# Operating Instructions
# **EngyVolt RV12**

Multifunction electrical energy meter



Endress+Hauser [EH]

People for Process Automation
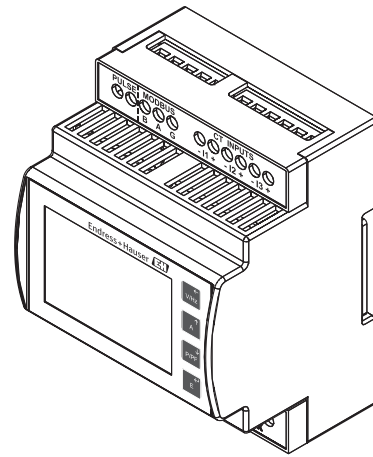
# Table of contents

# 1 Safety instructions

The reliable and safe operation of the device is only ensured if the user reads these Operating Instructions and complies with the safety instructions they contain.

## 1.1 Workplace safety

For work on and with the device:
▶ Wear the required personal protective equipment according to federal/national regulations.

## 1.2 Requirements concerning the staff

The personnel for installation, commissioning, diagnostics and maintenance must fulfill the following requirements:
▶ Trained, qualified specialists: must have a relevant qualification for this specific function and task
▶ Are authorized by the plant owner/operator
▶ Are familiar with federal/national regulations
▶ Before beginning work, the specialist staff must have read and understood the instructions in the Operating Instructions and supplementary documentation as well as in the certificates (depending on the application)
▶ Following instructions and basic conditions

The operating personnel must fulfill the following requirements:
▶ Being instructed and authorized according to the requirements of the task by the facility's owner-operator
▶ Following the instructions in these Operating Instructions

## 1.3 Operational safety

Risk of injury.
▶ Operate the device in proper technical condition and fail-safe condition only.
▶ The operator is responsible for interference-free operation of the device.

**Conversions to the device**

Unauthorized modifications to the device are not permitted and can lead to unforeseeable dangers.
▶ If, despite this, modifications are required, consult with Endress+Hauser.

**Repair**

To ensure continued operational safety and reliability,
▶ Carry out repairs on the device only if they are expressly permitted.
▶ Observe federal/national regulations pertaining to repair of an electrical device.
▶ Use original spare parts and accessories from Endress+Hauser only.

**Environmental requirements**

If a plastic transmitter housing is permanently exposed to certain steam and air mixtures, this can damage the housing.
▶ If you are unsure, please contact your Endress+Hauser Sales Center for clarification.
▶ If used in an approval-related area, observe the information on the nameplate.

## 1.4 Designated use

The multifunction electrical energy meter is designed to record, display and transmit electrical measured values in low-voltage systems with a maximum nominal voltage of

500 V L-L (289 V L/N), power connection via low-voltage current transformer x/5A at a nominal frequency of 45 to 66 Hz. It is suitable for use in single-phase power systems, and in three-phase power systems with three or four wires.

Among other values, the electrical energy meter measures the voltage, frequency, current, power, power factor, total harmonic distortion (THD) as well as active energy and reactive energy.

- The manufacturer accepts no liability for damages resulting from incorrect use or use other than that designated. It is not permitted to convert or modify the device in any way.
- The device is designed for mounting on a top-hat rail according to DIN 43880 and must only be operated in an installed state.

## 1.5     Technical improvement

The manufacturer reserves the right to modify technical data without prior notice. Please contact your sales center for information on modifications or updates to the Operating Instructions.

## 1.6     Return

The device must be packed in protective packaging if it is being returned for repair, for example. The original packaging offers the best protection. Repairs may only be performed by your supplier's service organization.

When returning the device for repair, enclose a note with a description of the problem and the application.

## 1.7     Notes on safety conventions and icons

### 1.7.1     Warnings

**⚠ DANGER**

**Causes (/consequences)**
Consequences of non-compliance (if applicable)
▸  Corrective action
▸  This symbol alerts you to a dangerous situation. Failure to avoid the situation will result in a fatal or serious injury.

**⚠ WARNING**

**Causes (/consequences)**
Consequences of non-compliance (if applicable)
▸  Corrective action
▸  This symbol alerts you to a dangerous situation. Failure to avoid the situation can result in a fatal or serious injury.

**⚠ CAUTION**

**Causes (/consequences)**
Consequences of non-compliance (if applicable)
▸  Corrective action
▸  This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or more serious injuries.

> **NOTICE**
> **Causes (/consequences)**
> Consequences of non-compliance (if applicable)
> ▸ Corrective action
> ▸ This symbol alerts you to situations which may result in damage to property.

### 1.7.2 Document symbols

|  |  |
|---|---|
| ☑ | Permitted<br>Indicates procedures, processes or actions that are permitted. |
| ☑☑ | Preferred<br>Indicates procedures, processes or actions that are preferred. |
| ☒ | Forbidden<br>Indicates procedures, processes or actions that are forbidden. |
| 🛈 | Additional information, tips |
| 📖 | Reference to documentation |
| 🗎 | Reference to a page in this manual |
| 🖼 | Reference to a graphic |

# 2 Identification

## 2.1 Device designation

### 2.1.1 Nameplate
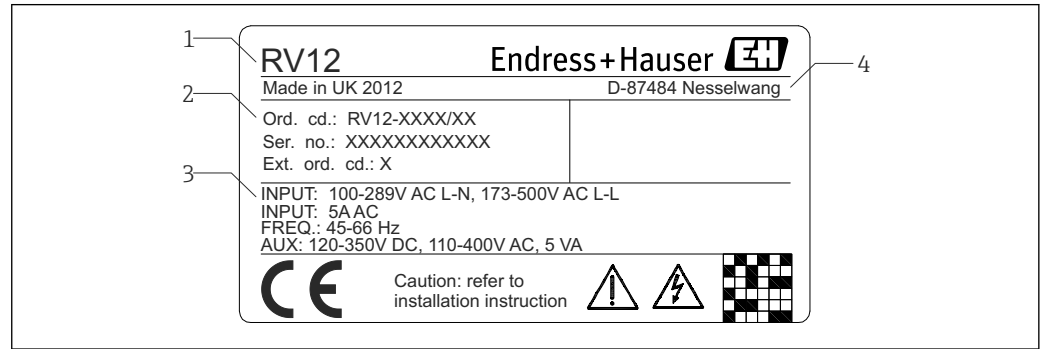


⊠ *1   EngyVolt RV12 nameplate (example)*

*1   Device designation*
*2   Order code, serial number and extended order code of the device*
*3   Input variables and power supply*
*4   Year of manufacture and manufacturer address*

## 2.2 Scope of delivery

The scope of delivery comprises:
- Multifunction electrical energy meter for top-hat rail mounting
- Brief Operating Instructions
- Comprehensive Operating instructions are available for download at www.endress.com/download

## 2.3 Certificates and approvals

### 2.3.1 CE mark, declaration of conformity

The device is designed to meet state-of-the-art safety requirements, has been tested and left the factory in a condition in which it is safe to operate. The device meets the relevant standards and directives as per EN 61 010-1 "Safety requirements for electrical equipment for measurement, control and laboratory use".

Thus, the device described in these Operating Instructions meets the legal requirements for the EU directives. The manufacturer confirms successful testing of the device by affixing to it the CE mark.

For an overview of all available certificates and approvals, refer to the "Technical data" chapter.

# 3 Installation

## 3.1 Incoming acceptance, transport, storage

Compliance with the permitted storage and transportation conditions is mandatory. Precise specifications are provided in the "Technical data" section (→ 🖹 28).

### 3.1.1 Incoming acceptance

On receipt of the goods, check the following points:
- Is the packaging or the content damaged?
- Is the delivery complete? Compare the scope of delivery against the information on your order form.

### 3.1.2 Transport and storage

Please note the following:
Pack the device so that is protected against impact for storage and transport. The original packaging provides optimum protection.

## 3.2 Installation conditions

The device can be mounted on a standard top-hat rail.

Measuring devices must be mounted in a dry location at stable ambient temperatures that do not exceed or drop below the range of −10 to 55 ℃ (14 to 131 ℉). There should be minimum tension from vibrations. If possible, the measuring device should be mounted in such a way that the contrast of the display is not affected by direct sunlight or strong lighting. The LCD display is optimized for vertical reading. If the display is read horizontally, lighting conditions can affect the readability of the display.

## 3.3 Dimensions
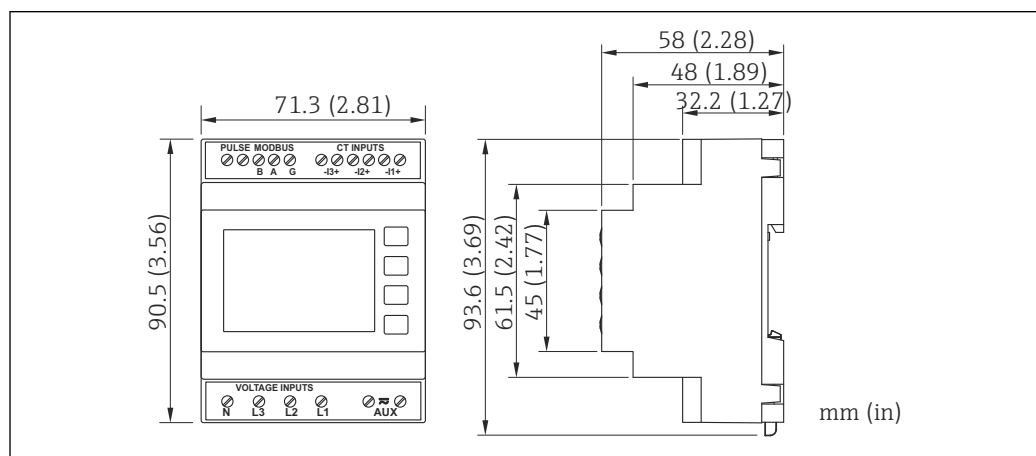


🖻 2     *Device dimensions*

## 3.4    Installation instructions
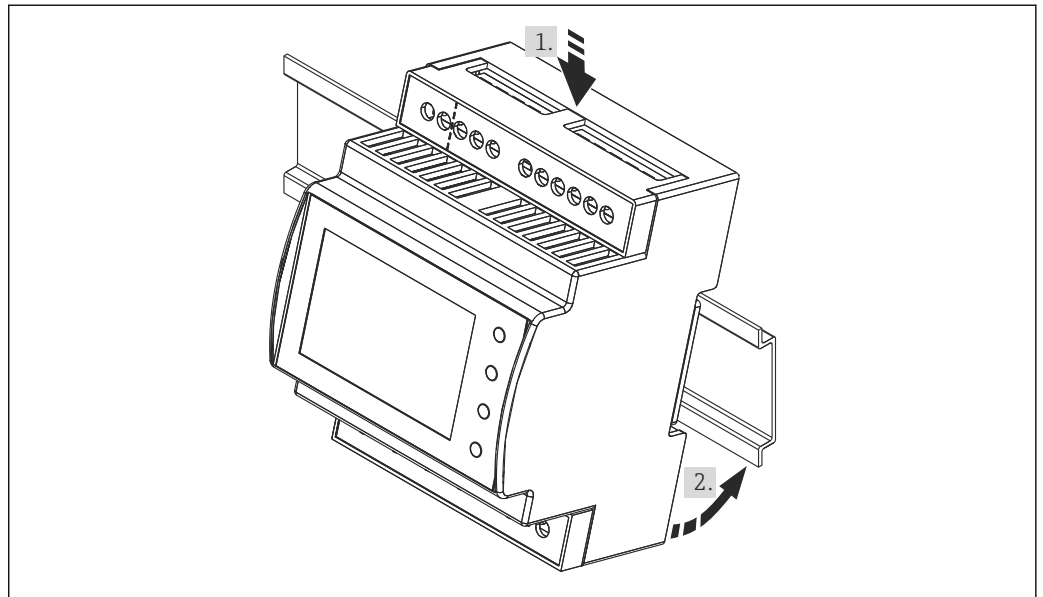


A0016514

1.  Fit the device on the top-hat rail from above.

2.  Push the bottom of the device back until it locks into place.

To remove the device from the top-hat rail, lever down the black tab at the bottom of the device (use a suitable tool such as a screwdriver).

## 3.5    Post-installation check

Is the device securely mounted on the top-hat rail and locked in place?

# 4     Wiring

**⚠ WARNING**

**Danger! Electric voltage!**
▶ The entire electrical connection must be performed when the device is de-energized.
▶ Establish the protective ground connection before making any other connections.

**NOTICE**

**Cable heat load**
▶ Use suitable cables for temperatures that are 5 ℃ (9 ℉) above the ambient
  temperature.

Incorrect supply voltage can damage the device or cause malfunctions
▶ Before commissioning the device, make sure that the supply voltage matches the
  voltage specifications on the nameplate.

Incorrect wiring can damage the device
▶ Observe the terminal designations on the device.

Electrical overloading can damage the device
▶ Provide overcurrent protection elements for the power cables.
▶ Provide a suitable switch or power-circuit breaker for emergency shutdown in building
  installations. This switch must be provided close to the device (within easy reach) and
  marked as a circuit breaker.

## 4.1     Supply voltage

The supply voltage is designed for the range from 100 to 400 V AC and 120 to 350 V DC.
Preferably, the supply voltage should be provided from a source other than the measured
voltage. The measured voltage can be used if it is within the tolerance limits of the supply
voltage.

## 4.2     Electrical connection

To ensure maximum accuracy, we recommend that the current signal connecting cables
pass through additional ferrite cores (e.g. of type 742 701 110 from Würth Elektronik) at
least six times.

