eGauge Configuration Guide

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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 working properly:

1. The direction in which the CTs point matters. The sticker on the CTs should always point towards the entity being measured. For example, the utility when measuring power from the power grid, inverters for solar and/or wind generators, appliances when measuring loads, or a panel when measuring individual 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 "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 three sections:

1. Connected CTs
2. Registers (formerly called "Sources")
3. Totaling

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

After any of the settings have been changed, they can be saved by clicking on the "Save" button near the bottom of the page. For security reasons, you will be prompted for a username and password before the settings can be saved. When connected directly to the device (e.g., http://eGaugeNN.local or after clicking the "LAN Access" link), username "owner" can be used in combination with default password "default".

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.

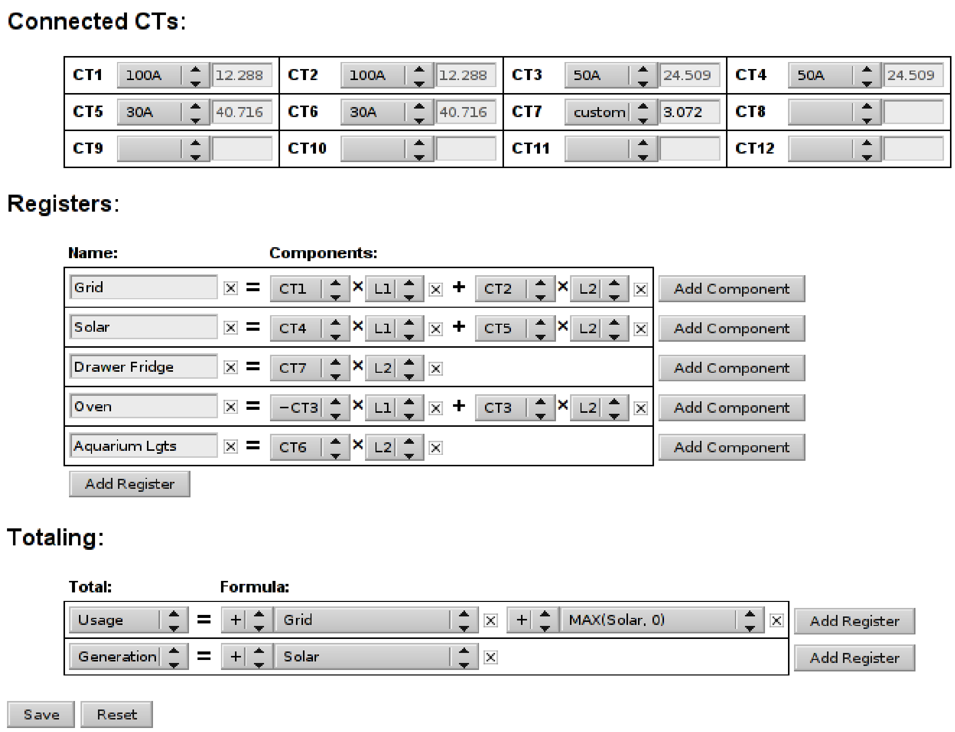


Figure 1: Example of eGauge Installation-Settings Page

Note: Firmware versions prior to v0.80 used the name "sources" instead of "registers." The name was changed to "registers" for clarity's sake, because registers can record both power sources (such as solar systems) and loads (such as appliances). To check which firmware a device has installed, click on the "Status" link in the top right section of an eGauge device's web-page.

1.1 CT Configuration

This section defines what kind of CT is connected to each of the twelve CT positions. A blank entry indicates that no CT is connected or that the CT isn't needed by any of the registers (see below). When a CT is connected to the device, simply select the appropriate current-rating from the pull-down list for the position that the CT is plugged into. For example, if a 100A CT is plugged into CT position 2, click on the pull-down list for CT2 and select "100A".

For each CT position, it is also possible to select "custom" as the CT rating. In this case, it is possible to manually enter a scaling factor. 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 large CTs that encompass all four conductors per phase, it is usually much more economical to install smaller CTs that encompass only a single conductor per phase. Assuming the current on the four conductors is balanced, the smaller CTs will capture a fourth of the total current per phase. To compensate for that, enter a custom scale factor that is a quarter of factor that would normally be used for the current the CT is rated for. For example, if a 100A CT were used, the scale factor would normally be 12.288 (displayed when "100A" is selected). To multiply the measured current by a factor of four, we would enter a scale factor which is a fourth of 12.288, or 3.072.

