Wireless Energy Meter

User Manual

72027101 - v1.0

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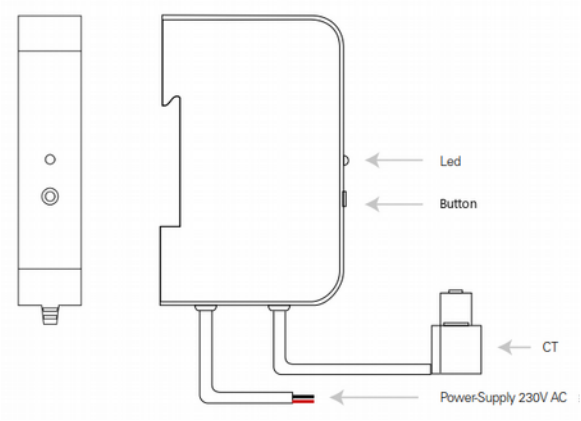
1 Overview

The Wireless Energy Meter performs real-time measurement of power, energy, voltage, and current, and transmits them wirelessly to a central controller.



The Wireless Energy Meter (WEM) is a smart device that performs quasi real-time measurements of the electricity consumption of the home by continuously monitoring the power line.
WEM will be installed into the main distribution board, with the amperometric clamp closed around the live wire of a 1-phase system. This allows WEM to measure the line voltage and current, and thus compute the total power and energy consumption of the home.
After a simple configuration phase, WEM starts reporting the measurement it takes to a central controller device, such as a home gateway, by means of the Z-Wave wireless technology. Z-Wave is a widespread and interoperable wireless home control technology based on the ITU-T 9959 open standard.
WEM has an intuitive user interface, with a LED informing the user about its current state, and a push button to let the user issue the necessary commands.
WEM can measure and report the following physical dimensions:

- Total Accumulated Active Energy (Wh),
- Instantaneous Active Power (W),
- RMS Voltage (V),
- RMS Current (A).

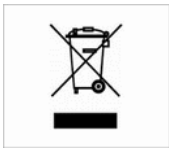
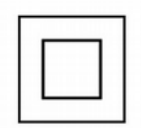
WEM allows to fine-tune the way the measurements are performed and reported by means of several parameters, which can be set by most controllers on the market.

2 Definitions and symbols

The following acronyms are used throughout the document:

- CC Command Class
- TAAE Total Accumulated Active Energy
- WEM Wireless Energy Meter

The following table describes the symbols used throughout the document.

	This wireless energy meter is in conformity with the CE directives.
	Do not dispose of electrical appliances as unsorted municipal waste, use separate collection facilities. Contact your local government for information regarding the available collection systems.
	Double insulation.
	For indoor use only. This electrical equipment is designed for indoor use only.
	Danger. Electric shock risk. Do not open the enclosure.
	Read carefully this manual before operating.
	Z-Wave Plus compatible device.
	Alternate current power supply

3 Main features

- 1-phase energy meter, 230 Vac, 50 Hz.
- Split-core clamp for current measurement.
- Measurement of voltage, current, energy, and active power.
- Direct measurement up to 32 A.
- Total Accumulated Active Energy (Wh) counter.
- Certified Z-Wave Plus wireless technology.

4 Technical specifications

- Order number: SYS-72027-ENL/01.

- Operating voltage: 230 Vac, 50 Hz
- Power consumption: 1.7 W
- Maximum current measurement: 32 A
- Operating temperature: from 0 to +40°C
- Storage temperature: from -10 to +85 °C
- Relative humidity: <95% (without condensation)
- Device protection: IP20
- Insulation characteristics: 3.75 kV
- Mounting: on 35 mm rail
- Dimensions: 80 x 48 x 17 mm
- Weight: 122 g
- Power cable: 2 wire cable 20 AWG, total length 690 mm
- Current probe: split-core current transformer, total length 660 mm
- Radio frequency range: 868.40 and 869.85 MHz (EU)
- Operating distance: up to 90 m (outdoor)
- Internal fuse: 315 mA.

5 Installation

The installation of WEM shall be performed in two steps. At first, WEM should be physically installed into the main distribution board, as explained below. Then, WEM needs to be included into an existing Z-Wave network, as explained in 6.1. Once powered on and properly configured, WEM sends the controller a series of periodic reports containing the performed measurements.

