LonWorks ™ System Integrator Guide for the Intelli-Fin ™ Boiler Interface Controller

Before Serial # I03H0015780

By Lochinvar Corporation

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Intelli Fin™
by Lochinvar

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Who should read the System Integrators Guide?

The system integrators guide is designed for use by anyone that could benefit by connecting the Intelli-Fin™ unit to a LonWorks™ building automation system. Specifically consulting engineers, and building owners will find the Benefits of System Integration section useful. LonMark™ system integrators will find the detailed information required to integrate the

Intelli-Fin™ into a building automation system. System Integrators are expected to have previous experience with LonWorks systems.

This document is intended to be used by LonMark system integrators that use LNS™ based tools, but information included here may enable system integrators to integrate Intelli-Fin boilers in to other systems.

Abbreviations used in this document

BAS	Building automation system that uses LonWorks digital communications to exchange information between the equipment and human interfaces in the system.
BIC	Boiler Interface Controller for Lochinvar Intelli-Fin units. Sometimes the BICs are referred to as XL10 controllers.
Binding	The process of logically connecting the information in a source node to the information in a destination node(s). When the information in the source node changes, the new value is automatically communicated to the destination node(s) over the LonWorks network.
CD	Command Display Module – A dedicated human interface for the BIC. Also known as a HIP (Human interface Panel)
Configuration Parameters	A device or object performs various predetermined and fixed functions that are selected by variables called configuration parameters. The configuration parameters may select various functions from a repertoire of functions or the configuration parameter may vary the function in some way (such as change the gain in a PID control loop).
Device or Node	An electronic module that controls mechanical equipment, displays controller information to a human, or connects the communications network to another network. The nodes communicate with one another over the LonWorks network.
LNS	LonWorks Network Services - A server used by network tools to manage, monitor, and control the nodes on LonWorks networks.
PC	Personal computer work station running building management software
Object	Each device contains one or more object. Each object has defined inputs, outputs, configuration parameters, and predetermined functionality.
Site or System	A site or system is one building or one campus. A site consists of several devices connected together by one LonWorks network. Even if the devices are miles apart, they may belong to one site if one LonWorks network interconnects them.
Sequencer	A sequencer is a device that controls several units that are connected together for greater heating capacity. The sequencer controls the water temperature by commanding the several units to turn on or off depending on the water temperature. The sequencer directs which units are firing at each moment and also directs the firing rate of each unit when they are turned on.
Unit	Refers generically to either Boilers or Water Heaters. Intelli-Fin units may either be boilers (for supplying hot water for heating systems or water heaters for supplying hot water for some process). More details requirements will be specifically called out.

Trademarks

Intelli-Fin is a registered trademark of Lochinvar Corporation

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References

"LonMark Application Layer Interoperability Guidelines" Revision 3.2 by LonMark Interoperability Association
"LonMark Layers 1 – 6 Interoperability Guidelines" Revision 3.0 by LonMark Interoperability Association
"LonMark External Interface File Reference Guide" Revision 4.0A by Echelon Corporation
"LonMark Resource File Developer's Guide" by Echelon Corporation
"LonWorks Technology device Data" by Motorola
"SNVT Master List and Programmers Guide" by Echelon Corporation
"The LonWorks Network Services (LNS) Architecture Strategic Overview" white paper by Echelon Corporation
"The LonWorks Network Services (LNS) Architecture Technical Overview" white paper by Echelon Corporation
"LNS Programmers' Guide for Windows" by Echelon Corporation
"Junction Box and Wiring Guideline for Twisted Pair LonWorks Networks" by Echelon Corporation

"Installation and Service Manual - Intelli-Fin Hot Water Heating Boilers" by Lochinvar

See www.echelon.com for more information about LonWorks.
See www.lonmark.com for more information about LonMark

Benefits of System Integration

The benefits of integrating equipment into a building automation system generally are:

- Reduced energy cost
- Improved comfort, and / or safety for building occupants
- Accommodate building use by enabling unique functions
- Reduced equipment maintenance cost
- Information sharing to reduce installed cost

The benefits are enabled because the building equipment can "talk" to one another, can "report" certain conditions automatically to a remote location, and can be "reprogrammed" . For example:

- Energy is saved by reducing comfort when the building or a space in the building is not occupied. The space temperature can be allowed to float higher or lower when the building is not occupied.

- Automatic off site monitoring of building equipment is an economic way of providing equipment maintenance only when needed. A single off site monitoring station can monitor hundreds of buildings with little or no human intervention.

- By keeping track of equipment run time, maintenance can be "requested" by the equipment when it is time for maintenance.

- By viewing the current operating conditions of building equipment over a remote communications connection (telephone line), a technician can often diagnose a problem from his office. The service person can be sure to bring the required parts on his truck when he visits the site.

- Many temporary "repairs" may be made over a remote communications connection to keep the building running at reduced functionally or efficiency, until a service person can visit the site.

- Periodically the operating conditions of building equipment can be entered into a "trend log". The log can later be viewed on a PC to show system performance. The log can verify that the system is (or is not) operating properly without a person having to be there to watch a system operate. Trend logs can be used for troubleshooting complaints made by building occupants.

- The control strategies can be tuned to decrease maintenance, and increase comfort. By viewing a carefully designed trend log, operating parameters of the equipment may be tuned for a desired result.

- The equipment may cooperate in an emergency. For example: In case of a fire, ventilation is turned off in the fire area reducing the oxygen available to the fire while other areas are pressurized to reduce smoke damage. After the fire, outside air is used to purge the smoke from the building.

- Some sensors may be shared by many devices. For example: One outside air temperature sensor may be shared by many controllers resulting in lower installed cost.

- Custom features may be added to the building to accommodate the building use. For example:

    1. An industrial process that requires hot water may cause the boiler (water heater) temperature to be high only when the process is operating to save energy.
    2. A building owner may wish to charge extra energy cost when the building is occupied beyond normal hours. A billing device may monitor building occupancy to bill the tenant when the space is occupied beyond normal hours.
    3. In a multi-unit system, a custom unit sequence may be implemented by the system integrator.

When equipment can "talk" to one another, each piece of equipment is capable of some system functionality. The BIC is able to:

*Note: See "BIC Details" for a complete list of features. Items marked with * are currently not available for integration in a BIC system.*

Control the temperature of the water supplied by the unit(s):

- One BIC controls one unit that supplies hot water for building heat or another process
- More than one BIC and unit can be connected together to increase system heating capacity
- One BIC acts to sequence several units on / off with variable firing rates

Receive information and commands from other devices:

- Unit and Pump Commands *
- Outdoor temperature *
- Water temperature set point of the water may be adjusted by a schedule and remotely *
- Occupancy sensor may over ride the schedule *
- Unit BICs may be sequenced by one sequencer BIC

Send information to other devices:

- Occupancy sensor *
- Outdoor temperature of local sensor *
- One sequencer BIC can be configured to sequence other unit BICs

Report to a human operator or automatic device:

- Return, supply, and bypass water temperature
- Outdoor temperature
- Effective set point and Occupancy state
- Pump status
- Variable firing rate, bypass, and boiler load percentage or water heater recovery rate
- This BIC is the unit sequencer (otherwise it is a unit controller)
- Detailed unit operation states – For example: Hot Surface Igniter, Gas valve
- Alarms - For example: Sensor, Communications or Flame Failure; Low Air Pressure Water Flow or Gas Pressure; Invalid Set Points or Configurations; Device Disabled; High Temperature; Boiler not Operating; Heat Mode Fail; Blocked Drain
- Name identifier and BIC Program version

Receive information from a human operator:

- Temperature set points for occupied and unoccupied state
- Manual Control for trouble shooting *
- Manual Occupancy override *
- Run Time Limit *

When the functionality of all the devices in a system are put together the benefits of system integration can be realized. For example the following devices may be shared by BICs and other controllers to provide benefits that the BIC alone could not provide:

*Note: See "BIC Details" for a complete list of features. Items marked with * are currently not available for integration in a BIC system.*

- Occupancy scheduler to provides occupancy related energy savings through a schedule for building occupancy *

- Occupancy override provides one or more means for overriding the schedule when the building becomes occupied during a scheduled unoccupied period. Typically a user interface (may be a PC) is used to initiate an override period but turning on the lights manually or disarming the security system could be used to indicated occupancy. *

- Off site communications device enables remote control and monitoring. For example:

1. The Echelon Serial LonTalk Adapter (SLTA) and a modem connects between a dial up analog telephone line and the LonWorks Network so a remote PC may monitor and control the building.
2. Internet server connects between a LonWorks network and the Internet (TC/IP) network enable a PC with Internet browser to monitor and control a building.

- An alarm logging device that receives alarms from devices and periodically checks devices for out of range conditions reports alarms to local and / or remote PCs.

