TECHNICAL NOTE

IEC 61557-12 reference standard

Energy Efficiency

When **energy** matters

socomec
Innovative Power Solutions

Introduction

APPLI 812 A

To understand the operation of an electrical installation and to anticipate any risks of deviation, the parameters that govern the operation of the equipment must be monitored.
To do this, appropriate measuring devices must be installed to gather the measurements. This document describes the aims of measuring the various electrical parameters and the importance of referring to reference standard IEC 61557-12 for the characteristics of power metering and monitoring devices (PMDs).

Contents

Performance of the electrical installation

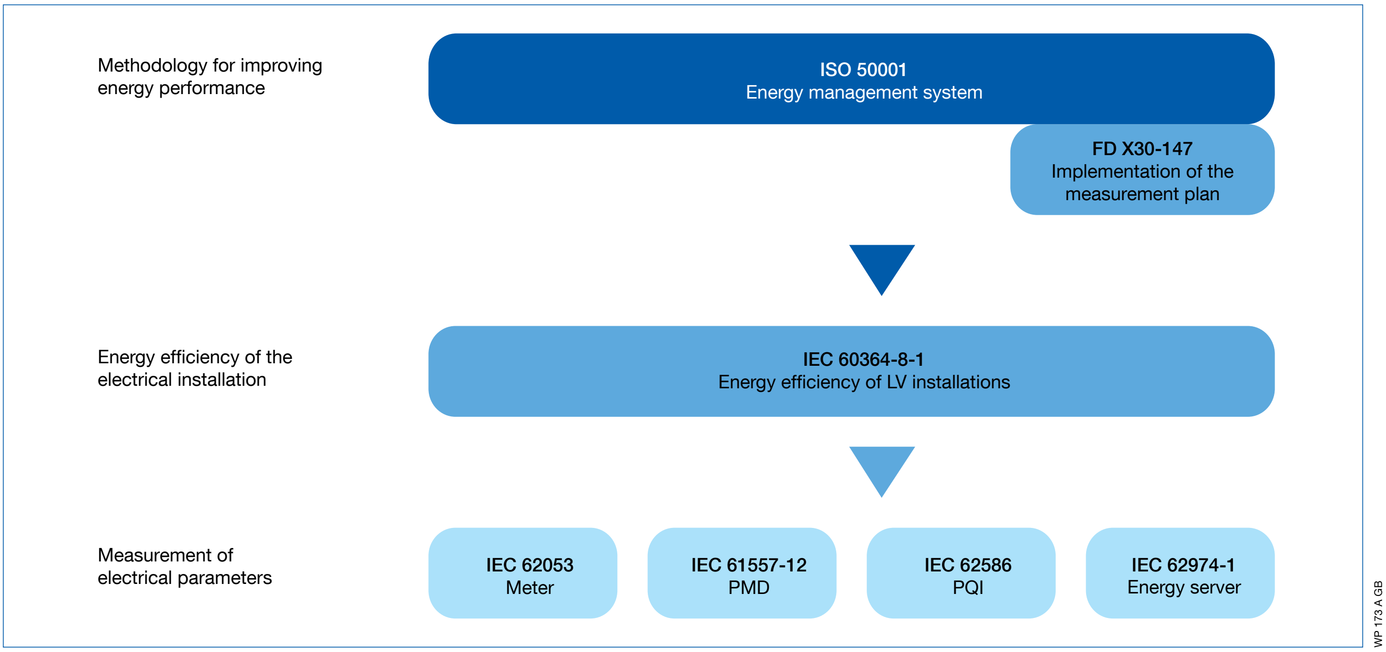

Fig. 1 - Energy performance and standards.

To improve energy efficiency of buildings, it is becoming increasingly important to consider both the electrical load consumption and the operating performance of the electrical installation to have all the parameters available to maintain and improve it.

