogue with the previous generation RTUs.

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

5.2.1.Network conditions

The MV networks on which the RGDM units are installed, can be operated with:

- the isolated neutral,
- the neutral connected to earth via an impedance (Petersen coil with additional resistance),
- the neutral connected to earth via a resistance,
- the neutral directly grounded or with the neutral connected by grounding transformer using or not a resistance.

The network conditions for which it must be possible to use the RGDM device are specified in Table 2:

Table 2 – Network Conditions	
Operating voltage Vn (primary concatenated values)	6 ÷ 36 kV ±10% (MV) 230 ÷ 400 V ±10% (LV)
Rated operating frequency:	50 ÷ 60 Hz ± 5%
Maximum three-phase short-circuit current	16 kA
Maximum single-phase fault to earth current (with isolated neutral)	500 A
Maximum peak value of the one-way current component, superimposed on the single-phase fault to earth current (with compensated neutral):	√2 x 500 A
Maximum value of the decay time constant , for the one-way component:	150 ms
Residual voltage in the network in the absence of a fault	0 ÷ 10% Vn
Degree of dissymmetry of voltages	≤ 5%

5.2.2.Installation conditions

An example of the possible installation conditions for the RGDM device are illustrated in Figure 1, Figure 2 and Figure 3.

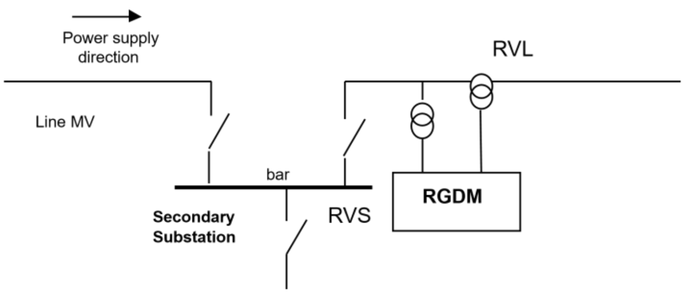

Figure 1 – RGDM installed on output busbar

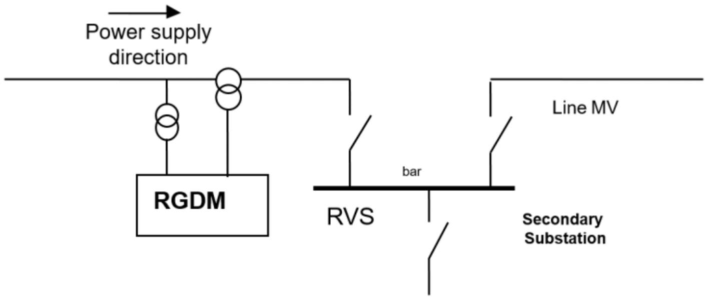

Figure 2 – RGDM installed on input busbar

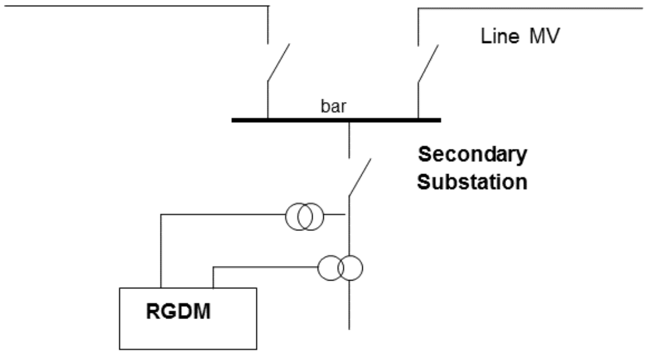

Figure 3 – RGDM installed on shunt line

In the figures, the voltage:

- In the secondary sub-station is indicated by **RVS**.
- On the line on which the RGDM is installed, it is indicated as **RVL**.

The RGDM device has to detect fault conditions downstream of its installation point, in relation to the direction of the power supply in the line. In order to satisfy this requirement, in all the cases listed in the previous figures, and for all power supply conditions for the MV line, a specific function is required, hereinafter referred to as inversion. An inversion of direction is controlled remotely, using a UP remote control peripheral unit, or by means of the IEC 61850 protocol.

An inversion of direction is received by the RGDM and results in:

- A change in the angular sector of the 67N.S1, 67N.S2 and 67N.S3 thresholds.
- A change in the angular sector of the 67.S1, 67.S2, 67.S3, and 67.S4 thresholds.
- Use of the RVS or RVL signal, as a signal on which automatic selection of the faulty section is based.

For all the cases indicated above, the direction of measurement must not be changed.

The inversion command can be received, either by means of the IEC 61850 protocol, or via digital input, as described in Figure 15.

The RGDM is also used in the MV ring networks, and in the EasySat Satellite Centers. The installation, configuration or communication modes must not change for those cases.

5.2.3. Condition for Interfacing with the RTU

There are two conditions for interfacing the RTU with the RGDM:

1. The RGDM communicates with the RTU using an optical cable connected to the LC port (multimode fiber optic). Via the RTU, the RGDM:
    - Sends signals and measurements;
    - Receives remote control signals from the remote control system.
    - Is able to activate the selectivity logic for the faulty section.

   In this condition, the RGDM manages the open and close commands autonomously, as it is connected to the OdM, via a cable attached to the MI terminal board.

2. The RGDM communicates with the RTU via a wired connection through the MB terminal board. and the RTU implements the commands to the OdM.

6. HW REQUIREMENTS

6.1 Enclosure and layout

The device's casing must be in steel or aluminum (the plate must be at least 1mm thick), in terms of electromagnetic compatibility and rigidity of the structure and must have a hinged front panel that does not require the use of screws to secure it. At any points at which outside wiring is in contact with the casing, they must be protected by suitable cable glands or some similar solution to avoid friction.

Except for the side affected by the MU, MI and MB the entire casing must ensure a protective level of IP30; any ventilation holes are to conform to the protection level required, and such that they prevent penetration of dripping water.

Suitable solutions must be adopted on the back of the casing to reduce the mechanical vibrations transmitted by the frame on which the RGDM is to be mounted. These solutions must be assessed and approved by GridSpertise.

The container, which must have maximum dimensions of 300 x 200mm, must be made for surface mounting, to be fixed vertically using 4 x M5 screws, positioned as shown in the fixing template shown in Figure 4, and fitted with a cover that is easy to remove.

Fixing must be done with supports in PVC or some other material between the container and the compartment of the OdM, with characteristics that provide sufficient damping of the vibrations produced by the OdM, and adequate electrical isolation for the RGDM's electronics, from the rest of the compartment. The cover must also have an M8 or higher, by according to EN 14399, grounding bolt positioned on the right of the equipment at the bottom.

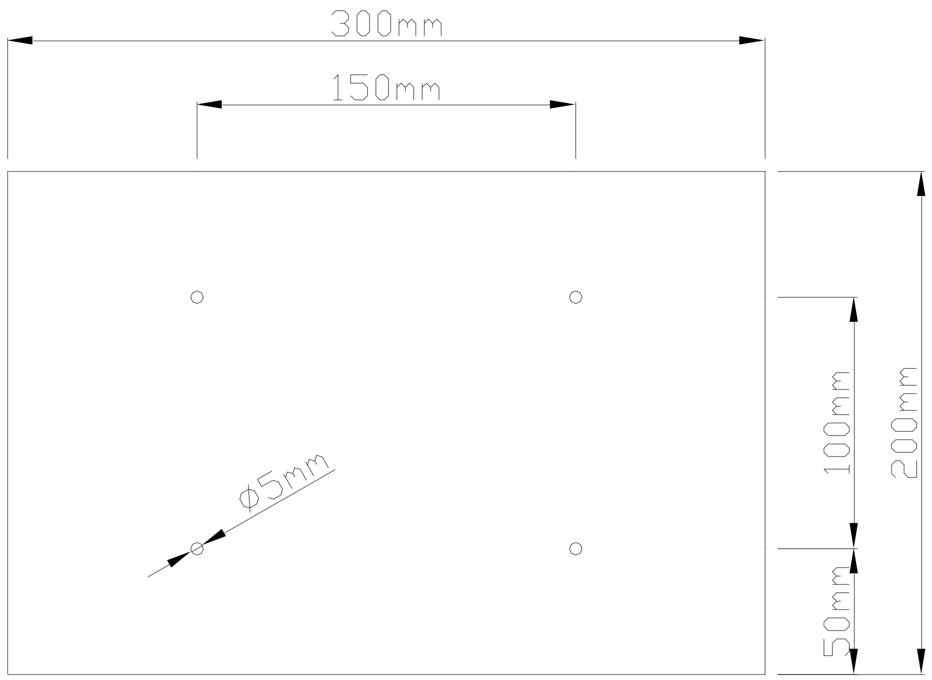

Figure 4 – Drilling template and fixing diagram of the RGDM

The RGDM's layout must be, as far as possible, as shown in Figure 5.

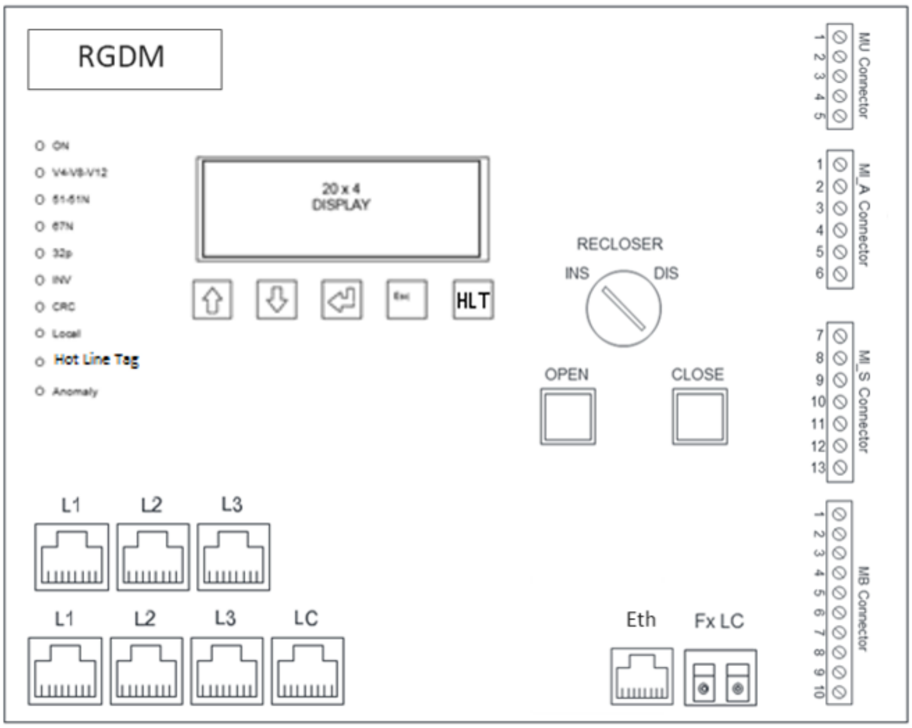

Figure 5 – External layout of the RGDM

The front door of the RGDM must have the following components installed on it:

- 2 buttons to open and close the OdM, with the following color coding:
  - Closing button: white pushbutton with **"I"** on it in black.
  - Opening button: black pushbutton with **"O"** on it in white. Different color will be declared during the procurement process (par. 10.2). Before sending the command to the OdM, it must requested a confirmation on the display by pushing the button.
- 1 button for HLT function par. 8.1.18.
- 1 switch, with two positions, for activating / deactivating rapid re-closing of the switch.
- 1 alphanumerical display, multi-line 20x4, with 4 navigation buttons, for browsing the RGDM's menus.
- RGDM terminal boards according to par. 6.5.3.
- 10 programmable LEDs according to par. 6.1.1.
- 6 RJ45 ports for CT-VT sensors according to par. 6.5.2.2.
- 1 RJ45 port for Synchronism Function and RGDAT sensor according to par. 6.5.2.3.
- Ethernet local port (local configuration).
- LC optic port (IEC 61850 communication).

6.1.1.LEDs

The device must have n° 10 programmable LEDs multicolor, on the front that meet the following requirements by default:

- ON (green)
- V4-V8-V12 (green)
- 51-51N (red)
- 67N (red)
- 32p (red)
- INV (green)
- CRC (yellow)
- Local (green)
- Hot Line Tag (red)
- Anomaly (red)

At any led can be assignable any signal or event that the RGDM manage with a binary output. Also the color of the programmable leds must be settable via software.

In front of the display on the programmable LEDs must be positioned a little label pocket.

6.1.2. Display

The display must show the following events:

- Fault events
- Inversion activated
- Voltage presence for the individual phases
- RGDM anomaly
- Measurements
- Display of configuration parameters
- Clock with calendar.
- NTP status.

According to the specifications below:

- A fault event must be indicated by displaying the relevant ANSI code, along with the date and time of the event.
- If the inversion command is active, the display must read INVERS_ACTIVE.
- If there is an internal anomaly, the red LED must switch on, and the display must read ANOMALY_RGDM.
- Under normal operating conditions, on the main screen of the display must be displayed: V, I, IP address RJ45, clock with date; by scrolling with the navigation arrows, other screens described below should be available.
- Second display screen, with: P and Q, Fiber IP address, NTP server status;
- Third display screen, with: switch status (BLIND and SyncroCheck), ARF, phase sense anomaly, UD presence;
- Fourth screen, if the UPG function (ref. GETP011-A1) is enabled, with: V_{MT}, P_{MT} and Q_{MT} measurements;
- Fifth screen, if UPG function is enabled:
  - Generator running (out of order);
  - Activation status of the UPG algorithm (associated with the status of the UPGon variable);
  - UPG active locally conditions (associated with the status of the UPGact variable);
  - VFLS or VFLI condition present.
- Sixth screen, if the UPG function is enabled (variables communicated to possible IDC_PROT):
  - 81P Threshold Settings;
  - PI open / closed status;
  - PG open / closed status.
- Seventh screen (fourth if UPG is not enabled), with: all active trip thresholds.

In addition, the four touch buttons below the display must be able to display the following parameters set in the RGDM:

- Date & Time [dd/mm/yyyy hh:mm:ss]
- Activation thresholds and times [e.g. 51.S3 hh:mm:ss:mmm]
- Actions stored in the circular memory
- IP addresses stored [e.g. 192.168.1.52]
- Network port MAC Address [e.g. MAC 00-17-42-37-52-CF]
- Fw for the CPU & date [vers. FW. 01.00 dd/mm/yyyy]
- CT-VT triad serial numbers
- RGDM serial n°

When in stand-by mode, the display's back lighting must be off, and it must switch on when any of the four buttons is pushed, or if a fault appear. In both cases, the display must stay on for a period of 3 minutes.

6.2 EMC

The RGDM must comply with the EMC requirements defined in IEC 60255-26, with the following additions:

a. Emission, CISPR32 must be adopted instead of CISPR22 cited in IEC 60255-26;
b. Immunity**,** requirements by Table 3 must be adopted in addition to the one cited in IEC 60255-26.

Table 3 – Immunity tests

N°	Description	Standard	Class	Level	Ports being tested				
					Casing	Vaux	Local	Range	Earth
1	Ring waves (100kHz)	IEC 61000-4-12	3	2kV CM (1)				X	
2	EM fields at radio frequency (80 - 3000MHz)	IEC 61000-4-3 IEC 61000-4-3/S1	3	10V/m (2)	X				
3	EM fields due to digital radio telephones (900 - 1890MHz)	IEC 61000-4-3 IEC 61000-4-3/S1	3	10V/m	X				
4	Interruptions and fluctuations in auxiliary power supply (3)	IEC 61000-4-29 IEC 61000-4-11		0% 50ms, 50% 100ms		X			
5	Magnetic fields from damped oscillators	IEC 61000-4-10	4	30A/m	X				

6	High energy surges 1.2/50us (SURGE)	IEC 61000-4-5 IEC 61000-4-5/A1	3	2kV phase-ground 1kV phase-phase		X (4)			
7	Conductor EM disturbance in common mode (15Hz - 150kHz)	IEC 61000-4-16 IEC 61000-4-16/A1	3	10-1-1-10V 50Hz 100V (60s) 50Hz 300V (1s)		X	X	X	

(1): This test is only applicable in common mode towards PE.

(2): Since a return interval of 1 sec is set for the EUT measurements, the persistence of each RF disturbance step must be at least 2 sec. If, due to the stimulator's switching transistors, a phenomenon of transient turbulence occurs in the EUT measurements, identify the critical frequencies and apply them persistently, in order to check their effect.

(3): Besides the tests are required by the norm, check correct functioning by applying a power supply at the extremes of the operating range, that is: 15V DC for at least 15 minutes and 35V DC for at least 15 minutes.

(4): The test done is applied directly to the power supply terminals, with a maximum of 0.5 m of wiring from the EUT.

6.3 Electrical safety

The insulation properties must be compliant with the standards on electrical safety referred in Table 4.

Table 4 – Standards for Electrical Safety	
IEC 60255-27	Measuring relays and protection equipment - Part 27: Product safety requirements
IEC 61243-5	Live working - Voltage detectors Part 5: Voltage detection systems (VDS)
IEC 60204-1	Safety of machinery - Electrical equipment of machines Part 1: General requirements
IEC 60529	Degrees of protection provided by enclosures (IP Code)

6.4 Environmental requirements

The Table 5 lists the environmental conditions the device specified in this document must comply to:

Table 5 – Climatic Conditions		
Description	**Rated Values**	**Tolerance**
Operating temperature	20°±3°C	from -25 to 85[°C]
Relative humidity		0% ÷ 95% RH, non condensing
Atmospheric pressure		67 ÷ 106 [kPa]

Altitude level		0 ÷ 3000 [m]

6.5 Electrical, electronic and measurement characteristics

The RGDM is the electronic processing unit for current and voltage signals coming from CT-VT which are not part of the supply. These sensors are connected to the RGDM by means of three suitable screened cables, with RJ45 terminations (CAT6 industrial).

The RJ45 terminals on the RGDM must be positioned low down, screened, related to earth, and positioned on the device so that the release tab is facing frontwards.

The RGDM has also different terminal boards, called MI,MU,MB (according to par. 6.5.3).

The RGDM's mother board houses the CPU, and the RAM and ROM memories. It also houses all the active and passive electronic components that the equipment requires to function. The Ethernet communication connector, the events display, and a series of buttons for browsing the equipment's menus.

In Figure 6 is shown a connection diagram of the RGDM.

CONNECTION DIAGRAM

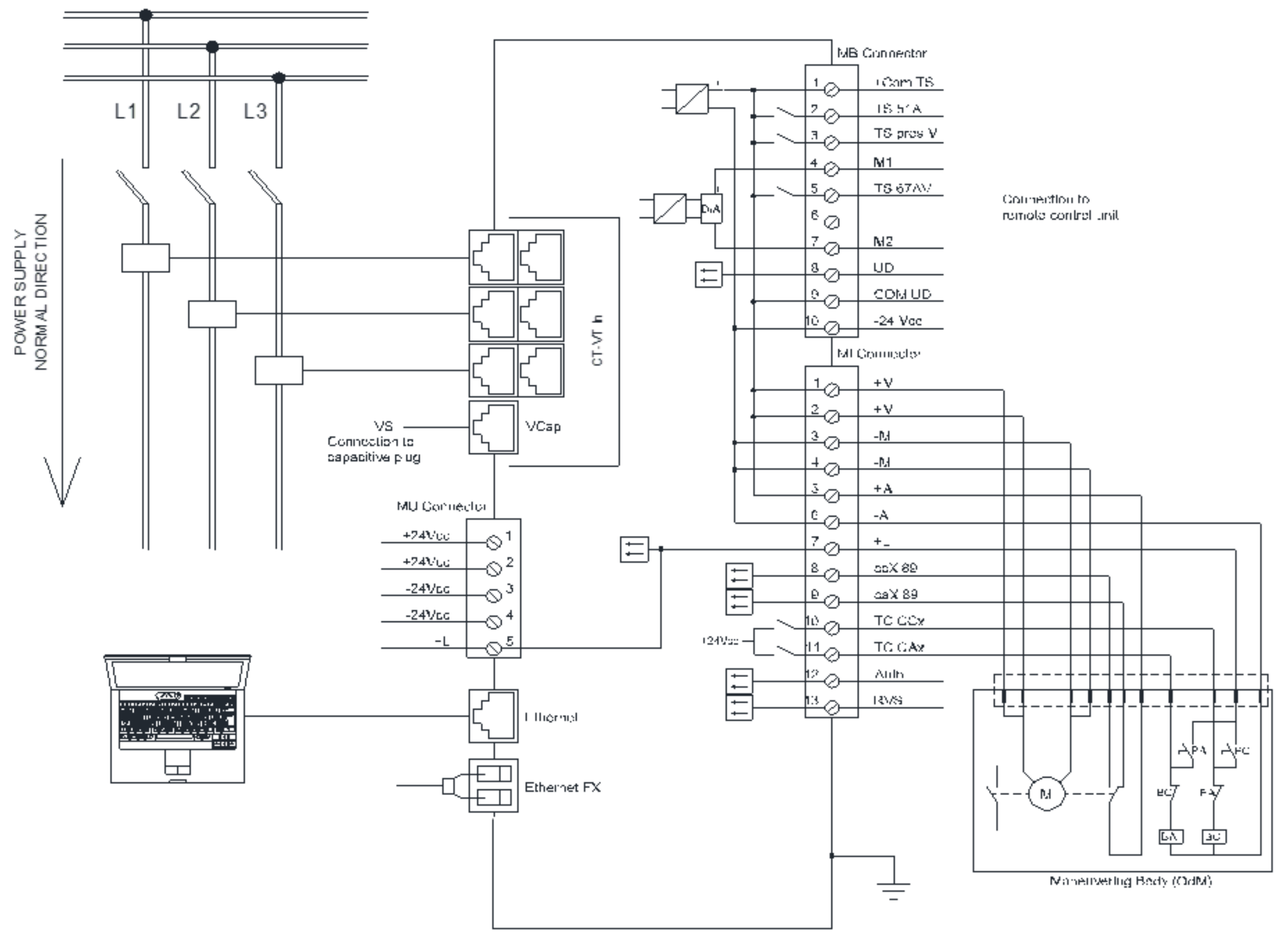

Figure 6 – Connection Diagram of the RGDM

6.5.1.Power supply

The nominal power supply voltage is 24 Vcc, and the power supply circuit must be isolated from the earth. Correct functioning must be guaranteed within a minimum range of 15 V ÷ 35 V, with nominal temperatures and in presence of alternating voltage component ≤ 10%.

The power supply circuit must be protected against inversion of polarity.

When there are no faults (to earth or for short circuits) and in the presence or absence of voltage, the RGDM, including the CT-VT, must have a consumption ≤ 15 W.

For power supply voltage values lower than the minimum operating range, the RGDM device must not emit any local or remote signal.

6.5.2.Analog Inputs

In this paragraph all the requirements for the RGDM analog inputs and the connection with the sensors are described.

6.5.2.1. Combinations between RGDM and sensors

Depending on the type of connection between the RGDM device and the sensors installed in the field, there are two modes of operation (it must be possible to select via SW, which mode of operation to use):

- RGDM mode;
- RGDAT mode;

In RGDM mode, the device can interface with:

1. integrated CT-VT sensors compliant to GSCT005 technical specification. In this case the connection with the sensors is done by the first 3 RJ45 inputs (L1,L2,L3) according to the Figure 7. The pin-out of the RJ45 connectors is indicated in Table 6.
   The seventh RJ45 input (LC) is used to measure the synchronism voltage according to par. 6.5.2.3. The pin-out of the RJ45 connector is indicated in Table 17.

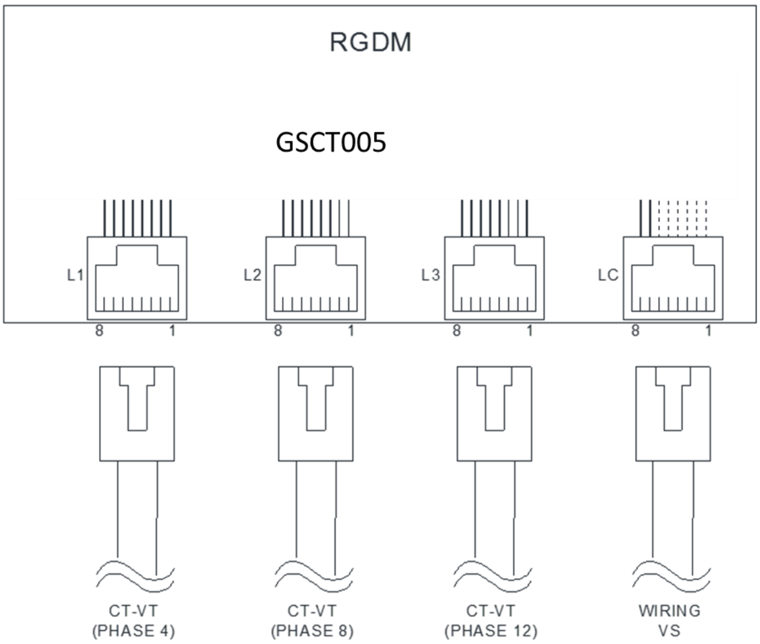

Figure 7 – GSCT005 sensor configuration

2. integrated CT-VT sensors compliant to DJ5400 technical specification. In this case the connection with the sensors is done by the others 3 RJ45 inputs according to the Figure 8. The pin-out of the RJ45 connectors is indicated in Table 7.
   The seventh RJ45 input (LC) is used to measure the synchronism voltage according to par. 6.5.2.3.The pin-out of the RJ45 connector is indicated in Table 17.

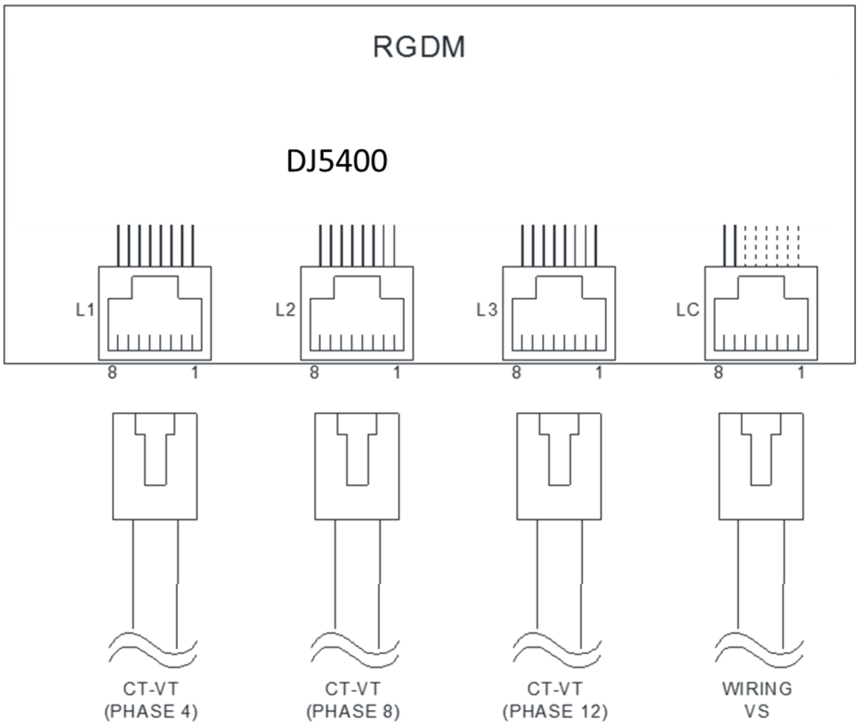

Figure 8 - DJ5400 sensors configuration

In RGDAT mode, the device can interface with:

3. Rogowski coils and capacitive plugs compliant with the RGDAT. In this case the connection with the current sensors must be possible both with the first three RJ45 connectors (GSCT005) and the second three RJ45 connectors (DJ5400).
   The seventh RJ45 input (LC) is used to measure line voltages coming from capacitive plugs according to par. 6.5.2.3. The pin-out of the RJ45 connector is indicated in Table 17.

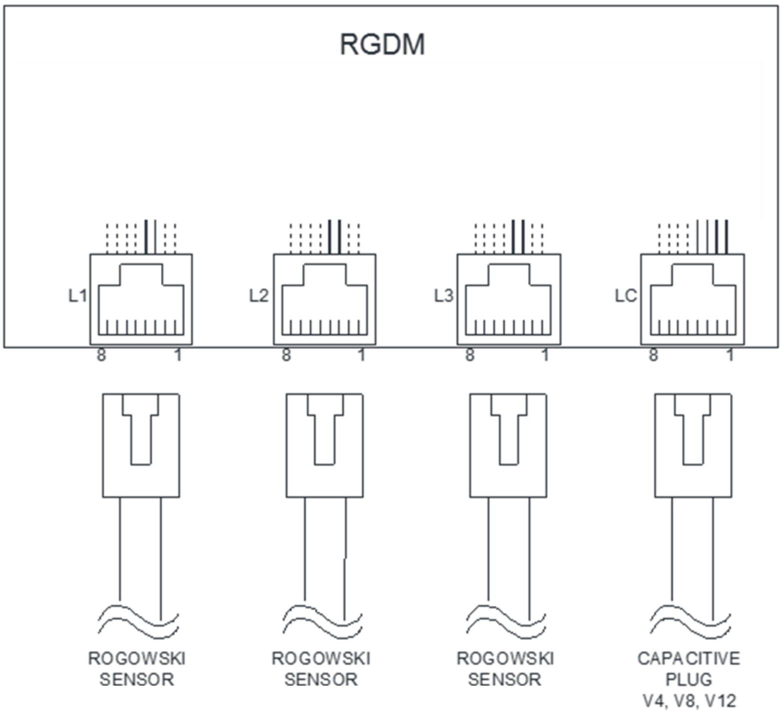

Figure 9 – RGDAT sensor configuration

6.5.2.2. Measurement Inputs for CT-VT sensors

The analog inputs are connected by specific conductors to the CT-VT sensors and then to the ground collector of the distributed system. Therefore, they must be protected from transient overvoltage during the fault.