5.1 Install the device into the distribution board

Warning: Danger of electrocution! Only a qualified and licensed electrician, with knowledge and understanding of electrical systems and electrical safety, should perform the electrical installation of WEM into the distribution board. Under any circumstances, do not touch exposed electrical circuit.; contact may result in electric shock.

Warning: Make sure to disconnect the power of the home electric network before installing the meter. Do not use or install in presence of water, steam, combustible or corrosive substances, or sources of heat (such as radiators). Do not install in humid places or where WEM can be subject to impacts. Install the device by strictly following the guidelines and diagrams provided in the present manual. Failure to follow the safety instructions contained in this manual may result in fire, electric shock, other injury or damage to the appliance.

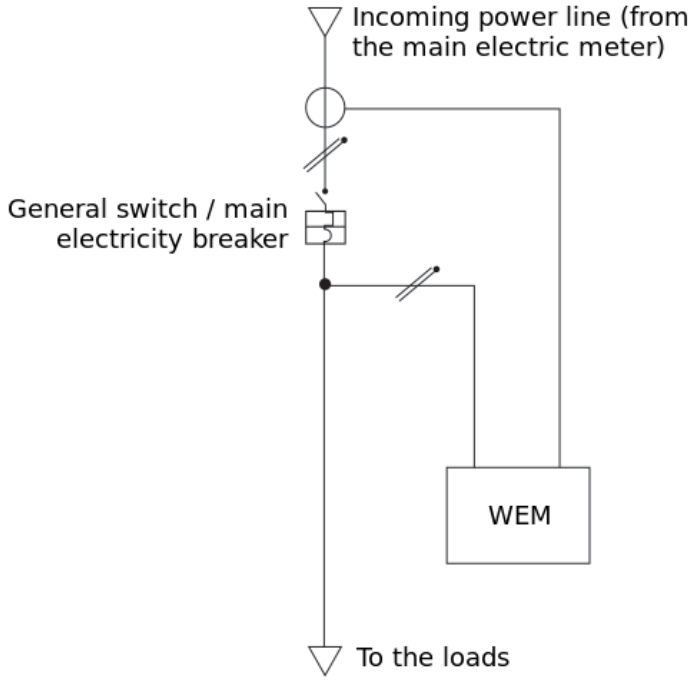
WEM must be connected to the main power line. WEM can be installed in different configurations depending on the structure of the power network and the available spaces. For example, WEM can be installed into the distribution board on a free DIN slot or loose. Placement of the product within the electric panel is left to considerations that the installer will evaluate depending on the particular installation, provided that the positioning of WEM must not mechanically compromise the case of the product.

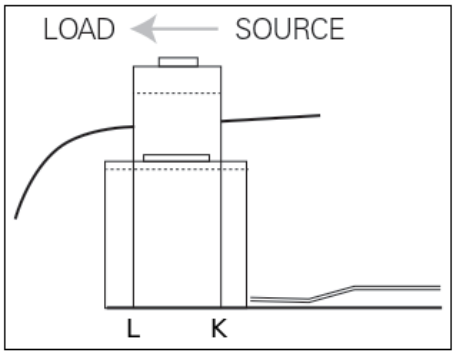
Note that WEM is equipped with a low-frequency radio antenna. This must also be taken into consideration when selecting a final installation location. Thick concrete walls, metal plates, motor devices, etc. all negatively affect the operating range of WEM.

Follow these steps to install WEM:

1. Turn off the main electricity breaker and open the distribution board.
2. Clip the clamp of WEM around the incoming live wire. Refer to the scheme below for the correct positioning of the clamp. Note that the clamp has the following indications: K → network side, L → load side. If placing the clamp around the neutral wire, the direction must be reversed.
3. Insert WEM neutral (black) and live (red) power supply wires respectively into the neutral and live bus terminals.
4. Mount WEM on the DIN rail of the distribution board.
5. Close the distribution board and turn the main breaker back on.

Electrical connection and positioning of the open-loop amperometric clamp should be performed according to the following scheme:





Lateral view of the clamp for correct placement around the live wire

The installer must respect the polarities of the live and neutral conductors and the direction of the clamp. If they are not placed correctly, WEM will not be able to read the power line. The LED indicator on the frontal side of the WEM enclosure might indicate the wrong positioning (see Table 2).

