

IB IL PM 3P/N/EF(-2MBD)-PAC

Inline modular power measurement terminal



Data sheet
8214_en_08

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1 Function description

Valid for hardware 03, firmware 1.20 or later

The power measurement terminal is designed for use within an Inline station.

It is used to analyze AC networks and can be found, for example, in distribution systems for measuring current, voltage, and power, as well as those used to identify distortion and harmonics.

You can run the power measurement terminal in five operating modes.

“Basic measured values” operating mode is used to acquire mains variables in three-phase mains. Mains variables are phase currents, neutral conductor current, phase and phase conductor voltages, real power, reactive power, and apparent power as well as the power factors of phases, energy flow directions, and frequency. The calculations for measured variables and operands are made according to DIN 40110 Parts 1 and 2 (non-sinusoidal variables).

“Scanning measured values” operating mode acquires the instantaneous values (scanning values) of a measurement signal. This measurement mode is used to analyze the curve shape of the measurement signal.

“Heating current measured values” operating mode is used for non-equivalence monitoring. Phase currents and phase voltages are measured to detect faults at an early stage.

“One-phase or three-phase synchronization” operating mode is used to acquire measured values that can be used for controlling the voltage, speed and the phase angle of a generator in order to connect to the mains.

Features

- Four 1 A/5 A AC inputs for phase currents and neutral conductor current
- Supports direct connection of three inputs for phase conductor voltages up to 690 V AC
- Triggers for measurement intervals can be freely defined
- Harmonics analysis
- Determination of maximum values
- Operating hours counter
- Power meter
- Bimetal filtering
- Short-time control
- Diagnostic and status indicators



This data sheet is only valid in association with the IL SYS INST UM E Inline user manual.

For more detailed information on the power measurement terminal, please refer to the UM EN IB IL PM 3P/N/EF-PAC user manual.



Make sure you always use the latest documentation. It can be downloaded at phoenixcontact.net/products.

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2 Ordering data

Products

| Description | Type | Order No. | Pcs. / Pkt. |
|---|---------------------------|-----------|-------------|
| Inline modular power measurement terminal for direct measurement of AC currents up to 5 A, including neutral conductor current and phase conductor voltages up to 400 V AC (phase to neutral conductor) or 690 V AC (phase to phase) complete with accessories (connectors and labeling fields) | IB IL PM 3P/N/EF-PAC | 2700965 | 1 |
| Inline modular power measurement terminal for direct measurement of AC currents up to 5 A, including neutral conductor current and phase conductor voltages up to 400 V AC (phase to neutral conductor) or 690 V AC (phase to phase) complete with accessories (connectors and labeling fields). Transmission speed: 2 Mbaud | IB IL PM 3P/N/EF-2MBD-PAC | 2700576 | 1 |

Accessories

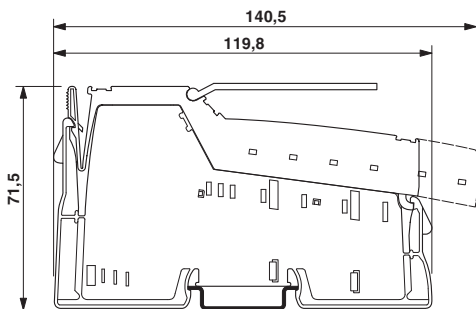
| Description | Type | Order No. | Pcs. / Pkt. |
|---------------------|--------------|-----------------------------|-------------|
| Current transformer | PACT MCR ... | See Phoenix Contact catalog | |

Documentation

| Description | Type | Order No. | Pcs. / Pkt. |
|--|-----------------------------------|-----------|-------------|
| "Automation terminals of the Inline product range" user manual | IL SYS INST UM E | - | - |
| "Inline Modular power measurement terminal: connection methods, operating modes, process data and PCP" user manual | UM EN IB IL PM 3P/N/EF(-2MBD)-PAC | - | - |