### 4.2.1    Connection in single-phase, 2-wire power network
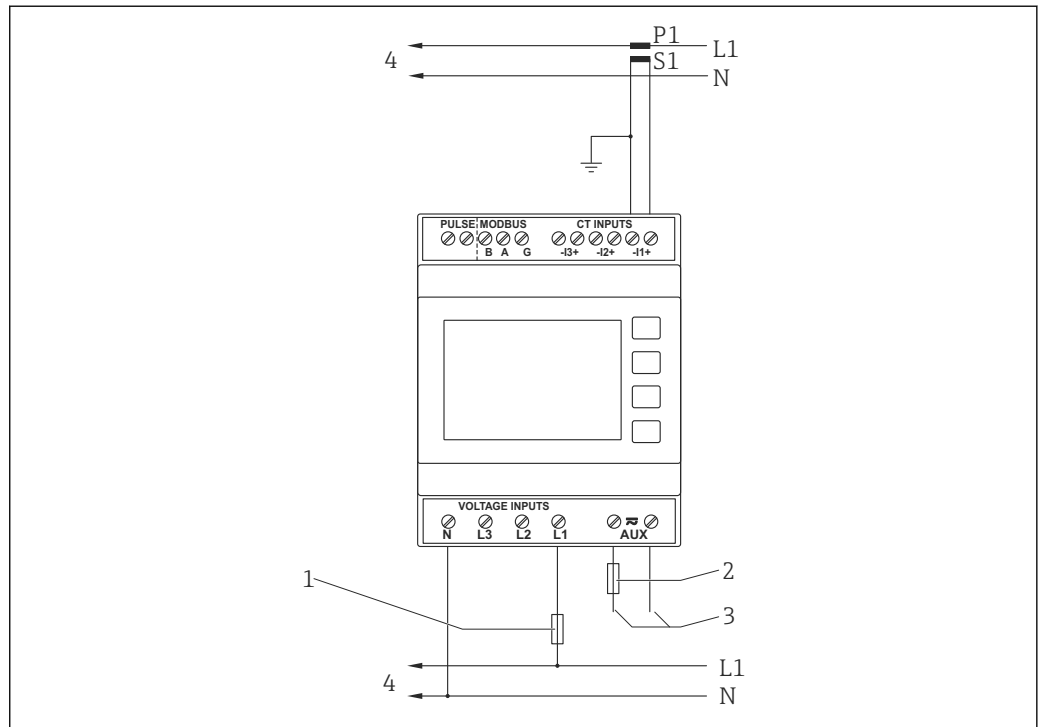


*⊡ 3      Connection in single-phase, 2-wire power network*

*1      Fast-acting fuse 1 A*
*2      Slow-blow fuse 1 A*
*3      Supply voltage*
*4      Load*

### 4.2.2    Connection in 3-phase, 3-wire power network

**⚠ WARNING**

**The neutral wire connection (terminal N) is indirectly connected with the voltage input terminals (terminals L1, L2, L3). If connected to a 3-wire system, the neutral wire adopts a potential between the other wires.**
Danger! Electric voltage!
▶ If the external wiring is connected to terminal N, it must be connected either to the neutral wire or protective ground to prevent the risk of electric shock from the neutral terminal.
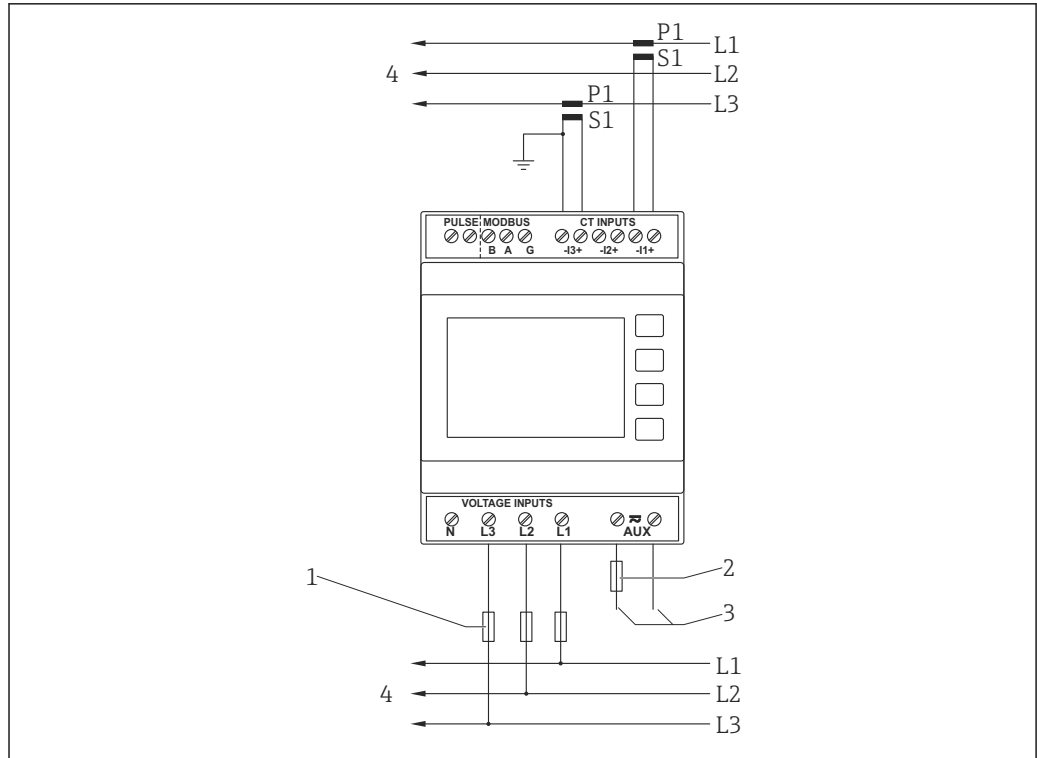
☒ 4    *Connection in 3-phase, 3-wire power network*

*1    Fast-acting fuse 1 A*
*2    Slow-blow fuse 1 A*
*3    Supply voltage*
*4    Load*

The "S2" secondary terminals of the current transformers are connected in the multifunction electrical energy meter. Only one protective ground connection ⏚ must be provided for this reason.

### 4.2.3   Connection in 3-phase, 4-wire power network
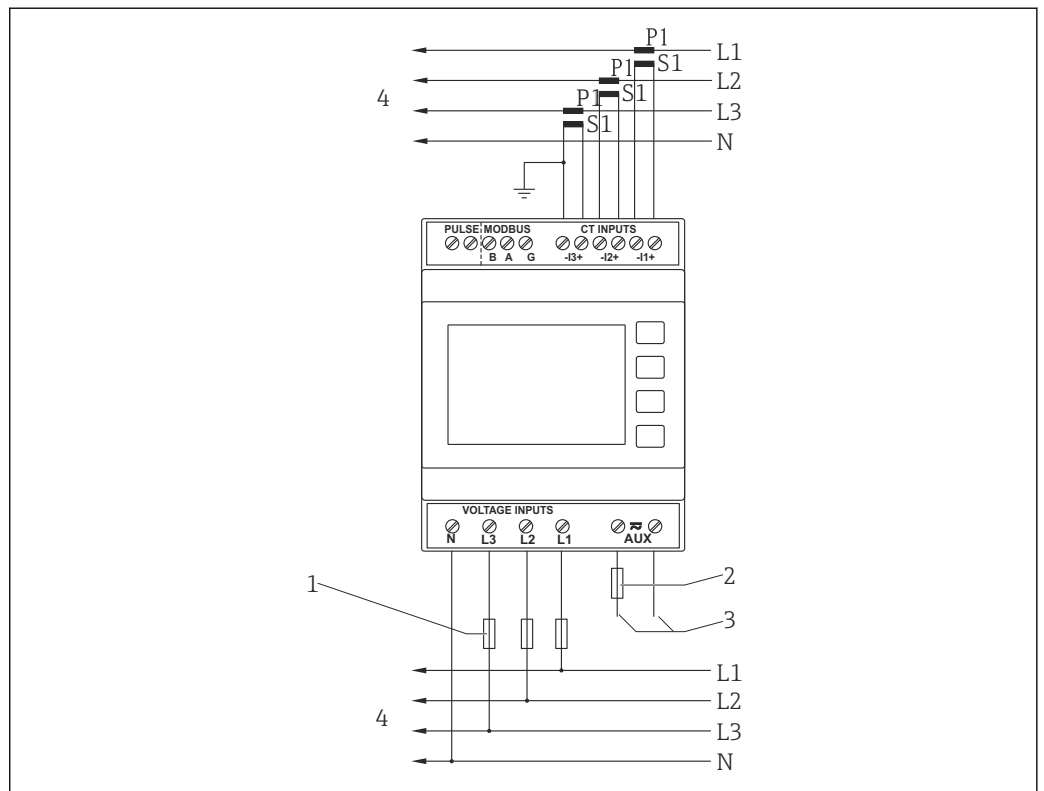


*⊠ 5      Connection in 3-phase, 4-wire power network*

*1      Fast-acting fuse 1 A*
*2      Slow-blow fuse 1 A*
*3      Supply voltage*
*4      Load*

The "S2" secondary terminals of the current transformers are connected in the multifunction electrical energy meter. Only one protective ground connection ⊕ must be provided for this reason.

## 4.3   Connecting the outputs

### 4.3.1   RS485 interface for communication via Modbus RTU or Metasys N2

The RS485 Modbus RTU interface is connected to the terminals labeled A, B, G which are provided for this purpose (→ ⊠ 3, ⊟ 11).

A shielded, two-wire cable is recommended for the connection between the RS485 master and the measuring device. A cable that is specially designed for connecting RS485 interfaces should be used where possible. However, satisfactory results can be achieved with most shielded cables for connection distances of just a few meters. Cat IV network cables also deliver satisfactory results. Given that the measuring device communicates with an external device via an RS485 connection, distances of up to 1200 m can be covered under good conditions. Electrical interference or other negative conditions can reduce the distance over which reliable operation is possible.

### 4.3.2    Pulse output

The pulse output is connected to the terminals marked "pulse" which are provided for this purpose.

A semi-conductor relay is provided. The nominal power is 250 V, 50 mA. Connecting cables must be as short as possible, meet the specific requirements and be filtered where necessary.

## 4.4    Post-connection check

| Device condition and specifications | Notes |
|---|---|
| Are cables or the device damaged? | Visual inspection |
| Electrical connection | Notes |
| Does the supply voltage match the specifications in the "supply voltage" section? | (→ 🖹 10) |
| Are the mounted cables strain-relieved? | - |
| Are the power supply and signal cables correctly connected? | (→ 🖹 10) and (→ 🖹 13) |

# 5    Operation

## 5.1    Display

The display screen is used in 2 operating modes:
• Display mode (→ 🗎 15) to display measured values
• Configuration mode (→ 🗎 15) of the multifunction electrical energy meter. The possible settings are described in the "Commissioning" section (→ 🗎 18).

## 5.2    Operating elements

You can directly access various measured values via the 4 keys on the front of the multifunction electrical energy meter. The keys are used to configure the device in the configuration mode.

| | |
|---|---|
| ← V/Hz A0016376 | Is used to display voltage and frequency. Press this key repeatedly to select voltage, frequency and %THD (total harmonic distortion). This is the "Back" function in the setup mode. |
| ↑ A A0016377 | Is used to display current. Press repeatedly to select phase and neutral currents (3P4W), maximum values and total harmonic distortion of currents. This is the "Up" function in the setup mode. |
| P/PF ↓ A0016379 | Is used to display power instantaneous values. Press repeatedly to select power (W, var & VA), power maximum values and power factor. This is the "Down" function in the setup mode. |
| ↵ E A0016378 | Is used to display energy. Press repeatedly to select imported/exported Wh and varh. Flashing of the current figure indicates that data is being added. The "1%" symbol means that values < 1 %the upper range value are not included in the energy calculation. This is the "Enter" function in the setup mode. |

## 5.3    Display mode

The measured values are shown on the backlit liquid crystal display.

*Order in which measured values are displayed in the display mode*

| Key | View No. | Description 3-phase, 4-wire | View No. | Description 3-phase, 3-wire | View No. | Single-phase, 2-wire |
|---|---|---|---|---|---|---|
| ← V/Hz A0016376 | 1 | V L1-N (voltage L1/N) V L2-N (voltage L2/N) V L3-N (voltage L3/N) | 1 | V L1-L2 (voltage L1/L2) V L2-L3 (voltage L2/L3) V L3-L1 (voltage L3/L1) | 1 | V L1 (voltage L1) |
| | 2 | V L1-L2 (voltage L1/L2) V L2-L3 (voltage L2/L3) V L3-L1 (voltage L3/L1) | | | | |
| | 3 | Frequency | 2 | Frequency | 2 | Frequency |
| | 4 | V L1-N %THD* (%THD voltage L1/N) V L2-N %THD* (%THD voltage L2/N) V L3-N %THD* (%THD voltage L3/N) | | | | |
| | 5 | V L1-L2 %THD* (%THD voltage L1/L2) V L2-L3 %THD* (%THD voltage L2/L3) V L3-L1 %THD* (%THD voltage L3/L1) | 3 | V L1-L2 %THD* (%THD voltage L1/L2) V L2-L3 %THD* (%THD voltage L2/L3) V L3-L1 %THD* (%THD voltage L3/L1) | 3 | V L1 %THD* |
| *) %THD = % Total Harmonic Distortion | | | | | | |

| Key | View No. | Description 3-phase, 4-wire | View No. | Description 3-phase, 3-wire | View No. | Single-phase, 2-wire |
|---|---|---|---|---|---|---|
| A ↑ A0016377 | 1 | A L1 (current L1) A L2 (current L2) A L3 (current L3) | 1 | A L1 (current L1) A L2 (current L2) A L3 (current L3) | 1 | A L1 (current L1) |
| | 2 | A neutral current | | | | |
| | 3 | A L1 MAX (Current L1, maximum value, time-integrated, maximum indicator function) A L2 MAX (Current L2, maximum value, time-integrated, maximum indicator function) A L3 MAX (Current L3, maximum value, time-integrated, maximum indicator function) | 2 | A L1 MAX (Current L1, maximum value, time-integrated, maximum indicator function) A L2 MAX (Current L2, maximum value, time-integrated, maximum indicator function) A L3 MAX (Current L3, maximum value, time-integrated, maximum indicator function) | 2 | A L1 MAX (Current L1, maximum value, time-integrated, maximum indicator function) |
| | 4 | A neutral current MAX (Maximum value, time-integrated, maximum indicator function) | | | | |
| | 5 | I %THD* L1 (%THD current L1) I %THD* L2 (%THD current L2) I %THD* L3 (%THD current L3) | 3 | I %THD* L1 (%THD current L1) I %THD* L2 (%THD current L2) I %THD* L3 (%THD current L3) | 3 | I %THD* L1 (%THD current L1) |
| P/PF ↓ A0016379 | 1 | kW active power kvar reactive power kVA apparent power | 1 | kW active power kvar reactive power kVA apparent power | 1 | kW active power kvar reactive power kVA apparent power |
| | 2 | kW MAX (active power, maximum value, time-integrated, maximum indicator function) | 2 | kW MAX (active power, maximum value, time-integrated, maximum indicator function) | 2 | kW MAX (active power, maximum value, time-integrated, maximum indicator function) |
| | 3 | PF power factor (with symbol: coil = inductive, capacitor = capacitance) | 3 | PF power factor (with symbol: coil = inductive, capacitor = capacitance) | 3 | PF power factor (with symbol: coil = inductive, capacitor = capacitance) |
| E ↵ A0016378 | 1 | kWh imported electrical energy (active component) | 1 | kWh imported electrical energy (active component) | 1 | kWh imported electrical energy (active component) |
| | 2 | kWh exported electrical energy (active component) | 2 | kWh exported electrical energy (active component) | 2 | kWh exported electrical energy (active component) |
| | 3 | kvarh imported electrical energy (reactive component) | 3 | kvarh imported electrical energy (reactive component) | 3 | kvarh imported electrical energy (reactive component) |
| | 4 | kvarh exported electrical energy (reactive component) | 4 | kvarh exported electrical energy (reactive component) | 4 | kvarh exported electrical energy (reactive component) |
| *) %THD = % Total Harmonic Distortion | | | | | | |

## 5.4 Configuration mode

The abbreviation for the parameter is displayed in the top display row in the configuration mode. The middle row displays the parameter value. The bottom row is used to confirm the set value of the parameter.

To enter the configuration mode, press and hold the [V/Hz] and [E] keys simultaneously for 5 seconds. The screen to enter the 4-digit password is displayed. No default password is set. A password can be used to prevent unauthorized access to the device settings. Once the correct password has been entered, the device is on the first level of the menu structure. If

a password was not configured for the device beforehand, the setup is called up by pressing the ⊞ key four times.