Overvoltage protection shall comply to the following requirements:

- The analog inputs shall withstand overvoltages caused by network transients
- The suppressors shall have voltage characteristics such as to protect the analogue inputs
- Peak current shall be 34 A with a pulse width of 8 µs on the rising edge and 20 µs on the falling edge.
- In general, the suppressors shall match with the impedances cited in GSCT005.
- The provider must identify the best positioning for the overvoltage protection considering the entire analog input stage.

The connection of the sensors to the RGDM must be in the form of 6 female RJ45 connectors, which will be used to send the CT-VT signals and the direct current auxiliary power supply for the active sensors.

The auxiliary power supplies of the active sensors must be isolated from primary power supply, from electrical ground and ground (ref to IEC 61869-7 and IEC 61869-8).

On the internal board of the RGDM the measurement points must be accessible, to make any measurements. The measurement inputs must be connected to differential instrumentation amplifiers (IA). The schematic principle is described in Figure 10; it is detached from the ADC power supply ground and from the ground. The ADC resolution must be at least 16 bit. Furthermore, the common mode rejection (CMR) of the differential instrumentation amplifier must be at least 100 dB.

For current input, the schematic principle is reported in Figure 11 (it is important to note that the figure represents a schematic principle: the manufacturer can modify it and discuss the architecture with GridSpertise, that must approve it in any case. Moreover the schematic doesn't contain several components, like overvoltage suppressors or any other necessary component). Resistors R1 has double effect: 1) loading common-mode signals, trying to attenuate them, and 2) create a stable input impedance. The dip switch DS1 is normally open and it can be used to connect the input electronic ground to the earth (normally the electronic ground must be insulated from the ground.

For voltage input, the schematic principle is reported in Figure 12 (it is important to note that the figure represents a schematic principle: the manufacturer can modify it and discuss the architecture with GridSpertise that must approve it in any case. Moreover the schematic doesn't contain several components, like overvoltage suppressors or any other necessary component). Resistors R2 creates a stable input impedance. The dip switch DS2 is normally open and it is used to connect the input electronic ground to the earth (normally the electronic ground must be insulated from the ground).

Any alternative solution to those implemented in the specifications, must be discussed beforehand and approved by GridSpertise.

The RGDM must have the possibility to be connected to sensors compliant with:

- the GSCT005 specification; the pinout is compliant to IEC 61869-10 and IEC 61869-11;
- the DJ5400 specification;

The PIN specification of the RJ45 connectors is reported in **Table 6** and **Table 7**.

Table 6 – GSCT005 Sensor Pin Table								
RJ45 PIN	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Current Sensor	**S1 (IL+)**	**S2 (IL-)**						
Voltage Sensor							**a (UL+)**	**n (UL-)**
Transducer Electronic Data Sheet (TEDS)			**+**			**-**		
Power Supply				**+**	**-**			

Table 7 – DJ5400 Sensor Pin Table								
RJ45 PIN	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Current Sensor			**S2 (IL-)**	**S1 (IL+)**				
Voltage Sensor					**n (UL-)**	**a (UL+)**		
Power Supply	**0 V Power Supply Reference**	**0 V Power Supply Reference**					**+**	**-**

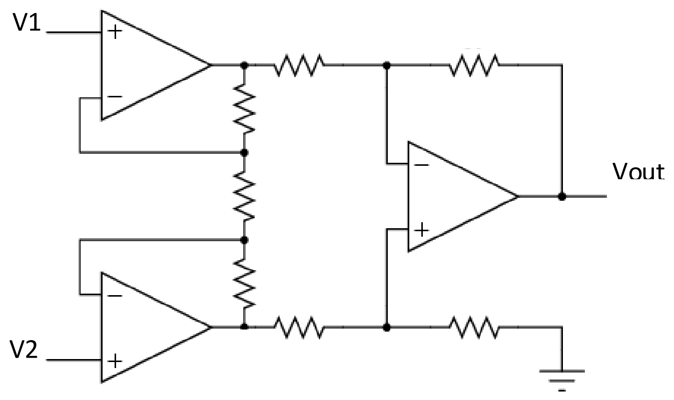

Figure 10 – Schematic principle for the instrumentation amplifier (IA)

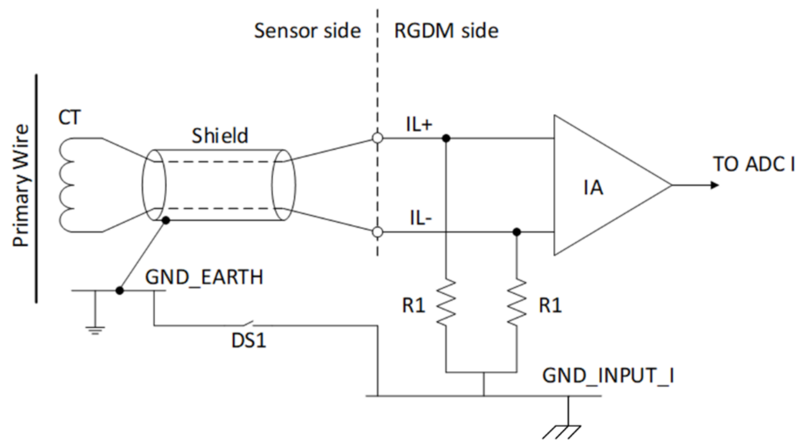

Figure 11 – Schematic principle for the current input

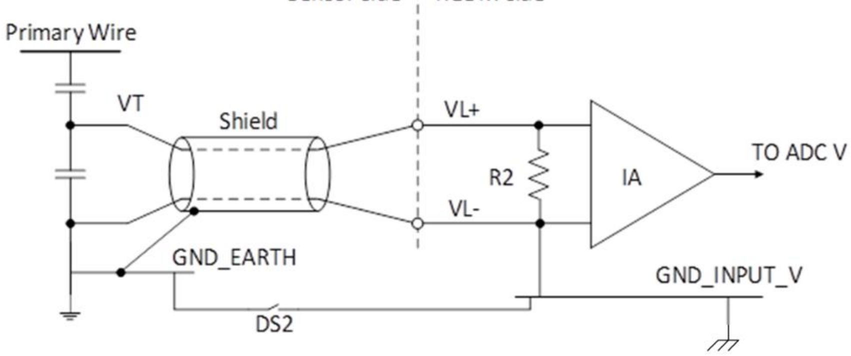

Figure 12 – Schematic principle for the voltage input

Following tables summarize pass-band, anti-aliasing filter main characteristics, sampling characteristics, including COMTRADE files sampling.

Table 8 – Pass-band (for all of the analog inputs) and anti-aliasing filter		
PASS-BAND	Flat in the interval from 0,5 Hz to 6 kHz	Mandatory
MANDATORY NOTES: 1. the pass-band must be flat and linear in the interval from 0,5 Hz to 6 kHz. This requirement must be verified with connected sensors (GSCT005 and DJ5400), in particular for current sensors, feeding the test quantity on the primary sides. Test sensors must be compliant with the GSCT005. Manufacturer will choose the internal architecture that ensure this requirement. This architecture must be shared with GridSpertise and validated by GridSpertise. 2. In the interval from 0,5 Hz to 6 kHz, no saturations of the acquiring stadium are allowed, for any type of power network transient. 3. Manufacturer will give to GridSpertise the frequency response of the device, in order to prove the requirement compliancy. Frequency response can be generated applying a frequency sweep on the primary side, at constant current amplitude. 4. Manufacturer will choose a sampling architecture that must ensure a correct sampling synchronization with the signal to be sampled. This architecture must be shared with GridSpertise and validated by GridSpertise. 5. Manufacturer will choose a sampling architecture that must ensure a correct sampling frequency, oriented to ensure the required pass-band and avoid sampling aliasing, filters aliasing, filter incorrect behavior (e.g. in case of fast power network transients), “sample loosing” phenomena, etc. This architecture must be shared with GridSpertise and validated by GridSpertise. 6. COMTRADE files must contain all of the samples, to avoid loss of information. “Under-sampling” of COMTRADE files is allowed, but also under an enable/disable option. COMTRADE files must contain also ADC current channels before integration, even if analogue integrator is implemented. 7. Every numerical filter inside the device must be elaborated with a time-step equal to the sampling period (sampling time-step) and all of the filters must be synchronized each other. 8. The entire acquisition cycle, filtering and numerical calculation (including the DFT elaboration) of all the analog inputs (3 currents, 4 voltages) and software built inputs (residual current, residual voltage) must be synchronous to the sampling period (sampling time-step) and then to numerical filters. 9. Aliasing any numerical filter is not allowed. Then the sampling frequency must be choose also in according to this requirement.		
ANTI-ALIASING FILTER		
ARCHITECTURE	Hardware filter	
ORDER	≥ Fourth	Mandatory
TYPE	Butterworth	Mandatory

Table 9 reports an example of internal architecture, in terms of filters, to elaborate current derivative sensors signal. The transfer function parameters indicated in the table must be configurable.

Table 9 – Example of Current Signal Integration Filters (For Derivative Current Signal)	
HIGH-PASS FILTER	
TYPE	Numeric filter
ORDER	First
CUT-OFF FREQUENCY	0,5 Hz
LOW-PASS FILTER	
TYPE	Numeric filter
ORDER	First
CUT-OFF FREQUENCY	5 Hz
MANDATORY NOTES Using an integrator cut-out frequency equal to 5 Hz, it is necessary to integrate frequencies in the band 0, 5 Hz to 5 Hz to "rebuild" the signal in this band. The RGDM must also sample the derivative current signal before integration; in order to detect high impedance fault and for predictive logic. The manufacturer will propose a technical solution to satisfy these requirements.	

6.5.2.2.1. Analog Input for the voltage sensors

The analogue voltmetric inputs are used to measure the secondary signal coming from the CT-VT sensors, in order to convert it into a digital signal, suitable for the protection and measurement functions. The secondary signal from the CT-VT sensors is a signal that is directly proportional to the primary voltage, in terms of a constant multiplier coefficient, equal to the ratio between Primary and Secondary.

The RGDM's analog inputs must have a secondary signal measurement range of 0 Vrms to 3,96 Vrms to which the following primary values correspond: 0 kV and $\frac{68{,}6\ \text{kV}}{\sqrt{3}}$, which corresponds to a ratio between the primary and secondary value of $\frac{10000\ \text{V}}{1\ \text{V}}$.

The precision of each individual input must be less than 0,2% for the amplitude and 0,5° for the phase; the standard deviation between the three voltmetric inputs must be less than 0,02.

The nominal value for the primary voltage must be able to be configured within a range of:

- Minimum calibration value = $\frac{6}{\sqrt{3}}$ kV -10%
- Maximum calibration value = $\frac{36}{\sqrt{3}}$ kV +10%
- Calibration steps 0,5 kV

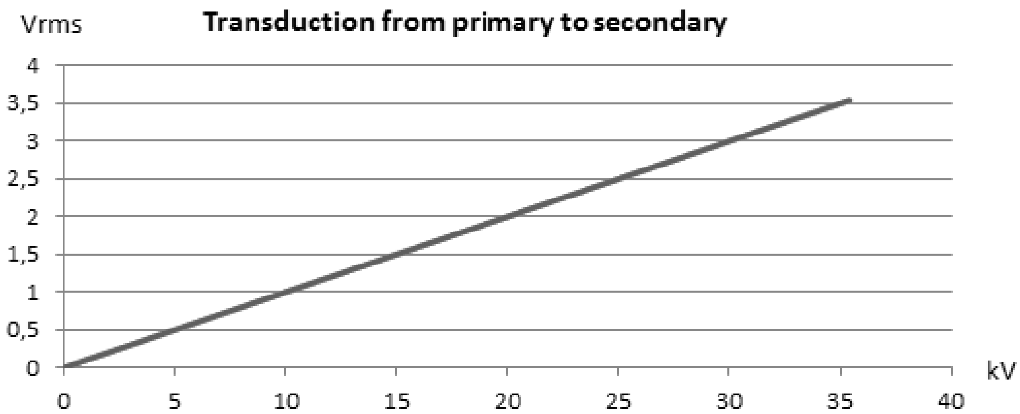

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Figure 13 – Linear voltmetric inputs

In addition, the RGDM must be able to handle a further transformation ratio of $\frac{230\ V}{1\ V}$, configurable by software, for the low voltage measurements.

The electrical characteristics for the voltage analog inputs are reported in Table 10. The analog voltage input type, is reported in Table 11.

The resistance that analogue input must offer to the sensor must be 2 MΩ ±5%, without introducing eddy reactors. The input capacity value must be less than 50 pF.

Table 10 – Characteristics of the voltmetric circuits	
	Reference
Peak-peak value	+15V
Voltage Sensor Ratio	10000 V / 1 V
Input resistance	2 MΩ ± 5%
Input capacity	< 50pF
Maximum admissible measurement error ε	< 0,2%
Admissible standard deviation between the Voltmetric inputs	< 0,02
Maximum admissible angle error	< 0,5°

Table 11 – Voltage Measurement Inputs		
TYPE	Pure differential balanced input, based on instrumentation amplifier with negative input connected to the ground (see Figure 12)	Mandatory

The precision and standard deviation requirements are there to satisfy the dual need for:

- Guaranteeing adequate precision for the measuring and protection functions.
- Calculating the values of 3Vo as the sum of the individual measurements for the three phase voltages measured, without introducing 3Vo values that are not real.

6.5.2.2.2. Analog Input for the current sensors

The analogue amperometric inputs are used to measure the secondary signal coming from the CT-VT sensors, in order to convert it into a digital signal, suitable for the protection and measurement functions.

The electrical characteristics for current analog inputs are reported in Table 12. The current sensor ratio compliant to GSCT005 and DJ5400 are reported in Table 13 and Table 14.

The analog current input type is reported in Table 15.

The resistance value, that must offer analogical input to the sensor, must be 20 kΩ ± 5%, without introducing eddy reactors. In particular, the eddy capacity value must be less than 500 pF.

Table 12 – Characteristics of the amperometric circuits	
	Reference
Peak-peak value	+15 V
Input resistance	20 kΩ ± 5%
Input capacity	< 500pF
Maximum measurement error from 550 to 8800 A	< 3,0%
Maximum measurement error from 50 to 550 A	< 0,2%
Maximum measurement error from 1 to 50 A	< 0,5%
Maximum admissible angle error	< 0,5°

Table 13 – GSCT005 sensor electrical characteristics	
Current Sensor Ratio	1000 A / 300 mV

Table 14 – DJ5400 sensor electrical characteristics	
Current Sensor Ratio	1000 A / 31 mV

Table 15 – Current Measurement Inputs		
TYPE	Pure differential balanced input, based on instrumentation amplifier with common-mode signal suppression	Mandatory

The precision and standard deviation requirements are there to satisfy the dual need for:

- Guaranteeing adequate precision for the measuring and protection functions.
- Calculating the values of 3Io as the sum of the individual measurements for the three phase currents measured, without introducing 3Io values that are not real.

The secondary signal coming from the CT-VT sensors is a signal that can be proportional:

- directly, to the current value transduced by the sensor, with three different scales;
- Directly to the current derivative, in relation to the time $L\frac{di}{dt}$, with three different scales.

It must be possible to select the input modes, using configuration software.

Depending on the measurement mode chosen, the RGDM will have the following ranges of variation of the primary current and relative secondary input voltage:

- (case 1, linear) the current measuring range must be between 0 and 8800 A, with a primary secondary ratio of $\frac{1000A}{31mV}$ which corresponds to a maximum RMS voltage of 272,8 mV;
- (case 2, linear) the current measuring range must be between 0 and 8800 A, with a primary secondary ratio of $\frac{1000A}{100mV}$ which corresponds to a maximum RMS voltage of 880 mV;
- (case 3, linear) the current measuring range must be between 0 and 8800 A, with a primary secondary ratio of $\frac{1000A}{300mV}$ which corresponds to a maximum RMS voltage of 3,96 Vrms;
- (case 1, derivative) the current measuring range must be between 0 and 8800A, with a primary secondary ratio of $\frac{1000A}{31mV}$ which corresponds to a maximum RMS voltage of 272,8 mV;
- (case 2, derivative) the current measuring range must be between 0 and 8800A, with a primary secondary ratio of $\frac{1000A}{100mV}$ which corresponds to a maximum RMS voltage of 880mV;
- (case 3, derivative) the current measuring range must be between 0 and 8800 A, with a primary secondary ratio of $\frac{1000A}{300mV}$ which corresponds to a maximum RMS voltage of 3,96 Vrms;

For the RGDM, the nominal primary current value to be used as a reference for measurements in p.u. must be 500 A. It must be possible to set the nominal current values between 0 and 500 A in 1 A steps.

The precision of each individual input must be less than 0,2%, and the standard deviation between the three amperometric inputs must be such that on the 3Io it guarantees a resultant ≤ 0,3 A, with a positive current sequence of 300 A.

Due to the nature of the transducers with derivation, the signals acquired will be proportional to the frequency, and must therefore be integrated analogically or numerically. The measurements and graphic reconstructions must guarantee a higher response linearity in relation to the scale range, up to the 3rd harmonic (8800 A at 150 Hz).

6.5.2.2.3. Calibration of Analog Inputs

The RGDM must be able to use software to calibrate each individual input, both amperometric and voltmetric, with a complex coefficient represented in modulus and phase.

The calibration coefficients are indicated in the GSCT005.

Table 16 shows the regulation fields for the software. The calibration coefficients must not be taken as increasing or decreasing the measurement dynamic, but as compensation for the errors of the CT-VT sensors themselves.

Table 16 – Calibration coefficients		
	Range	Step
Gain calibration coefficient	0,95 ÷ 1,05	0,0005
Phase coefficient	-0,5° ÷ 0,5°	0,025

6.5.2.2.4. Sensors Polarity

The device software must provide the possibility of configuring the polarity of both current and voltage sensors.

6.5.2.3. Measurement Input for Synchronism Function and RGDAT sensor

The RGDM device must have an additional voltmetric measuring input with RJ45 connector.

It must be possible to select via SW, two different uses cases based on the configuration of the RGDM:

- this input is used for the measurement of the reference busbar voltage for the automatic parallel function par. 8.1.13. The input must automatically calibrate when the switch position is close and set its voltage equal to that of the corresponding phase.
- This input is used to measure line voltages (V4,V8,V12) from voltmetric sensors used for RGDAT device. It must be used the same calibration method implemented in the RGDAT.

Table 17 – Synchronism Function/RGDAT Sensor Pin Table								
RJ45 PIN	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Busbar/Line Voltage phase 4	V_{4+}	V_{4-}						
Busbar/Line Voltage phase 8			V_{8+}	V_{8-}				
Busbar/Line Voltage phase 12					V_{12+}	V_{12-}		

Any alternative solution to that implemented in the specification must be previously discussed and approved by GridSpertise.

6.5.3. Terminal boards

The RGDM must have four terminal boards, as shown in the main diagram illustrated in Figure 5

The MB terminal board, relates to the RGDM's connection to the current RTU.

The MU terminal board is used for the power supply of the RGDM.

The MI connectors are divided into MI_A (1…..6) and MI_S (7…..13).The MI terminal board is used to the interface the RGDM with the MV RMU (according to GSCM004). The first 6 terminals relate to the RGDM's power supply and the switch spring loading motors power supply. Terminal n° 7, marked +L, is always located to the remote control signal, and if already wired to MU, this can remain free. The remaining terminals are to be connected to acquire the switch's status and to send the OdM's open and close commands.The two relays used to command the OdM must also be fitted on the RGDM's board.

All the terminal boards must be of an extractable type, with a 5.08mm pitch, and it must be possible to extract them from the equipment without disconnecting the wiring (without fixing flanges).

6.5.3.1. MB Terminal Board

A terminal board must be set up inside the RGDM (Figure 14), named MB, suitable for housing conductors with a section up to 2.5 mm2, to which the connection cable must be connected for the remote control peripheral unit (UP).

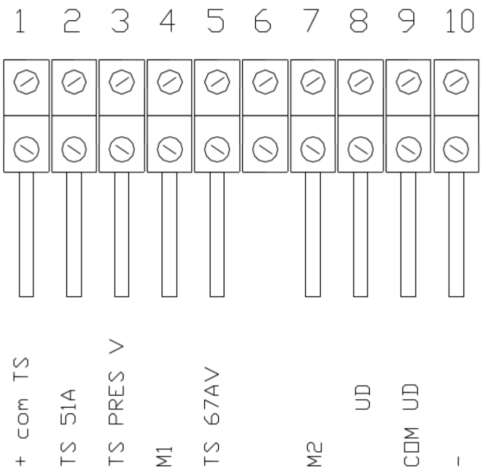

Figure 14 – Signals Output Terminal Board (MB)

The electrical characteristics of the MB terminal board are shown in Table 18.

Table 18 – MB terminal board		
1	+ com TS	Power supply (+24Vcc) and Common remote signals
2	TS 51	Multi-phase or double single-phase fault
3	TS PRES V	MV voltage on (level)
4	M1	Remote measurement - pole 1 (positive)
5	TS 67	Single-phase and intermittent arc (downstream) fault
6		
7	M2	Remote measurement - pole 2 (negative)
8	UD	Inversion of direction command 67 AV (common)
9	COM ID	Inversion of direction command 67 AV
10	-	Power supply (-24Vcc)

4-20mA Transducers:

All the measurements done by the RGDM can be sent by a 4÷20 mA transducer (M1, M2). There is only one transducer and so one of the n measurements can be sent. All the measurements must be able to modulate the measurement scale range to 20 mA , with these characteristics:

- Output level (terminals 4 and 7 in Figure 14): 4 ÷ 20 mA
- Precision not taking the measurement sensors into account: ±1%

- Maximum load impedance on the measurement converter: 720 Ω
- Remote measurement update time: 100 msec

Both output poles to the UP must be not connected to ground. The power supply of the converter must be isolated from the internal supply and 24 Vdc power supply.

The MB terminal board has 1 Digital Input used for the Inversion command (UD):

The command for inversion of direction, UD, must be formed as indicated in Figure 15.

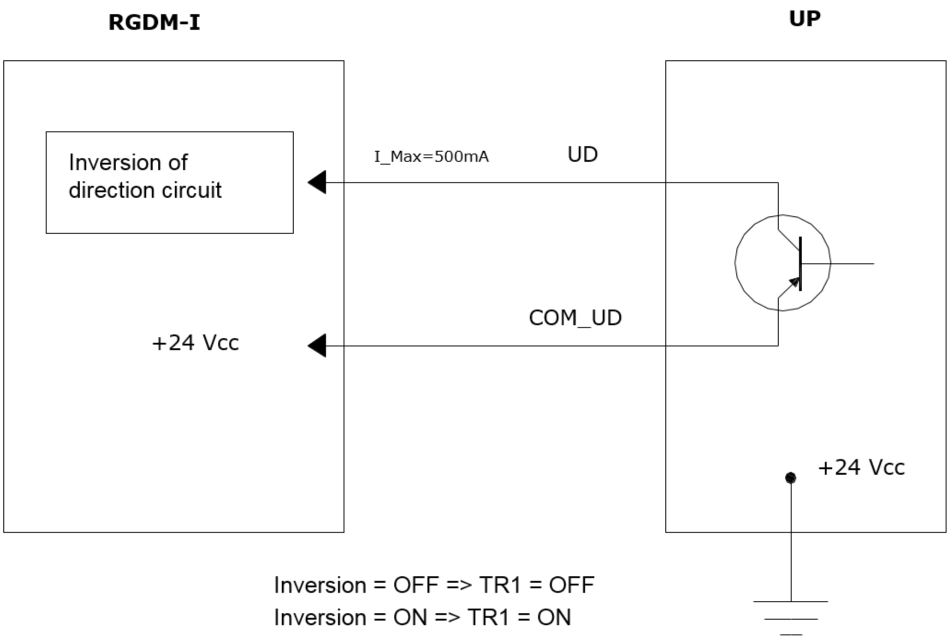

Figure 15 – Diagram for inversion of direction command for detecting single-phase faults to earth

The MB terminal board has 3 Signaling relays (TS51, TS PRES V, TS67).

Connection to the RTU

For the electrical connection between the indoor RGDM and the remote control unit (device power supply and signal transfer) a cable must be provided (Figure 16) that is 9 m long, in the form of 9 x 1mm2. The connection cable for the outdoor RGDM is shown in Figure 17.

One end of the cable must be fitted with the rectangular connector shown in Figure 16. The other end must be set up for connecting the MB terminal board in the RGDM. Each cable conductor must be equipped with tip ends, as well as indelible identifying markings, according to the numbering of the MB connector.

Type of installation	Cable length	Termination
Indoor RGDM for MV/LV substation	9 m	Figure 19
Outdoor RGDM	1,10 m	Figure 20

The connector must be made of isolating material with adequate electrical, mechanical, and climatic characteristics. It must also be complete with a cable clamp.

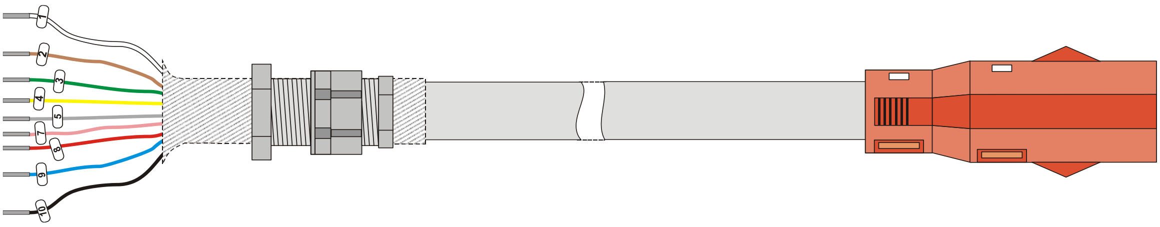

Figure 16 – Connection cable for Indoor RGDM

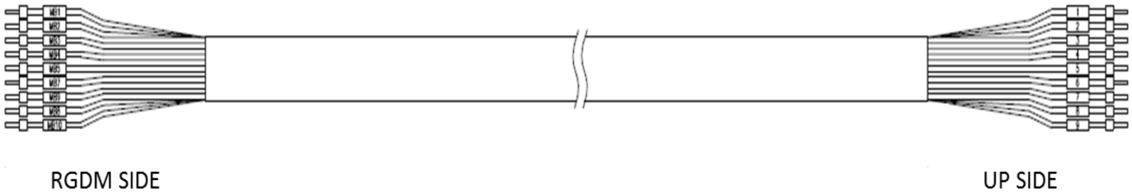

Figure 17 – Connection cable for Outdoor RGDM

The male contacts (the female contacts are part of the fixed part installed on the UP - not included in the supply), must be able to accept conductors with a section of up to 2 mm2, and guarantee the following characteristics:

- Nominal operating voltage 24 V
- Nominal current 13 A
- Voltage drop over a male-female pair crossed by a 5A current ≤50 mV
- Insertion/extraction force 0,40 ÷10 N/contact

The cable's characteristics must be as follows:

- Nominal voltage: 300/500 V

- Formation: 9 x 1 mm2
- Flexible annealed, not tinned, copper conductors
- R2 quality PVC insulation
- Outside diameter (of the insulation) of the cores: ≤3 mm
- Rz quality PVC sheath
- Flameproof characteristics in accordance with IEC 60695-1-10
- Cores distinguished by colors, according to CENELEC HD 186 S2

Cores of the same color can also be accepted, provided the reference numbers for the MB terminal board are stamped on the core itself.

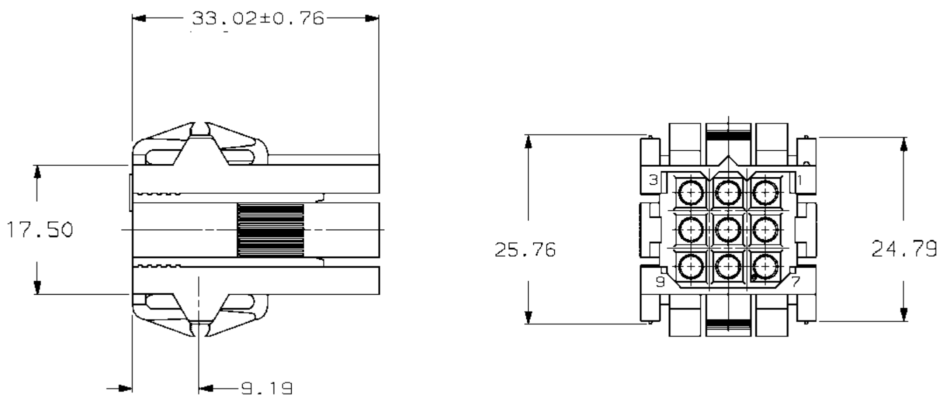

Figure 18 – Rectangular connector to the RTU

A belt-type marking device must be fitted at both ends of the cable, made of PVC, to be used, during installation, to indicate the number and name of the compartment it relates to.

Table 19 – 9 pole Connector table		
1	Com TS	Power supply (+24Vcc) and Common remote signals
2	TS 51 A	Multi-phase or double single-phase fault
3	TS PRES V	MV voltage on (level)
4	+M1	Measurement - pole 1
5	TS 67AV	Single-phase fault (downstream)
6	-M2	Measurement - pole 2

7	COM ID	Inversion of direction command 67 AV (common)
8	UD	Inversion of direction command 67 AV
9	-	Power supply (-24Vdc)

6.5.3.2. MU Terminal Board

The MU terminal board connects the power cables between the UP/Primary RTU and the RGDM in extended configuration. The power supply cables of the RGDM (at least 2.5 mm2) must be connected to this terminal board. In addition, a +L signalling cable will make it possible to set the MV/LV substation equipment locally or by remote control, via a selector located on the UP/Primary RTU.

When the local command is activated, the RGDM will enable the open and close buttons on the board and, if applicable, those replicated in the GSCM004.