6 Operation

WEM can be operated by means of the push button in the front part of the case. Several LED blinking patterns give indication of the current WEM operating status.

When keeping the button pressed, the state blinking is suspended and is replaced by short blinks that indicate when each timer (1, 3, 5, 10 s) is reached.

Table 1. Button actions.

Button action	WEM state	WEM operation
Short pressure (1 second)	Idle	Start network joining procedure.
Short pressure (1 second)	Synchronizing, Joined	Send Node Information Frame (NIF).
Medium pressure (3 seconds)	Learning, Joined	Start network leaving procedure; all network-related data is erased, new data acquisition is stopped.
Long pressure (5 seconds)	Any	Reboot device; all data is retained.
Very long pressure (> 10 sec)	Any	Factory reset; erase all persistent data, restore configuration parameters to default value.

Table 2. LED blinking patterns.

WEM State	Blinking pattern	Description
Off	Off	Meter off (not powered)
Initialization	Blinks at 3 Hz (1 pulse every 0.33 sec)	Meter is performing the initialization check-ups
Idle	Blinks at 0.3 Hz (1 pulse every 3 sec)	Meter is on, not joined, everything is ok, no action is performed (waiting for user commands).
Learning	Triple-blink at 0.5 Hz (3 pulses every 2 sec)	Meter is joining the network
Synchronizing	Long-blinks at 0.5 Hz (1 long-pulse every 2 s)	Meter has joined the network and is waiting for time synchronization from the controller
Joined, Comm. Ok	Blink at 1 Hz (1 pulse every second)	Meter joined and sync'd with the controller and communication is working
Joined, Comm. Fail	Blinks at 5 Hz (1 pulse every 0.2 sec)	Meter joined and sync'd with the controller, but communication has failed
Joined, Clamp Rev.	Double-blinks at 0.3 Hz (2 pulse every 3 sec)	Meter joined and sync'd with the controller, but the clamp is reversed
Leave network	Long-blinks at 1 Hz (1 long-pulse every sec)	Meter is leaving the network and deleting network persistent data; data acquisition has been stopped.
Reset	On	Meter is performing a factory reset and deleting all persistent data (calibration data is retained)
Hardware Error	Long-blinks at 0.3 Hz (1 long-pulse every 3 s)	A hardware error has occurred inside the Meter that prevents its correct operation

6.1 Add the device to the Z-Wave network

Once WEM is installed and connected to the power line for the first time, it goes into the "Idle" state. To add WEM to the Z-Wave network, it is first necessary to put the primary Z-Wave controller into inclusion

mode (refer to the controller user manual). Then, press the WEM button for about 1 second. WEM enters the "Learning" state and the LED changes blinking pattern. When the learning phase ends successfully, WEM enters the "Synchronizing" state, and then the "Joined, Comm. Ok" state.
If the clamp is not placed correctly, the "Joined, Clamp Rev." state is entered in place of the "Joined, Comm. Ok" one. If the inclusion fails, WEM goes back to the "Idle" state.

6.2 Remove the device from the Z-Wave network

To remove WEM from the network, it is first necessary to put the primary Z-Wave controller into exclusion mode (refer to the controller user manual). Then, press the WEM button for about 3 seconds. WEM enters the "Leaving" state, and waits for the controller to acknowledge its exclusion. When the exclusion process is complete, WEM goes into the "Idle" state. If the exclusion process fails, WEM goes back to its previous state.

6.3 Configure the device

WEM provides a series of tunable parameters that regulate the way the measurements are collected and reported. Table 3 shows the list of configurable parameters together with their number (index), unit of measure, size (in bytes), range of allowed values, and default (factory) value. Information on what each parameter controls or changes in the behaviour of the product is reported in the next subsections.

Table 3. List of configurable parameters.

