



Panel Phasing and eGauge installation

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1 Overview

There are two main types of electrical systems: split-phase and three-phase (such as a Wye or Delta). Split-phase systems are usually present in homes and small businesses, while three-phase systems are more common in large buildings, factories, and industrial settings. A “split-phase” system can consist of two legs of a three-phase system; this is common in apartment buildings.

When installing the eGauge, the phases must be correctly connected to the unit’s L1, N, L2, and L3 terminals (as applicable based on the number of phases) and these associations must be reflected on the eGauge’s installation page (*Settings* → *Installation*). Each CT will be monitoring a conductor on one of the available phases, and the association between the CT and the phase that it is monitoring must be reflected on the installation page as well. For example, an entry of CT1xL2 indicates that CT1 is monitoring a circuit on the phase connected to L2.

1.1 Terminology

- Split-phase: Electrical service or panel containing two voltage lines and a neutral.
- Single-phase: Circuit consisting of two conductors; either two voltage lines, or a voltage line and neutral.
- Three-phase: Electrical Service or panel containing three voltage lines, with or without a neutral.
 - Delta: Three-phase service or panel **without neutral**.
 - Wye: Three-phase service or panel with neutral.
- Phase: A single voltage line on a system. There are at maximum three phases on a system or panel.
- Leg: A single voltage line, typically referring to a particular line input of the eGauge (such as L1, L2, or L3). Leg and phase may be used interchangeably.
- Backfeed: When a renewable energy system (such as solar) produces more power than the location demands, and power is pushed back onto the grid rather than being drawn.
- Configuration Guide: The manual and instructions for configuring the eGauge main unit. This can be found at <http://www.egauge.net/docs/config-guide.pdf>.

2 Phasing diagrams

2.1 Split-phase

Split phase panels will generally have two “hot” lines and one neutral line. Figure 1 shows a split-phase installation.¹

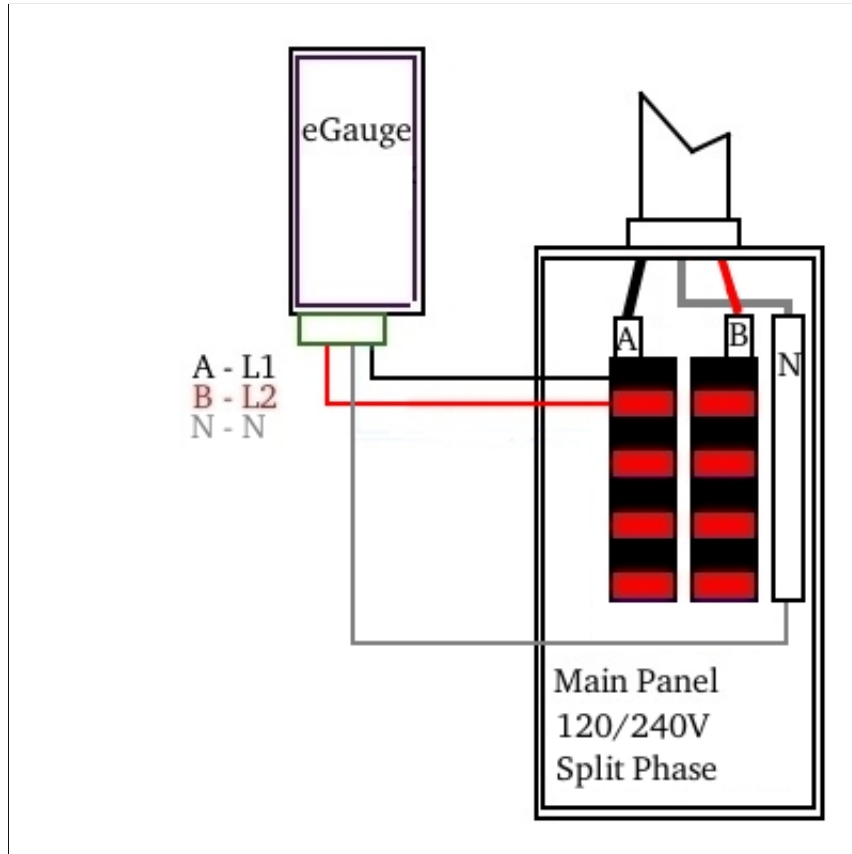


Figure 1: Split-phase panel

¹Miscellaneous styles of “split phase” systems may consist of different voltages. Please see Configuration Example 2.1 “Standard Split-Phase” from the eGauge Configuration Guide for an example of a standard split-phase system.

