

ONSET

Onset EG4xxx Configuration Guide

(for firmware v3.1 or newer)

Onset Computer Corp
470 MacArthur Blvd
Bourne, MA 02532

<http://www.onsetcomp.com>
800-564-4377
loggerhelp@onsetcomp.com

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1 Overview

This guide explains how to configure the Onset meter so it properly reflects the physical reality of an installation. There are three sections to this guide: the first is a brief introduction to the web pages used to configure the Onset meter, the second is the main section and consists of a list of examples reflecting common installation scenarios. The third section contains tips on how to fix up installation mistakes through the web configuration rather than having to go out to a site and correct the physical mistake.

Onset establishes a few basic rules. Following these rules is not strictly required, but they help to keep things straight and properly working:

1. The direction in which the Current Transformers (CTs) point matters. **The white sticker on the CTs should always point towards the entity being measured.** For example, towards the utility when measuring power from the power grid, towards the inverter for solar and/or wind generators, towards appliances when measuring loads, or towards the panels when measuring subpanels.
2. Power readings that are **positive** numbers indicate that power is being delivered **from the entity being measured** whereas **negative** numbers indicate power being delivered **to the entity**. For example, when a solar system produces more power than a site uses, the excess power is delivered back into the grid. In this case, the power reading for the grid will be negative, since the grid is consuming the excess power.

To configure the meter, start a compatible browser on a computer and connect to the device's web page. See the Owner's Manual for details on how to do that. Once connected to the device, click on the "LAN Access" link in the top-right of the page. This redirects the browser to a page ensuring a direct LAN connection to the device. If the page does not load, you will not be able to make changes to the device settings, unless remote administration is enabled. Please contact Onset technical support for details on how to enable that. Once the page has loaded, click on the "Settings" link in the top-right of the page, then click on "Installation" in the navigation-bar on the left of the new page.

As illustrated in Figure 1, the Installation page has five sections:

1. Potential Transformers (PTs)
2. Current Transformers (CTs)
3. Remote Devices
4. Registers
5. Totals and Virtual Registers

We describe the purpose of each section in more detail below.

After any of the settings have been changed, they need to be saved by clicking on the "Save" button near the bottom of the page. When doing that for the first time, you may be prompted for authorization to make the changes. You can enter "owner" as the user name. By default, the password is "default" (no quotes). If you receive an error stating you are not authorized to make changes, make sure to click on the "LAN Access" link in the top-right of the page.

To restore the settings which are currently active on the device, click on the "Reset" button. This will revert any changes you have made to the page since the last save.

Potential Transformers (PTs):

L1 L2 L3

Current Transformers (CTs):

Use high-gain mode

CT1	<input 400a"="" type="text" value="JD JS 36mm/1.42"/>	<input type="text" value="x1"/>	CT2	<input 400a"="" type="text" value="JD JS 36mm/1.42"/>	<input type="text" value="x1"/>	CT3	<input 400a"="" type="text" value="JD JS 36mm/1.42"/>	<input type="text" value="x1"/>
CT4	<input 100a"="" type="text" value="JD JS 16mm/0.63"/>	<input type="text" value="x1"/>	CT5	<input 100a"="" type="text" value="JD JS 16mm/0.63"/>	<input type="text" value="x1"/>	CT6	<input type="text"/>	<input type="text"/>
CT7	<input type="text"/>	<input type="text"/>	CT8	<input type="text"/>	<input type="text"/>	CT9	<input type="text"/>	<input type="text"/>
CT10	<input type="text"/>	<input type="text"/>	CT11	<input type="text"/>	<input type="text"/>	CT12	<input type="text"/>	<input type="text"/>
CT13	<input type="text"/>	<input type="text"/>	CT14	<input type="text"/>	<input type="text"/>	CT15	<input type="text"/>	<input type="text"/>

Remote Devices:

Device name: Protocol: Device address:

Registers (5 of 64 in use):

Name:	Recorded value/formula:	
Main Panel (3 phase)	<input type="text" value="x"/> = <input type="text" value="P"/> =	<input type="text" value="CT1"/> <input type="text" value="x"/> <input type="text" value="L1"/> <input type="text" value="x"/> + <input type="text" value="CT2"/> <input type="text" value="x"/> <input type="text" value="L2"/> <input type="text" value="x"/> + <input type="text" value="CT3"/> <input type="text" value="x"/> <input type="text" value="L3"/> <input type="text" value="x"/>
Subpanel (single phase)	<input type="text" value="x"/> = <input type="text" value="P"/> =	<input type="text" value="CT4"/> <input type="text" value="x"/> <input type="text" value="L1"/> <input type="text" value="x"/> + <input type="text" value="CT5"/> <input type="text" value="x"/> <input type="text" value="L2"/> <input type="text" value="x"/>
CT1 Amperage	<input type="text" value="x"/> = <input type="text" value="I"/> <input type="text" value="x"/>	<input type="text" value="CT1"/>
L1 Voltage	<input type="text" value="x"/> = <input type="text" value="V"/> <input type="text" value="x"/>	<input type="text" value="L1"/>
L1 Frequency	<input type="text" value="x"/> = <input type="text" value="F"/> <input type="text" value="x"/>	<input type="text" value="L1"/>

Totals and Virtual Registers:

Usage	= +	<input type="text" value="Main Panel (3 phase)"/>	<input type="button" value="Add Register"/>
Generation	=		<input type="button" value="Add Register"/>

Figure 1: Example of meter Installation-Settings Page

1.1 Potential Transformer (PT) Configuration

This section is used to inform the device of any potential-transformers (PTs) that may be installed. Usually, no PTs are installed and the settings here can be left at the default value of “direct (no PT)”.

1.2 Current Transformer (CT) Configuration

This section defines what kind of current-transformer (CT) is connected to each of the CT positions. A blank entry indicates that no CT is connected. When a CT is connected to the device, simply select the appropriate CT selection from the pull-down list for the position the CT is plugged into. For example, if a 100A 0.94" J&D split-core CT is plugged into CT position 2, click on the pull-down list for CT2 and select "JD JS 24mm/0.94" 100A".

The format of the CT drop-down option is "[MFG] [MODEL] [SIZE_MM] / [SIZE_IN] [AMPERAGE]"

[MFG]	2-letter manufacturer code (see table 1)
[MODEL]	CT Model (see table 2)
[SIZE_MM]	Inner-diameter in millimeters
[SIZE_IN]	Inner-diameter in inches
[AMPERAGE]	Amperage rating of CT (not breaker amperage)

MFG code	Manufacturer
JD	J&D
CC	Continental Control Systems
ML	Magnelab
AE	AccuEnergy
CR	CR Magnetics

Table 1: CT manufacturer code description

MODEL	Description
JS	Split-core CT
JRFS	Rogowski coil (rope CT)
ACT	High accuracy split-core CT
SCT	Split-core CT
RCT	Rogowski coil (rope CT)
CR	Solid-core DC CT
CRS	Split-core DC CT

Table 2: CT model description

A multiplicative scale can be applied to the CT reading by entering a positive number greater than 0 to the box right of the CT pull-down option. This is generally used if a single CT is measuring one set of parallel feeds of the same phase.

WARNING: in many cases, parallel feeds are not perfectly balanced, and could have significant differences. Because of this, we suggest monitoring each conductor, either by using a CT for each individual conductor, or by using larger diameter CTs to encompass multiple parallel feeds (of the same phase).