Index	Parameter	Unit	Size	Allowed range	Default value
2	MEAS_PERIOD	s	1	30 – 120	30
3	MAX_REP_INTERVAL	10 s	1	3 – 60	6 (= 60 s)
4	RES_ACTIVE_POWER	W	1	1 – 100	4
5	RES_RMS_VOLTAGE	100 mV	2	1 – 1000	10 (= 1 V)
6	RES_RMS_CURRENT	10 mA	2	1 – 1000	10 (= 100 mA)
8	CLAMP_REVERSED	–	1	0, 1, 0xFF	0xFF
9	ENABLE_CRC16	–	1	0, 1	1 (true)
10	AVG_PERIOD	5 s	1	0 – 6	1

To better understand the meaning and usage of these parameters, it is helpful to illustrate how WEM executes the measurements and reports them to the controller or associated device. When WEM is in the normal operative state ("Joined, Comm. Ok"), it works in the following way:

1. Every MEAS_PERIOD, WEM samples the line to read the values of the observed physical dimensions (active power, RMS voltage, and RMS current); it then calculates and saves the TAAE value in the internal memory.
2. WEM sends a report if any of the following rules is true:
   - *Var_Measure* > *Res_Measure*,
   - *Time_Difference* > MAX_REP_INTERVAL,

   where:
   - *Var_Measure* is the absolute variation of a given measure (Instantaneous Active Power, RMS Voltage, RMS Current) during the last MEAS_PERIOD interval;

- *Res_Measure* is one of the following parameters: RES_ACTIVE_POWER, RES_RMS_VOLTAGE, RES_RMS_CURRENT;
- *Time_Difference* is the time elapsed since the last report was sent.

3. Every 15 minutes, and at the end of each day, WEM stores the TAAE value into its internal memory; the controller can then ask for these values by means of the Meter Table Monitor Historical Data Get command.

6.3.1 Measurement period

MEAS_PERIOD represents the minimum reporting interval, i.e. 1/MEAS_PERIOD is the maximum reporting frequency. WEM checks for changes in the line measures every MEAS_PERIOD. If there are meaningful changes, a report is sent to the controller.

6.3.2 Maximum reporting interval

MAX_REP_INTERVAL is the maximum time that can elapse without sending a report. If no meaningful events occur, WEM sends one measurement every MAX_REP_INTERVAL seconds.
Notice that, since the check is performed every MEAS_PERIOD (as described in 6.3), the reporting interval is rounded to the smallest multiple integer of MEAS_PERIOD (e.g. MEAS_PERIOD = 45, MAX_REP_INTERVAL = 12, reports are sent every 135 s).

6.3.3 Resolution

RES_ACTIVE_POWER, RES_RMS_VOLTAGE, RES_RMS_CURRENT are the minimum quantity (resolution) that triggers a report for active power, RMS voltage, and RMS current, respectively. They can be used to tune the sensitivity of WEM to changes in these physical dimensions.

6.3.4 Clamp position

CLAMP_REVERSED is a read-only parameter that the controller can query to learn about the current placement of the clamp. During the measurement phase, WEM checks whether the clamp has been placed correctly or reversed (with regard to phase rotation). In the latter case, WEM notifies the user with a different blink pattern and stores this information into the CLAMP_REVERSED parameter. The clamp is placed correctly if CLAMP_REVERSED = 0 and is reversed if CLAMP_REVERSED = 1. If CLAMP_REVERSED = 0xFF a fault occurred and it was not possible to detect the clamp position.

6.3.5 CRC16 encapsulation

ENABLE_CRC16 parameter provides for an extra layer of redundancy in order to protect low bit rate transmissions against radio channel errors. This applies to the reports and frames sent spontaneous by WEM. Requests from the controller are always answered as asked. WEM will send CRC16 encapsulated frames to the associated node if this has proved to support it and the ENABLE_CRC16 parameter is set to 1. Otherwise, reports will be sent with no extra CRC16 encapsulation.

6.3.6 Average period

AVG_PERIOD determines the time window used to compute an average over the line readings. Each unit of AVG_PERIOD is worth 5 seconds. If AVG_PERIOD = 0 no average is computed and the last sample is returned. Note that the maximum average window coincides with the minimum value of MAX_REP_INTERVAL. Also note that a delay of up to the average window can be introduced in returning the measurements (each measurement is returned only when ready).