3 Technical data

Dimensions (nominal sizes in mm)



| | |
|--------|---------|
| Width | 48.8 mm |
| Height | 136 mm |
| Depth | 71.5 mm |

General data

| | |
|--|---|
| Color | Green |
| Weight | 200 g |
| Number of connectors | 4 (coded) |
| Operating mode | Process data mode with 12 words/PCP with 2 words |
| Permissible temperature (operation) | -25°C ... +60°C |
| Permissible temperature (storage/transport) | -25°C ... +85°C |
| Permissible humidity (operation/storage/transport) | 10% ... 95% without condensation (according to IEC 61131-2) |
| Permissible air pressure (operation/storage/transport) | 80 kPa ... 106 kPa (up to 2000 m above sea level) |

General data

| | |
|--------------------------|---|
| Measuring category | CAT II/400 V according to EN 61010-1 CAT III/300 V according to EN 61010-1 |
| Real energy accuracy | According to IEC 62053-21 Class 1 |
| Reactive energy accuracy | According to IEC 62053-23 Class 2 |
| Degree of protection | IP20 according to IEC 60529 |
| Protection class | III, IEC 61140, EN 61140, VDE 0140-1 |

Connection data

| | |
|-------------------------|---|
| Designation | Inline connector plug |
| Connection method | Spring-cage connection |
| Conductor cross section | 0.2 mm ² to 1.5 mm ² (solid or stranded), AWG 24 - 16 |

Inline local bus interface

| | |
|---|---------------------|
| Connection method | Inline data jumpers |
| Transmission speed of IB IL PM 3P/N/EF-PAC | 500 kbps |
| Transmission speed of IB IL PM 3P/N/EF-2MBD-PAC | 2 Mbps |

Power consumption

| | |
|--------------------------------|-----------------|
| Communications power U_L | 7.5 V DC |
| Current consumption from U_L | 130 mA, typical |
| Power consumption at U_L | 1 W, typical |
| Power dissipation | 1 W, typical |

Inputs: Current measuring input

4 inputs for phase currents and neutral conductor current for direct current measurement up to 5 A AC:

| | |
|---|---|
| Adjustable nominal range 1 | 0 A ... 1 A |
| Adjustable nominal range 2 | 0 A ... 5 A |
| Currents greater than 5 A AC with AC current transformers (PACT): | |
| Adjustable transformer ratio 1 A ... 30,000 A | 1 A or 5 A |
| Adjustable transformer ratio range ± 100 per mill | |
| Nominal value | 1 A AC or 5 A AC |
| Measuring range | 0 A AC ... 1.2 A AC or 0 A AC ... 6 A AC |
| Accuracy | 0.25% of nominal value; for mains frequencies of 20 Hz ... 100 Hz |
| Overload | 140% continuous; 150 A for 10 ms (1 half wave at f_N) |
| Cable length | 10 m, maximum (please observe the data of the measuring transducer) |

Inputs: Voltage measuring input

Supports direct connection of 3 inputs for phase conductor voltages up to 690 V AC (phase to phase)

| | |
|--|---|
| Mains frequency | 20 Hz ... 100 Hz |
| Phase to phase | 0 V AC ... 690 V AC |
| Not phase to phase: phase - neutral (N) | 0 V AC ... 400 V AC |
| Neutral conductor (N) – ground | 45 V AC, maximum |
| There is no maximum voltage limit when voltage transducers are used: | |
| Adjustable transformer ratio 100 V ... 30,000 V | 100.0 V ... 690.0 V |
| Adjustable transformer ratio range ± 100 per mill | |
| Phase nominal value | 400 V AC phase voltage ($690 V/\sqrt{3}$) |
| Neutral conductor maximum value | 45 V AC to ground, maximum |
| Measuring range | 0 V AC ... 440 V AC |
| Accuracy | 0.25% of nominal value; for mains frequencies of 20 Hz ... 100 Hz |
| Overload | 120% continuous |
| Cable length | 10 m, maximum (please observe the data of the measuring transducer) |

