eGauge Configuration Guide

Before continuing, we highly recommend checking out our Getting Started guide at
`http://egauge.net/start`

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.

Please review the Getting Started guide at `http://eGauge.net/start` for a short introduction on installing and configuring the eGauge meter.

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

1. Potential Transformers (PTs)

2. Sensors [1]

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. If the original purchaser of the meter has a special configuration called a "personality" that defines usernames and passwords, one of those must be used. If there was not a personality used or it did not have custom passwords set, the default username is "owner". The "owner" account password prior to January 2021 was "default". After January 2021, "owner" account passwords are randomized and printed on a label on the bottom side or back side of the unit. 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.

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[1]Changed from "Current Transformers" in firmware v4.0 Update firmware in Tools → Firmware Upgrade or use the old config guide at egauge.net/help/v3config

Potential Transformers (PTs):

L1 | direct (no PT) ▼ | L2 | direct (no PT) ▼ | L3 | direct (no PT) ▼

Sensors:

CTid ®

Use high-gain mode ☐

S1	JD JS 36mm/1.42" 400A ▼	✕1	S2	JD JS 36mm/1.42" 400A ▼	✕1	S3	JD JS 36mm/1.42" 400A ▼	✕1
S4	JD JS 16mm/0.63" 50A ▼	✕1	S5	JD JS 16mm/0.63" 100A ▼	✕1	S6	JD JS 16mm/0.63" 100A ▼	✕1
S7	JD JS 16mm/0.63" 100A ▼	✕1	S8	JD JS 10mm/0.39" 30A ▼	✕1	S9	JD JS 10mm/0.39" 30A ▼	✕1
S10	▼		S11	▼		S12	▼	
S13	▼		S14	▼		S15	▼	

Remote Devices:

| Device name: | | Protocol: | | Device address: | | | |
| Secondary | ✕ = | remote eGauge via UDP ▼ | 1708009 | ✓ ⓘ | Edit |
| Add Device |

Registers (10 of 64 in use):

Name:		Recorded value/formula:											
Main Service	✕ =	P ▼	=	S1 ▼	✕L1 ▼	✕ +	S2 ▼	✕L2 ▼	✕ +	S3 ▼	✕L3 ▼	✕	Add Component
Solar	✕ =	P ▼	=+	S4 ▼	✕L1 ▼	✕ +	−S4 ▼	✕L2 ▼	✕				Add Component
Mech Room Panel	✕ =	P ▼	=	S5 ▼	✕L1 ▼	✕ +	S6 ▼	✕L2 ▼	✕ +	S7 ▼	✕L3 ▼	✕	Add Component
120V Transformer Panel	✕ =	P ▼	=	S8 ▼	✕L2 ▼	✕ +	S9 ▼	✕L3 ▼	✕				Add Component
Secondary - Main Room	✕ =	Secondary ▼	P114 (Main Room) ▼										
CT1 Amperage	✕ =	S ▼	S1 ▼	normal value ▼									
CT1 Frequency	✕ =	S ▼	S1 ▼	frequency ▼									
L1 Voltage	✕ =	L ▼	L1 ▼	normal value ▼									
L1 Frequency	✕ =	L ▼	L1 ▼	frequency ▼									
Add Register

Totals and Virtual Registers:

Usage	=	+ ▼	Main Service ▼	✕ + ▼	Secondary - Main Room ▼	✕	Add Register
Generation	=	+ ▼	Solar ▼	✕			Add Register
Battery	=						Add Register
Battery left	=						Add Register
A.Usage	✕ =	+ ▼	Secondary - Main Room ▼	✕			Add Register
Add Virtual Register

Save | Reset

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.

It is highly recommended to use the eGauge High Voltage Sensor if measuring 480V or 600V deltas (no neutral) or 347/600V wye systems. The eGauge High Voltage sensor can read up to 707Vac. For more information visit `http://egauge.net/support/m/ev1000`.

1.2   Sensor Configuration

This section defines what kind of sensor or current-transformer (CT) is connected to each of the CT positions. Depending on the eGauge model, there are between 12 and 30 inputs. A blank entry indicates that no CT or sensor is configured.

1.2.1   CT orientation

The direction or orientation of the CT matters and affects the polarity (positive or negative) of the power values. While power values are correct in either orientation, having negative values will cause the cumulative values (aka meter readings) to decrease over time.

It is imperative to have CTs oriented in a consistent manner, as power values are typically added together and inconsistent polarity will cause those values to be higher or lower than real. For example, if a three-phase service has 1 kW on each phase (3kW total consumption), but the CTs are oriented inconsistently, they may read 1kW, -1kW, and 1kW. When added together, the total will read 2 kW, not 3 kW, due to the reversed CT.

The table below describes the proper orientation for CTs to give positive power readings.

MODEL	Orientation for positive readings
J&D Split-Core	Point the arrow **against the direction** of current flow
Blue Continental Control AccuCT	Face the sticker **against the direction** of current flow
eGauge ECS series	Point the arrow in the **same direction** as the current flow
Orange flexible rope CTs	Point the arrow **against the direction** of current flow

Table 1: CT model description

1.2.2   Classic CT configuration method

When using a CTid enabled sensor, skip to section 1.2.3.

When a non-CTid enabled 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 2)
`[MODEL]`	CT Model (see table 3)
`[SIZE_MM]`	Inner-diameter in millimeters
`[SIZE_IN]`	Inner-diameter in inches
`[AMPERAGE]`	Amperage rating of CT (not breaker amperage)

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.

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

Table 2: 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 3: CT model description

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).

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.

