



eGauge Configuration Guide

(for firmware v2.16 or newer)

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1 Overview

This guide explains how to configure eGauge 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 eGauge, 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.

eGauge 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 eGauge, 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 eGauge 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):

CT1	SCT 19mm/0.75" 100A	CT2	SCT 19mm/0.75" 100A	CT3	SCT 10mm/0.39" 50A	CT4	
CT5		CT6		CT7		CT8	
CT9		CT10		CT11		CT12	

Remote Devices:

Device name: 2ndary Protocol: remote eGauge via UDP Device address: proto1

Registers (7 of 16 in use):

Name:	Recorded value/formula:	
Grid	P	<input type="button" value="Add Component"/>
Solar	P	<input type="button" value="Add Component"/>
Grid Leg 1 Current	I	
Grid Leg 2 Voltage	V	
Grid Leg 1 Frequency	F	
Mech Room	2ndary Mech Room	

Totals and Virtual Registers:

Usage	Grid	Solar+	<input type="button" value="Add Register"/>
Generation	Solar		<input type="button" value="Add Register"/>
A.Usage	Mech Room		<input type="button" value="Add Register"/>
A.Generation			<input type="button" value="Add Register"/>

Figure 1: Example of eGauge 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)”. However, if PTs have been installed, the voltages that the device will measure at the L1, L2, or L3 pin will be lower than the actual line-voltage and the appropriate voltage-division ratios need to be selected in this section. For example, with PTs that transform 34,500V (34.5kV) down to 120V, the ratio “34.5kV:120V” should be selected.

1.2 Current Transformer (CT) Configuration

This section defines what kind of current-transformer (CT) is connected to each of the twelve 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 0.75” Magnelab CT is plugged into CT position 2, click on the pull-down list for CT2 and select “SCT 19mm/0.75” 100A”. Firmware prior to v2.16 does not have as descriptive drop-down selections. In that case, simply select the CT amperage rating (e.g., choose “100A” for any 100A Magnelab CT).

The format of the CT drop-down option is “[MODEL] [SIZE_MM]/[SIZE_IN] [AMPERAGE]”. See table 1 for a description of CT model prefixes. The CT inner-diameter is represented in millimetres as SIZE_MM and in inches as SIZE_IN. The amperage rating of the CT (not the circuit being monitored) is defined as AMPERAGE.

MODEL	Manufacturer	Description
JS	J&D	Split-core CT
JRFS	J&D	Rogowski coil (rope CT)
ACT	Continental Control Systems	High accuracy split-core CT
SCT	Magnelab	Split-core CT
RCT	Magnelab	Rogowski coil (rope CT)
CR	CR Magnetics	Solid-core DC CT
CRS	CR Magnetics	Split-core DC CT

Table 1: CT model prefix 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 most commonly used when a CT measures only a portion of the total current being carried on a phase. For example, suppose that a large commercial building receives its utility power through four equal sized conductors per phase. Rather than installing a large CT that encompasses all four conductors, it may be more economical to install a smaller CT that encompasses only a single conductor. Assuming the current on the four conductors is balanced, the smaller CT will capture a **fourth** of the total current per phase. To compensate for that, enter a value of 4 in the multiplier box.

It is also possible to select “custom” as the CT rating. This option may be used to fine-tune the CT scale factor, such as if the CT has been extended long distances and voltage drop must be compensated for. It is not necessary to adjust the scale factor under most circumstances, and should not be done unless advised to do so by eGauge Systems.

1.2.1 Rope CTs (Rogowski Coils)

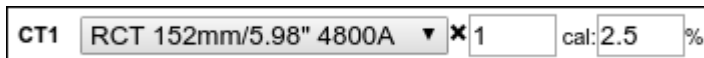
Self-powered rope CTs are wired directly to the eGauge with a green 2-pin plug and look as shown below:



Self-powered rope CTs have a fixed amperage of 4800A. To configure a *self-powered* rope CT, select “RCT 152mm/5.98” 4800A” from the appropriate CT drop-down menu. Prior to firmware v2.16, choose “Rope 6”” from the drop-down menu.

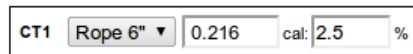
Legacy 6” Rope CTs

Rope CTs sold by eGauge Systems before July 2014 are “calibrated” rope CTs. These 6” rope CTs each have slightly different output characteristics. Because of this, each rope CT came with a calibration sticker connected to the CT leads. For accurate operation, the value printed on the calibration sticker has to be entered into the eGauge configuration. Specifically, to configure a *calibrated* rope CT with a calibration sticker, note the box labeled “cal:”. In this box, enter the value printed on the calibration label. This is usually a value in the range from -20% to +20%. In the example below, we entered a value of 2.5%.



Legacy 6” Rope CT with calibration example (firmware v2.16 or greater)

Current Transformers (CTs):



Legacy 6” Rope CT with calibration example (firmware prior to v2.16)

The calibration section is only used for calibrated rope CTs. Leave this value blank or at zero for newer 6” Rope CTs without calibration stickers.

1.3 Remote Devices

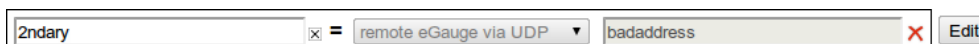
This section is used to define remote devices whose data should be recorded. Examples of remote devices are other eGauges, PV inverters, or weather stations. If you are not planning on recording data from a remote device, skip this section.

For a list of compatible devices, protocols, configuration examples, and information on reading custom Modbus devices, please visit the Third-Party/Remote device section at egauge.net/third-party-devices/ or from egauge.net to Products → Third-Party/Remote Devices

For our running example, we will select “remote eGauge via UDP” as the protocol and “proto1” as the device’s address. After entering the address, click the “Done” button. For security-reasons, eGauge may prompt you for authentication before this step can be completed. If so, enter username “owner” and the matching password (which is “default” by default). Assuming proper authorization, the screen will then change to this:



Note that the protocol and address fields have been grayed out, indicating that they are not editable anymore. Should you need to make changes, click the “Edit” button again. Also note that the question-mark after the address field has changed to a green check-mark. This indicates that the eGauge was able to communicate with the remote device and that it has fetched the list of available registers from that device. If this step had failed for some reason, there would be a red cross-mark instead of the green check-mark, as shown below:



There are several reasons why you might get a red cross-mark after clicking “Done”:

- **Wrong address.** Verify that the address you entered is correct and has the proper format.
- **Wrong protocol.** Verify that you selected a protocol suitable for the remote device.
- **Remote device not working.** Verify that the remote device is up and running.
- **Remote device not reachable.** Verify that the remote device can be reached from the eGauge. If the remote device is another eGauge, you can use the `Settings→HomePlug` screen to verify that the remote device can be reached with good signal strength.