Scanning rate

Internal scanning values for each full wave for all measuring inputs 64, synchronous with the mains frequency in the range 20 Hz ... 100 Hz

Process data update

Scanning measured values mode 10 values every 2 ms

Other operating modes Period length (20 ms at 50 Hz) or multiples can be set

Limitations

No limitation of simultaneity, no derating

Programming data

| | |
|-------------------------|----------|
| ID code (hex) | DC |
| ID code (dec) | 220 |
| Length code (hex) | 0C |
| Length code (dec) | 12 |
| Process data channel | 192 bits |
| Input address area | 12 words |
| Output address area | 12 words |
| Parameter channel (PCP) | 2 words |
| Register length (bus) | 14 words |



For the programming data/configuration data of other bus systems, please refer to the corresponding electronic device data description (e.g., GSD, EDS).

Error messages to the higher-level control or computer system

| | |
|---|-------------------------------|
| Two phase conductors mixed up | Yes, peripheral fault message |
| One phase conductor not connected or phase conductor open circuit | Yes, peripheral fault message |
| Measuring circuit fault | Yes, peripheral fault message |
| Value range for transformer/transducer factors exceeded | Yes, peripheral fault message |
| Value range for other settings exceeded | Yes, peripheral fault message |

Electrical isolation/isolation of the voltage areas

Common potentials

The voltage inputs are connected to the neutral conductor via protective impedance.

The neutral conductor connection is safe to touch when not connected. (Total current <3.5 mA according to EN 61010-1: 2010)

Separate potentials (Each at least 2.5 kV AC 1 minimum, according to EN 61010-1)

The current inputs are isolated from all other circuits.

Impulse withstand capability of current and voltage inputs 4 kV (according to EN 61010-1)

24 V main voltage U_M , 24 V segment voltage U_S , 24 V analog power supply U_{ANA} , GND, and FE are not interrupted, are not used, and are isolated from all other potentials.

U_{L+} , U_{L-} , and the local bus are isolated from all other potentials.