The parameter to be configured is selected with the ⊞ and ⊞ keys. When the ⊞ key is pressed, the parameter is selected and the user enters the second level of the menu structure. Values can be changed at this level, such as the values of the system configuration, for example. There is a third level in the menu structure for some parameters, such as the parameters for communication. This level is reached in the same way. Once the necessary settings have been made, press the key to return to the first level in the menu structure.

Generally speaking, the ⊞ and ⊞ keys change the value of the parameter; the ⊞ key confirms the change / setting and skips to the next display screen (next parameter).

You can exit the configuration mode at any time by pressing the ⊞ and ⊞ keys simultaneously for 5 seconds. Any changes that have already been made are retained. You can also exit the configuration mode by repeatedly pressing the ⊞ key. In both cases, the device switches back to the last measured values displayed.

The possible settings are described in the "Commissioning" section (→ 🕮 18).

### 5.4.1     Entering numbers

Users must frequently change digits in the configuration mode, usually in the middle row of numbers.

The ⊞ key is used to increase and the ⊞ key to decrease a value.

The current digit to be changed flashes on the screen. Pressing the ⊞ key accepts the set value and switches to the next digit. In each particular row of numbers, the digits are set in succession from left to right.

Pressing the ⊞ key takes you back to the previous digit.

Once the last digit has been accepted, "SET" is displayed in the bottom row of the display.

## 5.5     Power-up screen

After powering up the energy meter (switching on the supply voltage), a number of screens are displayed by way of a self-test.

1st screen: All the LCD segments are displayed. This is used as a self-test for the display.

2nd screen: The firmware version of the energy meter is displayed.

3rd screen: Displays the result of the self-test when powering up the energy meter.

The device then switches to the first measured value display and displays the voltage values.

# 6    Commissioning

## 6.1    Post-installation check and switching on the device

Perform all the final checks before commissioning the device.

- Checklist for "post-installation check" (→ 🗎 9)
- Checklist for "post-connection check" (→ 🗎 14)

When the operating voltage is applied, a number of screens are first displayed by way of a self-test (→ 🗎 17).

If you are commissioning the device for the first time, program the setup as described in the following sections. If you are commissioning a device that is already configured, the device starts measuring immediately as defined in the settings and the values are shown on the display.

## 6.2    Menu structure

| | | First level | Second level | Third level |
|---|---|---|---|---|
| | | CHNG PASS<br>Change password | NPWd<br>(new password) | Change the value of the password.<br>Range for selection: 0 to 9 999 |
| Main menu | Password entry | SYS (system configuration) | Choose from:<br>- 1P2W (single-phase, 2-wire)<br>- 3P3W (3-phase, 3-wire)<br>- 3P4W (3-phase, 4-wire) | |
| | | CT (current transformer primary value) | Change the value. Range for selection: 1 to 9 999 A | |
| | | dIT (integration time of average values for maximum indicator function) | Choose from:<br>- 60 minutes<br>- 30 minutes<br>- 20 minutes<br>- 15 minutes<br>- 10 minutes<br>- 8 minutes<br>- 5 minutes<br>- OFF | |
| | | RSET (reset) | Choose from:<br>- dmd (maximum time-integrated average values - maximum indicator function)<br>- ALL<br>- hour (kWh & kvarh) | |
| | | COMS (communication) | FMT (protocol) | Choose from:<br>- Modb (Modbus RTU)<br>- N2 (Johnson Controls Metasys N2) |
| | | | bAUd (baud rate) | Choose from:<br>- 2 400<br>- 4 800<br>- 9 600<br>- 19 200<br>- 38 400 |
| | | | PARI (parity) | Choose from:<br>- None<br>- Odd<br>- Even |

| First level | Second level | Third level |
|---|---|---|
| | STOP (stop bits) | Choose from:<br>• 1<br>• 2 |
| | Addr (device address) | Choose value from between 1 to 247 |
| RLY (relay) | OP1 (value assignment to pulse output relay 1) | Choose from:<br>• NONE<br>• kWh EXPORT<br>• kWh IMPORT<br>• kvarh EXPORT<br>• kvarh IMPORT |
| | RATE (pulse value) | Choose from:<br>• 0.1<br>• 1<br>• 10<br>• 100<br>• 1000 |
| | PULS (pulse length) | Choose from:<br>• 60 ms<br>• 100 ms<br>• 200 ms |
| NRGY (energy) | | Choose from:<br>• KILO<br>• MEGA |
| | Lmt | Choose from:<br>• OFF<br>• ON |
| TEST | Choose from:<br>• disp ON (tests the segments of the LC display)<br>• disp TOGL (display toggle. Tests the segments of the LC display alternately)<br>• PHAS SEQ (checks the phase sequence) | |
| SOFT (software) | Displays the version number of the internal software (firmware) | |

### 6.2.1 Configuration example for the current transformer primary value

1. 

A0016388

   Press the [V/Hz] and [E] keys simultaneously and hold for 5 seconds.

   ↳

A0016389

   The screen to enter the password is displayed.

2. To enter the default password "0000" which is set at the factory, press the [E] key four times or enter a password that has already been configured and press [E] to confirm.

↳

SYS
3P4W

The screen to make the settings for the system configuration is displayed.

3. Repeatedly press the ⊞ key until the screen to set the current transformer primary value "CT" is displayed.

↳

CT
0005 A
SET
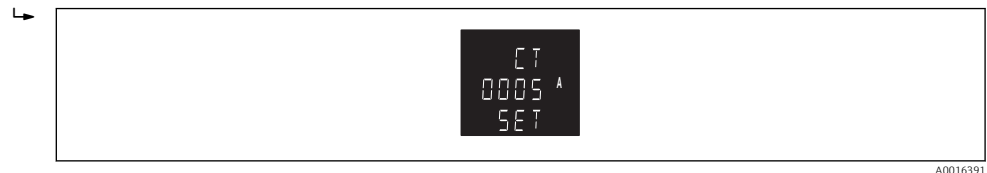
4. Press the ⊞ key.
   ↳ The first digit starts flashing.

5. Use the ⊞ and ⊞ keys to set the desired value.

6. Press the ⊞ key to confirm the set value.
   ↳ The next digit starts flashing.

7. Repeat this procedure until the last digit has been set and confirmed.
   ↳ The set value is displayed as follows, for example: 0100 = 100 A, 1000 = 1 000 A, etc. "SET" now also appears on the display.

The current transformer primary value is now configured. Press the ⊞ key to return to the first level in the menu structure. Other parameters can now be selected for configuration in the first level.

If no more settings need to be made, press the ⊞ key again to switch to the display mode.

## 6.3 Device settings

Calling up the Setup menu

1. Press the ⊞ and ⊞ keys simultaneously for 5 seconds.
   ↳ The screen to enter the password is displayed.

2. To enter the default password "0000" which is set at the factory, press the ⊞ key four times or enter a password that has already been configured and press ⊞ to confirm.
   ↳ The screen to make the settings for the system configuration is displayed.

### 6.3.1 Changing the password - CHNG PASS

1. Call up the Setup menu.

2. Press the ⊞ key.
   ↳ CHNG PASS is displayed.

3. Press the ⊞ key.
   ↳ The first digit starts flashing.

4. Use the ⊞ and ⊞ keys to select the value of the first digit.

5. Press the ⊞ key to confirm.
   ↳ The next digit starts flashing.

6. Repeat this procedure until the last digit has been set and confirmed.
   ↳ "SET" now also appears on the display.

### 6.3.2 System configuration - SYS

1. Call up the Setup menu.
2. Press the ⌷ key.
3. Use the ⌷ and ⌷ keys to choose from the following configuration options: 1P2W (single-phase, 2-wire = alternating current system), 3P3W (3-phase, 3-wire = three-phase system without a neutral wire), 3P4W (3-phase, 4-wire = three-phase system with a neutral wire)
4. Press the ⌷ key to confirm your selection.

"SET" is displayed.

### 6.3.3 Current transformer primary value (CT)

The transformer primary current must be configured in the range from 1/5 A to 9 999/5 A to ensure current, power and energy values are displayed and recorded correctly. The setup sequence is explained in the (→ 🖺 19) configuration example. Factory setting "0005".

### 6.3.4 Setting the demand integration time (maximum indicator function) - dIT

This function specifies the integration time for determining the maximum value for the current and power (details, ). The values are displayed with "minutes" as the unit. Factory setting "60".

1. Call up the Setup menu.
2. Press the ⌷ or ⌷ keys until dIT is displayed.
3. Press the ⌷ key.
4. Use the ⌷ and ⌷ keys to choose from the following configuration options: 60, 30, 20, 15, 10, 8, 5, OFF (= no integration time, the maximum value displayed refers to the peak value measured directly)
5. Press the ⌷ key to confirm your selection.

"SET" is displayed.

### 6.3.5 Reset – RSET

This function resets saved values.

1. Call up the Setup menu.
2. Press the ⌷ or ⌷ keys until RSET is displayed.
3. Press the ⌷ key. Initial display: "dmd"
4. Use the ⌷ and ⌷ keys to choose from the following functions: dmd (reset the maximum values), ALL (reset kWh, kvarh and maximum values), hour (reset kWh and kvarh)
5. Press the ⌷ key to reset the value.

"RSET" is displayed.

### 6.3.6 Communication settings – COMS

This function is used to make the settings for the RS485 interface which enables the device to communicate via the Modbus or the Metasys N2 protocol.

1. Call up the Setup menu.
2. Press the ⌷ or ⌷ keys until COMS is displayed.
3. Press the ⌷ key.

4. Press the ⬆ or ⬇ keys until the desired parameter is displayed.

5. Use the ᴇ key to start configuring the parameter.

6. Proceed as described in the following sections.

### Protocol - PROT

The multifunction electrical energy meter is designed for communication via the RS485 interface via Modbus RTU or alternatively via Metasys N2.

1. Use the ⬆ and ⬇ keys to choose from the following values: Modb (Modbus protocol), N2 (Metasys N2 protocol)

2. Press the ᴇ key to confirm your selection.
   ↳ If "N2" is selected, it is only possible to configure the device address (→ 🗎 22). The other communication parameters cannot be modified.

"SET" is displayed.

### Setting the baud rate - bAUd

The baud rate needed for Modbus RTU communication via the RS485 interface is selected in this function. Factory setting: "9600"

1. Use the ⬆ and ⬇ keys to choose from the following values: 2400, 4800, 9600, 19200, 38400.

2. Press the ᴇ key to confirm your selection.

"SET" is displayed.

### Setting the parity - PARI

This function sets the parity of the RS485 interface. Factory setting: "NONE"

1. Use the ⬆ and ⬇ keys to choose from the following values: None, Odd, Even.

2. Press the ᴇ key to confirm your selection.

"SET" is displayed.

### Stop bits - STOP

This function sets the number of stop bits for communication via the RS485 interface. As a prerequisite, the parity must be set to "NONE". Factory setting: "1"

1. Use the ⬆ and ⬇ keys to choose from the following values: 1 = 1 stop bit, 2 = 2 stop bits.

2. Press the ᴇ key to confirm your selection.

"SET" is displayed.

### Setting the device address - Addr

The device address must be configured for the multifunction electrical energy meter to communicate in a Modbus RTU or a Metasys N2 network. Factory setting: "1", display: "001"

The possible setting for Modbus is between 1 and 247, and between 1 and 255 for Metasys N2.

1. The first digit starts flashing once the parameter has been called up. Use the ⬆ and ⬇ keys to set the desired value.

2. Press the ᴇ key to confirm.
   ↳ The next digit starts flashing.

3. Set all 3 digits as required.

4. Press the ᴇ key to confirm.

"SET" is displayed.

### Setting the floating point - Ordr

This function displays the direction of the floating point. Changes to the setting cannot be made from the energy meter. This setting can only be changed if an RS485 interface is available and the device is integrated into a Modbus RTU network.

### 6.3.7 Setting the relay output - RLY

This function defines the settings for the output relay (pulse output for energy).

1. Call up the Setup menu.
2. Press the 🅰 or ⏻ keys until RLY is displayed.
3. Press the 🅴 key. Initial display: "IMPORT", "RLY", "kWh"
4. Press the 🅴 key again to assign the desired function to the pulse output.
5. Use the 🅰 and ⏻ keys to choose from the following values: kwH IMPORT (= use as pulse output for kWh Import), kWh EXPORT (= use as pulse output for kWh Export), kvarh IMPORT (= use as pulse output for kvarh Import), kvarh EXPORT (= use as pulse output for kvarh Export), NONE (= not used)
6. Press the 🅴 key to confirm your selection.

"SET" is displayed. The device goes to the next parameter "RATE".

### Pulse rate - RATE

This function defines the pulse rate of the pulse output. Factory setting: "1"

1. Press the 🅴 key.
2. Use the 🅰 and ⏻ keys to choose from the following values: 0.1 (= 1 pulse corresponds to 0.1 kWh / kvarh, 1 (= 1 pulse corresponds to 1 kWh / kvarh), 10 (= 1 pulse corresponds to 10 kWh / varh, 100 (= 1 pulse corresponds to 100 kWh / kvarh), 1000 (= 1 pulse corresponds to 1 000 kWh / kvarh).
3. Press the 🅴 key to confirm your selection.

"SET" is displayed. The device goes to the next parameter "PULS".

### Pulse length - PULS

This function defines the length of a pulse. Values displayed are in the unit "ms". Factory setting: "200"

1. Press the 🅴 key.
2. Use the 🅰 and ⏻ keys to choose from the following values: 60, 100, 200
3. Press the 🅴 key to confirm your setting.

"SET" is displayed. The device returns to the first menu level.

### 6.3.8 Setting the display of energy values – NRGY and setting the measurement limit (low energy cut-off) - Lmt

This function specifies whether the energy values are displayed with the "k" or "M" sign (kWh & kvarh MWh & Mvarh).

1. Call up the Setup menu.
2. Press the 🅰 or ⏻ keys until NRGY is displayed.
3. Press the 🅴 key. To skip the setting and continue configuring the "Lmt" press the 🅰 or ⏻ key instead.

4.  Use the ⬆ and ⬇ keys to choose from the following values: KILO (for kWh / kvarh), X 1 (for Wh / varh), MEGA (for MWh / Mvarh).

5.  Press the ⮐ key to confirm your selection.
    ↳ "SET" is displayed. The device goes to the next parameter "Lmt".

6.  Press the ⮐ key.
    ↳ The display shows "Lmt" at the top and "ON" in the middle row. In addition "1 %" is displayed on the bottom left.

7.  Press the ⬆ or ⬇ keys to switch between "ON" and "OFF".
    ↳ If Lmt is active, "1 %" appears on the bottom left of the display. The function is used to activate measurement signal suppression to suppress incorrect measurements caused by noise on the measuring cables. This can be required if the measuring cables - particularly the cables between the multifunction electrical energy meter and the external current transformers are not shielded and/or are routed in the immediate vicinity of the primary circuits. The 1% limit always refers to the full scale value of the power measurement, which results from the maximum input voltage and the set transformer primary current, while taking the interlinkage factor into consideration if necessary. If the function is switched on, "1 %" also appears on the bottom left of the display in the display mode.

8.  Press the ⮐ key to confirm your selection.

"SET" is displayed. The device returns to the first menu level.