You will only be able to define new registers for remote devices listed with a green check-mark. However, eGauge is careful to never delete already configured registers for remote devices, even if the remote devices may be (temporarily) inaccessible. Removing the remote register entry completely, however, will remove any registers using that remote device.

1.4 Register Configuration

This section defines what data gets recorded in the internal database of the eGauge device. Each register has a unique name that identifies what it is recording. There is a fixed upper limit on the number of registers a device can record. Depending on the generation of the hardware, the limit may be eight, twelve, or sixteen registers. Devices can also be ordered with an optional alternative database, which increases the limit to 64 or 128 registers. To make it easy to keep track of how many registers are in use and how many registers are available in total, the title of this section displays this information in the format “(*N* of *M* in use)”, where *N* is the number of registers in use and *M* is the total number of registers available.

With the default 16-register database, registers record the data with one minute granularity for the most recent year. For the next 29 years, granularity drops to fifteen minutes. Data older than 30 years gets overwritten with newer data, so 30 years of history is the most the device can record. Note that registers record *averages*: for the most recent year, the recorded data consists of one-minute averages. For the next 29 years, the data consists of fifteen-minute averages.

1.4.1 Register Name

Register names may contain any ASCII/UTF-8 characters except for control characters such as backspace, delete, or newline. Most punctuation marks such as slash, backslash, quotes, etc., are all permissible. The exception is that you may not enter a register name that ends with a plus (+), minus (-), vertical-bar (|), or asterisk (*).

Through UTF-8, it is possible to use symbols from non-English character sets. However, note that non-English symbols encoded in UTF-8 occupy up to four bytes of memory. eGauge limits the length of register names to 31 bytes. With English characters, register-names can therefore be up to 31 characters long. With non-English characters, fewer symbols can be stored in a register-name, with the exact maximum length depending on the chosen symbols. As a rule of thumb, non-ASCII Latin characters (e.g., accented characters such as German Umlauts) consume two bytes per symbol and symbols from ideographic languages such as Chinese consume four bytes per symbol.

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:

Registers (7 of 12 in use):

Name:	Recorded value/formula:
Grid	P =+ CT1
Solar	P =+ CT3
Grid Leg 1 Current	I = CT1
Grid Leg 2 Voltage	V = L2

Add Register

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 (CT1–CT12).
- V**: Records the RMS **voltage** measured by one of the lines (L1–L3).
- F**: Records the **frequency** measured on one of the lines (L1–L3).
- #**: Records numeric data. The only numeric data available at this time is a quantity called “.excess”. When there are remote devices, the quantity has a non-zero value only if a remote device was temporarily unavailable and eGauge is catching up with the remote device’s current data. The details of this register are arcane but a non-zero value can be used as an indicator that there were some (temporary) communication problems with remote devices and that the eGauge is now catching up to the current data, which may cause the temporary inflation of up to $\pm 10\%$ of the values read from remote registers.
- =**: Formula register. Records the value obtained by evaluating the specified formula. See Section 1.4.4 for details.

remote device name: Selecting the name of a remote devices (in our example, 2ndary), allows you to record a register from that device. Before adding a remote register, make sure that there is a green check-mark (✓) indicator to the right of the address field of the remote device. If the indicator is a question-mark (?), click on it to fetch the list of registers available from the remote device. If the indicator is a red cross-mark (✗), the eGauge was unable to communicate with the remote device. See the previous section for information on how to resolve the problem.

In the example of Figure 1, we see six rows in the `Registers` section: the first two record power (P). We will discuss those in more detail in the next section. The third row defines a register recording the current (I) of CT1, the fourth row defines a register recording the voltage (V) of line L2 (e.g., red leg in a split-phase residential installation). The fifth row defines a register that records the frequency (F) of line L1. Finally, the sixth row defines a remote register that records the data from the “Mech Room” register of remote device 2ndary.

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:

Registers (7 of 12 in use):

Name:	Recorded value/formula:
Grid	= P = CT1 * L1 + CT2 * L2
Solar	= P
Grid Leg 1 Current	= I
Grid Leg 2 Voltage	= V
Grid Frequency	= F
Mech Room	= 2ndary

Options for Solar register:

- = Record net of positive and negative power
- + Record positive power
- Record negative power
- | Record absolute power (ignore sign)
- * Record apparent power ($V_{RMS} \cdot I_{RMS}$; needed for Power-Factor)

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 can be used, for example, when measuring pure loads where the direction of the power-flow is known.
- * (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.

Note that the values of the different register subtypes are dependent on each other, except for apparent power. For example, given the positive-only and the net register values, the negative-only register value

can be calculated as the difference of the two. To conserve storage space, eGauge automatically exploits these dependencies and only records the minimum data needed. Because of this, eGauge never uses up more than three registers no matter what combination of subtypes are selected.


Firmware versions older than v1.00 supported only the recording of net real power (=). The other subtypes were added for increased flexibility. For example, the positive-only (+) register can be used to accurately calculate total power usage at a site with a photo-voltaic (PV) solar system. It can also be used to accurately track energy-flow of a utility meter, which can be helpful for cases where a utility charges a different rate for consumed power than it pays for power fed back into the grid. Using the absolute (|) subtype can simplify CT installation for, e.g., pure loads. By ignoring the sign of the calculated power, the measured power is always positive, no matter which way the CT is installed. Finally, the apparent power (|) subtype enables power-factor tracking as the ratio between apparent power and the absolute value of real power is the power-factor.