- A trend logging device periodically records information from devices to store a trend log for troubleshooting.

- A user interface PC running building management software may do one or more of the following:

1. Local and / or remote communications to various sites including dial in capability for remote alarm logging.
2. Display a list of all the sites known to the building management software and a list of devices at each site.
3. Display the current status of devices.
4. Display and change occupancy schedules, zone set points, manual occupancy and other parameters.
5. Display and configure the alarm and trend logs.
6. Advanced features for multi site monitoring (scheduled periodic monitoring of buildings, change the schedule at multiple sites with only one entry, and others)
7. Manage user permissions, restricting the functions available to each user according to job description.
8. Configuration of the devices and the network (available only to installers and system integrators)
9. Manually control devices (available only to installers)

- Other devices may be needed in the system as determined by the application requirements and system integrator.

LonWorks overview

Some of the features of the LonWorks system are:

- All devices use the LonTalk protocol defined and documented by Echelon Corporation. The protocol defines the electrical communications signals used by devices, the type of wire to use between devices, and how information is exchanged between the devices.

- Each device contains a unique identifier called the neuron – id. Most devices contain a microprocessor called the "neuron" and each neuron is given a unique 48 bit identifier at the time of manufacture. The neuron – id is read by a PC tool during the installation process. An example of a neuron – id is the hexadecimal number 00 01 3F EE 2F 7A.

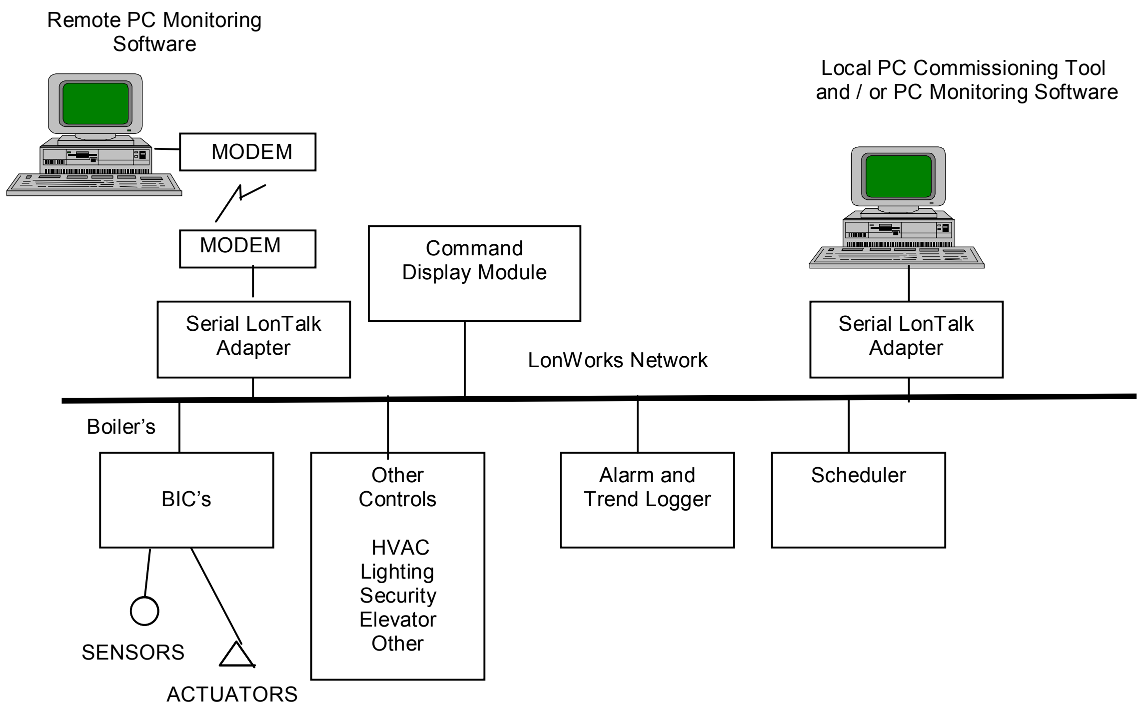
- Each device has a unique address identifier. The unique addresses are assigned by a system integrator using a PC tool that keeps track of all the devices and their addresses in the system. The neuron – ids, addresses, device names, and device types are saved in the tool data base.

- Each device has information that may be shared with other devices. The information is stored in each device in "network variables" and optionally in "files". Each device type has a set of network variables and files unique to the device type. PC tools read computer files that tell them what network variables and files are available in each device type. *See "BIC Details" for a list of network variables found in the BIC.*

- A device will report a network variable to other devices when ask or "polled" by another device. For example: water temperature, device state, alarms, etc, may be polled by a PC to display the current values on the screen. The PC needs a data base of device addresses, device names, and device types to retrieve and display information from devices.

- A network variable in a source device may be "bound" to volunteer information to destination device(s). For example: the output network variable on the outdoor air temperature sensor may be bound (connected) to all the network variable inputs on devices that use outdoor air temperature. When ever outdoor air temperature changes, the sensor sends the new temperature to all the devices that need it. Binding is done by the system integrator using a PC tool to tell the devices to bind the network variable output in one device to input network variables in another device(s). The binding information is saved in the PC tool data base.

- All bound network variables are volunteered by the source device when the network variable value changes
- Some bound network variables may also be volunteered by the source device periodically even if no change has been made. The periodic volunteering of information is called the heart – beat, and is used by the destination device(s) to determine that the source node is still working. If the destination device fails to receive the information periodically, the destination device will take alternative action.
- Some of the input network variables or files are stored in non-volatile memory and used by the device to tailor the device operation to the application. These variables are called "configuration parameters" and are set by the installer or system integrator using a PC tool. The configuration parameters are saved in the PC tool data base.



Typical LonWorks Building Automation System with many features interconnected on the LonWorks network.

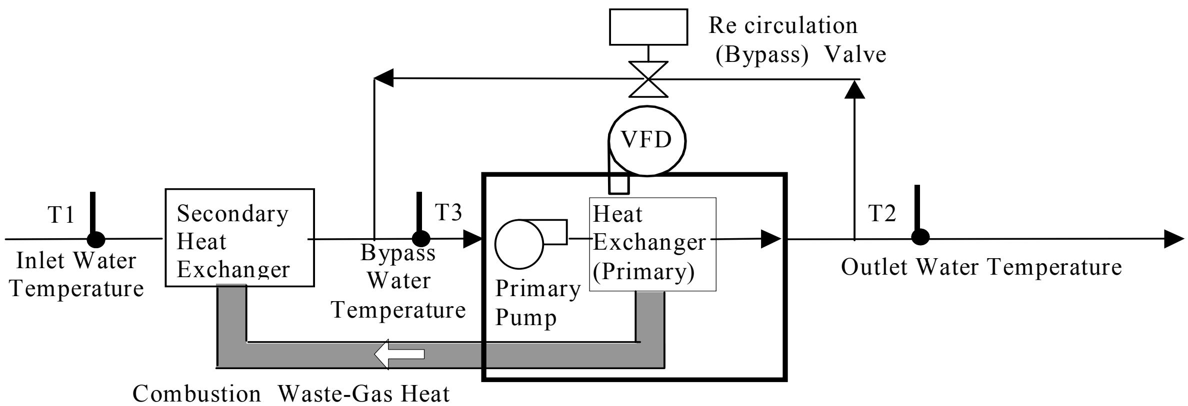
BIC details

One unit

The basic unit diagram is shown below. Fuel (such as natural gas), mixed with air, burns in a combustion chamber to heat the water in a primary heat exchanger. The water is also pre-heated by exhaust gases in a secondary heat exchanger to increase efficiency. Water is circulated through the heat exchangers by a primary pump. The amount of air (and fuel) supplied is controlled using a variable speed fan. Fan speed is controlled using an electronic circuit called a variable frequency drive (VFD). A BIC can control water temperature by changing the speed of the fan and cycling the burner off and on. In addition a bypass valve allows some of the heated water to be re-circulated back to the primary heat exchanger to control the water temperature in the primary heat exchanger independent of loading. The temperatures measured at the inlet, bypass, and outlet are used to adjust the air flow and bypass valve.