### 6.3.9 Self-test – TEST

This screen contains several functions for performing self-tests on the multifunction electrical energy meter.

1.  Call up the Setup menu.

2.  Press the ⬆ or ⬇ keys until TEST is displayed.

3.  Press the ⮐ key.

4.  Use the ⬆ and ⬇ keys to choose from the following values: diSP ON (when selected by pressing the ⮐ key, all the segments of the LCD display are switched on to allow users to detect a segment failure); diSP TOGL (when selected by pressing the ⮐ key, the display alternates between two different display modes. This helps the user identify whether individual segments do not switch off); PHAS SEQ (when selected by pressing the ⮐ key, this function checks whether the voltage and current connections have been established correctly on the energy meter. PSEQ (phase sequence), V 123, I 123 is displayed if all the connections are correct. If PSEQ, V 132, I 123, for example, is displayed, this indicates that a voltage connection is faulty. If PSEQ, V 12_, I 123, for example, is displayed, this indicates that a voltage connection is missing.

### 6.3.10 Displaying the software version – SOFT

This function directly displays the version of the internal software (firmware).

1.  Call up the Setup menu.

2.  Press the ⬆ or ⬇ keys until SOFT is displayed.

3.  Press the ⮐ key.

# 7    Maintenance

**⚠ WARNING**

**The device is energized.**

Danger! Risk of electric shock!

▶ Before performing any cleaning work on the device, the device must be de-energized. Live transformer cables must never be opened to remove any dust or dirt that may have accumulated.

In normal use, the measuring device does not require any maintenance.

The front of the measuring device should be wiped with a dry cloth only. Use minimum pressure and never apply pressure to the tinted viewing window. If necessary, the rear can also be wiped with a dry cloth. Only isopropyl alcohol can be used as a cleaning agent and should be used sparingly. Never use water. If the rear of the device or the terminals should be accidentally contaminated with water, the measuring device must be dried carefully before further service. If it is suspected that water or another contaminant might have entered the device, the device must be examined and overhauled at the factory.

All terminals must be examined regularly for corrosion and to ensure that the terminal connections have not become loose. This is particularly important if the device is exposed to vibrations.

# 8      Troubleshooting

## 8.1      Spare parts

No spare parts are available for the EngyVolt devices since the devices do not contain any components that can be replaced or configured by the user.

## 8.2      Return

Observe the following points when returning the device:
- Contact your Endress+Hauser Sales Center to obtain information about the procedure and basic conditions.
- Enclose a description of the error if sending in a device for repair.

## 8.3      Disposal

The device contains electronic components and must therefore be disposed of as electronic waste. Please pay particular attention to the national disposal regulations in your country.

# 9    Accessories

No accessories are available for this device.

# 10 Technical data

## 10.1 Input

| Measured variable | **Measured process variables** |
|---|---|

Current (L1, L2, L3,), voltage (L1/N, L2/N, L3/N or L1/L2, L2/L3, L3/L1 respectively), frequency in low-voltage systems

**Calculated process variables**

EngyVolt RV12: active, reactive and apparent power, power factor (Cos-Phi), imported and exported active and reactive energy, total harmonic distortion (current L1, L2, L3; voltage L1/N, L2/N, L3/N or L1/L2, L2/L3, L3/L1 respectively), neutral current, max. current (L1, L2, L3, N) [1], max. active power [1].

EngyVolt RV15: active, reactive and apparent power, total harmonic distortion (current L1, L2, L3; voltage L1/N, L2/N, L3/N or L1/L2, L2/L3, L3/L1 respectively), active and reactive energy, neutral current, max. current (L1, L2, L3, N) [1], max. active power [1].

| Measuring range | | |
|---|---|---|
| | Nominal voltage | 100 to 289 V AC L-N (173 to 500 V AC L-L) |
| | Voltage measuring range | 25 to 600 V |
| | Maximum short-duration overvoltage | 2 x nominal voltage for 1-second application repeated 5 times in 5-minute intervals |
| | Nominal current (secondary) | 5 A AC RMS |
| | Secondary current measuring range | 0.05 to 6 A |
| | Maximum short-duration overcurrent | 10 x nominal current for 1-second application repeated 5 times in 5-minute intervals |
| | Primary current measuring range | 1 to 9 999 A (per phase) |
| | Frequency | 45 to 66 Hz |
| | Nominal power (secondary) | 1 445 W (3-phase 4 325 W) |
| | Power measuring range (secondary) | 14.45 to 2 080 W (3-phase: 43.25 to 6 228 W) [1] |
| | Power measuring range (primary) | 5 to 12 450 000 W (12.45 MW) [1] |
| | Power consumption voltage circuits | <0.2 VA per phase |
| | Power consumption current circuits | <0.6 VA per phase |

1) depending on CT

| Energy counter | 0 to 9 999 999.9 Wh, kWh, MWh / varh, kvarh, Mvarh |
|---|---|

---

1) calculated from the integrated averages and representation as maximum value over an adjustable interval of 5, 8, 10, 15, 20, 30, 60 min

## 10.2   Output

Output signal          **Pulse output**

| Number | EngyVolt RV12: 1<br>EngyVolt RV15: max. 2 (optional, via extension modules) |
|---|---|
| Contact load | 50 mA maximum at 250 V AC |
| Version | Semiconductor relay |

**RS485 MODBUS**

| Number | EngyVolt RV12: 1<br>EngyVolt RV15: 1 (optional, via extension module) |
|---|---|
| Type | Two-wire, half-duplex |
| Baud rate | 2400, 4800, 9600, 19200, 38400 |

## 10.3   Power supply

Supply voltage

| AC nominal voltage | 110 to 400 V AC ±10 % |
|---|---|
| DC nominal voltage | 120 to 350 V DC ±20 % |

Power consumption      5 VA

Electrical connection      The measuring device is designed exclusively for operation on external current converters.

The multifunction EngyVolt RV12 and RV15 electrical energy meters are suitable for single-phase and three-phase power systems with 3 or 4 wires.

The "S2" secondary terminals of the current converters are connected in the electrical energy meter. Only one protective ground connection ⏚ is provided for this reason.

Terminals          Screw-clamp terminals 0.05 to 2.5 mm² (30 to 14 AWG)

## 10.4   Performance characteristics

Reference operating
conditions

| Reference temperature | 23 ℃ ±1 ℃ (73.4 ℉ ±1.8 ℉) |
|---|---|
| Input wave form | 50 or 60 Hz ±2 % |
| | Sinusoidal (distortion factor < 0.005) |
| Supply voltage | Nominal voltage ±1 % |
| Supply voltage frequency (with AC) | Nominal frequency ±1 % |
| Supply voltage wave form | Sinusoidal (distortion factor < 0.05) |

Maximum measured error        Extended measured error: IEC 688: 1992

| Current (A) | 0.5 % of nominal current |
|---|---|
| Voltage (V) | 0.5 % of max. nominal voltage (4 % for I2 in 3-phase 3-wire operation) |
| Calculated neutral current (A) | 4 % of nominal current |
| Frequency (Hz) | 0.1 Hz |
| Power factor (PF = Cos-Phi) | 0 to 1<br>Power factor is only indicated when the measured VA is over 3 % of range maximum |
| Active power (W) | ±1 % of nominal power |
| Reactive power (var) | ±1 % of nominal power |
| Apparent power (VA) | ±1 % of nominal power |
| Active energy (kWh) | Class 1 (IEC 62053-21) |
| Reactive energy (kvarh) | ±1 % of measuring range |
| THD | 1 % up to 31st harmonic |

**Display repetition rate**

1 s typically up to >99 % of the full scale value

**Measurement and calculation interval**

Max. 300 ms (maximum with %THD measurement)

Influence of ambient          Current and voltage: 0.013 %/℃ (0.0072 %/℉) of nominal value
temperature
                              Power: 0.018 %/℃ (0.01 %/℉) of measuring range

Error change due to           2 x error allowed for the reference condition applied in the test. Error due to temperature
variation of an influence     variation as above.
quantity in the manner
described in Section 6 of
IEC 688:1992

Error in measurement          2 x error allowed at the end of the reference range adjacent to the section of the
when a measurand is           measuring range, where the measurand is currently operating / being tested.
within its measuring range,
but outside its reference
range

Warm-up period                1 minute

## 10.5  Installation

Mounting location             **EngyVolt RV12**

                              Housing for top hat rail mounting as per DIN 43880

Orientation                   Vertical

## 10.6    Environment

| | |
|---|---|
| Ambient temperature range | –10 to 55 °C (14 to 131 °F) |

| | |
|---|---|
| Storage temperature | –20 to 70 °C (–4 to 158 °F) |

| | |
|---|---|
| Humidity | 0 to 90 %, non-condensing |

| | |
|---|---|
| Altitude | Up to 2 000 m (6 560 ft) |

Degree of protection

| EngyVolt RV12 | EngyVolt RV15 |
|---|---|
| IP30 minimum | Degree of protection at front IP52 |
| | Degree of protection at rear IP30 |

| | |
|---|---|
| Shock resistance | 30 g in 3 planes |

| | |
|---|---|
| Vibration resistance | 10 to 50 Hz, IEC 60068-2-6, 2 g |

| | |
|---|---|
| Electromagnetic compatibility | EMC emissions: BS EN 61326, Class A |
| | Interference immunity: BS EN 61326, Class A |

| | |
|---|---|
| Dielectric strength | 3.25 kV for 1 minute between communication outputs and measuring inputs, communication outputs and supply voltage. Supply voltage and measuring inputs |

## 10.7    Mechanical construction

Dimensions        **EngyVolt RV12 (top-hat rail)**
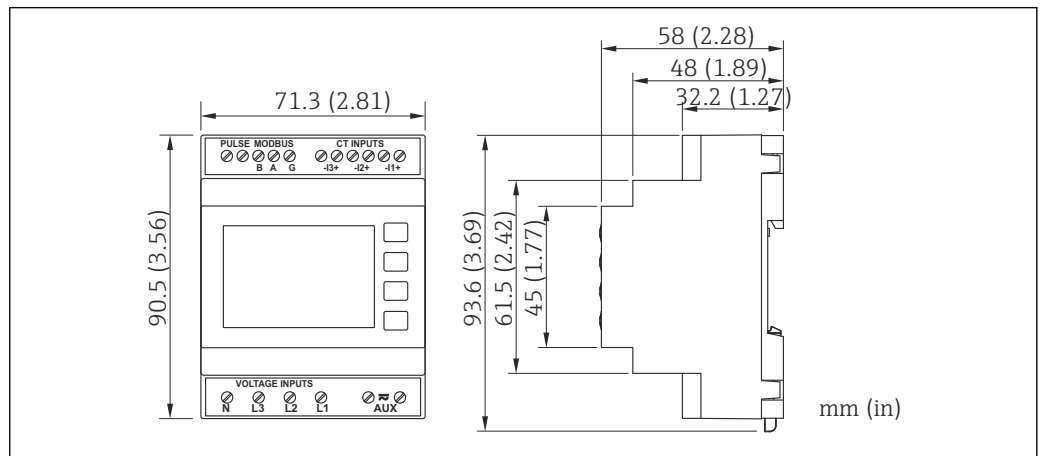


🖻 6    *Device dimensions*

| | |
|---|---|
| Weight | 300 g (0.66 lb) |

| Materials | Polycarbonate as per UL94V0 |
|---|---|

# 10.8   Operability

Local operation
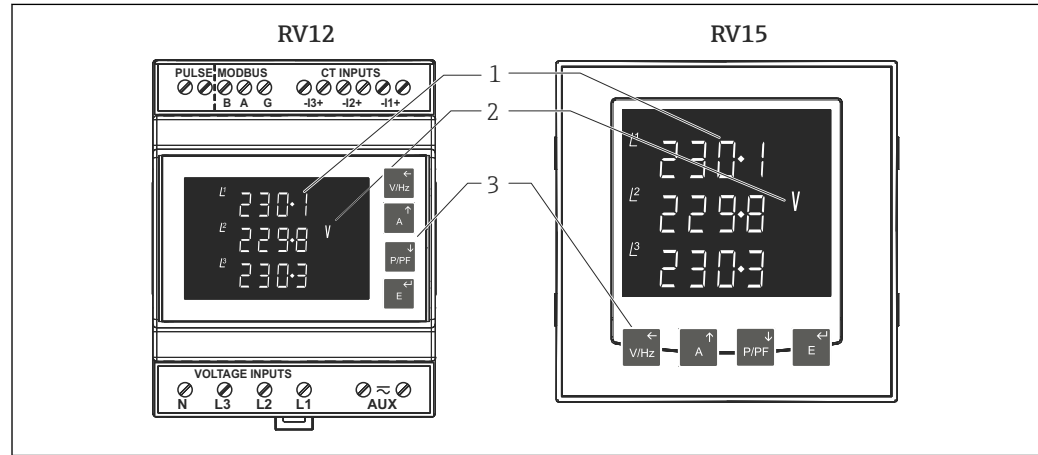


☒ 7        *Display and operating elements of the EngyVolt devices*

*1        Three-line display*
*2        Symbol for parameter displayed*
*3        Operating keys*

The display screen is used in 2 operating modes:
- Display mode to indicate measured values
- Configuration mode of the multifunction electrical energy meter

**Display mode**

The measured values are shown on the backlit liquid crystal display. The user can call up and run through 15 different views using the operating elements on the front panel.

**Configuration mode**

The abbreviation for the parameter is displayed in the top display row in the configuration mode. The middle row displays the parameter value. The bottom row is used to confirm the set value of the parameter. Generally speaking, the "A" and "P/PF" keys change the value of the parameter; the "E" key confirms the change / setting and skips to the next display screen (next parameter).

## 10.9    Certificates and approvals

**CE mark**

**Declaration of Conformity**

The product meets the requirements of the harmonized European standards.

As such, it complies with the legal specifications of the EC directives.

The manufacturer confirms successful testing of the product by affixing to it the CE mark.

**Other standards and guidelines**

- IEC 60529:
  Degrees of protection provided by enclosures (IP code)
- IEC 61010-1: 2001
  Safety requirements for electrical equipment for measurement, control and laboratory use

# 11    Appendix

## 11.1    Basis of measurement and calculations

### 11.1.1    Phase to Phase voltages for 3 phase 4 wire devices

Phase to Phase voltages are measured directly and calculated as RMS values. Situations where the phases are not spaced 120 degrees apart (e.g. 4 wire open delta) are indicated correctly.

### 11.1.2    Reactive and Apparent Power

Active powers are calculated directly by multiplication of voltage and current samples. Reactive powers are calculated using the frequency corrected quarter phase time delay method. Apparent power is calculated as the square root of the sum of the squares of active and reactive powers.

### 11.1.3    Energy resolution

Cumulative energy counts are reported using the standard IEEE floating point format. Reported energy values in excess of 1 000 000 one million may show a small non cumulative error in the integer digits due to the limitations of the number format. Internally the count is maintained with greater precision. The reporting error is less than 1 part per 1 000 000 and is automatically corrected when the count increases.

