

WATTNODE[®]

for LONWORKS[®]
User's Guide



Rev 1.22

(M1)

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1 Overview

1.1 WattNode

The WattNode 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 to measure power generation. 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 WattNode is a LonMark interoperable product. Functionally, it can be viewed as three sensors in one package: a power meter (watts), an energy meter (watt-hours), and a demand meter (watts)—demand is the average power over a specified time interval. These quantities are output as LonWorks Standard Network Variable Types (SNVTs). The choice of three different output units (SNVTs) for each measurement allows developers to choose the most convenient representation. Additionally, the WattNode can be configured to alarm at over-range power, under-range power, and over-range demand power.

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 models that are available.

Model	VAC phase to neutral	VAC phase to phase	Phases	Wires	Neutral Present
WNA-1P-240-xxx	120	240	1	2 or 3	Yes
WNA-3Y-208-xxx	120	208,240	3	4	Yes
WNA-3Y-400-xxx	240	400	3	4	Yes
WNA-3Y-480-xxx	277	480	3	4	Yes
WNA-3Y-600-xxx	347	600	3	4	Yes
WNA-3D-208-xxx	N/A	208	3	3	No
WNA-3D-480-xxx	N/A	480	3	3	No
WNA-4WD-240-xxx	120/208	240	3	4	Yes

The transceiver suffixes (-xxx) are -TP78 or -FT10.

Table 1.1: WattNode 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 **4.2.3 Energy 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 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 LonMark[®]

The WattNode is certified as meeting LonMark Interoperability Guidelines version 3.0. The guidelines ensure that products from different manufacturers can be integrated together in a network. The guidelines also specify consistent documentation and network variable organization to speed installation.

1.3.2 External Interface File (XIF)

The external interface file contains definitions for all the network variables in the WattNode 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

Improper installation procedures may result in injury or death.

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) 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).
- 6) Never connect the WattNode to a live circuit. Split-core CTs may be placed around live wires.
- 7) Always connect the CTs to the WattNode before connecting the line voltages to the WattNode. Note: in some installations the CT screw terminals will be at line voltage.
- 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 models. Note: Ground wires do not carry current except in the case of a malfunction of the circuit being measured and are not used by the WattNode.

2.2.1 Single-Phase Two-Wire

The single-phase two-wire 120 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 WNA-1P-240 or WNA-3Y-208.

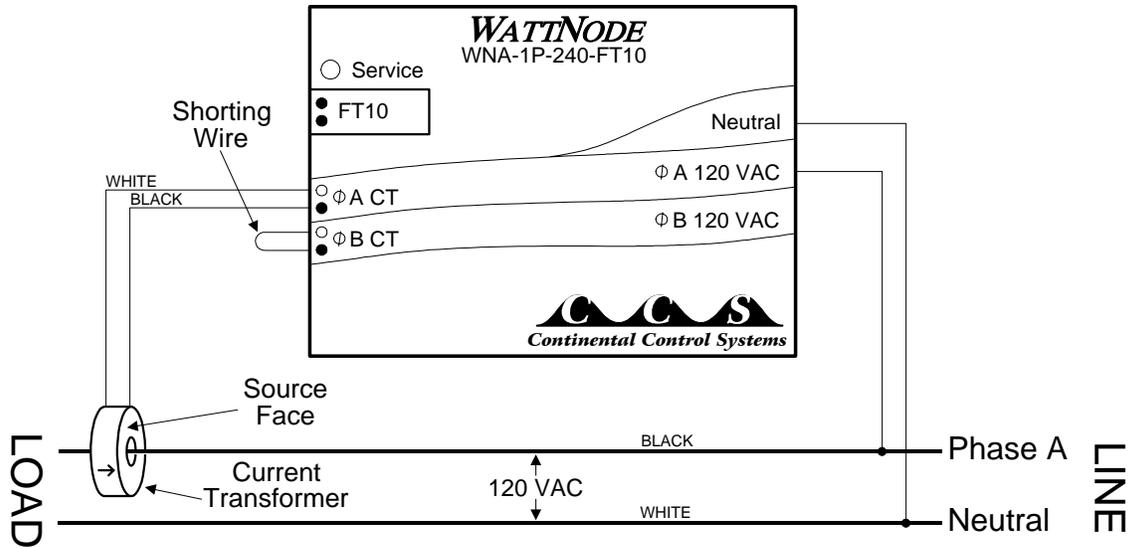


Figure 2.1: Single-Phase Two-Wire Connection

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. The ground wire is not connected. This results in 120 VAC between either line wire and neutral, or 240 VAC between the two line wires. Single-phase three-wire circuits can be measured with models WNA-1P-240 or WNA-3Y-208. Note: Neutral must be connected.

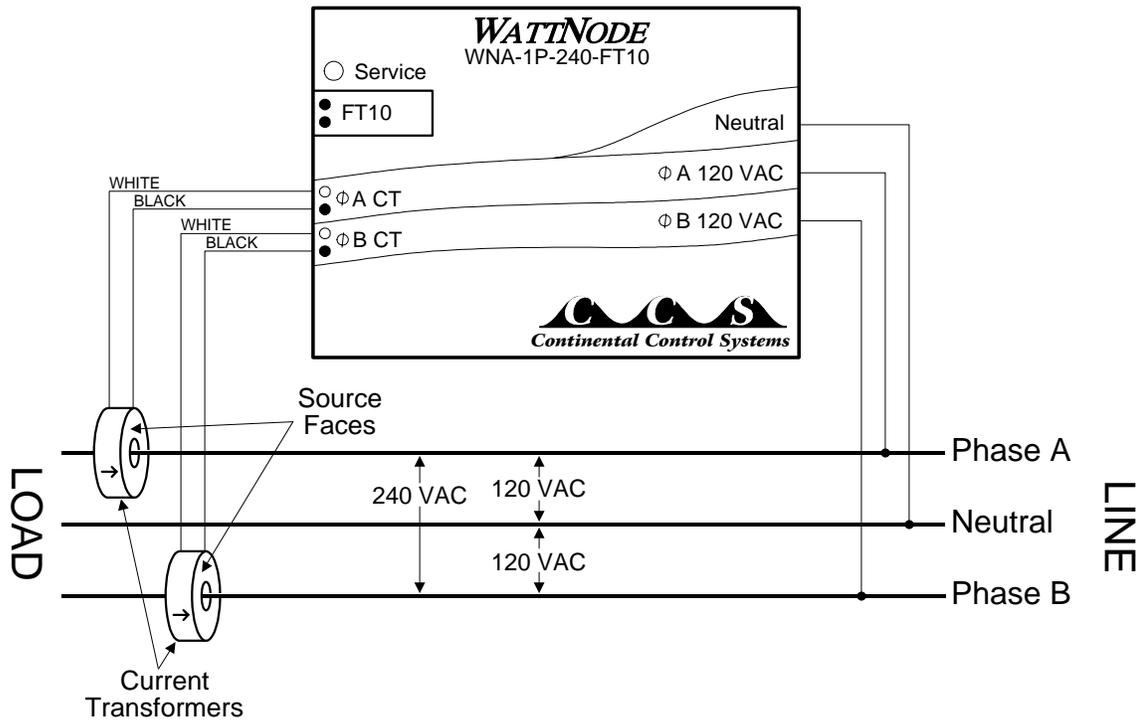


Figure 2.2: Single-Phase Three-Wire Connection

2.2.3 Three-Phase Three-Wire Delta

WARNING

This configuration is dangerous because there is no neutral wire, and as a result, the screw terminals to connect the CTs will have line voltages on them whenever the WattNode is powered. Therefore, for safety, it is critical that the WattNode is not powered while connecting the CTs.

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-208 (208 VAC phase to phase) or the WNA-3D-480 (480 VAC phase to phase).