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 `Grid` and `Solar` registers look as follows:

Name:	Recorded value/formula:	
Grid	$\times = P \quad -$	$CT1 \times L1 \quad + \quad CT2 \times L2 \quad \times$ <input type="button" value="Add Component"/>
Solar	$\times = P \quad =+$	$CT3 \times L1 \quad + \quad -CT3 \times L2 \quad \times$ <input type="button" value="Add Component"/>

This shows that `Grid` 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). In other words, the power coming from the two legs of the split-phase power feed from the utility are combined into a single register. It would of course be possible to record the two legs in separate registers, but that would use up more of the available storage space and would add a level of detail that most customers do not care about.

It is illustrative to look at the power-components for the `Solar` register since it uses $-CT3$ in the second component. Naively, a 240Vac solar inverter would have to be measured by two CTs: one per leg. However, provided there is no current flowing on the Neutral wire (usually the case for a single-phase inverter), we know that at any given point in time, the current flowing out of leg 1 of the inverter has to flow back into leg 2 and vice versa (the flow of current reverses 60 times a second assuming a 60Hz power system). Thus, instead of measuring the second leg of the inverter with a fourth CT, we can simply use the negated value of $CT3$, i.e., $-CT3$ to accurately calculate the power delivered from the inverter. This saves the cost of a CT and the time that would be required to install it. Note that the minus-sign in $-CT3$ should not be taken too literally in the formula: it causes the polarity of the component to be reversed for real power calculations, but for apparent power calculations, the sign has no effect, since the RMS value of the current measured by $CT3$ and $-CT3$ is by definition always positive.

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, suppose register `Grid` measures the real power used at a site, then register `Grid*` would measure the apparent power used at the same site. To record the power-factor for the site, we would have to divide the absolute value of `Grid` by `Grid*`. This can be accomplished by defining a formula register as shown below:

Name:	Recorded value/formula:		
Grid Power Factor	=	number	1000 * abs(\$"Grid") / \$"Grid**"
Irradiance	=	SMANet	
Panel Temp	=	SMANet	
Ambient Temp	=	SMANet	
Wind Speed	=	SMANet	
Add Register			
Totals and Virtual Registers:			
Usage	=	number	
		total harm. dist	
			Add Register

In this example, we named the register “Grid Power Factor” and selected the equal-sign (formula-register) as the register type (see Section 1.4.2). Next, we selected the type of physical quantity that is being recorded by the register. As described in more detail in Appendix ??, various choices are available here: power, voltage, irradiance, and so on. In our case, power-factor is a unit-less number, so we selected `number` from the drop-down box. Finally, we entered a formula of `1000*abs($"Grid")/$"Grid**"` for calculating the value of the register. Here, `regname` is used to obtain the current (second-by-second) value of register `regname`, so `"Grid"` will evaluate to the current site-usage (in Watts) and `"Grid**"` evaluates to the apparent power used by the site. As you might expect, the `abs()` function calculates the absolute value of the value passed to it (i.e., it returns the passed value after dropping its sign). Dividing the value returned by the `abs()` function by the apparent power yields a number between 0 and 1 (the power-factor). Why do we multiply this quotient by 1,000? To understand that, you need to know that eGauge records number-type quantities as signed integer values. Thus, any value between 0 and 1 would get rounded to either 0 or 1, which wouldn’t be very informative. By multiplying it by 1,000, we instead can record the power-factor with a precision of 3 digits. For example, a value of 983 would correspond to a power-factor of 0.983.

A list of functions that are available for use in calculating the value of a formula register can be found in Appendix ??. An online-version of this function-list can also be found in the `Help` section of the eGauge web-pages. Apart from basic mathematical functions such as square-root-, exponential-, or min- and max-functions, there are some time-related functions available to read the time-of-day, month of the year, and the weekday. Also, there are some convenience-functions available to calculate, for example, expected output from a solar PV array or to calculate reactive power given measured real and apparent power.

Below are two more examples of useful applications of formula registers.

Solar (predicted)	=	power [W]	P_PV(\$"Irradiance", \$"Panel Temp", 27*225, -0.38)
Heating Degrees	=	temp. [Celsius]	max(0, 18.333-\$"Ambient Temp")

The first (`Solar (predicted)`) shows how to calculate and record the predicted power of a solar PV array given solar irradiance (`"Irradiance"`), the panel temperature (`"Panel Temp"`), the rated power of the PV array (27 panels of 225W each), and the temperature-coefficient of the panels (-0.38%). Note that irradiance and panel temperature would have to be measured by a weather-station that is compatible with eGauge, such as the SMA Sunny SensorBox. Note that predicted PV-output is a physical quantity measured in Watts, so we selected “`power [W]`” as the physical quantity for this register.


The second example (`Heating Degrees`) shows how to record heating degrees given a register called “`Ambient Temp`,” which records the ambient (outside) temperature at a site. Heating degrees is defined to be the average temperature by which a room would have to be heated to keep it at a comfortable temperature of 65° Fahrenheit (18.333° Celsius). If the outside temperature is above 65F (18.333C), no heating is

required and the formula is defined to return 0 in that case (the maximum value of 0 and a negative number is 0). If the ambient temperature is any lower than that, the formula returns the difference as 18.333 minus a number smaller than that will be a positive number. Note that we selected “temp. [Celsius]” as the physical quantity for this register, as heating degrees is a temperature. This also illustrates the point that formula registers always record physical quantities using the metric system. Any conversions to user-preferred units have to happen when the recorded values are being presented to the user, e.g., through the built-in web-pages.


