WattNode® Plus

for LonWorks®

User's Guide

Continental Control Systems

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FCC INFORMATION

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area can cause harmful interference in which case the user will be required to correct the interference at his own expense.

Standard Product Warranty

All products sold by Continental Control Systems, LLC (CCS) are guaranteed against defects in material and workmanship for a period of one year from date of shipment. CCS's responsibility is limited to repair, replacement, or refund. CCS reserves the right to substitute equivalent new or used parts.

This warranty covers only defects arising under normal use and does not include malfunctions or failures resulting from: misuse, abuse, neglect, improper application, improper installation, acts of nature, or repairs by anyone other than CCS.

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1 Overview

1.1 WattNode Plus

The WattNode Plus is designed for use in demand side management (DSM), sub-metering, and energy monitoring applications where accuracy at reasonable cost is essential. It is also possible to use the WattNode Plus to measure generated power. Models are available for single-phase, three-phase wye, and three-phase delta configurations for voltages from 120 VAC to 600 VAC, 60 Hz.

The enhanced WattNode Plus measures and communicates the following quantities over a twisted pair (FTT-10) network:

- True RMS Power - Watts (Phase A, Phase B, Phase C, All Phases)
- Reactive Power - VARs (Phase A, Phase B, Phase C, All Phases)
- Power Factor (Phase A, Phase B, Phase C, All Phases)
- True RMS Energy - Watthours (Phase A, Phase B, Phase C, All Phases)
- Reactive Energy - VAR-hours (All Phases)
- AC Frequency
- Computed RMS Voltage (Phase A, Phase B, Phase C)
- Computed RMS Current (Phase A, Phase B, Phase C, All Phases)
- Demand
- Peak Demand

The WattNode Plus also adds datalogging. It logs the current energy and time at the completion of every demand subinterval (default is 15 minutes). The logged data can be used to compute the demand (average power) for each interval, as well as the peak demand during the logging period. The non-volatile datalogging memory holds 3700 rows, which corresponds to 38.5 days of logging with a 15 minute interval.

The LonWorks network interface allows a virtually unlimited number of WattNodes to be monitored from one central location with automatic real-time monitoring, data logging, and demand profiling.

The following table shows the various WattNode Plus models that are available.

Model	VAC phase to neutral	VAC phase to phase	Phases	Wires	Neutral Present
WNB-3Y-208-FT10	120	208-240	3	4	Yes
WNB-3D-240-FT10	120-140	208-240	3	3-4	Optional
WNB-3Y-400-FT10	240	400	3	4	Yes
WNB-3Y-480-FT10	277	480	3	4	Yes
WNB-3D-480-FT10	277	480	3	3-4	Optional
WNB-3Y-600-FT10	347	600	3	4	Yes

Table 1: WattNode Plus Models

1.2 Current Transformers

The WattNode can use either toroidal or split-core (opening) current transformers (CTs). The WattNode requires CTs with internal burden resistors generating 0 – 0.333 VAC. This type of CT eliminates the shock hazard of the 5 amp output CTs. They are also generally smaller and lower cost. **Do NOT use 5 amp output CTs**. Split-core CTs offer greater ease of installation, because they can be installed without disconnecting the circuit being measured (although connecting the voltage terminals on the WattNode requires that at least one circuit in the service panel be turned off). Toroidal CTs are more compact, more accurate and less expensive, but they require that the measured circuit be disconnected during installation.

The rated current of the CTs should normally be chosen at or above the maximum current of the circuit being measured. See section **6.2 Current Transformers** for CT specifications. The WattNode can measure up to 150% of rated maximum power with reduced accuracy, so occasional overloads are acceptable. CTs are nonlinear at very low power levels and may report less than the true current.

CTs can measure lower currents than they were designed for by passing the wire through the CT more than once. For example, to measure currents up to 1 amp with a 5 amp CT, pass the wire through the CT once, then loop back around the outside of the CT, and pass the wire through the CT again. Repeat until the wire passes through the CT 5 times. The CT is now effectively a 1 amp CT instead of a 5 amp CT; therefore, set the CT current rating to 1 amp as described in section **4.2.2 Power Configuration**. In general, the current rating of the CT is divided by ***n*** where ***n*** is the number of times that the wire passes through the CT.

1.3 LonTalk® Network

The WattNode Plus communicates using Echelon's® LonTalk network protocol. This interoperable network standard supports many physical media and allows easy communication between LonTalk compatible devices and monitoring computers. Network variables interface the WattNode to the network. Each device on the network may have both input and output network variables. During network setup, output network variables may be bound (connected) to input network variables of the same type. Whenever an output network variable is updated, the new value is propagated over the network, and all devices which have input network variables bound to the updated output will update their internal copies of the variable.

1.3.1 External Interface File (XIF)

The external interface file contains definitions for all the network variables in the WattNode Plus and hardware parameters pertaining to the node, such as transceiver type. The XIF file also contains self-documentation information about the WattNode and all of the network variables. Most network management tools can use XIF files to pre-install a node before the actual node has been connected to the network. Some network management tools require the use of the XIF file during installation. Every order of WattNodes includes a disk with the required XIF file. If you use the XIF file for installation, it is important that the XIF file matches the WattNode version and transceiver type.

2 Hardware Installation

2.1 Precautions

DANGER — HIGH VOLTAGE HAZARD

WARNING - THESE INSTALLATION/SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

Different versions of the WattNode measure circuits with voltages from 120 VAC single-phase to 600 VAC three-phase. **These voltages are lethal!** Always adhere to the following checklist:

1) CCS recommends that a **licensed electrician** install the WattNode.
2) The WattNode does not contain any user serviceable parts; return to CCS for service.
3) Verify that circuit voltages are within the proper range for the WattNode model.
4) Only use CTs with a 0 – 0.333 VAC output. Never use 5 amp output CTs.
5) CTs on different phases should be separated by at least 1 inch (25mm) and the primary conductors for each phase should be separated by at least 1 inch (25mm) from each other and from neutral.
6) Ensure that the line voltage inputs to the WattNode have either fuses or circuit breakers on each voltage phase (not needed for the neutral wire).
7) Never connect the WattNode to a live circuit. Split-core CTs may be placed around live wires.
8) Do not place more than one voltage wire in a screw terminal.
9) Remember that the screw terminals are **not** insulated. Do not contact metal tools to the screw terminals if the circuit is live!
10) Before turning on power to the WattNode, ensure that all the wires are securely installed by gently tugging on each wire.
11) Do not install the WattNode in an environment where it may be exposed to temperatures below -30°C or above 60°C, excessive moisture, dust or other contamination.

2.2 Measurement Configurations

Below is a list of different power measurement configurations, with connections and recommended WattNode Plus models. The wye and delta models are very similar and in some cases may be interchanged. The only difference between a wye and a delta model of the same voltage rating are the input terminals used for the power supply: wye models are powered from Neutral and Phase A, delta models are powered from Phase A and Phase B. This means that a delta model may be used to measure wye circuits, provided that Phase B is connected (not true with single phase circuits). Wye models should not be used for delta circuits, because there is no neutral present.

2.2.1 Single-Phase Two-Wire

The single-phase two-wire 120 VAC or 230 VAC configuration is most often seen in homes and offices. The two wires are neutral and line. The unused CT inputs must be shorted with an insulated jumper wire. Single-phase two-wire circuits can be measured with models WNB-3Y-208 (for 120 VAC circuits) or WNB-3Y-400 (for 230 VAC circuits).