4 Internal basic circuit diagram

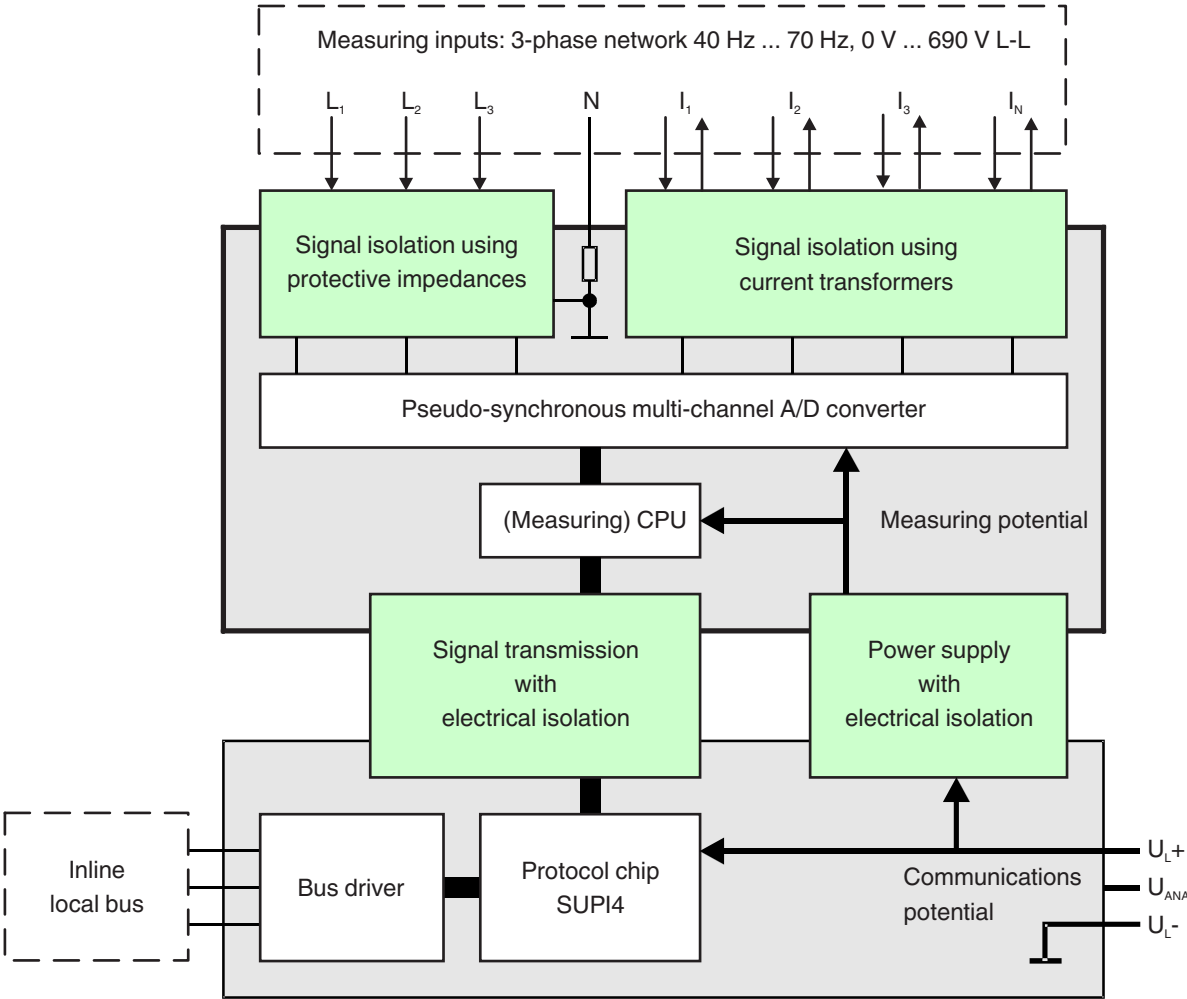


Figure 1 Internal basic circuit diagram

5 Local diagnostic and status indicators

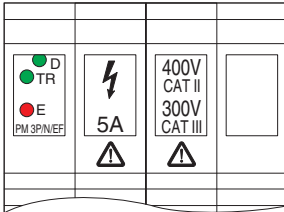


Figure 2 Local diagnostic and status indicators

| LED | Color | Meaning |
|-----|-------------------|--|
| D | Green | Diagnostics (bus and communications power) |
| | On | Bus active |
| | Flashing (0.5 Hz) | Communications power present, bus not active |
| | Flashing (4 Hz) | Local bus error |
| TR | Green | PCP communication |
| | On | PCP communication active |
| E | Red | Error |
| | On | An error has occurred: <ul style="list-style-type: none"> - Two phase conductors mixed up (voltage paths) - Phase conductor not connected (voltage paths) - Overload of measuring inputs - Measuring circuit fault - Firmware runtime error |

6 Terminal point assignment

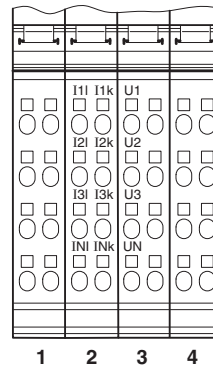


Figure 3 Terminal point assignment

| Connector | Terminal point | Assignment | Remark |
|---------------------|--------------------|---|--|
| Connector 1 (green) | | Not used | |
| Connector 2 (gray) | I1, I2, I3, IN | Current measurement | Output |
| | I1k, I2k, I3k, INk | Current measurement | Input |
| Connector 3 (gray) | U1, U2, U3 | Voltage measurement | |
| | UN | Neutral conductor connection (45 V AC, maximum) | Remains open on three-wire mains without neutral conductors. |
| Connector 4 (green) | | Not used | |

7 Operating modes

You can run the terminal in different operating modes:

- Basic measured values
- Scanning measured values
- Heating current measured values
- Single-phase or three-phase synchronization

7.1 Basic measured values

Basic measured values measurement mode acquires mains variables.