1.2 Register Configuration

This section of the installation page defines how individual current and voltage measurements are combined to calculate power figures for one or more registers. Each register is recorded separately in the database built into eGauge, so this section also defines the level of detail that gets recorded. For example, it would be possible to define a separate register for each phase of a measured entity. However, this level of detail is usually not necessary, so more typically, eGauge is configured to combine all the phases of an entity into a single register.

In Figure 1 we see that five registers have been defined: `Grid`, `Solar`, `Drawer Fridge`, `Oven`, and `Aquarium Lgts`. Additional register can be defined by clicking on the "Add Register" button. Similarly, existing registers can be deleted by clicking the remove icon to the right of the register name.

If we look at register `Drawer Fridge`, we see it is defined as `CT7*L2`. What this means is that the power for the drawer fridge is calculated as the product of the current measured by CT7 and the voltage measured on line L2. If the drawer fridge were wired to both legs, a component could be added by clicking on the "Add Component" button to the right. Similarly, an existing component can be deleted by clicking on the remove icon to the right of the component which is to be deleted.

Looking at register `Grid`, we see that it is defined as the sum of two products: `CT1*L1 + CT2*L2`. This is typical for a residence with a split-phase connection to the utility's power grid. The definition says that the total power coming from the utility is the sum of the power on both legs. Note that if a site has a renewable energy system (e.g., a solar system), the products `CT1*L1` and `CT2*L2` may become negative, indicating power is being fed back into the grid.

Register `Oven` is also interesting: it is defined as `-CT3*L1 + CT3*L2`. What this means is that the current readings on CT3 are first negated and then multiplied by the voltage on line L1 then that is added to the (original) readings from CT3, multiplied by the voltage on line L2. This is useful for pure 240Vac loads (or, in general, multi-phase loads), where it is known that the current in one leg is exactly the same as in another leg, except that the direction of the current flow is reversed.

> **Note:** By default, there is a storage-limit of eight registers. Please contact eGauge Support if you have applications requiring more registers.

1.2.1 Register Name Syntax

Register names may contain any ASCII/UTF-8 characters except for control characters such as backspace, delete, or newline. Punctuation marks such as slash, backslash, quotes, etc., are all permissible. Through UTF-8, it is also 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 storage. eGauge limits the length of register names to 15 bytes. With English characters, register-names can therefore be up to 15 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.

1.2.2 Special Register Names

Register names that start with `Grid` or `Subpanel` are in treated specially. Normally, any register that supplies power (reports positive power figures) is considered a renewable energy source. Of course, grid power is not usually from renewable energy sources (or at least not to a significant enough degree), so eGauge treats sources with those special names as non-renewable. In practical terms, the main effect of this is that in the legend of the main graph, registers with those special names do *not* appear there, since their data is sufficiently represented in the total consumption figure.

1.3 Totaling Rules Configuration

This final section defines how registers should be combined to form certain higher-level quantities. At this time, there are two such quantities: `Usage` and `Generation`. The former represents total power consumption at a site. The latter represents the total amount of renewable power being generated on site.

On the graph of the eGauge main page, total consumption (`Usage`) is represented by a thick red line and total renewable energy production is represented by a thick green line.

In Figure 1, we see both quantities defined: `Generation` is defined as being equal to register `Solar`. If there were multiple renewable energy systems (e.g., multiple solar systems and/or wind turbines), the register for each system would be added to this line. Registers are added by clicking on the "Add Register" button to the right. Similarly, a register can be deleted by clicking the remove icon ☒ to the right of the register name.

Each register can either be added to or subtracted from the total, as indicated by the plus or minus sign which can be selected from the drop-down menu to the left of the register name.

In addition to directly adding or subtracting the value of a register, it is also possible to add only positive or negative values of a register. In Figure 1 this is shown in the line for the `Usage` total: it adds `MAX(Solar,0)` rather than just `Solar`. What this does is add the value of register `Solar` to the total, provided it has a positive value. If it is negative, the register's value is ignored. The formula `MIN(Solar,0)` would do the opposite: add the register's value, provided it is negative and ignore it otherwise. See Section 2.1 for an example of how the `MAX` operator is used.