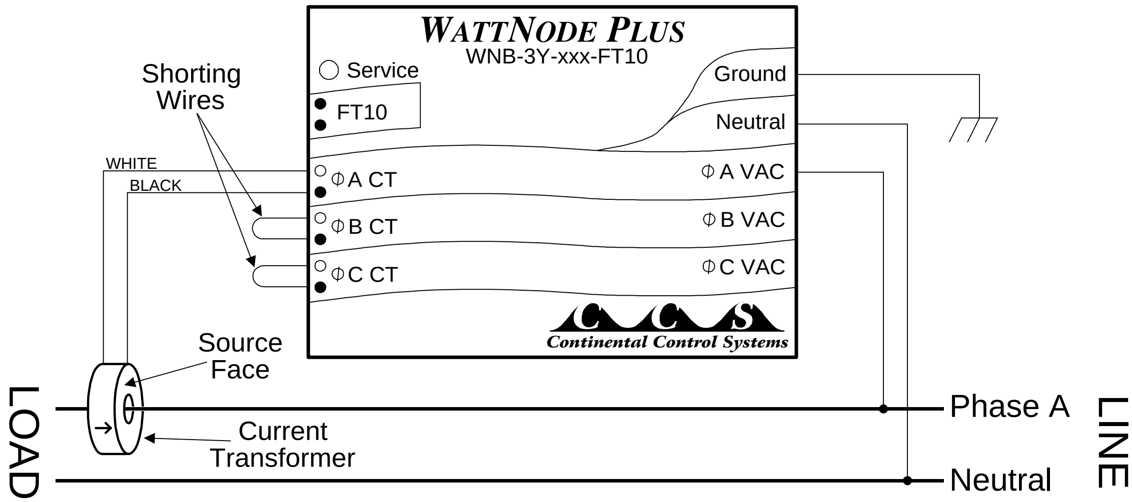

Figure 2: Single-Phase Two-Wire Connection

2.2.2 Single-Phase Three-Wire

This is seen in residential and commercial service with 240 VAC for large appliances. The three wires are neutral and two line voltage wires with AC waveforms 180° out of phase. This results in 120 VAC between either line wire and neutral, and 240 VAC between the two line wires. Single-phase three-wire circuits are be measured with the WNB-3Y-208. This configuration requires neutral—to measure a 240 VAC circuit without neutral, use the WNB-3D-240-FT10 and only connect phases A and B.

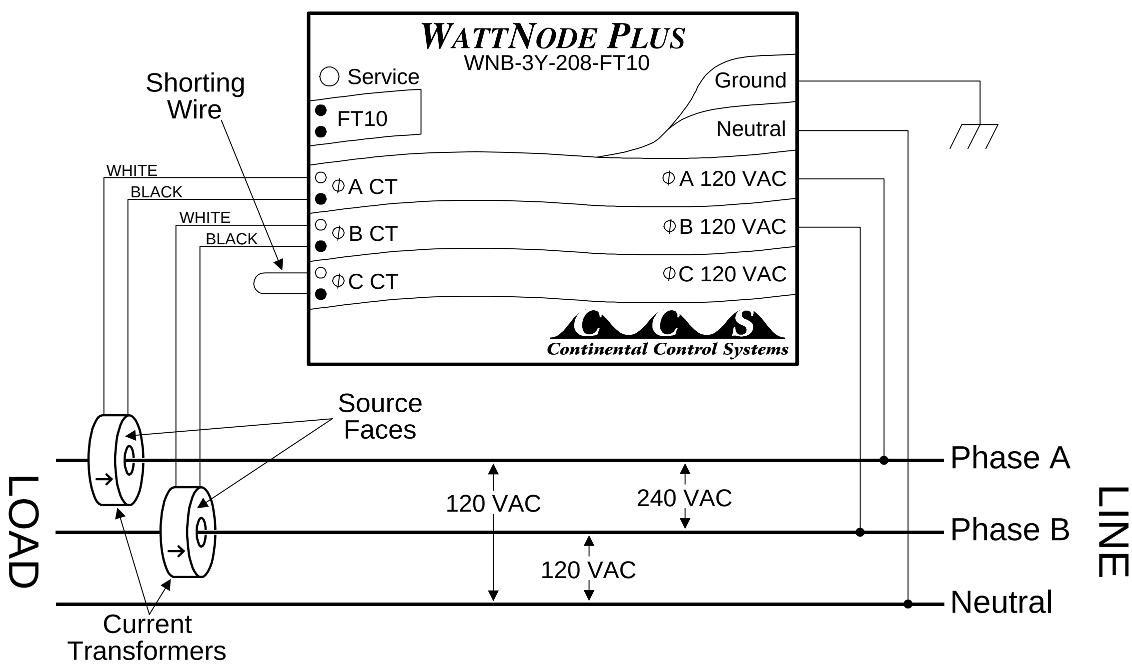

Figure 3: Single-Phase Three-Wire Connection

2.2.3 Three-Phase Four-Wire Wye

This is typically seen in manufacturing and industrial environments. The wires are neutral and three power lines with AC waveforms shifted 120° between the successive phases. With this configuration, the line voltage wires may be connected to the phase A, B and C terminals in any order, **so long as the CTs are connected to matching phases**. It is important, however, that the neutral line be correctly connected. Three-phase four-wire wye circuits should be measured with the WNB-3Y-208 (208 VAC phase to phase and 120 VAC phase to neutral), the WNB-3Y-400 (400 VAC phase to phase and 230 VAC phase to neutral) , the WNB-3Y-480 or WNB-3D-480 (480 VAC phase to phase and 277 VAC phase to neutral), or the WNB-3Y-600 (600 VAC phase to phase and 347 VAC phase to neutral).

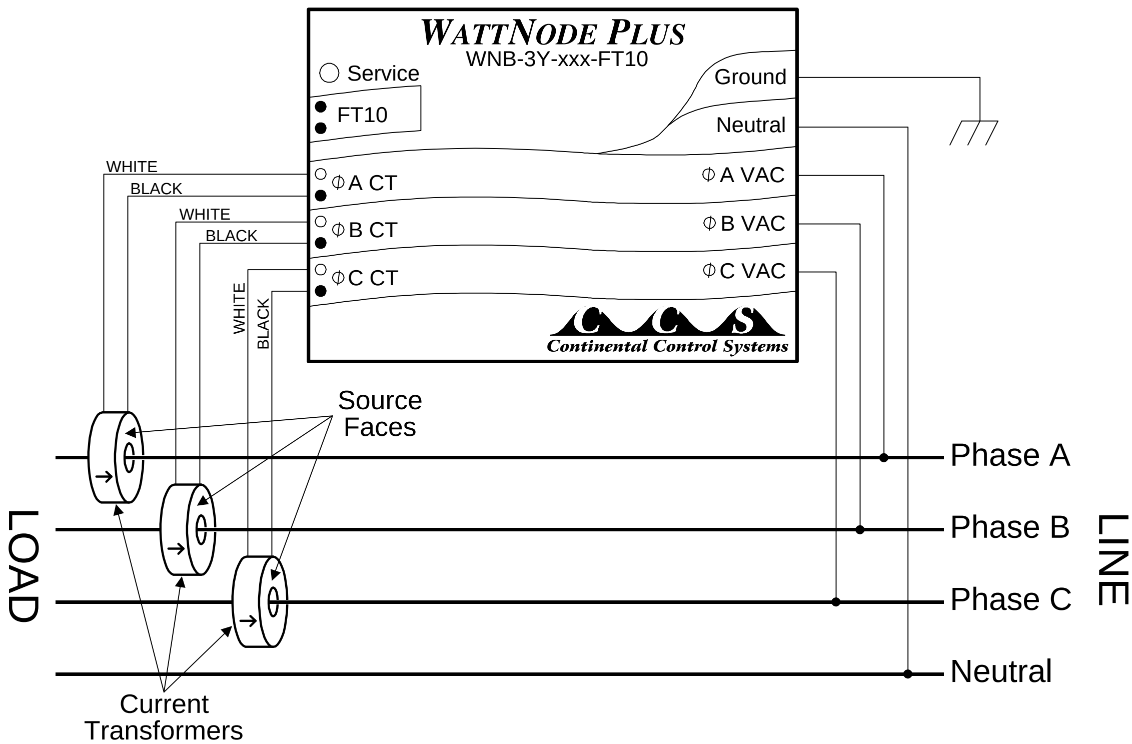

Figure 4: Three-Phase Four-Wire Wye Connection

2.2.4 Three-Phase Three-Wire Delta

This is typically seen in manufacturing and industrial environments. There is no neutral wire, just three power lines with AC waveforms shifted 120° between the successive phases. With this configuration, the line voltage wires may be connected to the phase A, B and C terminals in any order, so long as the CTs are connected to matching phases. Three-phase three-wire delta circuits should be measured with the WNA-3D-240 (208 - 240 VAC phase to phase) or the WNA-3D-480 (480 VAC phase to phase).