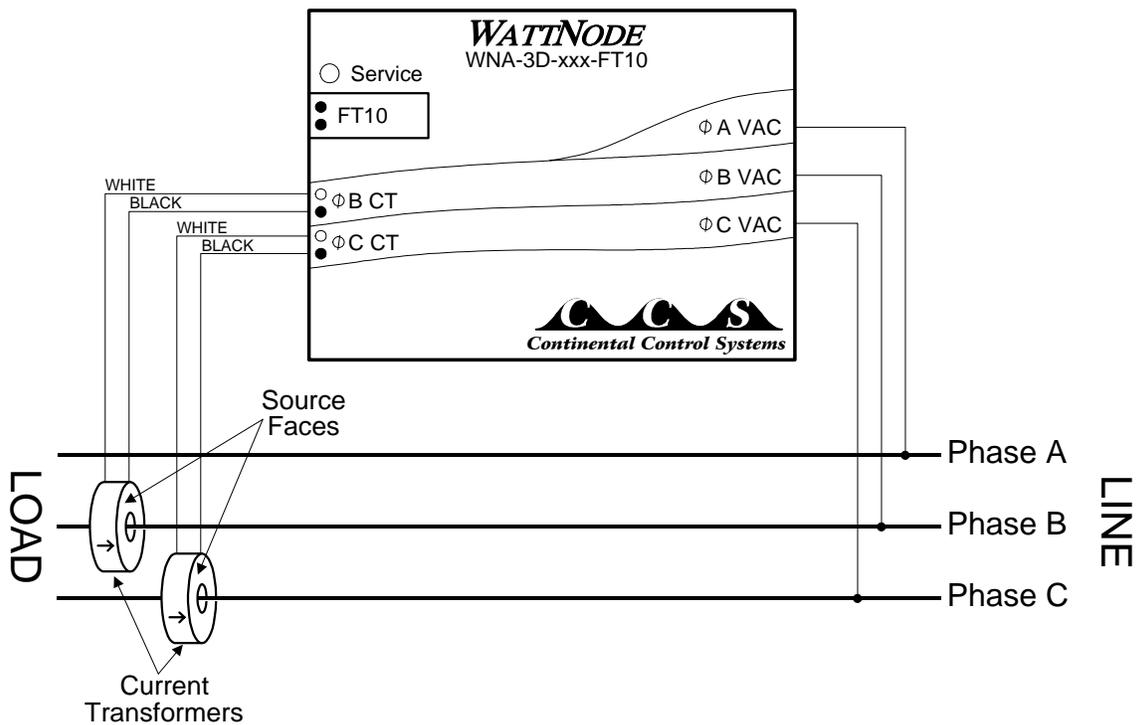


Figure 2.3: Three-Phase Three-Wire Delta Connection

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 2.4** 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.

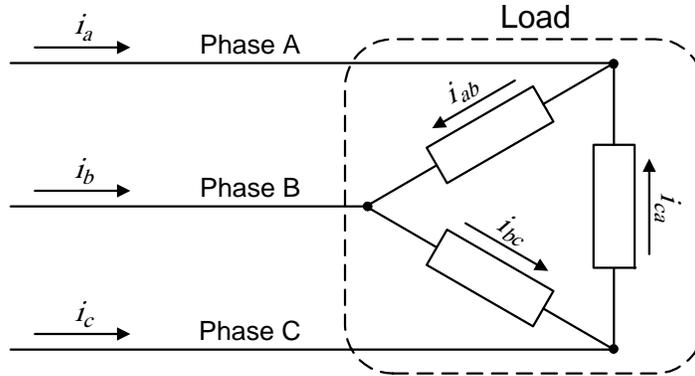


Figure 2.4: Three-Phase Delta Currents

2.2.4 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 WNA-3Y-208 (208 VAC phase to phase and 120 VAC phase to neutral), the WNA-3Y-400 (400 VAC phase to phase and 230 VAC phase to neutral), the WNA-3Y-480 (480 VAC phase to phase and 277 VAC phase to neutral), or the WNA-3Y-600 (600 VAC phase to phase and 347 VAC phase to neutral).

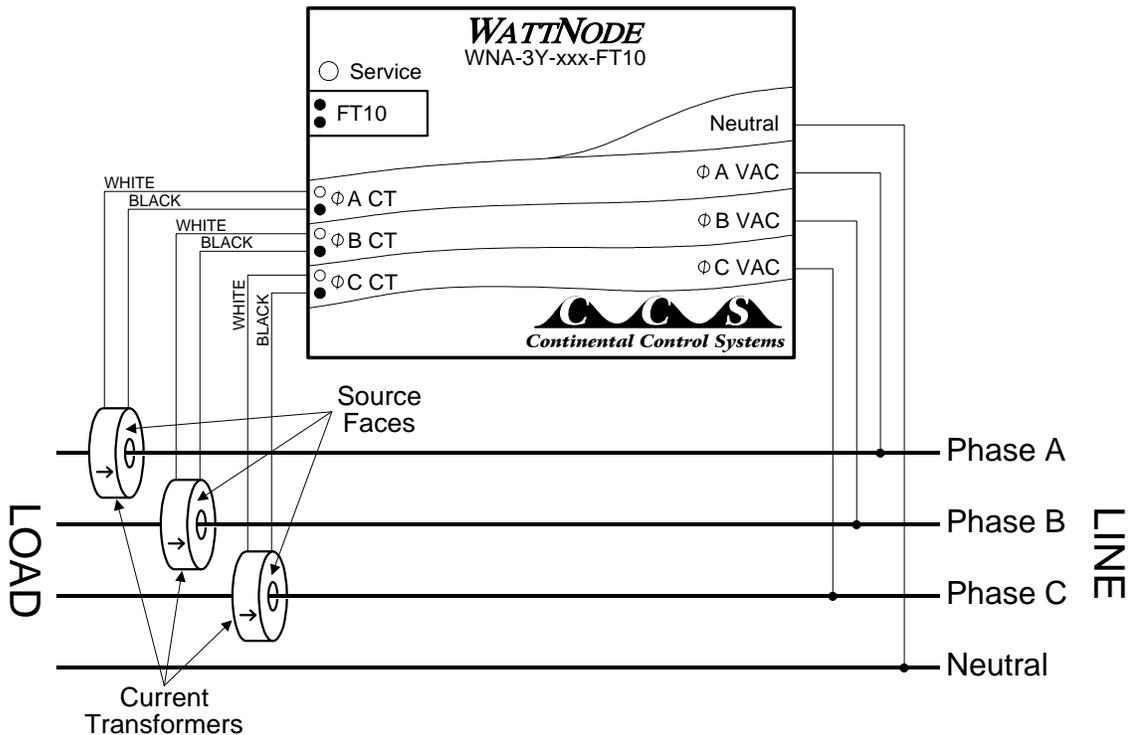


Figure 2.5: Three-Phase Four-Wire Wye Connection

2.2.5 Three-Phase Four-Wire Delta

CAUTION

This configuration must be wired correctly. The voltage between neutral and the phase A line input must be only 120 VAC. Connect the 208 VAC “Wild Phase” to the phase C line input.

This is typically seen in manufacturing and industrial environments. This configuration provides a 240 VAC three phase delta, two 120 VAC phases (to neutral), and a single 208 VAC phase—known as the “Wild Phase”. When wiring this configuration, take care that the phase A voltage is 120 VAC relative to neutral. Three-phase four-wire delta circuits must be measured with the WNA-4WD-240.

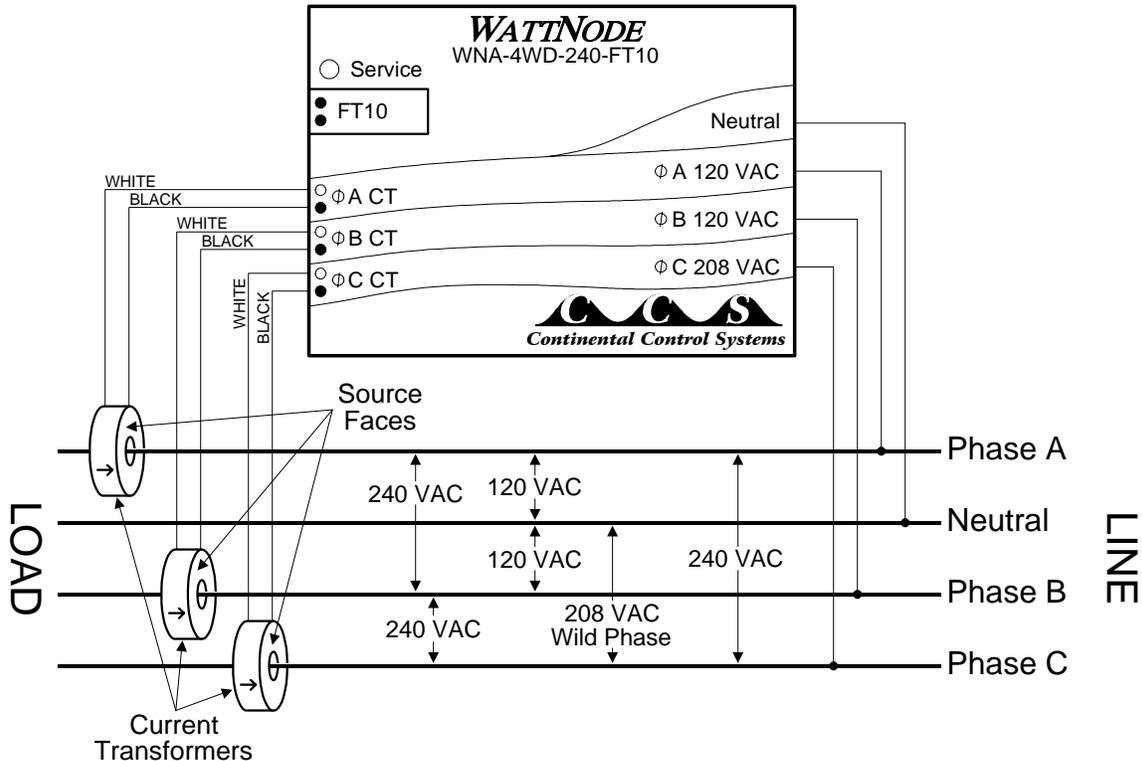


Figure 2.6: Three-Phase Four-Wire Delta Connection

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" (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 2.7 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.

