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Fixed installed indoor Power Quality Instrument

This global standard define the characteristics of the fixed installed indoor Power Quality Instrument (according to IEC 62586-1) and accessories for measurement of power quality parameters in a.c. distribution systems with a declared fundamental frequency of 50 Hz or 60 Hz.

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It is for internal Use. Each Country can provide a translation in local language but the official reference document is this GS English version.

Revision	Data	List of modifications
00	13.11.2015	First draft
01	29.01.2016	First approved edition
02	05.04.2019	Second approved edition. Introduction of PQI-A-FI2-G and PQI-S-FI2-G families. Remodulation of several requirements from basic to extended. New extended requirements.

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1 ACRONYMS

- a. **1PPS** A pulse per second signal
- b. **CLI** Caller Line Identification
- c. **CS** Current Sensor
- d. **CSV** Comma-separated values
- e. **DHCP** Dynamic Host Configuration Protocol
- f. **DHCPv6** Dynamic Host Configuration Protocol (IPv6)
- g. **DNP3** Distributed Network Protocol
- h. **DNS** Domain Name System
- i. **GPS** Global Positioning System
- j. **GPSA** GPS Accessories
- k. **GPSR** GPS Receiver Time Syncro Receiver
- l. **GS** Enel Global Standard
- m. **HMI** Human-Machine Interface
- n. **HTTP** Hypertext Transfer Protocol
- o. **HTTPS** Hypertext Transfer Protocol Secure
- p. **JSON** JavaScript Object Notation
- q. **M3G** Modem GSM – GPRS – UMTS (2G + 3G)
- r. **NTP** Network Time Protocol
- s. **NTP** Network Time Protocol
- t. **PIMS** PQI management system
- u. **PQ** Power Quality
- v. **PQI** Power Quality Instrument according to IEC 62586-1
- w. **PQIA** Power Quality Instrument Accessories
- x. **PQMS** Power Quality Management System
- y. **REST** Representational State Transfer
- z. **RTU** Remote Terminal Unit

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- aa. **SIM** Subscriber Identity Module
- bb. **SMA** SubMiniature connector version A
- cc. **TCP** Transmission Control Protocol
- dd. **UPS** Uninterruptible Power Supply
- ee. **VS** Voltage Sensor

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

The Power Quality Instrument (PQI) described in this GS is inside the category PQI-A by according to IEC 62586-1 and it can be classified in three classes provided in Table 1.

Table 1 – PQI product family and description		
PQI type	Product family code	Description
PQI-A-FI2-G type R	PQI-A-FI2-G	PQI rack 19" mounting
PQI-A-FI2-G type W	PQI-A-FI2-G	PQI wall mounting with plugs
PQI-A-FI2-G type D	PQI-A-FI2-G	PQI top hat rail 35 X 15 mounting
PQI-A-FI2-G type B	PQI-A-FI2-G	PQI Half rack 19" mounting
PQI-S-FI2-G type R	PQI-S-FI2-G	PQI rack 19" mounting
PQI-S-FI2-G type W	PQI-S-FI2-G	PQI wall mounting with plugs
PQI-S-FI2-G type D	PQI-S-FI2-G	PQI top hat rail 35 X 15 mounting
PQI-S-FI2-G type B	PQI-S-FI2-G	PQI Half rack 19" mounting
PQI-A-FI1-H type R	PQI-A-FI1-H	PQI rack 19" mounting
PQI-A-FI1-H type W	PQI-A-FI1-H	PQI wall mounting with plugs
PQI-A-FI1-H type D	PQI-A-FI1-H	PQI top hat rail 35 X 15 mounting
PQI-A-FI1-H type B	PQI-A-FI1-H	PQI Half rack 19" mounting
Power supply enhancement	PQI enhancement	See par. 7.1
Output channels enhancement	PQI enhancement	See par. 7.2
Voltage dip monitoring according to Italian Regulation enhancement	PQI enhancement	See par. 7.4
Energy measurement enhancement	PQI enhancement	See par. 7.6
Mains signalling voltage enhancement	PQI enhancement	See par. 7.7

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Specific RTU functionalities according to Spanish requirements enhancement	PQI enhancement	See par. 7.8
IEC 61850 enhancement	PQI enhancement	See par. 7.9
Triggered events registration enhancement	PQI enhancement	See par. 7.10
Trends registration enhancement	PQI enhancement	See par. 7.11
Configuration file enhancement	PQI enhancement	See par. 7.12
Typical PQI type R Italy	PQI enhancement	See par. 10.5
Typical PQI type R Spain	PQI enhancement	See par. 10.5
Typical PQI type D Spain	PQI enhancement	See par. 10.5
Typical PQI type R Romania	PQI enhancement	See par. 10.5
Typical PQI type B Chile	PQI enhancement	See par. 10.5
Typical PQI type W Brazil	PQI enhancement	See par. 10.5
Typical PQI type P Colombia	PQI enhancement	See par. 10.5

All the PQI can be equipped with the accessories provided in Table 2.