### 11.1.4    Power factor

The magnitude of Per Phase Power Factor is derived from the per phase active power and per phase reactive power. The power factor value sign is set to negative for an inductive load and positive for a capacitive load. The magnitude of the System Power Factor is derived from the sum of the per phase active power and per phase reactive power. Individual phases whose apparent power is less than 2 % of nominal are not included in power factor determinations. The system power factor value sign is set to negative for an inductive load and positive for a capacitive load. The load type, capacitive or inductive, is determined from the signs of the sums of the relevant active powers and reactive powers. If both signs are the same, then the load is inductive, if the signs are different then the load is capacitive. The magnitude of the phase angle is the ArcCos of the power factor. Its sign is taken as the opposite of the VAr's sign.

### 11.1.5    Maximum demand (drag indicator)

The maximum power consumption of an installation is provided as power utilities often levy related charges. Many utilities use a thermal maximum demand indicator (MDI) to measure this peak power consumption. An MDI averages the power consumed over a number of minutes, reflecting the thermal load that the demand places on the supply system. The Integra Ci3 digital meter uses a sliding window algorithm to simulate the characteristics of a thermal MDI instrument, with the demand period being updated every minute.

Demand Integration Times can be set to various values. Maximum Demand is the maximum power or current demand that has occurred since the unit was last reset. This is maintained as a continuous record of the highest demand value that has been reached. Note: During the initial period when the "sliding window" does not yet contain a full set of readings (e.g. during initial commissioning). Then maximum demands may not be true due to the absence of immediate historical data.

### 11.1.6    Total harmonic distortion – THD

The calculation used for Total Harmonic Distortion is: THD = ((RMS of total waveform – RMS of fundamental) / RMS of total waveform) x 100. This is often referred to as THD–R, and lies in the range 0 to 100 %. THD measurement is subject to the 'range of use' limits. The device may give erratic or incorrect readings where the THD is very high and the fundamental is essentially absent. For low signal levels the noise contributions from the signal may represent a significant portion of the "RMS of total waveform" and may thus generate unexpectedly high values of THD. In this case the product will produce a display of 0 (zero). Typically, display of THD will only produce the 0 (zero) value when the THD calculation has been suppressed due to a low signal level being detected. It should also be noted that spurious signals (for example, switching spikes) may be included in the "RMS of the total waveform" and will be used in the calculation of THD. The display of THD may be seen to fluctuate under these conditions.

### 11.1.7    Testing the phase sequence

The voltage and current inputs must be greater than 5 % of nominal for the test to operate reliably.

In the 3 phase 4 wire operating mode the measured values are referenced from L1.

For the voltage sequence test, the phase of L2 relative to L1 must be within the window 240 ±48 degrees and L3 relative to L1 must be within the window 120 ±48 degrees to record the sequence V123.

Alternatively, the phase of L2 relative to L1 must be within the window 120 ±48 degrees and L3 relative to L1 must be within the window 240 ±48 degrees to record the sequence V132.

For the current sequence test, the phase of I1 relative to L1 must be within the window 0 ±48 degrees, I2 relative to L1 must be within the window 240 ±48 degrees, and I3 relative to L1 must be within the window 120 ±120 degrees to record the sequence i123.

Alternatively the phase of I1 relative to L1 must be within the window 0 ±48 degrees, I2 relative to L1 must be within the window 120 ±48 degrees, and I3 relative to L1 must be within the window 240 ±48 degrees to record the sequence i132.

In the 3 phase 3 wire operating mode measurements are referenced from L1-L2.

For the voltage sequence test, the phase of L2-L3 relative to L1-L2 must be within the window 240 ±48 degrees L3-L1 relative to L1-L2 must be within the window 120 ±48 degrees to record the sequence V123.

Alternatively, the phase of L2-L3 relative to L1-L2 must be within the window 120 ±48 and L3 relative to L1-L2 must be within the window 240 ±48 degrees to record the sequence V132.

For the current sequence test, the phase of I1 relative to L1-L2 must be within the window 330 ±48 degrees, I2 relative to L1-L2 must be within the window 210 ±48 degrees, and I3 relative to L1-L2 must be within the window 90 ±48 degrees to record the sequence i123.

Alternatively, the phase of I1 relative to L1-L2 must be within the window 330 ±48 degrees, I2 relative to L1-L2 must be within the window 90 ±48 degrees, and I3 relative to L1-L2 must be within the window 210 ±48 degrees to record the sequence i132.

## 11.2    Modbus implementation

### 11.2.1    Modbus protocol overview

This section provides basic information for interfacing a multifunctional electrical energy meter to a Modbus protocol network. If background information or more details of the EngyVolt implementation is required please refer to the following sections of this document. EngyVolt devices offer the option of an RS485 communication facility for direct

connection to SCADA or other communications systems using the Modbus Protocol RTU slave protocol. The Modbus Protocol establishes the format for the master's query by placing into it the device address, a function code defining the requested action, any data to be sent, and an error checking field. The slave's response message is also constructed using Modbus Protocol. It contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error occurs in receipt of the message, the device will make no response. If the device is unable to perform the requested action, it will construct an error message and send it as the response.

The electrical interface is 2-wire RS485, via 3 screw terminals. Connection should be made using twisted pair screened cable and the following electrical data:

| Nominal inductivity | 0.2 µH/ft |
| Nominal capacity line-line | 24 pF/ft |
| Maximum operating voltage | 300 V RMS |

All "A" and "B" connections are daisy chained together. The screens should also be connected to the "Gnd" terminal. To avoid the possibility of loop currents, an Earth connection should be made at only one point on the network. Line topology may or may not require terminating loads depending on the type and length of cable used. Loop (ring) topology does not require any termination load. The impedance of the termination load should match the impedance of the cable and be at both ends of the line. The cable should be terminated at each end with a 120 Ω resistor. The load capacity of the resistor should be 0.25 W. A total maximum length of 1 200 m (3 900 ft) is allowed for the RS485 network. A maximum of 32 electrical nodes can be connected, including the controller. The address of each EngyVolt device can be set to any value between 1 and 247. Broadcast mode (address 0) is not supported. The maximum latency time of an EngyVolt device is 60 ms, i.e. this is the amount of time that can pass before the first response character is output. The supervisory program must allow this period of time to elapse before assuming that the device is not going to respond.

The format for each byte in RTU mode is:

| Coding system | 8-bit per byte |
| --- | --- |
| Data format | 4 bytes (2 registers) per parameter.<br>Floating point format (to IEEE 754)<br>Most significant register first (Default).<br>The default may be changed if required - See Holding Register "Register Order". |
| Error check field | 2 byte Cyclical Redundancy Check (CRC) |
| Framing | 1 start bit<br>8 data bits, least significant bit sent first<br>1 bit for even/odd parity (or no parity)<br>1 stop bit if parity is used; 1 or 2 bits if no parity |

**Data coding**

All data values in the EngyVolt device are transferred as 32 bit IEEE 754 floating point numbers, (input and output) therefore each device value is transferred using two Modbus protocol registers. All register read requests and data write requests must specify an even number of registers. Attempts to read/write an odd number of registers prompt the device to return a Modbus protocol exception message.

The multifunctional electrical energy meters can transfer a maximum of 40 values in a single transaction, therefore the maximum number of registers requestable is 80. Exceeding this limit prompts the device to generate an exception response.

Data transmission speed is selectable between 2400, 4800, 9600, 19200 and 38400 baud.

### 11.2.2   Input registers

Input registers are used to indicate the present values of the measured and calculated electrical quantities. Each parameter is held in two consecutive 16 bit registers. The following table details the 3X register address, and the values of the address bytes within the message. A tick (☑) in the column indicates that the parameter is valid for the particular wiring system. Any parameter with a cross (✗) will return the value Zero. Each parameter is held in the 3X registers. Modbus Protocol Function Code 04 is used to access all parameters.

| For example, to request | Amps 1 (current Phase 1) | Start address | = 0006 |
|---|---|---|---|
| | | No of registers | = 0002 |
| | Amps 2 (current Phase 2) | Start address | = 0008 |
| | | No of registers | = 0002 |

Each request for data must be restricted to 40 parameters or less. Exceeding the 40 parameter limit will cause a Modbus Protocol exception code to be returned.

| Address (Register) | Parameter number | EngyVolt input register parameter description | | Modbus-Startadresse Hex | | 3 Ø | 3 Ø | 1 Ø |
|---|---|---|---|---|---|---|---|---|
| | | | Unit | Hi Byte | Lo Byte | 4 W | 3 W | 2 W |
| 30001 | 1 | Phase 1 line to neutral volts | Volt | 00 | 00 | ☑ | ✗ | ☑ |
| 30003 | 2 | Phase 2 line to neutral volts | Volt | 00 | 02 | ☑ | ✗ | ✗ |
| 30005 | 3 | Phase 3 line to neutral volts | Volt | 00 | 04 | ☑ | ✗ | ✗ |
| 30007 | 4 | Phase 1 current | Ampere | 00 | 06 | ☑ | ☑ | ☑ |
| 30009 | 5 | Phase 2 current | Ampere | 00 | 08 | ☑ | ☑ | ✗ |
| 30011 | 6 | Phase 3 current | Ampere | 00 | 0A | ☑ | ☑ | ✗ |
| 30013 | 7 | Phase 1 power | Watt | 00 | 0C | ☑ | ✗ | ☑ |
| 30015 | 8 | Phase 2 power | Watt | 00 | 0E | ☑ | ✗ | ✗ |
| 30017 | 9 | Phase 3 power | Watt | 00 | 10 | ☑ | ✗ | ✗ |
| 30019 | 10 | Phase 1 volt amps | VA | 00 | 12 | ☑ | ✗ | ☑ |
| 30021 | 11 | Phase 2 volt amps | VA | 00 | 14 | ☑ | ✗ | ✗ |
| 30023 | 12 | Phase 3 volt amps | VA | 00 | 16 | ☑ | ✗ | ✗ |
| 30025 | 13 | Phase 1 volt amps reactive | Var | 00 | 18 | ☑ | ✗ | ☑ |
| 30027 | 14 | Phase 2 volt amps reactive | Var | 00 | 1A | ☑ | ✗ | ✗ |
| 30029 | 15 | Phase 3 volt amps reactive | var | 00 | 1C | ☑ | ✗ | ✗ |
| 30031 | 16 | Phase 1 power factor (*1). | - | 00 | 1E | ☑ | ✗ | ☑ |
| 30033 | 17 | Phase 2 power factor (*1) | - | 00 | 20 | ☑ | ✗ | ✗ |
| 30035 | 18 | Phase 3 power factor (*1) | - | 00 | 22 | ☑ | ✗ | ✗ |
| 30037 | 19 | Phase 1 phase angle | Degrees | 00 | 24 | ☑ | ✗ | ☑ |
| 30039 | 20 | Phase 2 phase angle | Degrees | 00 | 26 | ☑ | ✗ | ✗ |
| 30041 | 21 | Phase 3 phase angle | Degrees | 00 | 28 | ☑ | ✗ | ✗ |
| 30043 | 22 | Average line to neutral volts | Volt | 00 | 2A | ☑ | ✗ | ✗ |
| 30047 | 24 | Average line current | Ampere | 00 | 2E | ☑ | ☑ | ☑ |
| 30049 | 25 | Sum of line currents | Ampere | 00 | 30 | ☑ | ☑ | ☑ |
| 30053 | 27 | Total system power. | Watt | 00 | 34 | ☑ | ☑ | ☑ |
| 30057 | 29 | Total system volt amps | VA | 00 | 38 | ☑ | ☑ | ☑ |
| 30061 | 31 | Total system Var. | var | 00 | 3C | ☑ | ☑ | ☑ |

| Address (Register) | Parameter number | EngyVolt input register parameter description | Unit | Modbus-Startadresse Hex Hi Byte | Lo Byte | 3Ø 4W | 3Ø 3W | 1Ø 2W |
|---|---|---|---|---|---|---|---|---|
| 30063 | 32 | Total system power factor (*1) | - | 00 | 3E | ☑ | ☑ | ☑ |
| 30067 | 34 | Total system phase angle | Degrees | 00 | 42 | ☑ | ☑ | ☑ |
| 30071 | 36 | Frequency of supply voltages | Hz | 00 | 46 | ☑ | ☑ | ☑ |
| 30073 | 37 | Import Wh since last reset (*2) | kWh/MWh | 00 | 48 | ☑ | ☑ | ☑ |
| 30075 | 38 | Export Wh since last reset (*2) | kWh/MWh | 00 | 4A | ☑ | ☑ | ☑ |
| 30077 | 39 | Import varh since last reset (*2) | kvarh/Mvarh | 00 | 4C | ☑ | ☑ | ☑ |
| 30079 | 40 | Export varh since last reset (*2) | kvarh/Mvarh | 00 | 4E | ☑ | ☑ | ☑ |
| 30081 | 41 | VAh since last reset (*2) | kVAh/MVAh | 00 | 50 | ☑ | ☑ | ☑ |
| 30083 | 42 | Ah since last reset (*3) | Ah/kAh | 00 | 52 | ☑ | ☑ | ☑ |
| 30085 | 43 | Total system power demand Δt (*4) | Watt | 00 | 54 | ☑ | ☑ | ☑ |
| 30087 | 44 | Maximum total system power demand Δt (*4) | Watt | 00 | 56 | ☑ | ☑ | ☑ |
| 30101 | 51 | Total system VA demand Δt | VA | 00 | 64 | ☑ | ☑ | ☑ |
| 30103 | 52 | Maximum total system VA demand Δt | VA | 00 | 66 | ☑ | ☑ | ☑ |
| 30105 | 53 | Neutral current demand Δt | Ampere | 00 | 68 | ☑ | ✗ | ✗ |
| 30107 | 54 | Maximum neutral current demand Δt | Ampere | 00 | 6A | ☑ | ✗ | ✗ |
| 30201 | 101 | Line 1 to Line 2 volts | Volt | 00 | C8 | ☑ | ☑ | ✗ |
| 30203 | 102 | Line 2 to Line 3 volts | Volt | 00 | CA | ☑ | ☑ | ✗ |
| 30205 | 103 | Line 3 to Line 1 volts | Volt | 00 | CC | ☑ | ☑ | ✗ |
| 30207 | 104 | Average line to line volts | Volt | 00 | CE | ☑ | ☑ | ✗ |
| 30225 | 113 | Neutral current | Ampere | 00 | E0 | ☑ | ✗ | ✗ |
| 30235 | 118 | Phase 1 L/N volts THD | % | 00 | EA | ☑ | ✗ | ☑ |
| 30237 | 119 | Phase 2 L/N volts THD | % | 00 | EC | ☑ | ✗ | ✗ |
| 30239 | 120 | Phase 3 L/N volts THD | % | 00 | EE | ☑ | ✗ | ✗ |
| 30241 | 121 | Phase 1 Current THD | % | 00 | F0 | ☑ | ☑ | ☑ |
| 30243 | 122 | Phase 2 Current THD | % | 00 | F2 | ☑ | ☑ | ✗ |
| 30245 | 123 | Phase 3 Current THD | % | 00 | F4 | ☑ | ☑ | ✗ |
| 30249 | 125 | Average line to neutral volts THD | % | 00 | F8 | ☑ | ✗ | ☑ |
| 30251 | 126 | Average line current THD | % | 00 | FA | ☑ | ☑ | ☑ |
| 30255 | 128 | -Total system power factor (*5) | Degrees | 00 | FE | ☑ | ☑ | ☑ |
| 30259 | 130 | Phase 1 current demand Δt | Ampere | 01 | 02 | ☑ | ☑ | ☑ |
| 30261 | 131 | Phase 2 current demand Δt | Ampere | 01 | 04 | ☑ | ☑ | ✗ |
| 30263 | 132 | Phase 3 current demand Δt | Ampere | 01 | 06 | ☑ | ☑ | ✗ |
| 30265 | 133 | Maximum phase 1 current demand Δt | Ampere | 01 | 08 | ☑ | ☑ | ☑ |
| 30267 | 134 | Maximum phase 2 current demand Δt | Ampere | 01 | 0A | ☑ | ☑ | ✗ |
| 30269 | 135 | Maximum phase 3 current demand Δt | Ampere | 01 | 0C | ☑ | ☑ | ✗ |
| 30335 | 168 | Line 1 to line 2 volts THD | % | 01 | 4E | ☑ | ☑ | ✗ |
| 30337 | 169 | Line 2 to line 3 volts THD | % | 01 | 50 | ☑ | ☑ | ✗ |
| 30339 | 170 | Line 3 to line 1 volts THD | % | 01 | 52 | ☑ | ☑ | ✗ |
| 30341 | 171 | Average line to line volts THD | % | 01 | 54 | ☑ | ☑ | ✗ |

| *1) | The power factor has its sign adjusted to indicate the nature of the load. Positive for capacitive and negative for inductive. |
|------|------|
| 2*) | There is a user option to select either k or M for the energy prefix. |
| 3*) | The same user option as in 2 above gives a prefix of none or k for Amphours |
| 4*) | The power sum demand calculation is for import power only. |
| 5*) | The negative total system power factor is a sign inverted version of parameter 32, the magnitude is the same as parameter 32. |
| 6*) | There is a user option to select None, k or M for the energy prefix. |