In addition, there are safety features to ensure the following conditions are met before fuel is turned on:

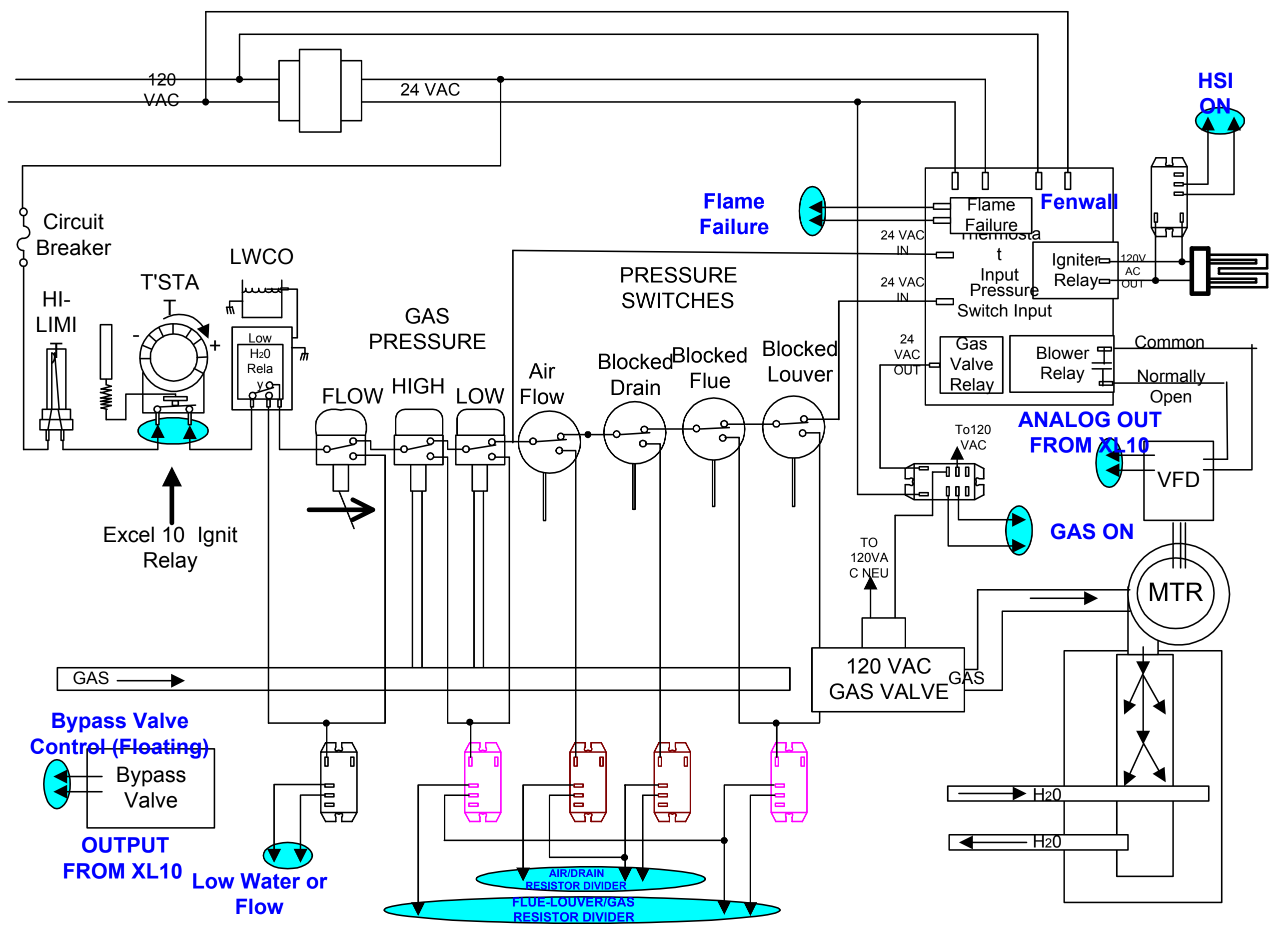
- There is water flowing in the heat exchanger
- There is no unburned fuel in the combustion chamber or flue before the burner flame is ignited
- There is air flow and the flue is not blocked
- The drain for the water that condenses from the exhaust gas is not blocked
- The gas pressure is within tolerances
- The ignition system is working
- After the fire has been established, the outlet and inlet temperatures are compared to show that water is actually being heated.



Intelli- Fin Block diagram

One BIC controls the temperature of the water delivered by one unit. A BIC receives the water temperature and other information from sensors, and commands the fan, bypass valve, and ignition system to heat the water. The BIC also interfaces via a LonWorks network to other equipment for system wide coordination and reporting.

The wiring diagram below shows the typical connection between the BIC and the safety sensors and controls. This wiring drawing is not to be used for wiring or interface details. It is to be used for an overview of boiler operation only.



The physical inputs connected between the unit and the BIC are listed below:

Input	Function
Inlet Water Temperature	Measure inlet water temperature
Outlet Water Temperature	Measure outlet water temperature
Bypass Water Temperature	Measure water temperature entering the primary heat exchanger
Outdoor Air Temperature(Optional)	Measure outdoor temperature
Low Air and Blocked Drain Input	Indicate loss of airflow or drain blockage from the low air pressure sensor and blocked drain sensor. (External switches and resistor network used to create 2 to 10 volts input voltages to indicate switch status)
Low Gas Pressure Input and Blocked Flue	Indicates gas pressure problem or blocked flue from the high and low gas pressure sensor and blocked flue sensor. (External switches and resistor network used o create 2 to 10 volts input voltages to indicate switch status) – Applies only to a unit controller.
Time Clock Input	Scheduled building occupancy. Used to determine the temperature set point of the control system. (External switches and resistor network used to create 2 to 10 volts input voltages to indicate switch status) – Uses the same physical input as the Low Gas Pressure Input and Blocked Flue sensor – Applies only to the sequencer.
Manual Disable	Manual request to disable the unit . Manual disable is not a power disconnect. The controller still has power present, but will shut down firing, or prevent starting to fire. If the unit is firing, a post-purge sequence is performed. A disabled unit will allow the pump to operate if configured for Continuous Pump.
HSI Status	Indication of HSI On from the ignition device.
Gas Valve Status	Indicates that power has been applied to the gas valve solenoid implying that gas is being supplied.
Low Water Flow	Indicates loss of pump water flow from water level or water flow sensor.
Hard Lockout	Indicates flame failure from Ignition device.

The physical outputs from the BIC are listed below:

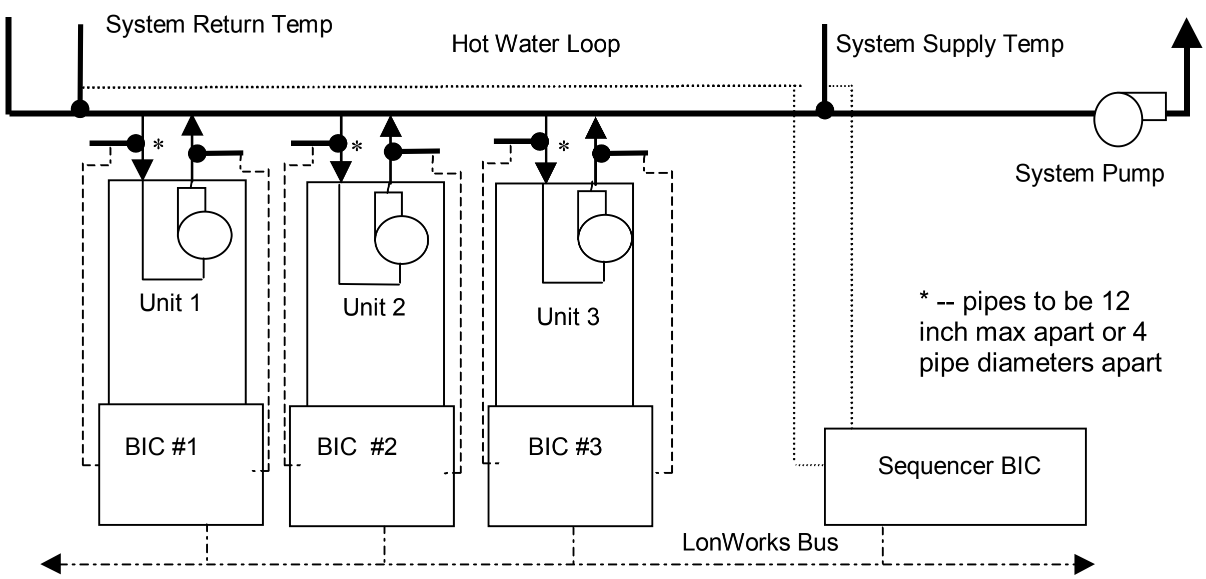
Output	Function
Primary Pump	Turns water pump off and on.
Aux. Call for Heat	Turns Auxiliary relay off and on.
Ignition control	Turns the ignition control (to Fenwal Unit) off and on.
Bypass Open	Bypass floating control 24 vac output causes the bypass valve to open. The analog bypass valve allows hot supply water to mix with colder inlet water in the primary heat exchanger to avoid condensation on the primary heat exchanger. Only the secondary heat exchanger is allowed to have condensation. This floating output is attached to a bypass floating valve actuator and causes the valve to slowly open. The typical motor travel time from stop to stop is 160 seconds.
Bypass Close	Bypass floating control 24 vac output causes the bypass valve to slowly close. See Bypass Open description above.
Dial Out Alarm	On/Off for external phone system dial out alarm to third party device. The third party device is Sensaphone® Model 1104 dial-out device. A dial out alarm is commanded due to one or more of the following: • water flow failure • low or high gas pressure fail • blocked drain • flame failure Optional output for stand alone systems. Several BIC Dial Out Alarm outputs may be connected in parallel to one dial out device. Each Sensaphone® Model 1104 is capable of annunciating four unique messages for via 4 unique digital inputs.
Variable Speed Blower	Control the speed of the variable speed blower motor. This pulse width modulation output is attached to an analog output converter that drives a variable frequency drive to control the speed of the air supply blower.