1.2.1 High-gain mode

Available on EG4xxx models, High-gain mode amplifies the signal to the meter CT ports by 10 times. This allows, for example, a 100A CT to act as a 10A CT. High-gain mode affects **all CT inputs**. Note, selecting high-gain mode immediately changes the CT drop-down option to its respective lower amperage-rated value. For example, enabling high-gain mode with a 100A CT will change the drop-down option to indicate a 10A CT. Likewise, a CT configured for 75A will appear as a 7.5A CT.

1.2.2 Rope CTs (Rogowski Coils)

Self-powered rope CTs are wired directly to the meter with a green 2-pin power plug. Rope CTs are excellent for bus-bars and large switch-gear applications. Self-powered rope CTs are flexible and easy to install but will not be accurate at low amperages. Rope CTs are configured like split-core CTs. For example, the 4" AccuEnergy 106mm rope should be configured as `AE RCT 106mm/4.17" 2775A`.

Rope CTs should not be used to monitor solar arrays, as solar uses a large range of amperages, often insufficient for accurate monitoring with rope CTs when the inverter is in standby.

1.3 Remote Devices

EG4xxx can read data from Modbus TCP and RTU. For remote device configuration assistance, please contact Onset support.

1.4 Register Configuration

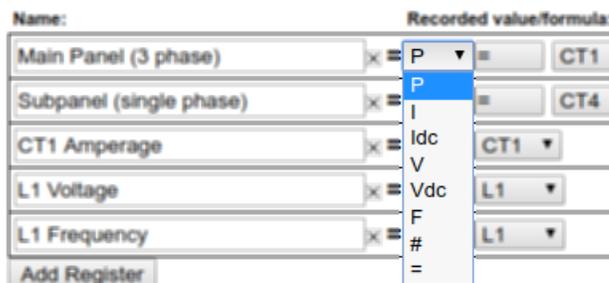
This section defines what data gets recorded in the internal database of the meter. Each register has a unique name that identifies what it is recording.

1.4.1 Register Name

Register names may contain any ASCII/UTF-8 characters except for control characters. With English characters, register-names can be up to 31 characters long.

1.4.2 Register Type

Each register can be configured to record one of several types of data. The type can be selected from the drop-down menu to the right of a register-name. In our example, the drop-down menu looks as follows:



The entries in this popup-menu have the following meaning:

- P:** Records the **power** calculated from one or more current/voltage-pairs.
- I:** Records the RMS **current** measured by one of the connected CTs.
- Idc:** Records the DC (mean) **current** measured by one of the connected CTs.

- v**: Records the RMS **voltage** measured by one of the connected line voltages.
- vdc**: Records the DC (mean) **voltage** measured by one of the connect CTs.
- F**: Records the **frequency** measured on one of the channel inputs (CTs or voltage lines).
- #**: This is a special debug register.
- =**: Formula register. Records the value obtained by evaluating the specified formula. See Section 1.4.4 for details.

In the example of Figure 1, we see five rows in the `Registers` section: the first two calculate power (P). We will discuss those in more detail in the next section.

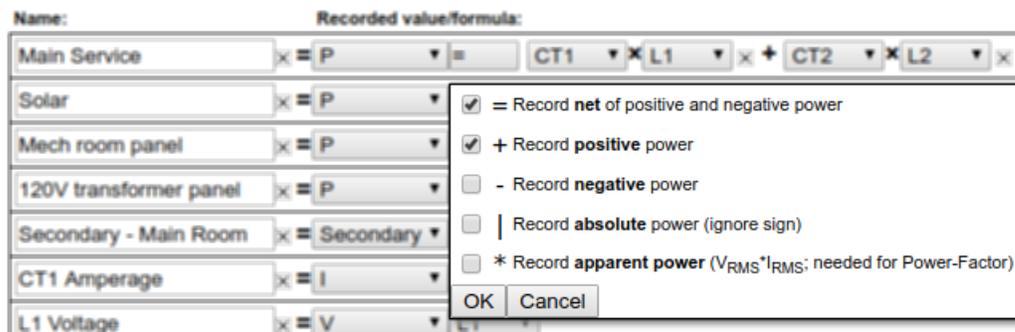
The third row is a register that records the current (I) of CT1, and the fourth records the voltage (V) of line voltage input L1. Lastly the fifth register records frequency (F) of line voltage input L1.

A register can be added by clicking on the “Add Register” button. An existing register can be deleted by clicking on the remove icon  to the right of the register name.

1.4.3 Recording Power

There are two parts to configuring a register to record power: first, the subtype(s) to be recorded need to be selected, second, the power-components that should be used to calculate the power need to be specified.

Power Subtypes The subtypes to record for a power register are selected by clicking on the subtype-selector button to the right of the register-type button. This will pop up the dialog shown below:



As shown here, there are five subtypes which can be recorded by turning on the corresponding checkbox:

- = (net)**: Checking this box ensures that the net flow of power is available as a register-value. The value of such a register increases when the calculated real power is positive and decreases when it is negative. This is equivalent to a utility’s net-meter, for example.
- + (positive-only)**: Checking this box ensures that a register-value is available that increases only when the calculated real power is positive. When the real power is negative, the register-value does not change. This can be used, for example, to record only the power generated by an inverter or only the power consumed from the utility.
- (negative-only)**: Checking this box ensures that a register-value is available that increases only when the calculated real power is negative. When the real power is positive, the register-value does not change. This can be used, for example, to record only the power consumed by an inverter when there is no sun or only the power fed back into the grid.

- | **(absolute):** Checking this box ensures that a register-value is available that counts independent of the sign of the calculated real power. That is, the register-value increases by the absolute value of the real power regardless of whether it is positive or negative. This is not often used.
- * **(apparent):** Checking this box ensures that apparent power is recorded in a register. Apparent power is the sum of the product of the RMS voltage and current of each power-component. As such, apparent power always has a non-negative value. This can be used, for example, to track the quality of the power as the ratio of apparent power and absolute real power is the power-factor.

When you are done selecting subtypes, click on the **OK** button to save the selection or on the **Cancel** button to revert to the previously existing configuration.

Power Components The power components define which currents and voltages are to be combined to calculate a register's power figure. In our example, the power components for the `Main Panel (3 phase)` and `Subpanel (single phase)` registers look as follows:

Name:	Recorded value/formula:	
Main Panel (3 phase)	<input type="checkbox"/> = P ▾ =	CT1 ▾ × L1 ▾ × + CT2 ▾ × L2 ▾ × + CT3 ▾ × L3 ▾ ×
Subpanel (single phase)	<input type="checkbox"/> = P ▾ =	CT4 ▾ × L1 ▾ × + CT5 ▾ × L2 ▾ ×

This shows that `Main Service (3 phase)` power is calculated as the product of the current measured by CT1 and the voltage measured on line L1 (e.g., black leg) plus the current measured by CT2 and the voltage measured on line L2 (e.g., red leg), plus the current measured by CT3 and the voltage measured on line L3 (e.g., blue leg).

The `Subpanel (single phase)` power is calculated from CT4 on L1, plus CT5 on L2.

To add a new power-component to a register, click on the “Add Component” button. To delete a component, click on the remove icon  to the right of the component.