1.2.3   CTid® (EG4xxx only)

Available only on the EG4xxx models and with compatible sensors, CTid® allows for automatic detection and configuration of sensor inputs. A selection of CTid enabled CTs and other sensors are sold by eGauge Systems. To configure these sensors, click the blue CTid® button above the CT drop-down menu.

For more information, see `http://egauge.net/support/ctid`

1.2.4   High-gain mode (EG4xxx only)

Available only on the EG4xxx models, High-gain mode amplifies the signal to the eGauge sensor ports by 10 times. This allows, for example, a 100A CT to act as a 10A CT. High-gain mode affects **all sensor 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.

1.2.5 Rope CTs (Rogowski Coils)

Self-powered rope CTs are wired directly to the eGauge 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

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 full information on using remote devices, please visit `http://egauge.net/support/remote-devices`.

For our running example, we will select "`remote eGauge via UDP`" as the protocol and "`1708009`" 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 any-more. 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, and both are using HomePlug, you can use the `Settings →` `HomePlug` screen to verify that the remote device can be reached with good signal strength.

For additional information on why it failed, you may click the info button ("i" in a blue circle) to the right of the red x.

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, sixteen or 64 registers. Devices can also be ordered with an optional alternative database, which increases the limit to 64, 128, or 256 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.

The latest generation of hardware (EG4xxx) by default use a 64-register database. The latest hour of second-by-second data is stored in volatile memory (cleared upon reboot). The latest year of data is stored in minute-by-minute granularity. The following 10 years of data is stored in 15-minute granularity. After that, data is condensed to 1-day for the lifetime of the device. All data is retained on the device; the device does not copy the data to the internet.

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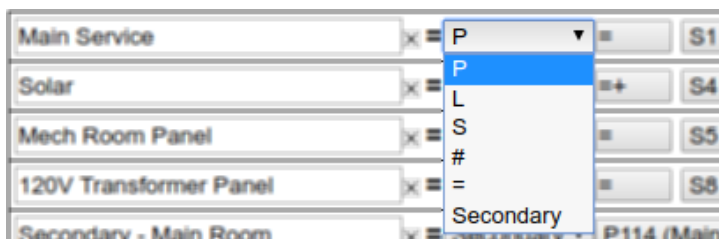
The entries in this popup-menu have the following meaning:

P: Records the **power** calculated from one or more current/voltage-pairs.

L: From a **Line voltage** input, records either *normal value* (AC), *DC-only (mean) value*, or *frequency* of the chosen Line input.

S: From a **Sensor** input, records either *normal value* (AC), *DC-only (mean) value*, or *frequency* of the chosen Sensor input.

#: 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, `Secondary`), 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 nine rows in the `Registers` section: the first four calculate power (`P`). We will discuss those in more detail in the next section.

The fifth row defines a remote register that records the data from the "`P114 (Main Room)`" register of remote device `Secondary`.

The sixth row is a register that records the AC current of the CT connected to port 1 (`S → S1 → normal value`). The seventh records the frequency of the CT connected to port 1 (`S → S1 → frequency`).

The eighth records the AC voltage of line input 1 (`L → L1 → normal value`). The last register records the frequency of line of line input 1 (`L → L1 → frequency`).

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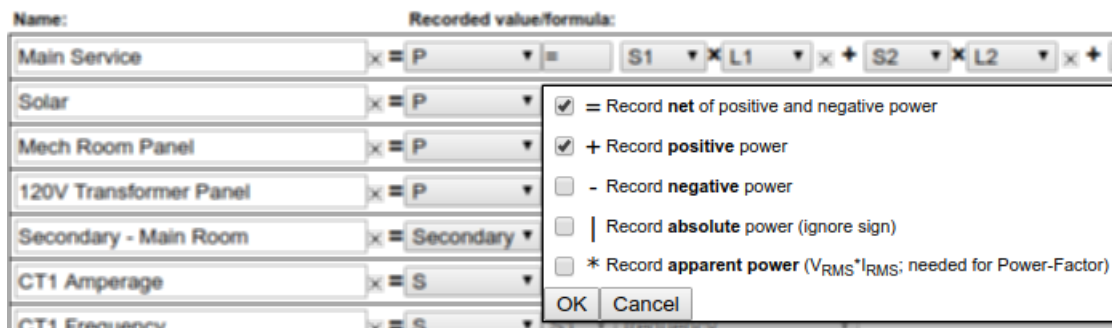
As shown here, there are five subtypes which can be recorded by turning on the corresponding checkbox:

= (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. **WARNING**: This calculates the total power of all components in the formula and then takes the absolute value. Given a formula of `CT1*L1 + CT2*L2` where `CT1*L1` is –500 W and `CT2*L2` is +300 W, the resulting value will be +200 W, not 800 W.

∗ (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 `Main Service` and `Solar` registers look as follows:

This shows that `Main Service` power is calculated as the product of the current measured by CT1 (S1) and the voltage measured on line L1 (e.g., black leg) plus the current measured by CT2 (S2) and the voltage measured on line L2 (e.g., red leg), plus the current measured by CT3 (S3) and the voltage measured on line L3 (e.g., blue leg). In other words, the power coming from the three legs of the three-phase power feed from the utility are combined into a single register. It us possible to record the three 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 `-S4` 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 another CT, we can simply use the negated value of `S4`, i.e., `-S4` 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 `-S4` 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 `S4` and `-S4` 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 `Main Service` measures the real power used at a site, then register `Main Service*` 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 `Main Service` by `Main Service*`. This can be accomplished by defining a formula register as shown below:

In this example, we named the register "`Main 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 B, various choices are available here: power, voltage, irradiance, and so on. In our case, power-factor is a unit-less number between 0 and 1, so we selected `Number with 3 decimals` from the drop-down box. Finally, we entered a formula of `abs($"Main Service")/$"Main Service*"` 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. 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).