In addition, the configuration of buildings is constantly changing (restructuring, extensions, creation of new activities etc.), so the electrical installation must also change to take into account these new requirements, which may entail, for example:
• adding photovoltaic sources and energy storage
• installing LED lighting
• increasing the number of AC/DC converters
• increasing the number of power switching devices
• adding critical or sensitive loads, etc.
• …

Regarding tools for those working on electrical installations, standard IEC 60364-8-1 (Low-voltage electrical installations - Energy efficiency) suggests a method for maintaining and improving performance based on an iterative process to be applied during the life cycle of the installation.
Those working on the electrical installation may be divided into groups depending on the type of actions to be carried out. These actions may vary according to criteria such as the organisation, type and size of the company.

IEC 60364-8-1 suggests classification of these actions and the corresponding stakeholders:

Action	Details	Generally performed by
Energy audit and measure		Auditor or energy manager
Set the basics	• Initial equipment selection, higher efficiency consumption devices • Initial service settings, etc.	Installer
Optimize	• HVAC control • Lighting control • Variable speed drives • Automatic power factor correction, etc.	Installer/tenant or user, energy manager
Monitor, maintain the performance	• Meters installation • Monitoring services • Electrical energy efficiency analysis, software, etc.	Energy manager/tenant or user
Control, improve	• Verification, maintenance, etc.	Energy manager/tenant or user

Table 1 – Process for electrical energy efficiency management and responsibilities (excerpt from IEC 60364-8-1).

Parameters for electrical measurement and applications

To effectively monitor an electrical installation, it is important to measure a large number of electrical parameters. The aims of these measurements will differ from one application to another. Two major complementary applications can be identified:
• energy efficiency,
• monitoring of the electrical installation.

Each of these applications meets specific criteria.

Energy efficiency

The aim is to improve the energy performance* of a company by implementing an energy management system (for example, ISO 50001).

The data measured will make it possible to analyse:
• the share of consumption by activity, zone, use,
• what are the most important kinds of use,
• what is the suitable operation of installation for the tariff structure offered by the supplier of electrical energy,
• potential sources of energy saving.

Following this approach, the table below summarises the main measurements and their objective.

Measurement	Measurement objective
Active energy Ea (Wh)	• Load consumption measurement • Distribution by zone and use
Reactive energy Er (varh)	• Measurement of the energy absorbed by the loads (motors, transformers etc.)
Load curve P (W)	• Monitoring of average power consumed according to an integration period to optimise the energy supply contract
Predictive power Predictive (W)	• Anticipation of contracted power excess for load-shedding operations
Power factor PF, cos(φ)	• Reference indicator for energy suppliers to be optimised to avoid penalties

Table 2 – Measurements for energy efficiency.

** Energy performance is expressed as measurable results related to energy efficiency, energy use and energy consumption (Source: ISO 50001).*

Installation monitoring

The aim is to improve and maintain the quality of the electrical installation of a company to ensure its availability and safety.

To do that, a measurement of the electrical parameters should be set up so the following can be carried out:
• characterisation of the loads and their distribution within the installation,
• the detection of deviations,
• variations in voltage,
• the occurence of voltage unbalance,
• the presence of harmonics.

By monitoring changes in these parameters, it is possible to anticipate or detect a deterioration in equipment over time as well as the risk of a process being interrupted.
It ensures optimum use of the equipment, continuity of service and performance of the installation while keeping losses and overconsumption associated with this to a minimum.