1.4.4 Formula Registers

Formula registers are a powerful tool to record quantities that can be derived from other, directly-measured registers. For example register `Main Panel` measures the real power used at a site, then register `Main Panel*` would measure the apparent power used at the same site. To record the power-factor for the site, we would have to divide `Main Service` by `Main Service*` and take the absolute value. This can be accomplished by defining a formula register as shown below:

Main Panel	<input type="checkbox"/> = P ▾ = *	CT1 ▾ × L1 ▾ × + CT2 ▾ × L2 ▾ × + CT3
Main Panel Power Factor	<input type="checkbox"/> = ▾	number with 3 decimals ▾ abs("\$Main Panel"/"\$Main Panel*")

In this example, we named the register “Main Panel Power Factor” and selected the equal-sign (formula-register) as the register type (see Section 1.4.2). We set the unit type as “number with 3 decimals”. Finally, we entered a formula of `abs("$Main Panel"/"$Main Panel*")` for calculating the value of the register. Here, `$"regname"` is used to obtain the current (second-by-second) value of register `regname`, so `$"Main Service"` will evaluate to the current site-usage (in Watts) and `$"Main Service*"` evaluates

to the apparent power used by the site. The `abs()` function calculates the absolute value of the value passed to it (i.e., it's always positive).

An online-version of the function-list can be found in the `Help` section of the meter web-pages.

Several caveats apply to using formula registers:

- Do not reference a formula register from another formula register. The result can be unpredictable.
- Calculating formulas takes time. Do not overload the meter with unnecessary formula registers.
- All calculations are performed using single-precision IEEE-754 floating-point numbers. The final value of a formula register is then rounded to a 64-bit signed integer number.

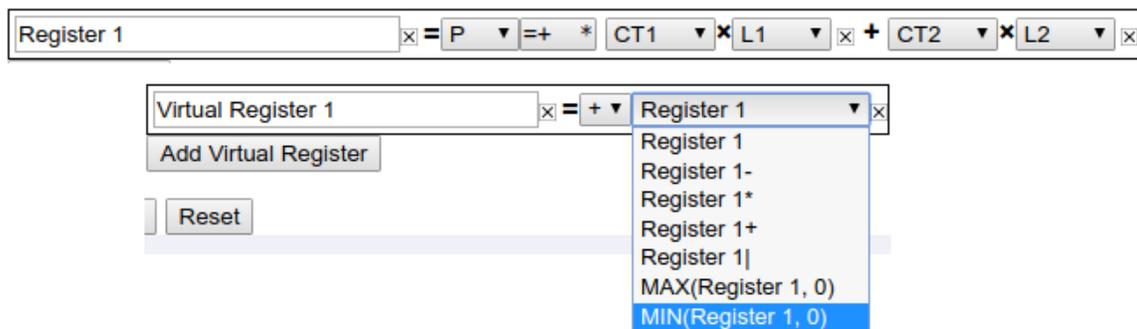
1.5 Totals and Virtual Registers Configuration

Virtual registers are calculated as a sum or difference of real (physical) registers. Virtual registers do not take up any space, and a virtual register can be added and removed in the same manner as physical registers.

A register is added by clicking on the `Add Register` button. A register can be removed by clicking on the remove icon  to the right of the register drop-down menu. You can select whether there register should be added to or subtracted from the virtual registers value by selecting `+` or `-` from the drop-down menu to the left of the register name, respectively.

Each power register will show up in several variations in the menu, namely with one variant for each selected subtype (see “Power Subtypes” in section 1.4.3 Recording Power). Positive-only registers end in a `'+'`, negative-only registers end in a `'-'`, absolute-registers end in a `'|'`, and apparent power registers end in a `'*'`. Net registers do not have an appended symbol and just appear as the register name.

In the image below, `Register 1` has net, positive-only, and apparent power subtypes selected, so the virtual register has choices for net, positive-only, negative-only, apparent power, and absolute (negative-only and absolute are calculated on-the-fly because both `'net'` and `'positive-only'` subtypes are chosen).



The menu also has entries of the form `MAX(reg, 0)` and `MIN(reg, 0)`. Those are for backwards compatibility with configurations created by older firmware and should no longer be used.

1.5.1 Totals

There are two special virtual registers called `Usage` and `Generation`. These are called *totals* and their value is used to represent *total site usage* and *total site generation*. In the dashboard graph, total usage is represented by a thick red line, and total generation is represented as a thick green line. The totals are always present (cannot be deleted), but if a site does not measure usage or if there is no site-local power generation, the respective total can be left blank.

1.5.2 Defining Views

Views can be used to define a restricted or alternate view of the data recorded by the meter. For example, views could be used to view the usage/generation data for an individual condo when a single meter is used to meter several condos.

A view is defined by pre-pending the view-name and a dot in front of a register name. In our example, the virtual-register rows shown below define a view called `A`:

A.Usage	x = + ▾	Mech room panel ▾	x	Add Register
A.Generation	x =			Add Register

With this setup, selecting view `A` in the dash-board will display register `Mech Room Panel` as the total site usage and nothing (zero) as the total site generation. That is, within a view, the register-names `Usage` and `Generation` serve as the totals for that view. You can define an arbitrary number of other register names within a view to display additional information in that view.

2 Configuration Examples

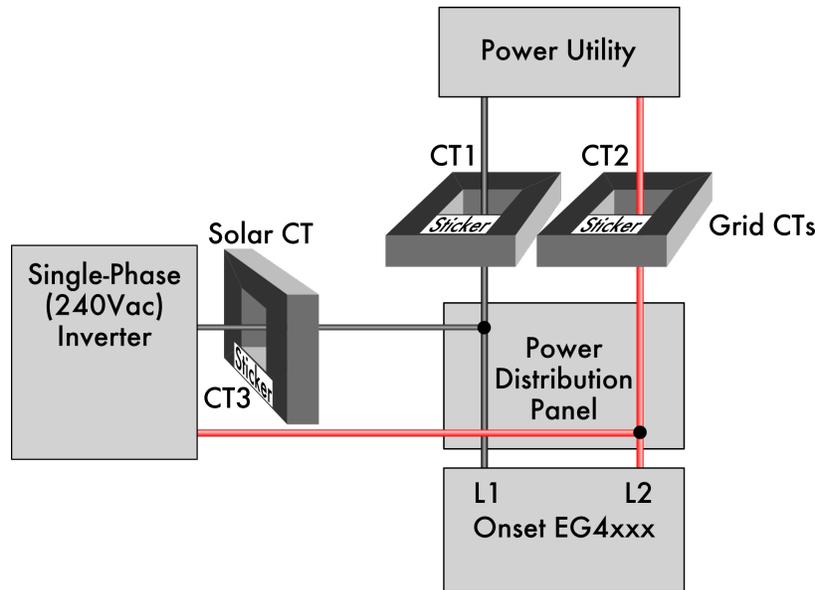
The following pages illustrate various common installation scenarios and matching configurations. For clarity, the diagrams have been simplified in the following manner:

- No circuit breakers are shown.
- The CT wires are not shown.
- The Neutral and Ground wiring is not shown.
- Most examples are partial configurations. For a complete system, the configurations from various examples may have to be combined.

Please review the Owner's Manual for detailed installation requirements. For safety, the meter always must be wired to a breaker and the breaker should be labeled "Onset Meter Disconnect."