If a site does not provide either total consumption or renewable energy production, the corresponding totaling rule can be removed by selecting the blank entry from the pop-down menu. Note that blanking out both entries in the totaling rules would cause *no* lines to be displayed in the graph on the device's main page, which would not be useful. However, eGauge readily supports sites measuring only renewable energy production or only power consumption, so leaving one or the other blank is no issue.

2 Configuration Examples

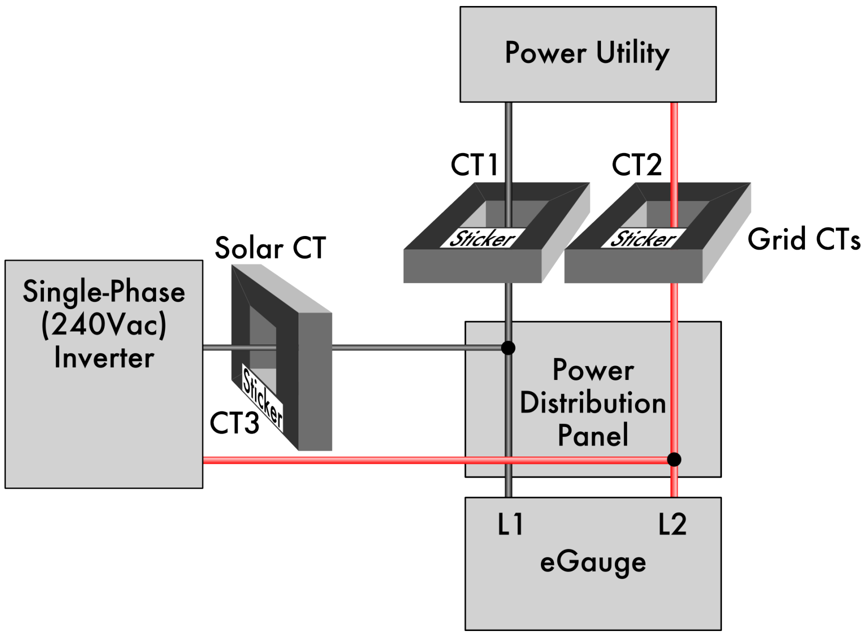
The following pages illustrate various common installation scenarios and matching configurations. For clarity, the diagrams have been simplified in the following manner:

- 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 Disconnected."

2.1 Standard Split-Phase

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



Registers

```
Grid   =  CT1*L1 + CT2*L2
Solar  =  CT3*L1 + -CT3*L2
```

Totaling

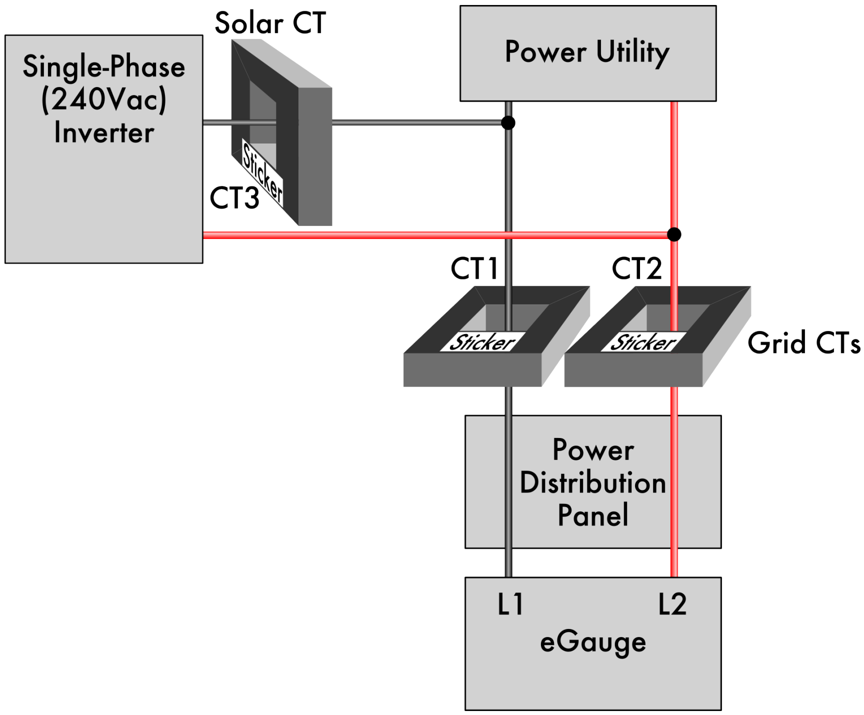
```
Usage       =  Grid + MAX(Solar, 0)
Generation  =  Solar
```