Several caveats apply to using formula registers:

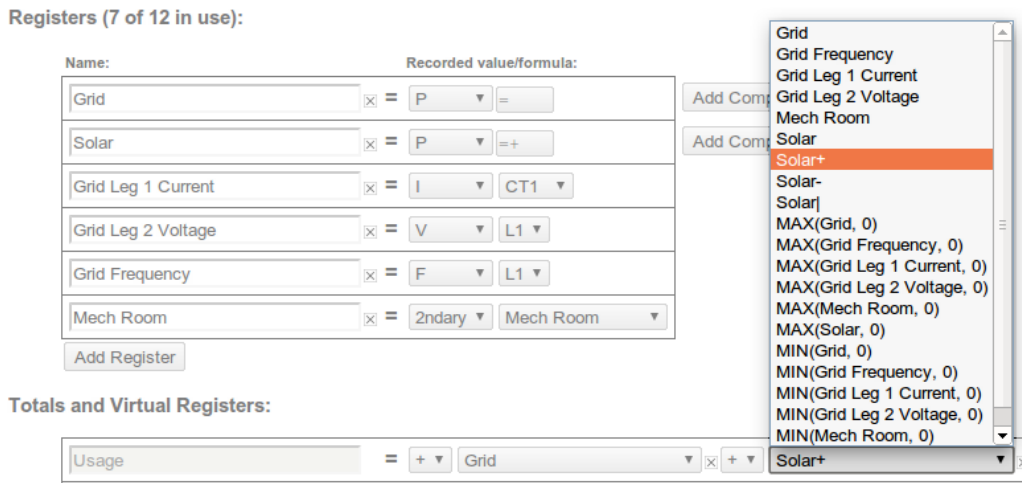
- You might wonder what would happen if a formula attempted to use the value of another formula register. The answer is that this is an undefined operation. It could return the current value of that register, the previous second's value of the register, or any other value. Thus, formulas should refer only to measured (physical) registers.
- Calculating formulas takes time. The more complicated a formula is, the more time it takes to calculate its value. In extreme cases, it might be possible to overload a device by defining lots of complicated calculations, especially if the device is already heavily loaded, e.g., due to lots of power calculations. If this were to happen, the device-response could become sluggish, even to the point where it might seem unresponsive.
- 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. As such, virtual registers do not consume any storage space and there is no a priori limit on how many of them you can define. A virtual register can be added by clicking on the “Add Virtual Register” button. To remove one, click on the remove icon  to the right of the register name. In our example, this section looks as follows:

Usage	=	+ ▾	Grid	×	+ ▾	Solar+	×	Add Register
Generation	=	+ ▾	Solar	×				Add Register
A.Usage	×	=	+ ▾	Mech Room	×			Add Register
A.Generation	×	=						Add Register
Add Virtual Register								

For each virtual register, you can define an arbitrary number of registers which are added or subtracted together when calculating the virtual register's value. 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. The register to be added or subtracted can also be selected from a drop-down menu. In our example, this menu looks as follows:



Each power register will show up in several variations in the menu, namely with one variant for each available subtype. If you look back at the register configuration for *Grid*, only the net (=) subtype is being recorded, so it shows up only once as *Grid* (since net metering is the default for eGauge, the equal-sign is omitted from the name, unlike for any other subtype). However, for *Solar*, both net (=) and positive-only (+) subtypes are being recorded. Because of this, all subtype variants except for apparent power appear in the menu: *Solar* (net), *Solar+* (positive-only), *Solar-* (negative-only), and *Solar|* (absolute). The last two are available because they can be calculated from net and positive-only.

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. Instead of $MAX(reg, 0)$, use the positive-only variant of a register (i.e., *reg+*) and instead of $MIN(reg, 0)$, use the negative-only variant of a register (i.e., *reg-*).

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 an eGauge device. For example, views could be used to view the usage/generation data for an individual condo when a single eGauge device 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*:



With this setup, selecting view **A** in the dash-board will display register `Mech Room` 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

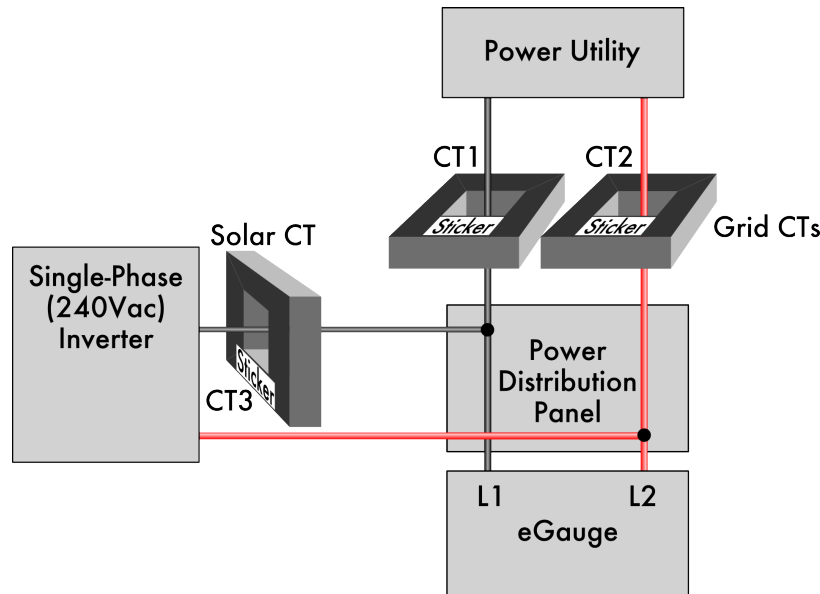
The following pages illustrate various common installation scenarios and matching configurations. For clarity, the diagrams have been simplified in the following manner:

- 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 eGauge device always must be wired to a breaker and the breaker should be labeled "eGauge Disconnect."

2.1 Standard Split-Phase

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

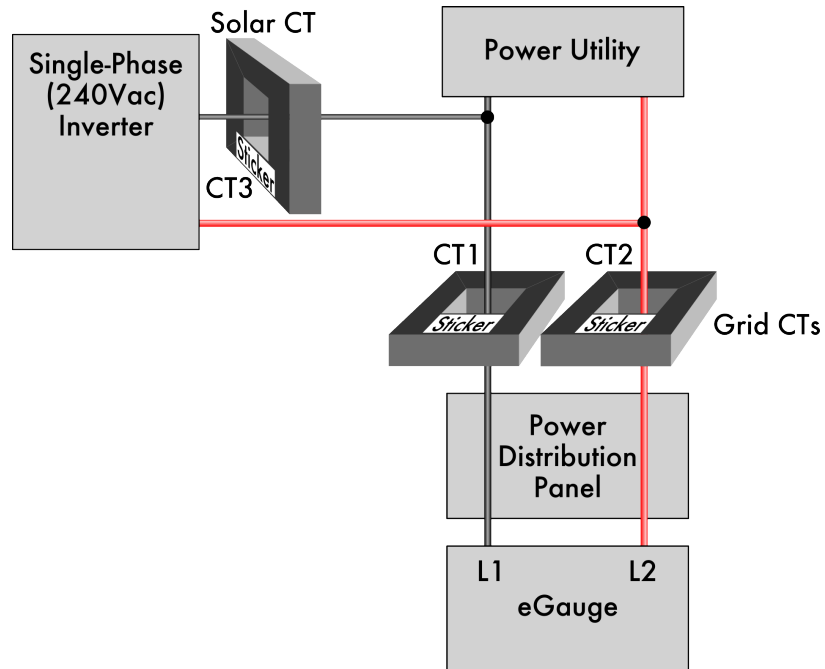
$$\begin{aligned} \text{Usage} &= \text{Grid} + \text{Solar} + \\ \text{Generation} &= \text{Solar} \end{aligned}$$

