Advanced Pulse WattNode - Option PV (Photovoltaic)

With Option PV, a single WNB-3Y-208-P Advanced Pulse WattNode can measure the net energy consumption or generation of a house with solar panels or wind generators, AND the energy being generated by the solar panels or wind generators. This WattNode provides three pulse output streams:

- P1 - The energy the house takes from the grid.
- P2 - The energy the house puts onto the grid (generated energy). If you have a net utility meter, this energy would cause the meter to “spin backwards”. This happens when you are generating more energy than the house is consuming.
- P3 - The energy generated by the PV or wind generator.

In order to do this, a three-phase WattNode is used, with two of the phases configured to measure the house energy flow (positive or negative). The third phase is used to measure the energy generated by the solar or wind generation equipment (positive only). Since generated energy is almost always supplied to the house through an inverter, we’ll use the term “inverter” from now on.

Limitations

Option PV generally only works in residential settings with 120/240 VAC service (or 230 VAC service in Europe with the WNB-3Y-400-P model). Any building with three-phase service must use one WattNode to measure the net energy flow (consumed and/or generated), and a second WattNode to measure the inverter energy.

The WattNode with Option PV only has a single phase available to measure the inverter. If you have an inverter that generates a single 120 VAC output (or 230 VAC for Europe), you can measure the energy with full rated accuracy. If you have one or more inverters that connect to both L1 and L2, then you can still get good accuracy, but not quite as good. The error will generally be one-half of the percentage difference in AC voltage between L1 and L2. The L1 and L2 voltages should be well balanced, but for example, if your L1 voltage is 119.6 and your L2 voltage is 121.4, then the difference is 1.8 VAC or 1.5%, so your error would be approximately 0.75%. If you need better accuracy, you can use two separate WattNodes instead.

If you are running completely off-grid, you may or may not want to use a WattNode with Option PV. If you have batteries, you could treat them as a pseudo-grid and monitor the energy going in and out of the batteries as well as the generated energy. Be aware however, that the WattNode can only measure AC power, so if you charge batteries directly from PV without converting to 120/240VAC first, the WattNode won’t be able to monitor that flow.

Guidelines

For North American residential service, you will generally need two current transformers (CTs) of the same model to measure the net energy consumed or generated by the house. You will almost certainly want split core (opening) CTs for ease of installation. You should generally choose CTs with a rated current equal to your service rating. European users will normally only need a single CT.

To measure the inverter current, you can use either a split core or a solid core CT. Solid core CTs are generally more accurate and less expensive, but they require that you disconnect the inverter wire to feed it through the CT.

The inverter CT does not have to be the same model or rated amps as the CTs used to monitor the house. The inverter CT should be rated somewhat higher than the maximum current you expect to generate. If in doubt, use the inverter rated current as a guide. If you are going to pass more than one conductor through the CT (see wiring diagrams below), then the CT rated current must be high enough to handle the sum of the currents from all the conductors. For example, if your inverter is rated for 12A, 240VAC, and connects between L1 and L2, you will be passing both L1 and L2 through the CT for a combined maximum current of 24A, so you should select a 30A CT.

Note: Unless your inverter total current capacity is similar to the current rating of your electrical service, you generally won't use CTs with the same current rating for the house and the inverter.

Paralleling Current Transformers

If you are monitoring multiple inverters or 240VAC inverters and it isn't convenient to run all the conductors through one CT, you can use two or more CTs (they must all be exactly the same model), and wire them in parallel at the WattNode (see **Figure 3** for an example). The effective rated amps will be the sum of the rated amps of the paralleled CTs.

You should be extra careful when paralleling CTs, because if any of the CTs are installed backwards on the conductor, if any of the white and black wires are reversed, or if you have any bad connections, it is more difficult to detect and diagnose the problem than with a single CT.

Installation

Before installing the WattNode, review the precautions and instructions in the **Installation and Operation Manual**. See **Figures 1** and **2** below for wiring diagrams.

Powering the WattNode

The WattNode may be powered from an existing circuit, or may be provided by a dedicated circuit. **DO NOT** power the WattNode from the inverter circuit, because turning off the breaker won't remove power from the WattNode if the inverter is active. Electrical code rules require that you used a ganged circuit breaker to power the WattNode if you are monitoring multiple phases. The WattNode screw terminals can handle wire up to 12 AWG, which is generally compatible with circuit breakers up to 20A.