A list of functions that are available for use in calculating the value of a formula register can be found in Appendix A. 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.

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:

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 `Main Service`, only the net (=) subtype is being recorded, so it shows up only once as `Main Service` (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.

Two more special virtual registers have been added in firmware v4.0 called `Battery` and `Battery left`. These are intended to be filled by remote device data from a battery backup system, and used with the mobile-friendly dashlet interface introduced in firmware v4.0 and future firmware features.

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 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.

- Pay attention to phasing: CTs must be configured for the correct phase they are on. E.g., if a breaker feeding the eGauge L1 is black, CTs around the any black phase must be applied to L1. The first available breaker slot may not be the actual panel L1 and may cause an offset between the eGauge phasing and panel phasing. Visit `http://egauge.net/support/phasing` for more information on phasing and how to validate consistent phasing.

- CT directionality. AC CTs may face one of two directions, and will give a positive or negative power value depending on which direction the current flows. Positive or negative values are arbitrary, but care must be taken to orient all CTs consistently.

  To obtain positive power values:

  - For ECS model split-CTs with CTid, the arrow on the CT should point in the same direction of the current flow.
  - For all other split-core CT models, the current should flow into the end with the sticker, and out the non-stickered end.
  - For Rope CTs, the current should flow against the arrow.

  Bidirectional power will result in the opposite power polarity when the current direction changes.

- EG4xxx meter diagrams and other hardware are simplified for clarity.

- Ground wiring is not shown (note: eGauge meters and equipment do not have a ground connection).

- Most examples are partial configurations. For a complete system, the configurations from various examples may have to be combined.

- All Sensor inputs are Current Transformer inputs, so "CT1" and "S1" may be used interchangeably, similarly "CT3" and "S3" mean the same thing.

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 back-fed

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

Registers

```
Grid   =  [P] [= ] S1*L1 + S2*L2
Solar  =  [P] [=+] S3*L1 + -S3*L2
```
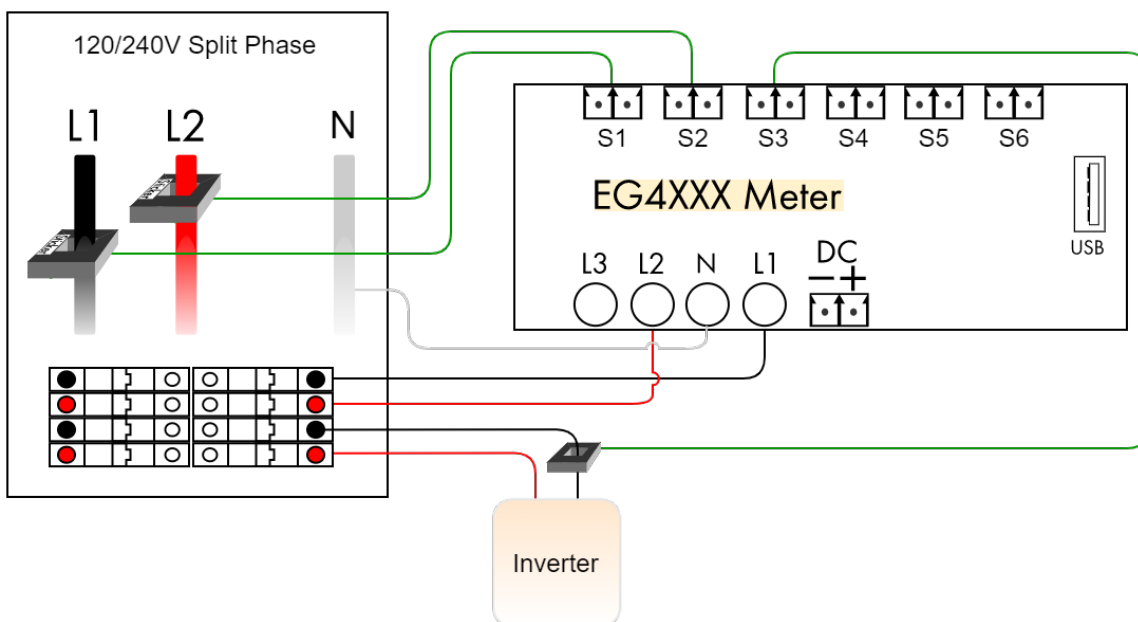
Totals and Virtual Registers

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

Notes:

- With a 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 2 CTs on the inverter, 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

```
Grid   =  [P] [= ] S1*L1 + S2*L2
Solar  =  [P] [=-] S3*L1 + -S3*L2
```
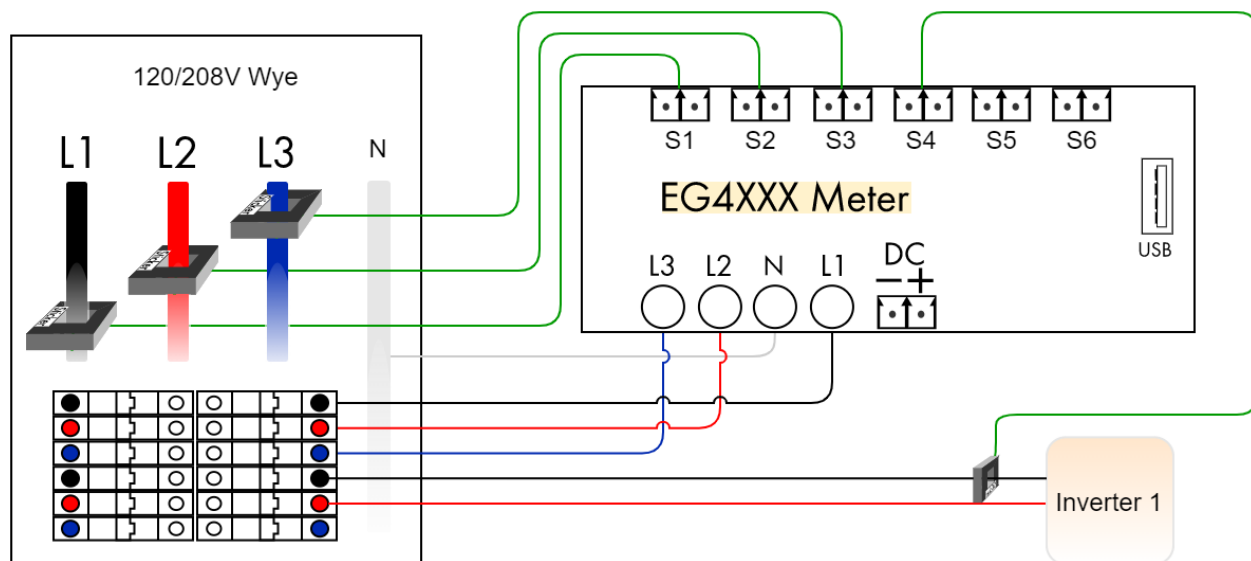
Totals and Virtual Registers