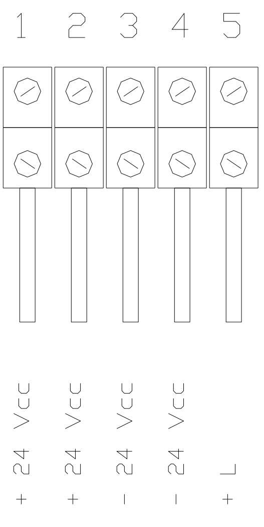

Figure 19 – MU Terminal Board

6.5.3.3. MI Terminal Board

A terminal board must be set up inside the RGDM (Figure 20), named MI, suitable for housing conductors with a section up to 2.5 mm2, to which the connection cable must be connected for the OdM. All the digital inputs must provide protection against inversion of polarity.

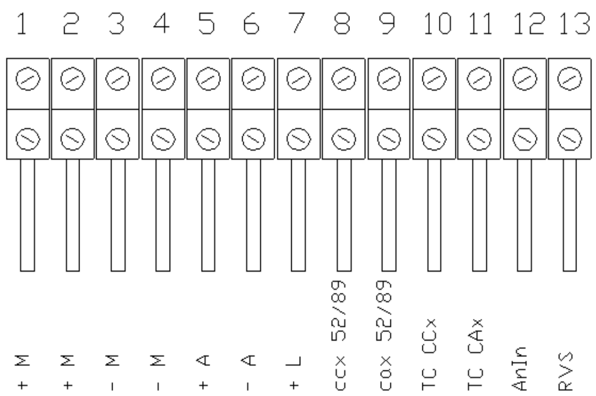

Figure 20 – OdM command output terminal board

The electrical characteristics of the MI terminal board are shown in Table 20.

Table 20 – MI terminal board			
1	MI_A	+M	Power supply, motors OdM (+) 24 Vdc
2	MI_A	+M	Power supply, motors OdM (+) 24 Vdc
3	MI_A	-M	Power supply, motors OdM (-) 24 Vdc
4	MI_A	-M	Power supply, motors OdM (-) 24 Vdc
5	MI_A	+A	Power supply RGDM and MV RMU command circuits (+) 24 Vdc
6	MI_A	-A	Power supply RGDM and MV RMU command circuits (-) 24 Vdc
7	MI_S	+L	MV/LV substation in local command (enabling buttons on RGDM and OdM)
8	MI_S	ccX 89	OdM closed signal
9	MI_S	caX 89	OdM open signal
10	MI_S	TC CCx	OdM Closing Command
11	MI_S	TC CAx	OdM Opening Command
12	MI_S	AnIn	Switch fault
13	MI_S	RVS	Bar power on

The MI terminal board has 5 digital inputs (ccX 89, cax89, AnIn,RVS,+L), according to par. 6.5.3.4.

The MI terminal board has 2 command relays (TC CCx and TC CAx), according to par. 6.5.3.5.

6.5.3.4. Digital inputs

The digital inputs miust have the following characteristics:

High level	8V: 48V dc
Low level	< 6V dc
Overload for 1s	48V dc

It must be possible to programme the digital inputs, and to associate any of the functions shown in Table 21. If more than one variable is selected, the input status will enable all the enabled functions.

Each input must be programmed for direct or inverted logic, and it must be possible to associate a t_{ON} and t_{OFF} timer, as indicated in Table 22.

For the protection function blocks:

- The block for the individual protection function started by the trip with the timers in reset state, and therefore the start-up circuits will not be blocked.
- The "*block all*" function, blocks all the protection functions, as well as the start-up circuits.

Table 21 – Input Functions

FUNCTION		
Iversion	Reset counters	Switch closing
RVS	Reset CB Monitor	SF6
Block 51/67.s1	Remote Trip	Contract time
Block 51/67.s2	Reset signals	Local
Block 51/67.s3	52a (ccX)	FSL/SFS enabling
Block 51/67.s4	52b (caX)	SFS Remote trip
Block 51N.s1	Switch opening	SFS Remote close
Block 51N.s2	Block Extension 46	SFS boundary
Block 51N.s3	Block 59ESB	Block All
Block 67N.s1	ES59B enabling	Include 25
Block 67N.s2	Breaker Failure	Exclude 25

Block 67N.s3	Include Hot Line Tag	Remote Trip
Block 67N.s4	Exclude Hot Line Tag	
Block 67N.s5	Exclude ZSC	
Block 59N.s1	Include SAL	
Block 59N.s2	Exclude SAL	
Block 59Vi.s1	Include Reclosing	
Block 46.s1	Exclude Reclosing	
Block 46.s2	Block Reclosing	

Table 22 – Programming Input		
Description	Value	Um
IN1		
Logic	DIRECT	
IN1 t_{ON}		
Value	0,00	s
IN1 t_{OFF}		
Value	0,00	s

6.5.3.5. Command and signaling relays (Digital Output)

The characteristics of the five relays differ for command and signaling relays.

Command relays:

- Nominal current ≥ 5 A
- Disconnection power at 24 Vdc ≥ 10 A (with L/R = 40 ms)
- Coil / contacts insulation ≥ 3 kVdc
- Number of guaranteed electrical manoeuvres ≥ 10^5
- Number of guaranteed mechanical manoeuvres ≥ 10^6

Each command must be sent to the field by means of actuator relays, with armed +24V contacts. The section and isolation of the circuits and conductors must be suitable for handling 10A direct current and a voltage of 24 V.

It must be possible to enable or disable the relays from the "Remote control enabling" switch, activated by the "Local / Remote Control" switch on the UP.

The activation time must be programmable between at least 0.0 (minimum relay time) and 2 seconds in 0,01 sec steps.

It must be possible to measure the driving currents of the circuit-breaker control coils (opening and closing).

The output command is sensitive to the rising edge of the trip, in all the 3 modes.

- Impulsive: the duration of the output command is equal to the Delay Time parameter, regardless of the duration of the trip signal.
- Memorized: Following a trip change, the output command signal remains high until the reset condition occurs.
- Not memorized: The duration of the output command is equal to the duration of the Delay Time, only if trip < delay time. Otherwise, if trip > Delay Time, the output command duration is equal to the trip duration.

Signaling relays:

• Nominal current	≥ 2 A
• Disconnection power at 24 Vdc	≥ 0,5 A (with L/R = 40 ms)
• Coil / contacts insulation	≥ 3 kVdc

It must be possible to programme the digital outputs, and to associate:

- the start and trip of all the protection functions;
- All internal RGDM signals;
- All the digital Inputs and virtual inputs;
- All the PLC variables;
- All the function associate to the Digital Input described in **Table 21**.

6.5.3.6. Virtual Inputs and Virtual outputs

There must be 32 virtual inputs and 16 virtual outputs, which can be associated via IEC 61850 protocol or related to the device's internal PLC logic.

All the input and output functions described in par 6.5.3.4 and par. 6.5.3.5, can be associated with each virtual input and output.

It must be possible to configure the Vout signal to continue for the time established beforehand, or for the duration of the associated function. It must be possible to associate a test function to the Vout in order to generate GOOSE or Report signals.

6.5.4.Reliability requirements

By according to the terms and definitions from IEC 60050-192, the RGDM useful life (or lifetime), is the time interval, from first use until user requirements are no longer met, due to economics of operation and maintenance, or obsolescence. In this context, “first use” excludes testing activities prior to hand-over of the item to the end-user.

The useful life must exclude the early life failure period (infant mortality period); the Supplier must perform all necessary tasks to eliminate the “child mortality” of the devices before the delivery and these activities must be fully described in the documentation, which must accompany the device. Accordingly, the Supplier must certify that the equipment, when delivered, has commenced its constant failure rate period.

The Supplier must declare the failure rate of the device to ensure that it is consistent with the project specifications (the underlying calculation method will be reported in the documentation) and must not exceed 0,3% per year failure and the 4.5% cumulative failure in the lifetime, when the device is installed and operated the required environmental conditions.

The “constant fault-rate” period means the “lifetime” of the device and must be greater than 15 years, with the exception of batteries, displays and Flash E2PROM, for which “life cycle” must not be less than 10 years.

For the purpose of fault analysis, a possible restoration (reparation or maintenance) doesn’t affect the error rate during “lifetime”.

A fault is defined as the loss of operation of the device that requires its removal from the substation or the change of the SW on board to eliminate the defect.

For the purpose of the analysis of the device’s reliability during its lifetime, the “pertaining faults” exclude improper use or a wrong operation; accordingly, the Supplier must define in detail the usage conditions and the correct operation of the equipment.

The RGDM must be designed for an expected mean operating time between failures (MTBF) longer than 30 years. The RGDM must be designed for an expected mean time to restoration (MTTR) smaller than 3 h.

7. CONFIGURATION AND COMMUNICATION REQUIREMENTS

In this chapter are specified all the configuration and communication requirements of the RGDM control unit.

7.1 Device software

The RGDM must be equipped with SW that allows it to be connected to a PC for configuring, monitoring, and diagnostics on the equipment. The configuration software included in the supply (with an unlimited number of user's licenses), must be compatible with the actual operating systems when the tender is released.

All the SW supplied must be able to work in a not administrator context, and taking Microsoft's guidelines for compatibility for Windows systems into account.

The application package must be silent and unattended, and must only create working folders that can be accessed without administrator's rights. The application package must provide standard installation methodology (rather Windows Installer, Install Shields etc).

It must be possible to use the SW for viewing and saving all the measurements taken by the RGDM, in both modulus and phase, with the relevant time (hh:mm:ss.000) and date (dd:mm:yyyy). It must be possible to export the measurements in .xls and .txt format.

The device software architecture must provide separation between machine database and 61850 database, in order to manage separately the two sections.

The software must be able to manage dual-mode configuration of the RGDM, if the device is used in the RGDM version, whereas it must be possible to activate an SW template for setting and configuring the device as RGDAT. A further template must be available for the programming modes for the UPG function (ref. GETP011-A1) and for the ARF functions, etc.

The SW must include the graphic interface templates, from which it must be possible to program and enable the RGDM's various functions.

The unit's firmware must be equipped on a not-volatile memory that can be updated in the field.

It must be possible to execute at least the following operations for the UPG functions (ref. GETP011-A1):

- Parameter management.
- Displaying UPG date and time
- Displaying digital statuses
- Displaying measurements
- UPG diagnostics

It must be possible to view:

- The version of the firmware currently installed.
- The instantaneous data for the V_{MT} – P – Q measurements, updated at a frequency of 1 second.

- The values saved for the V_{MT} - P - Q measurements, recorded at 1 minute intervals, and contained in the panel's memory buffer.
- The current status of all the signals managed by the UPG.

7.1.1.Configuration functionality

All the parameters referred to in the specifications below, must be able to be edited via the web server interface. The RGDM must have Web-Server functionality, so that remote interrogation and re-programming of the device is possible.The default configuration of the parameters is to be according to the default values indicated in these specifications.

The parameters included in the IEC 61850 model are also to be viewable and editable, as specified in the GETP013.

The supplier is to provide a configuration file that is suitable for storing and for loading configuration information again. This includes both information editable via the web interface, and that editable via the 61850 protocol. It must be possible to use this option for both downloading and uploading a configuration when the equipment is replaced, or for uploading a new configuration. It must be possible to send the file from a remote location.

It must be possible to restore the device to its factory condition by a combination of the buttons used to navigate the dispaly.

7.1.1.1. Remote configurability via 61850

The RGDM device must allow remote configuration of its configuration parameters, via the relevant IEC 61850 protocol functions. The parameters configurable remotely via 61850 are listed in the GETP013.

The IED must be able to receive the CID configuration files by 61850 file transfer and via SFTP. The CID file must be activated by a 61850 command, and by a command from the configuration software.

The CID file must be managed by the IED and, once implemented, it must configure the communication part of the IED. The CID file must also be able to configure any parameters related to the protection functions, but this functionality must be subject to an enabling flag, which must be present on the web page and in the configuration software.

It must be possible to take the CID file from the device, via configuration software, via 61850 transfer files and by SFTP.

The name of the file will be defined by the GridSpertise operator, and must be kept the same when withdrawing the file itself. The CID file has no default name, and must be accepted by the receiving IED.

If taking on the CID file involves rebooting the equipment, this rebooting must ensure that the protection functions are available within 30 sec, and the communication server is available within 1 minute.

The performance of the protection functions, emitting / subscribing of GOOSE, and issuing of reports, must not be affected by the maximum number of subscribed BLIND GOOSE protocols.

The IED must ensure that, after a client has been disconnected (or physically switched off), the reports enabled by the same client are issued. This implies introducing a keep alive mechanism towards the client, implemented by the IED.

Normally, the rebooting time for a client can be estimated to be 20 sec.; therefore, the IED must recognize disconnection of a client within a time at least shorter than 15 sec, in order to present the reports in a not-reserved state, when the client is connected again.

7.1.1.2. Configuration via software

The configuration software must:

- Allow the procedure to be launched for entering parameters for the CT-VT sensor. If the calibration procedure fails, the program must provide an indication of the type of error encountered.
- Allow setting of the thresholds, times, and activation sectors for all the protection functions.
- Guarantee the integrity of the data to and from the calibration program, by checking coherence of the data.
- Allow setting towards the RTU to which it is interfaced that may be an UP/Primary RTU. If the RGDM is set for connection to a UP, the SW must be able to mask all the functions / parameters not necessary for the UP to function.
- Allow setting and enabling of the UPG function (ref. GETP011-A1).
- Allow setting of the ARF parameters (this function is enabled electro-mechanically, via a selector on the electronics board).
- Allow the CID files made available by the TMF 2020 configuration device to be loaded.
- Allow management and creation of GOOSE Control Blocks and Report Control Blocks.
- Allow CID files and other IEDs to be loaded, in order to configure subscriptions between GOOSE protocols. The subscription technique to be adopted is described in the “GOOSE Subscription Technique” document.

7.1.2. Monitoring and diagnostic functionality

The configuration software must allow:

- The reference phase for calculating all the other phases is established, by convention, on voltage V4.
- Monitoring of the phase current.
- Monitoring of residual voltage and residual current (in modulus and related phase delay).
- Launching of a diagnostic test for the equipment.
- Simulation of the action of each of the signals provided by the equipment to the Remote Control Peripheral Unit.
- Viewing of the recorded events buffer (min 128).
- The possibility, by means of a SW setting, to save not only the triggers but also the start-ups in a circular buffer.

The RGDM device must carry out a watchdog activity, in order to allow the detection CPU to detect an infinite program loop or a deadlock situation.

The red LED switching on and a suitable message must indicate any error condition, following detection of a fault by the CPU. If location allows detailed information, this must be displayed clearly or using a suitable code. The same information must be made available on the PC.

When there is a fault on the panel, the self-diagnosis system must ensure that untimely commands and misleading signals are not emitted, to the greatest degree possible.

The fault status of the RGDM or one of its accessory functions, must result in a signal being emitted to the center. In addition, the three sensors must be checked to ensure they are working properly, and the correctness of the power supply must be checked.

Any anomaly found must result in:

- All the outputs being opened, including that related to the Power On signal (TS PRES V) which, in such a case, is forced to an OFF status.
- Local indication of the fault by the relevant flashing red LED switching on, and showing the cause of the anomaly on the display.
- If the anomaly relates to one or more sensors, which sensor is out of order must be shown on the display and via the interface software.

All anomaly states on the device, both partial and total, must be saved on a specific Log text file, not on a volatile memory, and must allow detailed analysis of the causes of software and hardware anomalies.

An event for loss of subscribed GOOSEs must be provided in the Log; if a repeat GOOSE is not received within twice the maximum time a loss of synchronism for the subscribed GOOSE is recorded.

In addition to the entry in the Log, it must be possible trough the RGDM web server, to insert a new variable able to manage the presence of the subscribed GOOSEs. It must be possible also to have the information related to the GOOSE (e.g. TAG inside the GOOSE).

It must be possible to download the file both using the configuration software, and by means of emergency procedures if irreversible blocks occur on the machine. The LOG information must be able to be sent (ref. SysLog RFC3164, RFC3195).

7.1.3.Revision functionality

The device must allow its own firmware to be updated in the field, via the Ethernet port, with the possibility of this update being done from a remote location, if necessary, via SFTP and SCP and using the IED WebServer.

If even only one of the three sensors is changed in the field (this possibility is required in any case), a function must be provided for resetting the characteristic parameters of the CT-VT sensor, and resetting all the functions. Such an action must be carried out and started by the configuration SW, by means of a specific routine, to be implemented in the SW itself.

7.1.4.Memory

The RGDM must be able to store a series of fault events and signals locally, as well as the measurements taken. The memory for each type of event must be created with a circular buffer with FIFO (First In First Out) type operating logic.

The device must store the following information in a non-volatile type memory, broken down by operating groups:

- **Faults Register**: 200 activation events (cause of the action, date & time, all the measurements at 20ms)
- **Events Register:** 1024 generic events (list of start-ups, actions, digital status, date & time, info)
- **Measurement functions:**
  - 4320 measurements (one every 10 minutes, for 30 days) for P, Q, I and V (magnitude and anglevalues, date & time). In particular, the RGDM must store the value calculated as theminute average, which is also sent to the centre using the data network in place.
  - 200 events of max THD (max. THD, date & time)
- **DG management functions: (ref. to GETP011-A1)**
  - 10080 measurements for P, Q, and V respectively (date & time value), sent using the UPG function, by the generator to the RGDM.
  - 10080 measurements for P, Q, and V respectively (date & time value), detected using the UPG function, by the RGDM at the delivery point.

It must be possible to view and export all the data saved using the SW provided, while the export format can be either .txt or .xls.

The events must be stored in the following page format:

Event code **dd/mm/yyyy** **hh:mm:ss.000**

Example: **67_S2** **26/03/2009** **21:06:37.000**

The events to be stored in the circular memory, in the format indicated above, are listed in Table 23. The event log must also show the state of the variable with timestamp. All the I/Os both physical and virtual must be recorded. Each event must be written using the code indicated in the same table:

Table 23 – Code and event to save	
67N_S1	Directional earth trigger for first threshold
67N_S2	Directional earth trigger for second threshold
67N_S3	Two-way trigger for double single-phase fault to earth
67N_S4	Trigger for intermittent fault to earth
51_S1	Maximum phase current trigger
67_S2	Maximum directional phase current trigger
67_S3	Maximum directional phase current trigger
67_S4	Maximum directional phase current trigger

32P.S1	Maximum power trigger
79_RR	Rapid re-closing commanded
79_RL	Slow re-closing commanded
79_RM	Saved re-closing commanded
79_FR	Re-closing failed
59N_S1	Maximum single-pole voltage trigger
59Vi_S1	Maximum inverse voltage trigger
59N_S1Avv	Maximum single-pole voltage start-up
59Vi_S1Avv	Maximum inverse voltage start-up
AnPa	Panel Anomaly
AnCT-VT	Sensor Anomaly
67N_S1Avv	Directional earth start-up for first threshold
67N_S2Avv	Directional earth start-up for second threshold
67N_S3Avv	Double single-phase to earth threshold directional start-up
67N_S4Avv	Intermittent fault to earth start-up in S1 and S2
51_S1Avv	Maximum phase current start-up
67_S2Avv	Maximum directional phase current start-up
67_S3Avv	Maximum directional phase current start-up
67_S4Avv	Maximum directional phase current start-up
87_R2H	INRUSH current protection trigger
87_R2HAvv	INRUSH current protection start-up
47_S1	Voltage cyclical direction inversion trigger
47_S1Avv	Voltage cyclical direction inversion start-up
Max THD_V	Exceeding voltage THD threshold
Max THD_I	Exceeding current THD threshold

32P.S1Avv	Maximum active power start-up
RVL	Voltage presence

Remote reading and extraction of data saved on the RGDM must be possible, and transmission of data in the RGDM must be handled using the SFTP protocol.

The RGDM must include a double backup memory (one for the protection functions, and one for the measurement and DG management functions, ref. GETP011-A1) in which previous configuration data must be stored.

This is done to avoid situations in which, during an unsuccessful update that could also be sent by the center by SFTP, the previous configuration is lost.

Each pair of memories must work using the following logic:

- The first modulus must be used to store the calibration values and any operating parameter.
- The second modulus must be used when updating or reprogramming the equipment.

In these cases, the new data must be stored temporarily in this memory, and transferred to the first when the transfers are complete. This means that the second will always act as a backup for what the equipment is busy doing.

7.2 Communication Ports and protocols

One ethernet port must be provided in copper (RJ45 console port), and another optic type 100base-FX with LC connector. The Ethernet interfaces must support the TCP/IP-UDP protocol. It must be possible to set and edit the IP address, the Subnet Mask, the board's default gateway, as well as all the parameters in general, in order to configure the latter in a LAN (ref. 7.2.1.1). Both ports must be able to have the same services, including IP (static/dynamic) flexibility, and to support IEC 61850 services.

Via the Ethernet port, all the measurements taken by the RGDM must be accessible, as well as all the trigger signals (including those put in common on the MB terminal board, such as 67.S4 trigger, for example), and the fault signals.

The RGDM must implement a network architecture, and so it must be possible to manage communication of data in both GOOSE and client/server mode. It must also be possible to programme the device, via the Ethernet port.

7.2.1.1. Configuration of communication addresses

The RGDM must support both Internet Protocol IPV4 and IPV6 versions, in native mode, and all application messages are to use the IEC 61850 protocol.

The RGDM must have:

- A static address (192.168.1.1) not associated with any gateway (for local connection)

Therefore, before it is activated, the operator (local configurer) must configure the following fields:

- Static address
- Netmask
- Default gateway.

The following services must be available:

- WEB server
- NTP client
- SSH server

File transfer procedures are to be managed using the related functions provided by the IEC 61850 protocol. These references are to be configured manually, or they will be provided by a configuration server, at the time of activating the RGDM, and subsequently, following changes to the consistency of the network, line set-ups, etc.

The algorithm for determining these addresses, is to be located in the Server, which will be the only one from which the RGDM can receive configuration data. Therefore, its address is also to be configured by the operator before starting up the RGDM (configuration server address).

The configuration server must be able to configure the list of IEDs subscribed within each RGDM, made up of a maximum of 100 IED elements.

The RGDM must therefore be able to store:

- 1 remote server (Primary RTU) address
- 1 static IP address 192.168.1.1
- 1 default gateway IP address
- 1 Netmask IP address
- 100 GOOSE to configure the list of IEDs subscribed

7.2.1.2. IEC61850 Communication protocol

The IEC 61850 communication protocol is described in GETP013.

7.2.1.3. DNP3 Communication protocol

The DNP3 communication profile must be implemented for enabling straightforward integration of the RGDM into existent SCADA/RTU solutions.

The DNP3 protocol, on Ethernet Port, shall meet the following requirements:

- Level of implementation of the DNP3.0: Level 2
- Transport Layer: TCP/IP
- Binary Input:

- Time stamp event buffer capacity: 120
- Time Stamp Accuracy: 1ms
- Order of points: Sequential and configurable by the user;

- Analog Input:
  - The buffer management method must allow the configuration to only send the last update of the point value or quality. Method also known by:
    - Last Value
    - Most Recent Value
    - One event per point
  - Order of points: Sequential and configurable by the user;
- Control Relay:
  - Order of points: Sequential and configurable by the us;
- Support for the following functions:
  - Confirm
  - Read
  - Write
  - Enable Unsolicited
  - Disable Unsolicited
  - Direct Operate
  - Select Before Operate
  - Delay Measurement
  - Record Current Time
- Support the following controls:
  - Reset Link (Data Link Control)
  - Clear Restart (Request Write IIN1.7)
  - Delay Measurement (Obj 52)
  - Write Time Date (Obj 51)
- Support the following general questions:
  - Binary Input All (Obj 1 Var 0)
  - Analog Input All (Obj 30 Var 0)
  - Counter Input All (Obj 20 Var 0)
- Support the following events of questions:
  - Class 1 (Obj 60 Var 2)
  - Class 2 (Obj 60 Var 3)
  - Class 3 (Obj 60 Var 4)

- Support sending events through unsolicited messages;
- It should present mechanisms to deactivate the unsolicited messages after failure to send them;
- Allow configuration of the following parameters for DNP3 configuration:

ITEMS AVAILABLE FOR CONFIGURATION	**CONFIGURABLE VALUES**
IP Address, Mask, and Gateway	Defined in purchase order
DNP service port on TCP	7000 to 65.000
Equipment DNP Address	1 a 9999
DNP reporting address (SCADA)	1 a 9999
Standard variation for general interrogations of digital inputs	Binary Input With Status (Obj 1 Var 2)
Standard event variation for digital inputs	Binary Input Change With Time (Obj 2 Var 2)
Class Assignment to Digital Input Group	1
Individual noise filter for each digital input (debounce)	0 to 100ms [step 5ms]
Standard variation for general analog input interrogations	Analog Input 16Bits With Flag (Obj 30 Var 2)
Standard event variation for analog inputs	Analog Change 16 Bits Event Without Time (Obj 32 Var 2)
Class Assignment to the analog input group	2
Deadband for each analog input (deadband)	In engineering or gross values
Individual scale for each analog input (Multiplier / Splitter)	0,001 a 1000
Individual zero range for each analog input (suppress zero)	In engineering or gross values
Standard variation for general counter interrogations	Counter Input 32Bits With Flag (Obj 20 Var 1)
Standard event variation for counters	Counter Input Change 32 Bits Event Without Time (Obj 22 Var 1)
Class Assignment to the group of counters	3

Date and time synchronization via protocol	Yes, on request initiated by SCADA
Enable sending unsolicited messages	Yes, with activation and deactivation of the service by SCADA
Enable verification for unsolicited messages	Yes
Time for retransmission of unsolicited messages (Confirmation Timeout)	1 a 30s [step 1s]
Number of unsolicited messages transmission retries	Always 1 a 60 [step 1]
Required amount of events for transmission of an unsolicited message per class	1 a 50 [step 1]
Maximum age of an event for transmission of an unsolicited message per class	0 a 30s [step 100ms]

Providing Information to the Supervisor

The conditioning and mapping of information for digital, analog, counter inputs end controls will be agreed with the supplier according to the need of the site to be installed. The supplier must provide the minimum number of configurable points as follows:

- Digital Input: 40
- Analog Input: 20
- Digital Output: 10
- Counter:10

7.2.1.4. Synchronization

The RGDM must be able to receive configuration packages on IEC 61850, called CID. The average size of a CID package is 1 MB. The memory buffer dedicated to this data must therefore be suitably oversized.

The time measurement for both protection functions and more general purposes such as DG management, for example, must all refer to the same time reference.

This must be calculated starting from a quartz oscillator, with the following characteristics:

- Frequency stability: 10 ppm
- Frequency Aging 5 ppm/year
- Operating temperature -25°C to +70°C

Synchronization of the clock and calendar must be done by means of a specific message sent periodically by the center (Primary RTU server). The synchronization protocol for the various devices is NTP.

When the equipment is started again, the clock and calendar must show updated values for at least 24 hours after being switched off. Accumulation subsystem must be used for this purpose. When the power supply is restored, if the interruption has exceeded the autonomy time provided for, the clock and calendar can present two conditions:

- Resetting with events already recorded in the logger.
- Resetting with no event recorded in the logger.

In the former case, the clock and calendar must be reset according to the most recent chronological reference, stored in the logger. In the second, case, however, the values must be started as follows:

- Time 00:00:00,000
- Date 01/01/2016.

8. FUNCTIONAL REQUIREMENTS

The RGDM is an evolved instrument, designed to protect, automate, monitor, and measure of network quantities and distributed generation (DG) management.

It must be able to measure:

- Line currents and the residual (calculated) current by means of three analogue input channels, one for each line current.
- Line voltages and the residual (calculated) voltage by means of three analogue input channels, one for each phase voltage.

By means of the measurements indicated above, the RGDM must detect the following events:

a. Protection functions:

- Directional/phase overcurrent protection **67/51**.
- Directional residual overcurrent protection **67N**.
- Directional intermittent earth arcs detection **67N.S4**
- Residual overcurrent protection **51N**.
- Second harmonic return, for inrush currents **2ndH REST.**
- Negative sequence overcurrent protection **46**
- Residual Overvoltage protection **59N**
- Inverse Overvoltage protection **59Vi**
- Overvoltage detection protection function **ES59B**
- Discrimination between voltage present/absent **(RVL)**
- Frequency protection **EAC**
- Maximum active power directional protection **32P**.
- Automatic Reclosing function **(ARF 79)**
- Automatic Parallel function **(Synchrocheck 25)**
- Cold load pick-up function;
- Breaker Failure function;
- Skip shot Function;
- Broken Conductor function;
- Hot Line Tag function;
- Cycle direction checking function (**ANSI 47**);
- Voltage and Current Sensor Supervision function;

All the protection functions, excluding 32P and 47, must have the "Breaker Failure" control, for monitoring the circuit breaker opening / closing times. The control timer TBF must be set from 60ms to 10s, in steps of 10ms. Exceeding the time required for the command must produce a logic status of "Breaker Failure", recorded in the event log and sent to IEC61850.

All the maximum current thresholds (51/51N and 67/67N) must have the "Cold Load Pickup" function, by means of a TCLP timer that allows delaying the intervention from non-energized lines. The control timer TCLP must be set from 0ms to 100s, in steps of 10ms (until 10s) and 100ms (10s to 100s).

b. Automation function (ref. to GETP011-A1):

- Logic selectivity of the faulty section.
- Sending / receiving signals and commands, via evolved IP type networks, in accordance with the IEC 61850 standard or DNP3.

c. Measurement and monitoring functions:

- Measurement of electrical V, I, P, Q and cosφ quantities.
- Monitoring of currents and voltages (harmonics in the node).

d. Auxiliary function:

- PLC function.
- Disturbance recording (Oscilloperturbography).

e. DG management functions (ref. to GETP011-A1):

- Regulation of the voltage profile along the line, by means of static converter control.
- PI control and remote disconnection of DG.
- Prevention of PG tripping for DG logic selectivity.

List of Definitions

Start-up time is the time lapse between detection of the fault conditions, and when the start-up completed command is sent, if required.