Multiple units for increased capacity

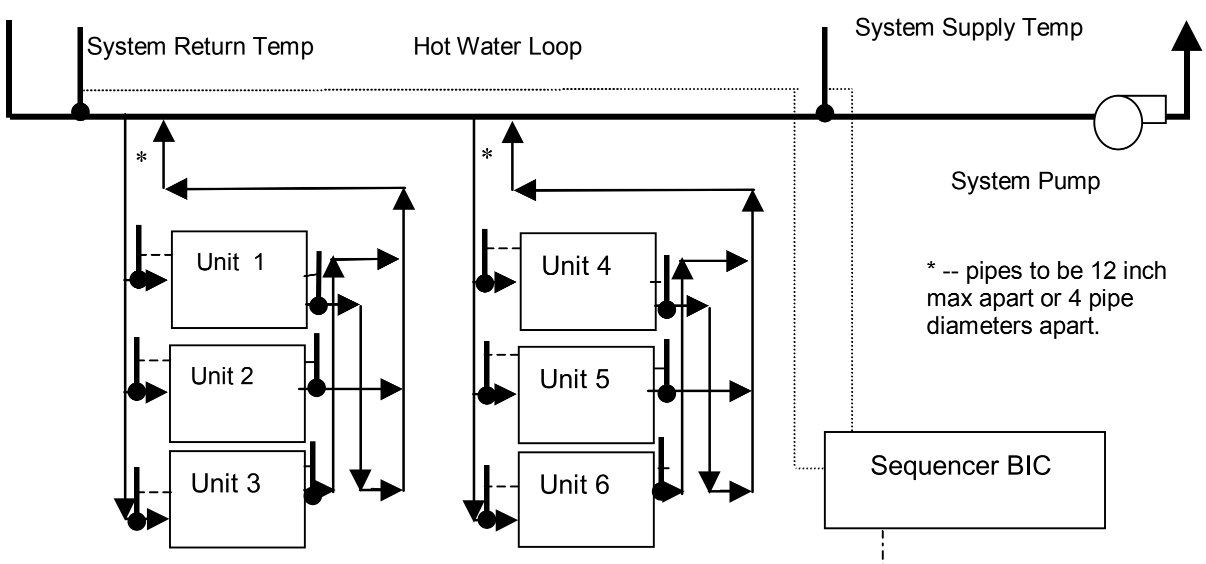
To increase the capacity of a system, it is possible to connect the units together with piping and controls as illustrated in the figures below. There is a BIC for each unit that monitors the inlet and outlet temperatures for each unit and controls the ignition, fan speed, and bypass valve. In addition there may be a BIC configured to be a sequencer. The sequencer BIC monitors the system supply and return temperatures, and controls the System Pump. In addition the sequencer BIC commands the units to turn on / off and controls the firing rate of each unit in predetermined sequences. The sequencer BIC communicates with the unit BICs over a LonWorks network via network variables designed for sequence control.

The sequencer can be configured at the factory for:

- First unit On First unit Off. Example: If the boilers turn on in the 1,2,and 3 turn sequence, then when there is less demand for heat, stage 1 is turned off first, then stage 2, then stage 3.
- First unit On Last unit Off. Example: If the boilers turn on in the 1,2,and 3 turn sequence, then when there is less demand for heat, stage 3 is turned off first , then stage 2, then stage 1.
- Efficiency Optimized. More boilers run at a time at a lower firing rate instead of one boiler at a higher firing rate
- Efficiency Optimized Run time equalization. Same as Efficiency Optimized except with equal run time on all boilers.



Up to three units connected



More than three units connected

Intended uses

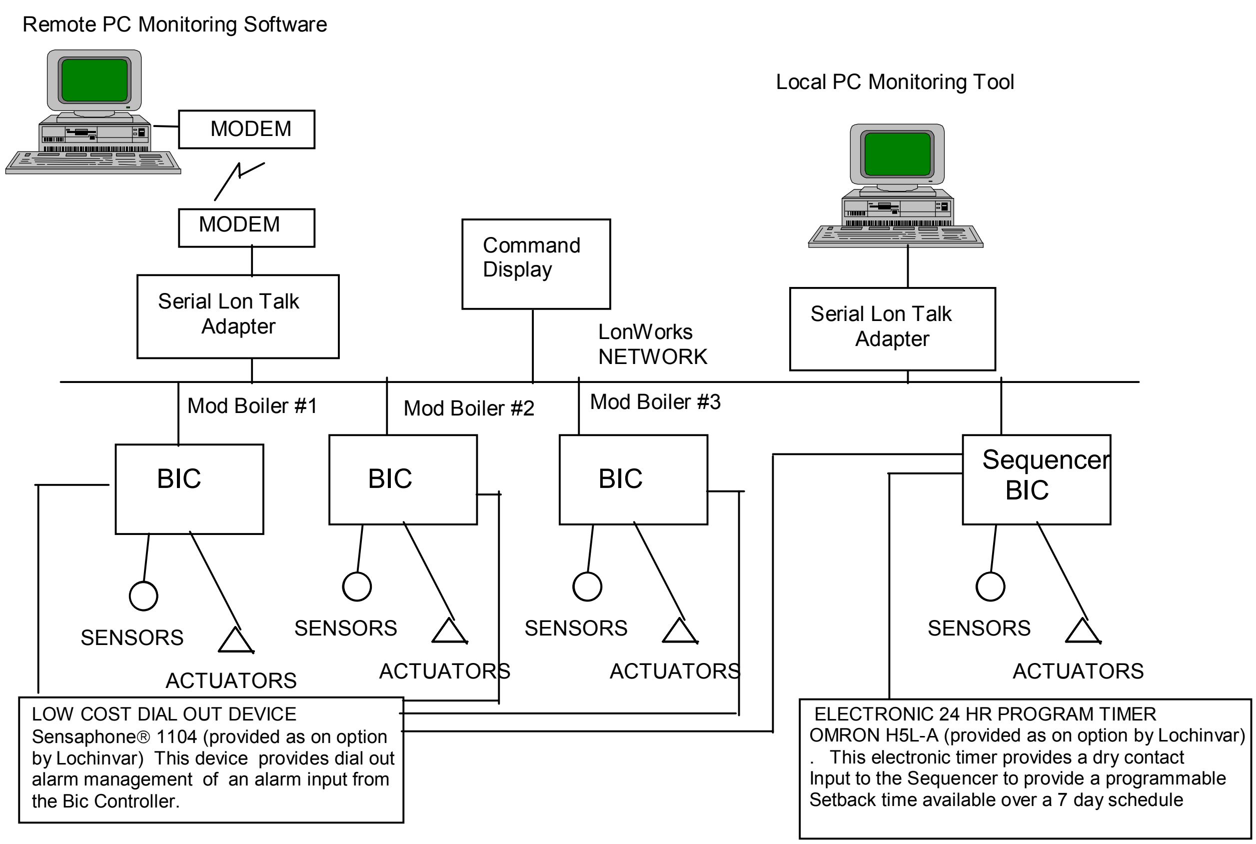
There are several intended usage scenarios of the BIC as illustrated by the diagram below.

- **Single stand alone unit.** One BIC controls one unit. Command display module is local human interface for the unit. Optional dial out alarm system.

- **Multiple sequenced units.** Up to 16 units connected together in a group for increased capacity. Each unit is controlled by a BIC. An additional BIC is the sequencer. Command display module is the local human interface for the units and sequencer. Optional local hardwired time clock connected to the sequencer. Optional dial out alarm system (all alarm outputs may be wired in parallel).

- **Multiple sequenced units with network local or remote monitoring.** Up to 16 units connected together in a group for increased capacity. Each unit is controlled by a BIC. An additional BIC is the sequencer. Local or remote IntelliStation PC monitoring software. Local command display module. Optional local hardwired time clock. Optional dial out alarm system (all alarm outputs may be wired in parallel). There may be one or more sequenced group monitored by IntelliStation monitoring software. IntelliStation is a full featured workstation made specifically for BIC.

- **Multiple sequenced units integrated into a building automation system.** Up to 16 units connected together in a group for increased capacity. Each unit is controlled by a BIC. An additional BIC is the sequencer. Local command display module. Third party local or remote workstation monitors the system. There may be one or more sequenced group monitored by the workstation.