Table 2 – PQI accessories		
PQI accessory	Product family	Description
Power supply cable, with first termination according to the PQI power supply input and the second according to country rules;	Cables	See 8.1.a
One cable for each input and output with both termination according to the specific terminal block.	Cables	See 8.1.b
Modem 2G/3G (M3G) or higher configuration;	Modem kit	See 8.2.a
Cellular antenna with magnetic mount, with 10 m RG-174U cable and termination with SMA male connector.	Modem kit	See 8.2.b
GPS receiver (GPSR);	GPS kit	See 8.3.a

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20 m cable for connection to PQI, both termination in RJ12;	GPS kit	See 8.3.b
GPS antenna with magnetic mount and/or wall plugs, with 5 m cable, with L bracket;	GPS kit	See 8.3.c
extra bracket for wall mounting.	GPS kit	See 8.3.d

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3 NORMATIVE REFERENCES AND BIBLIOGRAPHY

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

3.1 For all countries

IEC 60529	Degrees of protection provided by enclosures (IP code)
IEC 60715	Dimensions of low-voltage switchgear and controlgear - Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories
IEC 61000 series	Electromagnetic compatibility (EMC)
IEC 61006-5	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment
CISPR 32	Electromagnetic compatibility of multimedia equipment – Emission requirements
IEC 61000-4-30	Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods.
IEC 62586-1	Power quality measurement in power supply systems – Part 1: Power quality instruments (PQI).
IEC 62586-2	Power quality measurement in power supply systems – Part 2: Functional tests and uncertainty requirements.
IEC 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements.
IEC 61010-2-032	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 2-032: Particular requirements for hand-held and hand-manipulated current sensors for electrical test and measurement
IEC 60297-3-100	Mechanical structures for electronic equipment - Dimensions of mechanical structures of the 482,6 mm (19 in) series - Part 3-100: Basic dimensions of front panels, subracks, chassis, racks and cabinets.
ISO/IEC 7810	Identification cards - Physical characteristics
IEC 60870-5-104	Telecontrol equipment and systems - Part 5-104: Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles
IEC 60870-5-101	Telecontrol equipment and systems - Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks
IEC 62749	Assessment of power quality - Characteristics of electricity supplied by public networks
IEC 62053-22	Electricity metering equipment (a.c.) - Particular Requirements - Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)
IEC 17065	Conformity assessment - Requirements for bodies certifying products, processes and services
IEC 61850 series	Communication protocols for IED at electrical substation
IEEE 1159.3	IEEE Recommended Practice for the Transfer of Power Quality Data.
NMEA 0183	National Marine Electronics Association electrical signal requirements, data transmission protocol and time, and specific sentence formats for a 4800-baud serial data bus
GSTQ003	Power Quality Management System
GSTQ002	Extended Power Quality Data Interchange Formats

3.2 For EU countries

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EN 50160	Voltage characteristics of electricity supplied by public distribution systems.
EU directive 2004/108/CEE	EMC directive
EU directive 2006/95/CEE	Low Voltage directive
EU directive 93/68/CEE	CE marking directive

3.3 For Italy

RSE 12004159	Specifiche tecnico-funzionali delle apparecchiature di monitoraggio della qualità della tensione per le reti MT.
RSEpaper	R. Chiumeo, M. de Nigris, L. Garbero, C. Gandolfi, L. Tenti, E. Carpaneto, "Implementation of a New Method for an Improved Voltage Dips Evaluation by the Italian Power Quality Monitoring System in Presence of VT Saturation Effects", International Conference on Renewable Energies and Power Quality (ICREPQ'10), Granada (Spain), 23rd to 25th March, 2010.
ARG/elt 198/11	Testo integrato della qualità dei servizi di distribuzione e misura dell'energia elettrica per il periodo di regolazione 2012-2015

3.4 For Brazil

PRODIST Módulo 8	Procedimentos de Distribuição de Energia Elétrica no Sistema Elétrico Nacional – Módulo 8 – Qualidade de Energia Elétrica Rev. 10
Procedimentos de Rede ONS– Submódulo 2.8	Gerenciamento dos indicadores de desempenho da rede básica e dos barramentos dos transformadores de fronteira, e de seus componentes

3.5 For Colombia

Resolución CREG 024 -2005	normas de calidad de la potencia eléctrica aplicables a los servicios de Distribución de Energía Eléctrica
Resolución CREG 016-2007	Por la cual se modifica parcialmente la Resolución CREG 024 de 2005 que establece las normas de calidad de la potencia eléctrica aplicables a la Distribución de Energía Eléctrica en el Sistema Interconectado Nacional.
Resolución CREG 065-2012	establece las normas de calidad de la potencia eléctrica aplicables en el Sistema Interconectado Nacional
Resolución CREG 038-2014	Por la cual se modifica el Código de Medida contenido en el Anexo general del Código de Redes

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4 REPLACED STANDARDS

Codification	Country	Title
DV908	Italy	Apparecchiatura di monitoraggio della qualità della tensione delle reti elettriche MT
SNC021	Spain	Convertidores de medida para potencias activa y reactiva, tensión e intensidad de uso general.

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5 APPLICATION FIELDS

The PQI will be installed in the HV, MV or LV distribution grid in order to measure all the relevant PQ parameters. The relevant PQ parameters are defined in IEC 61000-4-30, IEC 62749 and EN 50160.

The installation will be a substation or another indoor premise in a country where one or more utilities are under Enel control.

The PQI must include RTU functionalities in order to allow data exchange (according to GSTQ002) with the PQMS. The PQMS is the Power Quality Management System (according to GSTQ003), including data acquisition from PQI.

Security by design is mandatory for any devices developed to be installed in the ENEL premises; the Enel requirements will be declared during the procurement process (par. 10.2).

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6 PQI BASIC REQUIREMENTS

According to IEC 62586-1 all the requirements for PQI must be respected, just the particular requirements for the PQ parameter “mains signalling voltage” can be intended as extended requirements (par. 7.7).

By according to Enel possible locations for PQI, three alternatives are possible (the choice will be declared during the procurement process par. 10.2):

- a. PQI-S-FI2-G;
- b. PQI-A-FI2-G;
- c. PQI-A-FI1-H.

Additional requests are present in this chapter.