6.4 Device Association

WEM supports sending reports to associated devices. WEM supports the Lifeline association group (group identifier: 1) with at most one associated device. WEM uses the Lifeline association group to send the following commands:

- Configuration Report,
- Time Parameters Get,
- Meter Report,
- Meter Table Current Data Report,
- Meter Table Historical Data Report,
- Device Reset Locally Notification.

The controller shall setup the Lifeline association in WEM in order for this to send the meter reports and the device reset notification to the controller (or to a different node). Refer to the controller user manual for setting up the Lifeline association in WEM. The parameters described in 6.3 regulate the reporting activity through the Lifeline.

6.5 Reset the device to factory default values

WEM can be reset to the factory default values at any time by pressing the button for about 10 seconds, until the LED turns steadily on. WEM performs the reset operations and the button can be released. When the reset is complete, WEM enters the “Idle” state.

Note that this reset procedure does not remove WEM from a classic Z-Wave controller or in situations where WEM cannot communicate with the Z-Wave Plus controller. Therefore this procedure should be used only when the primary controller is missing or inoperable. To remove WEM from the network under normal circumstances the exclusion procedure described in 6.2 should be used.

6.6 Operation with devices from other manufacturers

WEM is a certified Z-Wave device. Therefore it can be operated in any Z-Wave network with other Z-Wave certified devices from other manufacturers. All non-battery operated nodes within the network will act as repeaters regardless of vendor to increase reliability of the network.

7 Supported Z-Wave Plus functionalities

WEM is a device of type *Whole Home Meter – Simple* (Generic Type: Meter, Specific Type: Simple Whole Home Meter) and supports the following command classes (CC):

- Z-Wave Plus Info, version 2;
- Version, version 2;
- Manufacturer Specific, version 2;
- Association, version 2;
- Association Group Information, version 1;
- Device Reset Locally, version 1;
- CRC-16 Encapsulation, version 1;
- Power Level, version 1;
- Meter, version 4;
- Meter Table Monitor, version 2;
- Time Parameters, version 1;

- Configuration, version 1;
- Time, version 2.

Specifically, WEM uses either the Meter CC or the Meter Table Monitor CC to report the current measurements, depending on their number and size. The historical data can be queried by the controller using the Meter Table Monitor CC. A set of Meter Reports is periodically sent in place of a single Meter Tbl Current Data Report to allow coexistence with third-party and legacy controllers.
The Configuration CC is used to set and read the WEM parameter values.

7.1 Version

WEM application is split in two parts. Accordingly two firmware version and sub-version numbers will be returned by the Version Report Command. Please report them both when contacting the support for technical assistance.

7.2 Meter

WEM supports the following parameters of the Meter CC:

- Meter Type: Electric meter (0x01);
- Rate Type: Import (0x01);
- Scale: kWh (0x00), W (0x02), V (0x04), A (0x05).

In case a Meter Get Command is received with an unsupported parameter, WEM will ignore the request and send no Report frame.
If a Meter Get Command is received with an unspecified parameter, the following default values are used:

- Rate Type: Import (0x01);
- Scale: kWh (0x00).

In case of internal error, a Meter Report Command may be sent with all Meter Value fields set to zero.
In all cases, the Meter Report Command has the fields Delta Time set to zero and no Previous Meter Value nor Scale 2 values.
WEM supports resetting all counters to zero by means of the Meter Reset Command.

7.3 Meter Table Monitor

WEM uses the Meter Table Current Data Report command to send current measurements either in reply to a Get command sent by the controller or when triggered by the configured parameters.
The reported measures are mapped to the following dataset fields and precision:

Table 4. Mapping of WEM measures and units to Z-Wave dataset bits and precision.

WEM measure	Byte #	Bit #	Description	Precision
Total Accumulated Active Energy (100 mWh)	1	0	Total Primary Active Energy (kWh)	4
Instantaneous Active Power (100 mW)	1	4	Instantaneous Primary Active Power (kW)	4
RMS Voltage (100 mV)	2	2	Voltage Phase 1 (V)	1
RMS Current (10 mA)	2	5	Ampere Phase 1 (A)	2