Network Variables Available to the System Integrator

************ WARNING !!!! ************

The BIC contains additional network variables and configuration parameters other than the ones described here. The system integrator should not attempt to bind to the unspecified network variables or attempt to change them since some of the network variables may present safety issues.

************ WARNING !!!! ************

The BIC contains two objects. The LonMark node object (object number 0) and the Lochinvar boiler object (object number 1). Network variables are assigned to each of them. The following BIC network variables are available for use by system integrators. The BIC contains other network variables, but they are intended for factory configuration, or for future enhancements. Changing or binding to network variables that are not described below could cause safety problems and therefore the system integrator should not attempt to change the unspecified network variables or bind to the unspecified network variables.

Object		Network variable name	Mechanism	Data Structure in resource file
Node (0)	NV1	nviRequest	Input network variable	SNVT_obj_request
Node (0)	NV2	nvoStatus	Output network variable	SNVT_obj_status
Node (0)	SCPT 25	nciConfigSr	Configuration parameter network variable stored in non - volatile memory - EEPROM life is limited to 10,000 writes and should not be written frequently	SNVT_config_src
Boiler (1)	UNVT 1	nciOAReset	Configuration parameter network variable stored in non - volatile memory - EEPROM life is limited to 10,000 writes and should not be written frequently	UNVT_oa_reset
Boiler (1)	NV1	nvoData	Polled output network variable	UNVT_ctl_data
Boiler (1)	NV2	nvoIO	Polled output network variable	UNVT_io
Boiler (1)	NV3	nviSeqShare	Input to units bound to sequencer	UNVT_seq_share
Boiler (1)	NV4	nviModBoilrShare	Inputs to sequencer bound to units	UNVT_mod_share
Boiler (1)	NV5	nvoSeqShare	Output from sequencer bound to units – commands unit sequencing	UNVT_seq_share
Boiler (1)	NV6	nvoModBoilrShare	Output from units bound to sequencer – Feedback from units to sequencer	UNVT_mod_share

More details for each network variable are given below. All of the variables apply to the BIC when it is used as a unit controller and when it is used as a sequencer unless specifically stated. There is no difference between the boiler and the water heater except that the configuration parameters are set differently at the factory.

Node Object (nviRequest, nvoStatus, and nciConfigSr)

The following fields have been implemented in the BIC node object.

- nviRequest.object_id. The only valid object_id is 1 (boiler object). All other object_ids return nvoStatus.invalid_id = 1.
- nviRequest.object_request
- nvoStatus.ojbect_id returns the object_id requested by nviRequest.object_id
- nvoStatus.invalid_request
- nvoStatus.in_alarm
- nciConfigSr is available for network management tools to set to CFG_EXTERNAL when the network image is set by an outside source. Normally nciConfigSr is set to CFG_LOCAL when the node uses pre assigned binding to set its own network image.

The following nviReqest.object_request states have been implemented:

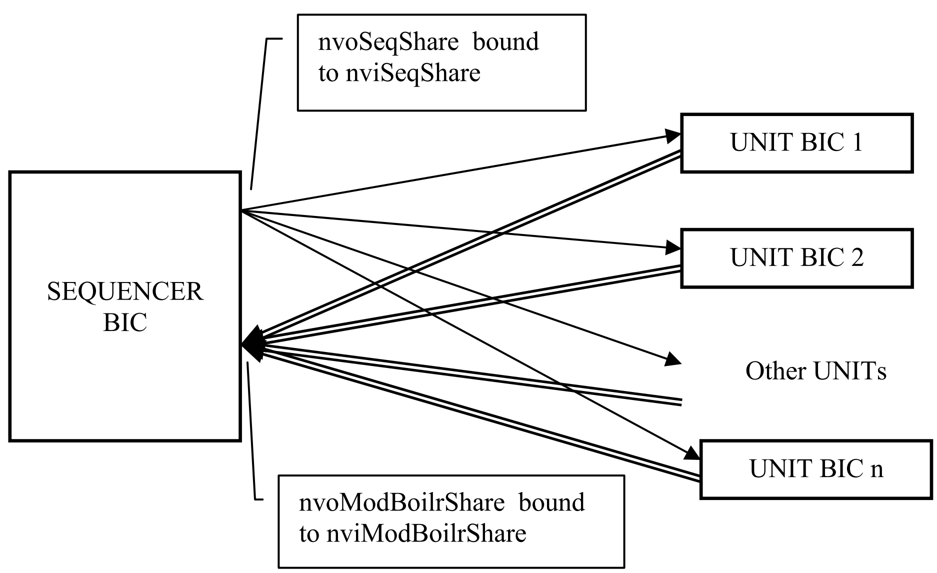
object_request state	**Action taken**
RQ_NORMAL	Switch to normal mode and report any alarms in nvoStatus.in_alarm. If the BIC (nvoDate.mode) is in MANUAL, FACTORY_TEST or DISABLED_MODE, restart at START_UP_WAIT mode.
RQ_UPDATE_STATUS	Report the current node status in nvoStatus.in_alarm.
RQ_REPORT_MASK	Report the supported functions of nvoStatus. nvoStatus.in_alarm is set to 1. nvoStatus.report_mask has not been implement. Therefore the node object is not in compliance with the current LonMark standards.
RQ_MANUAL_CTRL	Switch to manual control and report nvoStatus.in_alarm. If the BIC (nvoDate.mode) is not already in FACTORY_TEST or MANUAL modes, the BIC is set to either FACTORY_TEST or MANUAL mode depending on the value of nviManualValue.
RQ_DISABLED	If the BIC is not already in DISABLED_MODE, switch to DISABLED_MODE. If the BIC is in MANUAL or FACTORY_TEST, the mode is switched to START_UP_WAIT first and then later switches to DISABLED_MODE.
RQ_ENABLE	If the BIC (nvoDate.mode) is in MANUAL, FACTORY_TEST or DISABLED_MODE, restart at START_UP_WAIT mode.
others	nvoStatus.invalid_request is set to 1.

Data sharing between units and sequencer (nvoSeqShare, nviSeqShare, nvoModBoilrShare, nviModBoilrShare)

The variables nvoSeqShare, nviSeqShare, nvoModBoilrShare and nviModBoilrShare, are used to share information between the sequencer BIC and the unit BICs. Specifically the SEQUENCER uses nvoSeqShare connected (bound) to the UNITS nviSeqShare to request and modulate unit heat. Feedback from the UNITS nvoModBoilrShare connected (bound) to the SEQUENCER nvoModBoilrShare reports the actual unit response to the request.

Generally the information in these variables should not be displayed or viewed. The other variables have BIC status information in a more user friendly format.

- SEQUENCER.nvoSeqShare bound to all UnitBIC.nviSeqShare in a one to many binding.
- All UnitBIC.nvoModBoilrShare bound to SEQUENCER.nviModBoilrShare in a many to one binding.



Operating Mode (nvoData.Mode)

The operating mode or state of a BIC is reported by nvoData.mode (an enumerated data type – stmd_type). The states are given below. States apply to units and not sequencers unless otherwise stated.

Displayed	Raw Value	Meaning
START_UP_WAIT	0	The BIC has recently been reset due to power failure or other software reset and is going through an internal start up process. Also applies to sequencers.
IDLE	1	There currently is no call for heat and the unit is currently not heating water. Also applies to sequencers.
WATER_FLOW_EVAL	2	There is a call for heat but the unit is not currently heating water. The BIC has turned on the pump to circulate water through the unit, set the fan to the purge speed to purge the combustion chamber of combustible gases, and is evaluating water flow before proceeding to AIR_PRES_EVAL mode.
AIR_PRES_EVAL	3	There is a call for heat but the unit is not currently heating water. The BIC has turned on the pump to circulate water through the unit, set the fan to the purge speed to purge the combustion chamber of combustible gases. All previous steps have passed. The BIC is checking the flue air pressure before proceeding to BLOCK_DRAIN_EVAL mode.
BLOCK_DRAIN_EVAL	4	There is a call for heat but the unit is not currently heating water. The BIC has turned on the pump to circulate water through the unit, set the fan to the purge speed to purge the combustion chamber of combustible gases. All previous steps have passed. The BIC is checking that the condensate water drain is not blocked (if equipped with an optional condensate management system) before proceeding to LOW_GAS_PRESS_EVAL mode
LOW_GAS_PRESS_EVAL	5	There is currently a call for heat but the unit is not currently heating water. All previous steps have passed. The BIC is checking for sufficient gas pressure (if equipped with optional gas pressure switches) before proceeding to PRE_PURGE mode.
PRE_PURGE	6	There is currently a call for heat but the unit is not currently heating water. All previous steps have passed and the fan is continuing to purge the combustion chamber of combustible gases for a period of time before proceeding to IGNITION_EVAL mode
IGNITION_EVAL	7	There is a call for heat but the unit is not currently heating water. The Ignition request to the Fenwal control panel has been made. Proceed to BOILER_ON_EVAL mode.
BOILER_ON_EVAL	8	There is a call for heat and the unit should be heating water. The inlet and outlet water temperatures are being compared to show that the unit is heating water before proceeding to the HEAT mode.
HEAT	9	There is a call for heat and the unit is heating water. The fan speed and bypass valve position are being adjusted to maintain the water temperature set points. When heat is no longer called for, proceed to the POST_PURGE_PREPARE mode.
WATER_FLOW_FAIL_MODE	10	The primary pump is on but no water flow through the unit is detected. The fan and pump are on but the unit is not heating water. When there is no longer a call for heat, proceed to IDLE.
AIR_PRESS_FAIL_MODE	11	The fan has been turned on but no flue air pressure has been detected. The fan and pump are on but the unit is not heating water. When there is no longer a call for heat, proceed to IDLE.
BLOCK_DRAIN_FAIL_MODE	12	The condensate water drain is blocked. The fan and pump are on but the unit is not heating water. When there is no longer a call for heat, proceed to IDLE.
BLOCK_FLUE_FAIL_MODE	13	A blocked flue has been detected. The fan and pump are on but the unit is not heating water. When there is no longer a call for heat, proceed to IDLE.
LOW_GAS_PRESS_FAIL_MODE	14	There is a problem with the gas pressure. The fan and pump are on but the unit is not heating water. When there is no longer a call