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 `Grid + 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

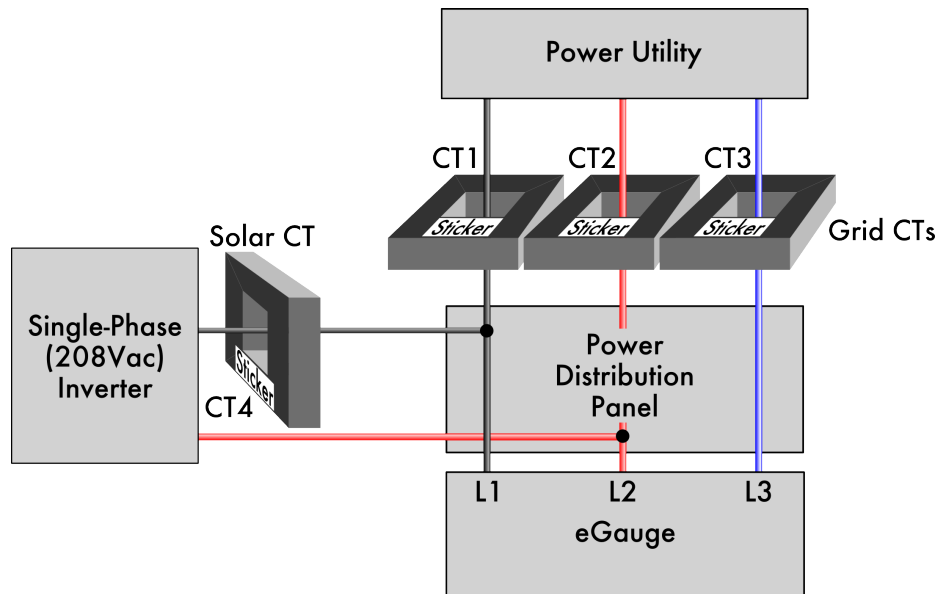
$$\begin{aligned} \text{Usage} &= \text{Grid} + \text{Solar}- \\ \text{Generation} &= \text{Solar} \end{aligned}$$

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 120/208Y

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



Registers

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

Totals and Virtual Registers

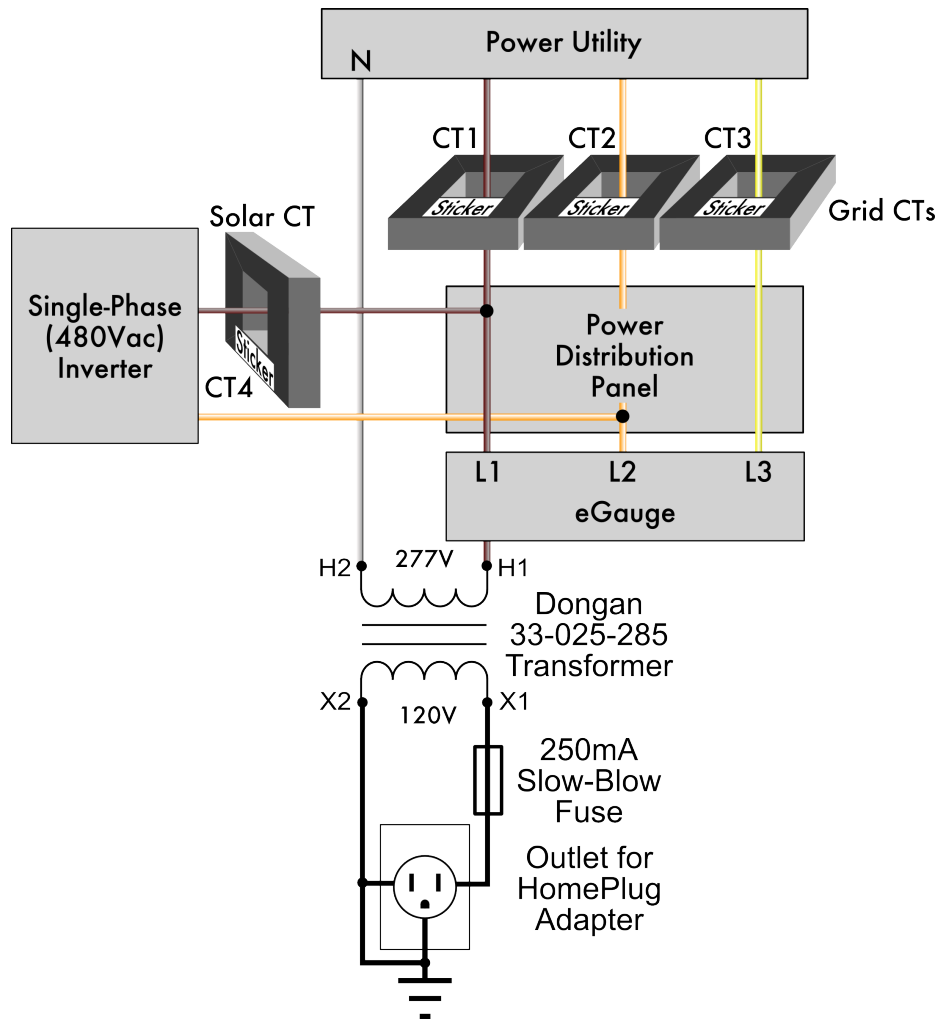
```
Usage      = Grid + Solar+
Generation = Solar
```

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 277/480Y

Three-phase 277/480V installation measuring power coming from a power utility (grid) and from a single-phase solar-system inverter.