Measurement	Measurement objective	Effects on equipment and risks
Voltage (U, V)	Detection of abnormal voltage supply	**• Motors** A change in voltage in relation to the nominal rating leads to an increase in current in the induction motors and to heating that can damage their insulation and lifespan. In addition, the torque at a given speed is proportional to the square of the applied voltage. If the voltage falls, the torque may be insufficient to initiate the load and may cause the motor to stop.
Frequency (f)	Detection of a frequency deviation	**• Motors** The motors are designed to operate efficiently at their nominal frequency. A frequency deviation can cause a three-phase induction motor to run more quickly or more slowly. This can lead to inefficient operation and/or overheating of the motor. **• IT** Significant change in frequency can lead to data loss, and in the worst case scenario, to a breakdown of the IT equipment. **• Other equipment** Other equipment in the installation such as transformers, capacitors and active filters can also be affected by frequency changes.
Current (I, I_N)	• Detection of current variations • Analysis of load current values • Identification of any overloads	**• Equipment** By monitoring the current consumed by the loads and significant increases, it is possible to prevent the protection devices from tripping which could, for example, interrupt a process.
Power (P, Q, S)	Analysis of power consumed by the loads	**• Installation** If the installation is incorrectly sized, tripping may occur. Power analysis makes it possible to better distribute the loads in the installation and minimise risks.
THDU **Voltage harmonics (Uh, Vh)** **THDI** **Current Harmonics (Ih)**	Analysis of THD and harmonic decomposition in voltage and current	**• Installation** Non-linear loads that generate harmonics are increasingly present in installations. The presence of harmonics leads to an increase in rms current in the circuits and a deterioration in the quality of the supply voltage. **Risks:** - Limits to the electrical system capacity relating to overloads - Increased losses - Higher risk of breakdowns - Overheating of equipment and cables - Disruption to the electronic systems - Level 3 harmonics: Overheating of the Neutral conductor and reduced safety
Voltage unbalance (Unb, Vnb) **Current unbalance (Inb)**	Analysis of voltage and current unbalance for three-phase loads	**• Motors** A voltage unbalance can cause a current unbalance leading to overheating, torque variations and vibration in the motors, which can lead to a degradation in their performance and lifespan.
Voltage dips (Udip, Vdip)	• Analyse the duration of voltage dips and their amplitude • Time stamp their occurrence	**• Motors** Voltage dips directly affect a motor, causing a drop in its torque and speed. They also indirectly affect the operation and reliability of a motor through its control because magnetic contacts, which open and close the circuit of a motor, are sensitive to voltage variations.
Voltage interruption (Uint, Vint)	• Analyse the duration of any interruptions • Time stamp their occurrence	**• Equipment** Power outages can cause a loss of production, material damage and even safety problems. They can also cause the Programmable Logic Controllers (PLC) to malfunction, as well as causing contactors, circuit breakers or protection relays to trip.
Voltage swells (Uswl, Vswl)	• Analyse the duration of overvoltages and their amplitude • Time stamp their occurrence	**• Equipment** The effects of voltage swells can be harmful in the long term. They can cause power supply outages and overheating generated by a degradation in the insulations, and then halt the equipment.

Table 3 – Measurements for monitoring of the electrical installation.

Note: For more detail, refer to the Technical note, "Advanced measurements and applications" which gives information on calculations and application examples.

Standard IEC 61557-12

What is the importance of this standard ?

To work from data that is suitable for the target application, which is essential for any energy performance project, measurements of the electrical parameters must be sufficiently reliable, accurate and repeatable in the environmental conditions to which the measurement devices will be subjected in the electrical panels:

- increase in ambient air temperature
- variation in the voltage and frequency of the grid
- electromagnetic disruptions caused by machines in an industrial setting

To ensure the measurements are appropriate, the devices must undergo tests that are representative of the operating conditions of an installation. Standard IEC 61557-12, designed for these requirements, is the reference standard for measurement devices for monitoring electrical installations.

Full title of IEC 61557-12: “Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. - Equipment for testing, measuring or monitoring of protective measures - Part 12: Power metering and monitoring devices (PMD)”.

This standard attempts to define criteria for compliance and accuracy, both for measuring energy, and for all other relevant parameters with a view to monitoring an electrical installation.

PMD definition

A measurement unit that complies with standard IEC 61557-12 is called a PMD (Power Metering and Monitoring Device). A measuring device that does not comply with this standard cannot be called a “PMD”.

Structure of a PMD

A PMD may be fitted with internal or external sensors depending on the applications it will be operating in and on the type of loads it will measure. IEC 61557-12 defines 4 types of PMD.

		Current measurement	
		PMD with an external sensor (current sensors outside the PMD) **-> PMD Sx**	Direct connected PMD (current sensors inside the PMD) **-> PMD Dx**
Voltage measurement	Direct connected PMD (voltage sensors inside the PMD) **-> PMD xD**	**PMD SD** Semi-direct insertion	**PMD DD** Direct insertion
	PMD with an external sensor (voltage sensors outside the PMD) **-> PMD xS**	**PMD SS** Indirect insertion	**PMD DS** Semi-direct insertion

Table 4 - Classification of PMD (excerpt from IEC 61557-12).