Displayed	Raw Value	Meaning
		for heat, proceed to IDLE. (Some units are wired to connect the high and low gas pressure sensors together so a LOW_GAS_PRESS_FAIL_MODE may in fact be issued when the gas pressure is too high)
FLAME_FAILURE_MODE	15	The Fenwal Ignition Controller has indicated a flame failure (Hard Lockout). The unit is not heating water. When there is no longer a call for heat, proceed to IDLE.
SOFT_LOCK_OUT_FAIL_MODE	16	There is a call for heat but no heat has been detected during BOILER_ON_EVAL and 5 minutes have gone by. The unit is not heating water. When there is no longer a call for heat, proceed to IDLE.
HEAT_MOD_FAIL_MODE	17	There is a call for heat. Heat has been detected but then the heat failed. A failure purge operation is taking place. The unit is not heating water.
MANUAL	18	Not currently supported.
FACTORY_TEST	19	The BIC is in the factory test mode. A BIC should never be in the factory test mode while operating a unit. The only way the BIC can be put into a FACTORY_TEST is by changing some of the unspecified network variables.
PUMP_ONLY	20	Not currently supported.
EMERGENCY_MODE	21	Not currently supported.
DISABLED_MODE	22	The unit is not heating water but the pump may be on or off depending on the pump configuration set at the factory. The DISABLED_MODE occurs when one of the following is true: • Disable switch on unit is set in the disable position • Improperly configured sequencer (configuration is performed at the factory) • A sensor that is critical to operation has failed
HIGH_TEMP_MODE	23	If the inlet, outlet, or bypass water temperature exceeds the high temperature limit configured in the factory, then the BIC turns off the heat. A post heat purge operation occurs during this mode.
OFF_MODE	24	Not currently supported.
SMOKE_EMERGENCY	25	Not currently supported.
POST_PURGE	26	At the end of a heating cycle, the fan continues to run to purge the combustion chamber and flue of combustible gases. At the end of the timed period, proceed to the IDLE mode.
FREEZE_PROTECT_MODE	27	If inlet, outlet, or bypass is less than the factory configured limit, heat is turned off (with a post heat purge) and the pump is turned on.
POST_PURGE_PREPARE	28	There is no longer a call for heat but the unit is still heating water. The air flow is set to a rate to prepare for shut down. At the end of the timed period, proceed to POST_PURGE mode.
FLOAT_OUT_SYNC	29	There is no call for heat and the BIC is calibrating the floating control analog outputs such as the bypass valve. The BIC performs the calibration so that the valve positions can be accurately reported at power up. The FLOAT_OUT_SYNC mode occurs only at power up reset, after START_UP_WAIT
IDLE_MIN_DELAY	30	Not used.
SPARE_MODE2	31	Not used.
SEQ_HEAT_0STGS	32	This BIC is the sequencer, is calling for heat and is cycling through the safety sensors checks before directing one or more units to begin heating water.
SEQ_HEAT_1STGS	33	This BIC is the sequencer and is currently requesting heat from one unit in the system.
SEQ_HEAT_2STGS	34	This BIC is the sequencer and is currently requesting heat from two units in the system.
SEQ_HEAT_3STGS	35	This BIC is the sequencer and is currently requesting heat from three units in the system.
SEQ_HEAT_4STGS	36	This BIC is the sequencer and is currently requesting heat from four units in the system.
SEQ_HEAT_5STGS	37	This BIC is the sequencer and is currently requesting heat from five units in the system.

Displayed	Raw Value	Meaning
SEQ_HEAT_6STGS	38	This BIC is the sequencer and is currently requesting heat from six units in the system.
SEQ_HEAT_7STGS	39	This BIC is the sequencer and is currently requesting heat from seven units in the system.
SEQ_HEAT_8STGS	40	This BIC is the sequencer and is currently requesting heat from eight units in the system.
SEQ_HEAT_9STGS	41	This BIC is the sequencer and is currently requesting heat from nine units in the system.
SEQ_HEAT_10STGS	42	This BIC is the sequencer and is currently requesting heat from ten units in the system.
SEQ_HEAT_11STGS	43	This BIC is the sequencer and is currently requesting heat from eleven units in the system.
SEQ_HEAT_12STGS	44	This BIC is the sequencer and is currently requesting heat from twelve units in the system.
SEQ_HEAT_13STGS	45	This BIC is the sequencer and is currently requesting heat from thirteen units in the system.
SEQ_HEAT_14STGS	46	This BIC is the sequencer and is currently requesting heat from fourteen units in the system.
SEQ_HEAT_15STGS	47	This BIC is the sequencer and is currently requesting heat from fifteen units in the system.
SEQ_HEAT_16STGS	48	This BIC is the sequencer and is currently requesting heat from sixteen units in the system.

Time in a given mode (nvoData.ModeTimer)

The BIC may be in a given mode for a period of time before the mode proceeds to the next mode. The time that has been spent in a given mode is reported in nvoData.ModeTimer which is an unsigned long (two bytes) data type with range of 0 to 65534 seconds. In a sequencer nvoData.ModeTimer starts from the beginning of a call for heat until there is no longer a call for heat.

Number of heat stages requested to be turned on (nvoData.HeatStages)

In a sequencer, the sequencer commands the units in the system to turn on or off. nvoData.HeatStages reports the number of stages (units) currently requested to be turned on by the sequencer. nvoData.HeatStages is an unsigned short (one byte) data type. In a unit controller, nvoData.HeatStages is one if there is a call for heat, and zero if there is not a call for heat.

Variable frequency drive position (nvoData.VFDPos)

The variable frequency drive position (VFD) determines the speed of the fan and is an indication of how much energy is being transferred to the water. nvoData.VFDPos, a SNVT_lev_percent data type, reports the percentage (0 to 100 percent) of fan speed being commanded by the BIC. When the ignition is on, zero percent means the fan is running at 25 percent of full speed and 100 percent means the fan is running at full speed. In a sequencer, nvoData.VFDPos reports the approximate overall requested fan speeds of the group of units that it controls.

The relationship between nvoData.VFDpos, VFD frequency, fan speed, and firing rate is linear. The end points are shown in the table below.

nvoData.VFDpos (percent)	VFD frequency (Hz)	Fan Speed (percent of full speed)	Firing Rate (percent of full firing rate)
0	15	25	25
100	60	100	100

The BIC reserves the option (in the future) to command the nvoData.VFDpos to a value grater than minimum to overcome cold inlet water temps (so condensate does not form on the primary heat exchanger).

Bypass valve position (nvoDataBypassPos)

The temperature of the water in the primary heat exchanger is controlled to prevent condensation in the primary heat exchanger. Condensation is allowed only in the secondary heat exchanger. Water circulated from the primary heat exchanger outlet back to the primary heat exchanger inlet is used to keep the primary heat exchanger above the condensation point. A bypass valve controls the amount of water being re-circulated based on the bypass water temperature. nvoData.BypassPos (SNVT_lev_percent data type), reports the bypass valve position. When nvoDataBypassPos is zero, the valve is closed, and when the nvoDayta.BypassPos is 100 percent, the valve is fully open.

The bypass valve is controlled via a floating control electrical connection. The bypass position is only an estimate of valve position based on how long the valve motor is driven open or closed with a known motor speed. Whenever the valve is intended to be closed all the way (for example at the end of a heating cycle), the motor is over driven to ensure that the valve is in a known position.