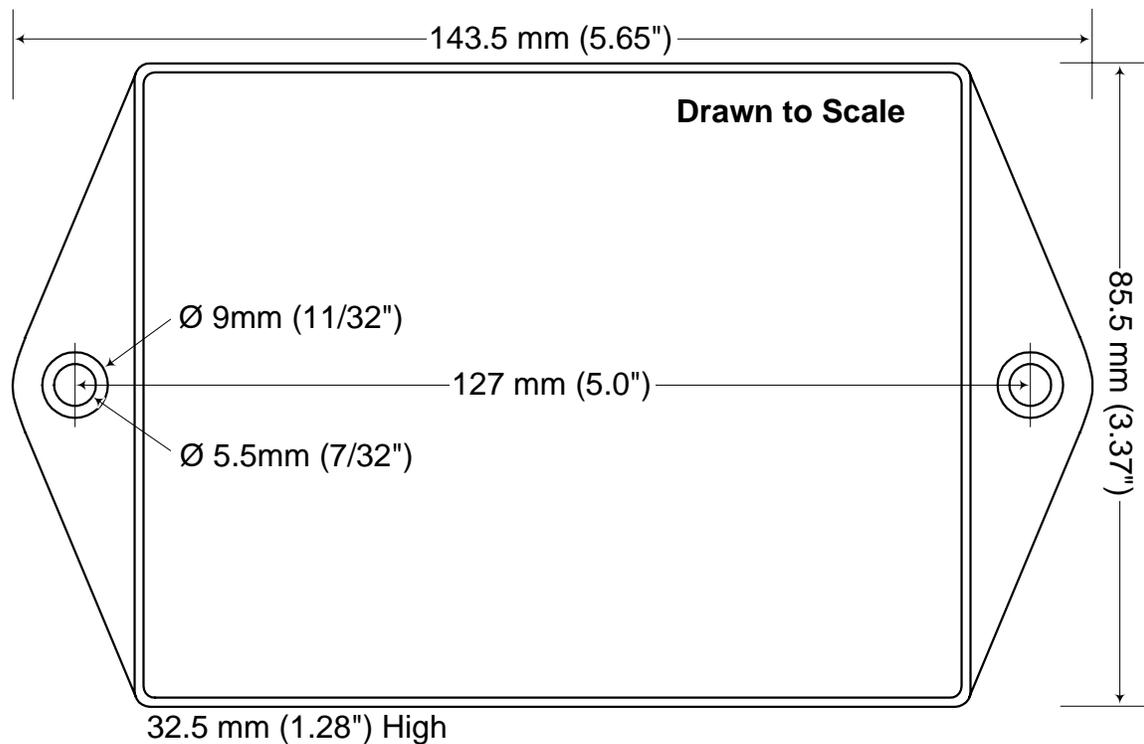


Figure 2.7: WattNode Dimensions

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 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.

The WattNode does not measure negative power and will instead indicate zero power. CTs are directional, so if they are mounted backwards or with the wires reversed the measured power will be negative. In an installation with just one CT, the WattNode would output zero power. In a multiple CT installation, if one CT were backwards and others were mounted correctly, then the reversed CT would cause the power on that phase to be subtracted from the power measured on the other phases, resulting in a plausible, but incorrect reading.

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.

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. Do not leave more than 5/16" (8 mm) or less than 7/32" (5 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) to prevent shock or shorting danger.

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 **4.2.3 Energy 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) or less than 7/32" (5 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 neutral, or phase A to phase B for delta models. If the WattNode is not receiving at least 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, including choice of transceivers, wiring, and termination. The WattNode may communicate over a twisted pair network or over the power lines. Power line transceivers do not require additional network wiring, but twisted pair transceivers require connection to a twisted pair network.

The WattNode may be purchased with the following transceivers:

Transceiver	Bit Rate	Max. Nodes ¹	Max. Distance	Max. Stub Length
TPT/XF-78	78 Kbps	64	1400 m	3.0 m
FTT-10	78 Kbps	64	500–2700 m	3.0 m ²

¹Per subnet (see Echelon LonWorks Products Databook for more details)

²Only applies to bus topology networks.

Table 2.1: WattNode Transceivers

The FTT-10 transceiver is compatible with LPT-10 Link Power Twisted Pair networks.

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 '**Network**' on the black terminal block. If the WattNode is connected without a stub, then two wires can be connected to each terminal. Each terminal should have one wire for each direction on the network. 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) Turn on power for 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 5 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 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 **4.2.3 Energy 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. 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 *nciGain* and *nciCTAmps*. The WattNode will also zero the accumulated energy total, demand and peak demand. Finally, any disabled measurement objects will be enabled.

3.3 Network Variables

The WattNode uses LonMark interoperable SNVTs (Standard Network Variable Type) and object definitions. The WattNode is designed as three independent sensor objects and one supervisory node object. The three objects report energy, power and demand. They may be independently activated, configured, and bound on the network. See section 4 **Operation** for detailed information on using and configuring the measurement objects.

The WattNode is programmed with self-documentation information formatted according to “LonMark Interoperability Guidelines version 3.0”. There is a self-documentation string for the whole WattNode that contains the LonMark header and the text names of each sensor object supported by the WattNode. These are followed by a brief description of the WattNode. The WattNode uses the following standard program IDs:

Transceiver	Standard Program ID
TP/XF-78	80:00:22:15:00:0A:01:00
TP/FT-10	80:00:22:15:00:0A:04:00

Table 3.2: LonMark Standard Program IDs

The WattNode also comes with an external interface file (XIF), which defines all of the network variables, the standard program ID, 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 for a WattNode before physically installing the WattNode.

The WattNode contains four LonMark objects: Node Object (#0), Energy Measurement Object (#1), Power Measurement Object (#2), and Demand Measurement Object (#3). Each object has several associated network variables (NVs). Each NV has a self-documentation string with a LonMark header indicating object number, variable type—LonMark object, manufacturer specific, or configuration—and variable number. The LonMark header is followed by text describing the NV.

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

nvi – Input to the WattNode.

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: *nviRequest*, *nviTimeSet*, *nciGain*, *nciCTAmps*, *nciDemPeriod*, and *nciDemSubints* (the last two only pertain to demand measurements, and need not be authenticated if demand is not being used).

3.3.2 Network Variable Summary

Variable Name	Variable Type	Default	Description
Node Object (#0)			
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)
nvoAlarm	SNVT_alarm		WattNode alarms
nciStsMaxSendT	SNVT_elapsed_tm	0 sec.	Status update interval (dy,hr,mn,sec,ms)
Energy Measurement Object (#1)			
nvoElecWH_f	SNVT_elec_whr_f		Energy (floating point watt-hours)
nvoElecKWH	SNVT_elec_kwh		Energy (0–65535 kilowatt-hours)
nvoEngyClrT	SNVT_time_stamp		Energy clear time (yr,mn,dy,hr,mn,sec)
nciGain	SNVT_muldiv	?, 65535	Calibration value (multiplier, divisor)
nciCTAmps	SNVT_amp	5.0 A	CT rated current (0–3276.7 amps)
nciWHMaxSendT	SNVT_elapsed_tm	5 sec.	Time between energy updates: 0–18 hrs.
Power Measurement Object (#2)			
nvoPower_f	SNVT_power_f		Instantaneous power (floating point watts)
nvoPowerW	SNVT_power		Instantaneous power (0–6553.5 W)
nvoPowerKW	SNVT_power_kilo		Instantaneous power (0–6553.5 KW)
nciWMaxSendT	SNVT_elapsed_tm	10 sec.	Maximum time between power updates: 0–18 hrs. (dy,hr,mn,sec,ms)
nciWMinSendT	SNVT_elapsed_tm	0 sec.	Minimum time between power updates: 0–18 hrs. (dy,hr,mn,sec,ms)
nciWMinDelta	SNVT_power_f	1.0e38 W	Amount by which power must change to force an output transmission
nciPowLimHi	SNVT_power_f	1.0e38 W	Power alarm high limit
nciPowLimLo	SNVT_power_f	0.0 W	Power alarm low limit
nciPowAlmSetT	SNVT_elapsed_tm	0 sec.	Power alarm set time: 0–18 hrs.
nciPowAlmClearT	SNVT_elapsed_tm	0 sec.	Power alarm clear time: 0–18 hrs.
nciPowLimHystHi	SNVT_power_f	0.0 W	Power alarm high hysteresis
nciPowLimHystLo	SNVT_power_f	0.0 W	Power alarm low hysteresis
nciPowAlarmInhT	SNVT_elapsed_tm	0 sec.	Initial power alarm inhibit time: 0–18 hrs (dy,hr,mn,sec,ms)
Demand Measurement Object (#3)			
nvoDemand_f	SNVT_power_f		Demand power (floating point watts)
nvoDemandW	SNVT_power		Demand power (0–6553.5 W)
nvoDemandKW	SNVT_power_kilo		Demand power (0–6553.5 KW)
nvoPkDemand_f	SNVT_power_f		Peak demand power
nvoPkDemandW	SNVT_power		Peak demand power (0–6553.5 W)
nvoPkDemandKW	SNVT_power_kilo		Peak demand power (0–6553.5 KW)
nvoPkDemResetT	SNVT_time_stamp		Peak demand reset time (dy,hr,mn,sec,ms)
nvoPeakDemT	SNVT_time_stamp		Peak demand time (dy,hr,mn,sec,ms)
nvoLoadControl	SNVT_switch		Demand alarm load control (on/off)
nciDemHiLim1	SNVT_power_f	1.0e38	Demand power alarm high limit 1
nciDemHiLim2	SNVT_power_f	1.0e38	Demand power alarm high limit 2
nciDemPeriod	SNVT_elapsed_tm	15 min.	Demand period: 1–720 min. (dy,hr,mn,sec,ms)
nciDemSubints	SNVT_count	1	Demand subintervals (1–15)