Activation time is the time (including the start-up time) lapse between detection of the fault conditions, and when the protective device commands opening of the OdM.

Delay time, when set, is the time, including the activation time that the protective device waits before sending the command to open the OdM; used to create chronometric selectivity between the various protective devices in the network.

Return ratio: The relay acts when the quantity in action reaches and exceeds the preset calibration value, and returns to stand-by when the quantity acting reaches a value, referred to as the return, which depends on the relay's construction characteristics. The ratio between the return value and the activation value, is said to be the relay's return ratio.

Return time: The time elapsed between the acting quantity reaching the return value, and when the relay is released.

Start time: The time interval between the moment the input quantity (ies) is/are applied, removed, or changed under specified conditions, and the moment the start output circuit changes status.

Base tripping time: The minimum time the protective device takes to detect the fault and emit the command, without any intentional delay.

Tripping time: The time interval between the moment the input quantity (ies) is/are applied, removed, or changed under specified activation conditions, and the moment the Trip output circuit changes status.

Effective value: In this document and for the RGDM device, the effective value of a quantity must be taken to be the component's actual value at the basic frequency before the fault, calculated with a mobile window of corresponding amplitude.

Residual voltage: Value of the vectorial sum of the phase voltages.

Residual current: Value of the vectorial sum of the phase currents.

8.1 Protection functions

The remote calibration mechanism for protection setting parameters must be intrinsically safe, which means that editing of parameters must be done in blocks, by means of a swap commanded by the Primary RTU, according to the IEC 61850 standard. All the protection functions (FdP) must be activated or deactivated.

The architecture of the RGDM shall allow a decoupling between the Protection Functions DataBase and the IEC61850 DataBase. This is to guarantee an easy modification of the two part independently.

In Figure 21 the logic diagram for an FdP (Protection Function) is shown. For functions not used in the FSL the back-up timer and the FSL enable logic mustn't be considered.

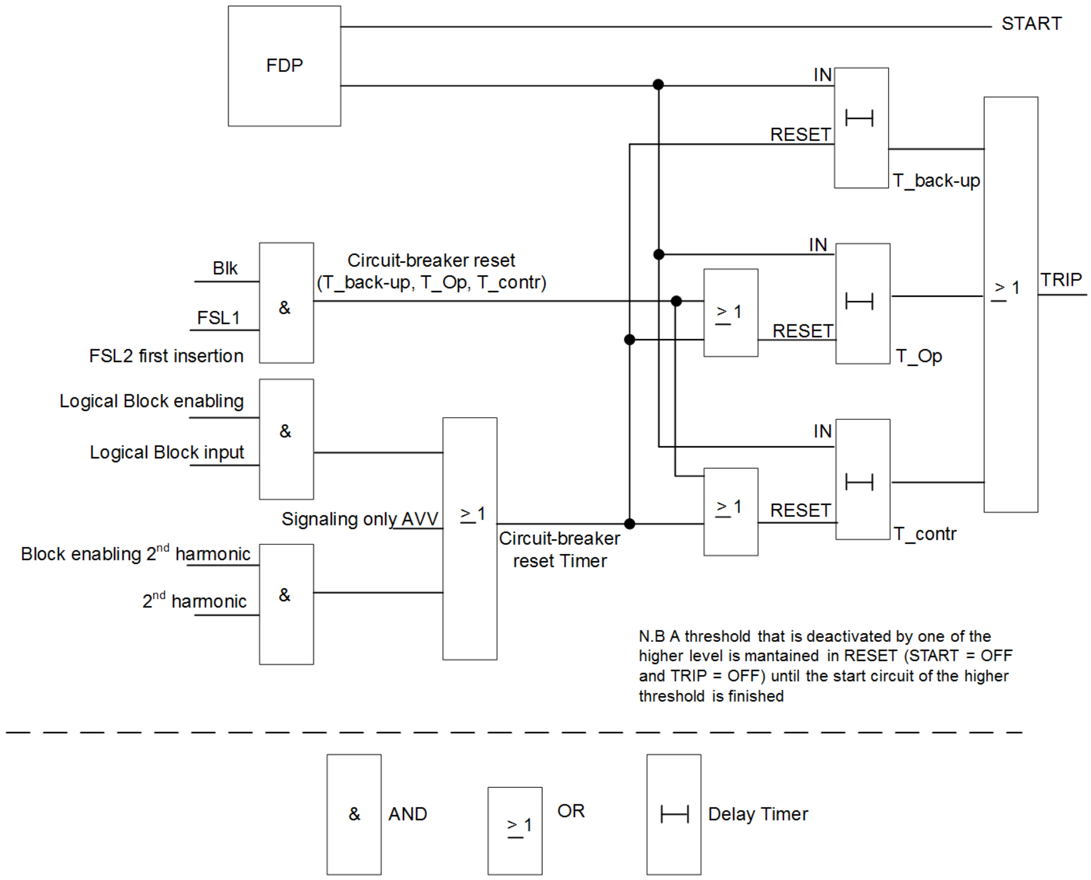

Figure 21 – Logic Diagram for an FdP

In the figure above:

- T_back-up is the "free time"
- T_contr is the contract time
- T_Op is the normal time between start and trip commands

- **IEC and ANSI Standard Overcurrent Curves**

All the phase/earth overcurrent protection functions must be inverse time or independent time. It must be possible to select by software both inverse timeor independent time as well as the type of the curves (IEC or ANSI).

$$t(G) = \left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c \right] \cdot T_p \qquad \text{when } G > G_s$$

where:

t(G)(seconds)	theoretical operate time with constant value of G,
k, c	constants characterizing the selected curve (in seconds),
α	constants characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the phase currents (IL1Four, IL2Four, IL3Four),
Gs	pre-set value of the characteristic quantity
T_p	is the Time Multiplier Setting value (also referred as TMS)

The end of the effective range of the dependent time characteristics (GD) is:

$$G_D = 20 * G_S$$

Title	k	c	α
IEC Inv	0,14	0	0,02
IEC VeryInv	13,5	0	1
IEC ExtInv	80	0	2
IEC LongInv	120	0	1
ANSI Inv	0,0086	0,0185	0,02
ANSI ModInv	0,0515	0,1140	0,02
ANSI VeryInv	19,61	0,491	2
ANSI ExtInv	28,2	0,1217	2
ANSI LongInv	0,086	0,185	0,02
ANSI LongVeryInv	28,55	0,712	2
ANSI LongExtInv	64,07	0,250	2

Table 24 – The constants of the standard dependent time characteristics

Resetting characteristics:

For IEC type characteristics the resetting is after a fix time delay (Reset delay). For ANSI types however according to the formula below:

$$t(G) = \left[\frac{k_r}{1-\left(\frac{G}{G_S}\right)^{\alpha}}\right] \cdot T_p \quad \text{when } G<GS$$

where:

t(G)(seconds)	theoretical reset time with constant value of G,
k_r	constants characterizing the selected curve (in seconds),
α	constants characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the phase currents (IL1Four, IL2Four, IL3Four),

Gs	pre-set value of the characteristic quantity
T_p	is the Time Multiplier Setting value (also referred as TMS); default 0,12s

Title	kr	α
IEC Inv	Resetting after fix time delay, according to pre-set parameter "Reset delay"	
IEC VeryInv		
IEC ExtInv		
IEC LongInv		
ANSI Inv	0,46	2
ANSI ModInv	4,85	2
ANSI VeryInv	21,6	2
ANSI ExtInv	29,1	2
ANSI LongInv	4,6	2
ANSI LongVeryInv	13,46	2
ANSI LongExtInv	30	2

Table 25 – The resetting constants of the standard dependent time characteristics

Inverse Time curves shall also be defined as a **custom curves defined by the user**, by the entry of at least 32 points (composed by relation - Multiple Icc/Ipickup versus Time) according to figure Figure 22 below, due to many situations of feeder topologies:

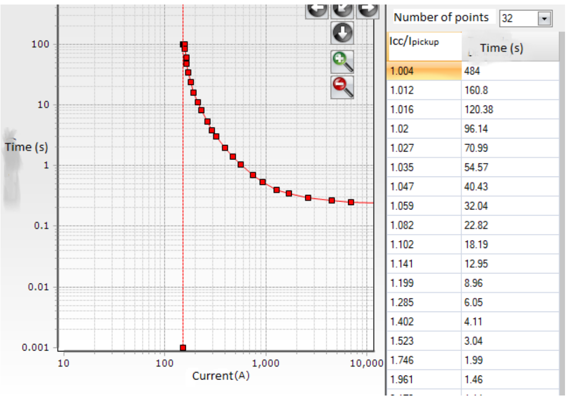

Figure 22 – Example of user defined curve configuration interface

- <u>**Second tripping time of protection functions (or contract time)**</u>

Each protection must be able to be configured with a second intervention time for the defined time functions.

The second tripping time is typically used as a contracted time, the main features are:

- The function must be include / exclude,
- If the CLP function is included, the second tripping time function has priority over the CLP function,
- The second tripping time function is activated on the status change from open to closed of the slave switch,

- The second tripping time remains enabled for a settable time, the same as the CLP function,
- It must be provided a function which can be enabled or disabled, with the following behavior: in case of automatic reclosing excluded, the second tripping time is kept active for functions in which it was enabled.

Table 26 – Setting parameters		
Minimum time (s)	Maximum time (s)	Step (s)
0,05	9,99	0,01
10	99,9	0,1
100	200	1

- **<u>Protection blocking function</u>**

The protection functions must have a virtual input, which can be configured on both physical and virtual inputs, in order to take the intentional delay timer to 0, and to keep the triggering command blocked. In this case, only start-ups are emitted. Figure 23 shows an example of blockage of the protection function.

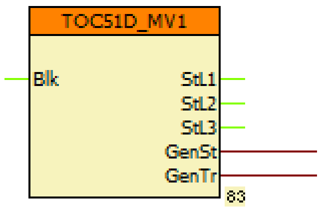

Figure 23 – Protection blocking function

- **Management on single-phase and two-phase network**

The device must have three different operating modes, depending on the network characteristics. In particular, it will be necessary to be able to set the operation of the RGDM also for single-phase and two-phase networks.

It will be possible to select one of the three operating modes using the SW configurator, indicating which of the three phase lines will be wired. For three-phase networks, it will be possible to wire both three single phases and two phases plus the residual components.

According to the actual network characteristics, therefore, the device must exclude the protection functions not applicable, as described in the following table.

	51	**67**	**51N**	**67N**	**32P**	**RVL**
Three Phase	●	●	●	●	●	●
Two Phase	●	●	○	○	●	●
Single Phase	●	●	○	○	○	●

● = Available

○ = Not Available

8.1.1. Directional overcurrent protection 67 and overcurrent protection 51

The device must detect overcurrents that exceed the threshold set, also due to closing proceedings due to a fault, as well as starting from a zero current and voltage condition at the point at which the RGDM is installed.

It must be possible to set the thresholds to directional or not directional and enabled/disabled.

Phase directionality implies an angular reference between currents and voltages, as indicated:

- **I4** in relation to **V8-12** (+90° in balanced conditions)
- **I8** in relation to **V12-4** (+90° in balanced conditions)
- **I12** in relation to **V4-8** (+90° in balanced conditions)

8.1.1.1. Setting parameters

The default value of the thresholds must be OFF and not directional. Below are listed the tables that synthetized the calibration parameters of the phase overcurrent protection functions.

All the calibration tables are drawn up taking In = 500 A into account.

Table 27 – Inverse time settings			
		Range	Step
- I_p	0,04 In	0,02 ÷ 3 In	0,001 In
- T_p	0,12 s	0,02 ÷ 60 s	0,01 s

Table 28 – Angular sector settings			
		Range	Step
Bisector		0° - 360°	1°
Semi-amplitude		0 – 180°	1°

Table 29 – Base time		
	Start-up	Activation
Threshold 51/67.Sx	20 ms ± 3%	40 ms ± 3%

Table 30 – Independent time settings				
	I default	T default	Range	Step
Threshold 51/67.S1	0,04 In	0,12 s	0,02 - 3 In	0,02 In
Threshold 51/67.S2	0,72 In	1 s	0,02 - 3 In	0,02 In
Threshold 51/67.S3	2,8 In	0,25 s	0,02 - 3 In	0,02 In
Threshold 51/67.S4	1 In	0,05 s	0,02 - 3 In	0,02 In

Table 31 – Delay times settings			
		Range	Step
T_delay_67.Sx		0,05 – 200 s	0,01 s

The delay times must include the basic activation time. It must be possible to contract the intervention time of the 4 phase overcurrent thresholds, with a double calibration table 51 / 67 and 51_c / 67_c.

8.1.1.2. Accuracy of the measurements

Table 32 – Error settings	
Amperometric error	≤ 3% in the range 1 – 5A ≤ 1% in the range 5 - 50A. ≤ 0,2% in the range 50 – 550 A ≤ 3% 550 – 8800 A
Error limit variation	≤ 3%

Table 33 – Time errors	
Error limit	≤3%
Error limit variation	≤1,5%
Return time	≤100msec
Return ratio	≥0,90 and ≤ 0,95

8.1.2.Directional residual overcurrent protection 67N

The device must detect earth faults downstream of where it is installed for networks with the following grounding systems:

- insulated neutral;
- neutral grounded trough an inductor with in parallel a resistor;
- neutral grounded trough a resistor;
- neutral directly grounded
- neutral grounded using zig-zag transformer

In the case of pure grounding reactance, detection of single-phase faults occurs after intentional closing of a parallel resistor.

The activation and deactivation of the protection functions must be independently of the kind of the grounding system. The device must detect earth faults without requiring changes to the provisions from switching from one type of network to the other.

Directional earth protection must include three activation thresholds, 67N.S1, 67N.S2 and 67N.S3 (default, included) aimed at selecting single and dual-phase faults to earth: one for operating with a network with neutral to earth with impedance, the second with an isolated neutral, and the third for detecting double single-phase faults to earth. Faults to earth in networks with a simple earthing resistance, can be selected from both thresholds, depending on the resistance current value resulting from the resistance itself.

Each 67N threshold must be:

- Able to be set and deactivated individually, that is, when deactivated it must not produce the external trip command, but must work together for internal logics.
- Able to be set to independent time or dependent time (NIT, VIT, EIT curves).

When set to dependent time, the thresholds must conform to the logics indicated in IEC 60255 and already explained for the 67.S1 threshold. If inverse time operation is selected for the 67Ns, the default settings are listed below.

	Default setting **67N_S1**	**Default setting** **67N_S2**	**Default setting** **67N_S3**	**Range**	**Step**
Operation	Directional	Directional	Directional	Enabled/Disabled Directional No-directional	--
Type of curve	Normal Inverse	Normal Inverse	Normal Inverse	NI, VIT, EIT	--
I_p	3A	3A	3A	1 – 500 A (Primary values)	0,5 A

T_p	0,87 s	0,87 s	0,87 s	0,02 s ÷ 60 s	0,01 s
V_0	6 % Vn	2% Vn	1% Vn	1 ÷ 100% Vn	0,5 %
Intervention sector	60º - 250º Bis: 155° Semi-Ampl: 95°	60º - 120º Bis: 90° Semi-Ampl: 95	190º - 10º Bis: 280° Semi-Ampl: 90°	0º - 360º	1º

The output command must continue for as long as the fault conditions continue, with a minimum duration of 150 msec.

8.1.2.1. Setting parameters

Table 34 – Base times for independent time 67N

	Start-up	Activation
Threshold 67N.S1	20ms ±3%	150ms ±3%
Threshold 67N.S2	20ms ±3%	150ms ±3%
Threshold 67N.S3	20ms ±3%	70ms ±3%

Table 35 – Independent time 67N activation levels setting

	$3I_0$	$3V_0$	Activation sector	Notes
Threshold 67N.S1	1-20A (primary values) Default: 2A in steps of 0,5A	1-100%En Default 6%En in steps of 0,5%En	Default: 60° - 250° Settable from 0° - 360° in steps of 1°	The sector must be defined in dual sector and semi-amplitude
Threshold 67N.S2	1-20A (primary values) Default: 2A in steps of 0,5A	1-100%En Default 2%En in steps of 0,5%En	Default: 60° - 120° Settable from 0° - 360° in steps of 1°	The sector must be defined in dual sector and semi-amplitude
Threshold 67N.S3	1-600A (primary values) Default: 150A in steps of 0,5A	1-100%En Default 6%En in steps of 0,5%En	Default: 190° - 10° Settable from 0° - 360° in steps of 1°	The sector must be defined in dual sector and semi-amplitude

Figure 24 explains the activation sectors for the 67N, depending on whether or not the inversion logic input is present.

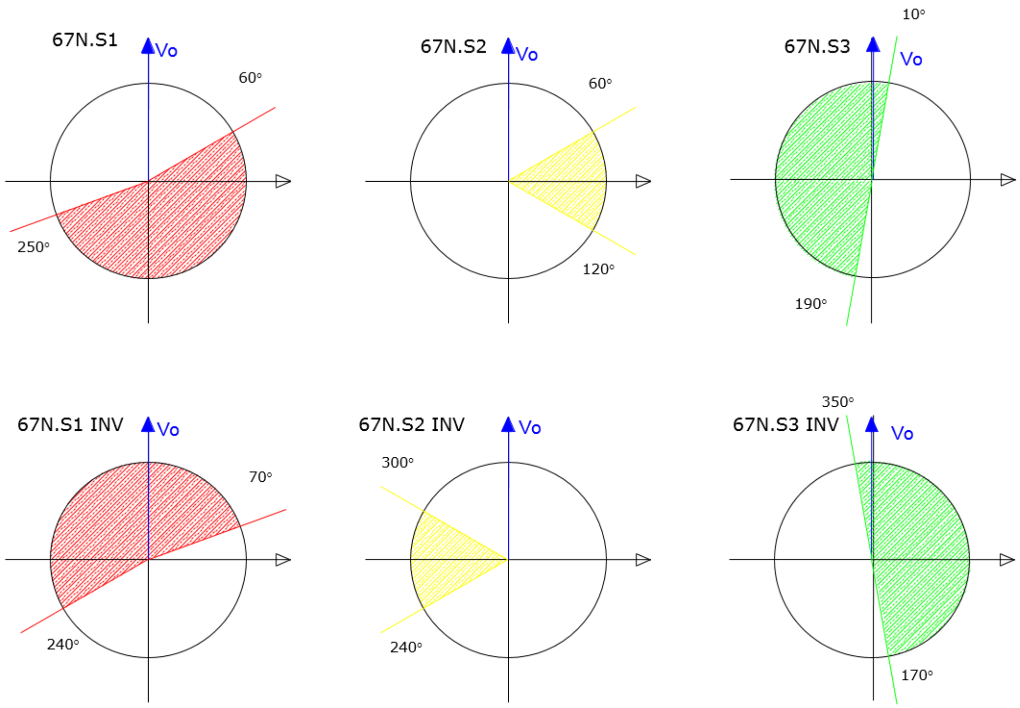

Figure 24 – Activation sectors for the directional fault to earth function

The activation sectors must be taken with Io as a reference in relation to Vo, or Vo in advance in relation to Io.

The effect of inversion must be that the activation sector is rotated through an angle of 180° (Figure 15).

Table 36 – Threshold 67N delay times setting			
	Default	Range	Step
T_del_67N.S1	1s	0,05 - 60s	0,05s in (0,05 -10) s 0,5s in (10-30) s
T_del_67N.S2	0,3s	0,05 - 60s	0,05s in (0,05 -10) s 0,5s in (10-30) s
T_del_67N.S3	0,1s	0,05 - 60s	0,05s in (0,05 -10) s 0,5s in (10-30) s

8.1.2.2. Accuracy of the measurements

Table 37 – Error settings	
Total error	amperometric ≤ 2% voltmetric ≤ 2%
Error limit variation	≤ 3%
Angle error	0,5°
Sector exit hysteresis	3°

Table 38 – Time errors	
Error limit	≤3%
Error limit variation	≤1,5%
Return time	≤100msec
Return ratio	≥0,90 and ≤ 0,95

8.1.2.1. RLS function

The RLS (Healthy Line Detection) function must be applied to all the tresholds of the protection function 67N. it must be enabled/disabled.

- The logic is based on the analysis of the first samples between 3Vo and 3Io at the beginning of the fault; when the instantaneous samples of both 3V0 and 3I0 are over the threshold, the triggering for the comparison will start;
- the number of the samples to be compared must be configurabile (odd number);
- Logic state must be 0 for healthy line;
- Logic state must be 1 for faulty line;
- if the samples are in phase opposition then the line will be faulty, otherwise it will be healthy, as shown in Figure 25.
- It must be provided a drop-off timer in order to maintain the logic state 1 if at least one of 3Vo and 3Io samples are below the threshold.

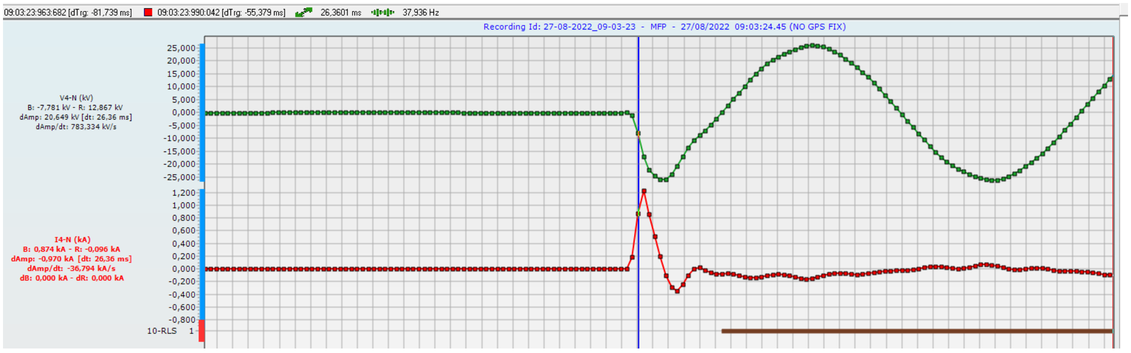

Figure 25 – Start of the single-phase fault on NC (compensated neutral) network

8.1.2.2. Directional intermittent earth arcs detection (67N.S4)

Directional earth protection must include a function that can be deactivated, for detecting the intermittent arcs (67N.S4) according to the principle logic indicated in Figure 26.

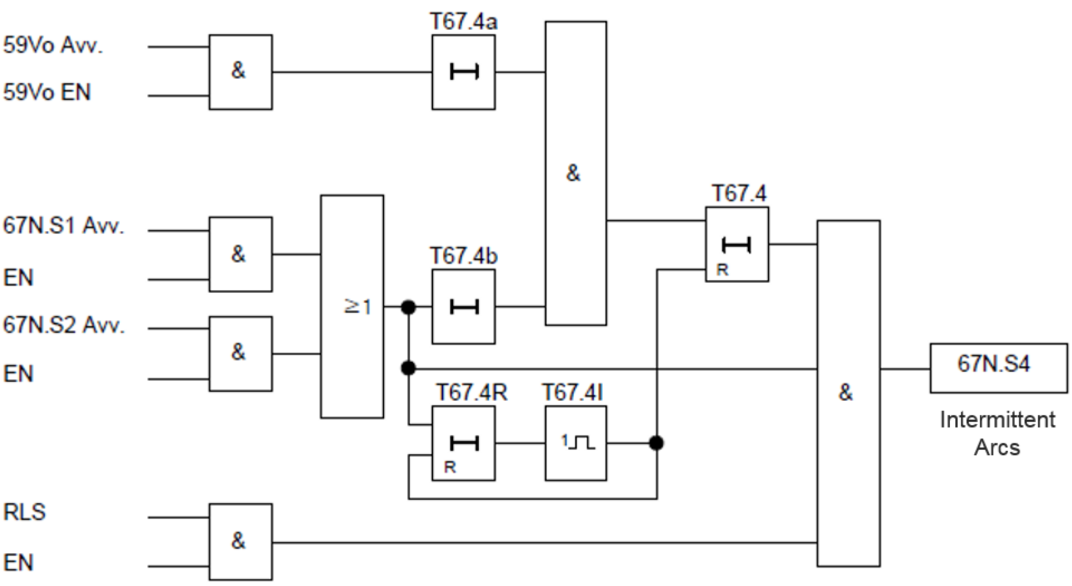

Figure 26 – Intermittent arc selection logic

Default parameters:

T67.4a = T67.4b =	0,1s
T67.4 =	10s
T67.4R =	9,5s
T67.4I =	0,02s

Table 39 – Time errors	
Error limit	≤3%
Error limit variation	≤1,5%
Return time	≤100msec
Return ratio	≥0,90 and ≤ 0,95

8.1.3. Residual overcurrent protection 51N

These thresholds can be inverse-time or independent-time. They must be enabled or disabled. They must be not directional and with the following setting parameters:

8.1.3.1. Setting parameters

Table 40 – Inverse time settings			
	Default 51N.S1	Range	Step
- I_p	0,04 In	0,02 ÷ 3 In	0,001 In
- T_p	0,12 s	0,02 ÷ 60 s	0,01 s

Table 41 – Base time		
	Start-up	Activation
Threshold 51N.Sx	20 ms ± 3%	40 ms ± 3%

Table 42 – Independent time settings			
	I_{trip}	Range	Step
Threshold 51N.S1	0,3 In	0,01 - 2 In	0,02 In
Threshold 51N.S2	1 In	0,01 - 2 In	0,02 In
Threshold 51N.S3	1 In	0,01 - 2 In	0,02 In

Table 43 – Delay times settings			
	Default	Range	Step
T_delay_51N.S1	0,15 s	0,05 - 60 s	0,01 s
T_delay_51N.S2	0,15 s	0,05 - 60 s	0,01 s
T_delay_51N.S3	0,15 s	0,05 - 60 s	0,01 s

NOTE: The delay times must include the basic activation time.

8.1.3.2. Accuracy of the measurements

Table 44 – Error settings	
Amperometric error	≤ 0,2% in the range 50 - 550 A. Over 550 A and up to 9 kA only tripping at the required activation time must be ensured, without a precision measurement.
Error limit variation	≤ 3%

Table 45 – Time errors	
Error limit	≤3%
Error limit variation	≤1,5%
Return time	≤100msec
Return ratio	≥0,90 and ≤ 0,95

8.1.4. Discrimination of INRUSH currents

In order to avoid untimely activations due to the transformers downstream of the device being energized, the device must block itself in relation to 51/51N and 67/67N threshold start-ups, when the second harmonic current (of any of the phases) exceeds the preset fraction of the basic current.

By means of the FFT, the function must compare the value for the 2nd harmonic with that of the threshold. If the value measured exceeds the threshold, it must block triggering for all the overcurrent (both phase and earth) protection function for the time set.

The logic must provide an OR for all phases, and it must be possible to deactivate the blocking function via the SW.

If, when the time set is exceeded, the overcurrent protection functions are still activates, even if the value of the 2nd harmonic is still higher than the threshold, the RGDM must recommence the normal protection logic and, where necessary, command triggering of the OdM.

8.1.4.1. Setting parameters

Table 46 – Activation threshold settings			
	Default	Range	Step
2ndH REST	25 % $I_{50\ Hz}$	10 – 50 % $I_{50\ Hz}$	5 %

Table 47 – Settings for blocking time T_ini_2ndH			
	Default	Range	Step
2ndH REST	450ms	50 – 3000ms	10ms

During blocking of the protection functions involved with the INRUSH currents, the related triggering timers must be reset.

8.1.4.2. Accuracy of the measurements

Table 48 – Error settings	
Total error	Amperometric ≤ 2%
Error limit variation	≤ 3%

Table 49 – Time errors	
Error limit	≤3%
Error limit variation	≤1,5%
Return time	≤100msec
Return ratio	≥0,90 and ≤ 0,95

8.1.5.Negative sequence overcurrent protection 46

The negative sequence overcurrent protection function IEEE 46 must be both dependent time and independent time mutually exclusive.

Two independent-time overcurrent stages with double time calibration must be provided. When configured, it should also be possible to convert to dependent-time according to IEC 60255 standard.

Table 50– Ind. Time 46 stages		
Standard Stages	**Accelerated Stages**	
46.S1	46.S1c	Independent time
46.S2	---	Reverse time IEC60255,

The IEEE 46 protection function, using the negative sequence current measurement function must be able to detect:

a. The two-phase faults at the ends of a relevant length line

b. Imbalances in powered loads

c. Inversion or breaking of the line conductors

The measurement function of the negative sequence overcurrent protection function IEEE 46 must seamlessly compare the related phasors with the corresponding calibration parameters described in **Table 52** set for both 46 stage. It must be provide two directional residual overcurrent thresholds, both time dependent and time independent, mutually exclusive, according to IEC 60255.

When a phasor is in the intervention sector, the following internal logical states occur:

Table 51– FdP 46 behavior				
FdP logical state	Displayed message	IEC 61850 Report to the RTU	Internal Logging	Disturbance recording
Start	46.Ax	Yes	Yes/No	Yes/No
Operate/Trip	46.Sx	Yes	Yes/No	Yes/No

If the measurement function of the phase overcurrent detects that the phasor left the tripping sector of one of the overcurrent stages, before the expiry of the tripping time, the protection must release.

8.1.5.1. Setting parameters

The stages must be settable according to the ranges indicated in the table beow.

Table 52– "46.x" setting parameters ranges							
Stage/Timers			**Operating mode**	**Start Current Value**		**Operate/Tripping Time**	
Stage	**Std.**	**Accelerated**		**Range**	**Step**	**Range**	**Step**
46.S1	T46.S1	T46.S1_c	Independent-Time	0,1÷5In	0,01In	0,1÷10 s 10÷100 s 100÷1000 s	0,01 s 0,1 s 1 s
46.S2	T46.S2	---	Inverse Time			Tp	

8.1.5.2. Accuracy of the measurements

For measurements accuracy, refer to the following prescriptions:

- Module Error ≤1% and Error limit variation ≤0,5%
- Times Error and Error limit variation in the measurement of the times according to the table below.