6.1 Enclosure

With reference to the enclosure, three alternatives are possible (the choice will be declared during the procurement process par. 10.2):

- a. Rack 19” mounting according to IEC 60297-3-100 (named type R);
- b. Wall mounting with plugs (named type W);
- c. Top hat rail 35 × 15 according to IEC 60715 (named type D);
- d. Half Rack 19” mounting according to IEC 60297-3-100 (named type B), that is simple a custom design where 2 devices behave as a single rack device (see figure 1);
- e. Panel mounting (named type P) with dimension 28 cm (Width) × 19 cm (Height) × 20 cm (Depth).

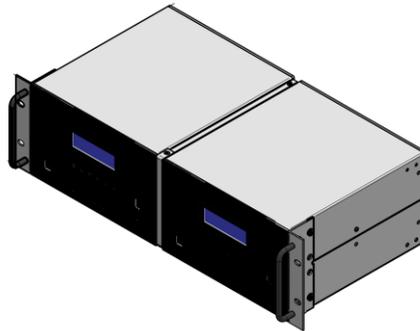


Figure 1 – Illustrative example of PQI type B arrangement

The enclosure must contains all the PQI and accessories (when specified). Name, trademark, CE mark (in EU), product number and serial number must be visible and not removable.

6.2 Power supply

The supply voltage must be compliant with all or some of the followings ranges (the choice will be declared during the procurement process par. 10.2):

- a. 110 Vdc (+15%, -15%);
- b. 110 Vdc (+30%, -60%);
- c. 125 Vdc (+30%, -30%);
- d. 125 Vdc (+15%, -15%);
- e. 220 Vdc (+10%, -60%);
- f. 207 ÷ 253 Vac with 50 Hz or 60 Hz as rated frequency;
- g. 20 ÷ 28 Vdc;
- h. 90 ÷ 130 Vac with 50 Hz or 60 Hz as rated frequency;
- i. 48 Vdc (+15%, -15%);

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- j. DC or AC supplies through the same power terminals within the range 120 Vdc (+ 15%, -15%) and 120 Vac (+ 15%, -15%) 60 Hz as rated frequency.

For all the AC supplies, according to IEC 61000-6-5 and IEC 61326-2-4, the 4 kV immunity level for fast transients and surges is required.

According to the IEC 61000-4-30 and IEC 62586-1, the PQI is called to work also in presence of power quality disturbances affecting also the power supply.

Relevant protection must be present against the accidental supply with non standard voltage.

The PQI shall arrange two terminal connectors for conductors up to 2.5 mm² (AWG 14).

6.3 Physical buttons and leds

The following physical buttons and leds must be available in front of the PQI (these functions can also be provided by means of a display and pushbuttons):

- a. Reset button;
- b. Power on led (green if PQI is turned on);
- c. Battery (if present as in par. 7.1) status (red if the battery is low, is not in charge or have another warning).

6.4 Measuring input channels

The electrical quantity to be measured may be either directly accessible, as it is generally the case in low-voltage systems, or accessible via measurement sensor like VS or CS. All the inputs must be synchronized.

With reference to IEC 61000-6-5 and IEC 61326-2-4, the 4 kV immunity level for fast transients and surges is required.

6.4.1 Voltage input channels

The PQI shall arrange at least 4 terminals for connecting the three phases plus neutral. Connection will be provided by means of conductors having a cross-section up to 4 mm² (AWG 12).

Voltage range shall be at least 480 V_{rms} phase-to-phase. Input impedance shall be higher than 1 MΩ. Measuring accuracy is not required above this +20% burden. DC measuring is not mandatory.

6.4.2 Direct current input channels

The PQI shall arrange at least 6 terminals for measuring the three phase currents. Connection will be provided by means of conductors having a cross-section up to 4 mm² (AWG 12). Current range shall be at least 5 Arms with a permanent overloading capacity up to +20% and 100 A during 1 second. Measuring accuracy is not required above +20%. DC measuring is not mandatory.

6.5 Communication ports and expansion slots

The device shall arrange at least 2 fast-ethernet RJ-45 ports 10/100 Mbps:

- a. One in the rear, for data exchange with the PQMS or for local configuration;
- b. One in the front for local configuration.

6.6 PQI management system

The PQI must be equipped with an internal PQI management system (PIMS) with web server.

The HMI with the PIMS must be possible connecting a PC to the Ethernet port and presenting hit as a web client; MS Internet Explorer v7 (or more) and Google Chrome v41 (or more) must be allowed.

The PIMS must allow:

- a. To configure the installation code;
- b. To visualize all the measurement performed by the PQI in real time (including the fasorial diagrams);

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- c. To manage all the data stored in the PQI internal data storage (par. 6.6);
- d. To manage the data exchange and communication issues;
- e. To perform all possible settings (including the VS and CS ratio);
- f. To manage PQI system alarms and warnings.

Configuration must be also uploaded as a single file/request by means of the PIMS, SFTP and REST servers (when required according to par.6.10.2).

If digital inputs are implemented, the PIMS must allow to define which field signal is received trough each digital input (by selection from drop-down menu), particularly the following case must be covered:

- g. Events from network protection devices, the PIMS must allow the configuration of the protection code;
- h. Open/close of a breakers/switches, the PIMS must allow the configuration of the breaker/switch code;
- i. Open/close of busbars couplers, the PIMS must allow the configuration of the coupler code and the code of the two busbar coupled.

The list of protection/breaker/switch/coupler codes will be shared by Enel and inserted in the drop-down menu by the supplier.

If analogue outputs are implemented the PIMS must allow to define which measurements (by selection from drop-down menu) are available trough the analog output (when required according to par. 7.2); the selectable measures are all the available (according to IEC 61000-4-30). Also the refresh time of the measures must be configurable according to par. 0, 6.12, 7.10 and 7.11.

The PIMS must allow to define which internal signal is available trough the digital output (by selection from drop-down menu), particularly the following case must be covered:

- j. All the internal system warnings/alarms;
- k. Over/under voltage/current events.