4 Operation

4.1 Node Object

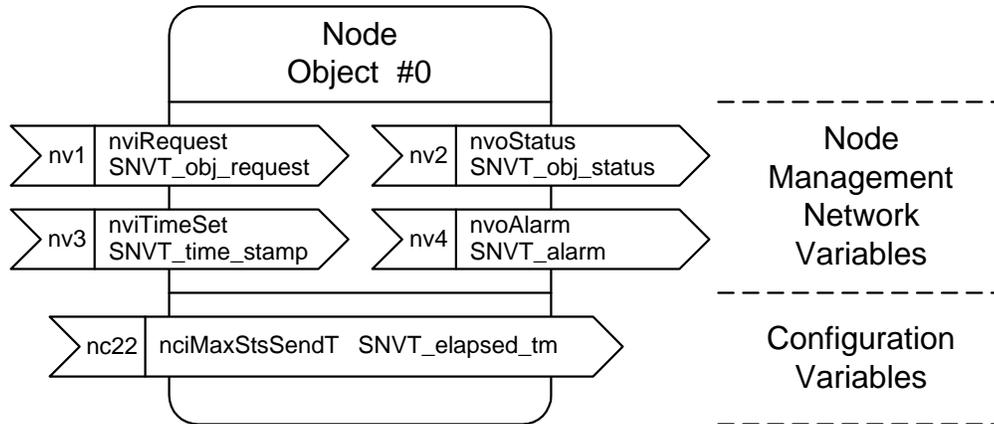


Figure 4.1: Node Object

The Node object in the WattNode provides status and request mechanisms, time of day, and alarms. The WattNode uses several floating point network variables. Instead of the scientific notation for floating point numbers ($1.23 \times 10^3 = 1230$), we will use the standard computer notation (1.23e3).

4.1.1 Requests

The request variable *nviRequest* is used to request information from or to change the state of any of the objects. The request contains the number of the object to which the request is directed and the request type.

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.

The *nviRequest* variable can zero values that may be used for billing. To prevent unauthorized tampering, authentication should be enabled for *nviRequest*. The NORMAL request will only zero energy or peak demand if the demand object was disabled when the NORMAL request was received.

Whenever energy is zeroed, the time stamp *nvoEngyClrT* will be set to the current time. Whenever peak demand is reset, the time stamp *nvoPkDemResetT* will be set to the current time. If demand is disabled and then enabled, *nvoPkDemResetT* will be set to the current time.

The following table shows the requests and effects for each object.

Request & Number	Node Object #0	Energy Object #1	Power Object #2	Demand Object #3
NORMAL 0	Enables all objects. Bound variables will be propagated on the network. Polled variables will be updated.	No effect.	Enables power object. Bound power variables will be propagated. Polled energy variables will be updated.	Enables demand object. Demand variable will be updated. Demand and peak demand are set to zero and demand is restarted.
DISABLED 1	Disables power and demand objects. <i>nvoStatus</i> is updated.	Invalid request.	Disables power object. Power output variables go to zero. <i>NvoStatus</i> is updated.	Disables demand object. Demand output variables go to zero. <i>nvoStatus</i> is updated.
UPDATE_STATUS 2	The status of each object is OR'd together field-by-field and reported in <i>nvoStatus</i> .	The status of the energy object is reported in <i>nvoStatus</i> .	The status of the power object is reported in <i>nvoStatus</i> .	The status of the demand object is reported in <i>nvoStatus</i> .
UPDATE_ALARM 4	Invalid request.	Invalid request.	<i>nvoStatus in_alarm</i> field is updated based on the power alarm state. <i>nvoAlarm</i> is also updated.	<i>nvoStatus in_alarm</i> field is updated based on the demand alarm state. <i>nvoAlarm</i> is also updated.
REPORT_MASK 5	Each field of <i>nvoStatus</i> used by the WattNode will be set to '1'.	Each field of <i>nvoStatus</i> used by the energy object will be set to '1'.	Each field of <i>nvoStatus</i> used by the power object will be set to '1'.	Each field of <i>nvoStatus</i> used by the demand object will be set to '1'.
OVERRIDE 6	Invalid request	Energy totals are set to zero and the <i>in_override</i> field is set in <i>nvoStatus</i> .	Invalid request	Peak demand is reset to the current demand and the <i>in_override</i> field is set in <i>nvoStatus</i> . The demand measurement is unaffected.
Any Other Request	Invalid request	Invalid request	Invalid request	Invalid request

Table 4.1: Requests

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 object (Node, Energy, Power or Demand) that received the request. The WattNode can also be configured to produce the status at regular intervals. The variable *nciStsMaxSendT* is used to configure the “heartbeat rate”, or the rate at which the status is automatically propagated. If *nciStsMaxSendT* is zero, then regular transmission is disabled. If the heartbeat is enabled, then each successive transmission sends the status for the next object, in a round-robin fashion.

The WattNode supports the following status fields:

object_id – The number of the object whose status is being reported (0=Node, 1=Energy, 2=Power, 3=Demand).

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.

disabled – Indicates when the object is disabled.

in_alarm – Indicates that an alarm condition currently exists for the object.

in_override – Indicates that the output value of the object has been reset to zero.

4.1.3 Time of Day

The time of day variable *nviTimeSet* is an input that the WattNode uses to timestamp alarms, peak demand, energy clear time and peak demand clear time. It also keeps demand intervals synchronized. It is not necessary to bind this variable, but if it is not set, then alarms will be reported with time fields set to zero, and the demand measurements will be timed off 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 bound to a time stamp network variable in 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 bound, it does not need to be updated frequently. Updating the time of day hourly or daily should be sufficient.

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*.

4.1.4 Alarms

The WattNode has both power and demand alarms. The power alarm can be configured for an over-power alarm and an under-power alarm. The demand alarm can be configured for two levels of over-power alarms. Whenever an alarm occurs, or is cleared, the Node object alarm SNVT *nvoAlarm* is updated. The alarm SNVT contains the following fields:

location – The 6 character location of the WattNode.

object_id – The number of the object reporting the alarm (2 - Power, 3 - Demand).

alarm_type – The alarm condition:

Alarm Type	Number	Description
AL_NO_CONDITION	0	No alarm condition present
AL_LOW_LMT_CLR_1	5	Clear alarm low 1
AL_LOW_LMT_CLR_2	6	Clear alarm low 2
AL_HIGH_LMT_CLR_1	7	Clear alarm high 1
AL_HIGH_LMT_CLR_2	8	Clear alarm high 2
AL_LOW_LMT_ALM_1	9	Set alarm low 1
AL_LOW_LMT_ALM_2	10	Set alarm low 2
AL_HIGH_LMT_ALM_1	11	Set alarm high 1
AL_HIGH_LMT_ALM_2	12	Set alarm high 2

Table 4.2: Alarm Types

priority_level – The priority of the alarm. Lower numbers indicate lower priority.

index_to_SNVT – The SNVT number of the variable that caused the alarm. This is needed so that the *value* field can be properly interpreted. Both the power and demand alarms use SNVT_power_f to report the value that caused the alarm.

value – The value of the variable that caused the alarm.

alarm_limit – The configured value at which the alarm is triggered.

timestamp – Year, month, day, hour, minute, and second fields indicating the time at which the alarm occurred. If the time of day has not been set, then all timestamp fields will be zero except year which will be 65535 to indicate that the time is not known.