### 11.2.3  Modbus protocol holding registers and EngyVolt set up

Holding registers are used to store and display instrument configuration settings. All holding registers not listed in the table below should be considered as reserved for manufacturer use and no attempt should be made to modify their values. The holding register parameters may be viewed or changed using the Modbus Protocol. Each parameter is held in two consecutive 4X registers. Modbus Protocol Function Code 03 is used to read the parameter and Function Code 16 is used to write. Write to only one parameter per message.

| Address (Register) | Parameter number | Parameter Holding register | Modbus start address Hex | | Valid range | Mode |
|------|------|------|------|------|------|------|
| | | | High Byte | Low Byte | | |
| 40001 | 1 | Demand time (Δt) | 00 | 00 | Read minutes into first demand calculation. When the Demand Time reaches the Demand Period then the demand values are valid. | ro |
| 40003 | 2 | Demand period (Δt) | 00 | 02 | Write demand period: 0, 5, 8, 10, 15, 20, 30 or 60 minutes. Default: 60 minutes. Setting the period to 0 will cause the demand to show the current parameter value, and demand max to show the maximum parameter value since last demand reset. | r/w |
| 40007 | 4 | System Volts | 00 | 06 | 289 (3p4w or 1p2w) 500 (3p3w) | ro |
| 40009 | 5 | System current | 00 | 08 | Valid range 1 to 9 999 A. | r/w |
| 40011 | 6 | System type | 00 | 0A | 3p4w = 3 3p3w = 2 1p2w = 1 | r/w |
| 40013 | 7 | Relay pulse width | 00 | 0C | Write relay on period in milliseconds: 60, 100, 200 Default: 200 | r/w |
| 40015 | 8 | Password lock | 00 | 0E | Write any value to password lock protected registers. Read password lock status: 0 = locked 1 = unlocked Reading will also reset the password timeout back to one minute. | r/w |
| 40019 | 10 | Network parity stop | 00 | 12 | Write the network port parity/stop bits for Modbus Protocol, where: 0 = One stop bit and no parity, default. 1 = One stop bit and even parity. 2 = One stop bit and odd parity. 3 = Two stop bits and no parity. Requires a restart to become effective. | r/w |

| Address (Register) | Parameter number | Parameter Holding register | Modbus start address Hex | | Valid range | Mode |
|---|---|---|---|---|---|---|
| | | | High Byte | Low Byte | | |
| 40021 | 11 | Note address | 00 | 14 | Write the network port node address. Default: 1 Valid range 1 to 247. Requires a restart to become effective. Note, both the Modbus Protocol and Johnson Controls node addresses can be changed via the display setup menus. | r/w |
| 40023 | 12 | Relay pulse divisor | 00 | 16 | Write pulse divisor index: $N = 2$ to 6 in $Wh/10^N$. Default: 3 | r/w |
| 40025 | 13 | Password | 00 | 18 | Write password for access to protected registers. Default: 0000 Read zero. Reading will also reset the password timeout back to one minute. | r/w |
| 40029 | 15 | Network baud rate | 00 | 1C | Write the network port baud rate for Modbus Protocol. Valid values: 0 = 2400 baud 1 = 4800 baud 2 = 9600 baud (default) 3 = 19200 baud 4 = 38400 baud Requires a restart to become effective. | r/w |
| 40031 | 16 | Energy units prefix | 00 | 1E | Write the units prefix for energy output values. 0 = no prefix (e.g. Wh) 1 = k prefix (e.g. kWh) 2 = M (e.g. MWh) | r/w |
| 40033 | 17 | Low power limit override | 00 | 20 | 0 = limit on 1% symbol off 1 = limit off 1% symbol on Default = 0 | r/w |
| 40037 | 19 | System power | 00 | 24 | Read the total system power, e.g. 3p4w returns System Volts x System Amps x 3. | ro |
| 40041 | 21 | Register order | 00 | 28 | Write: 2141 only | r/w |
| 40043 | 22 | High serial number | 00 | 2A | 0 - 16,777,215 | ro |
| 40045 | 23 | Low serial number | 00 | 2C | 0 - 16,777,215 | ro |
| 40087 | 44 | Relay1 energy type | 00 | 56 | Modbus Protocol input parameter for pulse relay 1: 0 = relay off 37 = Import Wh 38 = Export Wh 39 = Import varh 40 = Export varh Default = 38 | r/w |
| 40217 | 109 | Reset logged data | 00 | D8 | Write 1 to reset energy | r/w |

### Register order

Register order controls the order in which the device receives or sends floating-point numbers: - normal or reversed register order. In normal mode, the two registers that make up a floating point number are sent most significant register first. In reversed register mode, the two registers that make up a floating point number are sent least significant register first. To set the mode, write the value '2141.0' into this register - the instrument

will detect the order used to send this value and set that order for all Modbus Protocol transactions involving floating point numbers.

It is perfectly feasible to change EngyVolt devices set-up using a general purpose Modbus Protocol master, but often easier to use the device display, especially for gaining password protected access.

**Password**

Some of the parameters described above are password protected and thus require the password to be entered at the Password register before they can be changed. The default password is 0000. When the password has been entered it will timeout in one minute unless the Password or Password Lock register is read to reset the timeout timer. Once the required changes have been made to the protected parameters the password lock should be reapplied by

- allowing the password to timeout, or
- writing any value to the Password Lock register, or
- power cycling the instrument.

## 11.3     RS485 general information

Some of the information in this section relates to other product families, and is included to assist where a mixed network is implemented.

RS485 or EIA (Electronic Industries Association) RS485 is a balanced line, half-duplex transmission system allowing transmission distances of up to 1 200 m (3 900 ft). The following table summarises the RS-485 Standard:

| PARAMETER | Value |
|---|---|
| Mode of Operation | Differential |
| Number of Drivers and Receivers | 32 Drivers, 32 Receivers |
| Maximum Cable Length | 1 200 m (3 900 ft) |
| Maximum Data Rate | 10 Mbaud |
| Maximum Common Mode Voltage | 12 to −7 V |
| Minimum Driver Output Levels (Loaded) | ±1.5 V |
| Minimum Driver Output Levels (Unloaded) | ±6 V |
| Drive Load | Minimum 60 Ω |
| Driver Output Short Circuit Current Limit | 150 mA to GND<br>250 mA to 12 V<br>250 mA to −7 V |
| Minimum Receiver Input Resistance | 12 kΩ |
| Receiver Sensitivity | ±200 mV |

Further information relating to RS485 may be obtained from either the EIA or the various RS485 device manufacturers.

### 11.3.1     Half duplex

Half duplex is a system in which one or more transmitters (talkers) can communicate with one or more receivers (listeners) with only one transmitter being active at any one time. For example, a "conversation" is started by asking a question, the person who has asked the question will then listen until he gets an answer or until he decides that the individual who was asked the question is not going to reply. In a 485 network the "master" will start the "conversation" with a "query" addressed to a specific "slave", the "master" will then listen for the "slave's" response. If the "slave" does not respond within a pre-defined

period, (set by control software in the "master"), the "master" will abandon the "conversation".

## 11.3.2    Connecting the instruments

Screened twisted pair cable should be used. For longer cable runs or noisier environments, use of a cable specifically designed for RS485 may be necessary to achieve optimum performance. All "A" terminals should be connected together using one conductor of the twisted pair cable, all "B" terminals should be connected together using the other conductor in the pair. A line as described in (→ 🕮 35) or any other line with equal specification and a characteristic impedance of 120 Ω is recommended. The cable should be terminated at each end with a 120 Ω, min. 0.25 W, resistor and a capacitor with 1 nF in series with the resistor.
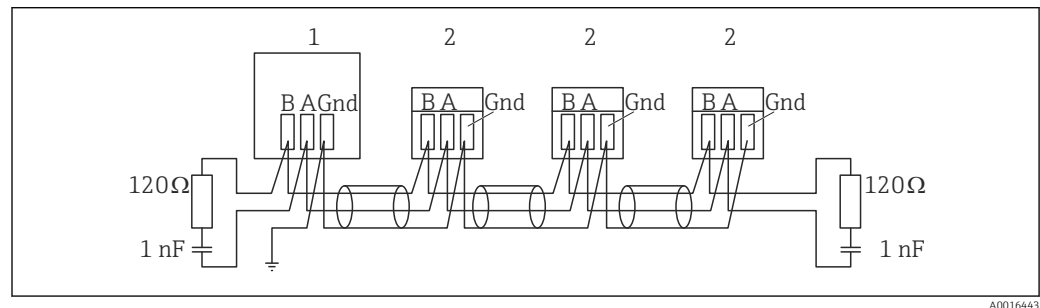


 *8      Modbus connection*

*1      Modbus Master*
*2      EngyVolt Modbus Slave*

There must be no more than two wires connected to each terminal, this ensures that a "Daisy Chain or "straight line" configuration is used. A "Star" or a network with "Stubs (Tees)" is not recommended as reflections within the cable may result in data corruption.
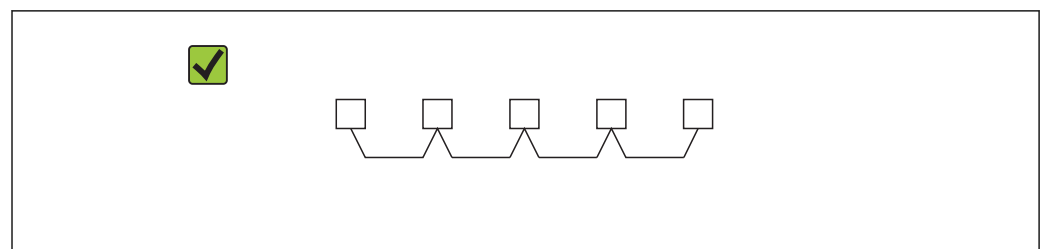


 *9      Correct straight line connection*
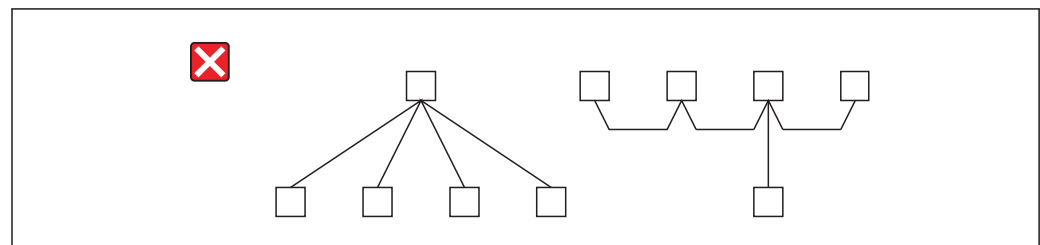


 *10     Incorrect star or stubs connection*

## 11.3.3    A and B terminals

The A and B connections to the EngyVolt devices can be identified by the signals present on them whilst there is activity on the RS485 bus.
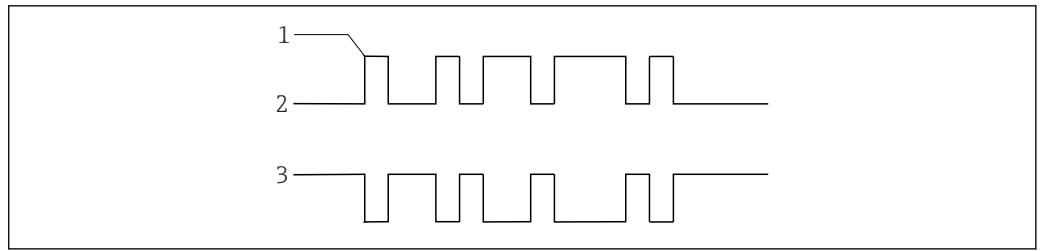
*11   RS485 signal*

*1     Start bit*
*2     Idle State (A) = no signal level on A*
*3     Idle State (B) = no signal level on*

### 11.3.4   Troubleshooting

This section contains general information. Specific notes for your individual system can be obtained from the technical support of the software used or from your system integrator.

- Start with a simple network, one master and one slave. With EngyVolt devices this is easily achieved as the network can be left intact whilst individual instruments are disconnected by removing the RS485 connection from the instrument.
- Check that the network is connected together correctly as described in (→ 🖹 42).
- Confirm that the data "transmitted" onto the RS485 is not echoed back to the PC on the RS232 lines. (This facility is sometimes a link option within the converter). Many PC based packages seem to not perform well when they receive an echo of the message they are transmitting.
- Confirm that the address of the instrument is the same as the "master" is expecting.
- If the "network" operates with one instrument but not more than one check that each instrument has a unique address.
- Each request for data must be restricted to 40 parameters. Violating this requirement will impact the performance of the instrument and may result in a response time in excess of the specification.
- Check that the Modbus Protocol mode (RTU or ASCII) and serial parameters (baud rate, number of data bits, number of stop bits and parity) are the same for all devices on the network.
- Check that the "master" is requesting floating-point variables (pairs of registers placed on floating point boundaries) and is not "splitting" floating point variables.
- Check that the floating-point byte order expected by the "master" is the same as that used by EngyVolt device. (Various software systems can use a number of formats.)
- If possible obtain a second RS232 to RS485 converter and connect it between the RS485 bus and an additional PC equipped with a software package, which can display the data on the bus. Check for the existence of valid requests.
- Especially for converters with USB connection, experience has shown that data transmission may be incorrect. Due to the variety of converters on the market a general type recommendation cannot be made. Use of a RS485/RS232 converter for connection to the serial PC interface is recommended.