The basic measured values can be output by full wave or averaged over 2, 4, 8, or a multiple of 4 full waves.

The following are mains variables:

- Mains frequency
- Phase voltages
- Phase conductor voltages
- Phase currents
- Neutral conductor current
- Real, reactive, and apparent powers
- Real power factors of the phases
- Power flow direction
- Power meter accuracy
 - For real energy: according to IEC 62053-21 Class 1
 - For reactive energy: according to IEC 62053-23 Class 2

7.2 Scanning measured values

Scanning measured values are the instantaneous values (scanning values) of a measured signal.

You can select the following signals:

- Current of a phase
- Voltage of a phase
- Neutral conductor current
- Instantaneous real power of a phase

This measurement mode is used to analyze the curve shape of the measurement signal.

7.3 Heating current measured values

Heating current measured values are used for non-equivalence monitoring of heating systems for temperature controllers, in order to detect faults at an early stage before they can lead to overtemperature or undertemperature.

- Measurement is the same as for basic measured values.
- The measured values are output per full wave.
- Only phase currents and phase voltages are measured.
- If voltage compensation is activated (secondary nominal heating voltage ≥ 50 V), heating current fluctuations caused by mains voltage fluctuations are compensated. This corresponds to a conductivity measurement.
- For evaluation, a function block is required that correlates the binary heating actuating signals of the controller instances with the measured values (non-equivalence monitoring).



The function block for PC Worx can be downloaded at phoenixcontact.net/products.

7.4 Synchronization

The synchronization modes provide measured values which can be used to control the voltage, speed, and phase angle of a generator, so that connection to the mains is possible.

One-phase synchronization mode

- Measurement is the same as for basic measured values.
- Economy circuits are not possible.
- The measured values are output per full wave.
- One phase voltage each from the mains, generator, and perhaps load, the phase angle between both voltages, and the frequency differences and the frequencies are measured.
- The currents are measured independently.
- Harmonics analysis and measurement of phase conductor voltages are not possible.

Three-phase synchronization mode

- Connection and configuration are the same as for basic measured values.
- Economy circuits are not possible.
- The bus cycle triggers measurement of object 0089_{hex}.
- All the basic measured values are also available.
- The basic measured values are output per full wave.
- In addition, the phase relations of each voltage and the average phase relation of the mains related to the bus cycle are calculated in order to be able to calculate the phase difference across several terminals.
- Harmonics analysis is not available.

Bus cycle for three-phase synchronization mode

- The process data for control word 0900_{hex} (object 0089_{hex}, synchronization angle) must only be requested at an interval of one period (20 ms at 50 Hz) plus about 4 ms or more because otherwise, synchronization would not be possible. If this is not the case, an error message is output and the phase angles are invalid.
- In between, any control words can be used to read basic measured values.
- The bus cycle should not be faster than about 4 ms because synchronization would then be unreliable.



The theoretical cycle time on the local bus can be determined using the Project+ software. To do so, create the station in Project+. The cycle time for the station is displayed under “Results/ Technical data”. The Project+ software can be downloaded at phoenixcontact.net/products.

8 Description of individual functions

Triggers for measurement intervals can be freely defined

Measurement intervals can be triggered at will for creating load profiles, e.g., using the synchronization pulse of the power supply company. The power values (real, reactive, and apparent power) of the elapsed interval averaged in the interval can be buffered for each interval in a remanent buffer in the controller ready for evaluation.

Harmonics analysis

FFT (Fast Fourier Transformation) is used to measure the r.m.s. values of both the fundamental waves and the harmonics of voltages and currents twice per second up to at least the 31st harmonic.

The individual harmonic distortion and total harmonic distortion are then calculated from this.

Determination of maximum values

Maximum values by amount are determined for most measured values.