The alarms are reported through the Node object, but they are configured by the Power and Demand objects. Full descriptions of the configuration and operation of the alarms are in sections **4.3.2 Power Alarms** and **4.4.4 Demand Alarms**.

4.2 Energy Measurement

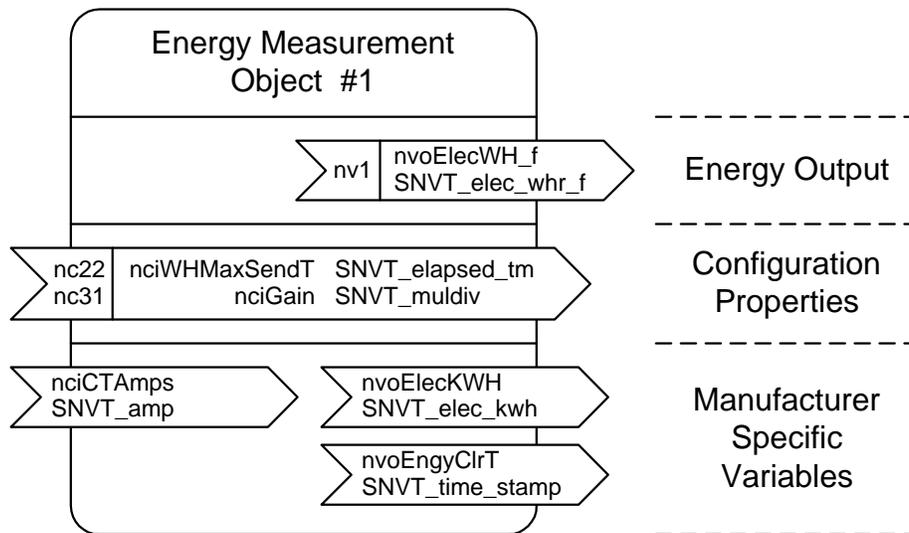


Figure 4.2: Energy Measurement Object

Many installations will only measure energy. It is used for sub-metering, or tracking the kilowatt-hours used by the measured circuit. Because of its accumulating behavior, this object can be used on networks that are accessed infrequently. For example, this measurement could be used in a sub-metering application, where the energy value was read monthly, either by manually connecting to the network or via a modem interface to a central monitoring office.

The energy total will always increase as long as the WattNode is online. The energy total is reset to zero by an override request, or when either `nciGain` or `nciCTAmps` is changed. For most metering applications, the best control choice is to let the energy total increase from the time of installation, or to reset the total to zero only once a year. It is possible to zero the total every time it is read out, but if a measurement is lost, it cannot be recovered. Whenever energy is zeroed, `nvoEngyClrT` will be set to the current time and date. This helps security, since tampering with the energy will update `nvoEngyClrT`.

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 30 seconds. When power returns, the last stored value stored is recovered.

4.2.1 Energy Output

The energy value is available in two different units:

Network Variable	Resolution	Range
<code>nvoElecKWH</code>	1.0 kilowatt-hour	0 to 50,000 kilowatt-hours
<code>nvoElecWH_f</code>	$1.2e-7 \times \text{measurement}$	0 to $1.0e38$ watt-hours

Table 4.3: Energy Output Network Variables

The integer output variable *nvoElecKWH*, rolls over to zero when its count reaches 50,000—at 50,000 kWh. This permits measurements across the roll over point. For example, in most home metering, only the three least significant digits are reported on the bill and if a measurement is smaller than the previous measurement, then it is assumed that a thousand kW boundary was crossed. So if the June measurement was 945 kW and the July measurement was 23 kW, then the energy consumed between measurements was 1023 kW – 945 kW = 78 kW. *nvoElecWH_f* is a floating point variable that never rolls over and that has a resolution of one part in 8 million of the current measurement value.

The energy value may be retrieved either by polling, or by binding the network variable, and setting *nciWHMaxSendT* to control the interval between updates. The energy is computed every 10 seconds, but any update rate between 10 seconds and 18 hours may be used. Set *nciWHMaxSendT* to zero seconds to disable automatic updates.

4.2.2 Zeroing Energy

To zero the energy, make an override request of the energy object. Send *nviRequest* to the WattNode with the *object_id* field set to 1 (Energy object), and the *object_request* field set to 6 (OVERRIDE). Energy will reset to zero, and then continue accumulating. The energy is also reset to zero whenever *nciGain* or *nciCTAmps* are changed (see the next section). Whenever energy is zeroed, *nvoEngyClrT* will be set to the current time and date. If the WattNode is being used for billing or sub-metering, see **3.3.1 Authentication** on information to prevent unauthorized zeroing.

4.2.3 Energy Configuration

The output energy, power and demand measurements all depend on the calibration of the WattNode and on the full-scale current rating of the CTs. The Energy object contains these variables, and must be configured even if the energy measurement is not being used. The WattNode is calibrated during assembly, and should never need adjustment. If the WattNode is being used for billing or sub-metering see **3.3.1 Authentication** on information to prevent unauthorized changes to the configuration.

The full-scale current rating of the CTs is set with the variable *nciCTAmps*. The type of this network variable is SNVT_amp, which ranges from 0 to 3276.7 amps in steps of 0.1 amps. This must be correctly set during installation. The full-scale rating of the CTs are printed on 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.

If you wish to calibrate the WattNode with CTs attached for better accuracy, or if the WattNode is being recalibrated as part of a maintenance schedule, then the variable *nciGain* changes the gain of the WattNode. The WattNode is recalibrated by connecting it to an accurate power standard, setting the power standard for the nominal operating voltage of the WattNode, and setting the current to the full-scale rating of the CTs. Then compare the power reported by the WattNode to the power produced by the power standard. If they are different, then adjust *nciGain* until they are within tolerance (0.5%). The variable *nciGain* is a SNVT_muldiv, and contains two fields, *multiplier* and *divisor*. Each is an unsigned integer that ranges from 0 to 65,535. Normally, the divisor is left at 65535, and the multiplier adjusted. This allows the value to be adjusted to within 0.01%.

As a calibration example, suppose the WattNode is connected to a 10 amp split-core CT and attached to an accurate power standard. The power standard is set to supply 115 VAC and 10 amps for a power of 1150 watts. If the WattNode's power output indicates 1139 watts, then the reading is 0.96% too low. To correct this, multiply *nciGain.multiplier* by 1150 / 1139. The general formula is:

$$nciGain.multiplier = nciGain.multiplier \cdot \frac{truePower}{indicatedPower}$$

The factory setting for *nciGain* is printed on the back label of the WattNode so that *nciGain* may be restored if its value is changed or lost.

4.3 Power Measurement

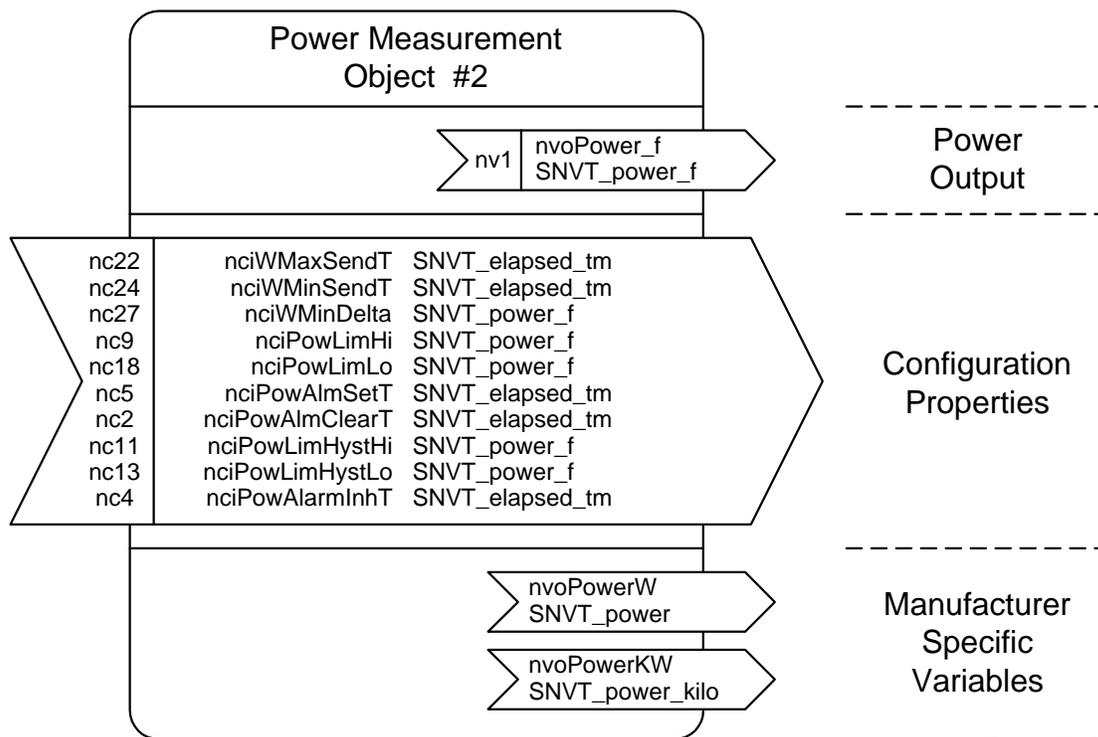


Figure 4.3: Power Measurement Object

The WattNode measures power over two second intervals by averaging the power over the preceding two seconds. The WattNode can be configured to update the power output network variables at intervals from 1 to 65,000 seconds. Every five seconds, the WattNode checks to see if any power alarms have been tripped or cleared.