2.2 Three-phase, Four-wire

Most three-phase panels have a conductor for each phase and a separate neutral line; these are referred to as three-phase, four-wire systems². Figure 2 shows a three-phase, four-wire installation. Note that each breaker connected to the eGauge is on a different phase.

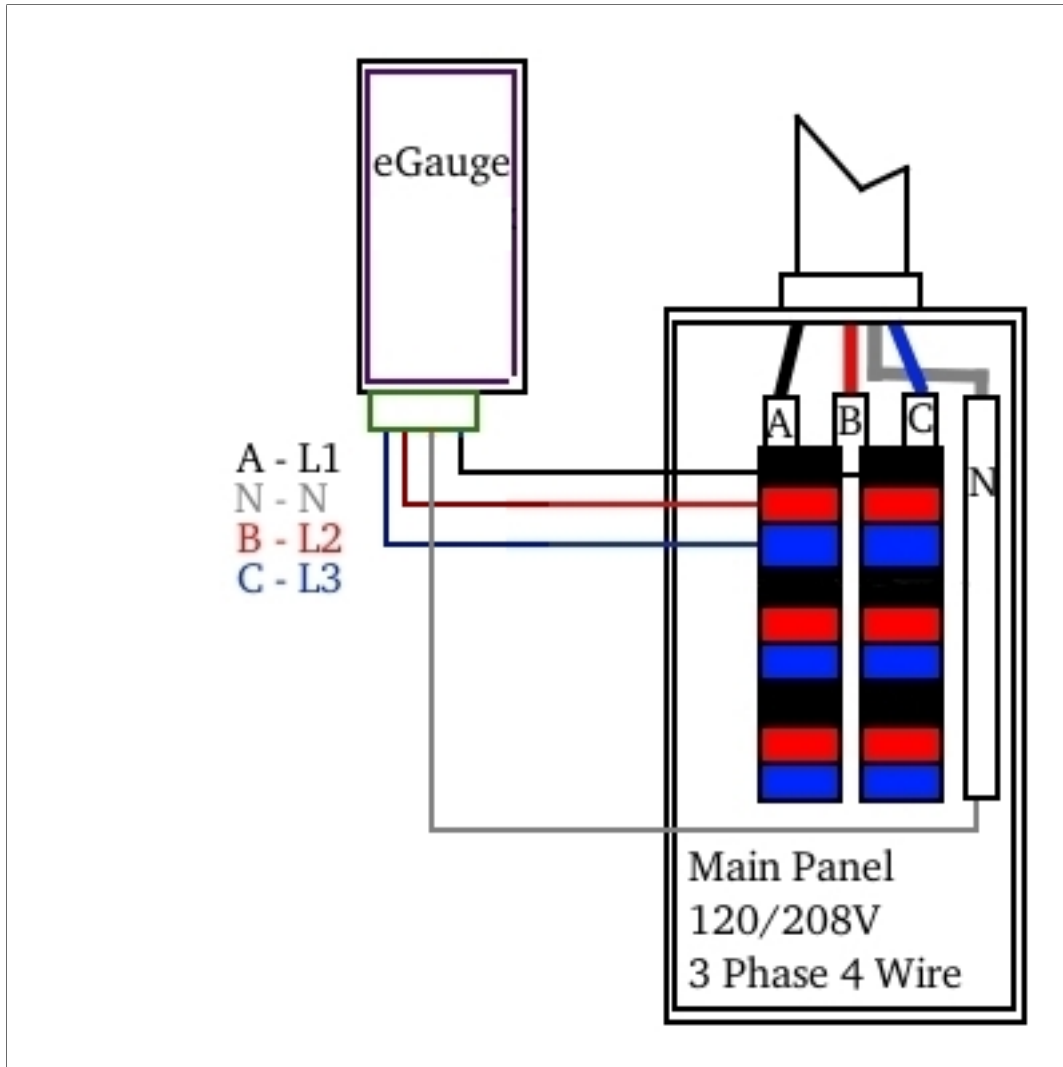


Figure 2: *three-phase, four-wire panel*

²A three-phase, four-wire system may contain different voltages, such as 120/208V or 277/480V. The eGauge can handle up to 277Vrms phase to neutral reference. Please see Configuration Example 2.3, "Three-Phase 120/208Y" in the eGauge Configuration Guide for more information.

2.3 Three-phase, Three-wire

Some three-phase systems do not have a neutral line. Figure 3 shows a three-phase, three-wire installation³. Note that the third phase is used as a voltage reference in the eGauge N terminal (Phase C → N) and that the L3 connection on the eGauge is not in use.