Bypass valve position does not apply to sequencers.

Boiler Run Time (nvoIO.BlrTotRtHr)

Boiler run time is the number of hours that the unit has been heating water and can be used to schedule unit maintenance. The run time is saved in non-volatile memory every eight hours of accumulated run time. Therefore a loss of power may cause up to eight hours of run time to be lost during a power outage. nvoIO.BlrTotRtHr reports the run time in hours. The data type is unsigned long (two bytes) and has a range from 0 to 65534 hours.

Temperature reports

The variables listed below reports various temperatures in the system.

Variable	Data Type	Range (Degrees C)	Function
nvoData.InletWaterTemp	SNVT_temp_p	10 to 120	Reports the Inlet water temperature. If the BIC is a sequencer, the temperature reported is the Return Water temperature.
nvoData.OutletWaterTemp	SNVT_temp_p	10 to 120	Reports the Outlet water temperature. If the BIC is a sequencer, the temperature reported is the Supply Water temperature.
nvoData.DeltaTemp	SNVT_temp_p	0 to 120 Delta Degrees	Reports the Outlet water temperature minus Inlet water temperature. If the BIC is a sequencer, the temperature reported is the Supply Water temperature minus the Return Water temperature.
nvoData.BypassTemp	SNVT_temp_p	10 to 120	Reports the temperature of the water entering the primary heat exchanger. Applies only to a unit (boiler or water heater). If the BIC is a sequencer, this sensor is replaced with a resistor and does not control or report anything meaningful.
nvoData.TempControlPt	SNVT_temp_p	10 to 120	Temperature control point. Applies to a single unit or to a sequencer. If this BIC is a unit being commanded by a sequencer, temperature control point is meaningless. The BIC is trying to heat the water to this temperature. Either the Inlet (Return) or Outlet (Supply) water temperature may be controlled as configured at the factory or selected via the Command Display. For boilers the temperature control point is selected by an algorithm that takes into account the effective occupancy, the set points entered in the configuration parameter nciOaReset, and the outdoor temperature (if equipped with an optional outdoor air package). For water heaters, the temperature control point is selected by an algorithm that takes into account the effective occupancy, and some of the set points entered in the configuration parameter nciOaReset. See the Control Point Calculation section for details.
nvoData.OutsideAirTemp	SNVT_temp_p	-40 to 120	Reports the outside air temperature. Outside temperature is only used by a single boiler or by a sequencer with multiple boilers to adjust the control point based on outdoor air temperature.
nvoData.CalcWaterFlow	SNVT_flow	0 – 10000 liters per second	Not Used.

On / Off information

All information is a one bit boolean (True/False) data type

Variable	Function	True	False
nvoData.PrimaryPmp	Reports that the primary pump (system pump in sequencers) output is enabled.	Pump on	Pump off
nvoData.IgnitEnab and nvoData.AuxCallHeat	Reports that power is being applied to the safety switches and the ignition system. If all of the safety requirements have been satisfied, then the ignition system will light the flame.	Ignition power on	Ignition power off
nvoData.DialOutAlarm	Dial out alarm is being commanded due to one or more of the following: • water flow failure • low or high gas pressure fail • blocked drain • flame failure	Alarm	No Alarm
nvoData.ManDisableIn	Reports the state of the disable input to the BIC.	Disable switch is in “RUN” mode	Disable switch is in “STOP” mode
nvoData.GlowBarOnIn	Reports the state of the HSI status input to the BIC.	HSI On	HSI Off
nvoData.GasValveOnIn	Reports the state of the gas valve input to the BIC.	Gas Valve is On	Gas valve is off
nvoData.LowWaterFlowIn	Reports the state of the low water flow input to the BIC.	Low water level or no water flow	Water level is OK or adequate water flow
nvoData.FlameFailIn	Reports the state of the hard lockout input to the BIC.	No flame detected when there should be a flame	Flame OK or no flame required
nvoData.LowAirIn	Reports the state of the low air input to the BIC.	Low air detected	Air flow is OK
nvoData.BlockDrainIn	Reports the state of the blocked drain input to the BIC.	Blocked drain	Drain OK
nvoData.LowGasIn	Reports the state of the gas pressure input to the BIC	The gas pressure is low or high.	The gas pressure is OK.
nvoData.BlockFlueIn	When the BIC is a controller, reports the state of the blocked flue input. When the BIC is a sequencer, reports the time clock input.	Flue Blocked or scheduled to be occupied	Flue not blocked or scheduled unoccupied
nvoData.SecondaryPmp	Not used		
nvoData.LocalAlarm	Not used.		
nvoData.SeqControllerCfg	Not Used		
nvoData.Out7	Not used		
nvoData.LEDOut	Not used		

Occupancy status

The temperature control point may be controlled by several factors. One factor is the occupancy of the building. Several occupancy sources of occupancy information are arbitrated by the occupancy arbitration logic to calculate an Effective occupancy for the control point. All the occupancy variables have the SNVT_occupancy enumerated data type. Occupancy only applies to a sequencer. Each state has the following meaning:

Displayed	Raw Value	Meaning
OC_OCCUPIED	0	The space is occupied. Typically the set point is set for comfort.
OC_UNOCCUPIED	1	The space is unoccupied. Typically the set point is set for least energy use.
OC_BYPASS	2	The space is scheduled to be OC_OCCUPIED or scheduled to be OC_STANDBY but some occupancy information (such as switch on the wall) has indicated that the space is currently occupied and that the scheduled occupancy is not correct. Typically a timer is started when the space becomes occupied. When the timer times out, the schedule takes over occupancy
OC_STANDBY	3	The space is not occupied but should be prepared to become occupied soon. Typically the set point for OC_STANDBY is between the set point for OC_OCCUPIED and the set point for OC_UNOCCUIPED.
OC_NUL	0xFF	This source of occupancy information is not connected or has failed.

The following variables report the occupancy control of set point temperature

Variable	Function	Valid Values
nvoData.SchedOcc	Scheduled occupancy determined by a time clock connected to the time clock input of the BIC.	OC_OCCUPIED OC_UNOCCUPIED
nvoData.EffectOcc	The effective occupancy state. In this model, the effective occupancy state is the scheduled occupancy.	OC_OCCUPIED OC_UNOCCUPIED
nvoData.OverRideOcc	For future use	
nvoData.ManualOcc	For future use	
nvoData.SensorOcc	For future use	

Configuration Parameters setting temperatures

All the temperature setting configuration parameters are SNVT_temp_p data type. They apply to all usage scenarios unless otherwise stated. The temperature setting configuration parameters are used to determine the control point. See the Control Point Calculation section for more details.

Variable	Function	Range (Degrees C)	Default Boiler Value (Degrees C)
nciOAReset.SetbackAmt UN OCCUPIED	Control point during the Unoccupied mode	10 to 120	60
nciOaReset.Setpoint OCCUPIED with out reset due to outdoor temperature	In a single boiler unit or boiler sequencer when the mode is occupied and the outdoor temperature is nciOAReset.OaMaxSetpoint or higher, then the control point is set to nciOAReset.Setpoint. In a single water heater unit or water heater sequencer when the mode is occupied, then the control point is set to nciOAReset.Setpoint.	10 to 120	71.1
nciOAReset.MaxSetpoint OCCUPIED with full reset due to low outdoor temperature	In a single boiler unit or boiler sequencer when the mode is occupied and the outdoor temperature is nciOAReset.OaMinSetpoint or lower, then the control point is set to nciOAReset.MaxSetpoint. Not used in a water heater.	10 to 120	82.2
nciOAReset.OaMinSetpoint Outdoor temperature that causes full reset	In a single boiler unit or boiler sequencer when the mode is occupied and the outdoor temperature is nciOAReset.OaMinSetpoint or lower, then the control point is set to nciOAReset.MaxSetpoint. Not used in a water heater.	-60 to 35	-23.3
nciOAReset.OaMaxSetpoint Outdoor temperature that causes no reset	In a single boiler unit or boiler sequencer when the mode is occupied and the outdoor temperature is nciOAReset.OaMaxSetpoint or higher, then the control point is set to nciOAReset.Setpoint. Not used in a water heater.	-60 to 35	15.5
nciOAReset.AbsMaxSetp	The control point is never allowed to go above nciOAReset.AbsMaxSetp. If the measured inlet, outlet, or bypass temperature exceeds nciOAReset.AbsMaxSetp, then BIC enters the HIGH_TEMP_MODE and the heat is shut off and a post purge operation is performed.	-60 to 200	125.0
nciOAReset.AbsMinSetp	The control point is never allowed to go below nciOAReset.AbsMinSetp.	-60 to 110	50.0
nciOAReset.OaHtgLockout	In a single boiler unit or a boiler sequencer, if the outdoor temperature, is greater than nciOAReset.OaHtgLockout, heating will be turned off. Not used in a water heater.	-60 to 35	20.0
nciOAReset.EmergSetpoint	Set point during an emergency – Not	10 to 120	54.4