4.3.1 Power Output

The power value is available in three different units:

Network Variable	Resolution	Range
<code>nvoPowerW</code>	0.1 watt	0 to 6553.5 watts
<code>nvoPowerKW</code>	0.1 kilowatt	0 to 6553.5 kilowatts
<code>nvoPower_f</code>	$1.2e-7 \times \text{measurement}$	0 to $1.0e38$ watts

Table 4.4: Power Output Network Variables

Any of these output units may be used, depending on the application. The `nvoPower_f` variable is a floating point variable that has a resolution of one part in 8 million of the current measurement value.

The update time interval of these power output variables is controlled by three configuration properties: the minimum interval between updates, the maximum interval between updates, and the change in power that triggers an update. The first configuration variable `nciWMinSendT` sets the minimum time that must elapse between updates to the power. This can be used to prevent the WattNode from overloading the network. The second configuration variable `nciWMaxSendT` sets the maximum time that may elapse between updates. Finally, `nciWMinDelta` may be used to force an update if `nciWMinSendT` time has elapsed since the last update and the power has changed by `nciWMinDelta` watts. The units for `nciWMinDelta` are floating point watts.

There are three strategies for receiving power updates over the network. For the first, it is not necessary to bind the power network variables. Instead, the monitoring node uses polling to retrieve the current power value. The second technique uses *nciWMaxSendT* to set an interval at which the WattNode will update all bound power variables. To use this technique, *nciWMinSendT* and *nciWMinDelta* must be set to their default values (0 seconds and 1.0e38 watts respectively). The third update technique uses all three configuration variables. *nciWMinDelta* is set to update power when at least *nciWMinSendT* time has elapsed since the last power update and the power has changed by the specified amount (150 watts for example). Use *nciWMinSendT* to limit updates if the power is fluctuating rapidly. Finally, *nciWMaxSendT* is set to update the value periodically even if the value does not change enough to trigger an update.

To disable the minimum update interval, set *nciWMinSendT* to zero time. To disable the maximum update interval, set *nciWMaxSendT* to zero time. These variables are actually elapsed time structures, so each field in the structure must be zeroed. To disable the send on delta feature, set *nciWMinDelta* to 1.0e38. The default configuration sets *nciWMaxSendT* to 10 seconds so that the power is updated every 10 seconds; *nciWMinSendT* is set to zero time to disable the minimum update interval and *nciWMinDelta* is set to 1.0e38 to disable send on delta.

4.3.2 Power Alarms

The power object supports alarms which can be tripped for excessive power and/or for insufficient power. In addition to the high and low alarm levels, hysteresis bands and alarm setting and clearing delays may be set. The alarm levels are configured in units of floating point watts over the range 0 to 1.0e38 W. The list of alarm configuration variables follows:

nciPowLimHi – The power value above which the high power alarm is set. This may be used to warn of overload conditions. The default value of 1.0e38 W disables this alarm.

nciPowLimLo – The power value below which the low power alarm is set. The low alarm can monitor that critical equipment or machinery is not shut off, or does not fail. The default value of 0.0 W disables this alarm.

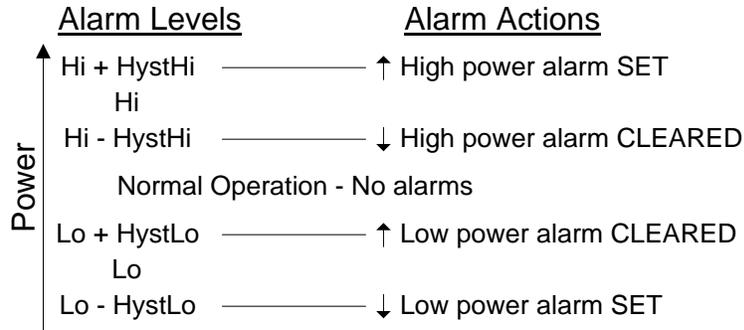
nciPowAlmSetT – This variable delays the activation of the power alarms, by requiring that the trip condition be met for the specified time interval before the alarm is set. This can be used to prevent alarms due to turn on surges. The default is zero delay.

nciPowAlmClearT – The variable delays the clearing of power alarms, by requiring that the clearing condition be met for the specified time interval before the alarm is cleared. The default is zero delay.

nciPowLimHystHi – This adds hysteresis, or deadband, to the high power alarm. To set the alarm, the power must exceed $nciPowLimHi + nciPowLimHystHi$ for time *nciPowAlmSetT*. To clear the alarm, the power must fall below $nciPowLimHi - nciPowLimHystHi$ for time *nciPowAlmClearT*. This can be used to prevent repeated alarm set-clear sequences if the power hovers near *nciPowLimHi*. The default hysteresis is zero, which disables the feature.

nciPowLimHystLo – This adds hysteresis, or deadband, to the low power alarm. To set the alarm, the power must fall below $nciPowLimLo - nciPowLimHystLo$ for time *nciPowAlmSetT*. To clear the alarm, the power must exceed $nciPowLimLo + nciPowLimHystLo$ for time *nciPowAlmClearT*. The default hysteresis is zero.

nciPowAlarmInhT – This prevents any alarms from being reported for an interval after the WattNode comes out of reset, or the power object is enabled. This could be used to allow time for the power to stabilize after an outage, without causing alarms.



Note: all alarm level variable names have the prefix 'nciPowLim' left off.

Figure 4.4: Power Alarm Levels

All power alarms set the *nvoAlarm* field *object_id* to 2 (Power Object) to indicate the source of the alarm.

As a result of measurement and processing delays, a power alarm may not be reported for up to 10 seconds after the onset of the alarm power level.

4.3.3 Power Alarm Example

As an example, suppose we are monitoring the power consumption of a cooling pump motor. Its normal power consumption is 20 kW. If its consumption goes up to 25 kW, then we want to warn that it may need service and may start overheating. Since the cooling pump is essential, we also want an alarm if the power falls below 10 kW to indicate that the pump may no longer be performing its cooling duty.

We set *nciPowLimHi* to detect the 25 kW (25,000 W) level alarm. Suppose we don't want the alarm turning on and off too frequently when the power is near 25 kW. First, we set the hysteresis; by setting *nciPowLimHystHi* to 1000 W, we change the alarm so that it does not come on until 26 kW, and does not turn off until 24 kW. Then if we want to prevent brief surges from tripping the alarm, we change *nciPowAlmSetT* to 20 seconds. This adds the requirement that 26 kW be exceeded for 20 seconds before the high power alarm is set. This also affects the low power alarm, so the value chosen may be a compromise.

Then, we use *nciPowLimLo* to detect the low power alarm. For this alarm we use hysteresis in conjunction with the tripping delay configured for the high level power alarm. We want the alarm to be set whenever the power falls below 10 kW, and be cleared whenever the power exceeds 14 kW. To achieve this, we set *nciPowLimHystLo* to 2 kW (2,000 W), and *nciPowLimLo* to 12 kW (12,000 W).