Registers

$$\begin{aligned} \text{Grid} &= [\text{P}] [=] \text{CT1} \cdot \text{L1} + \text{CT2} \cdot \text{L2} + \text{CT3} \cdot \text{L3} \\ \text{Solar} &= [\text{P}] [=+] \text{CT4} \cdot \text{L1} + -\text{CT4} \cdot \text{L2} \end{aligned}$$

Totals and Virtual Registers

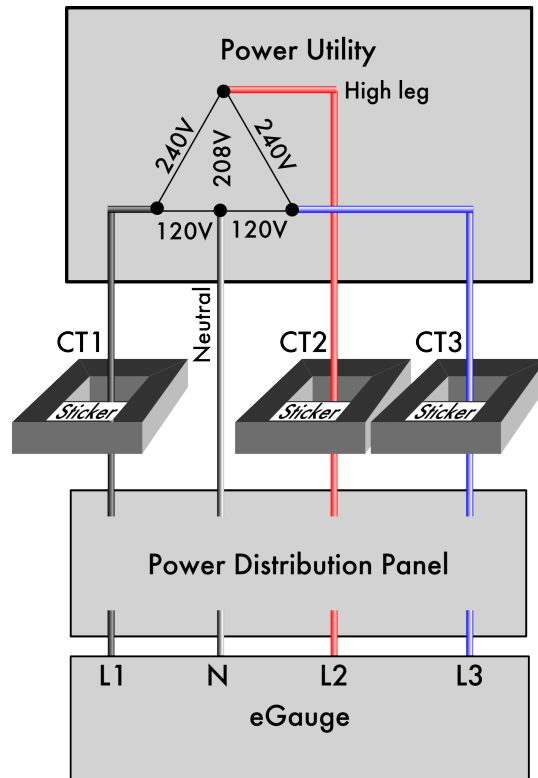
$$\begin{aligned} \text{Usage} &= \text{Grid} + \text{Solar} + \\ \text{Generation} &= \text{Solar} \end{aligned}$$

Notes:

- Same setup as for 120/208Y installation, except that a 277V transformer kit is needed to power the HomePlug adapter.

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

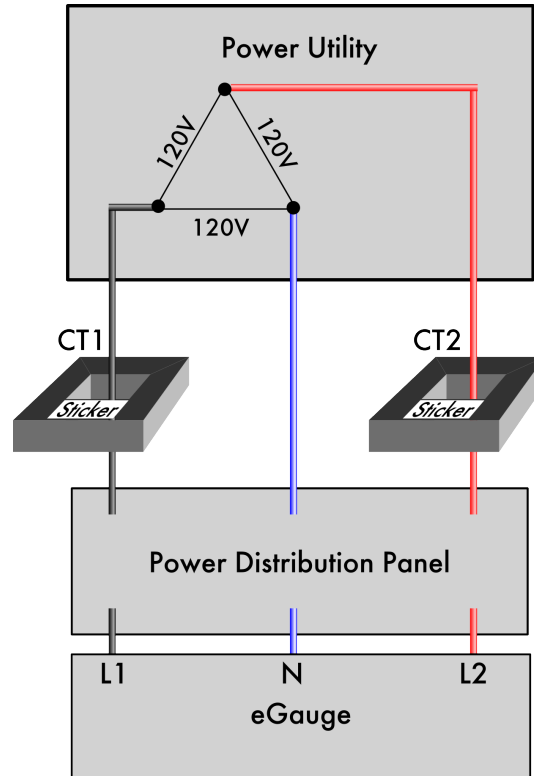
$$\text{Usage} = \text{Grid}$$

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

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

Totals and Virtual Registers

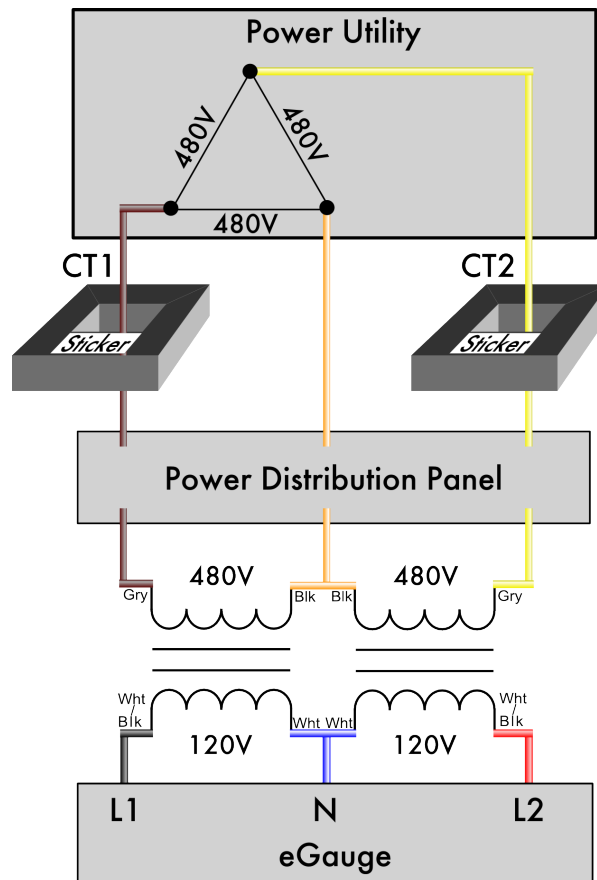
```
Usage = Grid
```

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 eGauge.
- 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