## 11.4   Modbus protocol general information

Communication on a Modbus Protocol Network is initiated (started) by a "Master" sending a query to a "Slave". The "Slave", which is constantly monitoring the network for queries addressed to it, will respond by performing the requested action and sending a response back to the "Master". Only the "Master" can initiate a query.

In the Modbus Protocol the master can address individual slaves, or, using a special "Broadcast" address, can initiate a broadcast message to all slaves. The EngyVolt devices do not support the broadcast address.

### 11.4.1 Modbus data format

The Modbus Protocol defines the format for the master's query and the slave's response. The query contains the device (or broadcast) address, a function code defining the requested action, any data to be sent, and an error-checking field. The response contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error occurred in receipt of the message then the message is ignored, if the slave is unable to perform the requested action, then it will construct an error message and send it as its response. The Modbus Protocol functions used by the EngyVolt devices copy 16 bit register values between master and slaves. However, the data used by the EngyVolt device is in 32 bit IEEE 754 floating point format. Thus each instrument parameter is conceptually held in two adjacent Modbus Protocol registers.

**Query**

The following example illustrates a request for a single floating point parameter i.e. two 16-bit Modbus Protocol Registers.

| First Byte | | | | | | | Last Byte |
|---|---|---|---|---|---|---|---|
| "Slave" address | Function code | Start address (Hi) | Start address (Lo) | Number of points (Hi) | Number of points (Lo) | Error check (Lo) | Error check (Hi) |

*"Slave" address:*

8-bit value representing the slave being addressed (1 to 247), 0 is reserved for the broadcast address. The EngyVolt devices do not support the broadcast address.

*Function code:*

8-bit value telling the addressed slave what action is to be performed. (3, 4, 8 or 16 are valid)

*Start address (Hi):*

The top (most significant) eight bits of a 16-bit number specifying the start address of the data being requested.

*Start address (Lo):*

The bottom (least significant) eight bits of a 16-bit number specifying the start address of the data being requested. As registers are used in pairs and start at zero, then this must be an even number.

*Number of points (Hi):*

The top (most significant) eight bits of a 16-bit number specifying the number of registers being requested.

*Number of points (Lo):*

The bottom (least significant) eight bits of a 16-bit number specifying the number of registers being requested. As registers are used in pairs, then this must be an even number.

*Error check (Lo):*

The bottom (least significant) eight bits of a 16-bit number representing the error check value.

*Error check (Hi):*

The top (most significant) eight bits of a 16-bit number representing the error check value.

**Response**

The example illustrates the normal response to a request for a single floating point parameter i.e. two 16-bit Modbus Protocol Registers.

| First Byte | | | | | | | | Last Byte |
|---|---|---|---|---|---|---|---|---|
| "Slave" | Function code | Byte count | First register (Hi) | First register (Lo) | Second register (Hi) | Second register (Lo) | Error check (Lo) | Error check (Hi) |

*"Slave" address:*

8-bit value representing the address of slave that is responding.

*Function code:*

8-bit value which, when a copy of the function code in the query, indicates that the slave recognized the query and has responded. (See also Exception Response (→ 🕮 46)).

*Byte count:*

8-bit value indicating the number of data bytes contained within this response

*First register (Hi) [2]:*

The top (most significant) eight bits of a 16-bit number representing the first register requested in the query.

*First register (Lo) [2]:*

The bottom (least significant) eight bits of a 16-bit number representing the first register requested in the query.

*Second register (Hi) [2]:*

The top (most significant) eight bits of a 16-bit number representing the second register requested in the query.

*Second register (Lo) [2]:*

The bottom (least significant) eight bits of a 16-bit number representing the second register requested in the query.

*Error check (Lo):*

The bottom (least significant) eight bits of a 16-bit number representing the error check value.

*Error check (Hi) [2]:*

The top (most significant) eight bits of a 16-bit number representing the error check value.

---

[2] Together, these four bytes represent the value of the floating point parameter requested in the query.

**Exception response**

If an error is detected in the content of the query (excluding parity errors and error check mismatch), then an error response (called an exception response), will be sent to the master. The exception response is identified by the function code being a copy of the query function code but with the most-significant bit set. The data contained in an exception response is a single byte error code.

| First Byte | | | | Last Byte |
|---|---|---|---|---|
| "Slave" address | Function code | Error code | Error check (Lo) | Error check (Hi) |

*"Slave" address:*

8-bit value representing the address of slave that is responding.

*Function code:*

8 bit value which is the function code in the query OR'ed with 80 hex, indicating that the slave either does not recognize the query or could not carry out the action requested.

*Error code:*

-bit value indicating the nature of the exception detected, see table of error codes (→ 🕮 54).

*Error check (Lo):*

The bottom (least significant) eight bits of a 16-bit number representing the error check value.

*Error check (Hi):*

The top (most significant) eight bits of a 16-bit number representing the error check value.

## 11.4.2    Serial transmission modes

There are two Modbus Protocol serial transmission modes, ASCII and RTU. EngyVolt devices do not support the ASCII mode.

In RTU (Remote Terminal Unit) mode, each 8-bit byte is used in the full binary range and is not limited to ASCII characters as in ASCII Mode. The greater data density allows better data throughput for the same baud rate, however each message must be transmitted in a continuous stream. This is very unlikely to be a problem for modern communications equipment.

| Coding system | Full 8-bit binary per byte. In this document, the value of each byte will be shown as two hexadecimal characters each in the range 0-9 or A-F. |
|---|---|
| Line protocol | 1 start bit, followed by the 8 data bits. The 8 data bits are sent with least significant bit first. |
| User option of parity and stop bits: | a) no parity & 2 stop bits<br>b) no parity & 1 stop bit<br>c) even parity & 1 stop bit<br>d) odd parity & 1 stop bit |
| User option of baud rate | a) 2 400 b) 4 800<br>c) 9 600 d) 19 200 |

The baud rate, parity and stop bits must be selected to match the master's settings.

### 11.4.3    Modbus protocol message timing

A Modbus protocol message has defined beginning and ending points. The receiving device recognizes the start of the message, reads the "Slave Address" to determine if they are being addressed and knowing when the message is completed they can use the Error Check bytes and parity bits to confirm the integrity of the message. If the Error Check or parity fails then the message is discarded.

In RTU mode, messages start with a silent interval of at least 3.5 character times. The first byte of a message is then transmitted, the device address. Master and slave devices monitor the network continuously, including during the 'silent' intervals. When the first byte (the address byte) is received, each device checks it to find out if it is the addressed device. If the device determines that it is the one being addressed it records the whole message and acts accordingly, if it is not being addressed it continues monitoring for the next message.

Following the last transmitted byte, a silent interval of at least 3.5 character times marks the end of the message. A new message can begin after this interval.

The entire message must be transmitted as a continuous stream. If a silent interval of more than 2.5 character times occurs before completion of the message, the receiving device flushes the incomplete message and assumes that the next byte will be the address byte of a new message. Similarly, if a new message begins earlier than 3.5 character times following a previous message, the receiving device may consider it a continuation of the previous message. This will result in an error, as the value in the final CRC field will not be valid for the combined messages.

### 11.4.4    How characters are transmitted serially

When messages are transmitted on standard Modbus protocol serial networks each byte is sent in this order (left to right):

Transmit Character = Start Bit + Data Byte + Parity Bit + 1 Stop Bit (11 bits total):

|  | Least Significant Bit (LSB) |  |  |  |  |  |  | Most Significant Bit (MSB) |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| Start | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Parity | Stop |

Transmit Character = Start Bit + Data Byte + 2 Stop Bits (11 bits total):

|  | Least Significant Bit (LSB) |  |  |  |  |  |  | Most Significant Bit (MSB) |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| Start | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Stop | Stop |

Transmit Character = Start Bit + Data Byte + 1 Stop Bit (10 bits total):

|  | Least Significant Bit (LSB) |  |  |  |  |  |  | Most Significant Bit (MSB) |  |
|---|---|---|---|---|---|---|---|---|---|
| Start | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Stop |

The master is configured by the user to wait for a predetermined timeout interval. The master will wait for this period of time before deciding that the slave is not going to respond and that the transaction should be aborted. Care must be taken when determining

the timeout period from both the master and the slaves' specifications. The slave may define the 'response time' as being the period from the receipt of the last bit of the query to the transmission of the first bit of the response. The master may define the 'response time' as period between transmitting the first bit of the query to the receipt of the last bit of the response. It can be seen that message transmission time, which is a function of the baud rate, must be included in the timeout calculation.
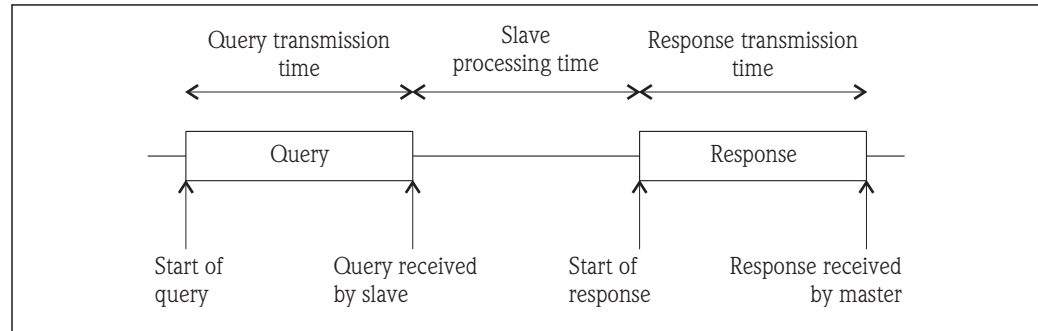


*☒ 12    Modbus data transmission*

### 11.4.5    Error checking methods

Standard Modbus protocol serial networks use two error checking processes, the error check bytes mentioned above check message integrity whilst Parity checking (even or odd) can be applied to each byte in the message.

**Parity checking**

If parity checking is enabled – by selecting either Even or Odd Parity - the quantity of "1's" will be counted in the data portion of each transmit character. The parity bit will then be set to a 0 or 1 to result in an Even or Odd total of "1's".

Note that parity checking can only detect an error if an odd number of bits are picked up or dropped in a transmit character during transmission, if for example two 1's are corrupted to 0's the parity check will not find the error. If No Parity checking is specified, no parity bit is transmitted and no parity check can be made. Also, if No Parity checking is specified and one stop bit is selected the transmit character is effectively shortened by one bit.

**CRC checking**

The error check bytes of the Modbus Protocol messages contain a Cyclical Redundancy Check (CRC) value that is used to check the content of the entire message. The error check bytes must always be present to comply with the Modbus Protocol, there is no option to disable it. The error check bytes represent a 16-bit binary value, calculated by the transmitting device. The receiving device must recalculate the CRC during receipt of the message and compare the calculated value to the value received in the error check bytes. If the two values are not equal, the message should be discarded.

The error check calculation is started by first pre-loading a 16-bit register to all 1's (i.e. Hex (FFFF)) each successive 8-bit byte of the message is applied to the current contents of the register.

> ℹ️ Only the eight bits of data in each transmit character are used for generating the CRC, start bits, stop bits and the parity bit, if one is used, are not included in the error check bytes. During generation of the error check bytes, each 8-bit message byte is exclusive OR'ed with the lower half of the 16 bit register.

The register is then shifted eight times in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. After each shift the LSB prior to the shift is extracted and examined. If the LSB was a 1, the register is then exclusive OR'ed with a pre-set, fixed value. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until all eight shifts have been performed. After the last shift, the next 8-bit message byte is exclusive OR'ed with the lower half of the 16 bit register, and the process repeated. The final contents of the register, after all the bytes of the message have been applied, is the error check value. In the following pseudo code "ErrorWord" is a 16-bit value representing the error check values.

```
BEGIN
        ErrorWord = Hex (FFFF)
        FOR Each byte in message
                ErrorWord = ErrorWord XOR byte in message
                FOR Each bit in byte
                        LSB = ErrorWord AND Hex (0001)
                        IF LSB = 1 THEN ErrorWord = ErrorWord – 1
                        ErrorWord = ErrorWord / 2
                        IF LSB = 1 THEN ErrorWord = ErrorWord XOR Hex (A001)
                NEXT bit in byte
        NEXT Byte in message
END
```

### 11.4.6  Function codes

The function code part of a Modbus Protocol message defines the action to be taken by the slave. EngyVolt devices support the following function codes:

| Code | Modbus protocol name | Description |
|------|---------------------|-------------|
| 03 | Read Holding Registers | Read the contents of read/write location (4X references). |
| 04 | Read Input Registers | Read the contents of read only location (3X references). |
| 08 | Diagnostics | Only sub-function zero is supported. This returns the data element of the query unchanged. |
| 16 | Pre-set Multiple Registers | Set the contents of read/write location (4X references). |

### 11.4.7  IEEE floating point format

The Modbus Protocol defines 16 bit "Registers" for the data variables. A 16-bit number would prove too restrictive, for energy parameters for example, as the maximum range of a 16-bit number is 65535. However, there are a number of approaches that have been adopted to overcome this restriction. Integra Digital meters use two consecutive registers to represent a floating-point number, effectively expanding the range to $\pm 1 \times 10^{37}$.

The values produced by EngyVolt devices can be used directly without any requirement to "scale" the values, for example, the units for the voltage parameters are volts, the units for the power parameters are watts etc.

#### What is a floating point number?

A floating-point number is a number with two parts, a mantissa and an exponent and is written in the form $1.234 \times 10^5$. The mantissa (1.234 in this example) must have the decimal point moved to the right with the number of places determined by the exponent (5 places in this example) i.e. $1.234 \times 10^5 = 123\,400$.

If the exponent is negative the decimal point is moved to the left.

#### What is an IEEE 754 format floating-point number?

An IEEE 754 floating point number is the binary equivalent of the decimal floating-point number shown above. The major difference being that the most significant bit of the

mantissa is always arranged to be 1 and is thus not needed in the representation of the number. The process by which the most significant bit is arranged to be 1 is called normalisation, the mantissa is thus referred to as a "normal mantissa". During normalisation the bits in the mantissa are shifted to the left whilst the exponent is decremented until the most significant bit of the mantissa is one. In the special case where the number is zero both mantissa and exponent are zero. The bits in an IEEE 754 format have the following significance:

| Data Hi Reg, Hi Byte. | Data Hi Reg, Lo Byte. | Data Lo Reg, Hi Byte. | Data Lo Reg, Lo Byte. |
|---|---|---|---|
| SEEE EEEE | EMMM MMMM | MMMM MMMM | MMMM MMMM |

Where:

S = represents the sign bit where 1 is negative and 0 is positive

E = is the 8-bit exponent with an offset of 127 i.e. an exponent of zero is represented by 127, an exponent of 1 by 128 etc.

M = the 23-bit normal mantissa. The 24th bit is always 1 and, therefore, is not stored.

Using the above format the floating point number 240.5 is represented as 43708000 hex:

| Data Hi Reg, Hi Byte. | Data Hi Reg, Lo Byte. | Data Lo Reg, Hi Byte. | Data Lo Reg, Lo Byte. |
|---|---|---|---|
| 43 | 70 | 80 | 00 |

The following example demonstrates how to convert IEEE 754 floating-point numbers from their hexadecimal form to decimal form. For this example, we will use the value for 240.5240.5 shown above.