Table 53– – Accuracy of the intervention times for the negative sequence overcurrent 46

Description	Range	Time	Error limit	Error limit variation
Start time	I = (0,1÷5) x Ireg	≤ 1.5 cycles	≤ 0.25 cycles	1,5%± 0.25 cycles
Operate/Tripping time without intentional delay time	I = (0,1÷5) x Ireg	≤ 1.5 cycles	≤ 0.25 cycles	1,5%± 0.25 cycles
Reset time		≤ 1.5 cycles	≤ 0.25 cycles	1,5%
Reset ratio		≥ 0,90 e ≤ 0,95 x Ireg		1,5%
Overshoot time	(I=10xIreg)	≤ 2 cycles	≤ 0.25 cycles	1,5%± 0.25 cycles

8.1.5.3. Extension of protection function 46

This function can be configured to trip the circuit-breaker or just to send an alarm (without tripping the circuit-breaker). Due to a possible malfunction when loads are low, it must be possible to activate the following logic to avoid incorrect operations:

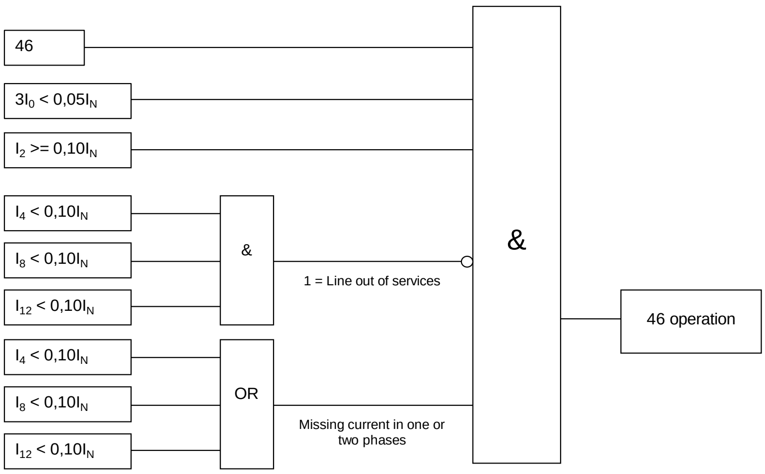

Figure 27 – Logical scheme: 46

Every level used in this logic can be set by the user. Other solutions will be subject to approval by Gridspertise.

8.1.6. Residual Overvoltage protection 59N

The device must include a 59N function, which can be associated with any relay or Vout. The measurement for 59N is provide by calculating the residual voltage as the vectorial sum of the three phase voltages at industrial frequency. The thresholds must be two:

- The first one, must be inverse or independent time
- The second one, must be independent.

Table 54 – 59N setting parameters		
Thresholds	Setting range	Step
59N1	From 0.01 - 1 Vn	0.01 Vn
59N2	From 0.01 – 1 Vn	0.01 Vn
59N delay time	From 1000 – 60000 ms	10 msec

8.1.7. Negative sequence Overvoltage protection 59Vi

The device must include a 59Vi function, which can be associated with any relay or Vout. The 59Vi measurement is provide from the calculation of the negative sequence voltage, as the vectorial calculation at industrial frequency of the three phase voltages measured.

Table 55 – 59Vi setting parameters		
Thresholds	Setting range	Step
59Vi	From 0.01 – 1.3 Vn	0.01 Vn
59Vi delay time	From 1000 – 60000 ms	10 msec

8.1.8. Overvoltage detection protection function (ES59B)

The overvoltage detection/supervision function ES59B is used for lines with connected co-generation plants. This function is just a supervision of the voltage on the line; if the function is in service, by settings, because there's a cogenerator connected downstream the RGDM. In case the cogenerator has disconnected (tripped by its protections), the line won't have voltage and the reclose attempts will be performed.

In case, the cogenerator is still connected, the reclose won't send closing order to the breaker (no recloser attempt when voltage on the line).

8.1.8.1. Protection behavior

This function can be Enabled and Disabled via SW configuration and inhibited by a Digital Input. The RGDM will assume that the protection is in service if the Digital Input is activated, and out of service when the Digital Input is deactivated.

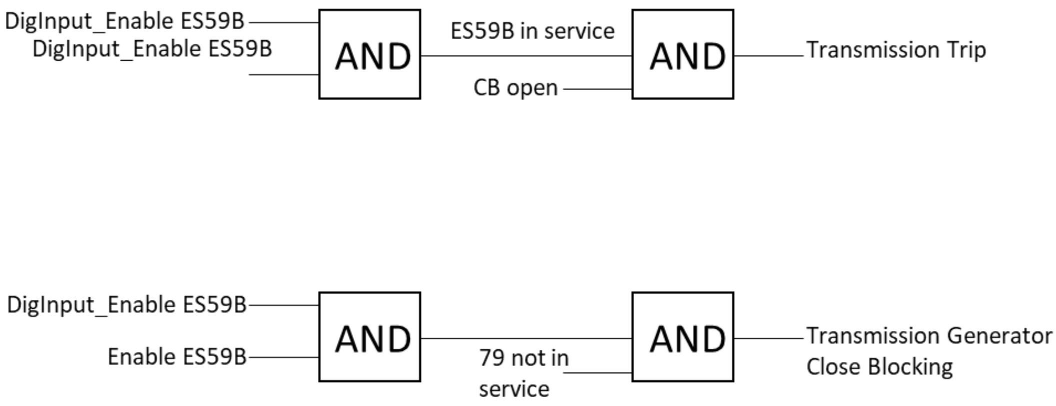

Figure 28 – Self producer cogeneration automatism

The ES59B protection performs also the following functions:

- Supervision of the line voltage to determine the operation of the self-producer user, when the breaker is opened,
- Block all attempts at closing the circuit-breaker according to the voltage presence on the line,
- Emission of the trip signal via communications (IEC61850-GOOSE) RGDM downstream. When the circuit-breaker is disconnected and ES59B is in service this Digital Output will be activated;
- Emission of the tele-blocking signal via communications (IEC61850-GOOSE) RGDM downstream. When the auto-reclosing automatism is out of service and ES59B is in service this Digital Output will be activated. Teleblock sending (maintained) is checked in case the 79 function is inhibited, in whenever of the following cases:
    - 79 function out of service by parameters (settings) and front button in RGDM in ON position
    - 79 function blocked by local operator: 79 in service by settings and front button in RGDM in OFF position
    - 79 function inhibited by remote command: 79 in service by settings, front button in RGDM in ON position and last command from Control Center Operator 79 OFF.

Table 56 – FdP ES59B behavior				
FdP logical state	Displayed message	IEC 61850 Report to the RTU	Internal Logging	Disturbance recording
Operate/Trip	ES59B.Sx	Yes	Yes/No	Yes/No

8.1.8.2. Setting Parameters

The stages must be settable according to the ranges indicated in the following table.

Table 57 – "ES59B" setting parameters ranges

Stage/Timers		Start Voltage Value		Operate/Tripping Time	
Stage	Std.	Range	Step	Range	Step
ES59B.X	TES59B.X	0,00÷1 Vn	0,01	0,05÷10 s 10÷100 s 100÷1000 s	0,01 s 0,1 s 1 s

8.1.9.Voltage detection function (RVL)

The RGDM device must be able to indicate voltage presence/absence on MV line (RVL signal), based on the following output signal logic:

- 0: Power Off
- 1: Power On

Changes between these two logic states are regulated by the diagram shown in Figure 29, in which the values shown are an example.

It must be possible to configure this function. shows the configuration parameters, whereas the power on/off on the LEDs must still be associated with the instantaneous start-up function.

Table 58 – Configuration parameters

Label	Setting range	UM
Power On enabling	ON/OFF	Track
Threshold UL>	0,5 – 1,1	Vn
Intentional delay UL> Ton	0,05 - 10	s
Threshold UL<	0,1 – 0,4	Vn
Intentional delay UL< Toff	0,05 - 10	s
Power On relay	K1/K2/K3/K4/K5	

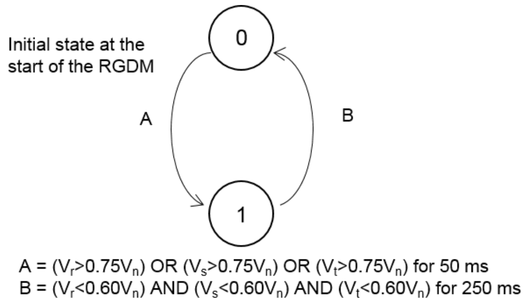

Figure 29 – Voltage On/Off function automation

A delay has been introduced for condition (B) in order to avoid Power Off being indicated in the event of:

- Waiting time for rapid re-closing.
- Voltage gaps "near" the RGDM.

Figure 30 shows an example that illustrates the functioning mode described above.

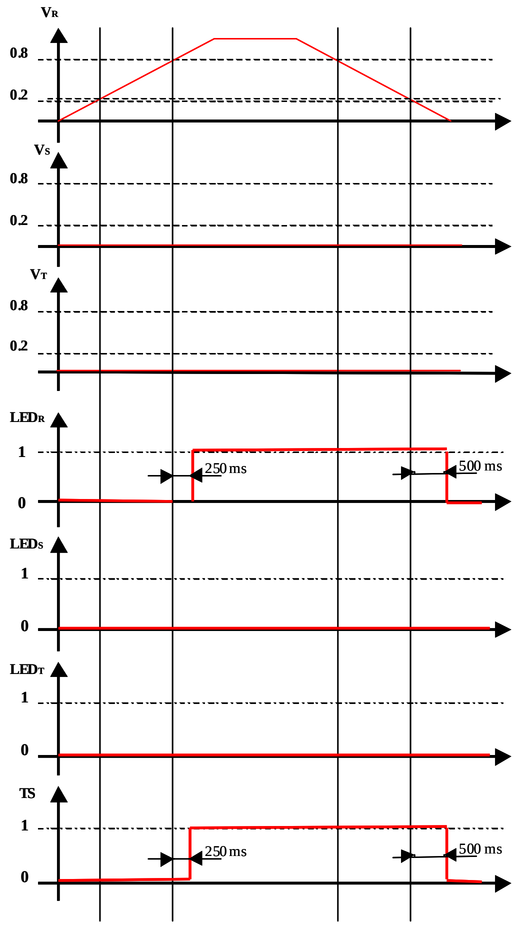

Figure 30 – Example of functioning of the Voltage On/Off logic

8.1.9.1. Accuracy of the measurements

Table 59 – Error settings	
Total voltmetric error	≤ 2% in the range 2% ÷ 190% Vn ≤ 0,5% in the range 80% ÷ 120% Vn
Error limit variation	≤ 3%

Table 60 – Time errors	
Error limit	≤3%
Error limit variation	≤1,5%
Return time	≤100msec
Return ratio	≥0,90 and ≤ 0,95

8.1.10. Frequency protection EAC

The frequency measurement must be performed on the three phase voltages monitored by the device.

8.1.10.1. EAC blocking stages

The function must be equipped with blocking stages that guarantee the reliability of the measurements and the correct behavior of the protections. The blocking stages are able to inhibit the operations based on the frequency measurement.

8.1.10.2. Undervoltage and overvoltage blocking stages

The three (V4, V8, V12) voltages must be monitored to support the operation of the device; if one falls below or rises above the preset minimum and maximum voltage thresholds respectively, the operation of all the tripping stages will be inhibited. This blocking stage must have two timers:

- Stage activation delay,
- Stage reset delay.

Table 61 – "Under/overvoltage blocking stages" setting parameters ranges

		Blocking settings		Blocking Time	
Stage	Active State	Range	Step	Range	Step
27	Ena/Dis	0 ÷ 1.4 Vn	0,05 Vn	0 ÷ 60 s	0,05 s
59	Ena/Dis	0 ÷ 1.4 Vn	0,05 Vn	0 ÷ 60 s	0,05 s

Table 62 – Accuracy of the intervention times for the "Under/overvoltage blocking stages"

Stage	Measurement Accuracy	Minimum intervention Time	Time measurement error
27	0,01 Vn	±50 ms	±50 ms
59	0,01 Vn	±50 ms	±50 ms

8.1.10.3. Maximum unbalance β blocking stage

It is required to implement stages based on the maximum difference between the magnitude of the single monitored voltages and their average value in order preclude the operation of the RGDM in case of unbalanced voltages.

The unbalance stage must have a reset delay time. This stage inhibits the operation of all tripping stages when the β ratio goes above a set value which value is so calculated as follows:

μ = (V4+V8+V12) / 3

$$\beta = \frac{\max[abs(V4-\mu); abs(V8-\mu); abs(V12-\mu)]}{\mu}$$

Table 63 – "β blocking stage" setting parameters ranges					
		Blocking settings		Blocking Time	
Stage	Active State	Range	Step	Range	Step
β	Ena/Dis	0,05 ÷ 1	0,05	0 ÷ 60 s	0,05 s

Table 64 – Accuracy for the intervention times for the "β blocking stage"			
Stage	Measurement Accuracy	Minimum intervention Time	Time measurement error
β	0,01 Vn	±50 ms	±50 ms

8.1.10.4. Max frequency difference γ blocking stage

This stage inhibits the operation of all the tripping stages when the maximum difference between the recorded frequencies of the monitored signals exceeds the preset γ value. The Max frequency difference blocking threshold must have a reset delay time.

γ = max ((frequency V_4 – frequency V_8); (frequency V_8 – frequency V_{12}); (frequency V_{12} – frequency V_4))

Table 65 – "γ blocking stage" setting parameters ranges					
		Blocking settings		Blocking Time	
Stage	Active State	Range	Step	Range	Step
γ	Ena/Dis	10 ÷ 100 mHz	0,10 mHz	0 ÷ 60 s	0,05 s

Table 66 – Accuracy for the intervention times for the "γ blocking stage"			
Stage	Measurement Accuracy	Minimum intervention Time	Time measurement error
γ	10 mHz	≤100 ms (4 cycles)	±50 ms

8.1.10.5. Maximum variation allowed between consecutive periods Maxdt blocking stage

The Maxdt blocking stage uses the following mechanism to inhibit the frequency measurements:

a. When Δt is greater than a value pre-set via the configuration SW (range 100÷7000 μs) it detects a perturbation on the phase and blocks the frequency (tripping) stages and the rate of change of frequency (tripping) stages,

b. EAC continue to measures the cycles and compare the last one with the second-last; only when Δt falls below the pre-set value via the configuration SW the perturbation on the phase is over and the frequency measurement must be re-established,

c. to restart and pass the frequency and the rate of change of frequency measurements to the (tripping) stages, it must properly fill the memories of the moving average (e.g. if N is the number of the cycles of the average calculation, then the frequency will be available after N cycles and the rate of change of frequency after N+N).

8.1.10.6. EAC tripping stages

The EAC will implement under frequency, over frequency and rate of change of frequency protection functions. These can be simultaneously/selectively enabled and can send the trip command towards the controlled circuit-breaker. The setting parameters ranges are specified in the Table 67 and Table 68, where the operating time are measured in a sliding temporal window of 5 cycles.

Table 67 – "Under/over frequency stages" setting parameters ranges					
stages settings			Operation Time		
Active State	Range	Step	Range	Step	cycles
Ena/Dis	0.9fn ÷ 1.1fn Hz	0,0002fn Hz	0 ÷ 3000 cycles	0,5 cycles	5 cycles

Table 68 – "Rate of change of frequency stages" setting parameters ranges					
stages settings			Operation Time		
Active State	Range	Step	Range	Step	cycles
Ena/Dis	±(0,1÷ 10) Hz/s	0,01 Hz/s	0 ÷ 3000 cycles	0,5 cycles	5 cycles

8.1.10.7. Frequency and voltage measurements

The frequency and voltage measurements must refer to the fundamental component and to the effective value. Suitable filtering systems must ensure the measured values are unaffected by any electromagnetic disturbances.

The frequency and rate of change of frequency measurements must be carried out with the required accuracy in the 45 - 65 Hz operating range, for voltage values 0.3 times greater than the rated one.

The voltage measurements must be carried out with the required accuracy in the 45 - 65 Hz operating range, for values from 0 to 1.4 times greater than the rated one. In the case of signals with a THD<10% the frequency measurements must be adjusted.

The frequency stages must be immune to the most common transients on the HV grid and GridSpertise will provide the related digital recordings (transformers energization, lines reclosing, short-circuits).

Note that the RGDM must base the frequency measurement by measuring the time between two zero crossings of a period and summing the N measured intervals, with N = number of periods to be integrated.

It is necessary that the number of samples used per period be sufficiently dense to approximate the curve between two consecutive samples by a straight-line segment. This means that the errors inserted in the time measurement between the zero-crossing and the sample position must be compensated by means of linear interpolation.

The manufacturer must clearly indicate the methodology and the calculation algorithm implemented in the RGDM (including also algorithms based on moving averages, sampling frequency, number of processed samples and the filtering systems) for making the following measurements:

- Frequency,
- Rate of change of the frequency,
- Voltage,
- Rate of change of the voltage.

8.1.10.8. EAC Function

The EAC function is made up of two protection stages based on EQUATION below and must be activated upon detecting the sign of active power.

The operation of the stages will be communicated according to the IEC 61850 series and must be associated with Vout virtual outputs.

EQUATION 1

$$81\_S_x = (((f_{x1} and \frac{df}{dt}) and (ON/OFF)) or (f_{x2} and (ON/OFF)) and seg\{\overline{P}\})$$

GridSpertise will provide the details for the implementation of the EAC FdP during the development phase.

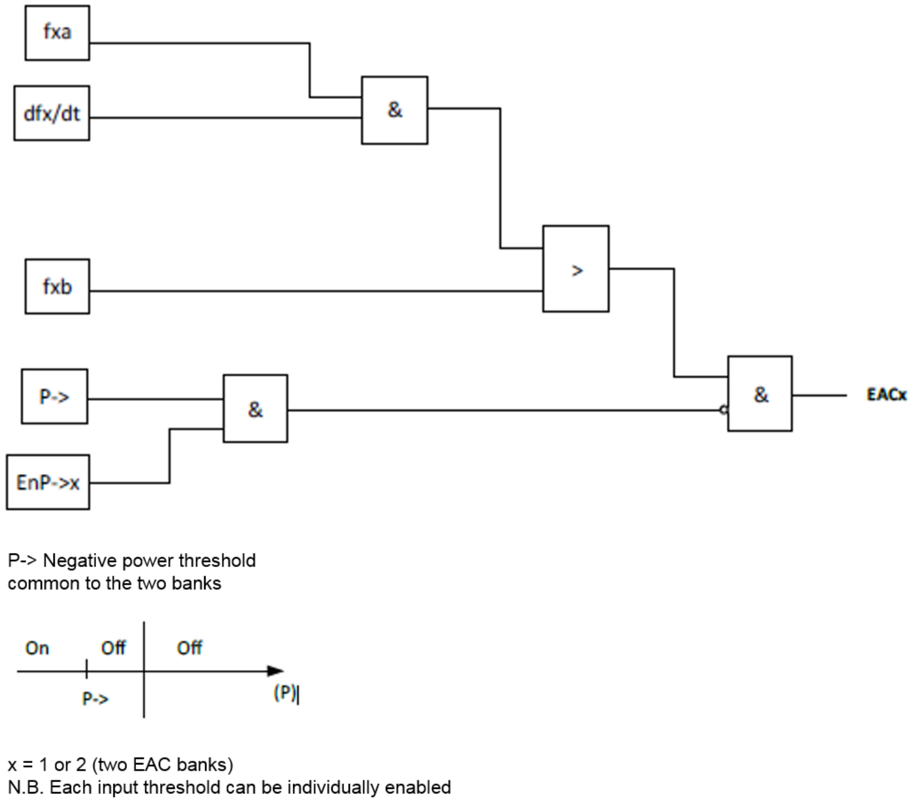

Figure 31 – EAC Logic

8.1.11. Directional Maximum Active Power 32P

The device must detect the maximum active power passing through the node it monitors. It must be possible to deactivate this function when the default state is deactivated.

The threshold must work in three different ways:

- Taking a positive direction of P as an activation reference.
- Taking a negative direction of P as an activation reference.
- Taking only the P modulus as an activation reference.

For each of these three modes, it must be possible to set three different reactions, if the threshold is exceeded:

- Only indication to the centre.
- Sending of an alarm signal to the centre and one for a reduction in active power to the generation unit monitored; if the 32P threshold continues to be exceeded for a period of time equal to 30 sec, the RGDM sends the trip command to the OdM.
- Trip command to the OdM and related indication.

The default operating mode must be d., whereas the reference direction must be a.

8.1.11.1. Setting parameters

Table 69 – Base times		
	Start-up	Activation
Threshold 32P.S1	50 ms ± 3%	150 ms ± 3%

Table 70 – Activation level settings			
	Default	Range	Step
Threshold 32P.S1	20 MW	0 – 30 MW	0.1 MW

Table 71 – Activation threshold settings		
	Default	Range
Threshold 32P.S1	Positive	Positive / Negative / Absolute

Table 72 – Delay times settings			
	Default	Range	Step
Delay time	30s	0 – 100s	0,01s
Delay time for the reset value	0s	0 – 100s	0,01s

The positive activation threshold is taken to be that in which the active component (I_d) of the current is in phase with the reference voltage (Figure 32).

The negative activation threshold is taken to be that in which the active component is opposite to the phase with the reference voltage (Figure 32).

The direction of the current is taken to be positive, when it comes out of the secondary sub-station towards the user, and negative when entering the secondary sub-station from the generator.

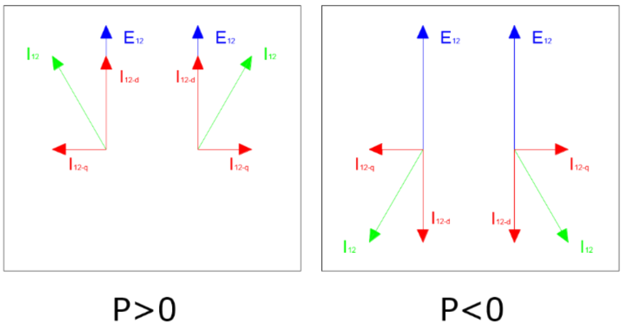

Figure 32 – Definition of power directions

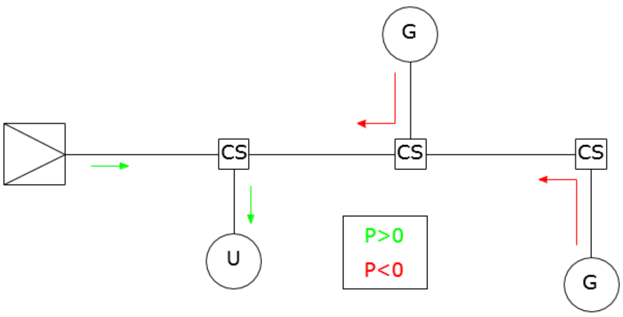

Figure 33 – Power direction convention

8.1.11.2. Accuracy of the measurements

Table 73 – Error settings	
Total error	Voltmetric ≤ 2% Amperometric ≤ 2%
Error limit variation	≤ 3%
Angle error	±2°
Sector exit hysteresis	3°

Table 74 – Time errors	
Error limit	≤3%
Error limit variation	≤1,5%
Return time	≤100msec
Return ratio	≥0,90 and ≤ 0,95

8.1.12. Automatic Re-Closing Function (ARF)

This function is normally managed by the UP/Primary RTU, however, it must be possible to enable the automatic re-closing function for local use, and only when the RGDM is in extended configuration.

Configuration of the automatic re-closing function via the RGDM, must require programming of a series of timers, presented briefly in Table 75 and set in terms of default values, increment steps, and admissible range. A brief description is also given of the role of each of these timers.

Each re-closing must occur when the power is on upstream (high RVS signal). It must be possible to ignore this parameter, by means of software exclusion.

After triggering, that result in opening of a switch, the absence of RVS inhibits the re-closing cycle.

When the reclosing of the switch is executed, the TN timer is started. The expiration of TN occurs if in closed state, no faults are detected within the TN period. When TN expires the re-closing cycle is cancelled definitively. If, however, the RVS signal is reinstated during the TN, the re-closing cycle must be started up.

Table 75 – Legends of the timers used for the automatic re-closing function

Timer name	Default value	Increment	Range	Description
TRR	600 ms	10 ms	100 – 5000 ms	Waiting time for rapid re-closing.
TRL	30 s	1 s	0 - 200 s	Waiting time for slow re-closing.
TN	70 s	1 s	5 - 200 s	Neutralization time
TD1	0 s	1 s	0 - 10 s	Discrimination time for slow re-closing.
TD2	5 s	1 s	0 - 10 s	Saved discrimination time for re-closing.

The following error limitations must be respected for each timer:

- Time error limit ≤3%±20ms
- Error limit variations ≤2%± 10ms

8.1.12.1. Re-closing programs

It must be possible to use local or remote configuration to select whether to enable the **automatic re-closing program function via the RGDM.**

If the **automatic re-closing program function via the RGDM** is enabled, this must be further configured, with one of the following possible programs:

- RR: Rapid re-closing ON/OFF
- RR+RL: Slow re-closing ON/OFF
- RR+RL+RM: Saved re-closing ON/OFF

This choice can be made both via the local and via the remote configuration device.

Selection of the RR program must not allow the number of re-closings to be carried out (on the configuration device). It is taken as given that the number of RRs us equal to one and other re-closings must not be done.

Selection of the RR+RL program must provide for an RR cycle, followed by a second RL re-closing cycle.

Selection of the RR+RL+RM program must allow personalization of the number of saved re-closing to be done after the two RR and RL cycles, as described in Table 76.

Table 76 – Legends of the Configuration possibilities for RR + RL program re-closings	
	Configurable number of re-closings
Rapid re-closing (RR)	1 (non editable)
Slow re-closing (RL)	1 (non editable)
Saved re-closing (RM)	0, 1, 2, 3

Automatic re-closing must be started after the MV RMU switches to the open, due to the emission of the command and triggering signal by the RGDM.

The RGDM must apply the re-closing sequence programmed by the switch that has opened, due to activation of the thresholds 67.S1 (51.S1), 67.S2 (51.S2), 67.S3 (51.S3), 67.S4 (51.S4), 67N.S1, 67N.S2, 67N.S3, 67N.S4, 51N.S1, 51N.S2, 59N.S1 and 59N.

8.1.12.2. Functioning when the re-closing program is not configured

When the RGDM detects activation conditions in relation to one of the thresholds 67.S1 (51.S1), 67.S2 (51.S2), 67.S3 (51.S3), 67.S4 (51.S4), 67N.S1, 67N.S2, 67N.S3, 67N.S4, 51N.S1, 51N.S2, 59N.S1, 59N.and the automatic re-closing program is not configured, it must send the triggering command to the MV RMU causing definitive opening. The FR signal must also be emitted, using the IEC 61850 protocol.

8.1.12.3. Rapid re-closing program (RR)

Rapid re-closing (RR) must be done when the switch is activated and opens due to one of the FdP’s thresholds triggering it.

Once the rapid re-closing command has been emitted, the RGDM must start the timer, TN. Thereafter, if:

- A new fault detection occurs within the TN, a triggering command/signal must be emitted to the MV RMU, and indication of failed FR re-closing must be enabled.
- No fault is detected within the TN, the re-closing cycle automation must go back into stand-by mode.

Manual or remote control closing of the switch, using the program provided in RR, must start the TN. Any triggering during this time frame must result in emission of the opening command for the MV RMU, in the basic time, without re-closing, and the indication of failed FR re-closing must be enabled.

8.1.12.4. Rapid + Slow + Saved (RR+RL+RM) program

Once the trigger command/signal has been emitted to the MV RMU, rapid closing must be activated, and the neutralization time TN must be started.

If no new triggering occurs within TN, the RGDM must go back to stand-by mode.

If, during TN a new trigger is activated in relation to one of the FdP thresholds, the TRL time must be started, at the end of which slow re-closing (RL) must be carried out. Once the resulting closing of the switch has occurred, the following must be started:

- Discrimination time TD1
- Neutralization time TN

In the case of a MIXED line, TD1 = 0; if the fault recurs immediately, a new not definitive trigger must be activated, after the waiting time for the first saved re-closing.

In the case of a line deemed to be CABLE, TD1 = 5; if the fault recurs within the TD1 time, a new not definitive trigger must be activated, with FR signaling.

In the case of a MIXED line, if a fault occurs within TN, opening of the switch must be commanded, and subsequent saved re-closing RM must be done when TN expires. For each subsequent saved re-closing, timers TN and TD2 must be started. If a fault occurs within TN, but after TD2, opening of the switch must be commanded, and subsequent saved re-closing RM is done when TN expires. If, on the other hand, the fault is detected within time TD2, a definitive trigger is activated, with indication of failed FR re-closing.

[*] In the case of a CABLE line, if a fault occurs within TN, but after TD1, opening of the switch must be commanded, and subsequent saved re-closing RM is done when TN expires. If, on the other hand, the fault is detected within time TD1, a definitive trigger is activated, with indication of failed FR re-closing.

This step [*] is repeated for the number of saved re-closings configures, using TD2 in place of TD1.

After a definitive trigger, any voluntary closing (local or remote) must start TN. If no trigger condition occurs within T, the automation goes back to stand-by mode, and the device is ready to carry out a new cycle.

8.1.12.5. Common function of the RR and RR+RL programs

The voluntary closing commands must reset the memory registers of the counter for saved closings.

Manual or remote control opening must always result in the automation going to stand-by mode, with definitive interruption of any re-closing cycle in progress.

It must be possible to indicate the cause of the failed re-closing, by correlating the indications, in order to make the failed re-closing information available in MMI / events register and 61850 messages.

The non-volatile memory must have a totalizator for the number of automatic (RR. RL, RM) re-closings done, and the number of failed re-closings (FR).

Remote commands must be provided, conveyed using the IEC protocol for inclusion (INCL) or exclusion (ESCL) of the re-closing function.