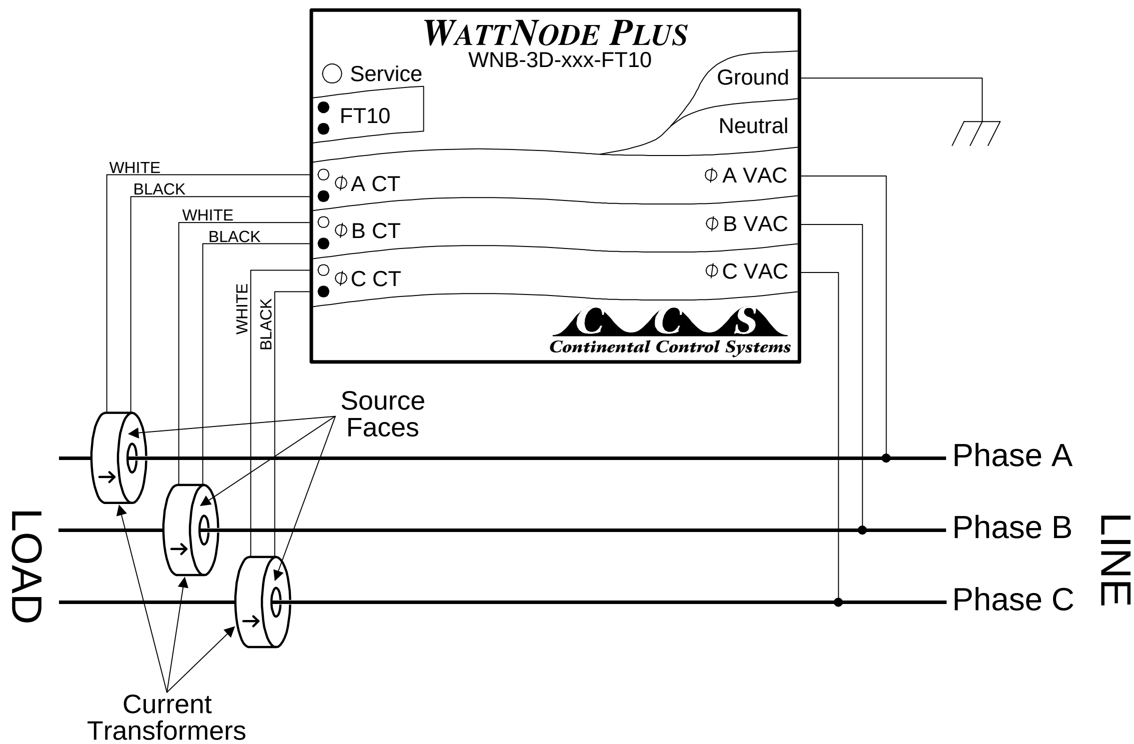

Figure 5: Three-Phase Three-Wire Connection

The three-phase delta configuration may require larger current transformers than expected. For balanced loads, the line currents are 1.732 (the square root of 3) times larger than the phase currents. For example, in **Figure 6** below, if phase currents i_{ab}, i_{bc}, and i_{ca} are each 100 amps, then line currents i_a, i_b, and i_c are each 173.2 amps. This circuit would therefore require CTs rated for at least 175 amps. When choosing the current rating for the CTs, determine if the maximum circuit current is a line current or a phase current.

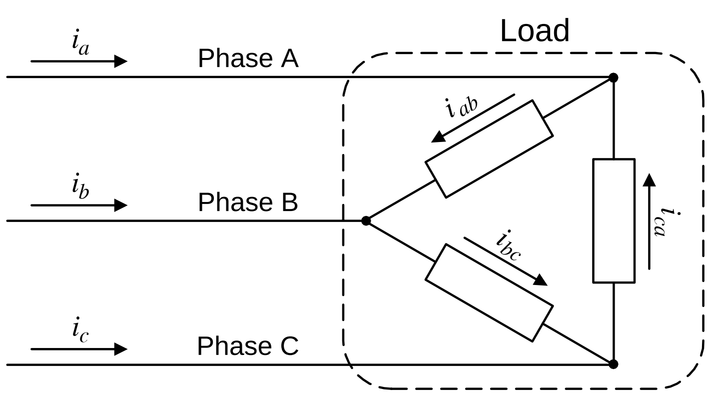

Figure 6: Three-Phase Delta Currents

2.3 Mounting

Mount the WattNode so that it is protected from moisture, direct sunlight and high temperatures. Due to its exposed screw terminals, the WattNode should always be installed in an electrical service panel or an electrical closet. The WattNode may be installed in any position.

The WattNode has two 7/32" (5.5 mm) mounting holes spaced 5.0" (127 mm) apart (center to center). These mounting holes are normally obscured by the detachable screw terminals. Remove the screw terminals by pulling outward while rocking from end to end. The WattNode or Figure 7 may be used as a template to mark mounting hole positions, but do not drill the holes with the WattNode in the mounting position because the drill bit or chuck may damage the plastic WattNode housing or connectors.

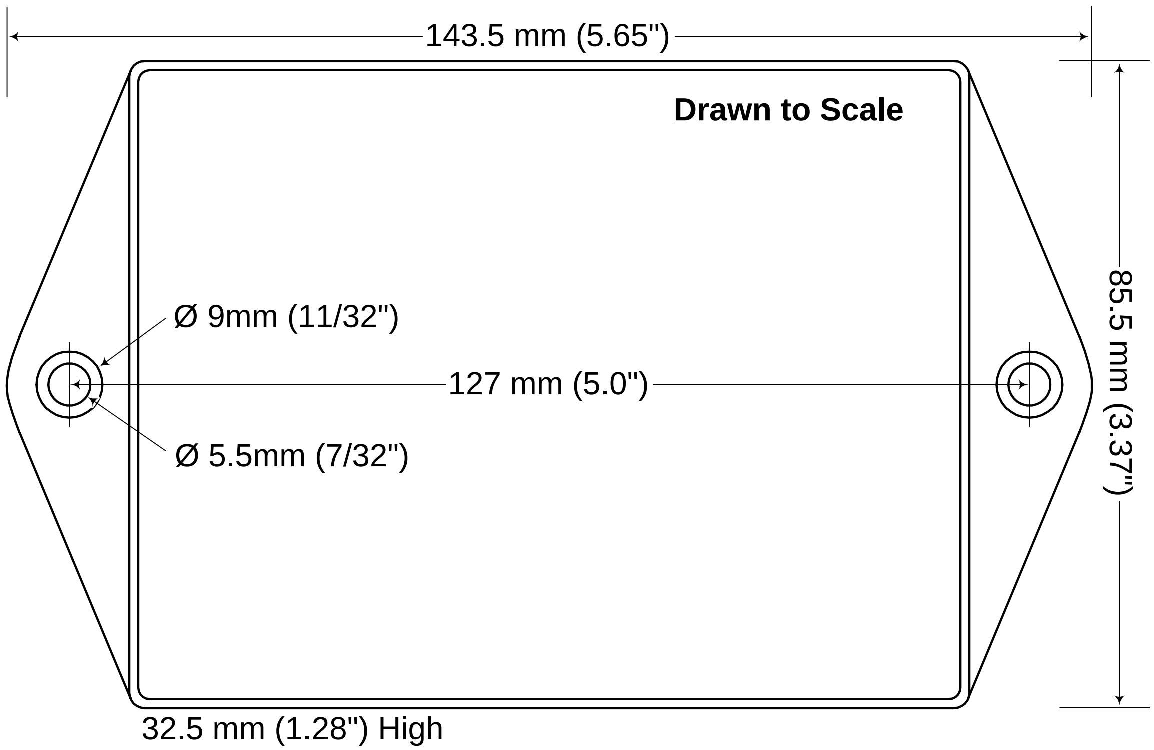

Figure 7: WattNode Dimensions

To protect the WattNode's plastic case, use washers if the mounting screws could pull through the mounting hole or damage the case. Also, take care not to overtighten the mounting screws, as long term stress on the case may cause cracking.

2.4 Connecting Current Transformers

The WattNode Plus will only work with CTs containing built-in burden resistors that produce 0.333 volts output at rated current. The use of any other CTs will result in incorrect power measurements, and may permanently damage the WattNode. CTs with 5 amp output will destroy the WattNode and must not be used. The WattNode's 0.333 VAC output CTs may be safely installed around wires carrying current because the built-in burden resistors eliminate any shock hazard.

There are two steps to connecting the current transformers: mounting each CT around the wire to be measured and connecting the CTs to the WattNode.