2.1 Standard Split-Phase back-fed

Basic installation measuring power coming from a power utility (grid) and from a single-phase solar-system inverter.



Registers

$$\begin{aligned} \text{Grid} &= [\text{P}] [=] \text{CT1} \cdot \text{L1} + \text{CT2} \cdot \text{L2} \\ \text{Solar} &= [\text{P}] [=+] \text{CT3} \cdot \text{L1} + -\text{CT3} \cdot \text{L2} \end{aligned}$$

Totals and Virtual Registers

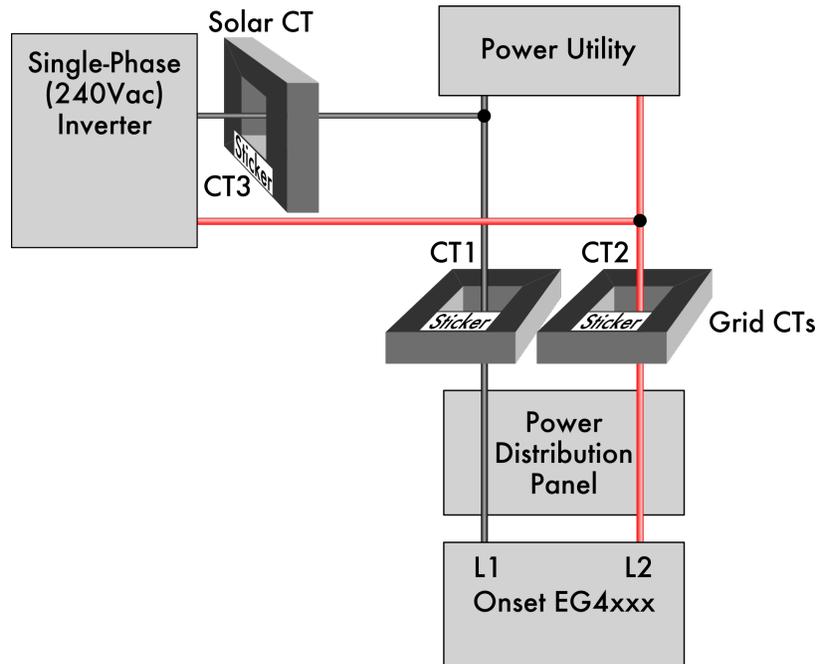
$$\begin{aligned} \text{Usage} &= \text{Grid} + \text{Solar} + \\ \text{Generation} &= \text{Solar} \end{aligned}$$

Notes:

- White stickers on CTs should point in the direction indicated in above diagram.
- Register definitions must be consistent with the wiring. CT1 and CT3 are on leg L1, so they must be multiplied by L1; CT2 is on leg L2, so it must be multiplied by L2.
- With single-phase inverter, the current flowing at any given instant on leg L2 is the negative of the current flowing on leg L1. Hence, rather than using a fourth CT, simply multiply the negated value of CT3 with L2 to calculate the power on that leg.
- The totaling rules indicate that total usage (consumption) is calculated as the sum of the power reported for register *Grid* and, the positive-only register *Solar+*. If the power reported for *Solar* is negative (indicating that the inverter is consuming power, e.g., during the night), then total usage is simply equal to the power reported for register *Grid*. It would be (slightly) wrong to define the *Usage* totaling rule as $\text{Grid} + \text{Solar}$ because in this case, the inverter's consumption would be canceled out of the usage, giving a lower than real consumption figure.

2.2 Direct-Feed Solar

Same as Standard Split-Phase installation, except that the inverter feeds directly into the power utility's grid. That is, the Solar CT is closer to the utility than the Grid CTs. This situation often arises when solar power is delivered via a line-side tap.



Registers

$$\begin{aligned} \text{Grid} &= [\text{P}] [=] \text{CT1} \cdot \text{L1} + \text{CT2} \cdot \text{L2} \\ \text{Solar} &= [\text{P}] [=] \text{CT3} \cdot \text{L1} + -\text{CT3} \cdot \text{L2} \end{aligned}$$

Totals and Virtual Registers

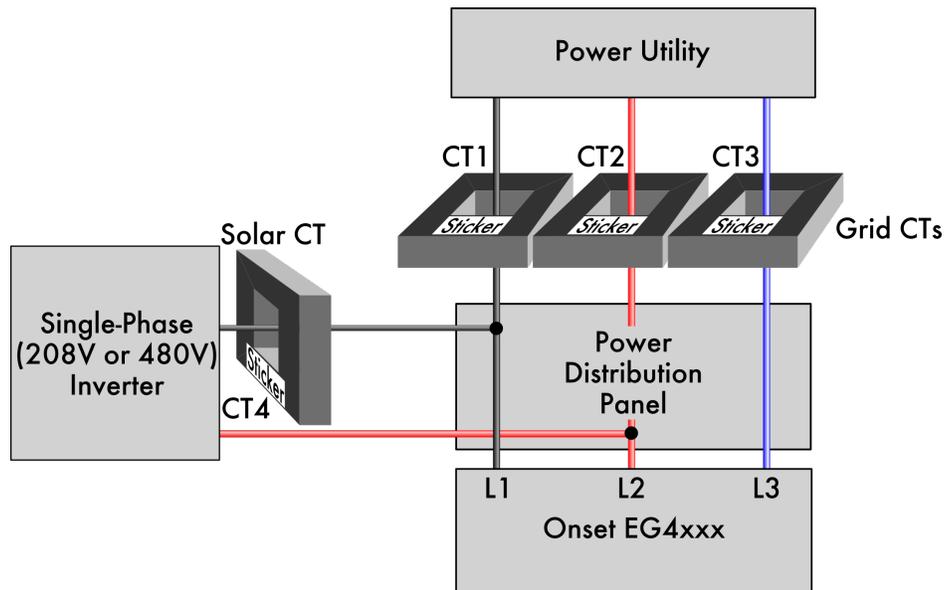
$$\begin{aligned} \text{Usage} &= \text{Grid} + \text{Solar} \\ \text{Generation} &= \text{Solar} \end{aligned}$$

Notes:

- The only difference compared to the standard installation is that `Solar+` was replaced by `Solar-` in the totaling rule for `Usage`. This is because the Grid CTs already capture total consumption, including any power coming from the solar system. The only exception is that when the inverter is consuming power (e.g., at night), that consumption is *not* captured by the Grid CTs. Adding `Solar-` corrects that because it will be equal to the amount of power consumed by the inverter, or zero when the inverter is producing power.

2.3 Three-Phase 120/208 or 277/480 Wye w/ single-phase inverter

Standard three-phase installation measuring power coming from a power utility (grid) and from a single-phase solar-system inverter. The color coding shows 120/208V, but applies to 277/480V as well. This diagram is for a Wye system with a neutral. Refer to delta diagrams for systems without neutral.