Execution of re-closing must only occur if all the conditions indicated below are true simultaneously (Figure 34):

- Re-closing program enabled via software (RR or RR+RL)
- Bistable relay in re-closing included position.
- The last remote enabling command for Re-closing was “INCL”.

If even just one of these conditions is false, the device will not carry out any re-closing.

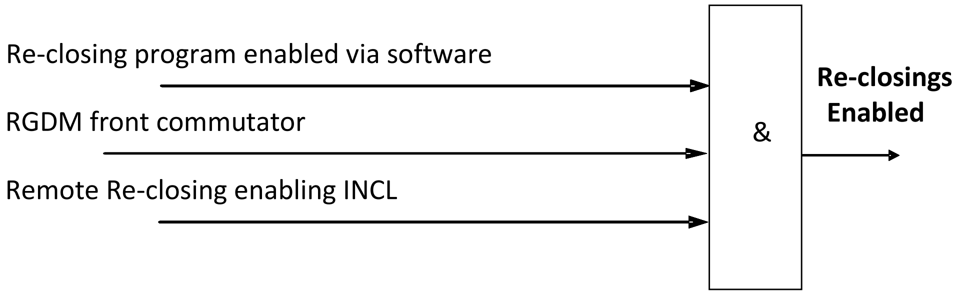

Figure 34 – Re-closing enabling logic

The automatic reclosing function must inhibit the closing if, following a manual closing, a fault occurs inside a control time window defined by the TDCM parameter.

A manual closing will trigger the TN, for the faults check while TN is active and the TDCM has expired, the automatic reclosing function will perform the first closing after the TRL expiration and then, according to the settings, the subsequent ones.

A (settable) recovery time is needed to consider the auto-reclosing cycle as finished. After this time expires, a trip will activate again a complete auto-reclosing cycle.

After a manual closing, the automatic reclosing function will be inhibited for a selectable time. After this time expires, the automatic reclosing function will be ready to operate in case there’s no other blocking condition

The status of reclosing included/excluded must be maintained in case of shutdown and subsequent restart of the device.

In addition to the automatic Re-closing functions available in the Figure 34 two inputs are required for Inclusion / Exclusion of Re-closing. It must be possible to configure these inputs on both physical and virtual inputs.

8.1.13. Automatic Parallel Function (Synchro-check IEEE 25)

Closing of the switch served by the RGDM, with a local or remote control, must be possible in one of the alternative ways, that can be selected using the SW parameter.

- Without checks of line voltages (downstream of the switch) and reference voltages (upstream of the switch).
- With checks if the line and reference voltages are in parallel.

In the former case, the command received will always be transmitted to the switch directly. In the second case, the command must set the time δ_{TRCM}, and check that the line and reference voltages are in place, after which the second parallel condition must be checked, as described below.

The δ_{TRCM} (hereinafter T) is a discrimination time, during which the synchronizer checks the synchronism status of the two networks. If, on expiry of this time, the parallel conditions are no longer in place, the device must reset the synchronism requests, until a new closing command is emitted.

Closing of the switch will always be allowed, in the absence of one or both of the voltages checked (line and reference).

For this function, the phase voltage must be used, the SW makes it possible to select which of the line voltages (V_4 V_8 V_{12}) must be closed, and a corresponding reference voltage taken upstream of the switch.

There are 2 modes in which this function must emit a closing command:

- Synchronous mode (PS)
- Asynchronous mode (PA)

It must be possible to select the two modes separately or jointly (PS or PA or PS + PA), independently, for Voluntary Manual Closing and for Automatic Slow Re-closing, according to the diagram below.

Voluntary Closing:

- PS (parallel synchronous)
- PA (parallel asynchronous)
- PS + PA

Automatic Slow Re-closing:

- PS (parallel synchronous)
- PA (parallel asynchronous)
- PS + PA

When this parallel check function is enabled, but is unavailable due to the absence of the parallel conditions, the UP/LAT must not emit any closing command (voluntary or automatic).

Inclusion / exclusion of the parallel check must be provided for, by configuring the programming parameters, and by means of commands sent using the IEC 61850 protocol.

8.1.13.1. Checking of parallel conditions between synchronous networks (PS)

This function is provided to connect two networks characterized by synchronous conditions, or by a very small shifting defined as the percentage difference between the line voltage frequency and the reference voltage frequency.

The very low shifting condition must be defined, according to the following condition:

- Shifting: ISI< S_{sin}

Evaluation of the shifitng must be done by means of suitable filtration, in order to introduce sufficient attenuation of the component related to stable electromagnetic oscillations of the networks, which could obstruct recognition of the synchronous situation. The electromagnetic oscillations have the following characteristics:

- $\omega_E = 5 \div 10\ s^{-1}$
- $\Delta f_E = \pm 0.1\%$

Therefore, a filter is required on the frequency measurement, with integration times ≥ 2s.

When synchronous conditions are checked, a time T is assigned during which, in addition to shifting, the following are also checked:

- Value of the difference between the line and reference voltage modules, lower than a maximum value ΔV_{sin}
- Value of the phase difference between the line and reference voltages, less than a maximum value of $\Delta\varphi$

Where the reference voltage is a voltage upstream of the switch to be closed, which is occurs on the MV terminals of the RGDM.

The regulation ranges for checking asynchronous parallel, are as follows:

Quantity	**Range**	**Step**
Voltage module difference (ΔV_{sin}) [% Vn]	5 ÷ 40	1
Phase difference between the voltages ($\Delta\varphi$) [°]	0 ÷ 60	1
Shifting (S_{sin}) [% fn]	0 ÷ 0,2	0,05
discrimination time δ_{TRCM} [s]	0÷600	1

8.1.13.2. Checking of parallel conditions between asynchronous networks (PA)

The quantities to be checked in order to emit a close command between asynchronous networks, must be:

- Phase angle between the line and the reference voltage decreasing: $d\varphi/dt < 0$
- Shifting less than a maximum shifting of S_{asin}
- Difference between the line and reference voltage modules, lower than a maximum value $\Delta Vasin$
- Shifting acceleration between the line and reference voltage frequencies, $(dS/dt) < dS_{asin}/dt$ on completion of evaluation of the shifting constancy. The acceleration limit value is: $dS_{asin}/dt = 0.01*(0.5-Ta)$

When these conditions are in place, the device must determine the advance time (Ta) for emitting the closing command, in relation to the closing time for the switch and the shifting, so that closing occurs when the line and reference voltages are almost in phase with each other.

The regulation ranges for checking asynchronous parallel between the networks, are as follows:

Quantity	Range	Step
Voltage module difference (ΔV_{asin}) [% Vn]	5 ÷ 40	1
Shifting (S_{asin}) [% fn]	0 ÷ 0,2	0,05
Advance time (Ta) [ms]	0 ÷ 200	1

The advance time Ta must be evaluated in the field by the RGDM, by means of a counter than measures the delay between the command given and the actual change of state of the limit switch. This measurement must be included in those for diagnosing the device.

8.1.14. Cold Load Pick Up function

Every FdP must be according to the Cold Load Pik Up (CLP) function. The Cold Load Pickup function must have two different operation mode. The first one, the pickup value of the 51 function must be equal a user defined parameter during a configurable time. The second mode, the 51 function must follow a specific curve during a configurable time. The kind of curve could be time defined or inverse time (IEC and ANSI Curves as specified). The CLP has following characteristics:

- The CLP function must be Enabled/Disabled inside the FdP
- The CLP function is activated when the circuit-breaker switch from open to close
- It must be possible closing or changing the intervention value of the protection for a settable duration time
- When the function is blocked, it maintains the delay time at 0s and continue to return the start-up stage of the FdP.

8.1.15. Breaker Failure function

The breaker failure function consist of two overcurrent directionless function, one for poly-phase faults and other for single-phase faults. The function is used to signal the lack of opening of the circuit breaker.

The main features are:

- The function must be Enabled/Disabled,
- It must be associable with an OR matrix to the protection functions to be monitored,
- The function is activated at the trigger command of the associated protections in the matrix,
- If the protection functions activated do not fall within the set time, a relay or a virtual output associable via SW must be command.

8.1.16. Skip Shot function

This function is used to reduce the recloses attempts in case of high level of fault currents, which minimize stress or damage to substation transformer, underground cables, jumpers or connections cables of the feeder. Another benefit is the optimization of fault location for such defect levels, that only occur in stretches next substation.

Its operation consists of acting/trip instantaneously if the magnitude of the fault current reaches a preset value, in the sequence, the RGDM can jump reclose attempt according to a predetermined setting, regardless of the function 79.

This function must be a function embedded by the manufacturer, with parameters bellow adjustable:

- Number of jumps of reclosing according to reclosing sequence (79);
- Pickup of current (A) to phase-phase and phase-ground;

The functionality shall be enabled or disabled and the following parameters shall be configured:

Table 77 – Configurable Parameters for the 79 Skip-Shot Autoreclose Blocking Function

79 SK enabling	OFF, ON
79 SK Current fault intensity thresholds	500 – 20000 A
Number of jumps of reclosing	0 up to 3 jumps, default 2 when it is set to 0, the IED will perform all the cycles. If for example the jump value is set to 1, It will skip one of the reclosing stages (the first one) and it will then perform all the other cycles If for example the jump value is set to 2, It will skip the first one and the second one reclosing stage, and it will then perform the last one.
Selection of Protection Functions	Es. 51,51N,67,67N etc…

8.1.17. Broken Conductor I2/I1 function

The broker conductor (phase interruption) function is based on exceeding of the ratio between the negative sequence current and direct sequence current.

The main features are:

- The function must be Enabled/Disabled
- The function must have a overcurrent threshold; after which the I2/I1 is active
- The function must have a discrimination current threshold, under this the function is inhibited

- If the I2 / I1 exceeds the set threshold, it must be able to activate a relay or a virtual output or both to send its status.
- A time defined setting with a range 0 to 60 seconds and step 0,1 seconds;
- A positive sequence voltage threshold that will avoid the operation for phase-to-phase short-circuits,
- with range 0 to 0.9 Vn and step 0.01.
- A zero sequence voltage threshold that will avoid the operation for phase-to-ground short-circuits, with range 0.1 to 1.3 Vn and step 0.01.

8.1.18. Hot Line Tag function

This function activates more sensitive overcurrent protection elements than your currently settings on the normal sequence reclosing, due to security purposes in the case of services in energized networks carried out by crews. Therefore, RGDM must allow dedicated overcurrent settings 50/50N and 51/51N (with the possibility of choosing time-current curves) with automatic reclose function (79) blocked.

When the equipment is in local mode, this function can only be enabled or disabled by the dedicated physical button (independent of the physical button of the reclosing function) on front panel of RGDM, and when in remote mode this function can only be enabled or disabled through the software or by means of a dedicated DNP3 command.

It should be noted that the hot-line-tag function differs from that of only blocking the reclosing because the latter remains with the overcurrent settings of the first operation of the reclosing sequence, which is used to maneuver the equipment into the system.

8.1.1.Cycle direction checking function (ANSI 47)

The device must have a function that uses the display and SW to indicate whether the three voltages connected to the RGDM is activated in the direct cyclical direction.

If the three voltages are activated in the inverse cycle direction, the RGDM must block the directional protection functions, and notify the operator via the display.

The function set up is an ANSI 47 protection system, that uses a triad of voltages to measure the direct sequence voltage (positive sequence U1) and the inverse sequence voltage (negative sequence U2).M

Table 78 – Setting parameters

Thresholds	Setting range	Step
Us1<	From 0,05 – 0,3 En	0,01 En
Us2>	From 0,7 - 1 En	0,01 En

8.1.1.VSS and CSS(Voltage and Current Sensor Supervision) function

By means of algorithms, the device must diagnose circuital switching off of the sensors in the RGDM's direction, and block the protection functions. This function must contain algorithms that are able to analyse coherence of the analogue quantities, associated with a real electricity network.

If the Vss detects an error in the measurements, the function must block the protection functions and deactivate the RVL function.

The measurement functions must continue working. The algorithms will be assessed and approved by GridSpertise.

8.2 Automation Functions

Ref. to GETP011-A1.

8.2.1. Optional timers signaling (ENDESA functionality)

Normally the behaviour of the signalling TS67 and TS51 is as described in the GETP011-A1 (Par. 7.1). The RGDM shall permit, through a flag (see red circle in Figure 35), the switch on other behaviour.

In detail:

- The command of relay 51 must be issued only when, after tripping of thresholds 51, 51N or 67NS2, the condition of “Voltage Absent” is detected within a certain time (T1, programmable, default setting: 0.5 s).
- The command of relay 67 must be issued only when, after tripping of thresholds 67NS1 or 67NS2, the condition of “Voltage Absence” is detected within a certain time (T1, programmable, default setting: 0.5 s).
- The return to quiescent status of relays 51 and 67 must occur when “Voltage Presence” condition is detected and that condition holds for a certain time (T2, programmable, default setting: 10 s).
- If there is no return of power within a certain time (T3, programmable, default setting: 4 hours), output contacts 51 and 67 return to quiescent status anyway.
- The signal of present voltage and absence voltage must be instantaneous value

According to the previous points:

- LEDs 51 and 67 must follow the state of respective relay.
- Event logging must also records the issuance of commands to relays 51 and 67, in addition to tripping of various thresholds.

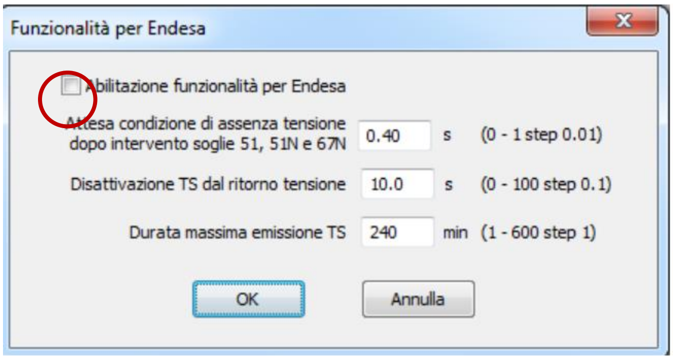

Figure 35 -Example of timers signaling.

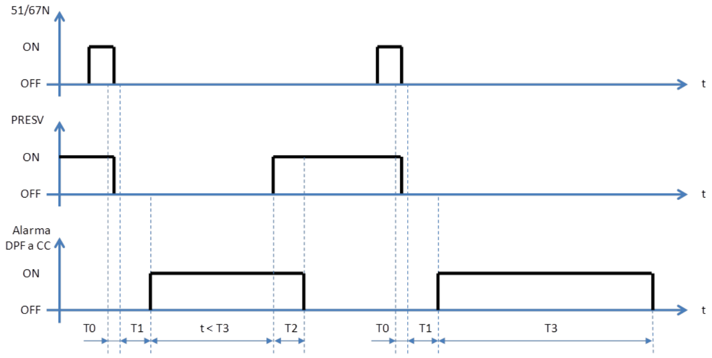

Figure 36 - Behavior of the signaling.

8.3 Measurement and monitoring functions

a. Phase current measurement

This function must provide the effective value for the phase currents. For all thresholds, this measurement is based on calculating the basic harmonic component, at 50/60 Hz, excepting for when second harmonic retention is enabled for inrush currents.

In this case, the calculation must take the basic and all the higher harmonics into consideration, up to the 25th.

Measurement of the harmonic components of current must take the real network frequency into account, with automatic adaptation within the useful basic interval, that is 50/60 Hz ±5%.

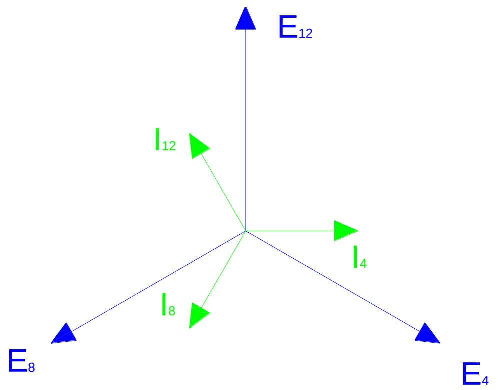

Figure 37 – Phase Current

b. Residual current measurement

This function must provide the actual value for the residual current, which is obtained from the vectorial sum of the three phase currents (Holmgreem insertion). This sum must take suitable calibration coefficients into account, in module and phase, added by means of software, to compensate for the CT-VT sensors.

$$3\vec{I}o = \vec{I}4 + \vec{I}8 + \vec{I}12$$

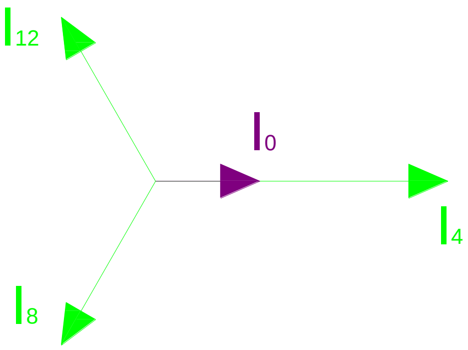

Figure 38 – Residual Current

This is based on the basic harmonic component measurement.

c. Phase voltage measurement

This function must provide the actual basic value at 50/60 Hz of the three phase voltages. E_{12} voltage on phase 12, E_4 voltage on phase 4 and E_8 voltage on phase 8.

Measurement must take the real network frequency into account, with automatic adaptation within the useful basic interval, that is 50/60 Hz ±5%.

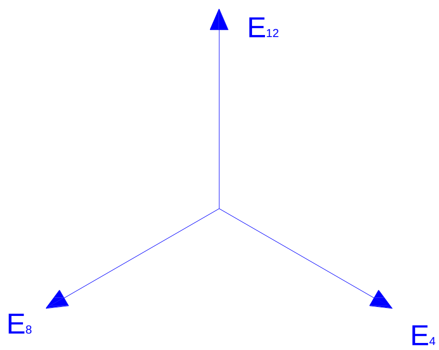

Figure 39 – Phase Voltages

d. Phase-to-phase voltage measurement

This function must provide the actual basic value at 50/60 Hz of the three phase-to-phase voltages. $V_{12\text{-}4}$ voltage between phases 12 and 4; $V_{8\text{-}12}$ voltage between phases 8 and 4; $V_{4\text{-}8}$ voltage between phases 4 and 8.

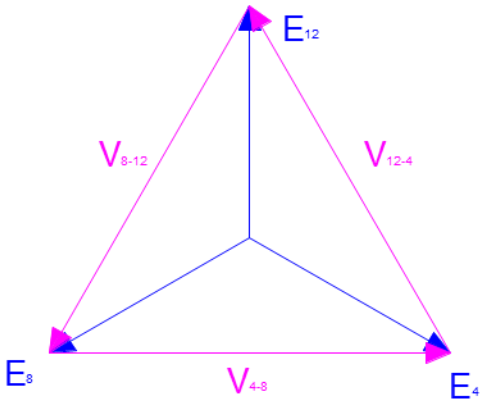

Figure 40 – Phase to Phase voltages

e. Residual voltage measurement

This function must provide the actual value for the residual voltage, which is obtained from the vector sum of the three line voltages.

This sum must take suitable calibration coefficients into account, in module and phase, added by means of software, to compensate for the CT-VT sensors.

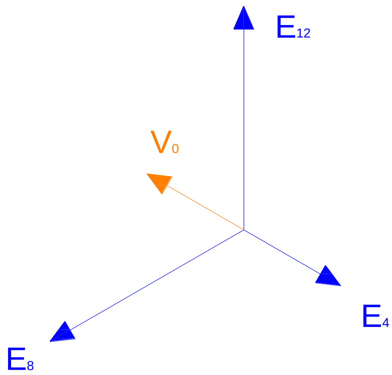

Figure 41 – Residual Voltage

This is based on the basic harmonic component measurement.

8.3.1. Measurement functions

The measurements handled by the RGDM can be acquired using 2 different methods:

- By means of messages coming from the IDC_DER, and sent using the 61850 (goose) protocol.

At intervals equal to Tm (typically 10 sec), the IDC_DER will send to the RGDM a package of data (goose), containing the "instantaneous" plant measurements, the structure of which is defined in the IDC_DER specifications and, in any case, are described in the *-icd file associated with the IDC_DER device. These instantaneous measurements must be processed to be sent to the Primary RTU as MMS spontaneous reporting messages (refer to the file *.icd related to the RGDM).

In addition, the above measurements acquired in transit, must be averaged over 10 min, to be sent to Primary RTU as MMS spontaneous report messages (averaged measurements).

NB: The icd profile distinguishes the instantaneous from the averaged measurements.

The samples in transit must be discarded if not qualified in the goose messages (see quality and availability bits), and begin again automatically, when normal operation conditions are reinstated. The measurements averaged over 10 minutes and also saved in a dedicated circular type log file (capacity: at least two days), which can be consulted locally.

- By means of the RGDM equipment's own measuring inputs.

The device must detect the VRMS value of the real voltages and currents for each phase.

The measurements always refer to the basic, at 50/60 Hz, with related frequency adaptation within limits of ±5%. If 2nd harmonic retention for inrush currents is enabled, on the other hand, the measurements for the three phase currents must take all the harmonics up to 25° into account.

These measurements must be used to detect the active and reactive power transiting the section in which the RGDM is installed.

The active power P and reactive power Q must be calculated as:

$$P = E_4 \cdot I_4 \cdot \cos\varphi_{E_4 I_4} + E_8 \cdot I_8 \cdot \cos\varphi_{E_8 I_8} + E_{12} \cdot I_{12} \cdot \cos\varphi_{E_{12} I_{12}}$$

$$Q = E_4 \cdot I_4 \cdot \sin\varphi_{E_4 I_4} + E_8 \cdot I_8 \cdot \sin\varphi_{E_8 I_8} + E_{12} \cdot I_{12} \cdot \sin\varphi_{E_{12} I_{12}}$$

The measurements of E_4, E_8, E_{12}, I_4, I_8, I_{12}, P, Q related to the primary values (kV, A, kW, kVAr) must be able to be viewed on the display. For the vectorial references ref. to Figure 41.

The measurements must be averages on a time basis Tm, typically 10 sec, and processed to be sent to the Primary RTU as MMS spontaneous reporting messages (see file *.icd related to the RGDM). The same measurements must be averaged on a first time base of 60 sec, and averaged again at 10 minutes, to be sent to the Primary RTU as spontaneous reporting messages (averaged measurements).

NB: The icd profile distinguishes the instantaneous from the averaged measurements.

The measurements averaged over 10 minutes and also saved in a dedicated circular type log file (capacity: at least two days), which can be consulted locally.

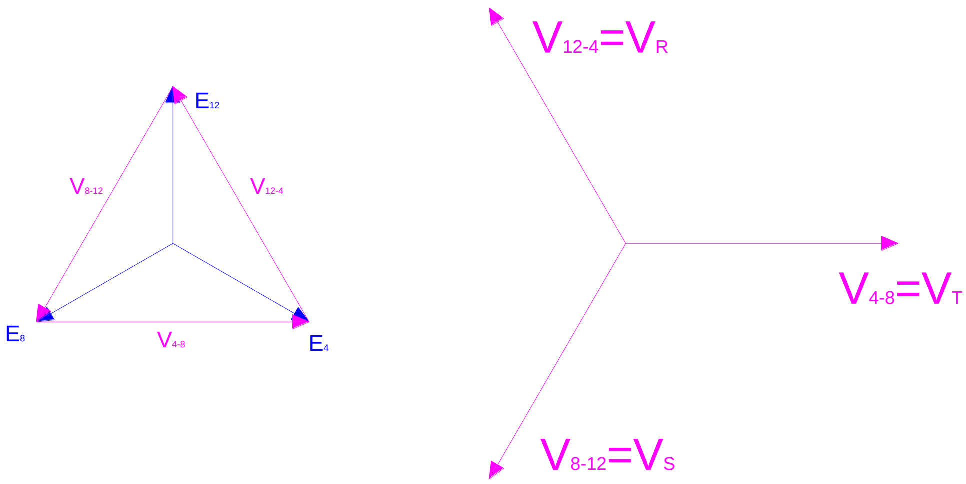

Figure 42 – Correlation of phase and phase-to-phase voltages

Measurement of the active and reactive power must be done with the possibility of estimating the direction of the power, according to the following convention: (with inversion mode deactivated)

- Positive when passing from the sub-station to the user.
- Negative when passing from the user to the sub-station.

The units of measurement that have to be handled and used to display the quantities are:

- Voltage kV
- Current A
- Active power kW
- Reactive power kVAr

The maximum scale range for the various quantities is:

- Voltage 36 kV
- Current 500 A
- Active power 15000 kW
- Reactive power 15000 kVAr

The configuration program must make it possible to set lower scale range values, with the following steps:

- Voltage 1 kV
- Active power 150 kW
- Reactive power 150 kVAr

Note: In addition to sending the measurements to Primary RTU, using the IEC 61850 protocol, RGDM must send the IDC_DER the three measurements V, P and Q at intervals that can be set of between 200ms and 60s with a default of 10s.

Measurements via 4-20mA transducer

When the RGDM is connected to the RTU eith the MB terminal board, it must be possible to use the relevant analogue output set aside for measurement on the MB terminal board, in order to be able to send the UO one of the following measurements: P, Q, V, I.

For the P and Q measurements, the sign must also be sent, according to the convention described below, and using the following principle:

Since the output on terminals 4 and 7 of the MB are of a 4-20 mA type, then RGDM must be set using a PC to transmit one of the measurements listed above, using the convention below:

For the P and Q measurements, 4-12 mA for negative values and 12-20 mA for positive values, taking 12 mA as the null value and 4mA as the negative scale range and 20mA as the positive scale range.

For the I and V measurements, the output must set 4 - 20 mA for the entire measurement range.

The samples must be discarded if a fault occurs, and restart automatically when the normal operating conditions are reinstated.

8.3.2. Quality Monitoring Function

At the measuring point, the device must determine the harmonic content (up to the 25^{th} harmonic) for both the line voltage and the current. In order to guarantee only the band pass harmonic content, the voltage and current measurements will be those obtained downstream of the anti-aliasing filter provided at the input.

For each of the line's three voltages and the three line currents, the THD must be calculated according to the following formulas respectively:

$$THD_V = \frac{\sqrt{\sum_{i=2}^{25} (V)_i^2}}{V_1} \qquad THD_I = \frac{\sqrt{\sum_{i=2}^{25} (I)_i^2}}{I_1}$$

The two THD measurements must be processed for sending to the Primary RTU, like for the other measurements acquired locally by the RGDM (calculation every 200ms, first average at 60 sec and second average at 10 minutes, to be sent as part of the spontaneous reporting, and saved in a log file).

8.4 Auxiliary Functions

Any alternative solution to those implemented in the specifications, must be discussed beforehand and approved by GridSpertise.

8.4.1.PLC Function

It must be possible to use configuration software to configure a PLC on board the device, able to create a boolean link between physical and virtual inputs, internal statuses of the device, and physical and virtual outputs. The minimum characteristics must be:

- Basic boolean functions with n° 4 inputs and one output, plus a timer.
- Minimum number of boolean functions = 30.
- Maximum execution time for a single boolean function = 10ms.
- Structure able to allow interconnection between boolean functions (out_A => in_B).
- Minimum operators required = OR(4in), AND(4in), NOT, XOR(2in), FF_RS, FF_Q, Comparator, Rising Edge sensibility, Falling Edge sensibility, Counters.
- Each internal timer in the basic boolean functions must be able to be of a Drop_On (delayed activation), Drop_Off (delayed deactivation), PULSE (impulse) type.
- The setting range for the timers must be 0ms ÷ 60000 ms.
- Boolean link between virtual inputs and outputs shall be possible, not only to be assigned to physical I/O.
- Programming must be in a CFC, ST or LD language.

8.4.2.Disturbance Recording (Oscilloperturbography)

The RGDM must have a Disturbance Recording function that allows the storage of fault-related events in a circular memory of, at least, 1000s.

The sampling frequency of the analog quantities requested in paragraph 6.5.2, allows the processing of signals up to 2.5 kHz by applying an anti-aliasing filter; a resolution of 1ms is required for the logic channels.

The RGDM device must be able to record the following signals in COMTRADE format:

- All the instantaneous analogue inputs (v4, v8, v12, i4, i8, i12, 3vo and 3io).
- The quantities calculated (in relation to the basic).
- The digital Input and Output statuses (all physical, starts, and activations), minimum number = 100.

A record in COMTRADE format must be kept of the driving currents of the circuit-breaker control coils (opening and closing) and a minimum of 10 records of each command must be stored in a circular buffer.

The reconstructed quantities, 3vo and 3io, must guarantee a correct phase relation with the source signals (v4, v8, v12 and i4, i8, i12) in order to allow off-line analysis of transient phenomena. The harmonic content of the 3vo and 3io signals must replicate that of the source signals.

Various solutions are provided for starting recordings, beginning from the intentional request made via software. It must be possible to activate recordings by virtual inputs enabled on IEC61850, via enabled physical inputs, via enabled PLC logic states, and by means of state triggers for the protections enabled. Especially for the latter, it will be possible to record events when enabled start-up thresholds are exceeded, and if the enabled thresholds are triggered.

The recording must last until the last triggering signal releases plus configurable (via SW) post-trigger and pre-trigger times. The recording must never exceed the maximum time configured via software.

The total time of the recording is equal to the sum of the:

- Pre-fault recording (duration configurable via software [0 ÷ 2000 ms]),
- Recording of the disturbance event (duration configurable via software [0 ÷ 70 s]),
- Post-trigger recording (duration configurable via software [0 ÷ 2000 ms]).

In any case the recording must last until the last configured trigger has released, which must happen inside the maximum limits set in the configuration.

Records storage: minimum 48 hours with loss of power supply.

In the case of the maximum fault duration (1s pre + 60s post) the minimum number of recordings must be 10. The number of recordings in the case of short duration faults, must guarantee a total of at least 600 sec saved in the device.

The non volatile memory must be managed in a circular manner.

The event that **triggers** recording, enabled via software, must not interfere with the device's protection and automation functions. Similarly, also queuing of a number of recordings to be saved in the non volatile memory, must guarantee correct functioning of the device, and the absence of voids in the events recorded.