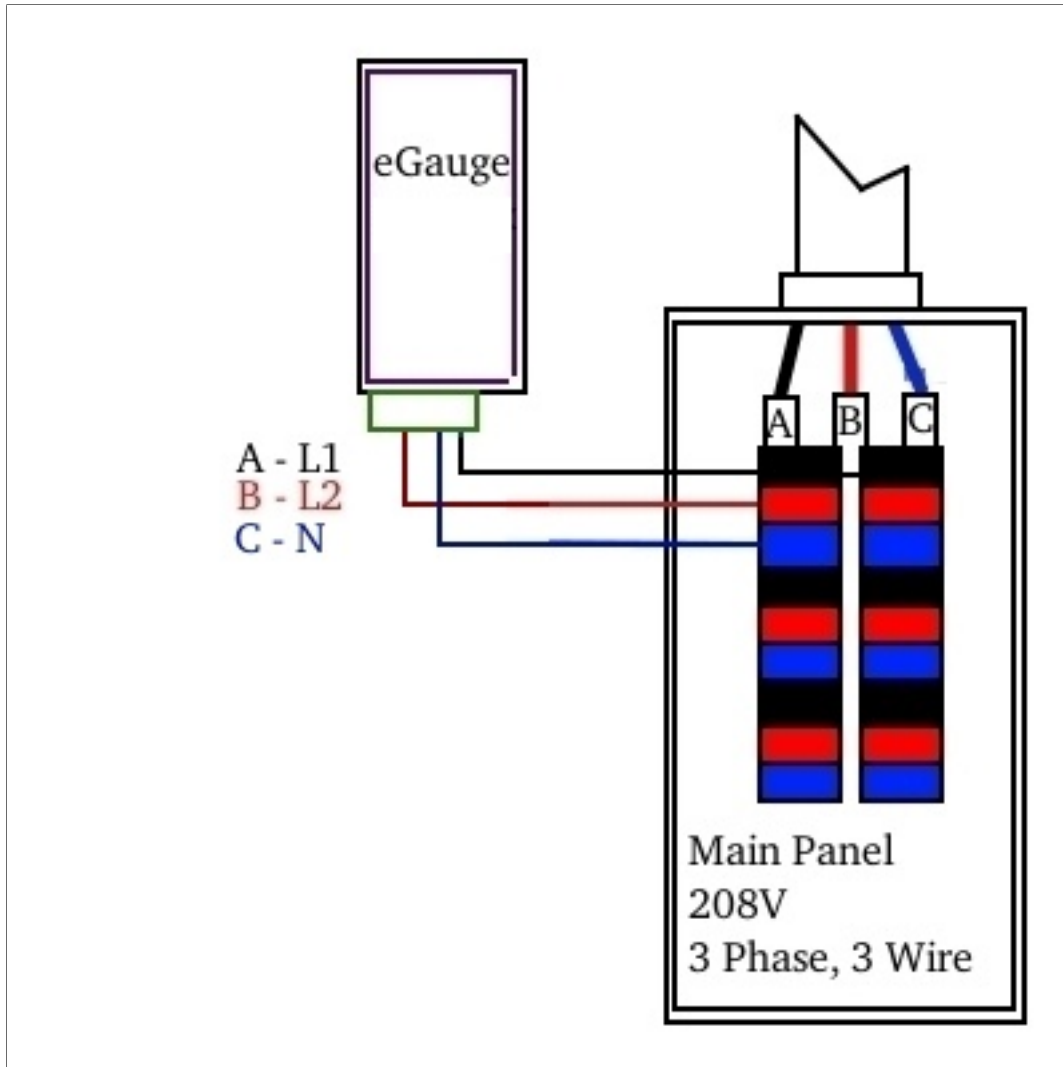


Figure 3: *three-phase, three-wire panel*

³A three-phase, four-wire system may contain different voltages, such as 480V, 208V, or 240V. The eGauge can handle up to 277Vrms phase to neutral reference. Please see Configuration Example 2.6, "Three-Phase Delta" in the eGauge Configuration Guide for more information.

3 Testing phase continuity

Determining which phase a given conductor is on requires a volt meter and access to the panel housing the eGauge:

1. Connect one end of the volt meter to the metal screws for L1, L2, or L3 (as appropriate) on the eGauge's 5-pin power plug.
2. Connect the other end of the volt meter to the conductor being monitored by a CT (do not connect the volt meter to the CT itself).

If the voltage between the two points reads **approximately zero**, then the conductor the CT is monitoring is on the **same phase** as the leg that is being tested (L1, L2, or L3).