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, if it is positive, `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

```
Grid    =  CT1*L1 + CT2*L2
Solar   =  CT3*L1 + -CT3*L2
```

Totaling

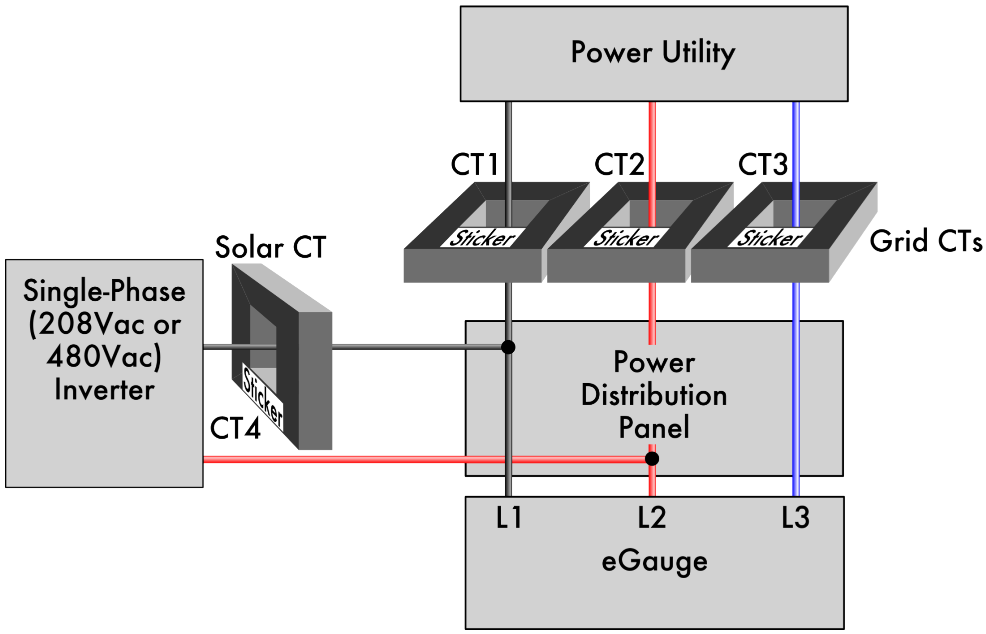
```
Usage       =  Grid - MIN(Solar, 0)
Generation  =  Solar
```

Notes:

- The only difference compared to the standard installation is that the `+MAX(Solar,0)` component was replaced by `-MIN(Solar,0` 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. The expression `-MIN(Solar, 0)` 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 Standard Three-Phase

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



Registers

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

Totaling

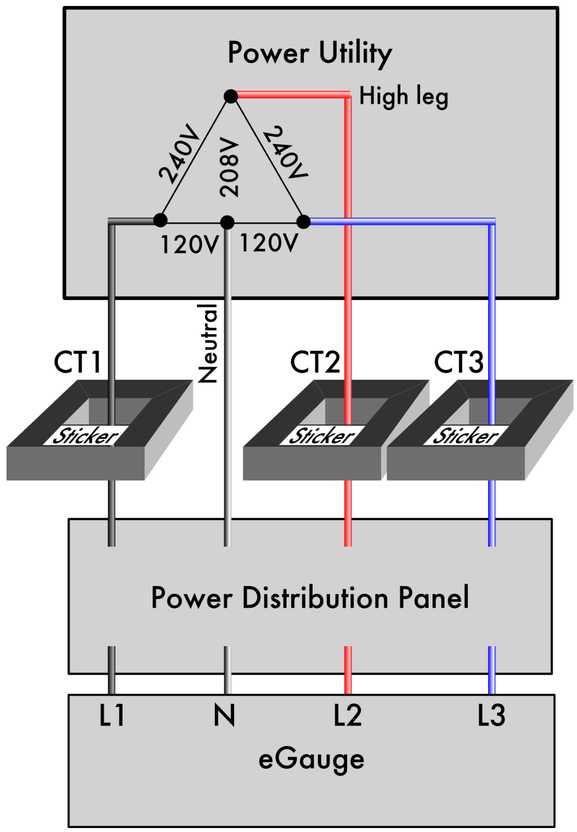
```
Usage       =  Grid + MAX(Solar, 0)
Generation  =  Solar
```