CTs are labeled with either a label which says "THIS SIDE TOWARD SOURCE", or with an arrow. Mount the CT so the label faces or the arrow points towards the current source—typically the circuit breaker for the circuit being measured or the utility's meter box. It is also possible to measure generated power by treating the generator as the source.

CTs are directional, so if they are mounted backwards or with the wires reversed, the measured power will be negative. Since the WattNode Plus has individual phase power measurements, you should verify that the power for each phase is positive. If any phases are negative, remount the CT facing the other direction (or swap the white and black wires).

Place the CTs around the line wires as shown in section **2.2 Measurement Configurations**. Split-core (opening) CTs may be placed around the line wires without disconnecting the wire. After a split-core CT has been placed around a wire, a nylon cable-tie should be secured around the CT to prevent inadvertent opening. Toroidal CTs require that the wire be disconnected before passing it through the opening in the CT. Always remove power before disconnecting any live wires.

Next, connect the CTs to the WattNode. The CT inputs to the WattNode are sensitive to ESD (electrostatic discharge), so you should discharge yourself by briefly touching the service panel case or some other grounded metal object before connecting the CTs to the WattNode. Route the twisted black and white wires from the CT to the WattNode. Any excess length may be trimmed from the wires if desired. Strip or trim the wires to expose 1/4" (6 mm) of bare wire. The current transformers connect to the black screw terminal block. Connect each CT, with the white wire aligned with the white dot on the label, and the black wire aligned with the black dot. Note the order in which the phases are connected, because the voltage phases **must** match the current phases for accurate power measurement. Any unused CT inputs must be shorted. You may trim short sections off the end of the CT wires to use as jumpers. Be careful to leave insulation on the exposed portion of the jumper(s).

The final installation step for the CTs is part of the network installation. The full-scale current rating of the CTs must be programmed into the WattNode so that it can correctly scale the output readings. For detailed instructions see section **4.2.2 Power Configuration**. To facilitate this step, the installer should record the CT full-scale current as part of the installation record for each WattNode. If the wires being measured are passed through the CT(s) more than once, then the recorded full-scale CT current is divided by ***n*** where ***n*** is the number of times that the wire passes through the CT.

2.5 Connecting Voltage Terminals

Disconnect power—by shutting off circuit breaker(s) or removing fuse(s)—before connecting the voltage lines to the WattNode. **The WattNode must be connected to voltage lines which are protected by fuses or circuit breakers.** Connect each voltage phase input to a circuit breaker on the required phase. If there is more than one circuit breaker on a phase, then any one of the circuit breakers may be used. When installing multiple WattNodes at the same site, it may be easier to provide separate circuit breaker(s) for the WattNodes.

The detachable screw terminals may be installed or removed while power is applied. CCS recommends the use of insulated gloves whenever working with a live circuit.

When connecting the WattNode, do not place more than one voltage wire in a screw terminal; use separate wire nuts or terminal blocks if needed. The screw terminals handle wire up to 12 AWG. Prepare the voltage wires by stripping the wires to expose 1/4" (6 mm) of bare wire. Do not leave more than 5/16" (8 mm) of bare wire. Connect each voltage line to the white terminal block as described in section **2.2 Measurement Configurations**. Double check that the voltage line phases match the phases to which the CTs are connected. After the voltage lines have been connected, make sure both terminal blocks are securely installed on the WattNode.

The WattNode is powered from the voltage inputs: phase A to phase B for 3-wire (delta) models, or phase A to neutral for all other models. If the WattNode is not receiving 60–80% of the nominal line voltage, it will stop measuring power. Since the WattNode consumes some power itself, a decision must be made about whether to place the CTs before or after the connection for the WattNode, so as to include or exclude the WattNode's own power consumption (1.5 – 3.0 watts).

2.6 Network Wiring

CCS recommends that an experienced LonWorks network installer be consulted for network design, particularly for the areas of topology, repeaters, wiring, and termination.

The WattNode Plus is currently only available with the FTT-10 transceiver. See section **6.7 Communication** for transceiver specifications.

The twisted pair networks are not polarized, so either network wire can be connected to either screw terminal. When connecting to a network, there is a maximum permissible stub length. The stub is the length of the branch wire connecting the main network to the WattNode. If the main network wiring is connected directly to the WattNode, the effective stub length is zero.

To connect the network wiring, strip the wires to expose 1/4" (6 mm) of bare wire on each of the two conductors. Then connect one conductor to each of the two terminals labeled **FT10** on the black terminal block. If the WattNode is connected without a stub, then two wires can be connected to each terminal. If this is done, then take extra care with the two wires in each terminal slot, so that they are both securely tightened. Any loose wires could disable an entire section of the network.

After the network wiring has been connected, check that all the wires are securely installed by gently tugging on each wire in turn. Also check that the terminal block connectors are completely seated. At this point power may be applied to the WattNode. Note: there is no harm in applying power before making the network connections.

2.7 Installation Summary

1) Mount the WattNode.
2) Turn off power before installing toroidal CTs or making voltage connections.
3) Place the current transformers (CTs) around the line wires of the circuit being measured. Take care to orient the CTs correctly.
4) Connect the twisted white and black wires from the CT to the black terminal block on the WattNode, matching the wire colors to the white and black dots on the label of the WattNode.
5) Jumper any unused CT inputs with an insulated shorting wire.
6) Connect the voltage wires to the white terminal block of the WattNode, and double check that the current measurement phases match the voltage measurement phases.
7) For twisted pair networks, connect the network wires (polarity is unimportant).
8) Apply power to the WattNode.

3 Network Configuration

3.1 Identifying the WattNode

The WattNode supports three network identification methods. The first requires that the WattNode's service button be pressed when requested by the network installation software. The second technique uses the WattNode's unique Neuron ID to identify the WattNode being installed. The third uses the network wink command to light the WattNode's service LED for 15 seconds.

Service button installation requires that the network management computer be near the WattNode during installation. This is possible either with very small networks, or with a portable network installation computer. If this technique is used, follow the procedure for installing a new node on the network in the network management software. When the software prompts you to press the service pin, press the black square button beside the black network connector (while pressed, the Service LED will light). If the network management software does not respond within several seconds, then there is probably some problem with the network (see section **5 Troubleshooting**).

Neuron ID installation is performed by manually entering the WattNode's Neuron ID into the network management software during node installation. This technique allows an electrician to install and record the location and Neuron IDs of several WattNodes. Once the WattNodes are physically installed, they can be configured remotely. The Neuron ID is printed on a permanent label located on the back of the WattNode.

Wink installation can be used when several WattNodes—and possibly other nodes—have been physically installed and need to be identified for the network. The network management software must be able to find unconfigured nodes on the network. When an unconfigured node is found, the network management software will be instructed to send the wink command to the node. By observing which WattNode responds to the wink command by lighting its service LED solidly for 5 seconds, the physical location of the WattNode may be matched with the network address.

The wink command may also be used after a WattNode has been configured on the network to verify its network communication and/or its physical location.

The WattNode will not produce accurate measurements until the full-scale current rating of the CTs is programmed into the Energy object; for instructions see section **4.2.2 Power Configuration**.

3.2 WattNode Reinitialization

The WattNode may be reinitialized to clear its configuration settings. Reinitialization can be used when the WattNode is installed in a new location or on a new network, or to restore all configuration network variables to the factory default values.

To reinitialize the WattNode, first remove power from the WattNode. Then, while holding the service button pressed, restore power. Continue holding the service button for five seconds after power is restored, then release. After a few seconds, the service LED should begin to flash (one second ON, one second OFF). Now the WattNode is ready to be installed.

Reinitialization deletes all network configuration, returning the WattNode to the unconfigured state (see section **5.1 Service LED**). All network variable bindings will be deleted and all of the configuration network variables will be restored to factory default values, except the calibration values and *nciCtAmps_f*. This does not zero the accumulated energy, reactive energy, or the energy log data.

3.3 Network Variables

The WattNode uses LonMark interoperable SNVTs (Standard Network Variable Type) and is programmed with self-documentation information. It also is supplied with an external interface file (XIF), which defines all of the network variables and transceiver parameters. The XIF file may be requested by network management software during installation and is particularly useful if you wish to configure the network software for a WattNode before physically installing the WattNode.