Operating hours counter

Operating hours are counted whenever currents greater than 0.5% of the nominal current are flowing.

Power meter

Operating times for real and reactive power are counted separately for consumption and supply or for inductive and capacitive.

S0 pulses

S0 pulses can be forwarded for energy recording outside the controller. They are available in three different rates.

Bimetal filtering

Filtered values are also available for the currents. The filter characteristic corresponds to bimetal measuring devices with time settings from one to twenty minutes.

Short-time control

Some operations in the terminal have to be triggered in real-time. These include:

- Freezing or resetting the power meter in order to acquire the energy consumption in an installation by production unit, for example
- Triggering power intervals in order to create a load profile
- Resetting maximum values
- Acknowledging completion or a state

This can be done via process data (control word 0C00_{hex}) or, in the case of non-time-critical operations, via PCP (object index 008C_{hex}).

9 Connection methods

Whatever connection method is used, the currents and voltages can be connected directly or via transformers/transducers. The following example shows the wiring for a four-wire three-phase mains with measurement of the neutral conductor current.

The potential of a connected neutral conductor must be close to ground and must not exceed 45 V AC to ground.

9.1 Direct connection

The power measurement terminal has the advantage that currents can be connected directly, i.e., live. Direct connection is possible up to a nominal current of 5 A and a phase voltage of up to 400 V.

In addition, the measuring range can be switched between 1 A and 5 A.

Configuration:

- Primary and secondary phase conductor voltage = 0 (default)
- Primary phase current = 0 (default)
- Secondary phase current = 1 A or 5 A for measuring range switchover

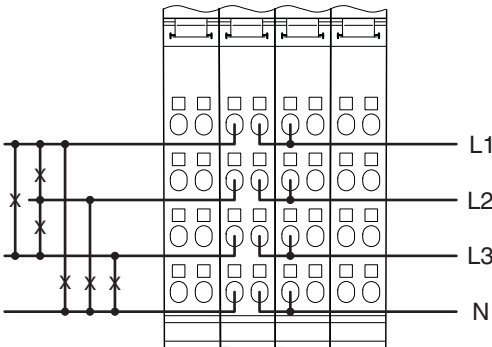


Figure 4 Direct connection

9.2 Connection with current transformers

Current transformers are required when connecting nominal currents higher than 5 A.

Ground the transformers for safety and to reduce secondary sources of interference.

Configuration:

- Primary and secondary phase conductor voltage = 0 (default)
- Primary and secondary phase current dependent upon the current transformer used

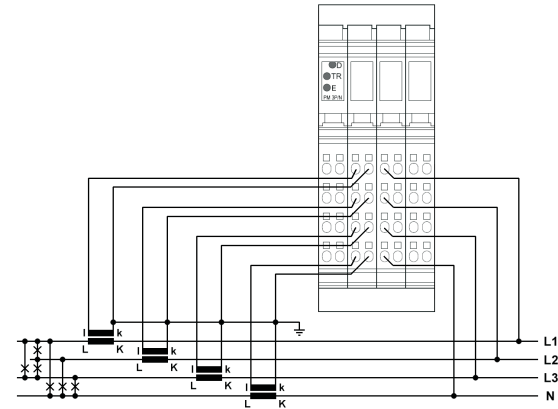


Figure 5 Connection with current transformers

9.3 Connection with current transformers and voltage transducers

Voltages

At voltages higher than $400 V_{LN}/690 V_{LL}$ (measuring category CAT II) or $290 V_{LN}/500 V_{LL}$ (measuring category CAT III), voltage transducers are required for the connection.

Ground the secondary neutral conductor connection of the transducers.

In high-voltage networks, single-position isolated voltage transducers grounded at the cold end (connection X instead of V) are used.

Currents

Use current transformers when connecting the currents, as the current measuring inputs are only isolated up to 290 V or 400 V dependent upon the measuring category.