Notes:

- Three-phase installations are 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.
- Same configuration applies both for 208Vac (120Vac to ground) and 480Vac (277Vac to ground) systems.
- 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 High-leg Delta Three-Phase

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



Registers

```
Grid  =  CT1*L1 + CT2*L2 + CT3*L3
```

Totaling

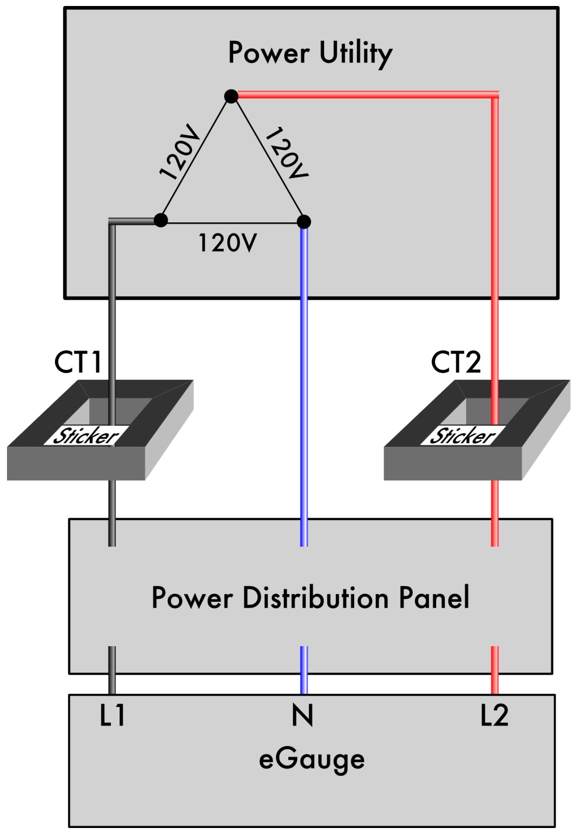
```
Usage  =  Grid
```

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.