If **any other reading** appears, the conductor the CT is monitoring is on a **different phase**.

This procedure is recommended for verification purposes during installation and can also be useful as a troubleshooting tool, especially when previous wiring was not performed to standard or there are multiple sub panels.

The yellow test points in Figure 4 show where a volt meter can be connected (for the sake of simplicity the neutral line is not shown). Note that this same testing procedure can be applied to three-phase installations as well.

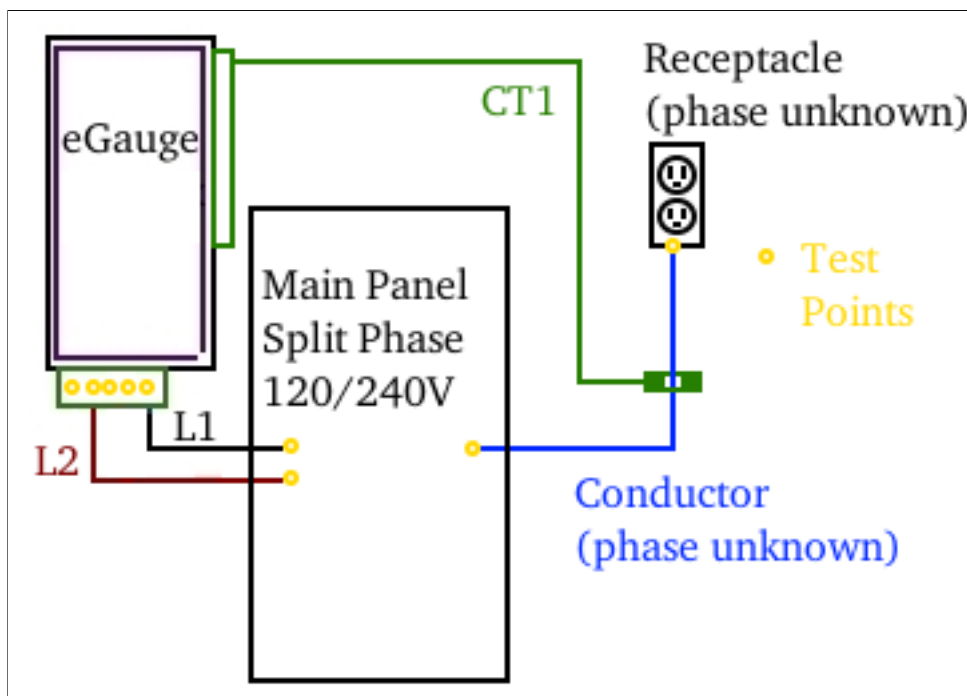


Figure 4: Phase-testing

In this split-phase example, the reading from L1 to a point on the blue conductor is $\sim 240V$ and the reading from L2 to a point on the blue conductor is $\sim 0V$. Thus, we know the blue conductor is on the same phase as L2.