Registers

```
Grid    = [P] [= ] CT1*L1 + CT2*L2 + CT3*L3
Solar   = [P] [=+] CT4*L1 + -CT4*L2
```

Totals and Virtual Registers

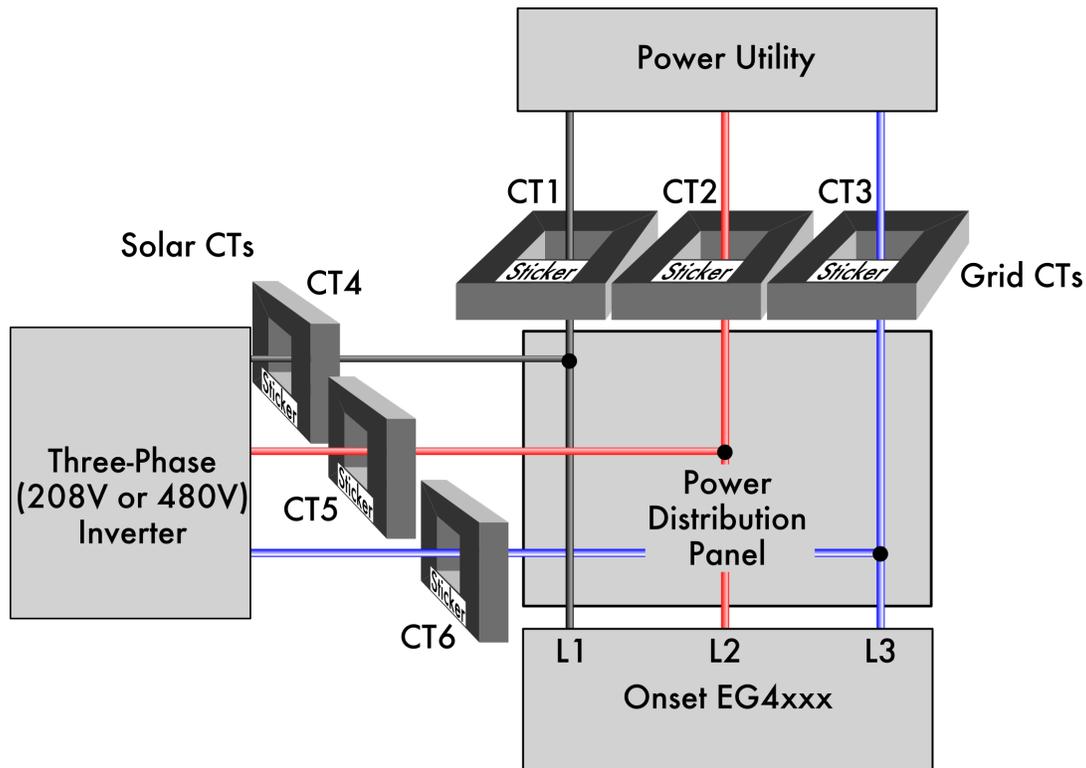
```
Usage      = Grid + Solar+
Generation = Solar
```

Notes:

- Three-phase installations are set up the same as split-phase systems, except that a third voltage-tap (L3) and a third Grid CT is required to measure power flow on phase 3.
- With multiple inverters, add one Solar CT per inverter and define a separate register for each inverter (e.g., `Solar 1` and `Solar 2`). Adjust the register definition according to the CT that is measuring the current and the phases that the inverter feeds onto. For example, CT5 measuring current onto L2 and also feeding onto L3: `Solar 2 = CT5*L2 + -CT5*L3`.
- If there are more than three single-phase inverters, it is more economical to measure the total solar output with one CT per phase.

2.4 Three-Phase 120/208 or 277/480 Wye w/ three-phase inverter

Standard three-phase installation measuring power coming from a power utility (grid) and from a three-phase solar-system inverter. The color coding shows 120/208V, but applies to 277/480V as well. This diagram is for a Wye system with a neutral. Refer to delta diagrams for systems without neutral.



Registers

```
Grid    = [P] [= ] CT1*L1 + CT2*L2 + CT3*L3
Solar   = [P] [=+] CT4*L1 + CT5*L2 + CT6*L3
```

Totals and Virtual Registers

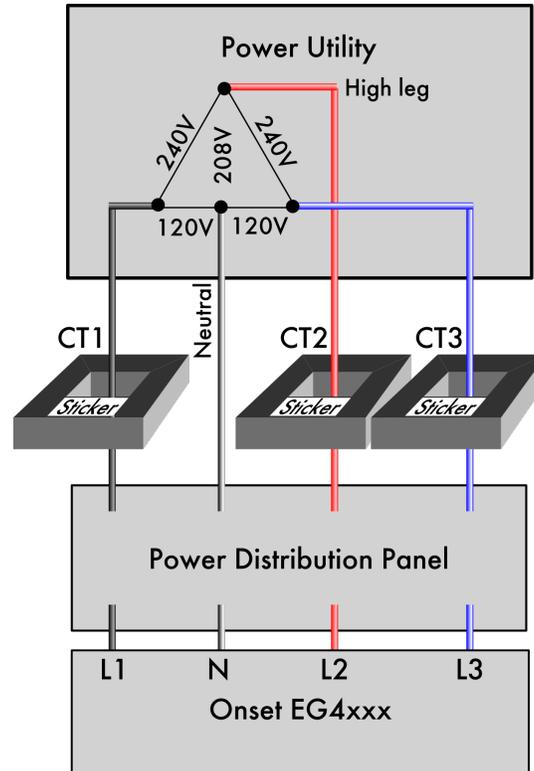
```
Usage      = Grid + Solar+
Generation = Solar
```

Notes:

- Three-phase inverter installations are the same as single-phase inverters on a three-phase system, but require a CT on each leg. Typically, even balanced three-phase inverters will not be balanced during the evening while in standby, so using a single CT may result in overnight generation or higher than actual inverter draw.

2.5 Three-Phase High-leg Delta

Three-phase high-leg delta installation measuring power coming from a power utility (grid).



Registers

$$\text{Grid} = [\text{P}] [=] \text{CT1} * \text{L1} + \text{CT2} * \text{L2} + \text{CT3} * \text{L3}$$

Totals and Virtual Registers

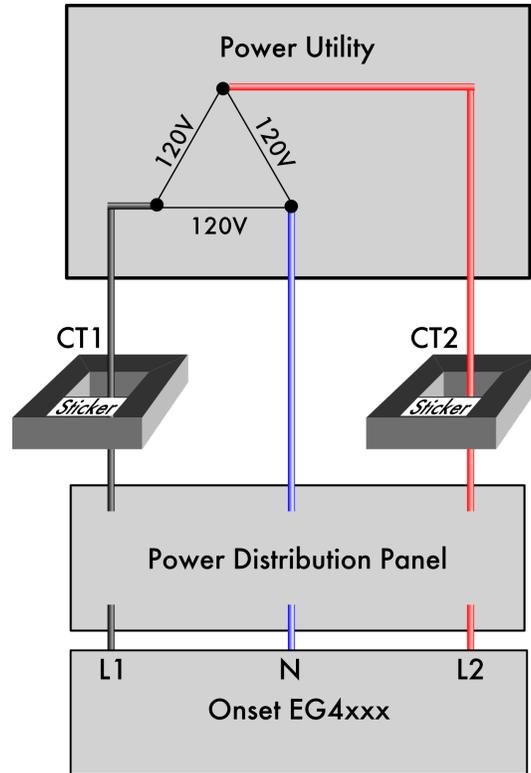
$$\text{Usage} = \text{Grid}$$

Notes:

- Wiring and configuration is identical to a standard three-phase site. The only difference is in the voltages measured on L1, L2, and L3:
 - L1 and L3 are 120Vac to neutral.
 - L2 is 208Vac to neutral.
- It does not matter whether the high-leg is wired to L1, L2, or L3, as long as all three phases are measured.