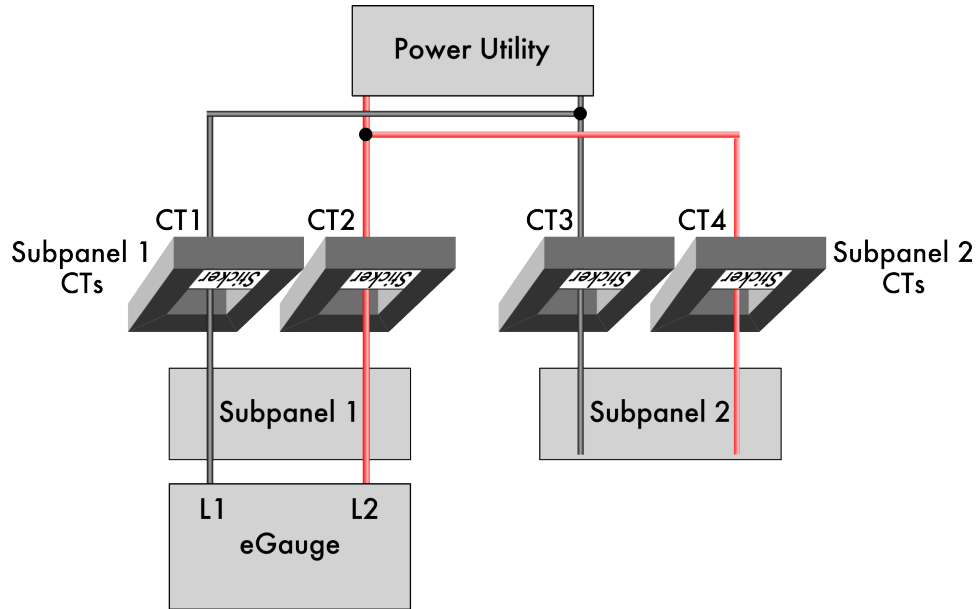
Usage = Grid

Notes:

- Please contact eGauge 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 eGauge.
- The HomePlug adapter should be plugged into an outlet wired in parallel with L1 and N of the eGauge and the outlet should be protected with a 0.5A Slow-Blow fuse.

2.8 Subpanels

This example illustrates how to measure subpanels.



Registers

```
Subpanel 1 = [P] [= ] CT1*L1 + CT2*L2
Subpanel 2 = [P] [= ] CT3*L1 + CT4*L2
```

Totals and Virtual Registers

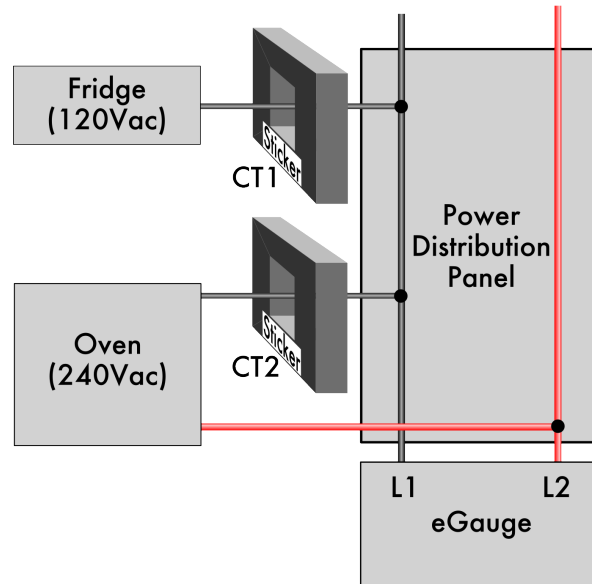
```
Usage = - Subpanel 1 - Subpanel 2
```

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 eGauge is installed in.

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
```

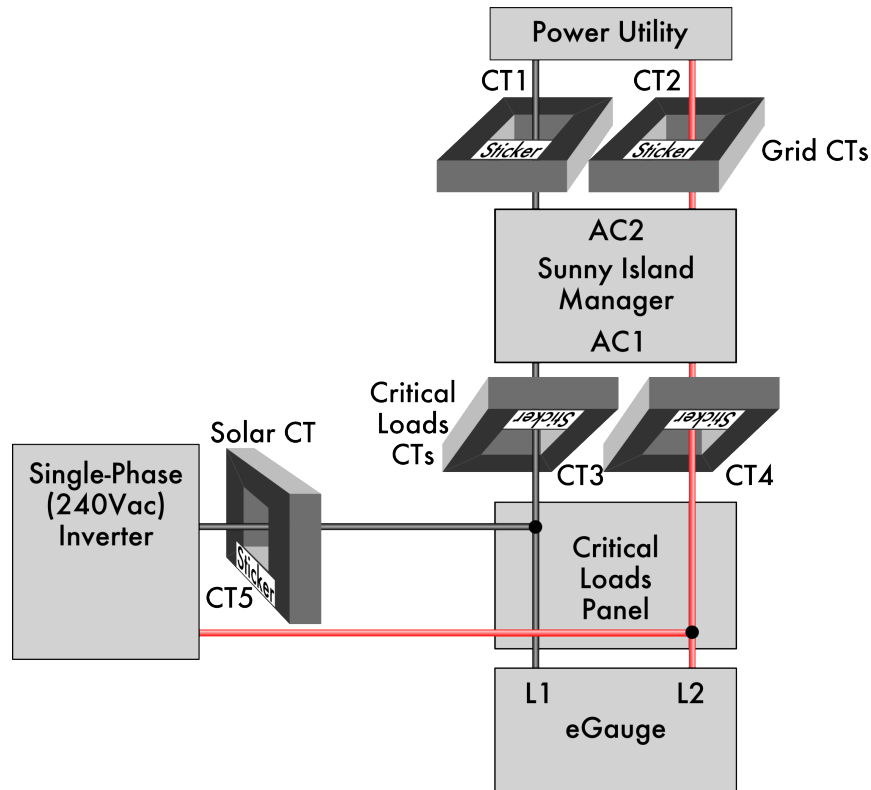
Totals and Virtual Registers

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.

2.10 SMA Sunny Island-based Battery-backed PV System

This example illustrates how to measure a battery-backed PV system using SMA Sunny Island manager.



Registers

Grid	=	[P] [=]	CT1*L1 + CT2*L2
Critical Loads Panel	=	[P] [=]	CT3*L1 + CT4*L2
Solar	=	[P] [=+]	CT5*L1 + -CT5*L2

Totals and Virtual Registers

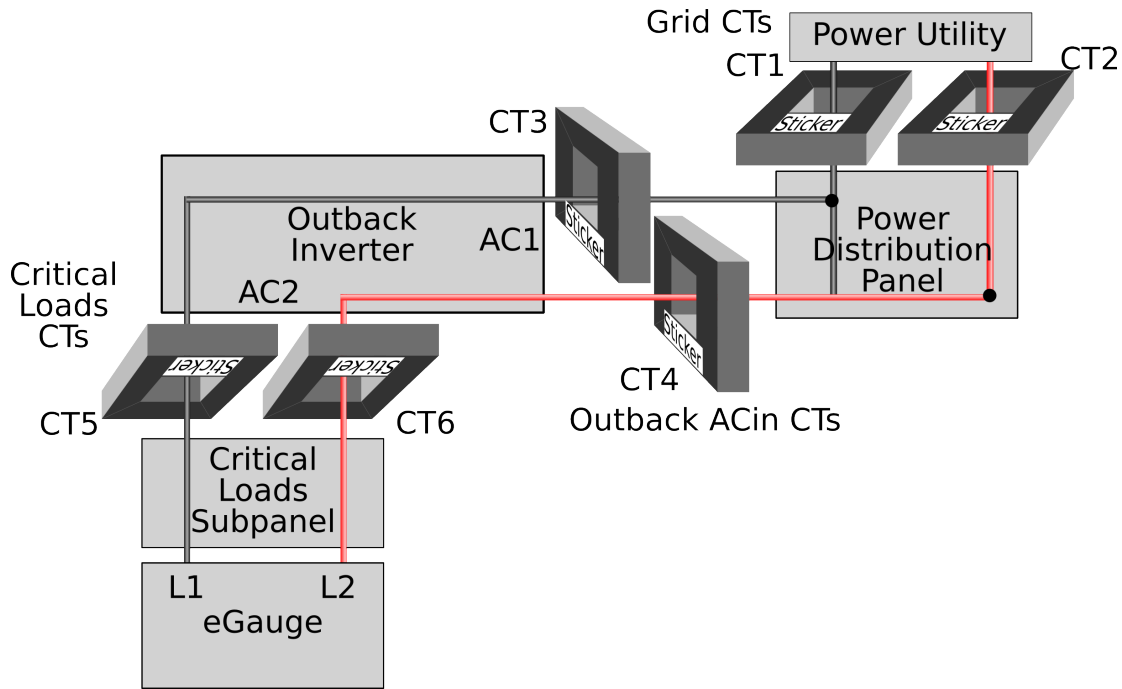
Usage	=	Grid + Solar+
Generation	=	Solar
Critical Loads Usage	=	-Critical Loads Panel - Solar+

Notes:

- The stickers on the CTs should point towards what is being measured: towards the utility for the Grid CTs, the subpanel for the Critical Loads CTs, and towards the PV inverter for the Solar CT.
- It is recommended, but not required, to power eGauge through the critical loads subpanel. Doing so ensures eGauge can properly record data even during a utility power outage.
- The Sunny Island manager has a built-in surge suppressor which filters out the HomePlug signal. Thus, the HomePlug adapter must be installed on the same side of the Sunny Island manager as the eGauge. We recommend powering both through the Critical Loads subpanel.

2.11 Outback System Using Separate Sets of CTs

This example illustrates how to measure a battery-backed solar system using an Outback inverter.



Registers