The PIMS must include also the automatic routine to exchange data with the PQMS:

- l. Scheduled data exchange;
- m. Data exchange after events.

6.7 Internal data storage

The internal storage shall be dimensioned for at least 10 years of events (at a rough rate of 100 daily events), 5 years of periodic recordings (at a rough rate of 1000 measurements every 10 minutes) and 1 year of waveforms (at a rate of 10 daily waveforms of 1-second length). Another way to fulfil this requirement is by arranging at least 32 Gb of internal data storage.

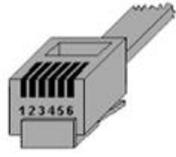
The data must be preserved also in case of 1 month PQI deenergization.

6.8 Synchronisation

The PQI shall arrange at least one of the following synchronisation methods:

- a. NTP.
- b. GPS source. In such a case the device shall arrange an RJ-11 connector to be connected to an upstream NMEA 0183 source via RS422/RS485 and a PPS signal (pulse per second electrical signal – it has a width of less than one second and a sharply rising or abruptly falling edge that accurately repeats once per second-). The pinout is shown in Figure 2.

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RJ11 6P6C (RJ12)	
Pin	Description
1	Vcc (5÷12 Vdc)
2	GND
3	PPS+
4	RS422 TX+
5	RS422 TX-
6	PPS-

Figure 2 – PQI RJ12 pinouts

6.9 IP stack

With reference to IP configuration, following alternatives must be implemented:

- IPv4 – fixed configuration (ip address, netmask, default gateway and DNS server).
- IPv4 – auto configuration (DHCP).
- IPv6 – fixed configuration (ip address, prefix length, default gateway and DNS server);
- IPv6 – stateless auto configuration;
- IPv6 – stateful auto configuration (DHCPv6).

6.10 Data exchange with PQMS

At least one of the following data and communication methods shall be arranged:

- PQDIF (according to IEEE 1159.3 and the ENEL Global standard GSTQ002), that is is a binary file format adopted to exchange PQ measurements and events between PQI and PQMS.
- HTTP/HTTPs REST server according also to ENEL Global standard GSTQ002.

The requested communication mode are the followings:

- PQI must be configured as a IPv4/IPv6 network node;
- PQI must be configured in point to point communication using GPRS/PSTN network, by using the phone number;
- The PQI must be able to operate as a SFTP client or a SFTP server.

6.10.1 PQdif data exchange

The scheduled data exchange is made in a random instant of a configurable range of the day. The PIMS must allow to configure this range from 00:00 to 24:00, granularity 1h; the default is a random from 01:00 to 06:00, in order to avoid that all the PQI will be set to send at same moment.

The PQI must create just a single PQDIF including all the PQ measure and events (par. 0, 6.12 and 6.13) detected in the last day; then PQI must start a SFTP connection (as a SFTP client) with the PQMS delivering the file. For example at 02:00 of Monday the PQDIF must create and send the PQDIF for the entire Sunday.

The name of the PQDIF file must have a formatting as “Prefix_SeedFileName_yyyyMMdd_hhmmss.pqd”, where Prefix indicates the manufacturer (2 char), SeedFileName is the unique identifier of the name installation code of PQI (max 16 char, must not contain the character '_' and the space character ' '), yyyyMMdd_hhmmss is the creation date (year 4-digit, month 2-digit, dd day 2-digit) and time (hour 2-digit, minutes 2-digit, second 2-digits).

The asynchronous data exchange is made immediately after a configurable event, trend (over a certain limit) or transient.

The PQI must create just a single PQDIF including all the PQ trends, transients and triggered events that generate the data exchange; then PQI must start a SFTP connection (as a SFTP client) with the PIMS delivering the file.

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The asynchronous data exchange is also made when the internal data storage occupation (par. 6.6) overcome a configurable occupation (default 80%), by sending all data stored.

6.10.2 HTTP/HTTPs REST server

The inbuilt REST server shall arrange the following capabilities:

- a. Folders and filenames list;
- b. Get/delete a single file;
- c. Get/delete a complete folders structure;
- d. Put a single file;
- e. Download a complete set of periodic measurements for a given time interval and requested variables (in order to deploy a fully distributed architecture);
- f. Download a set of waveforms or 10 ms RMS recordings for a given event id.
- g. Input parameters inside a GET or POST request.

With reference to the fully distributed architecture, by querying the PQI and getting a complete set of periodic or event-triggered measurements, a fully distributed architecture without a centralized database can be deployed. Upon request the centralized system would query a single PQI, retrieve periodic measurements and translate them into viewable information. This architecture is highly scalable, parallelizable, fault tolerant, robust and transparent to the end user.

Output format must be JSON or CSV. In case of a POST request a JSON input dictionary is requested.

Detailed description of the REST API is described in Enel Global Standard GSTQ002. Requested performance (e.g. speed and latency) is depicted in both Enel Global Standards GSTQ002

and GSTQ003. The device shall also arrange an IEC 60870-5-101/104, DNP3 or MODBUS TCP/RTU server for enabling straightforward integration into existent SCADA solutions.

6.11 Trends registration

The PQI must fulfill the measurement and aggregation methods stated in IEC 61000-4-30 at least for the following set of variables:

- a. Power frequency.
- b. Magnitude of supply voltage and current.
- c. Voltage and current unbalance.
- d. Voltage and current harmonics.
- e. Flicker.
- f. Active and reactive powers (they are not directly approached in the IEC 61000-4-30 but can be evaluated from supply voltage and current and aggregated in the same way).

All the configurations must be done in the PIMS.

6.12 Triggered events registration

According to IEC 61000-4-30 and Table 3, the PQI must provide a triggered events registration (data exchange between PQI and PQMS must be according GSTQ002). It is not mandatory to aggregate simultaneous events in different phases.