2.6 Three-Phase Delta

Three-phase delta installation measuring power coming from a power utility (grid).



Registers

$$\text{Grid} = [\text{P}] [=] \text{CT1} * \text{L1} + \text{CT2} * \text{L2}$$

Totals and Virtual Registers

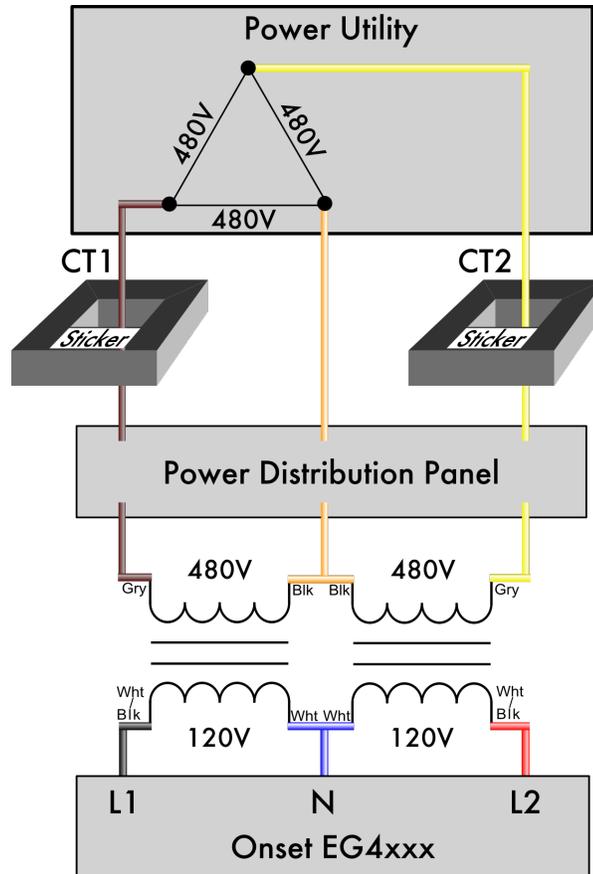
$$\text{Usage} = \text{Grid}$$

Notes:

- **CAUTION:** Since there is no neutral and none of the phases may be grounded, all conductive/metallic parts, including CT-plug screws and CT wiring should be considered live and hazardous!
- If one of the phases is grounded, wire that phase to the Neutral (N) pin on the meter.
- For best communication-performance, ensure that phases wired to L1 and N are the ones that are wired to the HomePlug adapter outlet.

2.7 Three-Phase Delta 480V

High-voltage (480V) three-phase delta installation measuring power coming from a power utility (grid).



Transformers:
 2x Functional Devices
 TR50VA008
 480V/120V 50VA

Gry: Grey wire (480Vac primary)
 Blk: Black wire (Comm primary)
 Wht/Blk: White + Black wire (120Vac secondary)
 Wht: White wire (Comm secondary)

Potential Transformers (PTs)

L1 = FDT-480-120
 L2 = FDT-480-120

Registers

Grid = [P] [=] CT1*L1 + CT2*L2

Totals and Virtual Registers

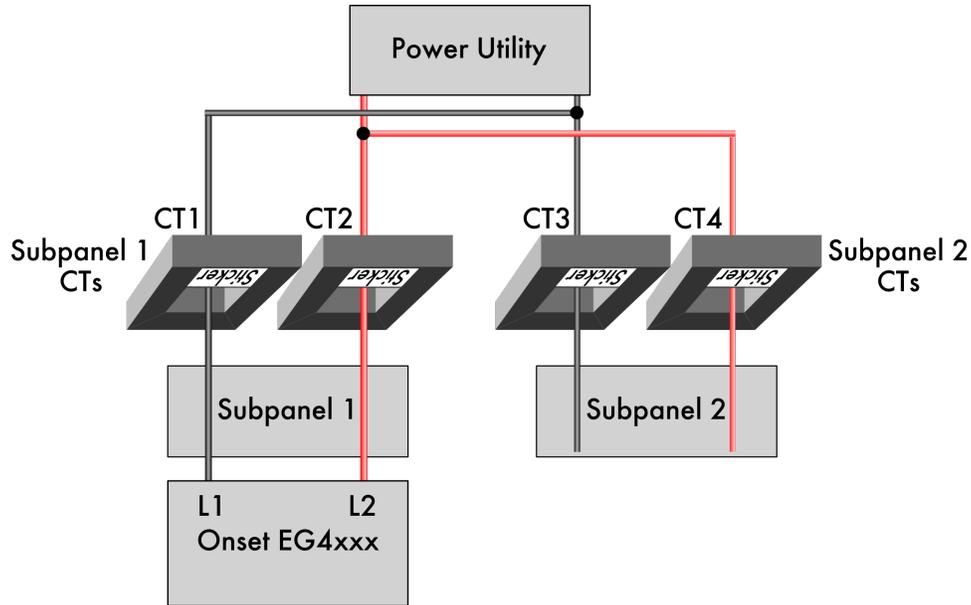
Usage = Grid

Notes:

- Please contact Onset support if your transformers do not match the supported setup above.
- **CAUTION:** Since there is no neutral and none of the phases may be grounded, all conductive/metallic parts, including CT-plug screws and CT wiring should be considered live and hazardous!
- If one of the phases is grounded, wire that phase to the Neutral (N) pin on the meter.
- It is imperative wiring and CT placement is done exactly as indicated in the diagram. Troubleshooting methods are limited on deltas using step-down transformers.

2.8 Subpanels

This example illustrates how to measure subpanels.



Registers

$$\begin{aligned} \text{Subpanel 1} &= [\text{P}] [=] \text{CT1} \cdot \text{L1} + \text{CT2} \cdot \text{L2} \\ \text{Subpanel 2} &= [\text{P}] [=] \text{CT3} \cdot \text{L1} + \text{CT4} \cdot \text{L2} \end{aligned}$$

Totals and Virtual Registers

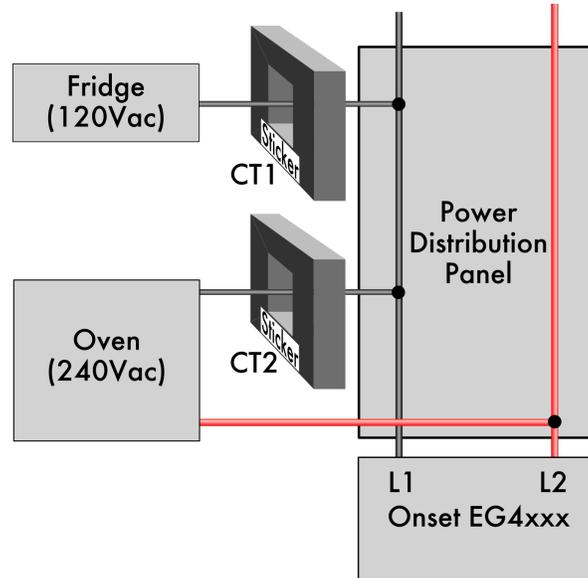
$$\text{Usage} = - \text{Subpanel 1} - \text{Subpanel 2}$$

Notes:

- The stickers on the CTs should point towards what is being measured, i.e., the subpanels.
- When properly installed, the subpanel registers will record negative power figures when power is being drawn on a subpanel, indicating a consumption.
- In the totaling rules, add together the *negative* value of each subpanel.
- It does not matter which subpanel the meter is installed in, but care must be taken to identify correct phasing. It is possible for phases to be reversed or inconsistent between panels.