The events recording logic will be as follows:

The **post_trigger** must be activated when a trigger event occurs (OR all the triggers activated), giving rise to a recording duration that is the same as the duration of the event, plus the **pre_trigger** time, up to the maximum set for a single recording.

A single recording must indicate, on the same temporal diagram: instantaneous values, calculated values (every 5 ms), and digital values (every 5 ms). The resolution must be at least 64 samples for period.

This data must be saved without being compressed, in COMTRADE 1999 and 2013 format.

The records must be accessible using the software provided, via SFTP and via the WebServer using cyber secure protocols.

The duration of the recording must last until the fallout of the last active trigger, and in any case does not exceed the maximum recording time set.

When the trigger expires, the device must record for a time equal to the set post-trigger.

8.5 DG Management Functions

The RGDM's distributed generation management functions are specified in GETP011-A1.

8.5.1. UPG Function

The RGDM must implement a function to control and manage the generators connected to the MV Network. The characteristics of this function are specified in GETP011-A1.

9. TESTING AND CERTIFICATIONS

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

The manufacturer shall supply all the information necessary to a full understanding of the below indicated aspects:

- computation algorithms
- sampling techniques
- self-diagnosis characteristics (time period, blocking actions and logics, accuracy)
- MMI and external communication; the interface page structure (local and via interface SW) shall be accepted by the technical unit before TCA process)
- device behaviour in case of partial damage/malfunctioning
- functional and disturbance immunity factory test results

9.1 TCA documents

The technical organization unit in charge of the Technical Conformity Assessment of the MFP 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 technical organization unit in charge of the TCA.

The TCA documents that shall be delivered include:

- 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).
- 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 technical organization unit in charge of the TCA**
- TCA dossier (Set of final documents delivered by the Supplier for the TCA)
- The supplier shall provide the TCA Dossier on digital support.

9.2 Quality

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

9.3 Type test list

a. Compatibility tests with CT-VT approved sensor
b. Visual examination
c. Isolation and dielectric strength tests
d. Out-of-range power supply tests
e. Electromagnetic compatibility tests
f. Thermal behavior tests
g. Mechanical compatibility tests

h. Climate compatibility tests
i. Checking of all the functions
j. Checking precision, only at the nominal voltages

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

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

9.4 Routine tests

The routine tests are those indicated in par. 9.3, clause b, c, j, k and here reported:

a. Visual examination and control of geometric characteristics,
b. Insulation and dielectric strength tests
c. Checking of all the functions
d. Checking precision, only at the nominal voltages

The routine tests must be carried out using a specifically designed and automated test equipment (ATS also named SCA). Each device must be accompanied by a report stating that all ATS tests have been concluded successfully. ATS could be certified from a third party laboratory, or is part of the Technical Conformity Assessment, as described in the GSTX001.

9.5 Pilot installation test

In a substation chosen by GridSpertise will be installed one RGDM granted 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 RGDM in the substation.

9.6 Type tests description

The correct operation of all the functions required in the present document shall be verified with the device supplied in standard conditions.

9.6.1. Visual examination

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.

With the exception of the point at which the field cables are inserted, the entire metal container must have a protection level of IP30, and must prevent the penetration of water dripping from above.

The presence of documentation enclosed with the device and the absence of visible defects must be checked during acceptance testing.

These tests will consist of the visual checking of:

- 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.

- 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.

9.6.2. Isolation and dielectric strength tests

The purpose of the tests is to verify the dielectric strength of the RGDM ST.

In addition, the dielectric strength of the electronic card must be verified according to what is prescribed below.

Each test must be performed by applying the voltage (of a value corresponding to the level specified for each circuit) between each of the following three circuits and the other two connected to ground:

- voltage inputs (level 3)
- current inputs (level 3 applied to the primary current transducers)
- remote signal outputs and 24 Vdc power supply (level 3).

The tests prescribed are all those cited below.

- impulse seal test;
- dielectric strength test;
- measurement of the insulation resistance value;

Table 79 – Isolation and dielectric strength tests

N°	Description	Standard	Class	Level
1	Dielectric strength (50Hz)	IEC 60255-27	4(*)	2kV CM
2	Isolation resistance (500V)	IEC 60255-27	3	> 100 Mohm

(*): The isolation class for open relay contacts is level 3, and for remote measurement (Icc) is level 2.

The presence of filter capacitors to earth results in the application of strength tests at a direct voltage of an equivalent value. In particular, the amplitude and duration will be:

- Class 4 = √2 x 2kV AC = 2.8kV DC for 60s
- Class 3 = √2 x 1kV AC = 1.4kV DC for 60s
- Class 2 = √2 x 0.5kV AC = 0.7kV DC for 60s

The circuit groupings for common isolation are as follows:

G.	TYPE	CIRCUIT TERMINALS FOR TESTS IN COMMON MODE
1	24 Vdc power supply Inputs from the field Relay outputs to the field	MU-1, MU-2, MU-3, MU-4, MU-5, MI-1, MI-2, MI-3, MI-4, MI-5, MI-6, MI-7, MI-8, MI-9, MI-10, MI-11, MI-12, MI-13, MB-1, MB-2, MB-3, MB-5, MB-8, MB-9, MB-10
2	Icc remote measurement	MB4, MB7 (along with auxiliary power supply for the CT-VT)
3	Measurement inputs with earth-related potential	LC-1, LC-2, PE (along with the RJ45 shield for measurements L1, L2, L3)

If referred to the respective groups, the auxiliary power supply for the CT-VTs and the RJ45 measurement screens, must not be connected to the test stimulator.

The circuit groupings for checking between open relay contacts, are as follows:

G.	TYPE	CIRCUIT TERMINALS
1a	Command relays:	MI-10, MI-11
1b	Signalling relays:	MB-2, MB-3, MB-5

The impulse withstand test is not done, as it is replaced by the more demanding, SURGE test.

9.6.3.Out-of-range Power Supply Tests

It must be verified that all the functions of the RGDM ST are inhibited by supplying the device with the values of the supply voltage that do not guarantee correct operation.

9.6.4.Electromagnetic Compatibility Tests

The purpose of the tests is to verify the correct operation of the RGDM ST subjected to the application of various electromagnetic phenomena.

The tests to be carried out as well as the methods of execution and evaluation of the results must be done, considering that:

- the function of the RGDM ST is intended as “protection”;
- the installation environment is intended as “MT station”;

- the signal port is intended for “local connections”.

The disturbances must be applied on the MA terminal board, with reference to the voltage inputs, and to the current transducers (primary signals) as regards the current inputs.

The procedure for verifying the correct operation of the RGDM during these tests must be agreed with GridSpertise.Criterion for evaluating the individual immunity tests.

The EUT must be configured to detect variations in the 3Io (at effective value related to the basic) and indicate triggers at the maximum current threshold 51N. The trigger set for the 3Io must be 2A for a duration of 1 sec. This threshold corresponds to the minimum settable for the 3Io (1A) plus twice the resolution accepted (0.5A).

The duration time required is half the time that must be set for the RF immunity scans.

The sensitivity criterion provides for using the 3Io as the most critical quantity.

This set-up called for the use of three passive smart termination sensors, connected to the EUT.

The set-up for the current channels, called for Rogowsky sensors, with a ration of 1000A : 100mV.

Any 51N trigger prejudices the successful completion of the test.

Since the tests would require the use of primary signals, application of the overlapping of effects principle was established, and checking, in the absence of a signal, of the maximum degree of variation in the critical reference measurement (3Io). The signal ports are taken to be “local connections”. The means for checking correct functioning of the RGDM during these tests must, in any case, be approved by GridSpertise.

9.6.5.Thermal behavior tests

The thermal map of the RGDM fed with the maximum values of the nominal range must be detected; the test must be carried out under the following normal climatic conditions:

- temperature: 15 ÷ 35 ° C
- atmospheric pressure: 86 ÷ 106 kPa
- relative humidity: 45 ÷ 75%

The over temperature values, measured near the individual components, must be used to verify that, at the highest operating temperature, the maximum permissible operating temperature for the components is not exceeded. The thermal map is also used for the definition of the thermal time constant for the temperature variation test.

With the EUTs powered for 1 hour, under reference ambient conditions (about 25°C and 50% RH), analyze the PCBs using a heat-sensitive camera, acquiring thermal images within the visible spectrum.

The purpose of this test is to identify the most critical components for each board, and to record their operating temperatures. Should one or more of the boards be inaccessible, remove them from the EUT and power them separately, waiting 1 hour before taking the images. If a heat-sensitive camera is not available, use a suitable thermometer with a thermocouple, probing (according to a criterion established by the manufacturer and explained in the report) the EUT’s most critical components.

At the maximum operating temperature, the hottest component must reach a temperature below or equal to 10°C with respect to its maximum permissible temperature. At the minimum operating temperature, the internal temperature of the device (air) must be higher or equal to 10°C than the test temperature.

9.6.6.Mechanical compatibility tests

The tests are divided into:

- sinusoidal vibration immunity tests (working equipment)
- resistance tests to transport and handling stresses (equipment not working)

The requirements to be applied are the following:

- sinusoidal vibration immunity V.H.3
- resistance to transport stresses and handling (test type, large-band random vibrations)

The procedure for verifying the correct operation of the RGDM during these tests must be agreed with GridSpertise.

MECHANICAL TEST									
N°	Description	Standard	Class	Level	Ports being tested				
					Casing	**Uaux**	**Local**	**Range**	**Earth**
1	Response to vibrations and resistance to vibrations	IEC 60255-21-1 IEC 60068-2-6	1	10-150Hz, 0.5g 1cycle 10-150Hz, 1g 20 cycles	X (1) X (2)				
2	Broad band random vibrations [(m/s2)2/Hz]	IEC 60068-2-64	1	5-10Hz, [0.0013] 10-50Hz, [0.02] 50-100Hz, [0.0013]	X (3)				

(1): The response test is done with the EUT powered, while the resistance test is done with no power to the EUT.

(2): The transportation test is done in the packaging chosen by the manufacturer for the supply, complete with the 9 m cable for the MB.

For the test with the EUT powered, the same assessment criteria are applied as those used for the immunity tests.

9.6.7. Climate compatibility tests

The reference levels of the individual test groups are as follows:

- Tests with powered equipment: level 4

The procedure for verifying the correct operation of the RGDM ST device during these tests must be agreed with GridSpertise.

CLIMATIC TEST							
N°	**Description**	**Type**	**Standard**	**Class**	**Temperatures**	**Humidity**	**Duration**
1	Operational EUT	Initial ref. (1)			+25°C	50% R.H.	1 hour
2	Operational EUT	Hot humid (2)	IEC 60068-2-78		+40°C	93% R.H.	96 hours
3	Operational EUT	Hot dry (3)	IEC 60068-2-2		+85°C	20% R.H.	16 hours
4	Operational EUT	Cold (4)	IEC 60068-2-1		-25°C	10% R.H. at temp. > +10°C	16 hours
5	Operational EUT	Variations (5)	IEC 60068-2-14		From -25°C to +70°C	10% R.H. at temp. > +10°C	3 hours
6	Operational EUT	Final ref. (6)			+25°C	50% R.H.	1 hour

(1): When thermal equilibrium is achieved, after about 1 hour, record the EUT's reference measurements, stimulated using a test box at the nominal voltage, current, and phase shift angle values. These will be used to evaluate variations at extreme temperatures.

(2)- (3): The change in temperature must not exceed 0.3°C/minute, whereas the humidity gradient can be set at 1.5%RH/minute. When thermal equilibrium is achieved, after about 1 hour, record the EUT measurements, checking that the quantities have not exceeded the measurement range errors under influential ambient conditions.

(4): The change in temperature must be set at 0.5°C/minute, resulting in a rise of about 3 hours. During the cooling phase, the humidity check may exceed 2.5%RH/minute, up to a limit of +10°C. Below this temperature, the humidity is not checked anymore. When thermal equilibrium is achieved, after about 1 hour, record the EUT measurements, checking that the quantities have not exceeded the measurement range errors under influential ambient conditions.

(5): The change in temperature must be set at 0.5°C/minute. During the heating phase, recommence checking the humidity after +10°C, with a gradient of 2.5%RH/minute. When the upper extreme is achieved, after about 1 hour, record the EUT measurements, checking that the quantities have not exceeded the measurement range errors under influential ambient conditions.

(6): When thermal equilibrium is achieved, after about 1 hour, record the EUT measurements and compare them with the initial reference values, as well as with the relevant errors under nominal conditions. Check correct reinstatement of performance.

Any performance losses in the display at the extreme temperatures are taken to be within the norm, but only if reinstatement of its functions is complete once back within the nominal temperatures (15-35°C).

9.6.8.Checking Of All the Functions

The functional test plan must be drawn up by the supplier and approved by GridSpertise.

GridSpertise reserves the right to carry out all or some of the functional tests.

Regular carrying out of all the functions indicated in these specifications must be carried out by powering the RGDM, complete with all parts, with the electricity supply at its nominal values. A request is made for some tests to be repeated at the extreme values for the electricity supply.

In the case of type tests, the tests must be repeated five times.

9.6.8.1. Testing detection of the presence / absence of voltage

The threshold check described in par. 8.1.5 must be done on the electronic board only, with a precision of 1% of the thresholds. The tests are only done in the board because the CT-VT sensors are characterized separately.

Behavior in all possible cases must be tested, as the voltage varies on all three phases.

The tests must be repeated at the extreme values for the electricity supply.

9.6.8.2. Checking the function for detecting a single-phase fault to earth

The threshold check described in par. 8.1.4 must be carried out on the electronic board powered at suitable secondary voltages and in the laying condition described in par.**Errore. L'origine riferimento non è stata trovata.**. The tests are done using secondary voltages, because the CT-VT sensors are characterized separately.

The following tests must be done under static conditions (that is, in a sinusoidal regime), for both the 67N.S1 and 67N.S2 regime, in order to determine the activation thresholds and times.

- Checking of the residual voltage threshold, with a precision of 1% (implementing a safe activation condition for residual current and offset angle values), equal to twice the current calibration value and the bisector of the activation sector respectively.
- Checking of the residual current threshold, with a precision of 1% (implementing a safe activation condition for residual voltage and offset angle values), equal to twice the voltage calibration value and the bisector of the activation sector respectively.
- Checking of the angular sector, with and without the inversion signal activated (implementing a safe activation condition for the residual current and residual voltage values, equal to twice the activation calibration value) , in order to guarantee an overall error of ± 2°.

In particular:

- The checks on the current thresholds must be done:
  - With a symmetrical, balanced triad of currents, with an effective value of 10 - 100 - 360 A, and
  - Creating the value for the residual components required by the individual check on each of the three phase CTs.
- The checks on the voltage thresholds must be done:
  - On the secondary, with a symmetrical voltage triad, with a value equivalent to the nominal primary voltage, and
  - Creating the residual voltage component required by the individual check on each of the three voltage input channels.

When checking the 67N.S2 threshold, the safe activation value for the residual voltage must not be higher than 4% in order to avoid superimposition with the 67N.S1 threshold.

Under static conditions (that is, in a sinusoidal regime) the tests must also be carried out that are indicated in Table 80, Table 81 and Table 82 to check the 67N.S1 threshold, and those indicated in Table 83, Table 84 and Table 85for checking the 67N.S2 threshold.

The tests indicated in Table 80 must be repeated at the extreme values for the electricity supply. The tests described in Table 80, Table 81 and Table 82:

- Must be repeated, applying the residual current to all three phases.
- Must be repeated, applying the phase currents with a triad of symmetrical but not balanced currents (on only one phase chosen), in order to create a current imbalance of 2 A with a 0° and 180° phase compared to the residual voltage.

The phase current indicated in the following tables must circulate in the three phases by means of a symmetrical, balanced triad.

Table 80 – List of tests to check the 67N.S1 directional earth function					
Calibration for threshold 67N.S1: 60° ≤ α ≤ 250° - Vo = 6% - I residual = 1.5 A					
Phase current (A)	Residual voltage		Residual current in the phase (A)		Expected behavior
Modulus	Modulus	Phase	Modulus	Phase	
360	6.15%	0	1.55	57°	No trigger

360	6.15%	0	1.55	63°	TS 67 AV
360	6.15%	0	1.55	180°	TS 67 AV
360	6.15%	0	1.55	247°	TS 67 AV
360	6.15%	0	1.55	253°	No trigger
100	6.15%	0	1.55	57°	No trigger
100	6.15%	0	1.55	63°	TS 67 AV
100	6.15%	0	1.55	180°	TS 67 AV
100	6.15%	0	1.55	247°	TS 67 AV
100	6.15%	0	1.55	253°	No trigger
10	6.15%	0	1.55	57°	No trigger
10	6.15%	0	1.55	63°	TS 67 AV
10	6.15%	0	1.55	180°	TS 67 AV
10	6.15%	0	1.55	247°	TS 67 AV
10	6.15%	0	1.55	253°	No trigger

Table 81 – List of tests to check the 67N.S1 directional earth function					
Calibration for threshold 67N.S1: 60° ≤ α ≤ 250° - Vo = 6% - I residual = 1.5 A					
Phase current (A)	Residual voltage		Residual current in the phase (A)		Expected behavior
Modulus	Modulus	Phase	Modulus	Phase	
360	5.85%	0	1.55	63°	No trigger
360	5.85%	0	1.55	180°	No trigger
360	5.85%	0	1.55	247°	No trigger
100	5.85%	0	1.55	63°	No trigger
100	5.85%	0	1.55	180°	No trigger

100	5.85%	0	1.55	247°	No trigger
10	5.85%	0	1.55	63°	No trigger
10	5.85%	0	1.55	180°	No trigger
10	5.85%	0	1.55	247°	No trigger

Table 82 – List of tests to check the 67N.S1 directional earth function					
Calibration for threshold 67N.S1: 60° ≤ α ≤ 250° - Vo = 6% - I residual = 1.5 A					
Phase current (A)	Residual voltage		Residual current in the phase (A)		Expected behavior
Modulus	Modulus	Phase	Modulus	Phase	
360	6.15%	0	1.48	63°	No trigger
360	6.15%	0	1.48	180°	No trigger
360	6.15%	0	1.48	247°	No trigger
100	6.15%	0	1.48	63°	No trigger
100	6.15%	0	1.48	180°	No trigger
100	6.15%	0	1.48	247°	No trigger
10	6.15%	0	1.48	63°	No trigger
10	6.15%	0	1.48	180°	No trigger
10	6.15%	0	1.48	247°	No trigger

Table 83 – List of tests to check the 67N.S2 directional earth function		
Calibration for threshold 67N.S2: 60° ≤ α ≤ 120° - Vo = 2% - I residual = 1.5 A			
Phase current (A)	Residual voltage	Residual current in the phase (A)	Expected behavior

Modulus (*)	Modulus	Phase	Modulus	Phase	
360	2.1%	0	1.55	57°	No trigger
360	2.1%	0	1.55	63°	TS 67 AV
360	2.1%	0	1.55	180°	TS 67 AV
360	2.1%	0	1.55	247°	TS 67 AV
360	2.1%	0	1.55	253°	No trigger
100	2.1%	0	1.55	57°	No trigger
100	2.1%	0	1.55	63°	TS 67 AV
100	2.1%	0	1.55	180°	TS 67 AV
100	2.1%	0	1.55	247°	TS 67 AV
100	2.1%	0	1.55	253°	No trigger
10	2.1%	0	1.55	57°	No trigger
10	2.1%	0	1.55	63°	TS 67 AV
10	2.1%	0	1.55	180°	TS 67 AV
10	2.1%	0	1.55	247°	TS 67 AV
10	2.1%	0	1.55	253°	No trigger

Table 84 – List of tests to check the 67N.S2 directional earth function					
Calibration for threshold 67N.S2: 60° ≤ α ≤ 120° - Vo = 2% - I residual = 1.5 A					
Phase current (A)	Residual voltage		Residual current in the phase (A)		Expected behavior
Modulus (*)	Modulus	Phase	Modulus	Phase	
360	1.9%	0	1.55	63°	No trigger
360	1.9%	0	1.55	180°	No trigger

360	1.9%	0	1.55	247°	No trigger
100	1.9%	0	1.55	63°	No trigger
100	1.9%	0	1.55	180°	No trigger
100	1.9%	0	1.55	247°	No trigger
10	1.9%	0	1.55	63°	No trigger
10	1.9%	0	1.55	180°	No trigger
10	1.9%	0	1.55	247°	No trigger

Table 85 – List of tests to check the 67N.S2 directional earth function					
Calibration for threshold 67N.S2: 60° ≤ α ≤ 120° - Vo = 2% - I residual = 1.5 A					
Phase current (A)	Residual voltage		Residual current in the phase (A)		Expected behavior
Modulus (*)	Modulus	Phase			
360	2.1%	0	1.45	63°	No trigger
360	2.1%	0	1.45	180°	No trigger
360	2.1%	0	1.45	247°	No trigger
100	2.1%	0	1.45	63°	No trigger
100	2.1%	0	1.45	180°	No trigger
100	2.1%	0	1.45	247°	No trigger
10	2.1%	0	1.45	63°	No trigger
10	2.1%	0	1.45	180°	No trigger
10	2.1%	0	1.45	247°	No trigger

Finally, an activation test must be done powering the RGDM with:

- A sinusoidal residual voltage with an amplitude 10% of the nominal voltage.
- A residual current with a component at 50 Hz with a 50 A modulus and 247° phase, in relation to a residual current, with a one way component, with an amplitude of √2 x 500 A and time constant of 150 ms.

Under these conditions, check that the RGDM reacts within less than 500ms.

The following tests are aimed at determining the ratios and return times.

Return ratio

- Residual voltage threshold: from the safe activation conditions (120% of the setting with residual current and staggering angle values equal to twice the current calibration value and the bisector of the activation sector respectively), gradually reduce the residual voltage, until the triggering relay is deactivated.
- Residual current threshold: from the safe activation conditions (120% of the setting with residual voltage and staggering angle values equal to twice the voltage calibration value and the bisector of the activation sector respectively), gradually reduce the residual current, until the triggering relay is deactivated.
- Angular sector, with and without the inversion signal activated (implementing a safe activation condition for the residual current and residual voltage values, equal to twice the activation calibration value), gradually leave the activation sector, until the trigger relay is deactivated.

Return time

- Residual voltage threshold: from the safe activation conditions (120% of the setting with residual current and staggering angle values equal to twice the current calibration value and the bisector of the activation sector respectively), reduce the residual voltage in steps, down to 80% of the calibration value.
- Residual current threshold: from the safe activation conditions (120% of the setting with residual voltage and staggering angle values equal to twice the voltage calibration value and the bisector of the activation sector respectively), reduce the residual current in steps, down to 80% of the calibration value.
- Angular sector: with and without the inversion signal activated (implementing a safe activation condition for the residual current and residual voltage values, equal to twice the activation calibration value), leave the activation sector in steps, with a margin of 5°.

9.6.8.3. Checking the maximum residual current function

The verification of the thresholds and precisions described in par. 8.1 must be carried out in the laying condition described in par. **Errore. L'origine riferimento non è stata trovata.** and supplying the primary side CT-VT current sensors.

Under static conditions (that is, in a sinusoidal regime) the residual current threshold and activation times must be checked, under the following conditions:

- With a symmetrical, balanced triad of currents, with an effective value of 10 - 100 - 360 A.

- Creating the residual component required by the individual check on each of the three phase CTs.

In addition, a safe activation test must be carried out with a residual component of 1000 A. This test must be done with a symmetrical, balanced, 10 A triad, and repeated creating the residual component for each of the three phase CTs. The subject of this test is only correct activation of the RGDM.

The tests indicated must be repeated at the extreme values for the electricity supply.

The following tests are aimed at determining the ratios and return times.

Return ratio

Residual current threshold: from the safe activation conditions (120% of the calibration), reduce the residual current gradually, until the trigger relay is deactivated.

Return time

Residual current threshold: from the safe activation conditions (120% of the calibration), reduce the residual current in steps until 80% of the calibration value.

9.6.8.4. Checking the maximum phase current function

The tests to check the thresholds must be repeated at the extreme values for the electricity supply. Under static conditions (that is, in a sinusoidal regime) the phase current threshold must be checked, for each of the three CTs.

In addition, the following checks must be done of certain activation at current values:

- 1000 A
- 2000 A
- 9000 A

The subject of this test is only correct activation of the RGDM.

The following tests are aimed at determining the ratios and return times.

Return ratio

Maximum current threshold: from the safe activation conditions (120% of the calibration), reduce the current gradually, until the trigger relay is deactivated.

Return time

Maximum current threshold: from the safe activation conditions (120% of the calibration), reduce the residual current in steps until 80% of the calibration value.

9.6.8.5. Transient tests

For the check under transient fault conditions, the RGDM must be powered with voltage and current wave forms obtained from fault simulations. In particular, the transient events related to the following conditions:

- Double single-phase fault to earth tests
- Closure due to fault tests
- Evolutionary fault tests
- Intermittent arcs
- Impulse test

The tests must be carried out powering the RGDM with voltage signals proportional to the primary fault voltages (assessed on the basis of the level of the analogue signal leaving the CT-VT voltage sensor), and with the primary fault currents, in the laying condition described in par.**Errore. L'origine riferimento non è stata trovata.**.

The voltage and current signals are provided in COMTRADE format.

A detailed description of the test cases and expected results is provided below.

The purpose of the functional tests is to check that the RGDM being tested conforms to the functional specifications in relation to its capacity to detect transient faults, and the presence/absence of the power supply.

The tests to be carried out relate to recognition of fault phenomena (single-phase to earth with intermittent arcs, double single-phase to earth, evolutionary) and re-closing when a fault occurs, as well as to detect that the power is on, especially when due to opening and closing of the line switch and/or OdM in the Secondary Sub-Station.

The network structure envisaged for the tests, obtained from simulations, is indicated in Figure 43 and constitutes a simplified network scheme that is sufficient for the purposes of the tests themselves.

The system comprises a 20 kV MV network, made of three equivalent lines. The extent of the network in terms of single-phase fault current varies from 100 A to 500A, as the case may be. Unless specified otherwise, the line indicated in Figure 43 as L1 is taken to have a length that makes up about 40% of the entire network (maximum value permitted), whereas the remaining two lines are taken to have a length that corresponds to 10% and 50% of the entire network respectively.

In cases with a compensated network, the scheme has been taken with a coil connected at the star centre of the transformer.

The three-phase short-circuit current at the MV bars is equal to about 10 kA.

The output quantities at the RGDM to be monitored to determine the outcome of the tests described, are the TS67AV, TS51A, and TSPRESV signals.

The tests must be carried out, with the following settings for the RGDM:

- For the S1 threshold:
  - A voltage setting of 6% and a residual current value of 2 A.
- For the S2 threshold:
  - A voltage setting of 2% and a residual current value of 2 A.

The tests must not be repeated when the inversion signal is active.

- **Double single-phase fault to earth tests**

With reference to Figure 43 for the double single-phase fault transients, the following are provided:

- Phase voltages, phase currents for line 1.
- Phase voltages, phase currents for line 2.

For each transient, this functional test is made up of two parts, carried out with the device powered at the quantities for line 1 and line 2 respectively. The faults are taken as occurring on different phases:

Case	Name	Ires line 1	α 1	Ires line 2	α 2	Test
1	gdomo1	282 A	262.5°	313 A	83°	T
2	gdomo2	173 A	245.5°	200 A	69°	T
3	gdomo3	108 A	242°	134 A	68°	T
4	gdomo4	165 A	71°	138 A	246 °	T

The results expected are indicated in the table below (in terms of output triggers and, between brackets, in terms of information that can be deduced from the events recording function).

Case	Name	Fault line 1	Fault line 2
1	gdomo1	trigger TS 51 A (51N)	trigger TS 51 A (51N)
2	gdomo2	trigger TS 51 A (51N)	trigger TS 51 A (51N)
3	gdomo3	trigger TS 67 AV (67S2)	trigger TS 67 AV (67N.S1 & 67N.S2)
4	gdomo4	trigger TS 51 A (51N)	trigger TS 67 AV (67N.S2)

- **Tests for closing (and rapid re-closing) for a permanent fault**

For the fault-related closing and re-closing transients, the phase voltages and phase currents are provided for the RGDMs in the position indicated in Figure 44.

The simulations done are for the following sequence of fault events: opening of switch "INT_1", opening of OdM "OdM_1", re-closing of switch "INT_1", re-closing (due to fault) of OdM "OdM_2".

For each transient, the functional tests is made up of 3 parts, set up by powering the device with the currents and voltages related to positions 1, 2 and 3, which correspond to three possible positions of the RGDM in relation to the fault.

Case	**Name**	**Ires pos1**	**α 1**	**Ires pos 2**	**α 2**	**Ires pos 3**	**α 3**	**Test**
1	Closing1	50 A	90°	62.5 A	90°	15 A	270°	T
2	Closing2	2.8 A	90°	3.5 A	90°	0.85 A	270°	T
3	Closing3	48.5 A	232°	33 A	206°	26.5 A	270°	T
4	Closing4	4.2 A	232°	2.9 A	206°	2.3 A	270°	T

The results expected are indicated in the table below (in terms of output triggers and, between brackets, in terms of information that can be deduced from the events recording function). The triggers indicated for the RGDMs on the line affected by the fault, must only be activated if a fault occurs.

Case	**Name**	**RGDM (1)**	**RGDM (2)**	**RGDM (3)**	**Test**
1	Closing 1	2 times TS 67 AV (67S1 & 67S2)	2 times TS 67 AV (67N.S1 & 67N.S2)	No trigger	T
2	Closing 2	2 times TS 67 AV (67S1 & 67S2)	2 times TS 67 AV (67N.S1 & 67N.S2)	No trigger	T
3	Closing 3	2 times TS 67 AV (67S1)	2 times TS 67 AV (67N.S1)	No trigger	T
4	Closing 4	2 times TS 67 AV (67S1)	2 times TS 67 AV (67N.S1)	No trigger	T

- **Evolutionary fault tests**

With reference to Figure 43, functioning of the RGDM must be checked in laying conditions (1), when a single-phase fault occurs, that evolves into various types of faults.