For example, a PMD SD is a PMD with direct voltage measurement without external sensors and current measurement using external current sensors.

Performance class

Accuracy
Accuracy given without any reference to the measurement range to which it is applied, in the conditions in which the measurement was taken, cannot ensure that the data measured is suitable for the target application. Standard IEC 61557-12 describes all these elements by way of a **performance class**.

Standards regarding electrical meters only deal with the accuracy of energy. These standards are IEC 62053-2x or EN 50470 (European standard for compliance with the MID directive) on metering energy.
In addition to energy, standard IEC 61557-12 will take into account all electrical parameters to be monitored.

To do this, the performance class will establish accuracy limits for a given measurement range in reference operating conditions for each of the electrical parameters offered to the user, so that an electrical installation can be characterised:
- energy and power,
- frequency,
- current,
- voltage,
- power factor,
- voltage outages, dips and swells,
- THD, harmonics,
- voltage and current unbalance.

Influence quantities
The factors that affect measurement accuracy will also be considered.
IEC 61557-12 gives limits for acceptable variations in accuracy linked to the influence of these factors called influence quantities.

The main influence quantities are:
- ambient temperature,
- voltage,
- frequency,
- voltage unbalance,
- harmonics in voltage and current,
- electromagnetic disturbances.

- The **performance class** specifies **measurement accuracy** for each of the electrical parameters over a measurement range in **reference conditions with additional variation limits caused by influence quantities.**
- The **performance class given for an electrical parameter** will be checked by way **specific tests as described in the standard**. These tests must be carried out by the metrology laboratory of the manufacturer or a third-party laboratory.

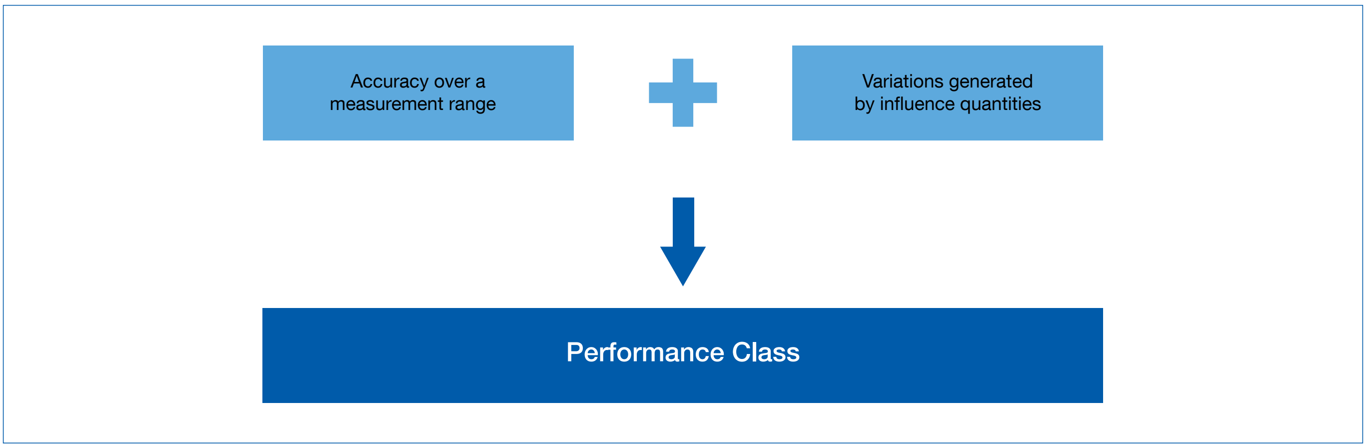

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Fig. 2 - Performance class of PMD.

Example of performance class

The performance class is defined for direct connected PMD and for PMD with external sensors. It takes into account the value of the power factor.
The following example describes how to interpret the performance class for the power and active energy of a PMD with external sensors. The same method must be applied for a direct connected PMD or to determine the performance class of other electrical parameters.