ℹ️ The floating-point storage representation is not an intuitive format. To convert this value to decimal, the bits should be separated as specified in the floating-point number storage format table shown above.

For example:

| Data Hi Reg, Hi Byte. | Data Hi Reg, Lo Byte. | Data Lo Reg, Hi Byte. | Data Lo Reg, Lo Byte. |
|---|---|---|---|
| 0100→0011 | 0111→0000 | 1000→0000 | 0000→0000 |

From this you can determine the following information.

- The sign bit is 0, indicating a positive number.
- • The exponent value is 10000110 binary or 134 decimal. Subtracting 127 from 134 leaves 7, which is the actual exponent.
- • The mantissa appears as the binary number 11100001000000000000000

There is an implied binary point at the left of the mantissa that is always preceded by a 1. This bit is not stored in the hexadecimal representation of the floating-point number. Adding 1 and the binary point to the beginning of the mantissa gives the following: 1.11100001000000000000000

Now, we adjust the mantissa for the exponent. A negative exponent moves the binary point to the left. A positive exponent moves the binary point to the right. Because the exponent is 7, the mantissa is adjusted as follows: 11110000.1000000000000000.

Finally, we have a binary floating-point number.

Binary bits that are to the left of the binary point represent the power of two corresponding to their position. The result is the following decimal value:

$.11110000 = (1 \times 2^7) + (1 \times 2^6) + (1 \times 2^5) + (1 \times 2^4) + (0 \times 2^3) + (0 \times 2^2) + (0 \times 2^1) + (0 \times 2^0) = 240$

Binary bits that are to the right of the binary point also represent a power of 2 corresponding to their position. As the digits are to the right of the binary point the powers are negative. For example: .100... = $(1 \times 2^{-1}) + (0 \times 2^{-2}) + (0 \times 2^{-3}) + ... = 0.5$

Adding these two numbers together and making reference to the sign bit produces the number +240.5.

For each floating point value requested two Modbus Protocol registers (four bytes) must be requested. The received order and significance of these four bytes for EbgyVolt devices is shown below:

| Data Hi Reg, Hi Byte. | Data Hi Reg, Lo Byte. | Data Lo Reg, Hi Byte. | Data Lo Reg, Lo Byte. |
|---|---|---|---|

### 11.4.8    Modbus commands supported

All EngyVolt devices support the "Read Input Register" (3X registers), the "Read Holding Register" (4X registers) and the "Pre-set Multiple Registers" (write 4X registers) commands of the MODBUS Protocol RTU protocol. All values stored and returned are in floating point format to IEEE 754 with the most significant register first.

**Read input registers**

MODBUS Protocol code 04 reads the contents of the 3X registers.

Example: The following query will request 'Volts 1' from an instrument with node address 1:

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 04 |
| Starting address High | 00 |
| Starting address Low | 00 |
| Number of points High | 00 |
| Number of points Low | 02 |
| Error check Low | 71 |
| Error check High | CB |

Data must be requested in register pairs i.e. the "Starting Address" and the "Number of Points" must be even numbers to request a floating point variable. If the "Starting Address" or the "Number of points" is odd then the query will fall in the middle of a floating point variable the product will return an error message.

The following response returns the contents of Volts 1 as 230.2.

But see also "Exception Response" later.

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 04 |
| Byte count | 04 |
| Data, High Reg, High Byte | 43 |
| Data, High Reg, Low Byte | 66 |
| Data, Low Reg, High Byte | 33 |
| Data, Low Reg, Low Byte | 34 |

| Field name | Example (Hex) |
|---|---|
| Error check Low | 1B |
| Erorr check High | 38 |

### 11.4.9 Holding registers

**Read holding registers**

MODBUS Protocol code 03 reads the contents of the 4X registers.

Example: The following query will request the prevailing 'Demand Time':

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 03 |
| Starting address High | 00 |
| Starting address Low | 00 |
| Number of points High | 00 |
| Number of points Low | 02 |
| Error check Low | C4 |
| Error check High | 0B |

ℹ️ Data must be requested in register pairs i.e. the "Starting Address" and the "Number of Points" must be even numbers to request a floating point variable. If the "Starting Address" or the "Number of points" is odd then the query will fall in the middle of a floating point variable the product will return an error message.

The following response returns the contents of Demand Time as 1, But see also "Exception Response" later.

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 03 |
| Byte count | 04 |
| Data, High Reg, High Byte | 3F |
| Data, High Reg, Low Byte | 80 |
| Data, Low Reg, High Byte | 00 |
| Data, Low Reg, Low Byte | 00 |
| Error check Low | F7 |
| Error check High | CF |

**Write holding registers**

MODBUS Protocol code 10 (16 decimal) writes the contents of the 4X registers.

The following query will set the Demand Period to 60, which effectively resets the Demand Time:

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 10 |

| Field name | Example (Hex) |
|---|---|
| Starting address High | 00 |
| Starting address Low | 00 |
| Number of registers High | 00 |
| Number of registers Low | 02 |
| Byte count | 04 |
| Data, High Reg, High Byte | 00 |
| Data, High Reg, Low Byte | 00 |
| Data, Low Reg, High Byte | 00 |
| Data, Low Reg, Low Byte | 00 |
| Error check Low | F2 |
| Error check High | AF |

Data must be written in register pairs i.e. the "Starting Address" and the "Number of Points" must be even numbers to write a floating point variable. If the "Starting Address" or the "Number of points" is odd then the query will fall in the middle of a floating point variable the product will return an error message.

In general only one floating point value can be written per query.

The following response indicates that the write has been successful. But see also "Exception Response" later.

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 10 |
| Starting address High | 00 |
| Starting address Low | 00 |
| Number of registers High | 00 |
| Number of registers Low | 02 |
| Error check Low | 41 |
| Error check High | C8 |

### 11.4.10  Exception response

If the slave in the "Write Holding Register" example above, did not support that function then it would have replied with an Exception Response as shown below. The exception function code is the original function code from the query with the MSB set i.e. it has had 80 hex logically OR'ed with it. The exception code indicates the reason for the exception. The slave will not respond at all if there is an error with the parity or CRC of the query. However, if the slave can not process the query then it will respond with an exception. In this case a code 01, the requested function is not support by this slave.

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 10 OR 80 = 90 |
| Exception code | 01 |
| Error check Low | 8D |
| Error check High | C0 |

### 11.4.11 Exception codes

**Table of exception codes**

| Exception code | Modbus protocol name | Description |
|---|---|---|
| 01 | Illegal function | The function code is not supported by the product. |
| 02 | Illegal data address | Attempt to access an invalid address or an attempt to read or write part of a floating point value. |
| 03 | Illegal data value | Attempt to set a floating point variable to an invalid value. |
| 05 | Slave device failure | An error occurred when the instrument attempted to store an update to its configuration. |

### 11.4.12 Diagnostics

MODBUS Protocol code 08 provides a number of diagnostic sub-functions. Only the "Return Query Data" sub-function (sub-function 0) is supported on EngyVolt devices.

**Example:**

The following query will send a diagnostic "return query data" query with the data elements set to Hex(AA) and Hex(55) and will expect these to be returned in the response:

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 08 |
| Sub-function High | 00 |
| Sub-function Low | 00 |
| Data byte 1 | AA |
| Data byte 2 | 55 |
| Error check Low | 5E |
| Error check High | 94 |

Exactly one register of data (two bytes) must be sent with this function.

The following response indicates the correct reply to the query, i.e. the same bytes as the query.

| Field name | Example (Hex) |
|---|---|
| Slave address | 01 |
| Function | 08 |
| Sub-function High | 00 |
| Sub-function Low | 00 |
| Data byte 1 | AA |
| Data byte 2 | 55 |
| Error check Low | 5E |
| Error check High | 94 |

## 11.5    RS485 Implementation of Johnson Controls Metasys

These notes briefly explain Metasys and EngyVolt device integration. Use these notes with the Metasys Technical Manual, which provides information on installing and commissioning Metasys N2 Vendor devices.

### 11.5.1    Application details

The EngyVolt multifunctional electrical energy meter is an N2 Vendor device that connects directly with the Metasys N2 Bus. This implementation assigns key electrical parameters to ADF points, each with override capability.

Components requirements:
- EngyVolt device with RS485 card and N2 port available.
- N2 bus cable

**Metasys release requirements**

- Metasys Software Release 12.04 or later
- NCM-361-8 or Metasys Extended Architecture NAE35,NAE45,NAE55

EngyVolt devices may be compatible with earlier releases of N2 software, but Johnson Controls only supports integration issues on the above.

**Support for Metasys integration**

Please contact the nearest Jonson Controls Energy Efficency or Johnson Controls System & Services representative. The address can be found on the Johnson Controls website.

**Design considerations**

When integrating the EngyVolt device equipment into a Metasys Network, keep the following considerations in mind.

Make sure all EngyVolt device equipment is set up, started and running properly before attempting to integrate with the Metasys Network.

A maximum of 32 devices can be connected to any one NCM N2 Bus segment, or up to 100 devices if repeaters are used.

From the instrument set-up screen, the Coms option must be set to N2, then the address set to the required value. All port settings will then be set automatically, see below.

| Device address | 1 to 255 |
|---|---|
| Port set up: | |
| Baud rate [1] | 9600 |
| Duplex | Half |
| Word length | 8 |
| Stop bits [1] | 1 |
| Parity [1] | no |
| Interface | RS485 |

1)    The user has to make sure that the values given are set up in the EngyVolt device in order to ensure compatibility with the N2 protocol network.

## 11.5.2  EngyVolt Metasys N2 point mapping table

| Name | Description | Unit | ADF point |
|------|-------------|------|-----------|
| V1 | Phase 1 line to neutral volts | V | 1 |
| V2 | Phase 2 line to neutral volts | V | 2 |
| V3 | Phase 3 line to neutral volts | V | 3 |
| A1 | Phase 1 current | A | 4 |
| A2 | Phase 2 current | A | 5 |
| A3 | Phase 3 current | A | 6 |
| KP1 | Phase 1 power | kW | 7 |
| KP2 | Phase 2 power | kW | 8 |
| KP3 | Phase 3 power | kW | 9 |
| KVA1 | Phase 1 volt amps | kVA | 10 |
| KVA2 | Phase 2 volt amps | kVA | 11 |
| KVA3 | Phase 3 volt amps | kVA | 12 |
| KVAR1 | Phase 1 volt amps reactive | kvar | 13 |
| KVAR2 | Phase 2 volt amps reactive | kvar | 14 |
| KVAR3 | Phase 3 volt amps reactive | kvar | 15 |
| PF1 | Phase 1 power factor | - | 16 |
| PF2 | Phase 2 power factor | - | 17 |
| PF3 | Phase 3 power factor | - | 18 |
| PA1 | Phase 1 phase angle | Degrees | 19 |
| PA2 | Phase 2 phase angle | Degrees | 20 |
| PA3 | Phase 3 phase angle | Degrees | 21 |
| AN | Neutral current | A | 22 |
| V12 | Line voltage P1-P2 | V | 23 |
| V23 | Line voltage P2-P3 | V | 24 |
| V31 | Line voltage P3-P1 | V | 25 |
| VLNAVG | Average line to neutral volts | V | 26 |
| AAVG | Average current | A | 27 |
| ASUM | Total system current THD V3 | A | 28 |
| VLLAVG | Average line voltage | V | 29 |
| KPSUM | Total system power | kW | 30 |
| KVASUM | Total system volt amps | kVA | 31 |
| KVARSUM | Total system Var | kvar | 32 |
| PFTOT | Total system power factor | - | 33 |
| PATOT | Total system phase angle | Degrees | 34 |
| FREQ | Frequency | Hz | 35 |
| LO_EGY_IMP_POW* | Imported Wh, lower value | 0.1 kWh | 36 |
| HI_EGY_IMP_POW* | Imported Wh, higher value | 100 MWh | 37 |
| LO_EGY_EXP_POW* | Exported Wh, lower value | 0.1 kWh | 38 |
| * The values represented refer to the prefix "k" for energy values. For prefix "M" they are larger by factor 1000. | | | |

| Name | Description | Unit | ADF point |
|---|---|---|---|
| HI_EGY_EXP_POW* | Exported Wh, higher value | 100 MWh | 39 |
| LO_EGY_IMP_VAR* | Imported Varh, lower value | 0.1 kvarh | 40 |
| HI_EGY_IMP_VAR* | Imported Varh, higher value | 100 Mvarh | 41 |
| LO_EGY_EXP_VAR* | Exported Varh, lower value | 0.1 kvarh | 42 |
| HI_EGY_EXP_VAR* | Exported Varh, higher value | 100 Mvarh | 43 |
| LO_EGY_VA* | VAh, lower value | 0.1 kVAh | 44 |
| HI_EGY_VA* | VAh, higher value | 100 MVAh | 45 |
| LO_EGY_AMP* | Ah, lower value | 0.1 Ah | 46 |
| HI_EGY_AMP* | Ah, higher value | 100 kAh | 47 |
| KPSUM_DMD | Total system power demand | kW | 48 |
| KPSUM_MAX_DMD | Maximum total system power demand | kW | 49 |
| KVASUM_DMD | Maximum total system power demand | kVA | 50 |
| KVASUM_MAX_DMD | Maximum total system VA demand | kVA | 51 |
| A1_DMD | Phase 1 current demand | A | 52 |
| A1_MAX_DMD | Maximum phase 1 current demand | A | 53 |
| A2_DMD | Phase 2 current demand | A | 54 |
| A2_MAX_DMD | Maximum phase 2 current demand | A | 55 |
| A3_DMD | Phase 3 current demand | A | 56 |
| A3_MAX_DMD | Maximum phase 1 current demand | A | 57 |
| AN_DMD | Neutral current demand | A | 58 |
| AN_MAX_DMD | Maximum neutral current demand | A | 59 |
| V1_THD | Line 1 to neutral volts THD | % | 60 |
| V2_THD | Line 2 to neutral volts THD | % | 61 |
| V3_THD | Line 3 to neutral volts THD | % | 62 |
| VLNAVG_THD | Line to neutral volts THD average | % | 63 |
| V12_THD | Line 1 to line 2 volts THD | % | 64 |
| V23_THD | Line 2 to line 3 volts THD | % | 65 |
| V31_THD | Line 3 to line 1 volts THD | % | 66 |
| VLLAVG_THD | Line to line volts THD average | % | 67 |
| A1_THD | Phase 1 Current THD | % | 68 |
| A2_THD | Phase 2 Current THD | % | 69 |
| A3_THD | Phase 3 Current THD | % | 70 |
| AAVG_THD | Phase Current THD average | % | 71 |
| RESET | Reset | - | 72 |
| * The values represented refer to the prefix "k" for energy values. For prefix "M" they are larger by factor 1000. | | | |

In order to generate a reset, write the following values to the register "RESET".

| Reset | Write |
|---|---|
| All energy values (electrical energy values) | 1011 |
| All demand average / maximum values | 1012 |
| Demand time base | 1013 |

ADF points are one-based in the JCI compliance test software but zero-based on the network.

# Index

## S

## T

## W

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