The simulations done represent a fault to earth event on the line, taking that, after a certain duration, this “evolves” into a different kind of fault.

Case	**Name**	**Description**	**Ires line 1**	**α 1**	**Test**
1	evolutionary1	67->51N (duration 67 : 125 ms)	23 A –> 192 A	90°	T
2	evolutionary2	67->51N (duration 67 : 125 ms)	23 A –> 521 A phase	90°	T
3	evolutionary3	51N -> 67(duration 51N 75 ms)	195 A –> 37 A	232°	T
4	evolutionary4	51-> 67 (duration 51 for 30 ms)	530 A phase–> 34 A	233°	T
5	evolutionary5	67-> 51N (duration 67 for 175 ms)	23 A –> 192 A	90°	T
6	evolutionary6	67-> 51 (duration 67 for 175 ms)	23 A –> 521 A phase	90°	T
7	evolutionary7	51N -> 67(duration 51N for 125 ms)	195 A –> 38 A	232°	T
8	evolutionary8	51-> 67 (duration 51 for 85 ms)	530 A phase–> 34 A	233°	T

The results expected are indicated in the table below (in terms of output triggers and, between brackets, in terms of information that can be deduced from the events recording function). The times indicated for the second activation (cases 5÷8) are taken from the instant the fault evolves.

Case	**Name**	**Expected behaviour**
1	evolutionary1	TS 51A (51N)
2	evolutionary2	TS 51A (51)
3	evolutionary3	TS 67AV (67N.S1)
4	evolutionary4	TS 67AV (67N.S1)
5	evolutionary5	TS 67AV (67N.S1 & 67N.S2) + TS51A (51N) after 80÷120 ms
6	evolutionary6	TS 67AV (67N.S1 & 67N.S2) + TS51A (51) after 40÷80 ms
7	evolutionary7	TS51A (51N) + TS 67AV (67N.S1) after 130÷170 ms
8	evolutionary8	TS51A (51) + TS 67AV (67N.S1) after 130÷170 ms

- **Tests related to intermittent arc simulations**

With reference to Figure 43, functioning of the RGDM must be checked in laying conditions (1), when an intermittent single-phase fault to earth occurs.

For each transient, this functional test is made up of two parts, carried out with the device powered at the quantities for line 1 and line 2 respectively.

Case	**Name**	**Type of network**	**Case description**	**Test**
1	arcint1	NI	Arcs for 20 ms, at 80 ms intervals, for a duration of 1 sec.	T
2	arcint2	NI	Arcs for 20 ms, at 130 ms intervals, for a duration of 1 sec.	T
3	arcint3	NC	Arcs for 20 ms, at 80 ms intervals, for a duration of 1 sec.	T
4	arcint4	NC	Arcs for 20 ms, at 130 ms intervals, for a duration of 1 sec.	T
5	arcint5	NC	Arcs for 120 ms, at 80 ms intervals, for a duration of 1 sec.	T
6	arcint6	NC	Arcs for 120 ms, at 130 ms intervals, for a duration of 1 sec.	T

The results expected are indicated in the table below (in terms of output triggers and, between brackets, in terms of information that can be deduced from the events recording function).

Case	**Name**	**Faulty line**	**Healthy line**
1	arcint1	TS 67 AV (67N.S4)	No trigger
2	arcint2	No trigger	No trigger
3	arcint3	TS 67 AV (67N.S4)	No trigger
4	arcint4	No trigger	No trigger
5	arcint5	TS 67 AV (67N.S4)	No trigger
6	arcint6	No trigger	No trigger

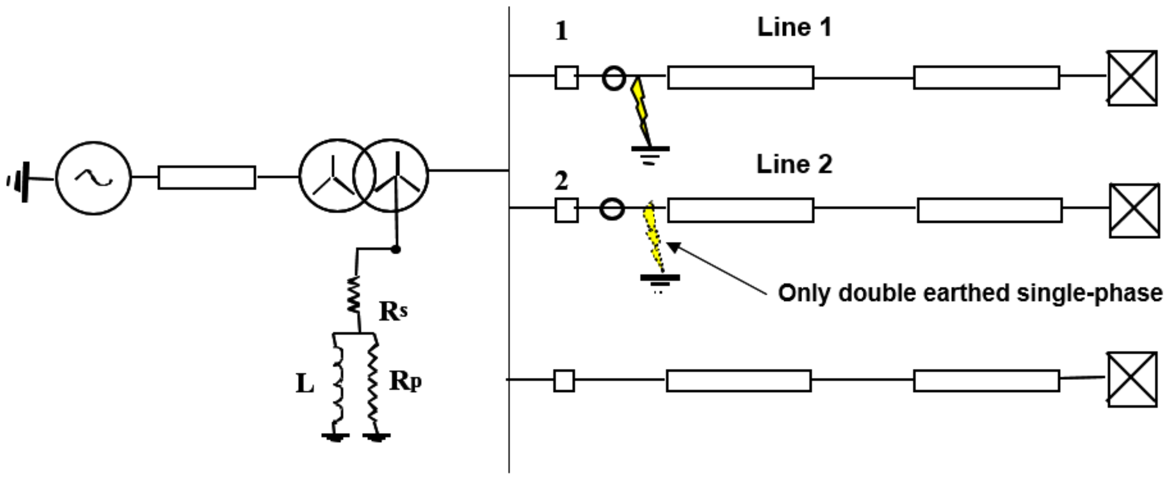

Figure 43 – Reference Network for TEST cases RGDM

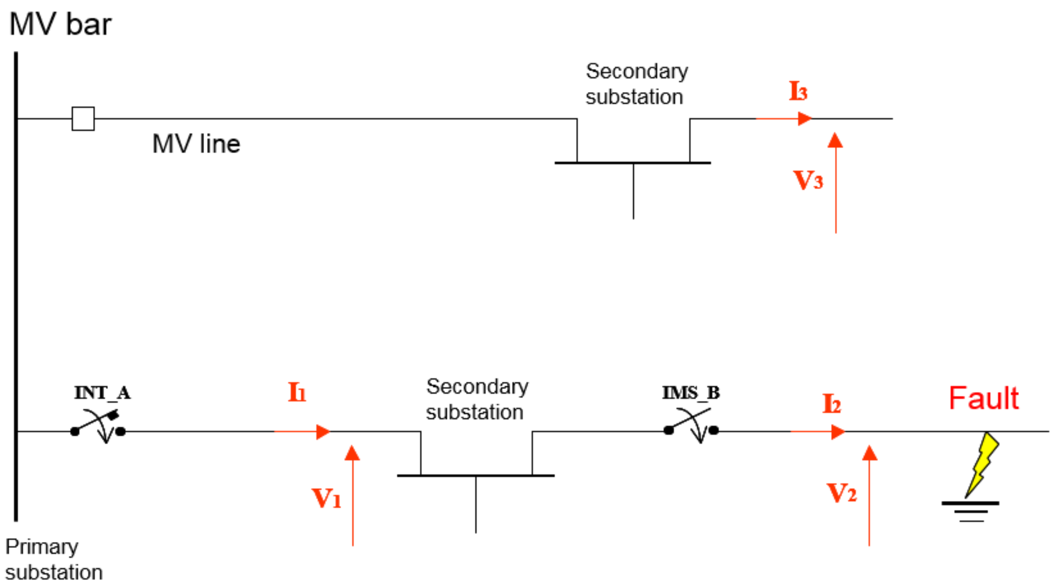

Figure 44 – Cases for closing due to fault

- **Impulse test**

An impulse response test must be performed by the RGDM as described below. The impulse tests must have the following characteristics:

- Analogue current Input 20 A (secondary signal coming from the CT sensor Rogowsky)
- Duration of the impulse: 1ms, 2 ms, 4ms and 8 ms.

Examples of the test are shown in the following figures.

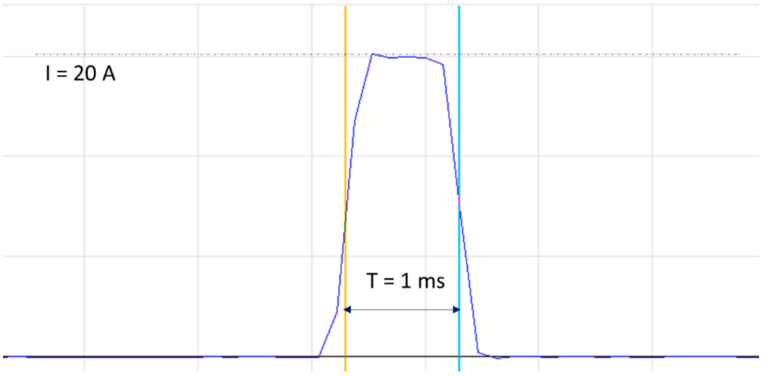

Figure 45 – Impulse test, T = 1 ms

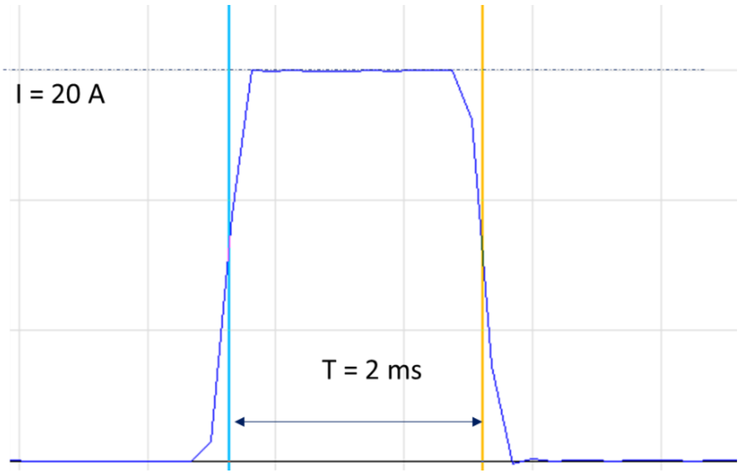

Figure 46 – Impulse test, T = 2 ms

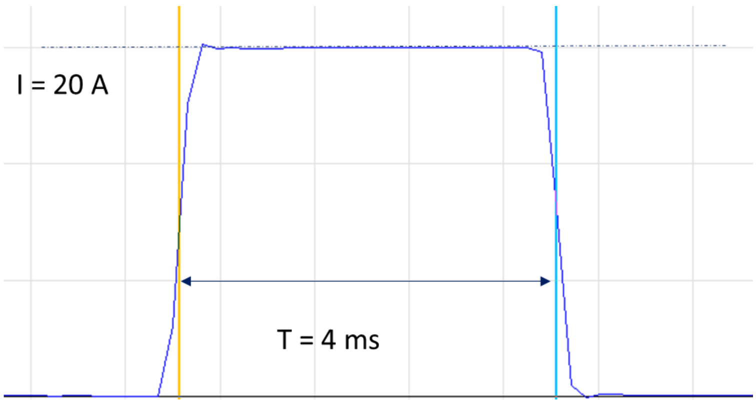

Figure 47 – Impulse test, T = 4 ms

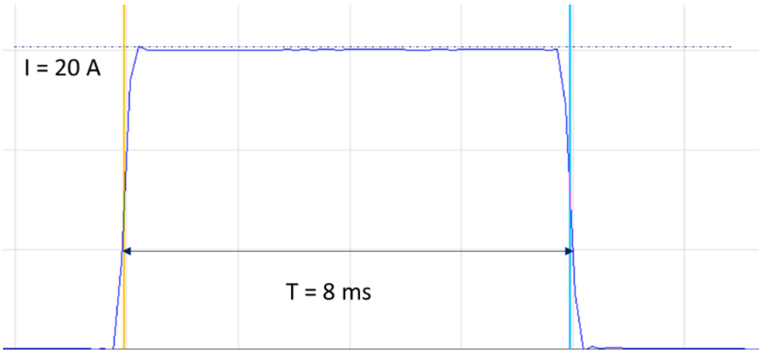

Figure 48 – Impulse test, T = 8 ms

9.6.8.6. Checking the measurement function

For checking the active and reactive power and phase voltage measurement function, the RGDM must be subjected to the tests listed in Table 86, with the RGDM powered at the secondary and primary voltages. The secondary power supply voltages must be such that a reference is obtained for calculating the active and reactive power at the primary voltage of 20 kV.

Table 86 – Checking the measurement function

	I			
Test n°	modulus (A)	phase (°)	P (kW)	Q (kVAR)
1	50	0.0	1732.051	0
2	50	36.9	1385.094	1039.958
3	50	-25.8	1559.398	-753.842
4	200	0.0	6928.203	0
5	200	36.9	5540.378	4159.833
6	200	-25.8	6237.591	-3015.37
4	360	0.0	12470.77	0
5	360	36.9	9972.68	7487.7
6	360	-25.8	11227.66	-5427.67

The error allowed when calculating the active and reactive power under the test conditions described above, must be less than 1%.

9.6.8.7. Checking continuous voltage compensation

To check the continuous voltage compensation, the RGDM must be subjected to the tests listed in Table 87:

- setting the 67N.S1 threshold with:
  - V_0 secondary 6 V
  - I_0 primary 5 A
  - Activation sector 60° ≤ α ≤ 250°
- Providing for 5 sec the value of V_{0pre} and a residual current of 1 A primary and phase of 0°;
- Providing the value of V_{0pre} in steps for 5 sec and a residual current of 10 A primary and phase of 0°;
- Checking the 67N.S1 trigger, with the activation time provided for, or the absence of said trigger.

Table 87 – Checking continuous voltage compensation

	V_{0pre}		V_{0post}		
Test n°	Modulus (V)	Phase (°)	Modulus (V)	Phase (°)	Trigger 67.S1
1	3.6	90	7.5	-28.6	YES
2	3.6	0	3.0	0.0	YES
3	3.6	45	4.8	-32.1	YES
4	3.6	90	6.5	-33.6	NO
5	3.6	0	1.8	0.0	NO
6	3.6	45	3.9	-41.7	NO

9.6.8.8. Checking continuous current compensation

To check the continuous current compensation, the RGDM must be subjected to the tests listed in Table 88:

- setting the 67.S1 threshold with:
  - V0 secondary 6 V
  - I0 primary 5 A
  - Activation sector 60° ≤ α ≤ 250°
- Providing the value of I_{0pre} for 5 sec and a residual voltage of 3.6 V and phase of 0°.
- Providing the value of I_{0pre} in steps for 5 sec and a residual voltage of 30 V and phase of 0°.
- Checking the 67.S1 trigger, with the activation time provided for, or the absence of said trigger.

Table 88 – Checking current compensation

	I_{0pre}		I_{0post}		
Test n°	Modulus (A)	Phase (°)	Modulus (A)	Phase (°)	Trigger 67.S1
1	1	90	5.6	10.3	YES
2	1	0	6.5	0.0	YES
3	1	45	6.3	6.5	YES
4	1	90	4.6	12.5	NO
5	1	0	5.5	0.0	NO
6	1	45	5.2	7.8	NO

9.6.8.9. Checking the performance of the 61850 protocol

The device must also be equipped with propriety Sw for both configuring all the protection and control parameters, and for configuring and managing the 61850 protocol part (creation of CID files).

The tests required are indicated below:

- Sending of the CID file from the SW to the device.
- Receiving of the CID file by the device.
- Sending of the CID file from the TMF 2020 to the device.
- Loading of the CID file generated by the TMF 2020 in the SW.
- Measuring the reception time for the GOOSE messages related to the generating cause, for example, for 67N protection activation, the times must be measured between the start of a fault event and sending the opening command to the switch, and the related GOOSE that switches the status to protection activated. Once these times have been measured, the difference between them is determined. The maximum admissible difference must not exceed 30 msec.
- The test described above is done for a series of 10 protection activations, broken up by 1 second pauses, measuring the times are described above. The time differences must stay below 30 msec.

GridSpertise reserves the right to add further tests to those indicated above, based on its incontestable judgement.

9.6.8.10. Checking tests for Par. 8.2.1

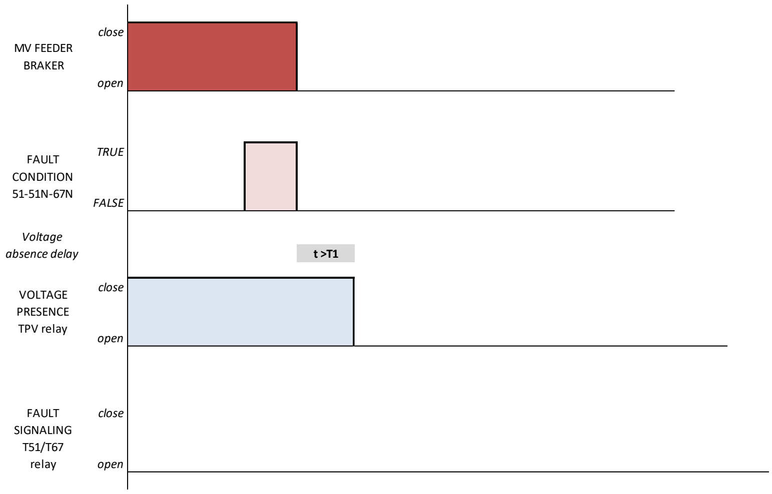

Figure 49 –test 1

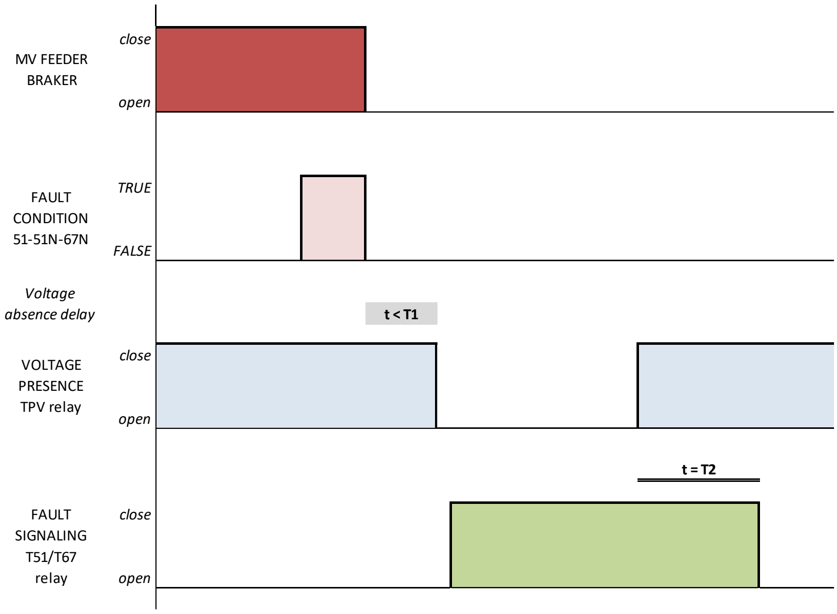

Figure 50 - test 2

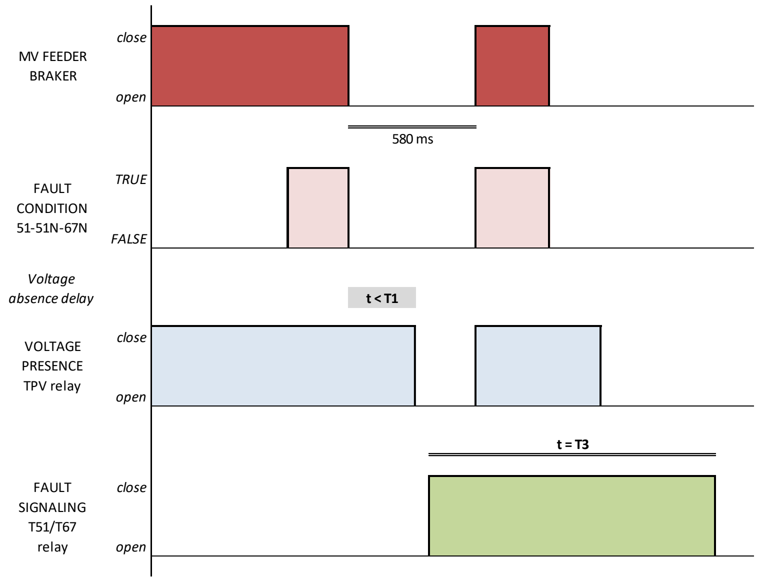

Figure 51 - test 3

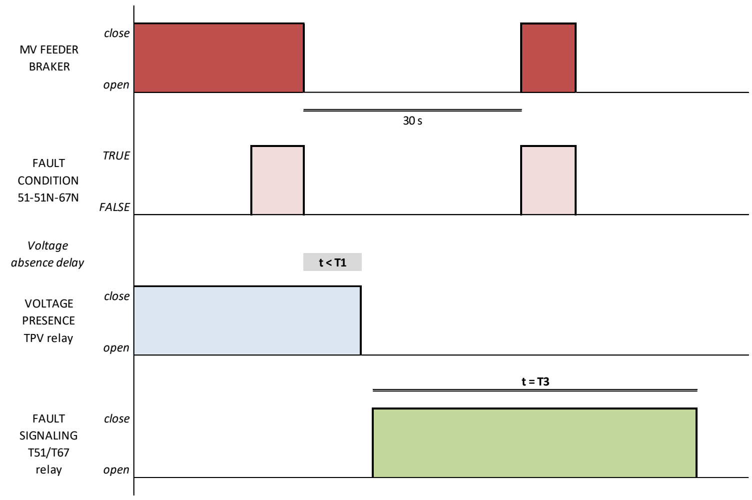

Figure 52 - test 4

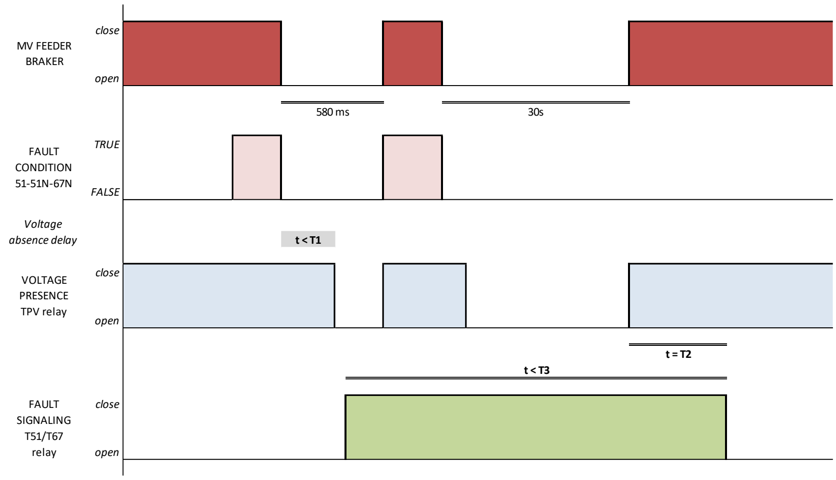

Figure 53 - test 5

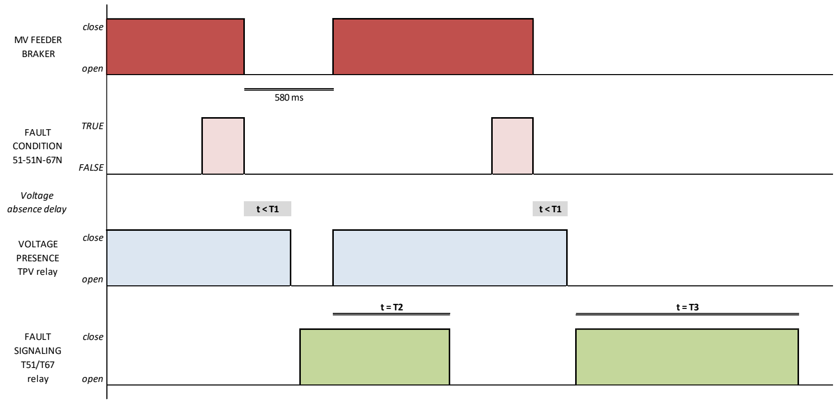

Figure 54 - test 6

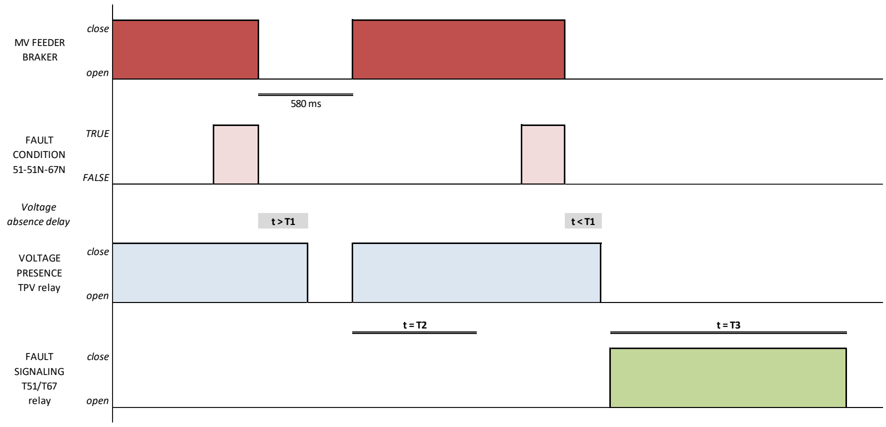

Figure 55 - test 7

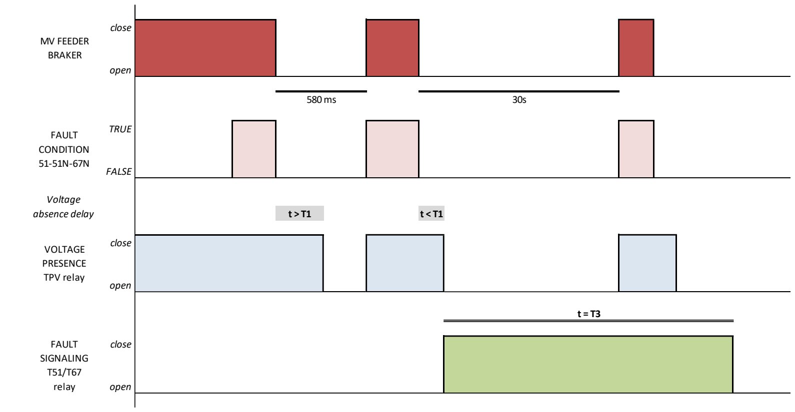

Figure 56 - test 8

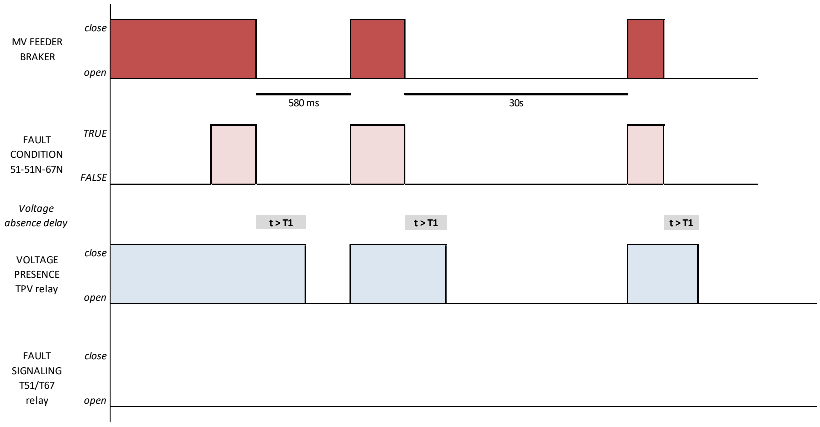

Figure 57 - test 9

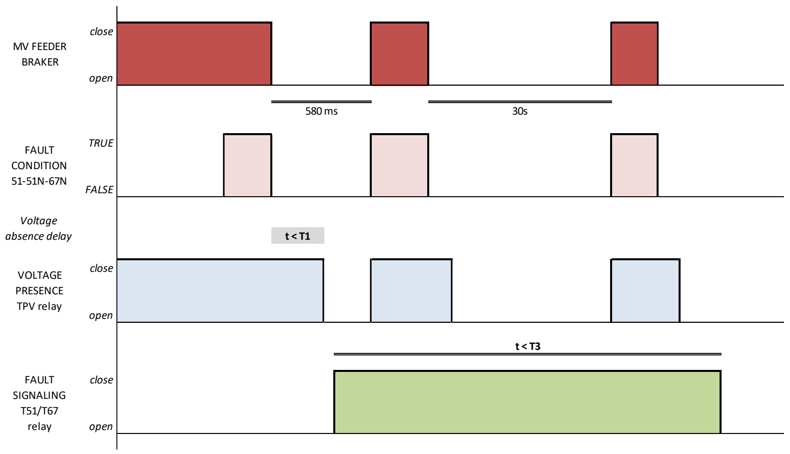

Figure 58 - test 10

9.7 Certification and self-certification

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).

10. MISCELLANEOUS

This chapter include further requirements, recommendations and additional information.

10.1 Required documentation

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

- RGDM data sheet with snapshots;
- installation, operation and maintenance manuals, with instructions on the installation and interfacing procedures;
- administrator's manual, for proper integration of RGDM into communication and IT networks (this document should describe any network service the RGDM is supplying);
- list of pre-installation checks to ensure that the components have been delivered correctly;
- quick installation and set-up guide;
- installation and one-wire diagrams (also in DWG/DXF formats);
- all software need to RGDM operation;
- parts list;
- required but not included parts list;
- recommended Tool List;
- electrical schematics;
- mechanical drawings;
- spare parts list;
- maintenance procedures;
- troubleshooting guide;
- component specification literature.

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

10.2 Clarification during procurement process

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

- Clarification for the color codes to be used:
  - Color codes according to the IEC standard (ref. par. 6.1.1)
  - Color codes according to the ANSI standard (green for open button and red for close button).

10.3 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.

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 GridSpertise 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), GridSpertise 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 GridSpertise.