Since you are using phase C (**ØC**) on the WattNode to measure the inverter power, you need to connect the correct line voltage:

- **Single-Phase Inverter on L1:** connect the **ØC** terminal on the WattNode's green plug to L1 (**ØA**) using a jumper wire or wire nut (**Figure 1**).
- **Single-Phase Inverter on L2:** connect the **ØC** terminal on the WattNode's green plug to L2 (**ØB**) using a jumper wire or wire nut (**Figure 1**).
- **Two-Phase Inverter on L1 and L2:** connect the **ØC** terminal on the WattNode's green plug to L1 (**ØA**) using a jumper wire or wire nut (**Figure 2**).

If you locate the WattNode outside the service panel, especially if it is a significant distance from the panel, UL requires that you also include a switch (or disconnect) to remove power from the WattNode for servicing or in the event of an emergency.

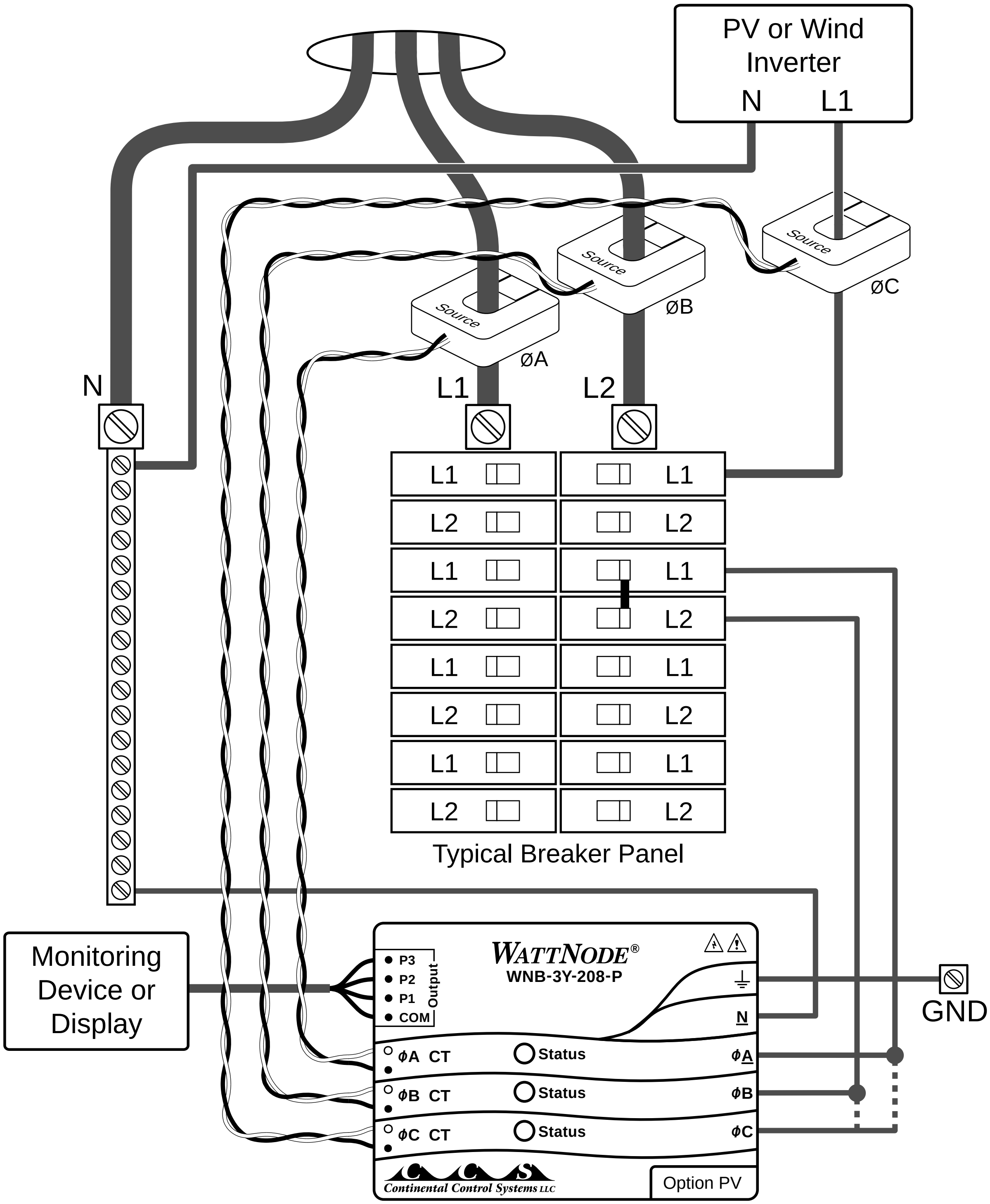

Figure 1: WattNode Installation Diagram with Single-Phase Inverter

Single-Phase Inverter

Connect the **ØA** and **ØB** WattNode phases to measure the total house consumption from the grid (see **Figure 1**). Jumper the **ØC** green screw terminal to whichever mains phase (L1 or L2) is connected to the inverter. Install the inverter CT with the “Source” face (or arrow) aiming toward the inverter, and connect the CT wires the **ØC CT** screw terminals: black wire → black dot, white wire → white dot.