Table 3 – Triggered events registration	
PQ parameter	Data registered for each event
Supply voltage dips	Event id. Starting and end timestamp (at least 10 ms accuracy) Residual voltage. Voltage phases involved (R, S, T, N, RS, ST, TR). Vero, Falso, ND (if the extended requirement in par. 7.4 is requested). Correlation with events detected by digital inputs (if optional DIs are requested)

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	Waveforms with at least 256 samples/cycle, 1 second pretrigger and overall recording duration of 5 seconds (configurable parameters). Half-cycle RMS recordings with at least 1 second pretrigger and overall recording duration of 5 seconds.
Supply voltage interruptions	Event id. Starting and end timestamp (at least 10 ms accuracy) Residual voltage. Voltage phases involved (R, S, T, N, RS, ST, TR). Correlation with events detected by digital inputs (if optional DIs are requested) Waveforms with at least 256 samples/cycle, 1 second pretrigger and overall recording duration of 5 seconds (configurable parameters). Half-cycle RMS recordings with at least 1 second pretrigger and overall recording duration of 5 seconds.
Supply voltage swells	Event id. Starting and end timestamp (at least 10 ms accuracy) Residual voltage. Voltage phases involved (R, S, T, N, RS, ST, TR). Correlation with events detected by digital inputs (if optional DIs are requested) Waveforms with at least 256 samples/cycle, 1 second pretrigger and overall recording duration of 5 seconds. Half-cycle RMS recordings with at least 1 second pretrigger and overall recording duration of 5 seconds.
Power frequency	Event id. Starting and end timestamp (at least 10 ms accuracy). Recorded extreme frequency value. Waveforms with at least 256 samples/cycle, 1 second pretrigger and overall recording duration of 5 seconds (configurable parameters). Half-cycle RMS recordings with at least 1 second pretrigger and overall recording duration of 5 seconds.
Overcurrent	Event id. Starting and end timestamp (at least 10 ms accuracy) Recorded maximum current. Phases involved (R, S, T, N). Waveforms with at least 256 samples/cycle, 1 second pretrigger and overall recording duration of 5 seconds (configurable parameters). Half-cycle RMS recordings with at least 1 second pretrigger and overall recording duration of 5 seconds.

All the configuration must be done in the PIMS. The number of waveforms to register after each event must be also configurable, the default is to register the related event waveform (if the event is a voltage dip the waveform will be the related voltage affected).

The events from digital inputs are correlated if detected in a time range around the PQ parameter detection; $\pm 100\text{ms}$ as a default value, step 20 ms configuration must be possible to enlarge that range (low limit and high limit must have independent configuration).

However all the events from digital input must be also exchanged (according to GSTQ002) with the PQMS.

The waveform registration is disabled for default, except for power frequency where is enabled after a certain event time (Figure 3); the minimum event time must be configurable between $20\text{ ms} \div 1\text{ s}$ (default 200 ms).

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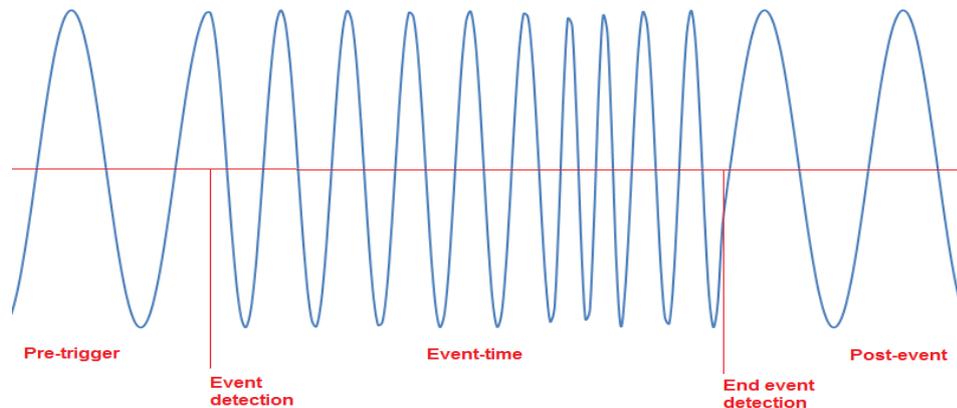


Figure 3 – Pre-trigger and post event times

The voltage/current waveform registration must be automatically activated after the triggered event with the following settings (Figure 3):

- a. Pre-trigger time from 20 ms to 1 s, step 20 ms and default 60 ms;
- b. Full event-time registration;
- c. Post-event time from 100 ms to 4 s, step 100 ms and default 300 ms;
- d. Samples/cycle waveform registration from 64 to maximum value
- e. Trigger range for over/undervoltages and over/under frequency are $\pm 10\%$ around the rated values as a default value, step 0.2% configuration must be possible to enlarge that range (low limit and high limit must have independent configuration).
- f. Trigger range for overcurrents must be fully configurable.

The aforementioned values are just minimal requirements, longer recording timespans are welcome.

The averaging window for calculation of power frequency shall be by default 200 ms long. It is advisable to be able to configure its length through the PIMS.

6.13 Crucial system events registration

According to par. 6.6.f the PIMS must manage system warnings and alarms in term of recording and data exchange with the PQMS (according GSTQ002).