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

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] [= ] S1*L1 + S2*L2 + S3*L3
Solar =  [P] [=+] S4*L1 + -S4*L2
```

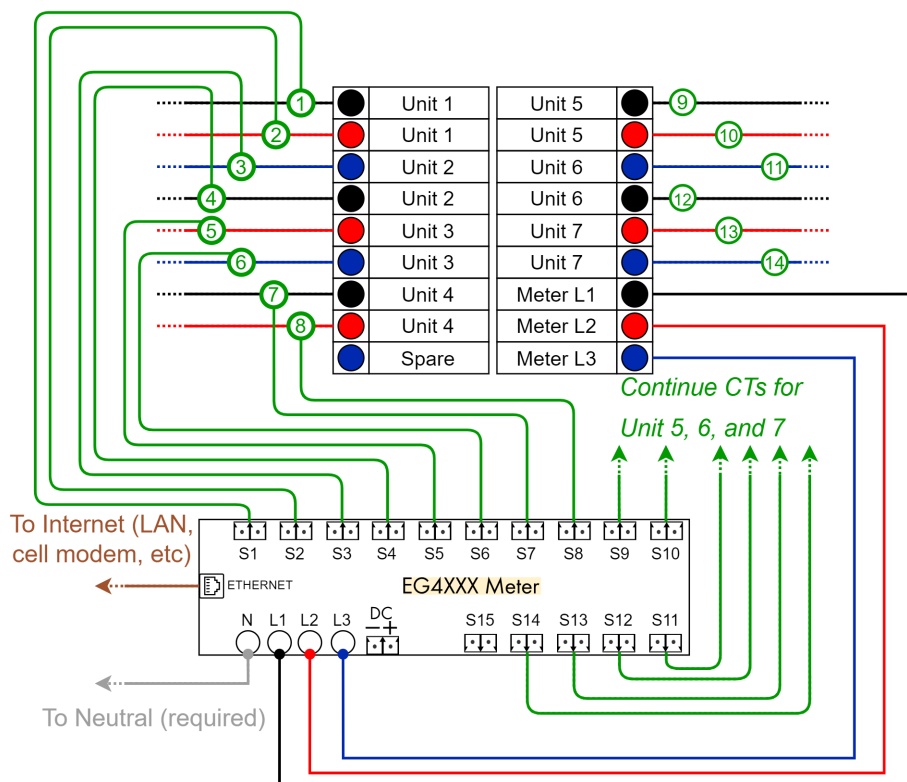**Totals and Virtual Registers**

```
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 = S5*L2 + -S5*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   Submetering single-phase units on a 120/208V service

The EG4xxx series meters are capable of monitoring up to 7 single-phase units (EG4015) or 15 single-phase units (EG4030) with a single meter. Single-phase units require 2 CTs each, one for each phase.

Registers

```
Unit 1  =  [P] [= ] S1*L1 + S2*L2
Unit 2  =  [P] [= ] S3*L3 + S4*L1
Unit 3  =  [P] [= ] S5*L2 + S6*L3
Unit 4  =  [P] [= ] S7*L1 + S8*L2
Unit 5  =  [P] [= ] S9*L1 + S10*L2
Unit 6  =  [P] [= ] S11*L3 + S12*L1
Unit 7  =  [P] [= ] S13*L2 + S14*L3
```