Configuration:

- Primary and secondary phase conductor voltage dependent upon the voltage transducer used
- Primary and secondary phase current dependent upon the current transformer used

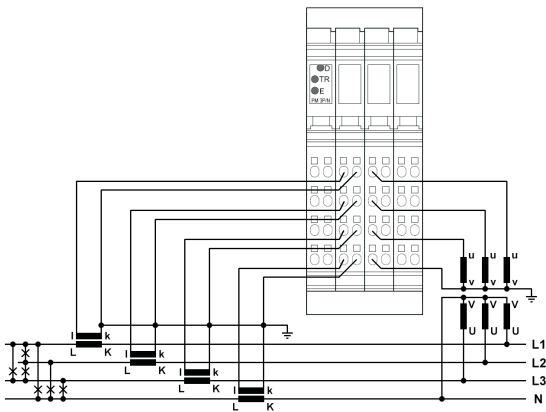


Figure 6 Connection with current transformers

9.4 Overview of the configuration of connection methods

The connection method parameter of the Config Table object is used to configure the connection method.

| Designation | Neutral conductor present | Use | Connection method code | Bit assignment in the connection method parameter of the Config Table object | | | | | | |
|--------------------------------|---------------------------|--|------------------------|--|---|---|---|---|---|---|
| | | | | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Three-phase current | No | Three-wire three-phase mains with uneven load | 00 _{hex} | 0 | 0 | 0 | 0 | 0 | 0 | |
| | | External two-wattmeter circuit | | | | | | | | |
| I1 + L1-N | No | Three-wire three-phase mains with even load, only phase 1 is measured (economy circuit) | 04 _{hex} | 0 | 0 | 0 | 0 | 0 | 4 | |
| I1 + L1-L3 | No | Three-wire three-phase mains with even load (economy circuit) | 05 _{hex} | 0 | 0 | 0 | 0 | 0 | 5 | |
| Three-phase current | Yes | Four-wire three-phase mains with uneven load | 10 _{hex} | 0 | 0 | 1 | 0 | 0 | 0 | |
| 3-phase | Yes | Any three phases, no rotating field | 11 _{hex} | 0 | 0 | 1 | 0 | 0 | 1 | |
| Open-Y | Yes | Four-wire three-phase mains with uneven load, with just two voltage transducers (economy circuit) | 12 _{hex} | 0 | 0 | 1 | 0 | 0 | 2 | |
| I1 + L1-N | Yes | Four-wire three-phase mains with even load, only phase 1 is measured (economy circuit) | 14 _{hex} | 0 | 0 | 1 | 0 | 0 | 4 | |
| Alternating current | Yes | Single-phase alternating current | 16 _{hex} | 0 | 0 | 1 | 0 | 0 | 6 | |
| Split phase | Yes | Two-phase mains | 17 _{hex} | 0 | 0 | 1 | 0 | 0 | 7 | |
| With neutral conductor current | Yes | On all networks which have a neutral conductor, the neutral conductor current can be measured additionally whatever the type of circuit. | 3x _{hex} | 0 | 1 | 1 | 0 | 0 | x | |

- Bit 7, 6 Not relevant
- Bit 5 = 0 Neutral conductor current not connected
- Bit 5 = 1 Neutral conductor current connected
- Bit 4 = 0 Neutral conductor not connected
- Bit 4 = 1 Neutral conductor connected
- Bit 3 Not relevant
- Bit 2 ... 0 Type of circuit

10 Process data words

The width of the process data channel is twelve words (word 0 ... 11): one control or status word and eleven data words.

The process data records are consistent along their entire length; they are mapped in full in IN0 to IN11.

If a process data record is shorter than twelve words, it is returned left-aligned and with zeros added.

For a description of the process data, please refer to the UM EN IB IL PM 3P/N/EF-PAC user manual.

11 PCP

The width of the parameter channel is two words.

For a description of the manufacturer-specific objects, please refer to the UM EN IB IL PM 3P/N/EF-PAC user manual.



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