Following crucial events must be approached as follow:

- a. NO GPS SYNCHRONIZATION, due to a recognition of a no synchronized time base (typically on start before engaging the GPS or absence/interruption connection to GPSR) the PIMS must record an event of "time base of sync", identifying the instant of start and the duration of this condition.
- b. MEMORY FULL, when the internal data storage occupation (par. 6.6) overcome the 80% of filling, identifying the instant of happening.
- c. VOLTAGE ANOMALY, due the persistence (at least 6 hours) of the voltage measurement in the range $\pm 10\%$ V_n for one or two channels of the PQI and the voltage measuring over the range $\pm 30\%$ V_n for the remaining channels (two or one, respectively). Identifying the instant of start and the duration of this condition. After the first recording (after 6 hours of the occurrence of the fault condition), the event is repeated at most once a day, for the duration of the fault condition. Note that the absence of voltage on all channels of the apparatus is not considered an anomaly voltage channels. Furthermore, the management of this event is significant only if the device is configured for three-phase measures, while not provided for single-phase measures.
- d. NO NTP SYNCHRONIZATION (if NTP is used instead of GPS).

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7 PQI EXTENDED REQUIREMENTS

The requirements from this chapter must be respected just if expressly requested during the procurement process par. 10.2.

7.1 Power supply enhancement

A battery must be present to assure a continuity of the measurements at least for 30 minutes of interruption of any other power supply disturbance (UPS function).

7.2 Current input channels enhancement

The PQI shall arrange:

- a. At least 6 terminals for measuring the three phase currents via current-to-voltage transducers. Connection will be provided by means of conductors having a cross-section up to 1.5 mm² (AWG 16). Voltage range shall be at least 3 V_{rms} with a permanent overloading capacity up to +100%. Input impedance shall be higher than 1 MΩ. Measuring accuracy is not required above +20%.
- b. With reference to the par. 6.4.2, additional 2 terminals must be added for neutral current measurement.

7.3 Other input and output channels enhancement

Input and output channels in Table 4 must be provided:

Type	N° of channels	Range	Terminal blocks
Analogue outputs	4	4 ÷ 20 mA	for conductors up to 2.5 mm ² (AWG 14).
Insulated digital outputs	1	24 ÷ 130 Vdc	for conductors up to 2.5 mm ² (AWG 14).
Insulated digital inputs	12	24 ÷ 130 Vdc	for conductors up to 2.5 mm ² (AWG 14).

Each analogue output channel shall be associated with any of the following internal variables through the PIMS:

- c. RMS voltage.
- d. RMS current.
- e. Active power.
- f. Reactive power.
- g. Power frequency.

For powers the zero-level will be adjusted in the middle of the overall range (i.e. 12 mA).

For frequency the output current range (4 ÷ 20 mA) must be optimized according to Table 5:

Power frequency [f]	Analog outputs current [mA]
f < 45 Hz	4 mA
45 Hz ≤ f ≤ 48.75 Hz	1.0667f – 44
48.75 Hz < f < 51.25 Hz	3.2f – 148
51.25 Hz ≤ f ≤ 55 Hz	1.0667f – 38.6667
f > 55 Hz	20 mA

7.4 Expansion ports

The PQI must be equipped with at least 1 expansion slot, that will allow:

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- a. The inclusion in the PQI of new accessories (particularly the M3G of par. 8.2), without the change of the dimension of PQI types W and D;
- b. The inclusion in the PQI of new accessories (particularly the M3G of par. 8.2), without the violation of rack standard dimension for PQI type R and avoiding to hide any embedded connector creating trouble in cabling;
- c. The replication of all the port of the new accessories;
- d. The complete data exchange between new accessories and PQI;
- e. The power supply of new accessories.

7.5 Voltage dip monitoring according to Italian Regulation enhancement

The PQI must be fully compliant with the technical specification RSE 12004159, in order to be inserted in the Italian voltage dip monitoring survey promoted by regulation ARG/elt 198/11.

Particularly the voltage dip validation system described in RSEpaper must be implemented in the PQI, but can be disabled in PIMS configuration (it is enabled for default).

7.6 Energy measurement enhancement

The PQI must include:

- a. active energy meter functionalities according to IEC 62053-22 Class 0.2S;
- b. reactive energy meter functionalities according to IEC 62053-23 Class 2;

The PQI has to measure energy with such levels of accuracy, but it is no requested to behave exactly as a commercial power revenue meter.

7.7 Mains signalling voltage enhancement

According to IEC 62586-1 all the requirements for the PQ parameter “mains signalling voltage” must be also respected.

7.8 Specific RTU functionalities according to Spanish requirements enhancement

In order to seamlessly integrate the PQI into Spanish substations, the PQI shall behave as a MODBUS RTU server according to ENDESA SNC021 local standard. This serial port may be provided natively or by means of a serial dongle.

The meter shall arrange a led emitter for either active or reactive power pulse metering. This functionality may also be provided by means of a dongle. This functionality may also be provided by means of a dongle or by direct Wh and VAr display on the front-panel.

7.9 IEC 61850 enhancement

The PQI shall arrange specific online measurements and fault recording capabilities (see GSTQ002 for detailed information).

7.10 Triggered events registration enhancement

Post-event time from 100 ms to 60 s, step 100 ms and default 300 ms has to be adopted instead what declared in the par. 6.12.

Moreover, acquisition of instantaneous waveforms for all voltage channels must be available. This function is aimed at storing the instantaneous samples of the monitored voltages/currents in event condition to allow post-processing for fault location maintenance; even if the event impacts just a single voltage or current.

All available and under use voltage/current channels must be included. The function involves the acquisition of all the waveforms and the RMS values of the channels in synchronous mode in the PQDIF file for each voltage event on any channel. So, not only the event affected waveform must be shared, but all the available waveforms.

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As a default configuration, the acquisition must be enabled for events in the voltage channels L1, L2, L3 (for dips, swells and interruptions) and in the homopolar voltage channel L4 (for swells). The voltages L1, L2 and L3 can be stored phase-to-neutral (L1-N, L2-N, L3-N) or phase-to-phase (L1-L2, L2-L3, L3-L1) depending on the type of wiring selected in configuration as recorded at this time.