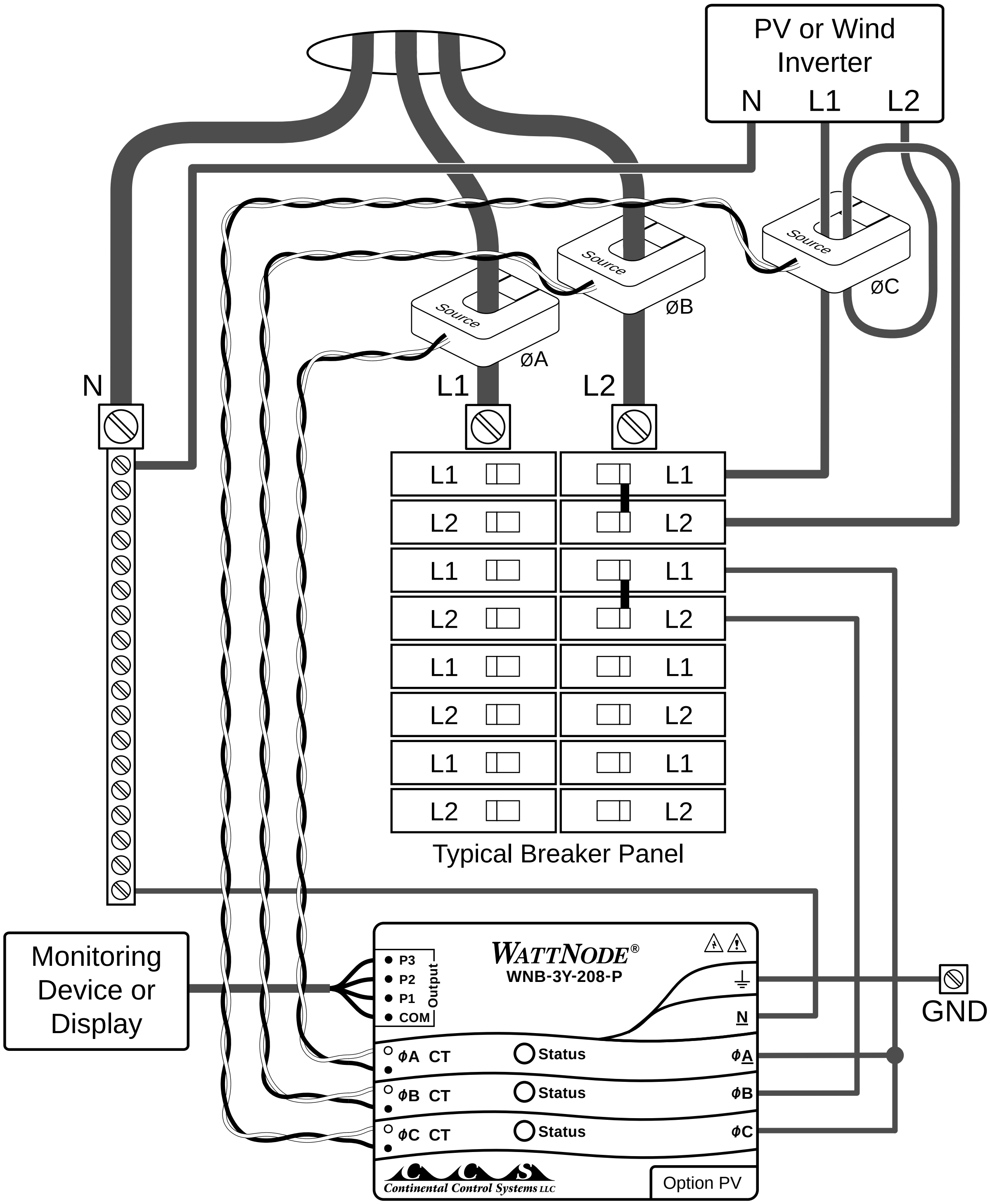

Figure 2: WattNode Installation Diagram with Two-Phase Inverter

Two-Phase Inverter

Connect the **ØA** and **ØB** WattNode phases to measure the total house consumption from the grid (see **Figure 2**). Jumper the **ØC** green screw terminal to the **ØA** (L1) terminal. Install the inverter CT around inverter L1 conductor with the “Source” face (or arrow) aiming toward the inverter. Then feed the inverter L2 conductor through the CT in the opposite direction. Since L2 is 180 degrees out-of-phase with L1, running it through the CT backwards inverts the phase measurement so that it matches L1. If this isn’t feasible, see **Inverter CT Alternatives** below for other options.

Multiple Single-Phase Inverters

If you have multiple single-phase inverters and they are all connected to the same house phase (either L1 or L2), then you can connect the WattNode as shown in **Figure 1**, but run the conductors for all the inverters through the inverter CT in the same direction.

If you have multiple single-phase inverters and they are connected to both house phases (L1 and L2), then you can connect the WattNode as shown in **Figure 2**. Run the conductors for all inverters on L1 through the inverter CT so that the CT "Source" face (or arrow) aims toward the inverter. Then feed the conductors for all inverters on L2 through the CT in the opposite direction. Since L2 is 180 degrees out-of-phase with L1, running the wires through the CT backwards inverts the phase measurements so they match L1. See **Inverter CT Alternatives** below for other options.

Multiple Two-Phase Inverters

Connect the WattNode as described for a **Two-Phase Inverter** (**Figure 2**). Pass the extra L1 and L2 conductors for the multiple inverters through the inverter CT, being careful to feed all the conductors for L2 through the CT backwards. You may find it difficult to feed all the inverter conductors through a single CT; if so, see **Inverter CT Alternatives** below for other options.

Inverter CT Alternatives

The most likely situation is that you cannot readily feed both L1 and L2 inverter conductors through the same CT, particularly since the L2 conductor has to feed through backwards. An alternative is to use two CTs as shown in **Figure 3** below.