```

Grid           = [P] [= ] CT1*L1 + CT2*L2
Outback ACin  = [P] [= ] CT3*L1 + CT4*L2
Critical Loads = [P] [= ] CT5*L1 + CT6*L2

```

Totals and Virtual Registers

```

Usage          = Grid + Outback ACin - Critical Loads
Generation     = Outback ACin - Critical Loads

```

Notes:

- The stickers on the CTs should point towards what is being measured: towards the Outback inverter for the Outback ACin CTs and towards the subpanel for the Critical Loads CTs.
- It is recommended, but not required, to power eGauge through the critical loads subpanel. Doing so ensures eGauge can properly record data even during a utility power outage.
- The Outback system's net output (solar system output net of any power used to charge batteries or power supplied by batteries) is equal to Outback ACin - Critical Loads. The first addend (Outback ACin) can be negative or positive, depending on whether power is flowing into the Outback Inverter or out of it, respectively. The second addend (Critical Loads) is always negative, indicating a load. For example, if 1000W is flowing out of AC1, then Outback ACin = 1000W and if 500W is flowing out of AC2 into the critical loads subpanel, then Critical Loads = -500W, so subtracting the latter from the former yields a total output of 1500W from the Outback Inverter.

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 the “Tools” link in the top right menu of the eGauge web pages. Click on that link, then click on “Channel Checker” in the left menu. Figure ?? provides an example of what this tool looks like.

As of Thu Nov 05 2009 15:21:49 GMT-0700 (MST):

Frequency:	59.99 Hz	Grid (L1^CT1)	567.2 W (PF 0.77)
L1 (ch0):	n/a	Grid (L2^CT2)	607.5 W (PF 0.81)
L1 (ch8):	120.5 V	Oven (L1^CT3)	-15.7 W (PF 0.67)
L2 (ch1):	121.3 V	Oven (L2^CT3)	-16.2 W (PF 0.69)
L3 (ch9):	n/a	Solar (L1^CT4)	50.8 W (PF 0.14)
CT1:	6.09 A	Solar (L2^CT5)	48.3 W (PF 0.14)
CT2:	6.18 A	Aquarium Lgts (L2^CT6)	-153.3 W (PF 0.99)
CT3:	0.19 A	Drawer Fridge (L2^CT7)	0.0 W (PF 0.00)
CT4:	2.95 A		
CT5:	2.93 A		
CT6:	1.27 A		
CT7:	0.05 A		
CT8:	n/a		
CT9:	n/a		
CT10:	n/a		
CT11:	n/a		
CT12:	n/a		

Figure 2: Example of eGauge Channel Checker Tool

The channel checker reports the real-time RMS voltages measured for each active voltage probe and the RMS currents for each active CT (eGauge automatically determines which voltage and current probes are active based on the register definitions; if a voltage or a CT is not used by any register, it is deactivated). 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.

3.1 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.

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.

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 additional details. 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>	Return value of preference-setting named p (e.g., "global.production.rated").
<code>FFTarg(f, c)</code>	Returns phase-angle of spectral component at frequency f of input channel c .
<code>FFImag(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.

B Physical Unit

The table below lists the various physical units supported by eGauge. 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. eGauge 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 (see “eGauge XML API” manual).

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 $\$0.11\mu$.