7.11 Trends registration enhancement

According to IEC 61000-4-30 and Table 6, the PQI must provide trend registration (data exchange between PQI and PQMS must be according GSTQ002).

All the configurations must be done in the PIMS.

Table 6 – Trends registration	
PQ parameter	Activable trends
Power frequency	10/12 cycles measurement (that is also the default) or multiples (just for the analog outputs), accuracy 0.01 Hz. 10 s measurement. Aggregation from 10 minute to 2 hours (step 10 minute, default 10 minutes).
Magnitude of the supply voltage Magnitude of current	10/12 cycles measurement (default for the analog outputs). 150/180 cycles aggregation measurement. Aggregation from 10 minutes to 2 hours (step 10 minute, default 10 minutes).
Supply voltage unbalance Current unbalance	10/12 cycles measurement (default for the analog outputs). 150/180 cycles aggregation measurement. Aggregation from 10 minutes to 2 hours (step 10 minute, default 10 minutes).
Voltage/Current harmonics	10/12 cycles measurement (default for the analog outputs). 150/180 cycles aggregation measurement. Aggregation from 10 minutes to 2 hours (step 10 minute, default 10 minutes).
Voltage/Current inter-harmonics	10/12 cycles measurement (default for the analog outputs). 150/180 cycles aggregation measurement. Aggregation from 10 minutes to 2 hours (step 10 minute, default 10 minutes).
Under/over deviation	10/12 cycles measurement (default for the analog outputs). 150/180 cycles aggregation measurement. Aggregation from 10 minutes to 2 hours (step 10 minute, default 10 minutes).
Flicker	10 minutes computation for P_{st} (default for the analog outputs). 2 hours computation for P_{it} (default for the analog outputs). Aggregation according to IEC 61000-4-15.

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7.12 Configuration file enhancement

This function determines the sending of a file with the same name to each PQDIF file extension .CFG (instead of .PQD), containing all the configuration parameters of the device and the data contained in the PIMS.

The proposed format of this file is text/Json.

It is also required the presence of IMSI SIM, IMEI MODEM and IP ADDRESS MODEM fields for storing the information related to the communication part and any other configuration setting available in the PIMS.

7.13 Communication enhancement

With reference to point 6.5.a, an 1gb ethernet optical port must be added in the rear, for data exchange with the PQMS or for local configuration.

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8 PQI ACCESSORIES

The accessories from this chapter must be included just if expressly requested during the procurement process par. 10.2.

8.1 Cables

The following cables must be included for PQI power supply and for connection of the trasducers:

- a. Power supply cable, with first termination according to the PQI power supply input and the second according to country rules;
- b. One cable for each input and output with both termination according to the specific terminal block.

8.2 Modem kit

The Modem kit is made by:

- a. Modem 2G/3G (M3G) or higher configuration;
- b. Cellular antenna with magnetic mount, with 10 m RG-174U cable and termination with SMA male connector.

The M3G must have the followings characteristics:

- c. Compatible with cellular frequencies 2G (GSM850, GSM900, DCS1800, PCS1900) and 3G (B1-2100, B2-1900, B5-850, B8-900);
- d. Installable in the PQI expansion slot (par. 6.5) or connected to an Ethernet or USB port.
- e. Compatible with SIM or mini SIM, according to ISO/IEC 7810;
- f. SMA female connector for external antenna;
- g. Compatible with CLI.

The antenna and cable in 8.2.b must assure >2.5dB gain and certified for indoor operation.

8.3 GPS kit

The GPS kit is made by:

- a. GPS receiver (GPSR);
- b. 20 m cable for connection to PQI, both termination in RJ12;
- c. GPS antenna with magnetic mount and/or wall plugs, with 5 m cable, with L bracket;
- d. extra bracket for wall mounting.

The GPSR must be >20 channels parallel tracking GPS receiver designed to operate with the L1 frequency, Standard Position Service, Coarse Acquisition code.

GPSR must be able to synchronize up to 10 devices, like PQI or other devices that need accurate synchronization signal, according to IEC 61010-1, IEC 61000-6-5, CISPR 32, NMEA 0183. It must have at least 10 RJ12 connectors (Figure 2), each one providing:

- e. RS422/485 serial connection (just TX+ TX- pins) with NMEA 0183 protocol;
- f. open-collector pulse-per-second (PPS+, PPS- pins) output synchronization signal;
- g. GPSR external power input (Vdc, GND pins).

The power supply input can be provided equally by each of the 10 devices connected to the receiver, without the need to assign to a single device the function of power source and exclude all other.

The power supply characteristics must be:

- h. $9 \div 14$ Vdc;
- i. <3 VA;
- j. 24 V MAX, 5 mA MAX of electrical range.

The 1PPS characteristics must be:

- k. >0.5 s of signal duration;

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- l. ± 100 ns of signal precision;
- m. < 24 V, < 5 mA of electrical range.

The cable in 8.3.b must have the both terminations in RJ12 (Figure 2).

The antenna and cable in 8.3.c must assure > 20 dB gain and certified for outdoor operation, also in term of environmental/safety/EMC requirements.

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9 TESTING AND CERTIFICATIONS

According to IEC 62586-1 and IEC 62586-2 all the requirements from this chapter must be respected. Enel has the right to ask a prototype for any kind of verification testing. That tests can be performed in the provider factory or laboratories, no cost participation by Enel.

9.1 Testing

Functional, environmental and safety type tests must be made according to IEC 62586-1.

Routine tests must be made according to IEC 62586-1.

Functional and uncertainty tests must be made according to IEC 62586-2.

9.2 IEC 61000-4-30 certification

The certificate of conformity to IEC 61000-4-30 must be provided.