4 Incorrect settings

Incorrect settings on the installation page that do not reflect the physical reality of the installation will not provide correct data. A CT can monitor a conductor on any phase as long as it is correctly configured on the installation page. Figure 5 shows an example of a typical three-phase grid monitoring setup, while Figure 6 shows the corresponding installation page. Figure 7 shows an incorrect installation page; note that the CTs are associated with the wrong phases as shown in Figure 5.

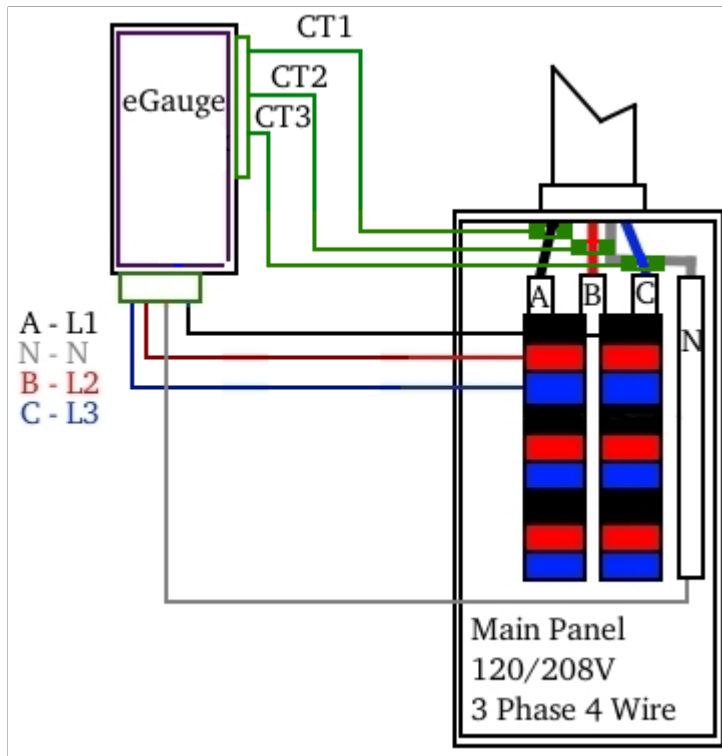


Figure 5: *Three-phase Grid monitoring*

Registers (1 of 128 in use):

Name: Recorded value/formula: $P = CT1 \times L1 + CT2 \times L2 + CT3 \times L3$

Figure 6: *Correct configuration on installation page*

Registers (1 of 128 in use):

Name: Recorded value/formula: $P = CT1 \times L2 + CT2 \times L3 + CT3 \times L1$

Figure 7: *Incorrect configuration on installation page*

5 Troubleshooting with the Channel Checker

When a system is configured incorrectly, it may be possible to identify the problem using the Channel Checker.

For installations involving multiple subpanels, it can be difficult to track down which conductor belongs to which leg or phase. If a CT is thought to have been installed on a conductor on the same phase as L1 but is actually monitoring a conductor on the same phase as L2, the reported power will be wrong. Note that CTs are directional; it is possible to install a CT so that power reads negative when the expected value should be positive and vice versa. Figure 8 below show examples of CTs monitoring a panel. Note that the stickers are both facing in the same direction; in this case towards the source of the load.