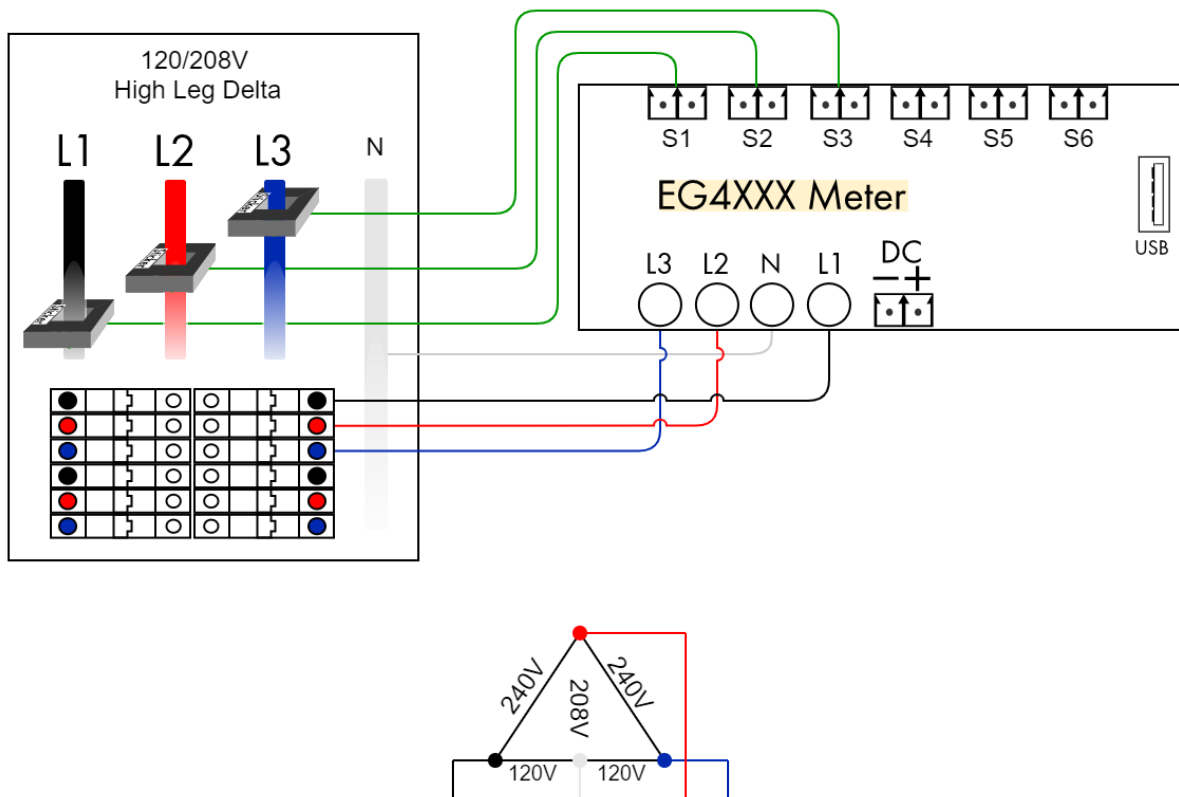### Totals and Virtual Registers

```
Usage  =  Unit 1 + Unit 2 + Unit 3 + Unit 4 + Unit 5 + Unit 6 + Unit 7
```

Notes:

- While the phasing pattern for units is typically staggered as L1 and L2, then L3 and L1, then L2 and L3, and so on, in this example it changes with Unit 5 because the breakers for Unit 5, 6, and 7 begin on the right-hand side of the panel.

2.5 Three-Phase High-leg Delta

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

Registers

```
Grid  =  [P] [= ] S1*L1 + S2*L2 + S3*L3
```
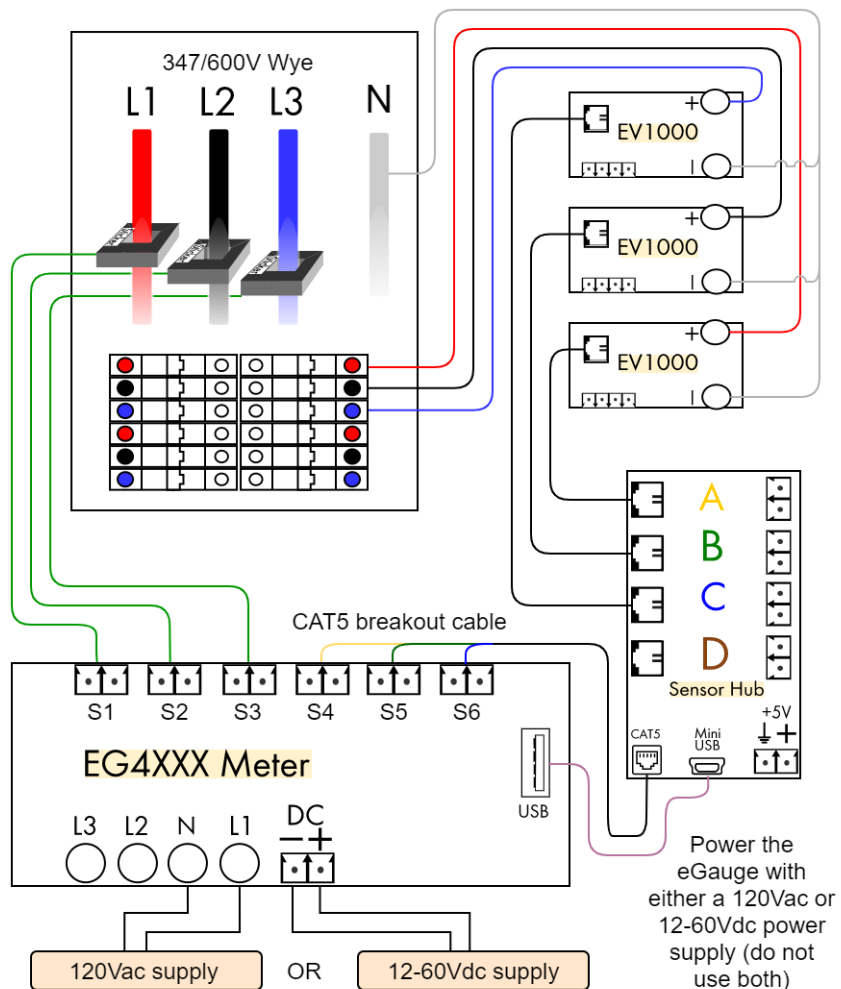
Totals and Virtual Registers

```
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.

2.6   Three-phase 347/600V Wye

Three-phase 347/600V Wye installation measuring power coming from a power utility (grid).

Registers