WattNode network variable names are prefixed with three letters indicating the variable type:

nvi – Input to the WattNode, but may also be read.

nvo – Output from the WattNode.

nci – Configuration network variable; normally an input to the WattNode, but can be read to determine the current configuration. All configuration variables are preserved during power outages.

3.3.1 Authentication

For installations where the WattNode will be used for billing, several of the network variables should be protected from unauthorized tampering. The LonTalk protocol supports a feature called authentication, which prevents unauthorized nodes from accessing specified network variables. The network management software must be used to enable authentication for each network variable being protected. Once protected, the network variable may only be accessed by nodes that know the authentication key. If authentication is enabled, be sure to record the authentication key. The following network variables should be protected with authentication if the WattNode is being used for billing or other critical applications: *nviTimeSet*, *nviCal*, *nciCtAmps_f*, *nciDemPerMins,* and *nciDemSubints*.

3.3.2 Network Variable Summary

Variable Name	Variable Type	Default	Description
General Variables			
nviRequest	SNVT_obj_request	0, normal	Object request (object_id, request)
nvoStatus	SNVT_obj_status		Object status
nviTimeSet	SNVT_time_stamp		Time of day (yr, mn, dy, hr, mn, sec)
nviCalSel	SNVT_count		Calibration selector
nviCal	SNVT_power_f		Calibration data (for the selected value)
Power Measurement			
nvoPowerSum	SNVT_power_f		Total power (watts)
nvoPower[0]	SNVT_power_f		Power for phase A (watts)
nvoPower[1]	SNVT_power_f		Power for phase B (watts)
nvoPower[2]	SNVT_power_f		Power for phase C (watts)
nciCtAmps_f	SNVT_amp_f	5.0 amps	CT rated current (amps)
nciPwrUpdtT	SNVT_elapsed_tm	5 sec.	Time between power updates: 0–18 hrs.
Energy Measurement			
nvoEnergySum	SNVT_elec_whr_f		Total true energy (watt-hours)
nvoEnergy[0]	SNVT_elec_whr_f		True energy for phase A (watt-hours)
nvoEnergy[1]	SNVT_elec_whr_f		True energy for phase B (watt-hours)
nvoEnergy[2]	SNVT_elec_whr_f		True energy for phase C (watt-hours)
nvoReacEngySum	SNVT_elec_whr_f		Total reactive energy (watt-hours)
nciEngyUpdtT	SNVT_elapsed_tm	5 sec.	Time between energy updates: 0–18 hrs.
Demand Measurement			
nvoDemand	SNVT_power_f		Demand power (floating point watts)
nvoPkDemand	SNVT_power_f		Peak demand power
nvoPeakDemT	SNVT_time_stamp		Peak demand time (dy, hr, mn, sec, ms)
nviLogRequest	SNVT_count		Used to request data from the demand log
nvoLogData	SNVT_str_asc		Used to read the requested data
nciDemPerMins	SNVT_count	15 min.	Demand period: 5–720 min.
nciDemSubints	SNVT_count	1	Demand subintervals (1–8)
Power Factor Measurement			
nvoPFavg	SNVT_pwr_fact_f		Average power factor for all phases
nvoPF[0]	SNVT_pwr_fact_f		Power factor for phase A (-1.0 to +1.0)
nvoPF[1]	SNVT_pwr_fact_f		Power factor for phase B (-1.0 to +1.0)
nvoPF[2]	SNVT_pwr_fact_f		Power factor for phase C (-1.0 to +1.0)
Reactive Power Measurement			
nvoReacPwrSum	SNVT_power_f		Total reactive power (watts)
nvoReacPwr[0]	SNVT_power_f		Reactive power for phase A (watts)
nvoReacPwr[1]	SNVT_power_f		Reactive power for phase B (watts)
nvoReacPwr[2]	SNVT_power_f		Reactive power for phase C (watts)
nciReacUpdtT	SNVT_elapsed_tm	5 sec.	Time between reactive power updates
Miscellaneous Measurements			
nvoVolts[0]	SNVT_volts_f		RMS voltage for phase A
nvoVolts[1]	SNVT_volts_f		RMS voltage for phase B
nvoVolts[2]	SNVT_volts_f		RMS voltage for phase C
nvoCurrent[0]	SNVT_amp_f		RMS current for phase A (amps)
nvoCurrent[1]	SNVT_amp_f		RMS current for phase B (amps)
nvoCurrent[2]	SNVT_amp_f		RMS current for phase C (amps)
nvoFreq	SNVT_freq_f		Line frequency for phase A (Hz)

4 Operation

4.1 General

The WattNode general variables provides status and request mechanisms, time of day, and calibration. The WattNode uses several floating point network variables. Note: instead of the scientific notation for floating point numbers ($1.23\times10^3 = 1230$), we will use the standard computer notation (1.23e3).

4.1.1 Requests

The WattNode Plus provides only minimal request and status features to meet the LonMark requirements, although other aspects of the WattNode's firmware are not yet LonMark compliant.

The request variable *nviRequest* is used to request information from or to change the state of the WattNode. The RQ_NORMAL, RQ_UPDATE_STATUS, and RQ_REPORT_MASK requests are supported. Currently, there is only one object for the entire WattNode, with an object number of 0.

In response to each request, the object's status is returned in *nvoStatus*. The status variable *nvoStatus* also indicates if the request was made of an invalid object number, or if the object doesn't support the request made of it.

4.1.2 Status

The WattNode produces a status output *nvoStatus* in response to each request. The status response will indicate the status of the WattNode. The WattNode supports the following status fields:

object_id – The number of the object whose status is being reported (0=WattNode).

invalid_id – Indicates that a request was made with an invalid object number.

invalid_request – Indicates that the object does not support the requested operation.

4.1.3 Time of Day

The time of day variable *nviTimeSet* is an input that the WattNode uses to synchronize demand, timestamp log data, and timestamp peak demand. It is not necessary to use this variable, but if it is not set, then the demand measurements will be timed from the WattNode's internal crystal. The internal crystal is stable to 0.02%, and will not contribute a significant error to demand measurements. Regular updates to the time of day prevent long term demand drift. Without updates to the time of day a timing error of 0.02% could result in a drift of up to 8 minutes per month. If the demand intervals of several WattNodes are supposed to stay synchronized, this may not be acceptable.

The *nviTimeSet* variable may be updated by a monitoring computer, or it may be bound to a separate clock node on the network. The WattNode internally tracks time, so if *nviTimeSet* is used, it does not need to be updated frequently. Updating the time of day hourly or daily should be sufficient. Due to demand synchronization issues, it is best not to update nviTimeSet at the same time a demand interval completes. If your demand interval is 15 minutes, the demand intervals complete on the hour, quarter past, half past, and three quarters past, so you should update the time some other time, say five minutes past the hour.

Tampering with the *nviTimeSet* variable can affect the timing of demand measurements that may be used for billing. To prevent unauthorized tampering, authentication should be enabled for *nviTimeSet*. It is possible to read *nviTimeSet* to verify the time of day (although it is not intended as a clock). It's value is updated every five seconds.

4.1.4 Calibration, Etc.

The WattNode Plus uses a pair of network variables for calibration and miscellaneous features. *nviCalSel* is a selector variable used to choose which calibration value to read or write. *nviCal* is an input network variable normally used to write calibration values, but which can also be read with polling.

Generally, the end-user **should never write** to any of these values and will only rarely have reason to read from any of them. If you have reason to change any of these values, contact CCS for more information.

nviCalSel	**Description**
0	Phase A energy and power gain.
1	Phase B energy and power gain.
2	Phase C energy and power gain.
3	Phase A voltage gain.
4	Phase B voltage gain.
5	Phase C voltage gain.
6	Phase A phase angle adjustment (radians).
7	Phase B phase angle adjustment (radians).
8	Phase C phase angle adjustment (radians).
9	Not used - Nominal VAC.
10	Not used - Minimum VAC for active phase.
11	Minimum register count in five seconds for a non-zero power reading.
12	Number of active phases.
13	Enables temperature measurement if non-zero (only if temperature option installed).
14	Measurement period pre-sample time in milliseconds (do NOT change).
20	Error code. A non-zero value indicates an error. Any writes zero the error code.
21	Tamper count (read only). Incremented whenever nciCtAmps_f, any calibration value, nciDemSubints, or nciDemPerMins are updated.
22	Temperature (read only). Indicates the temperature inside the WattNode in degrees Celsius (optional feature).