Excerpt from the standard

Specified measuring range		**Power factor**	**Intrinsic uncertainty limits for PMD of performance class C**		**Unit**
Value of the current for direct connected PMD Dx	**Value of current for PMD Sx with an external sensor**		**where C < 1**	**where C ≥ 1**	
$2\% I_b \le I < 10\% I_b$	$1\% I_n \le I < 5\% I_n$	1	±2.0 x C	No requirement	%
$5\% I_b \le I < 10\% I_b$	$2\% I_n \le I < 5\% I_n$	1	No requirement	±(1.0 x C + 0.5)	%
$10\% I_b \le I \le I_{max}$	$5\% I_n \le I \le I_{max}$	1	±1.0 x C	±1.0 x C	%
$5\% I_b \le I < 20\% I_b$	$2\% I_n \le I < 10\% I_n$	0.5 inductive 0.8 capacitive	±(1.7 x C + 0.15) ±(1.7 x C + 0.15)	No requirement No requirement	%
$10\% I_b \le I < 20\% I_b$	$5\% I_n \le I < 10\% I_n$	0.5 inductive 0.8 capacitive	No requirement No requirement	±(1.0 x C + 0.5) ±(1.0 x C + 0.5)	%
$20\% I_b \le I \le I_{max}$	$10\% I_n \le I \le I_{max}$	0.5 inductive 0.8 capacitive	±(1.0 x C + 0.1) ±(1.0 x C + 0.1)	±1.0 x C ±1.0 x C	%

Summary table with an external current sensor:

Specified measuring range Value of the current for PMDs with external current sensor (PMD Sx)	**Power factor**	**Intrinsic uncertainty limits for PMD of performance class C**	**Unit**
1 % In ≤ I < 5 % In	1	±2 x C	%
5% In ≤ I ≤ 120% In	1	±1 x C	%
2% In ≤ I < 10% In	0.5 inductive 0.8 capacitive	± (1.7 x C + 0.15) ± (1.7 x C + 0.15)	%
10 % In ≤ I ≤ 120% In	0.5 inductive 0.8 capacitive	± (1 x C + 0.1) ± (1 x C + 0.1)	%

C = PMD performance class where C < 1 and Imax = 120% In.

Example of a 0.5-class measuring device with a power factor = 1 and Imax = 120% In:

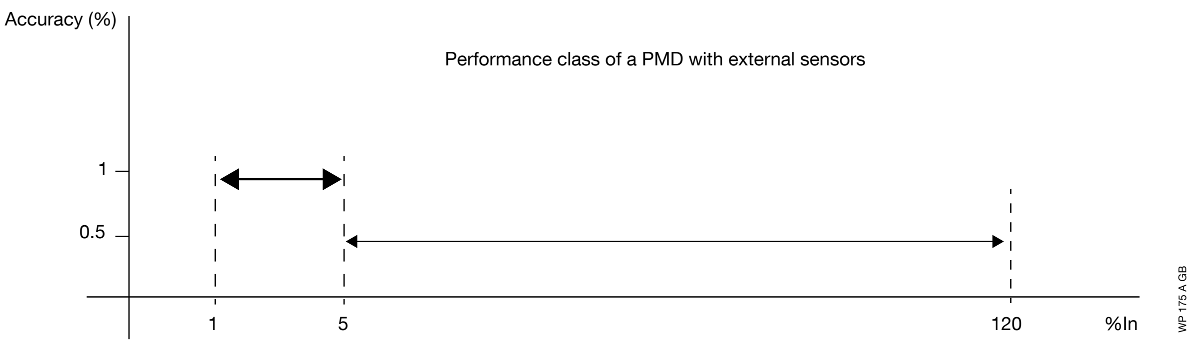


Fig. 3 - Example of performance class C = 0.5 for energy and active power.

In this example:

- range of measurement: 1 %In < I < 120 % In (Imax = 120% of nominal current In)
- performance class C = 0.5
  -> i.e. a total accuracy of **1 %** between 1 % and 5 % In
  0.5 % between 5 % and 120 % In

Example of influence
The example under consideration is the influence of voltage. The performance class is given for nominal voltage – if the voltage fluctuates between 80 % and 120 % of its nominal value, an additional error of 0.2 % will be tolerated for the accuracy of active power.
-> i.e.a total accuracy of **1.2 %** between 1 % and 5 % In
0.7 % between 5 % and 120 % In

- The performance class defines **the accuracy of the parameters measured by a PMD** (E, P, U, I, THD, harmonics, etc.) over a specified measurement range, while tolerating variations caused by influence quantities.
- It is an essential characteristic that enables **measurement performance levels** of PMD from different manufacturers to be compared.
- It **ensures** that users **can rely on the quality of the measurements** of their PMD subjected to the severe constraints of an electrical installation.