```
Grid  =  [P] [= ] S1*S4 + S2*S5 + S3*S6
```
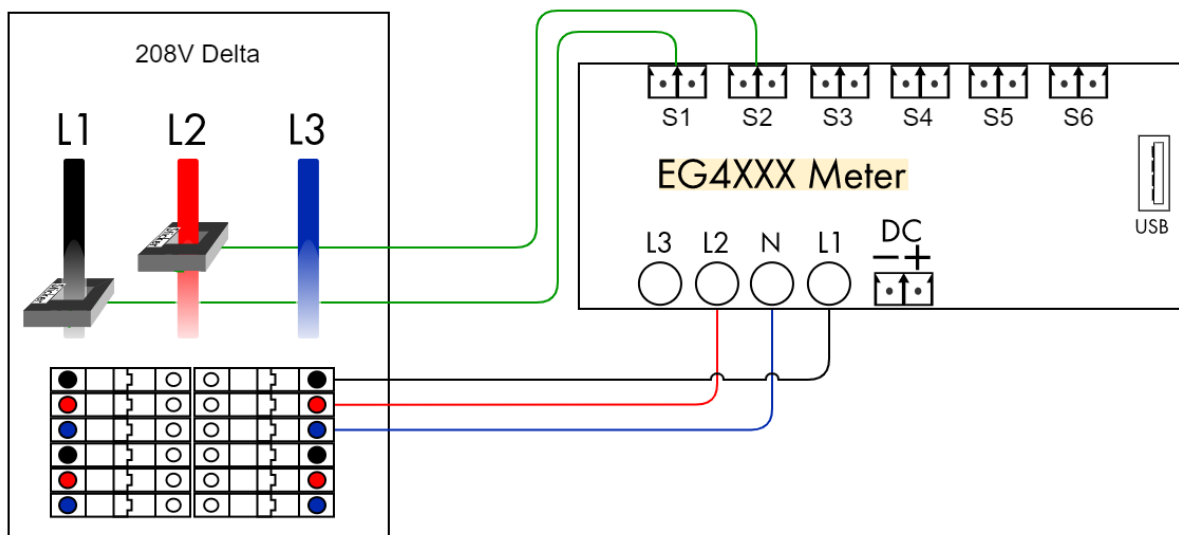
Totals and Virtual Registers

```
Usage  =  Grid
```

Notes:

- Requires the eGauge Sensor Hub, 3x EV1000 voltage sensors and an EG4xxx series meter.

- Please visit `http://egauge.net/support/m/ev1000` for more information on using the EV1000 high voltage sensors sensors and Sensor Hub.

2.7 Three-Phase Delta

Three-phase delta installation measuring power coming from a power utility (grid). The color diagram below shows a 208V delta, but this also applies to a 120V delta or 240V delta.

Registers

```
Grid  =  [P] [= ] S1*L1 + S2*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.

- The eGauge inputs can measure up to 277V L-N terminal. A 600V delta must be measured the same way as a 480V Delta.

2.8 Three-Phase Delta 480V

High-voltage (480V) three-phase delta installation measuring power coming from a power utility (grid). This same method may applies to a 600V delta.

Registers

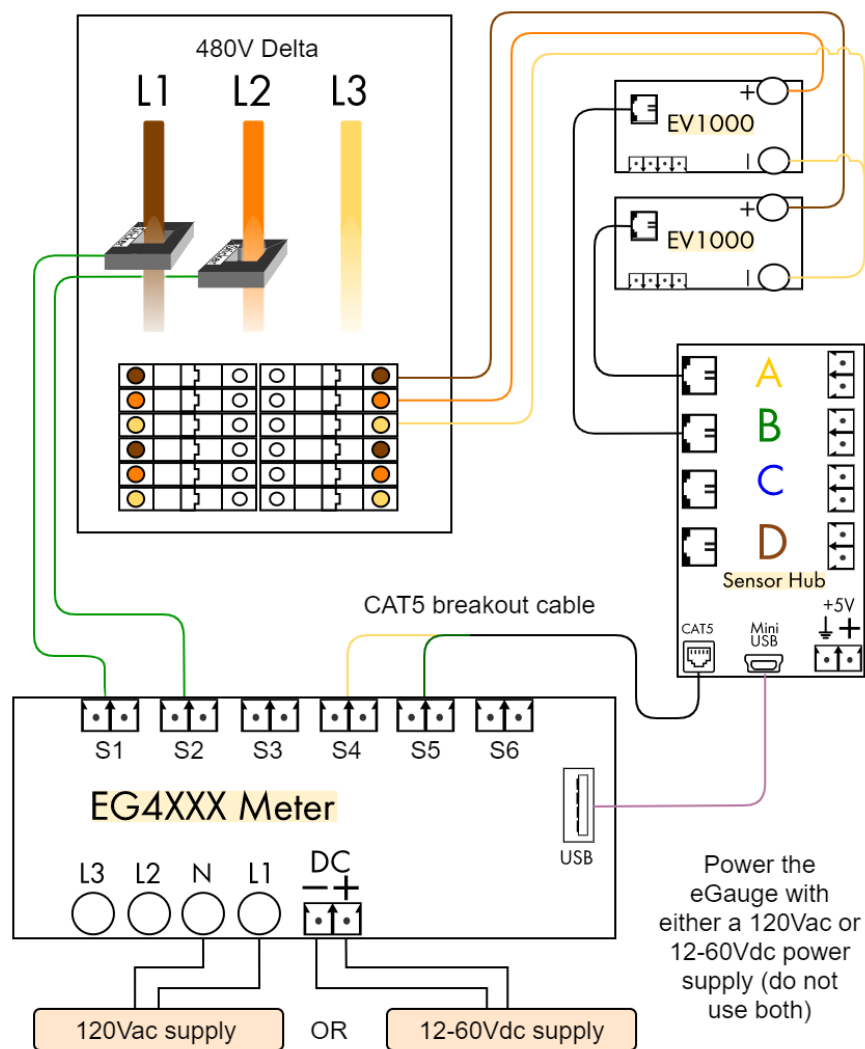   Grid = [P] [=] S1*S4 + S2*S5

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!