4.2 Power Measurement

The WattNode measures power every five seconds. The WattNode can be configured to update the power output network variables at intervals from 5 to 65,000 seconds, by changing *nciPwrUpdtT*.

4.2.1 Power Output

The WattNode Plus has four real power output variables:

nvoPowerSum – The sum of the real power from all active phases.

nvoPower[0] – The phase A power.

nvoPower[1] – The phase B power.

nvoPower[2] – The phase C power.

All of these are in units of floating point watts and will read both positive and negative power values. Negative power values are generally an indication of reversed CTs.

4.2.2 Power Configuration

The output energy, power and demand measurements all depend on the full-scale current rating of the CTs. The full-scale current rating of the CTs is set with the variable *nciCtAmps_f*. This is a floating point network variable of type SNVT_amp_f. This must be correctly set during installation. The full-scale rating of the CTs are printed on the label of the CTs. If more than one CT is used, they must all have the same full-scale rating. See section **1.2 Current Transformers** for more details on selecting CTs and their full-scale current rating.

4.3 Energy Measurement

More commonly known as KWH (kilowatt-hours), the energy is the integral of power over time. Many installations will only use the energy measurement. It is commonly used for billing or sub-metering. The WattNode Plus is set up so that only positive energy is measured: negative energy will **not** subtract from the total. Because energy is an accumulated value, it can be used on networks that are accessed infrequently (like a utility meter that only needs to be read once a month).

In the WattNode Plus, there is no means to reset the energy to zero (for billing security). However, energy will wrap around to zero when it reaches one terawatt-hour (1.0×10^{12} watt-hours).

During a power outage, the energy consumed will not be measured. Whenever the line voltage drops below 60–80% of nominal, the WattNode will shut down until power is restored. To preserve the energy measurement across power outages, the WattNode writes the current energy to non-volatile memory every 10 seconds. When power returns, the last stored value is recovered.

4.3.1 Energy Output

The energy value may be retrieved either by polling or by binding the network variable and setting *nciEngyUpdtT* to control the interval between updates. The energy is computed every five seconds, but any update rate between five seconds and 18 hours may be used. The WattNode Plus has four real energy output variables:

nvoEnergySum – The sum of the real energy from all active phases.

nvoEnergy[0] – The phase A energy.

nvoEnergy[1] – The phase B energy.

nvoEnergy[2] – The phase C energy.

All of these are in units of floating point watt-hours and will read only positive values.

4.3.2 Reactive Energy

The reactive energy (or VAR-hours) is the integral of the reactive power over time. Like active energy, it only accumulates positive values and overflows at one terawatt-hour (or teraVAR-hour).

nvoReacEngySum – The sum of the reactive energy (VAR-hours) from all active phases.

4.4 Demand Measurement

Demand is defined as the average power over a specified time interval. Typical demand intervals are 5, 10, 15, 30, 60, etc. up to 720 minutes, but the WattNode supports arbitrary demand intervals from 5 to 720 minutes. The WattNode records the peak demand with a time stamp for metering applications where the measurements may only be accessed weekly or monthly.

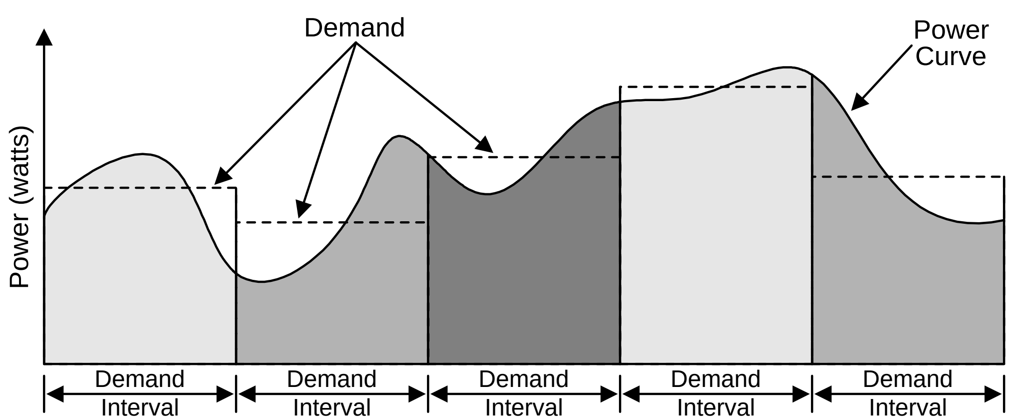

Figure 8: Demand Measurement

The WattNode also supports rolling demand (also called “sliding window”), in which the demand intervals are evenly divided into a fixed number of subintervals. At the end of each subinterval, the average power over the demand interval is computed and output. This results in better accuracy, especially for demand peaks which would not have lined up with the demand interval without subintervals. The first measurement will not be reported until one complete demand interval has elapsed. From 1 to 8 subintervals are supported, provided that the subinterval duration is at least 5 minutes. A subinterval count of one results in the standard demand measurement without rolling demand.

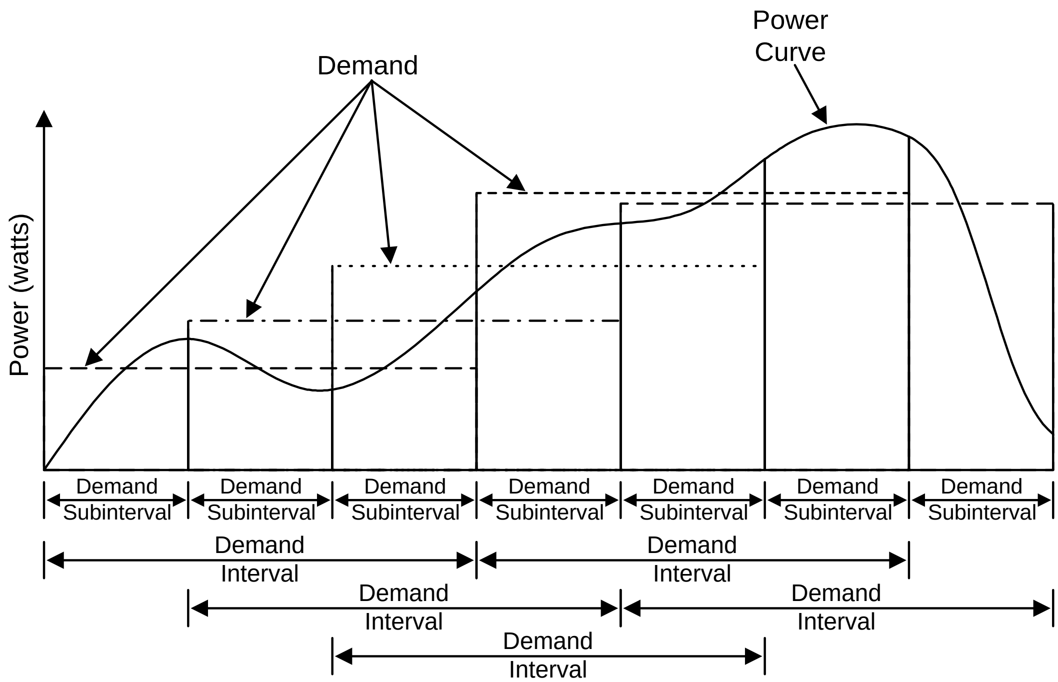

Figure 9: Rolling Demand with Three Subintervals

4.4.1 Demand Configuration

The variable *nciDemPerMins* sets the demand interval in minutes, and *nciDemSubints* sets the number of demand intervals. The time period of each subinterval is the demand interval divided by the number of subintervals. Setting this value to 1 disables subinterval computations. The demand period cannot be longer than 12 hours, and a demand subinterval cannot be less than 5 minutes. The *nciDemSubints* can be set from 1 to 8.

An example configuration could use a demand period of 1 hour with 4 subintervals. This would result in a subinterval period of fifteen minutes. Every fifteen minutes, the average power over the last hour would be computed and reported.

If the WattNode is measuring demand for billing or sub-metering, see **3.3.1 Authentication** on information to prevent unauthorized tampering with these configuration variables.