4.4 Demand Measurement

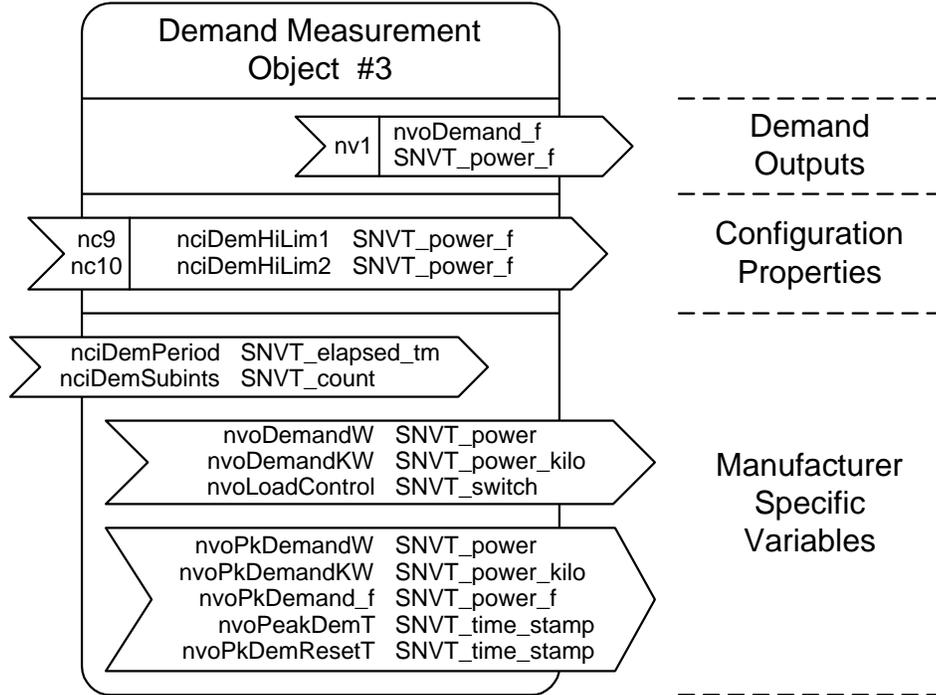


Figure 4.5: Demand Measurement Object

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 1 to 720 minutes. The WattNode records the peak demand with time stamp for metering applications where the measurements may only be accessed weekly or monthly.

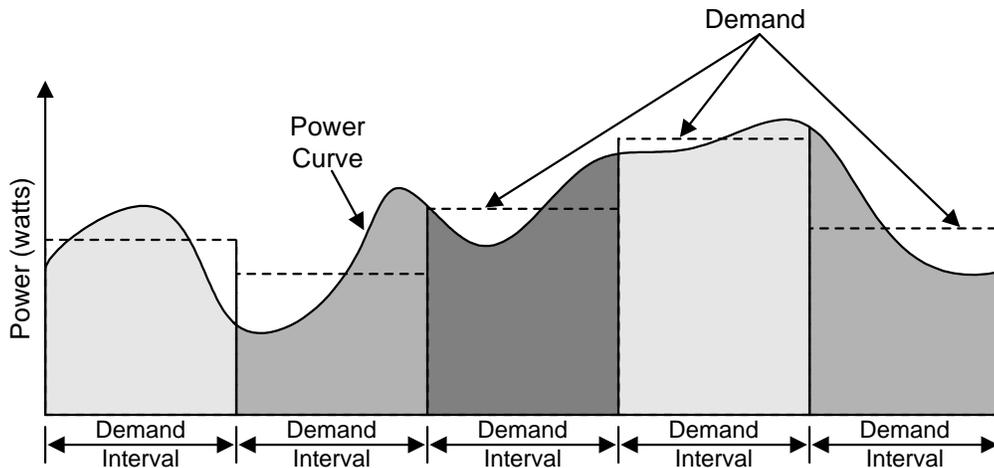


Figure 4.6: Demand Measurement

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 15 subintervals are supported, provided that the subinterval duration is at least 30 seconds. A subinterval count of one results in the standard demand measurement without rolling demand.

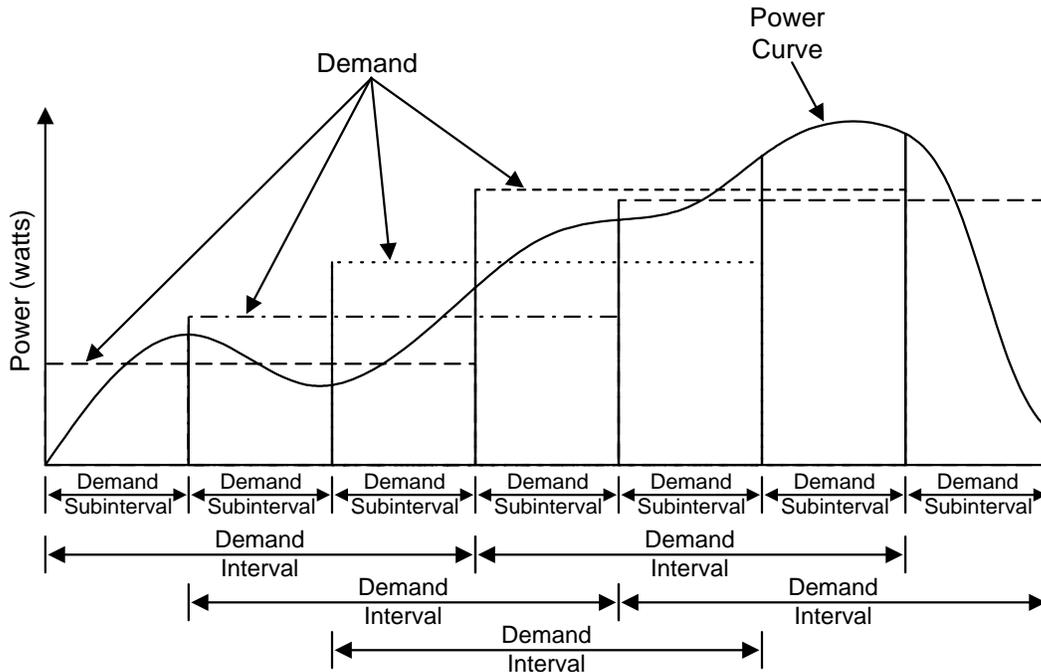


Figure 4.7: Rolling Demand with Three Subintervals

4.4.1 Demand Configuration

The demand is configured with *nciDemPeriod* to set the interval over which demand is measured, and *nciDemSubints* to set the number of demand subintervals. *nciDemPeriod* variable is a SNVT_elapsed_tm type variable which contains fields for day, hour, minute, second and millisecond. The demand interval can never be longer than 12 hours, so the day field should always be zero. The hour field can range from 0 to 12 hours, the minute field from 0 to 59 minutes, and the second field from 0 to 59 seconds. The millisecond field is not used.

The *nciDemSubints* can be set from 1 to 15. The time period of each subinterval is the demand interval divided by the number of subintervals. Setting this value to 1 disables subinterval computations.

An example configuration could use a demand period of 1 hour with 6 subintervals. This would result in a subinterval period of ten minutes. Every ten 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 Output

The demand power and the peak demand are each available in three different units:

Demand Network Variables	Peak Demand Network Variables	Resolution	Range
nvoDemandW	nvoPkDemandW	0.1 watt	0 to 6553.5 watts
nvoDemandKW	nvoPkDemandKW	0.1 kilowatt	0 to 6553.5 kilowatts
nvoDemand_f	nvoPkDemand_f	1.2e-7 × measurement	0 to 1.0e38 watts

Table 4.5: Demand Output Network Variables

Any or all of these output units may be used, depending on the application. These variables are updated every time a demand interval or subinterval ends. The *nvoDemand_f* and *nvoPkDemand_f* variables are floating point variables that have a resolution of one part in 8 million of the current measurement value.

Demand measurement starts whenever any of the demand configuration variables are changed, when the demand object is enabled with the *nviRequest* network variable. 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. If several WattNodes need to make synchronized demand measurements, then they should all be disabled. Then, at the desired start time for the demand interval, they should all be enabled. As *nviTimeSet* is regularly updated in all the WattNodes, then they will all stay synchronized.

To protect against losing data during a power failure, the WattNode updates non-volatile memory every thirty seconds with the current demand measurement data. If power fails, then when power returns, the WattNode will restore the demand measurement and continue from where it was when power failed (though up to 30 seconds of data may be lost). 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.

The WattNode will lose synchronization if *nviTimeSet* and its internal time differ by the larger of 30 seconds or 5% of the demand subinterval period. The synchronization, however, only considers the minutes and seconds within an hour, but not the hour itself. So if *nviTimeSet* disagrees by one hour and ten seconds from the internal clock, then the demand interval will be changed by ten seconds and remain synchronized. If the WattNode does lose synchronization, it will continue to measure demand, but the demand period start times may no longer be linked to the time of day. If power fails for long enough that the WattNode does lose synchronization, then the monitoring computer can resynchronize any WattNodes on the network.

Synchronizing the demand measurements—say to the hour—may be inadvisable for billing, as the customer could arrange to split periods of high demand across two demand intervals, resulting in lower demand for each of the two intervals. Using several subintervals largely eliminates the possibility of timing high load periods to reduce the peak demand. The overlapping demand intervals, ensures that the high load period will be largely centered in at least one interval.

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 by making an override request of the Demand object. To use the override technique for zeroing the peak demand, *nviRequest* must be sent with the *object_id* field set to 3 (Demand object), and the *object_request* field set to 6 (OVERRIDE). The peak demand is stored in non-volatile memory, so that its value is not lost during power outages. If the WattNode is measuring peak demand for billing or sub-metering, see **3.3.1 Authentication** on information to prevent unauthorized zeroing.