Overall accuracy of a PMD with external sensors

The accuracy of the overall measuring chain results from the accumulation of the measurement accuracy of each piece of equipment within that chain:

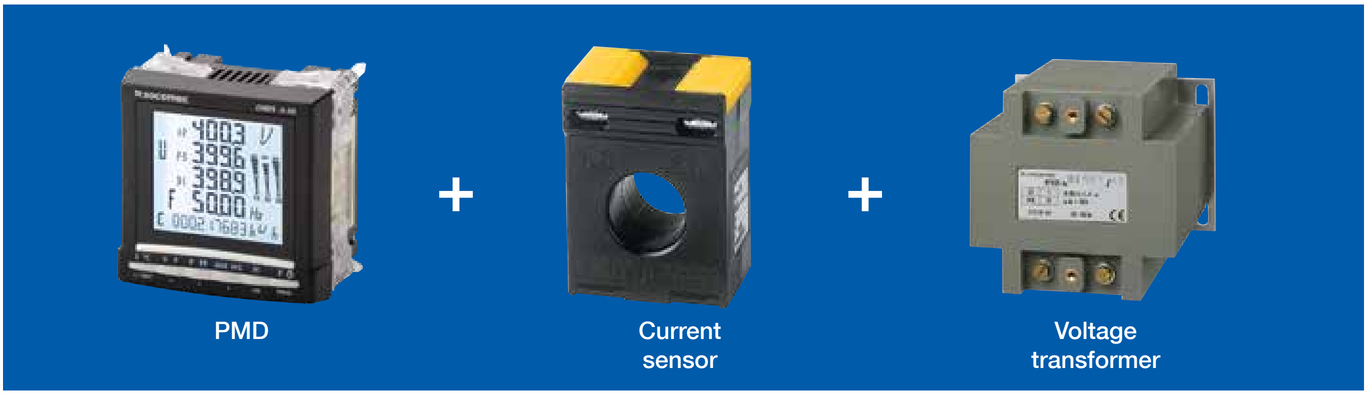


Fig. 4 - Measurement chain.

To obtain the overall accuracy of the measurement chain, the accuracy of each element has to be considered: PMD, current sensor, voltage transformer and cables.

To minimise the impact of the accuracy of the current sensor on overall accuracy, IEC 61557-12 gives recommendations for the accuracy of the sensor to be used depending on that of the PMD.

Performance class of the PMD without external sensors	Recommended sensor class to associate to the PMD	Typical overall accuracy
0.1	0.1 or higher	0.2
0.2	0.2 or higher	0.5
0.5	0.5 or higher	1
1	1 or higher	2
2	2 or higher	5
5	5 or higher	10

Table 5 - Recommended accuracy class of the sensor depending on the performance class of the PMD.

The table shows that choosing a sensor with an accuracy level that is identical to that of the PMD leads to an overall accuracy level that is twice as low.

PMDs using dedicated sensors will be considered direct connected PMD (PMD DD) and may require an overall performance class including sensors.

Note: for more details, refer to the Technical note, "Overall accuracy" which gives useful information for assessing the impact of the accuracy of sensors and the benefits of offering an overall performance class.

Other requirements

In addition to requirements regarding accuracy, IEC 61557-12 gives requirements regarding mechanical aspects, electrical safety, input/output and product marking.

Mechanical requirements

Tests regarding compliance with the degree of IP protection and withstand to vibration.
A PMD installed on a cabinet door must be at least IP 40.

Safety requirements

The PMDs must meet the safety requirements of IEC 61010. IEC 61010 is the reference standard for safety rules for electrical measurement devices.
The PMD must be designed to meet the following requirements:

- degree of pollution 2,
- overvoltage category III for supply circuits on the network,
- measurement category III for measurement input circuits.