WEM puts its current time in the Current Data Report command. This can be used to check the correctness of its internal clock.
When the clamp is reversed, the Operating Status Indication bit of the Meter Table Current Data Report Command is set to 1. This applies to the current data only. The position of the clamp is not stored for the historical data.
WEM uses the Meter Table Historical Data Report command to send the stored readings of the TAAE. The controller can query WEM by means of a Historical Data Get. WEM retrieves the historical values and sends each one in a separate Report frame, starting with the most recent value. The report frames are spaced by 2 second intervals. The historical series reporting might be stopped if another command (e.g. Meter Report) must be sent.
TAAE is the only supported dataset for the Historical Data commands. WEM replies with a single empty Report to the requests for other datasets. If it receives a Historical Data Get command with both TAAE and other datasets, the latter are ignored. WEM does not support historical requests for years before 2000.
If WEM receives a new Historical Data Get command before the completion of the previous response, it cancels the previous response and processes the new query.
WEM uses the Meter Table Capability Report Command to advertise its capabilities following to receiving a Get command from the controller.
All other features of this CC are not used (e.g. status, adm.number), and thus only empty or blank Report commands are sent in response to the related Get commands.

7.4 Time Parameters

This CC can be employed to set WEM internal clock.
WEM performs a check on the correctness of the time parameters it receives in the Set and Report Commands. If the Time Parameters values are found to be incorrect, WEM silently ignores them. In detail, a time is assumed to be valid if the values are within the following ranges:
Year: 2016 or greater;
Month: 1 – 12;
Day: depends on Month and Year (leap years are also accounted for);
Hour: 0 – 23;
Minute: 0 – 59;
Second: 0 – 59.
When the internal clock is not set, WEM replies to a Time Parameters Get command with a Report whose value is 2000-01-01 00:00:00 (midnight of 1st January 2000).
Note: the date and time are not saved to the internal memory; therefore, when the device is turned off, date and time are lost and must be set again.

7.5 Configuration

WEM implements version 1 of the Configuration CC to write and read the values of the parameters. The supported parameters are listed in Table 3.
WEM checks for the correctness of the parameter index, value and size according to the figures reported in Table 3. If any of them is found to be incorrect, WEM silently ignores the Set command. WEM replies to a Get Command for an unsupported parameter with a Report Command whose fields have the following values: parameter number = 0, size = 1, configuration value = 0x80 (-127). Note that parameter number 0 is not supported by WEM.

Please notice that the Configuration Value fields must always carry signed values, which are interpreted as such by WEM.
When WEM receives a valid Configuration Set command with the Default bit set, it restores the default value for the specified parameter only.

7.6 Time

This CC can be employed to check the WEM internal clock and to set / get the time zone and daylight saving time (DST) period.
When the internal clock is not set, WEM sets the RTC failure bit of the Time Report command to 1. The default date and time value is 2000-01-01 00:00:00 (midnight of 1st January 2000).
Note: similarly to the local time and date, the time offset is not saved to the internal memory; therefore, when the device is turned off, the time offset must be set again.

7.7 Send Node Information

A Node Information frame (NIF) can be sent by pressing the button for about 1 second. WEM sends a broadcast NIF only if it is already included in a network and not performing any other operation. Specifically, WEM sends a NIF if it is not in the Off, Initialization, Idle, Learning, Leave network, Reset, or Hardware Error states.
Note that if WEM is not yet included, pressing the button for about 1 second starts the inclusion procedure, which also sends a NIF, but as part of a more complex activity.

8 Certifications

The product was made with materials and components in accordance with the RoHS Directive 2002/95/EC, the WEEE directive 2003/96/EC, the Italian Legislative Decree 151/2005 and the other EC Directives as per the following regulations:

Electromagnetic compatibility (EMC):
CEI EN 61326-1 (2013-07) - ETSI EN301 489-1 V1.9.2 (2011)
ETSI EN301 489-3 V1.6.1 (2013) - CEI EN 55022 (2014) - CEI EN 55011 (2013)
CEI EN 55024 (2013) - CEI EN 61000-3-2(2007) - CEI EN 61000-3-3(2009)

Radio:
ETSI EN 300 220-1 v.2.4.1 (2012-05)
ETSI EN 300 220-2 v.2.4.1 (2012-05)
ETSI EN 301 489-1 v.1.9.2 (2011-09)
ETSI EN 301 489-3 v.1.4.1 (2002-08)
Cenelec EN 62311: 2008

Safety:
CEI 61010-1:2010