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.

When the peak demand is zeroed, the output value will be zero until the next demand interval or subinterval is completed. Since the peak demand may be used for billing, the time when it is zeroed is recorded in *nvoPkDemResetT*. This records the start of the peak demand measurement period and allows tampering to be detected. If the billing agent reads and resets the peak demand on January 31st at 10:30AM, then *nvoPkDemResetT* will contain that date and time. If an unauthorized person resets the peak demand before the next scheduled meter reading, say February 2nd, then the billing agent can detect this because *nvoPkDemResetT* will contain February 2nd instead of January 31st. For best billing security, use authentication as described in section **3.3.1 Authentication**.

4.4.4 Demand Alarms

The demand measurement object supports two levels of alarms for high demand. Since demand updates occur infrequently, there are no timers to delay the alarms, and no support for hysteresis in the demand alarms. Whenever a demand measurement is made, the new value is compared to each of the two alarm levels and if either of the alarm levels has been exceeded, then an alarm is reported with the *nvoAlarm* variable. If the demand is below the two alarm levels, then the absence of an alarm is reported. All demand alarms set the *nvoAlarm* field *object_id* to 3 (Demand Object) to indicate the source of the alarm.

The demand alarm configuration variables, *nciDemHiLim1* and *nciDemHiLim2*, use the SNVT_power_f type, which ranges from 0 to 1.0e38 W. *nciDemHiLim1* should be set to a lower level than *nciDemHiLim2*, which is a higher priority alarm. Alarms tripped by *nciDemHiLim1* are set to a priority of 1, while alarms tripped by *nciDemHiLim2* are set to a priority of 2 (higher priority). To disable either of the demand alarms, set the configuration variables to the maximum value of 1.0e38 W.

4.4.5 Load Control

The WattNode supports a load shedding feature. If the demand exceeds *nciDemHiLim2*, then the SNVT_switch type variable *nvoLoadControl* is set to OFF. This network variable can be used to control some load that may be turned off to save power during periods of high demand. *nvoLoadControl* goes back to ON when the demand falls below *nciDemHiLim1*. This allows some hysteresis to prevent rapid cycling of the load.

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 5.1 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.

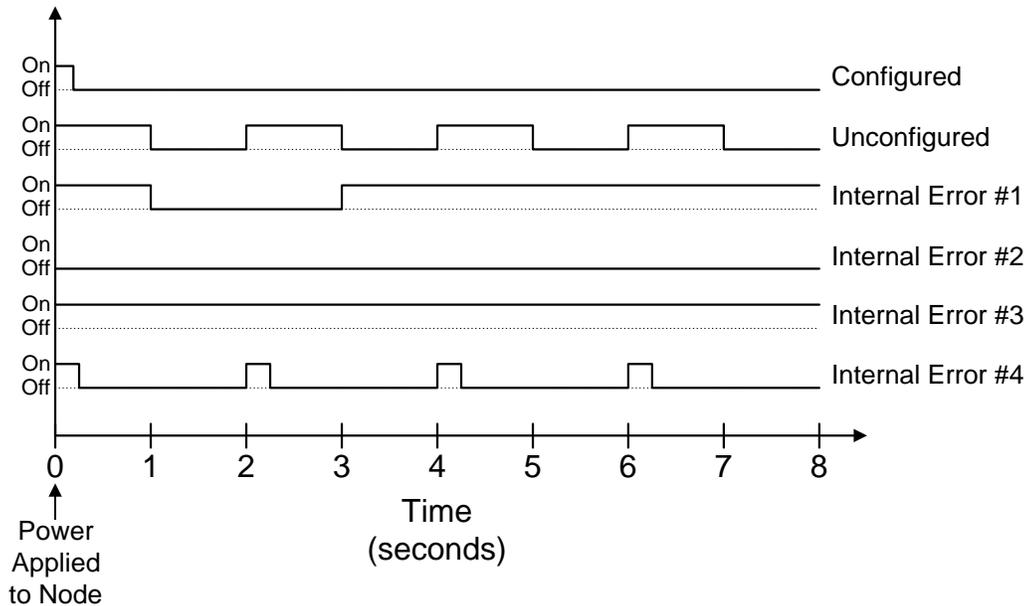


Figure 5.1: Service LED Behaviors

Any pattern of LED flashing not described by Figure 5.1 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.	
<u>Probable Causes</u>	<u>Corrective Actions</u>
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.	
<u>Probable Causes</u>	<u>Corrective Actions</u>
The <i>nciGain</i> value is set incorrectly.	See section 4.2.3 Energy Configuration to check configuration.
<i>nciCTAmps</i> is zero or negative.	Check that <i>nciCTAmps</i> is set to the correct positive 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 5.2.3 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.
One or more CTs may be installed backwards.	If the CT faces towards the load or the white and black wires have been reversed, then the power for that phase will be negative. To verify the direction of installation, follow 5.2.1 Test CT Polarity below.
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 5.2.2 Test CT Ordering below.
The Power Measurement Object (#2) is disabled.	See sections 4.1.1 Requests and 4.1.2 Status for information on enabling and disabling objects.
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.	
<u>Probable Causes</u>	<u>Corrective Actions</u>
The <i>nciGain</i> value is set incorrectly.	See section 4.2.3 Energy Configuration to check configuration.
<i>nciCTAmps</i> does not match the rating of the CTs.	Check that <i>nciCTAmps</i> 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 5.2.3 Test CT Output below to check the CTs.
The CTs are not the 0.333 VAC output type.	Visually check the CTs or follow 5.2.3 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.
One or more CTs may be installed backwards.	If the CT faces towards the load or the white and black wires have been reversed, then the power for that phase will be negative. To verify the direction of installation, follow 5.2.1 Test CT Polarity below.
The CTs are not all the same current rating.	Ensure that matching CTs are used for all phases.
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 5.2.2 Test CT Ordering below.
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.	
<u>Probable Causes</u>	<u>Corrective Actions</u>
The Demand Measurement object (#3) is disabled.	See sections 4.1.1 Requests and 4.1.2 Status for information on enabling and disabling objects.
The demand interval has not yet elapsed.	The first demand output will not occur until one complete demand interval has elapsed. After that, a new output will occur every time a subinterval elapses (assuming that there is more than one subinterval).
The WattNode is not functioning correctly.	Try reinitializing the WattNode, see section 3.2 WattNode Reinitialization .

5.2.1 Test CT Polarity

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 the other CTs and jumper their screw terminals with a shorting wire.
3. Check that the power is not zero with just one CT connected. If the power is zero, then reverse the CT wires (white to black and black to white) and check again. If the power is still zero, then go to **5.2.2 Test CT Ordering**.

5.2.2 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.

5.2.3 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 than 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
WNA-1P-240-xxx	120	240	1	2 or 3	Yes
WNA-3Y-208-xxx	120	208,240	3	4	Yes
WNA-3Y-400-xxx	240	400	3	4	Yes
WNA-3Y-480-xxx	277	480	3	4	Yes
WNA-3Y-600-xxx	347	600	3	4	Yes
WNA-3D-208-xxx	N/A	208	3	3	No
WNA-3D-480-xxx	N/A	480	3	3	No
WNA-4WD-240-xxx	120/208	240	3	4	Yes

Table 6.1: WattNode Models

The transceiver suffixes (-xxx) are -TP78 or -FT10.

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, 20, 30	40
CTT-0500-yyy	0.50"	15, 20, 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 6.2: 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, 20, 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 6.3: Split-core CTs

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

6.3 Accuracy

The WattNode's minimum accuracy is 0.45% of reading plus 0.05% of full-scale. The WattNode's temperature dependence is less than $\pm 0.01\% / ^\circ\text{C}$. 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.

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 power every 1.678 seconds and energy every 10.066 seconds. The demand is measured at the end of each demand interval or subinterval (measured to the nearest 0.839 seconds).

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 $+60^\circ\text{C}$

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

6.6.3 Mechanical

Enclosure: High impact, ABS plastic

Flame rating: 94HB

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

Connectors: Euroblock style pluggable terminal blocks

Light gray: 22 to 12 AWG, 600 V

Black: 26 to 16 AWG, 300 V

6.7 Communication

The WattNode may be purchased with the following transceivers:

Transceiver	Bit Rate	Max. Nodes ¹	Max. Distance	Max. Stub Length
TPT/XF-78	78 Kbps	64	1400 m	3.0 m
FTT-10	78 Kbps	64	500–2700 m	3.0 m ²

¹Per subnet (see Echelon LonWorks Products Databook for more details)

²Only applies to bus topology networks.

Table 6.1: WattNode Transceivers

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