2.9 Appliances

This example illustrates how to configure 120Vac (single leg) and 240Vac (two leg) appliances.



Registers

```

Fridge = [P] [= ] CT1*L1
Oven   = [P] [= ] CT2*L1 + -CT2*L2

```

Totals and Virtual Registers

Notes:

- Registers defined for appliances do not appear in the totaling rules. Just defining the registers will make them appear in the appropriate places (e.g., in the legend of the dashboard graph).
- A single CT is sufficient both for 120Vac and pure 240Vac appliances. 240Vac appliances with asymmetric currents on the two legs (i.e., with a non-zero current on Neutral) require separate CTs per leg/phase.

3 Troubleshooting

If an installation does not work as expected, we recommend using the channel checker tool to troubleshoot the problem. This tool is available through “Tools” link in the top right menu of the meter web pages then click on “Channel Checker” in the left menu. Figure 2 provides an example of what this tool looks like. Note, the two channel checker tables are displayed vertically one next to the other in the device interface. It is displayed horizontally on this page for readability.

As of Thu 25 Jan 2018 09:54:32am:

Channel	AC+DC (RMS)	AC (RMS)	DC (Mean)	Frequency
L1	121.570 V	121.570 V	-0.045 V	60.01 Hz
L2	121.650 V	121.650 V	-0.204 V	60.01 Hz
CT1	3.470 A	3.470 A	-0.047 A	60.08 Hz
CT2	7.407 A	7.407 A	-0.048 A	60.07 Hz
CT3	0.129 A	0.128 A	-0.019 A	275.24 Hz
CT4	7.774 A	7.774 A	-0.013 A	60.01 Hz
CT5	0.500 A	0.496 A	-0.061 A	321.91 Hz
CT6	0.236 A	0.235 A	-0.026 A	322.52 Hz
CT7	0.640 A	0.640 A	-0.017 A	60.02 Hz
CT8	0.243 A	0.243 A	-0.012 A	111.06 Hz
CT9	0.594 A	0.591 A	-0.062 A	229.26 Hz
CT10	3.764 A	3.764 A	-0.040 A	60.00 Hz

Register Name	Value	Power Factor
Grid (L1*CT1)	336.40 W	0.797
Grid (L2*CT2)	870.10 W	0.966
Solar SPR (L1*CT3)	-2.60 W	0.166
Solar SPR (L2*CT3)	-2.60 W	0.166
Solar Tigo+SPR (L1*CT4)	921.20 W	0.975
Solar Tigo+SPR (L2*CT4)	922.40 W	0.975
EV Charging (L1*CT5)	-0.30 W	0.005
EV Charging (L2*CT5)	-0.30 W	0.005
Oven (L1*CT6)	-0.60 W	0.021
Oven (L2*CT6)	-0.60 W	0.021
Comp Closet #1 (L1*CT7)	-56.30 W	0.724
Garage+Guest Bath+PHEV (L2*CT8)	-18.50 W	0.626
Cooktop+Mech Room (L1*CT9)	-28.30 W	0.392
Cooktop+Mech Room (L2*CT10)	-393.60 W	0.860

Figure 2: Example of meter Channel Checker Tool

The channel checker reports the real-time voltages measured for each active voltage probe and currents for each active CT (If a voltage or a CT is not used by any register, it is deactivated).

RMS (AC) and mean (DC) values for both CTs and voltage inputs are calculated. Frequencies for each channel input are also calculated and displayed here.

In addition to the currents and voltages, the page also reports power figure for each component of all registers. The power figure is accompanied by a power-factor, which is a value between 0 and 1. A value of 1 indicates a purely resistive load whereas a value of 0 indicates either a purely inductive or purely capacitive load. An unexpected power factor may be caused by a phase mixup, in which a CT amperage is applied to an incorrect phase it is not on.

3.1 Identify correct phasing

To identify a phase mixup or adequately confirm correct phasing, use a handheld voltmeter set to AC voltage for the electrical system the meter is monitoring. Connect one probe to the L1 screw terminal of the meter 5-pin power plug, and connect the other probe to the conductor a CT is monitoring. **DO NOT** make contact with the 2-pin CT plug, only to the high voltage conductor a CT is monitoring.

If the voltmeter shows phase-to-phase voltage, the probes are on two different phases and the conductor is not on L1. If the voltmeter shows 0V differential, the probes are on the same phase and the conductor is on L1.

This process should be repeated for all lines and conductors monitored.

3.2 Fixing Leg/Phase Mixups

For installations involving multiple subpanels, it is sometimes not easy to track down which conductor belongs to what leg or phase. If a CT is thought to have been installed on a conductor wired to L1 but actually was on a conductor wired to L2, the reported power will be wrong. In a split-phase system, the power will have wrong polarity (negative when it should be positive and vice versa). In a three-phase system, the power-factor will be significantly lower than expected. Rather than moving the CTs or the CT wiring, it may be easier to adjust the configuration to match reality. This can be done by adjusting the register definitions such that the incorrectly installed CT(s) are multiplied by the voltages that they're actually connected to. If the polarity of the reported power is correct and the power-factor is close to 1, that usually can be taken as a sign that the correct phases are being used. It is usually a good idea to temporarily turn off any renewable energy systems to confirm that the polarities and power-factors make sense even when there is no renewable power.

3.3 Fixing CTs Pointing in the Wrong Direction

If a CT accidentally was installed pointing in the wrong direction, its polarity will be reversed (i.e., the power will read negative when it should be positive and vice versa). Since fixing the installation may be time-consuming, it is usually easier to adjust the configuration. This can be done easily by adjusting all register definitions which use the incorrectly installed CT to use the CT value of opposite polarity. For example, if CT3 was installed incorrectly, change all appearances of CT3 to -CT3 and vice versa.

A Formula Operators and Functions

The following operators are available in register formulas (in decreasing order of precedence):

Operator:	Precedence:	Description:
$\$r$	6	The value of register r .
(e)	5	The value of parenthesized sub-expression e .
$-e$	4	The negative of e .
$e_1 * e_2$	3	The product $e_1 \cdot e_2$.
e_1 / e_2	3	The quotient e_1 / e_2 .
$e_1 + e_2$	2	The sum $e_1 + e_2$.
$e_1 - e_2$	2	The difference $e_1 - e_2$.
$e_1 < e_2$	1	1 if $e_1 < e_2$, 0 otherwise.
$e_1 > e_2$	1	1 if $e_1 > e_2$, 0 otherwise.
$e_1 \leq e_2$	1	1 if $e_1 \leq e_2$, 0 otherwise.
$e_1 \geq e_2$	1	1 if $e_1 \geq e_2$, 0 otherwise.
$e_1 = e_2$	1	1 if $e_1 = e_2$, 0 otherwise.
$e_1 ? e_2 : e_3$	0	e_2 if e_1 is not 0, e_3 otherwise.