Marking requirements

A certain number of characteristics must be marked on the PMD such as the voltage, current and frequency ranges.

Essential characteristics

Each PMD must display a summary of its main characteristics:

Characteristic	Value
Type of PMD	SD or DS or DD or SS
Operating temperature range	K55 (-10 °C to +55 °C) K70 (-25 °C to +70 °C)
Active power or active energy performance	0.1 - 0.2 - 0.5 -1 - 2

Table 6 - Main characteristics.

PMD SD K55 0.5 -> PMD with external current sensors
Operating temperature -10 to +55 °C
Performance class for Active power: 0.5

Fig. 5 - Example of main characteristics.

The performance class must be stated for each measurement parameter (U, I, P, PF…) made available for the user.

Summary of guarantees provided by IEC 61557-12

- Consideration of all the electrical parameters to be monitored within the electrical installation to ensure efficiency, availability and safety of the electrical energy.
- Reliable measurements that ensure accuracy and any potential deviations depending on the parameters that can affect the electrical installation.
- Products ensuring the safety of users in the working environment.

Socomec and IEC 61557-12 products

Measured parameters

The Socomec PMD fully meets the requirements of IEC 61557-12. They are divided into two categories:
• power metering and monitoring device,
• power metering and monitoring system.

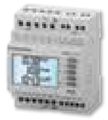
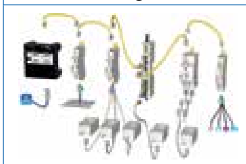
Product		Type of PMD	Active power and Active energy performance class	Temperature range	Parameters characterised by performance class
Power metering and monitoring device					
	DIRIS A-10	SD	0.5	K55	P, Q, S Ea, Er, Eap f, I, U, V THDu, THDi
	DIRIS A-14	SD	0.5	K55	P, Q, S Ea, Er, Eap f, I, U, V THDu, THDi
	DIRIS A-20	SD	0.5	K55	P, Q, S Ea, Er, Eap f, I, U, V THDu, THDi
	DIRIS A-30	SD	0.5	K55	P, Q, S Ea, Er, Eap f, I, U, V Unb THDu, Uh, THDi, Ih
	DIRIS B	DD	0.5 (with dedicated TE/iTR/TF sensor) 1 (with dedicated TR sensor)	K55	P, Q, S Ea, Er, Eap f, I, U, V Udip, Uswl, Uint Unb THDu, Uh, THDi, Ih
	DIRIS A-40	DD	0.5 (with dedicated TE/iTR/TF sensor) 1 (with dedicated TR sensor)	K55	P, Q, S Ea, Er, Eap f, I, U, V Udip, Uswl, Uint Unb THDu, Uh, THDi, Ih
	DIRIS A-100/A-200	DD	0.5 (with dedicated TE/iTR/TF sensor) 1 (with dedicated TR sensor)	K55	P, Q, S Ea, Er, Eap f, I, U, V Udip, Uswl, Uint Unb THDu, Uh, THDi, Ih
Power metering and monitoring system					
	DIRIS Digiware	DD	0.5 (with dedicated TE/iTR/TF sensor) 1 (with dedicated TR sensor)	K55	P, Q, S Ea, Er, Eap f, I, U, V Udip, Uswl, Uint Unb THDu, Uh, THDi, Ih *

Table 7 - Main characteristics and parameters measured for the DIRIS range.

** The parameters available depend on the chosen combination of U and I modules.*

Specification of performance classes

In accordance with standard IEC 61557-12, each parameter measured by the PMD must be characterised by a performance class.