4.4.2 Demand Outputs

These variables are updated every time a demand interval or subinterval ends:

nvoDemand – The average power over the demand interval (watts).

nvoPkDemand – The largest measured demand (can be reset to zero).

nvoPeakDemT – The timestamp for the peak demand

Demand measurement starts whenever any of the demand configuration variables are changed. If the time of day, *nviTimeSet,* is updated by a monitoring computer or a clock module on the network then the demand measurement intervals will remain synchronized to the time of day. For example, if you have one subinterval and the demand period is one hour, then each demand period will always conclude exactly on the hour.

If power fails, then when power returns, the WattNode restart the demand measurement. As soon as *nviTimeSet* is updated, the WattNode will resynchronize to the correct time of day, allowing multiple WattNodes to stay synchronized even through power failures.

4.4.3 Peak Demand

The peak demand measurement is updated every time a new demand measurement is made. It is cleared whenever the demand configuration changes, or sending '3' to *nviLogRequest*. The peak demand is stored in non-volatile memory, so that its value is not lost during power outages.

Whenever a new demand peak occurs, the peak demand value and *nvoPeakDemT* are updated. *nvoPeakDemT* is a SNVT_time_stamp that records the time at which the peak demand occurred, as this can sometime affect billing and may be useful in monitoring applications as well.

4.4.4 Demand Datalogging

The WattNode Plus has 3700 rows of non-volatile memory for datalogging. At the completion of every demand subinterval, the current time and energy are logged. This information can be retrieved to get a history of the last 38 days (with a 15 minute logging interval). The energy can be used directly, or it can be used to compute the demand (average power) for each logging interval, as well as the peak demand.

The log information is retrieved using the network variables nviLogRequest and nviLogData. Because of the wide dynamic range possible for energy values, the WattNode internally stores the energy as a 56 bit integer with units of 2.0e-5 watt-hours (therefore, a count of 50,000 corresponds to 1.00 watt-hour).

To get the most recently logged data, set *nviLogRequest* to 1, wait 200 milliseconds, then read the value of *nviLogData*. To read successive previous rows, set *nviLogRequest* to 2, wait 200 milliseconds, then read the value of *nviLogData*. The format of nviLogData is 15 bytes of binary data (stored in a SNVT_str_asc):

Byte#	1–7	8	9	10–11	12	13	14	15
Contents	Energy	Day	Month	Year	Second	Minute	Hour	Result

The result codes are:

0 = Success

1 = Non-volatile memory error

2 = No more log data available

3 = Error reading Daily Log (updated once per day with date)

4 = Error reading the Demand log (or no data available)

4.5 Power Factor Measurement

The power factor is the ratio of the real power to the apparent power, where the apparent power is the square root of the sum of the squares of the real and reactive powers. Resistive loads (incandescent lights, heaters) and power factor corrected devices have a power factor very near 1.0. Motors and other inductive or capacitive devices have lower power factors, typically ranging from 0.6 - 0.9.

The WattNode Plus outputs the following power factor variables (with the update rate controlled by nciReacUpdtT):

nvoPFavg – The average power factor for all active phases.

nvoPF[0] – The phase A power factor.

nvoPF[1] – The phase B power factor.

nvoPF[2] – The phase C power factor.

For delta circuits, the power factor is measured relative to ground. For reasons too mathematical to explain here, with a purely resistive load, a delta circuit will have a power factor of 0.87. For more information, see **The Handbook for Electricity Metering** in Section **7 References**.

4.6 Reactive Power Measurement

The reactive power (also know as VARs) is a measurement of the power which does not deliver useful work. Reactive power is a result of a phase shift between the voltage and current waveforms. A purely reactive load (never seen in practice) would have current flowing to the load, but the electric meter would not turn and the real power would be zero.

The WattNode Plus outputs the following reactive power output variables (with the update rate controlled by nciReacUpdtT):

nvoReacPwrSum – The sum of the reactive power for all active phases.

nvoReacPwr[0] – The phase A reactive power.

nvoReacPwr[1] – The phase B reactive power.

nvoReacPwr[2] – The phase C reactive power.

4.7 Miscellaneous Measurements

The WattNode Plus measures the power line frequency (phase A only) and reports the value with *nvoFreq*.

The WattNode also measures the average line voltages for each phase, from which it computes an estimated RMS line voltage and RMS current for each phase. These measurements may be less accurate than the power and energy measurements. In particular, their accuracy is related to the distortion of the voltage sine wave. For a voltage distortion of less than 10% (2% - 7% is typical), the accuracy of the RMS voltage and RMS current measurements should be better than 4.0%. For delta circuits, the measured voltage is relative to ground (there is no phase-to-phase measurement), while the measured current is the current in the supply conductors, which is not the same as the current in load (see **Figure 6**).

5 Troubleshooting

5.1 Service LED

The service LED indicates the operating condition of the WattNode firmware. Many problems can be diagnosed by observing the service LED. Figure 10 shows the different behaviors of the WattNode service LED after power up. During normal operation, after the initial power up, the LED should remain OFF. In addition, the service LED should always light while the service button is being pressed: this can be used to test that the WattNode is powered. The following terms describe the various states of the WattNode.

Unconfigured – The WattNode is operating properly, but has not yet been configured (installed) by network management software.

Configured – The WattNode is operating properly and has been configured by network management software.

Internal Error – The WattNode is not functioning correctly and must be returned for service.

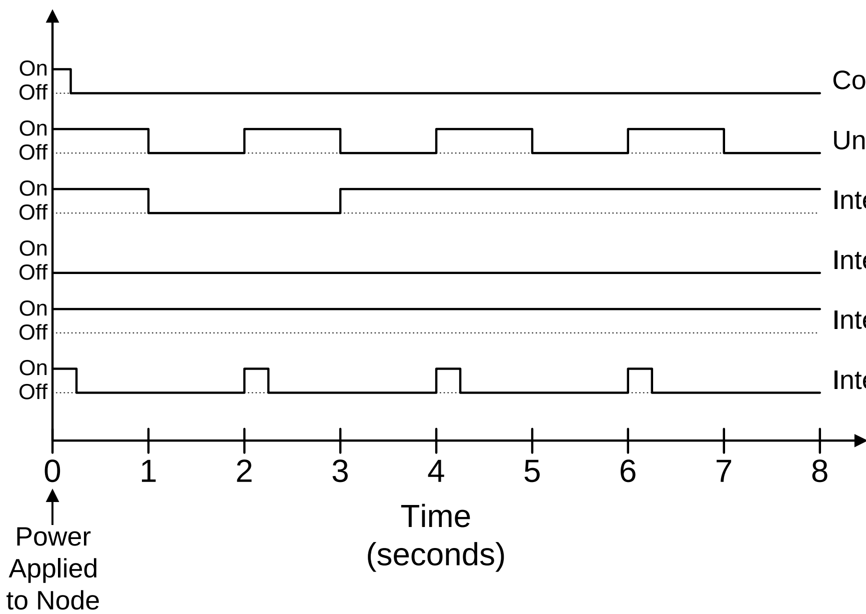

Figure 10: Service LED Behaviors

Any pattern of LED flashing not described by Figure 10 should also be treated as an internal error, and the WattNode returned for service. Before returning the WattNode, try cycling power at least once and observing the LED carefully. If possible, note the LED behavior, as this will help with diagnosing the problem.

5.2 Miscellaneous

SYMPTOM: The WattNode does not appear on the network.

Probable Causes	**Corrective Actions**
The WattNode is not powered	Check for power by pressing the service button and watching for the service LED to light.
The WattNode is not connected to the network	Check the network wires to the WattNode.
The WattNode's transceiver type is incorrect for the network	Check the transceiver type and network type.
The WattNode is not functioning correctly	Check the service LED behavior on power up.
	Try reinitializing the WattNode, see section **3.2 WattNode Reinitialization**.
	Return for service.

SYMPTOM: The WattNode is reporting zero power.

Probable Causes	**Corrective Actions**
***nciCtAmps_f* is zero.**	Check that *nciCtAmps_f* is set to the correct value.
The CT rating may be too large for the application or the load being measured may not be active.	If possible, verify that at least 5% of the CT's rated current is flowing through the CT. Follow **5.2.2 Test CT Output** below to check the CTs.
An unused pair of CT screw terminals has not been jumpered with an insulated shorting wire.	On any unused CT screw terminals, connect the white and the black terminals (indicated by dots on the label) together with a short insulated jumper wire. Strip both ends of the jumper wire to expose 1/4" (5mm) of bare wire.
The WattNode is not functioning correctly.	If another WattNode of the same model is installed and working, a suspect unit may be tested by disconnecting the screw terminals from the working unit, and plugging them into the suspect unit. If the suspect unit works correctly, then most likely it is the wiring to the suspect unit, and not the WattNode that is at fault.
	Try reinitializing the WattNode, see section **3.2 WattNode Reinitialization**.
	Return for service.