- Please visit `http://egauge.net/support/m/ev1000` for more information on using the EV1000 high voltage sensors and Sensor Hub.

2.9   Subpanels

This example illustrates how to measure subpanels.
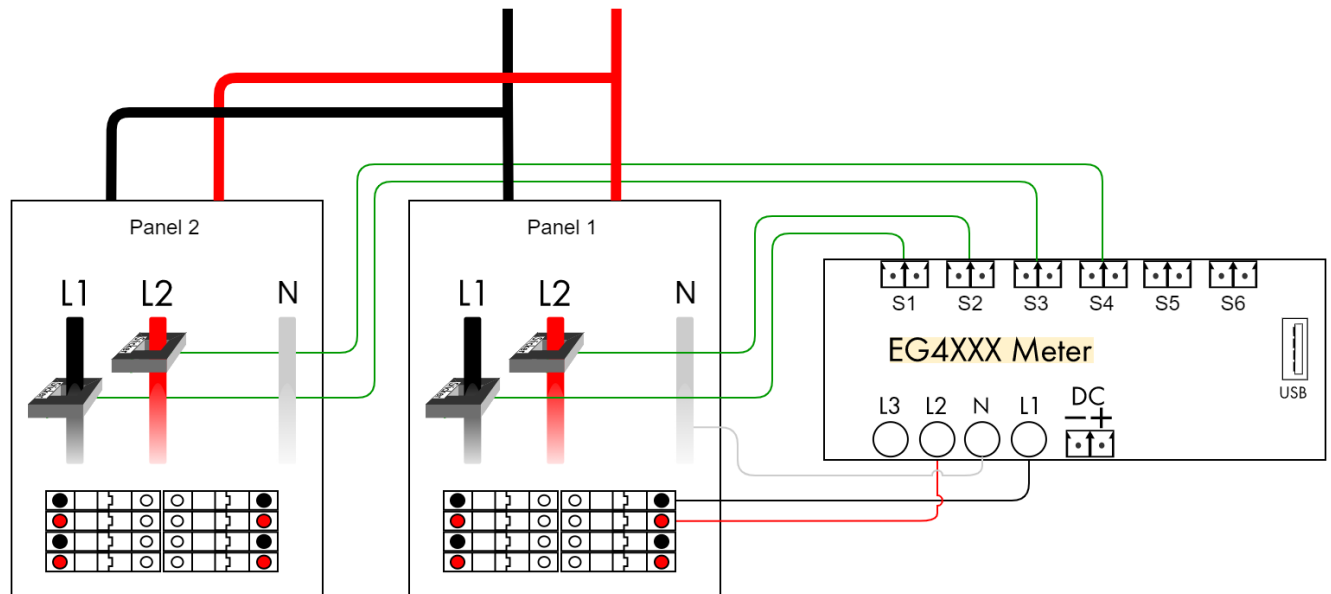
Registers

```
Subpanel 1  =  [P] [= ] S1*L1 + S2*L2
Subpanel 2  =  [P] [= ] S3*L1 + S4*L2
```

Totals and Virtual Registers

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

Notes:

- It does not matter which subpanel the meter obtains voltage from, but care must be taken to identify correct phasing. It is possible for phases to be reversed or inconsistent between panels.