2.5 Delta Three-Phase

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



Registers

```
Grid  =  CT1*L1 + CT2*L2
```

Totaling

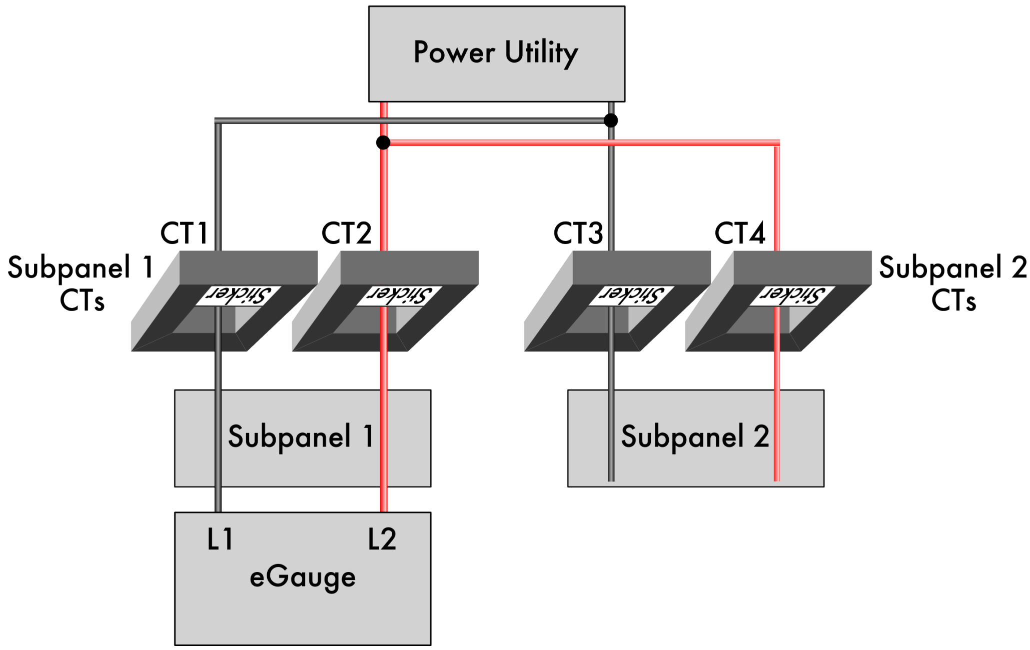
```
Usage  =  Grid
```

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.

2.6 Subpanels

This example illustrates how to measure one or more subpanels.



Registers

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

Totaling

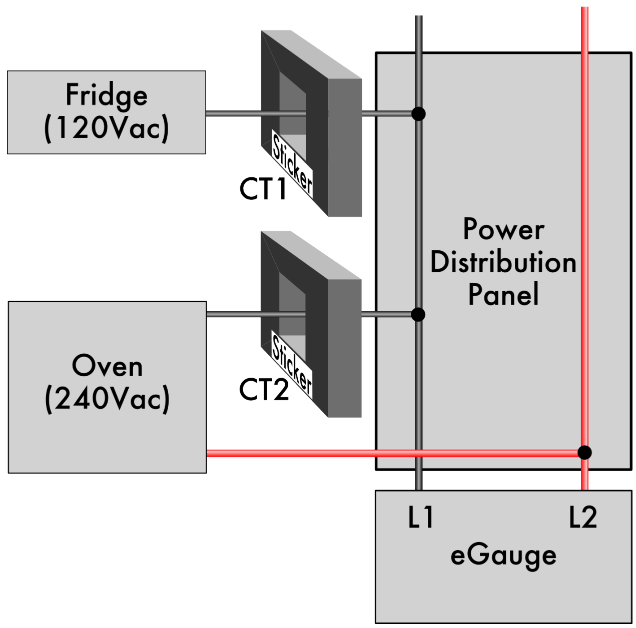
```
Usage  =  -Subpanel 1 + -Subpanel 2
```

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.