The certificate must summarize the results of a compliance report (based on compliance tests), that must be also provided; the compliance tests must be made according to IEC 62586-2.

The certificate and the report must be signed by a third party entity, qualified according to ISO/IEC 17025 and ISO/IEC 17065; however the final decision about the validity of the certification is made by Enel.

9.3 Certifications or self-certifications of calibration

A certificate or selfcertificate of calibration must be provided, it must be valid for the first 3 years from the delivery; so this document must certify that no further calibration is needed for the first 3 years.

During this period the PQI must preserve its metrological qualities (included the IEC 61000-4-30 conformity).

9.4 Other certifications and self-certifications

About the compliance of all the requirements recalled in this GS, a certificate or selfcertificate must be provided.

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

Certifications and self-certifications must be made according to IEC 62586-1 and IEC 62586-2 (included the template adopted).

9.5 RSE certification

This certificate of conformity must be provided if the extended requirement in par. 7.5 is requested.

The Italian institution Ricerca sul Sistema Energetico SpA (RSE) is the only entity that can certify the PQI according to this requirement.

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10 MISCELLANEOUS

This chapter include further requirement, recommendation and additional information.

10.1 Required documentation

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

- a. User's manual;
- b. Maintenance manual;
- c. Quick installation and set-up guide;
- d. Administrator's manual, for proper integration of PQI into communication and IT networks (this document should describe any network service the PQI is supplying);
- e. Installation and one-wire diagrams in DWG/DXF formats;
- f. PQI data sheet with snapshots;
- g. All software need to PQI operation;

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

A copy of these documentation must be accessible by the PIMS.

10.2 Clarification during procurement process

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

- a. Choice between PQI-A-FI2-G, PQI-S-FI2-G and PQI-A-FI1-H (chap. 6);
- b. Cybersecurity requirements (chap. 6);
- c. Choice about enclosure (par. 6.1);
- d. Choice about power supply (par. 6.2);
- e. Extended requirement included (chap. 7);
- f. Accessories included (chap. 8);
- g. Language for embedded sw and documentations.

10.3 Amendement

Because of the earlier stage of some international standards used in this GS, Enel may derogate some prescriptions.

The provider must official ask the possible derogation during the procurement process.

10.4 PQI delivery form

PQI, accessories etc. must be included in a single box, with adequate mechanical protection against vibrations and bumps; also the immunity to bad weather must be adequate. These boxes will be included in a main box.

The main box must be compliant with the selected transportation way.

The main box must have a external and well visible sticker with:

- a. PQI name;
- b. Trademark;
- c. CE mark (in EU);
- d. Product number and serial number;
- e. Number PQI included;
- f. Enel contract reference number.

Enel will provide all the detailed specification before the field delivery.

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10.5 Typical configuration

In order to facilitate the procurement process in each country, most typical devices and options have been listed. This list is not intended for limiting the available choices.

Table 7 – Most typical configurations.		
Id no.	Description	Applied options
1	PQI type R Italy	6 - PQI-A-FI1-H. 6.1.a - Rack 19" mounting according to IEC 60297-3-100 (named type R); 6.2.a - 110 Vdc (+15%, -15%); 7.2.a - Current input channels enhancement; 7.3 - Other input and output channels enhancement; 7.4 - Expansion ports; 7.5 - Voltage dip monitoring according to Italian Regulation enhancement; 7.6 - Energy measurement enhancement; 7.10 - Triggered events registration enhancement; 7.11 - Trends registration enhancement; 7.12 - Configuration file enhancement.
2	PQI type R Spain	6 - PQI-A-FI2-G; 6.1.a - Rack 19" mounting according to IEC 60297-3-100 (named type R); 6.2.d - 125 Vdc (+15%,-15%); 7.6 - Energy measurement enhancement; 7.8 - Specific RTU functionalities according to Spanish requirements enhancement
3	PQI type D Spain	6 - PQI-A-FI2-G; 6.1.c - Top hat rail 35 × 15 according to IEC 60715 (named type D); 6.2.d - 125 Vdc (+15%,-15%); 7.6 - Energy measurement enhancement; 7.8 - Specific RTU functionalities according to Spanish requirements enhancement
4	PQI type R Romania	6 - PQI-A-FI1-H. 6.1.c - Rack 19" mounting according to IEC 60297-3-100 (named type R); 6.2.a - 110 Vdc (+15%, -15%); 7.2.a - Current input channels enhancement; 7.4 - Expansion ports; 7.10 - Triggered events registration enhancement; 7.11 - Trends registration enhancement; 7.12 - Configuration file enhancement.
5	PQI type B Chile	6 - PQI-A-FI2-G; 6.1.d - Half Rack 19" mounting according to IEC 60297-3-100 (named type B), that is simple a custom design where 2 devices behave as a single rack device (see figure 1) 6.2.c - 125 Vdc (+30%,-30%); 7.6 - Energy measurement enhancement.
6	PQI type W Brazil	6 - PQI-A-FI2-G; 6.1.b - Wall mounting with plugs (named type W); 6.2.d - 125 Vdc (+15%,-15%); - 125 Vdc (+30%,-30%); 6.2.i - 48 Vdc (+15%, -15%);

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7	PQI type P Colombia	6 - PQI-A-FI2-G; 6.1.e - Panel mounting (named type P) with dimension 28 cm (Width) x 19 cm (Height) x 20 cm (Depth). 6.2.j - DC or AC supplies through the same power terminals within the range 120 Vdc (+ 15%, -15%) and 120 Vac (+ 15%, -15%) 60 Hz as rated frequency. 7.2.b - With reference to the par. 6.4.2, additional 2 terminals must be added for neutral current measurement. 7.6 - Energy measurement enhancement; 7.9 - IEC 61850 enhancement; 7.10 - Triggered events registration enhancement.
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