2.10 Appliances

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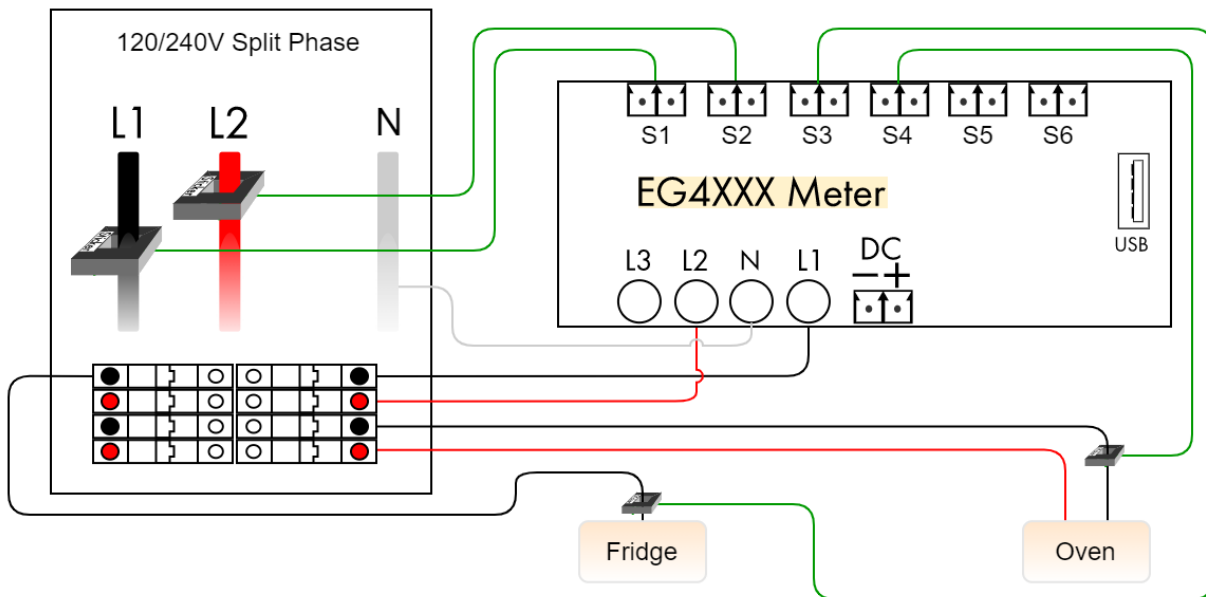
Registers

```
Grid    =   [P] [= ] S1*L1 + S2*L2
Fridge  =   [P] [= ] S3*L1
Oven    =   [P] [= ] S4*L1 + -S4*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 eGauge 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 eGauge 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 eGauge is monitoring. Connect one probe to the L1 screw terminal of the eGauge 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.
$e_1 <= e_2$	1	1 if $e_1 \leq e_2$, 0 otherwise.
$e_1 >= e_2$	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 $\texttt{abs}(e_1 - e_2) <$ ϵ, 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 is the URL of your eGauge device.

Function:	Description:
`abs(`*x*`)`	Absolute value of *x*.
`max(`*x,y*`)`	The greater value of *x* and *y*.
`min(`*x,y*`)`	The smaller value of *x* and *y*.
`mod(`*x,y*`)`	The remainder of dividing *x* by *y*.
`sqr(`*x*`)`	x^2.
`sqrt(`*x*`)`	$\sqrt{x}$.
`exp(`*x*`)`	10^x.
`log(`*x*`)`	Common (base-10) logarithm of x.
`floor(`*x*`)`	Largest integral value not greater than *x*.
`VAr(`*r,a*`)`	Given real power *r* and apparent power a, return reactive power.
`month()`	Number of months since January $(0 \ldots 11)$.
`wday()`	Number of days since Monday $(0 \ldots 6)$.
`mday()`	Returns the day of the month $(1 \ldots 31)$.
`time()`	Number of hours since midnight $(0 \ldots 23)$. Fractional part gives the part of the hour that has elapsed already, i.e., 0.5 for 30 minutes.
`P_PV(`*i,t,p,c*`)`	Given irradiance *i*, panel temperature *t*, STC-rated power p, and power-temperature-coefficient *c*, return expected PV output.
`pref("`*p*`")`	Returns value of preference-setting named *p* (e.g., `"global.production.rated"`).
`FFTarg2(`*f, c, r*`)`	Returns phase-angle of the spectral component at frequency *f* of the signal at input channel *c* relative to the reference channel *r*.
`FFTmag(`*f, c*`)`	Returns magnitude of spectral component at frequency *f* of input channel *c*.
`P_SunPower(`*i, t, p*`)`	Calculates expected power of SunPower array given irradiance *i*, panel temperature *t* and rated power p.
`THD(`*f, c*`)`	Returns total harmonic distortion of channel *c* for fundamental frequency *f*.
`conn_qual()`	Returns connection quality as percentage.
`conn_tech()`	Returns the connection technology as an integer.
`temp_internal()`	Returns device-internal temperature in degrees centigrade.
`isinf(`*x*`)`	Returns 1 if *x* is positive infinity or -1 if *x* is negative infinity, or 0 otherwise.
`isnan(`*x*`)`	Returns non-zero value if *x* is Not-a-Number.
`P_est(`*J, F, M,..*`)`	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.
`chan(`*s*`)`	Returns channel number for name *s*. *s* may be one of "L1" through "L3" for voltage inputs, or "CT1" through "CT12" for current inputs.
`rand()`	Returns random number in the range from 0 to 1 (inclusive).
`ravg(`*r, n*`)`	Calculates the running average of register *r* over the most recent *n* minute interval.
`savg(`*r, n*`)`	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 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	W	$1W$	$19.4GW$	P
app. power [VA]	Apparent power	VA	$1VA$	$19.4GVA$	S
react. power [var]	Reactive power	var	$1var$	$19.4Gvar$	PQ
voltage [V]	Voltage	V	$1mV$	$19.4MV$	V
current [A]	Current	A	$1mA$	$19.4MA$	I
freq. [Hz]	Frequency	Hz	$1mHz$	$19.4MHz$	F
irrad. [W/m^2]	(Solar) irradiance	W/m^2	$1W/m^2$	$19.4GW/m^2$	Ee
temp. [C]	Temperature	$°C$	$1m°C$	$19.4M°C$	T
humidity [%]	Relative humidity	$\%$	0.1%	$194M\%$	h
mass flow [kg/s]	Mass flow	kg/s	g/s	$19.4Gg/s$	Q
volumetric flow [m^3/s]	Volumetric flow	m^3/s	$1mm^3/s$	$19.4m^3/s$	Qv
speed [m/s]	Speed (e.g., rain-fall rate)	m/s	$1mm/s$	$19.4Mm/s$	v
res. [Ohm]	Resistance	Ω	1Ω	$19.4G\Omega$	R
monetary	Money	*var.*	$1.86n$	36.2	$
angle [deg]	Angle (e.g., wind-direction)	$°$	$1m°$	$360°$	a
number	Unit-less quantity	*n/a*	1	$19.4G$	#
total harm. dist	Total Harmonic Distortion	$\%$	0.1%	$194M\%$	THD
pressure [Pa]	Pressure (e.g., atmospheric)	Pa	$1Pa$	$19.4GPa$	Pa
charge [Ah]	Charge (e.g., battery)	Ah	$1mAh$	$19.4MAh$	Qe

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

Abbreviation	Physical unit name
V	Volt
A	Ampère
VA	Volt-Ampère
W	Watt
var	Volt-Ampère reactive
Hz	Hertz
g	gram
m	meter
$°$	degrees (angle)
$°C$	degrees Centigrade
Pa	Pascal (kg/ms^2)
Ω	Ohm

Prefix	Multiplier
n	10^{-9}
μ	10^{-6}
m	10^{-3}
k	10^{3}
M	10^{6}
G	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 $\$0.11\mu$.