Caveat: Care needs to be taken when comparing floating-point values for equality. Except when comparing the result of a conditional operator, it is usually better to replace $e_1 = e_2$ with a test of the form $\text{abs}(e_1 - e_2) < \epsilon$, where ϵ is the largest expected error.

The following table describes the list of functions that are available in formula registers using up-to-date firmware. Please refer to the function documentation on your specific device for the most up-to-date listing of available functions and full descriptions. This may be found at <http://DEV-URL/fundoc.html>, where DEV-URL is the URL of your eGauge device.

Function:	Description:
<code>abs(x)</code>	Absolute value of x .
<code>max(x,y)</code>	The greater value of x and y .
<code>min(x,y)</code>	The smaller value of x and y .
<code>mod(x,y)</code>	The remainder of dividing x by y .
<code>sqr(x)</code>	x^2 .
<code>sqrt(x)</code>	\sqrt{x} .
<code>exp(x)</code>	10^x .
<code>log(x)</code>	Common (base-10) logarithm of x .
<code>floor(x)</code>	Largest integral value not greater than x .
<code>VAr(r,a)</code>	Given real power r and apparent power a , return reactive power.
<code>month()</code>	Number of months since January (0...11).
<code>wday()</code>	Number of days since Monday (0...6).
<code>mday()</code>	Returns the day of the month (1...31).
<code>time()</code>	Number of hours since midnight (0...23). Fractional part gives the part of the hour that has elapsed already, i.e., 0.5 for 30 minutes.
<code>P_PV(i,t,p,c)</code>	Given irradiance i , panel temperature t , STC-rated power p , and power-temperature-coefficient c , return expected PV output.
<code>pref("p")</code>	Returns value of preference-setting named p (e.g., "global.production.rated").
<code>FFTarg2(f, c, r)</code>	Returns phase-angle of the spectral component at frequency f of the signal at input channel c relative to the reference channel r .
<code>FFTMag(f, c)</code>	Returns magnitude of spectral component at frequency f of input channel c .
<code>P_SunPower(i, t, p)</code>	Calculates expected power of SunPower array given irradiance i , panel temperature t and rated power p .
<code>THD(f, c)</code>	Returns total harmonic distortion of channel c for fundamental frequency f .
<code>conn_qual()</code>	Returns connection quality as percentage.
<code>conn_tech()</code>	Returns the connection technology as an integer.
<code>temp_internal()</code>	Returns device-internal temperature in degrees centigrade.
<code>isinf(x)</code>	Returns 1 if x is positive infinity or -1 if x is negative infinity, or 0 otherwise.
<code>isnan(x)</code>	Returns non-zero value if x is Not-a-Number.
<code>P_est(J, F, M,..)</code>	Returns current estimated average production in Watts given expected monthly production values (in kWh). J is January, F is February, M is March, and so on for each of the 12 months.
<code>chan(s)</code>	Returns channel number for name s . s may be one of "L1" through "L3" for voltage inputs, or "CT1" through "CT12" for current inputs.
<code>rand()</code>	Returns random number in the range from 0 to 1 (inclusive).
<code>ravg(r, n)</code>	Calculates the running average of register r over the most recent n minute interval.
<code>savg(r, n)</code>	Calculates the set average of register r over the previous n minute interval.

B Physical Unit

The table below lists the various physical units supported by the meter. In this table, column **Name** lists the name as it appears in the Web configuration interface (see Section 1.4.4). Column **Records** shows the physical quantity the register records and column **Unit** shows the physical unit that the data is being recorded with. The meter records data as discrete quantities. Column **Res** shows the smallest value that can be recorded by the register and column **Max @ 30 yr** shows the maximum value that can be recorded without causing an overflow for a period of at least 30 years. The final column, **Code**, lists the type-code used for the register in XML data.

Name	Records	Unit	Res	Max @ 30 yr	Code
power [Watts]	(Real) power	<i>W</i>	1 <i>W</i>	19.4 <i>GW</i>	P
app. power [VA]	Apparent power	<i>VA</i>	1 <i>VA</i>	19.4 <i>GVA</i>	S
react. power [var]	Reactive power	<i>var</i>	1 <i>var</i>	19.4 <i>Gvar</i>	PQ
voltage [V]	Voltage	<i>V</i>	1 <i>mV</i>	19.4 <i>MV</i>	V
current [A]	Current	<i>A</i>	1 <i>mA</i>	19.4 <i>MA</i>	I
freq. [Hz]	Frequency	<i>Hz</i>	1 <i>mHz</i>	19.4 <i>MHz</i>	F
irrad. [W/m ²]	(Solar) irradiance	<i>W/m²</i>	1 <i>W/m²</i>	19.4 <i>GW/m²</i>	Ee
temp. [C]	Temperature	<i>°C</i>	1 <i>m°C</i>	19.4 <i>M°C</i>	T
humidity [%]	Relative humidity	%	0.1%	194 <i>M%</i>	h
mass flow [kg/s]	Mass flow	<i>kg/s</i>	<i>g/s</i>	19.4 <i>Gg/s</i>	Q
volumetric flow [m ³ /s]	Volumetric flow	<i>m³/s</i>	1 <i>mm³/s</i>	19.4 <i>m³/s</i>	Qv
speed [m/s]	Speed (e.g., rain-fall rate)	<i>m/s</i>	1 <i>mm/s</i>	19.4 <i>Mm/s</i>	v
res. [Ohm]	Resistance	Ω	1 Ω	19.4 <i>GΩ</i>	R
monetary	Money	<i>var.</i>	1.86 <i>n</i>	36.2	\$
angle [deg]	Angle (e.g., wind-direction)	$^{\circ}$	1 <i>m$^{\circ}$</i>	360 $^{\circ}$	a
number	Unit-less quantity	<i>n/a</i>	1	19.4 <i>G</i>	#
total harm. dist	Total Harmonic Distortion	%	0.1%	194 <i>M%</i>	THD
pressure [Pa]	Pressure (e.g., atmospheric)	<i>Pa</i>	1 <i>Pa</i>	19.4 <i>GPa</i>	Pa
charge [Ah]	Charge (e.g., battery)	<i>Ah</i>	1 <i>mAh</i>	19.4 <i>MAh</i>	Qe

Physical unit abbreviations and SI-multiplier prefixes used in the above table:

Abbreviation	Physical unit name
<i>V</i>	Volt
<i>A</i>	Ampère
<i>VA</i>	Volt-Ampère
<i>W</i>	Watt
<i>var</i>	Volt-Ampère reactive
<i>Hz</i>	Hertz
<i>g</i>	gram
<i>m</i>	meter
$^{\circ}$	degrees (angle)
<i>°C</i>	degrees Centigrade
<i>Pa</i>	Pascal (<i>kg/ms²</i>)
Ω	Ohm

Prefix	Multiplier
<i>n</i>	10 ⁻⁹
μ	10 ⁻⁶
<i>m</i>	10 ⁻³
<i>k</i>	10 ³
<i>M</i>	10 ⁶
<i>G</i>	10 ⁹

Note: Monetary registers do not have a pre-defined unit. Instead, such values are displayed using the currency-symbol selected via one of the preference settings, for example \$. The resolution for this type is very fine because the cost of electricity per second is generally extremely low. For example, if the cost of electricity were $\$0.40/kWh$, the cost per Watt-second is only $\$0.11\mu$.