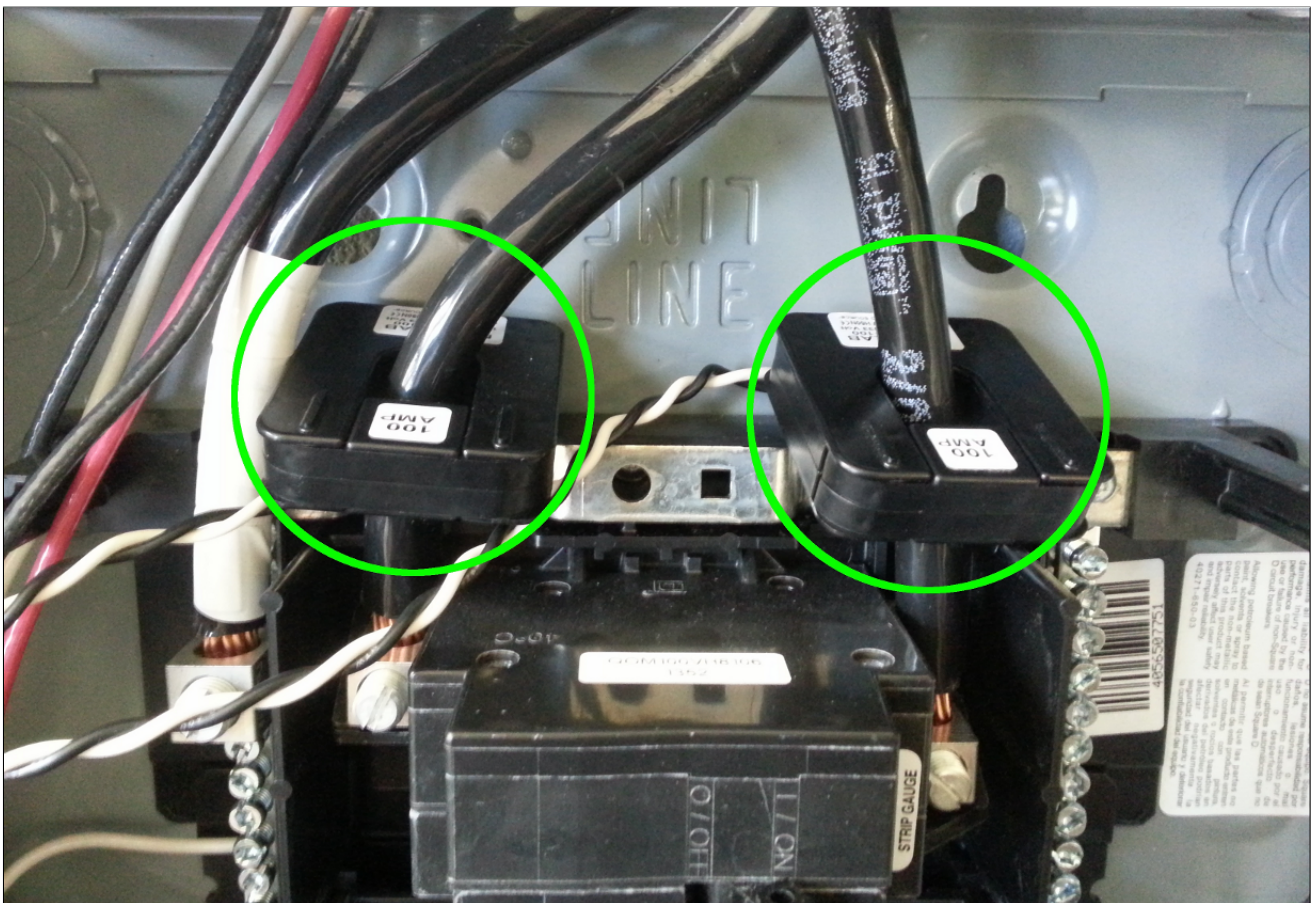


Figure 8: *CTs monitoring a split-phase panel*

Note that one of the CTs shown in Figure 9 has been installed backwards. On a split-phase panel, this type of installation error will cause the CT readings to cancel one another out (assuming a balanced load). On a three-phase panel, the total from all three CTs will be incorrect, and may vary between a positive and negative reading if the load is unbalanced.