SYMPTOM: The WattNode appears to be reporting incorrect values.	
Probable Causes	**Corrective Actions**
***nciCtAmps_f* does not match the rating of the CTs.**	Check that *nciCtAmps_f* is set to the correct value.
One or more CTs may be installed backwards.	If the CT faces towards the load (instead of the source) or the white and black wires have been reversed, then the power for that phase will be negative. Check *nvoPower[0]*, *nvoPower[1]*, and *nvoPower[2]* for positive values.
There is a wiring problem or error.	Check *nvoVolts* for each active phase. Also check *nvoPower* and *nvoPF* for each phase. Negative *nvoPower* values and/or *nvoPF* values less than 0.6 typically indicate that the voltage and CT wires may be wired out of phase.
The voltage and CT wires may be wired out of phase.	The best approach is to visually verify that everything is wired correctly, but if that is not a feasible option, then follow **5.2.1 Test CT Ordering** below.
The CT rating may be too large for the application or the load being measured may not be active.	If possible, verify that at least 5% of the CT's rated current is flowing through the CT. Follow **5.2.2 Test CT Output** below to check the CTs.
The CTs are not the 0.333 VAC output type.	Visually check the CTs or follow **5.2.2 Test CT Output** below to check the CTs.
An unused pair of CT screw terminals has not been jumpered with an insulated shorting wire.	On any unused CT screw terminals, connect the white and the black terminals (indicated by dots on the label) together with a short insulated jumper wire. Strip both ends of the jumper wire to expose 1/4" (5mm) of bare wire.
The CTs are not all the same current rating.	Ensure that matching CTs are used for all phases.
The XIF file does not match the WattNode's firmware version.	Ensure that you are using the XIF file from the disk that came with the WattNode.
The WattNode is not functioning correctly.	If another WattNode of the same model is installed and working, a suspect unit may be tested by disconnecting the screw terminals from the working unit, and plugging them into the suspect unit. If the suspect unit works correctly, then most likely it is the wiring to the suspect unit, and not the WattNode that is at fault.
	Try reinitializing the WattNode, see section **3.2 WattNode Reinitialization**.
	Return for service.

SYMPTOM: The demand measurement is not working.	
Probable Causes	**Corrective Actions**
The demand interval has not yet elapsed.	The first demand output will not occur until one complete demand interval has elapsed. After than, a new output will occur every time a subinterval elapses (assuming that there is more than one subinterval).

5.2.1 Test CT Ordering

1. Either remove power from the WattNode or unplug the CT screw terminals from the WattNode before working with the CT wires.
2. Check each CT in turn. Disconnect all other CTs and jumper their screw terminals with a shorting wire.
3. To order the phases correctly, match each CT to the pair of screw terminals that results in the largest power. If the reported power on a pair of screw terminals is zero, then also try reversing the CT wires. Throughout this test, unused CT inputs must be jumpered with a shorting wire between the white and black dots. In addition, if the power level of the load being measured is changing significantly, then this test may not yield correct results.

5.2.2 Test CT Output

1. Since some CTs may produce little or no output below 5% of rated current, verify that at least 5% of the CT's rated current is flowing through the CT. Use a clamp-on style current meter to measure the current in the wire that passes through the CT. If a clamp-on current meter is not available, go on to step 2.
2. Measure AC voltage across the CT wires (probe the screw terminals). If the voltage is less than 16 mV, then a) less then 5% of the CT's rated current is flowing, or b) the CT is defective. If the voltage is more than 333 mV, then a) more than the CT's rated current is flowing, b) the CT is defective, or c) the CT is not a 333 mV output CT. If you suspect that the CT may be defective, then a clamp on current probe may be used to verify the current flowing in the wire. If the clamp-on probe indicates that an AC current ranging from 5% to 100% of the CT's rated current is flowing and yet the voltage across the CT is not in the range from 16 to 333 mV, then the CT is probably bad. As a final test, unplug the CT screw terminals from the WattNode and measure the voltage again. If it is significantly different, then the WattNode may be defective.

6 Specifications

6.1 Models

Model	VAC phase to neutral	VAC phase to phase	Phases	Wires	Neutral Present
WNB-3Y-208-FT10	120	208-240	3	4	Yes
WNB-3D-240-FT10	120-140	208-240	3	3-4	Optional
WNB-3Y-400-FT10	240	400	3	4	Yes
WNB-3Y-480-FT10	277	480	3	4	Yes
WNB-3D-480-FT10	277	480	3	3-4	Optional
WNB-3Y-600-FT10	347	600	3	4	Yes

Table 11: WattNode Models

6.2 Current Transformers

The WattNode uses CTs with integral burden resistors generating 0.333 VAC at rated current. The maximum allowable current is dependent only on the physical size of the CT, not the rated current. Exceeding the maximum allowable current may damage CTs.

The accuracy of the toroidal CTs is rated as 1% from 10% to 130% of rated current. The following toroidal (solid core) CTs are available.

Model	I.D.	Rated Amps	Max. Amps
CTT-0300-yyy	0.30"	5, 15, 30	40
CTT-0500-yyy	0.50"	15, 30, 50, 60	80
CTT-0750-yyy	0.75"	30, 50, 70, 100	130
CTT-1000-yyy	1.00"	50, 70, 100, 150, 200	260
CTT-1250-yyy	1.25"	70, 100, 150, 200, 250, 300, 400	520

Table 12: Toroidal CTs

The accuracy of the split-core CTs is rated as 1% from 10% to 130% of rated current. The following split-core (opening) CTs are available.

Model	I.D.	Rated Amps	Max. Amps
CTS-0750-yyy	0.75"	5, 15, 30, 50, 70, 100, 150	200
CTS-1250-yyy	1.25"	70, 100, 150, 200, 250, 300, 400, 600	800
CTS-2000-yyy	2.00"	600, 800, 1000, 1200, 1500	2000

Table 13: Split-core CTs

The CT suffix (-yyy) is the rated current.

Bus-bar CTs are also available in a wide range of sizes and currents, ranging up to a 10" x 10" opening and currents up to 4000 amps.

6.3 Accuracy

The WattNode's power and energy accuracy is 0.45% of reading plus 0.05% of full-scale. The WattNode's temperature dependence is less than ±0.01% / °C. The total system accuracy is subject to CT accuracy.

The WattNode can measure power from 0.05% to 150% of rated power at reduced accuracy, which provides extra range for occasional high loads and for alarms. Due to their nonlinearity, however, the CTs may not produce accurate readings at very low power levels, and may saturate at very high power levels.

The RMS voltage and RMS current measurements have an accuracy of 4.0% for line voltage waveforms with less than 10% distortion (the accuracy gets progressively better with lower distortion).

6.4 Timekeeping

The WattNode's internal clock is accurate to 0.02% with a worst case drift of 8 minutes a month. If the time of day input variable *nviTimeSet* is updated once an hour, then the WattNode will never drift more than a second from the true time of day.

6.5 Update Rate

The WattNode measures all basic units every five seconds. The demand is measured at the end of each demand interval or subinterval (measured to the nearest five second interval).

6.6 Ratings

6.6.1 Electrical

Power Consumption: 1.5 – 3.0 watts

Operating Voltage Range: 80% to 120% of nominal

6.6.2 Environmental

Temperature: -30°C to +60°C

Humidity: 5 to 90% RH (non-condensing)

6.6.3 Mechanical

Enclosure: High impact, ABS plastic

- **Flame rating:** 94HB

Size: 143mm × 85mm × 32mm (5.63" × 3.34" × 1.25")

Connectors: Euroblock style pluggable terminal blocks

- **Light gray:** 22 to 12 AWG, 600 V
- **Black:** 22 to 12 AWG, 300 V

6.7 Communication

Transceiver: Echelon FTT-10

Bit Rate: 78 kbps

Maximum Nodes: 64 per subnet

Maximum Distance: 500–2700 meters (see Echelon LonWorks Products Databook for more details)

Maximum Stub Length:

- **Free Topology:** Unlimited
- **Bus Topology:** 3 meters

7 References

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