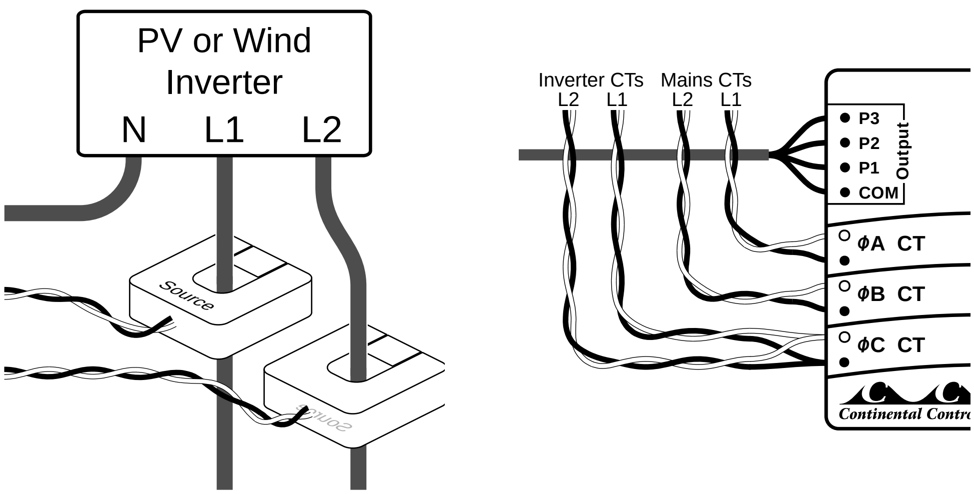

Figure 3: Dual Inverter CTs

The drawing on the left shows a second CT placed around the L2 inverter conductor, but with the "Source" face aiming away from the inverter—this is equivalent to feeding the wire through backwards. The drawing on the right shows both pairs of CT wires from the inverter feeding into the **ØC CT** screw terminals (make sure the keep the white wires together and the black wires together and to match up the pairs with the white and black dots on the label.

Similarly, if you have two single phase inverters on the same phase (let's say L1), and you cannot easily pass both conductors through a single CT, you can use two CTs. In this case, you'll want to orient both CTs so that their "Source" face (or source arrow) aim toward the inverter. Connecting the CTs at the WattNode is the same as shown in **Figure 3**.

Installation Verification

For information on verifying correct operation and diagnosing problems, see the **Installation and Operation Manual** section **Installation Diagnostics** or the **Quick Install Guide** section **Diagnostic LEDs**.

There are some specific guidelines for this application.

- If your inverter is not generating any power, the **ØC** status LED will be solid green, or may flash red slowly, indicating that the inverter is consuming a small amount of power.
- If your inverter is generating power and you've hooked up the inverter CT correctly, the **ØC** status LED will flash green. If you know you are generating power but the LED is flashing red, then check the following:
  - Is the inverter CT backwards?
  - Are the white and black CT wires swapped where they connect to the WattNode?
  - Is the **ØC** VAC input connected to the wrong phase?
- The **ØA** and **ØB** status LEDs indicate the power for the house. They should normally flash green, yellow, red-yellow, or red. Solid green indicates no measured power, but this is unlikely for a house. It's also reasonable for **ØA** and **ØB** LEDs to be flashing different colors, because there are different loads on L1 and L2 and may be different generated energy.
  - Green flashing indicates that the house is consuming energy from the grid on that phase.
  - Red flashing indicates that the house is generating more energy than it is consuming on that phase, so you are putting energy back into the grid.
  - Yellow flashing indicates that the house is consuming energy from the grid, but that the power factor is low. Certain loads (fluorescent lighting) can cause this and it's also common when you are generating significant power on this phase.
  - Red-yellow flashing indicates that the house is generating energy more energy than it is consuming on this phase, but that the power factor is low. This is common when the amount of energy you are generating is not much larger than the amount you are consuming.
  - Solid green indicates no measurable power. For typical residential installations, the WattNode won't measure below 10-20 watts for the house phases. The WattNode will generally measure down to 2-10 watts for the inverter, depending on the CT rated amps.

Power and Energy Computation

Every pulse from the WattNode corresponds to a fixed amount of energy. Power (watts) is energy divided by time, which can be measured as pulses per second (or pulses per hour). The following scale factor tables convert from pulses to energy (watt-hours or kilowatt-hours). This conversion can be complex with Option PV, because the scale factor is different for the inverter channel (P3 output) and you will probably have a different CT current rating for the inverter channel.

DO NOT use the scale factor tables from the **Installation and Operation Manual**, they will not be correct.

Scale Factors - P1 and P2 Outputs (Grid)

The following table provides scale factors for the P1 and P2 output channels (the energy the house consumes from the grid or puts on the grid) as a function of current transformer rated amps. This table assumes the WattNode was ordered with the standard full-scale pulse output frequency of 4.00 Hz (see **Custom Pulse Frequencies** below for other frequencies).