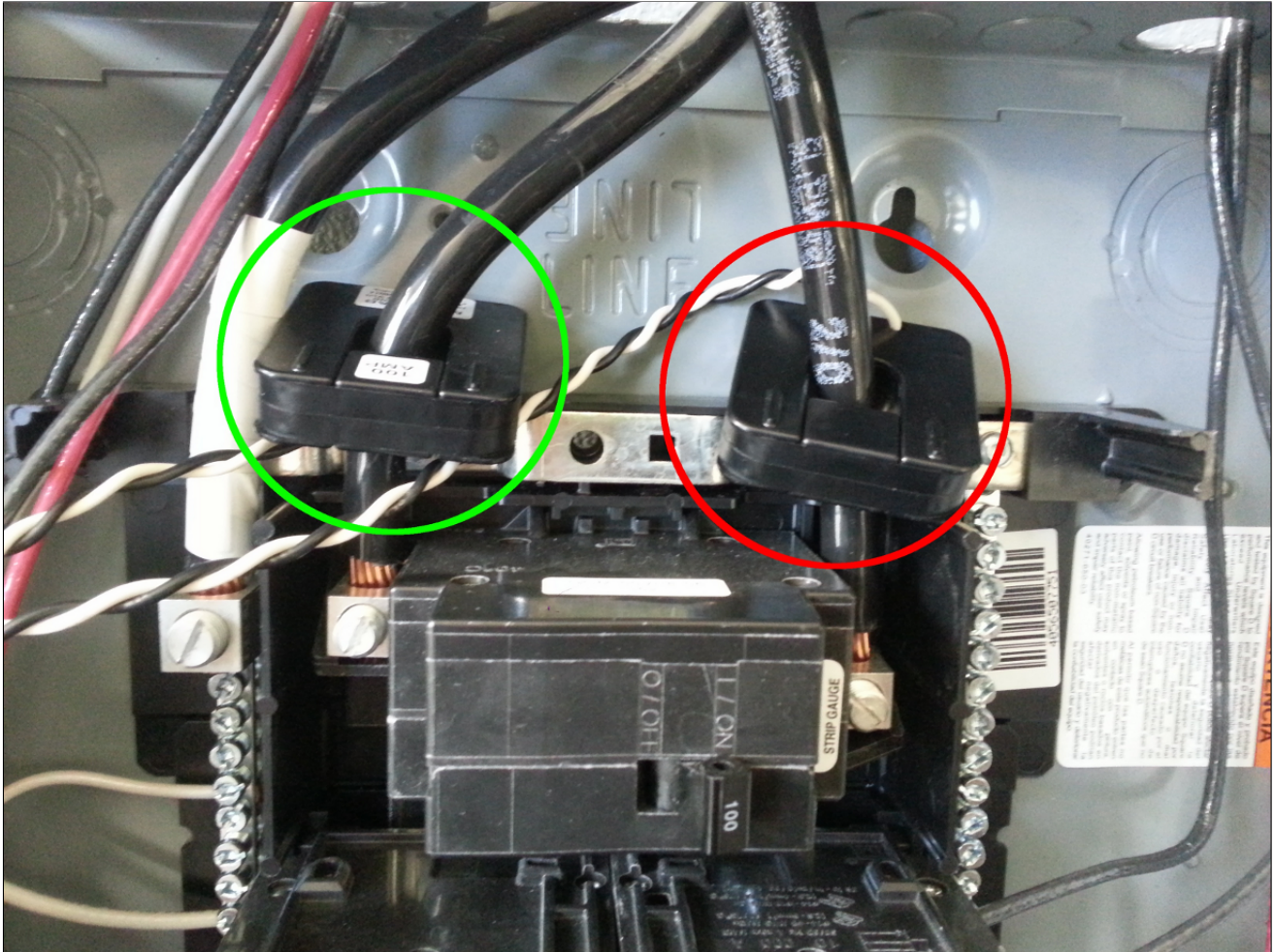


Figure 9: CTs monitoring a split-phase panel– note the CT on the right has been installed backwards

The Channel Checker (located under *Tools* → *Channel Checker*) provides a convenient way to check the wattage, polarity, and power factor of a CT/Leg combination. Note that the Channel Checker will only display combinations that have been saved on the Installation page. For example, if only CT1*L1 has been used, the Channel Checker will not display readings for CT1*L2 or CT1*L3. The left column displays input information, including frequency, voltage, and amperage. The right column displays power register output-wattage and power factor derived from the readings shown in the left column. Both columns display real time data.