2.7 Appliances

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



Registers

```
Fridge   =  CT1*L1
Oven     =  CT2*L1 + -CT2*L2
```

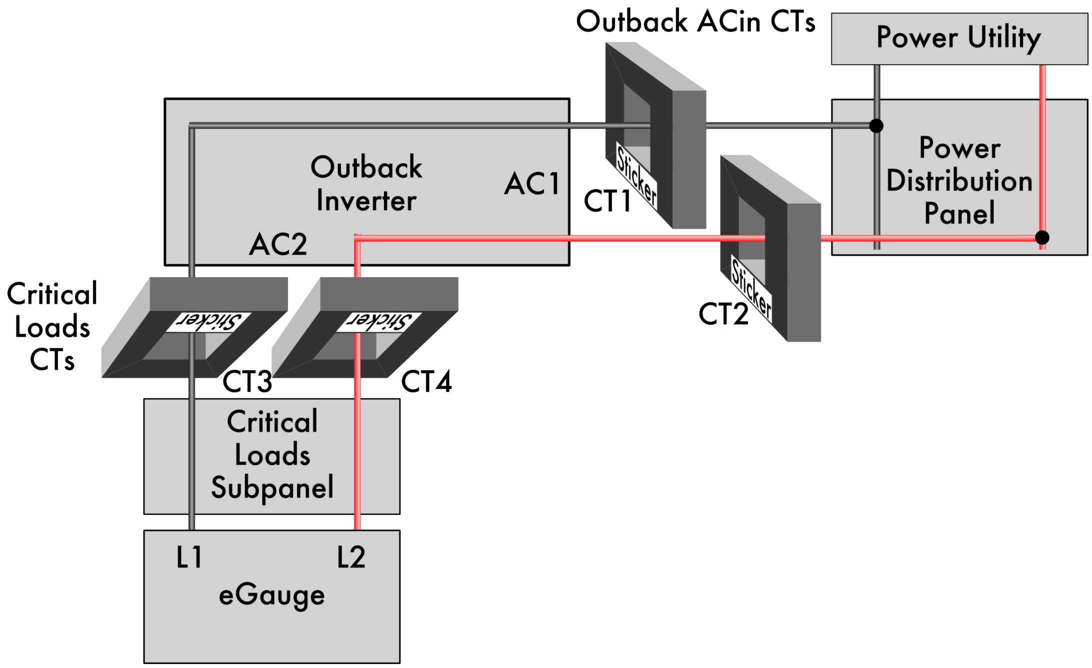
Totaling

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” section of the main 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.

2.8 Outback System Using Separate Sets of CTs

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



Registers

```
Outback ACin    =  CT1*L1 + CT2*L2
Critical Loads  =  CT3*L1 + CT4*L2
```

Totaling

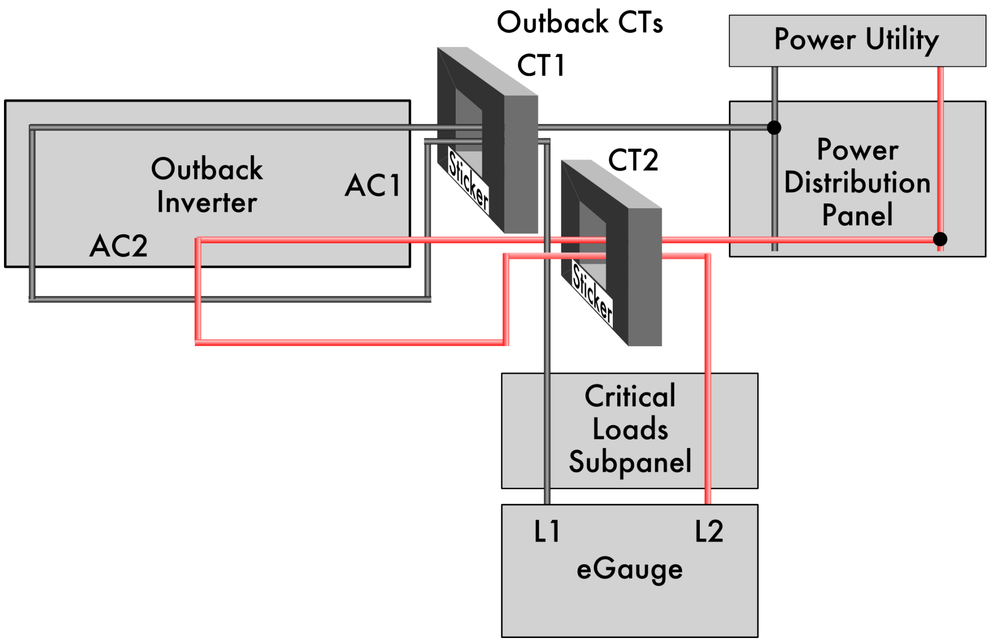
```
Usage       =  ...  + Outback ACin + -Critical Loads + ...
Generation  =  ...  + Outback ACin + -Critical Loads + ...
```

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 summand (`Outback ACin`) can be negative or positive, depending on whether power is flowing into the Outback Inverter or out of it, respectively. The second summand (`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.

2.9 Outback System Using Single Set of CTs

Same as previous example except that a single set of CTs is used to measure the Outback System's net output.



Registers

```
Outback   =  CT1*L1 + CT2*L2
```

Totaling

```
Usage        =  ...  + MAX(Outback, 0) + ...
Generation   =  ...  + Outback + ...
```

Notes:

- The stickers on the CTs should point towards what is being measured, i.e., towards the Outback inverter.
- The summing of the power coming out of AC1 and AC2 is achieved by running a pair of wires through each of the two CTs. It is critical to ensure that wires on the *same leg* are run through the CTs.
- This configuration uses fewer CTs than the previous example, but is usually more difficult to install because of the more complicated wire-runs.

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 2 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 realtime 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.