CT Size (amps)	Pulses per kilowatt-hour (PpKWH)		Watt-hours per pulse (WHpP)	
	WNB-3Y-208-P	**WNB-3Y-400-P**	**WNB-3Y-208-P**	**WNB-3Y-400-P**
50	1200.00	626.09	0.8333	1.5972
100	600.00	313.04	1.6667	3.1944
150	400.00	208.70	2.5000	4.7917
200	300.00	156.522	3.3333	6.3889
250	240.00	125.217	4.1667	7.9861
300	200.00	104.348	5.0000	9.5833
400	150.00	78.261	6.6667	12.778
600	100.00	52.174	10.000	19.167
any	$\frac{60{,}000}{\mathit{CTsize}}$	$\frac{31{,}304}{\mathit{CTsize}}$	$\frac{\mathit{CTsize}}{60.00}$	$\frac{\mathit{CTsize}}{31.304}$

Figure 4: Scale Factors - P1 and P2 Pulse Outputs (Grid Power)

Scale Factors - P3 Output (Inverter)

The following table provides scale factors for the P3 output channel (the energy the inverter generates), assuming the WattNode was ordered with the standard full-scale pulse output frequency of 4.00 Hz (see **Custom Pulse Frequencies** below for other frequencies). There is no pulse output indication if the inverter consumes power.

CT Size (amps)	Pulses per kilowatt-hour (PpKWH)		Watt-hours per pulse (WHpP)	
	WNB-3Y-208-P	**WNB-3Y-400-P**	**WNB-3Y-208-P**	**WNB-3Y-400-P**
50	2400.00	1252.17	0.4167	0.7986
100	1200.00	626.09	0.8333	1.5972
150	800.00	417.39	1.2500	2.3958
200	600.00	313.04	1.6667	3.1944
250	480.00	250.44	2.0833	3.9931
300	400.00	208.70	2.5000	4.7917
400	300.00	156.522	3.3333	6.3889
600	200.00	104.348	5.0000	9.5833
any	$\frac{120{,}000}{\mathit{CTsize}}$	$\frac{62{,}609}{\mathit{CTsize}}$	$\frac{\mathit{CTsize}}{120.00}$	$\frac{\mathit{CTsize}}{62.609}$

Figure 5: Scale Factors - P3 Pulse Output (Inverter Power)

Scale Factor Equations

The following presents two equivalent methods to compute power and energy from pulses. Be careful to use the correct scale factors, since they will be different for the P1 and P2 output channels than for the P3 channel.

- ***PulseCount*** - This is the count of pulses, which is used to compute energy. You can use the count of pulses over specified periods of time (like a month) to measure the energy for that period of time.

- ***PulseFreq*** - This is the measured pulse frequency (Hertz) out of the WattNode. This can also be computed by counting the number of pulses in a fixed period of time and then dividing by the number of seconds in that time period. For example, if you count 720 pulses in five minutes (300 seconds), then ***PulseFreq*** = 720 / 300 = 2.40 Hz.

Using the "Watt-hours per pulse" ***WHpP*** value from the tables above for your WattNode model and current transformer, you can compute energy and power as follows:

$$\text{Energy (watt-hours)} = WHpP \cdot PulseCount$$

$$\text{Power (watts)} = WHpP \cdot 3600 \cdot PulseFreq$$

To convert these values to kilowatt-hours and kilowatts, divide by 1000.

Using the "Pulses Per kilowatt-hour" ***PpKWH*** value from the tables above for your Watt-Node model and current transformer, you can compute energy and power as follows (multiply by 1000 to convert kilowatts to watts):

$$\text{Energy (kilowatt-hours)} = PulseCount / PpKWH$$

$$\text{Power (kilowatts)} = 3600 \cdot PulseFreq / PpKWH$$

Custom Pulse Frequencies

Instead of the normal 4.00 Hz, you may order the WattNode with custom pulse frequencies ranging from 0.01 Hz to 150 Hz. Higher frequencies frequently work better with displays like our LCDA-EP Energy & Power Display. You can even order a different pulse output frequency for the P3 pulse output channel so that the pulses per kilowatt-hour are the same for the P1, P2, and P3 channels.

If you do order your Option PV WattNode with custom pulse output frequencies, refer to the **Power and Energy Equations** section of the main manual for equations to use to compute power and energy from the output pulses. The only tricky part is the variable ***PpPO*** - "Phases per Pulse Output". Unlike regular WattNodes, Option PV WattNodes have two ***PpPO*** values:

- **P1 and P2 Pulse Outputs:** ***PpPO*** *= 2*, because there are two phases (**ØA** and **ØB**) providing energy for the P1 and P2 outputs.
- **P3 Pulse Output:** ***PpPO*** *= 1*, because there is only one phase (**ØC**) providing energy for the P3 output.

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