Figure 10 shows a view of the Channel Checker on a correctly configured system. Note that the polarity reading is positive and the power factor is above .700⁴ for each main line (P114 – L1, P114 – L2, and P114 – L3).

eGauge Channel Checker

As of Mon Apr 28 2014 11:55:03 GMT-0600 (MDT):

Frequency:	59.98 Hz	P114 - L1 (L1*CT1)	474.7 W (PF 0.904)
L1 (ch0):	122.64 V	P114 - L2 (L2*CT2)	1181.4 W (PF 0.953)
L1 (ch8):	n/a	P114 - L3 (L3*CT3)	443.8 W (PF 0.747)
L2 (ch1):	122.66 V	Receptacles - Warehouse (L3*CT4)	-120.7 W (PF 0.825)
L3 (ch9):	123.92 V	Receptacles - Lab (L2*CT5)	-16.0 W (PF 0.791)
CT1:	4.280 A	Bathroom (L2*CT6)	-211.8 W (PF 0.620)
CT2:	10.111 A	Receptacles - South (L2*CT7)	-41.7 W (PF 0.493)
CT3:	4.796 A	Lighting (L2*CT8)	-692.0 W (PF 0.996)
CT4:	1.181 A	Receptacles - North (L2*CT9)	-42.0 W (PF 0.501)
CT5:	0.165 A	Receptacles - NW and West Hall (L1*CT10)	0.2 W (PF 0.042)
CT6:	2.783 A	Environmental test chamber (L1*CT11)	-137.9 W (PF 0.632)
CT7:	0.689 A	Receptacles - North #2 (L3*CT12)	-249.3 W (PF 0.635)
CT8:	5.662 A		
CT9:	0.683 A		
CT10:	0.039 A		
CT11:	1.779 A		
CT12:	3.166 A		

Figure 10: Channel Checker of a correctly configured three-phase system

⁴Low power factor does not always indicate incorrect setup. Inductive and capacitive loads such as motors or lamp ballasts may lower power factor.

An example of an incorrectly configured three-phase system is shown in Figure 11. Note the negative readings and significantly lower power factors on the mains (P114 – L1, P114 – L2, and P114 – L3). Rather than physically adjusting the CTs or the CT wiring, it may be easier to adjust the installation page (*Settings* → *Installation*) to reflect reality. This can be done by modifying the register definitions such that the CT(s) are associated with the legs/phases that they’re actually monitoring.

eGauge Channel Checker			
As of Mon Apr 28 2014 11:56:56 GMT-0600 (MDT):			
Frequency:	59.96 Hz	P114 - L1 (L2*CT1)	-208.9 W (PF 0.406)
L1 (ch0):	122.35 V	P114 - L2 (L3*CT2)	-390.6 W (PF 0.320)
L1 (ch8):	n/a	P114 - L3 (L1*CT3)	-288.4 W (PF 0.491)
L2 (ch1):	122.96 V	Receptacles - Warehouse (L3*CT4)	-120.4 W (PF 0.823)
L3 (ch9):	123.83 V	Receptacles - Lab (L2*CT5)	-16.5 W (PF 0.808)
CT1:	4.189 A	Bathroom (L2*CT6)	-170.0 W (PF 0.534)
CT2:	9.859 A	Receptacles - South (L2*CT7)	-42.6 W (PF 0.499)
CT3:	4.796 A	Lighting (L2*CT8)	-694.3 W (PF 0.997)
CT4:	1.182 A	Receptacles - North (L2*CT9)	-42.4 W (PF 0.501)
CT5:	0.166 A	Receptacles - NW and West Hall (L1*CT10)	0.4 W (PF 0.088)
CT6:	2.590 A	Environmental test chamber (L1*CT11)	-129.2 W (PF 0.633)
CT7:	0.694 A	Receptacles - North #2 (L3*CT12)	-249.6 W (PF 0.637)
CT8:	5.664 A		
CT9:	0.688 A		
CT10:	0.037 A		
CT11:	1.669 A		
CT12:	3.163 A		

Figure 11: Channel Checker of an incorrectly configured three-phase system

If the polarity of the reported power is correct and the power-factor appears as expected, it is a sign that the correct phases are being referenced.

Usually, 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 may be significantly lower than expected and the polarity may be reversed.