Symbol	Function	Overall performance class DIRIS Digiware + dedicated sensors (TE, TR, TF) in compliance with IEC 61557-12	Measurement range
Pa	Total active power	0.2 DIRIS Digiware only 0.5 with TE, iTR or TF sensors 1 with TR sensors	10% - 120% In 2% - 120% In 2% - 120% In
Qa, Qv	Total reactive power (arithmetic, vectorial)	1 with TE, iTR or TF sensors	5% - 120% In
Sa, Sv	Total apparent power (arithmetic, vectorial)	0.5 with TE, iTR or TF sensors 1 with TR sensors	10% - 120% In
Ea	Total active energy	0.2 DIRIS Digiware only 0.5 with TE, iTR or TF sensors 1 with TR sensors	10% - 120% In 2% - 120% In 2% - 120% In
ErA, ErV	Total reactive energy (arithmetic, vectorial)	2 with TE, iTR or TF sensors	5% - 120% In
EapA, EapV	Total apparent energy (arithmetic, vectorial)	0.5 with TE, iTR or TF sensors 1 with TR sensors	10% - 120% In
f	Frequency	0.02	45 … 65 Hz
I, IN	Phase current, measured neutral current	0.2 DIRIS Digiware only 0.5 with TE, iTR or TF sensors 1 with TR sensors	5% - 120% In 10% - 120% In 10% - 120% In
INc	Calculated neutral current	1 with TE, iTR or TF sensors 2 with TR sensors	10% - 120% In
U	Voltage (Lp-Lg or Lp-N)	0.2	50 … 300 VAC Ph/N
PFA, PFV	Power factor (arithmetic, vectorial)	0.5 with TE, iTR or TF sensors 1 with TR sensors	0.5 inductive to 0.8 capacitive
Pst, Plt	Flicker (short, long)	-	-
Udip	Voltage dip (Lp-Lg or Lp-N)	0.5	-
Uswl	Voltage swell (Lp-Lg or Lp-N)	0.5	-
Uint	Voltage outage (Lp-Lg or Lp-N)	0.2	-
Unba	Voltage amplitude imbalance (Lp-N)	0.5	-
Unb	Voltage phase and amplitude imbalance (Lp-Lg or Lp-N)	0.2	-
THDu, THD-Ru	Total harmonic distortion rate of the voltage (relative to the fundamental, relative to the rms value)	1	Ranks 1 to 63
Uh	Voltage harmonics	1	-
THDi, THD-Ri	Total harmonic distortion rate of the current (relative to the fundamental, relative to the rms value)	1 with TE, iTR or TF sensors	Ranks 1 to 63
Ih	Current harmonics	1 with TE, iTR or TF sensors	-
Msv	Centralised remote control signals	-	-

Table 8 - Performance classes DIRIS Digiware (excerpt from the Instruction manual).

Overview of Socomec products and IEC 61557-12

- **DIRIS A -> PMD SD**
  - the current sensors are external,
  - the performance classes are only given for the PMD.
  > DIRIS A meets the requirements of IEC 61557-12 for a PMD SD

- **DIRIS B-30, DIRIS A-40, DIRIS A-100/A-200 and DIRIS Digiware -> PMD DD**
  - the PMDs are associated with dedicated TE, TR, iTR, TF sensors,
  - the performance classes are determined for the PMD + its dedicated sensors.
  > DIRIS B, DIRIS A-40, DIRIS A-100/A-200, DIRIS Digiware meet the requirements of IEC 61557-12 for a PMD DD.

References

- ISO 50001, Energy management systems - Requirements with guidance for use.
- FD X 30-147, Measurement plan for monitoring energy performance - Design and implementation.
- IEC 60364-8-1, Low-voltage electrical installations - Energy efficiency.
- IEC 61557-12, Electrical safety in low-voltage distribution networks - Power metering and monitoring devices (PMD).
- Technical note Overall accuracy.
- Technical note Advanced measurements and applications.

Socomec: our innovations supporting your energy performance

1 independent manufacturer

4,200 employees worldwide

8 % of sales revenue dedicated to R&D

400 experts dedicated to service provision

Your power management expert

POWER SWITCHING

POWER MONITORING

POWER CONVERSION

ENERGY STORAGE

EXPERT SERVICES

The specialist for critical applications

- Control, command of LV facilities
- Safety of persons and assets

- Measurement of electrical parameters
- Energy management

- Energy quality
- Energy availability
- Energy storage

- Prevention and repairs
- Measurement and analysis
- Optimisation
- Consultancy, commissioning and training

A worldwide presence

12 production sites
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- Italy (x2)
- Tunisia
- India
- China (x2)
- USA (x2)
- Canada

30 subsidiaries and commercial locations
- Algeria • Australia • Austria • Belgium • China • Canada
- Dubai (United Arab Emirates) • France • Germany
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