Variable	Function	Range (Degrees C)	Default Boiler Value (Degrees C)
	used		

Control Point Calculation

The control point is the desired temperature of the water. The sequencer BIC or the one unit BIC calculates the desired water temperature according to the following table depending on the effective occupancy and the factory configuration:

Effective Occupancy (nvoData.EffectOcc)	Factory configuration Water heater or boiler	nvoData.TempControlPt is set to the value listed below Note 1
OC_UNOCCUPIED	Don't Care	nciOAReset.SetbackAmt
OC_OCCUPIED	Single Water Heater Unit or Water Heater Sequencer Or Single Boiler Unit or Boiler Sequencer Commsioned at the factory to ignore outdoor temperature	nciOAReset.Setpoint.
OC_OCCUPIED	Single Boiler Unit or Boiler Sequencer Commissioned with Optional Outdoor Air Pkg Outdoor Air Sensor Failed or not connected	Use outdoor temperature =15.5 Degrees C See Note 2
OC_OCCUPIED	Single Boiler Unit or Boiler Sequencer Commissioned with Optional Outdoor Air Pkg Outdoor Air Sensor Working	Use actual outdoor temperature See Note 2

Note 1: The effective control point (nvoData.TempControlPt) is limited to values between nciOAReset.AbsMaxSetp and nciOAReset.AbsMinSetp.

In other words if the calculated control point from the steps above is above nciOAReset.AbsMaxSetp, then, nvoData.TempControlPt is set to nciOAReset.AbsMaxSetp. Also if the calculated control point from the steps above is below nciOAReset.AbsMinSetp, then, nvoData.TempControlPt is set to nciOAReset.AbsMinSetp.

Note 2: Exact control point calculation. The control point is set to a point on a line having the following equation:

nvoData.TempControlPt = nciOAReset.Setpoint + (X * A / B)

where

A = nciOAReset.MaxSetpoint – nciOAReset.Setpoint
Furthermore: A is limited to the 0 and 250 degrees C range before being used in the formula. Normally the tool that enters values in nciOAReset does not cause the limit to be exceeded but the limit protects the BIC from invalid values set by the tool.

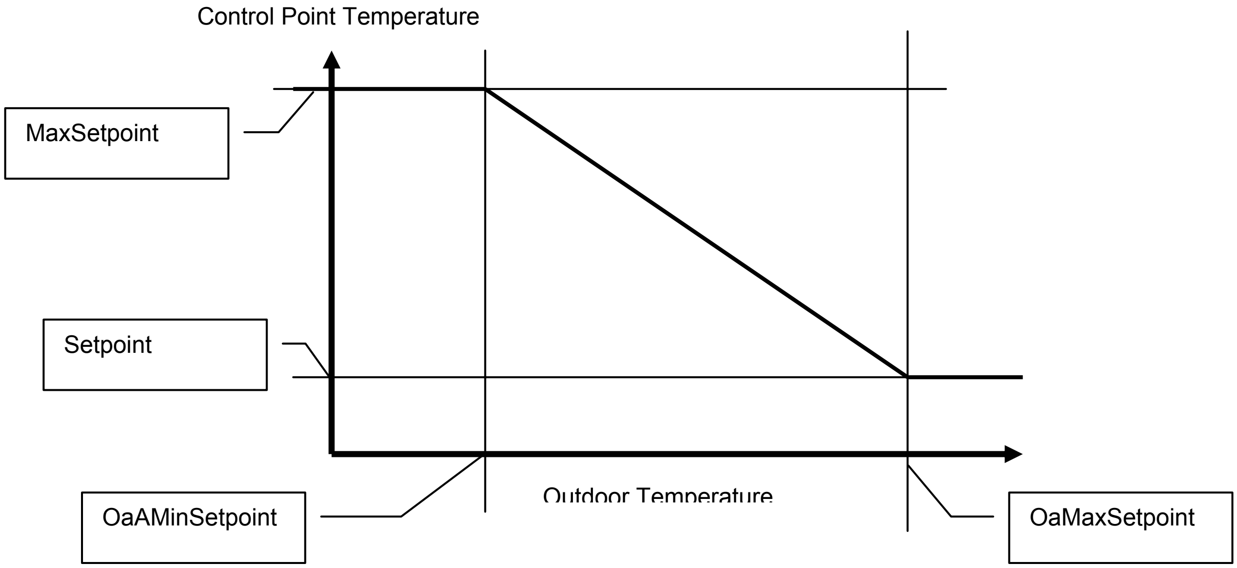
B = nciOAReset.OaMaxSetpoint – nciOAReset.OaMinSetpoint
Furthermore: B is limited to the 1 to 140 degrees C range before being used in the formula above. Normally the tool that enters values in nciOAReset does not cause the limit to be exceeded but the limit protects the BIC from invalid values set by the tool.

X = nciOAReset.OaMaxSetpoint – nvoData.OutsideAirTemp
Furthermore: X is limited to the 0 to B degrees C range before being used in the formula above.

If nvoData.OutsideAirTemp is greater than or equal to nciOAReset.OaMaxSetpoint, then X = 0 because of the limit and then the control point = nciOAReset.Setpoint.

If nvoData.OutsideAirTemp is less than or equal to nciOAReset.OaMinSetpoint, then X = B because of the limit and then the control point = nciOAReset.MaxSetpoint.

The equation is illustrated by the figure below:



BIC and CD Factory Set Configuration

************ WARNING !!!! ************

The BICs and CDs are configured at the factory. The system integrator must not change any of the BIC or CD configurations.

The system integrator must protect the configuration of the BIC and CD made in the factory. During installation, the system integrator must read the configuration parameters from the BICs into the tool data base (LNS data base) before trying to monitor or change anything in the BICs.

Altering the BIC configuration parameter may introduce inappropriate or unsafe unit operation.

Furthermore the factory sets the network image (domain, subnet, node, and bindings) so that BICs can communicate with one another and CDs can display BIC status. If you do not follow the procedure given in the Step by Step Integration Procedure, and write the network image you could cause the BICs and /or CDs to no longer communicate with one another.

************ WARNING !!!! ************

In all cases the BIC controller system and any optional command display modules are pre configured at the factory:

- Each BIC and the command display are assigned unique addresses (domain, subnet, node)
- Network image is pre loaded at the factory.

- All of the configuration parameters are loaded at the factory.

  The command display module(s) are configured to communicate with the BICs using subnet / node addressing. Each command display can support up to 17 BICs.

- Typically only one BIC per interconnected group is configured to be a sequencer.

What is LNS?

The acronym LNS means LonWorks Network Services. LNS provides network services that are necessary to build interoperable LonWorks systems or jobs. LNS resides in a device on the network (usually a PC but smaller versions are available) and provides services to any client (device) that requests them. Typically LNS is used by human interface devices (such as LonMaker) to manage the devices on the network. Specifically a human interface device may use the LNS server when installing, configuring, interconnecting, commissioning, monitoring and replacing devices on the LonWorks network. LNS does not display any network information directly. A separate user interface client (such as LonMaker) must be present to display and modify anything on the network.

LNS assumes that each device on the network contains objects. Each object has inputs, outputs, configuration parameters, and a predetermined fixed functionality. The objects may be configured and interconnected to perform desirable functions in the system.

LNS keeps track of the devices and objects in the system data base. The LNS server makes the information in its data base available to client devices such as human interfaces (like LonMaker) to perform their functions. Specifically, the LNS server stores the following information:

- Network interface information for each device type in the system. Specifies the object types and the data type structure in each device type. For example: The BIC is a device type with two objects and several network variables having specific data structures.
- Names, addresses and type of device of all the devices in system
- Configuration parameter values loaded into objects.
- Connections between object inputs and outputs in the system.
- Templates for each object type in a system. (Specifies inputs, outputs, configuration parameters, and default configuration parameter values).
- Additional template information to aid system design and monitoring.

The LNS server also performs the following functions at the request of a client:

- Add device in the LNS data base. The device may not yet physically exist but has been added to the data base during the design phase.
- Retrieve the neuron id of a physical device and assign the neuron id to a device in the LNS data base
- Commissions device. The commissioning process includes downloading the network address and binding (connection) information, and the configuration parameter information to the device over the LonWorks network.
- Add object and assign the object to a device in the LNS data base.
- Add connections between object inputs and outputs in the LNS data base
- Change the object configuration parameters in the LNS data base
- Retrieve information from devices (objects) for use by monitor user interfaces.

- When object configuration parameters or connections are changed in the LNS data base, send the changes to the device(s) that are already installed on the LonWorks network.

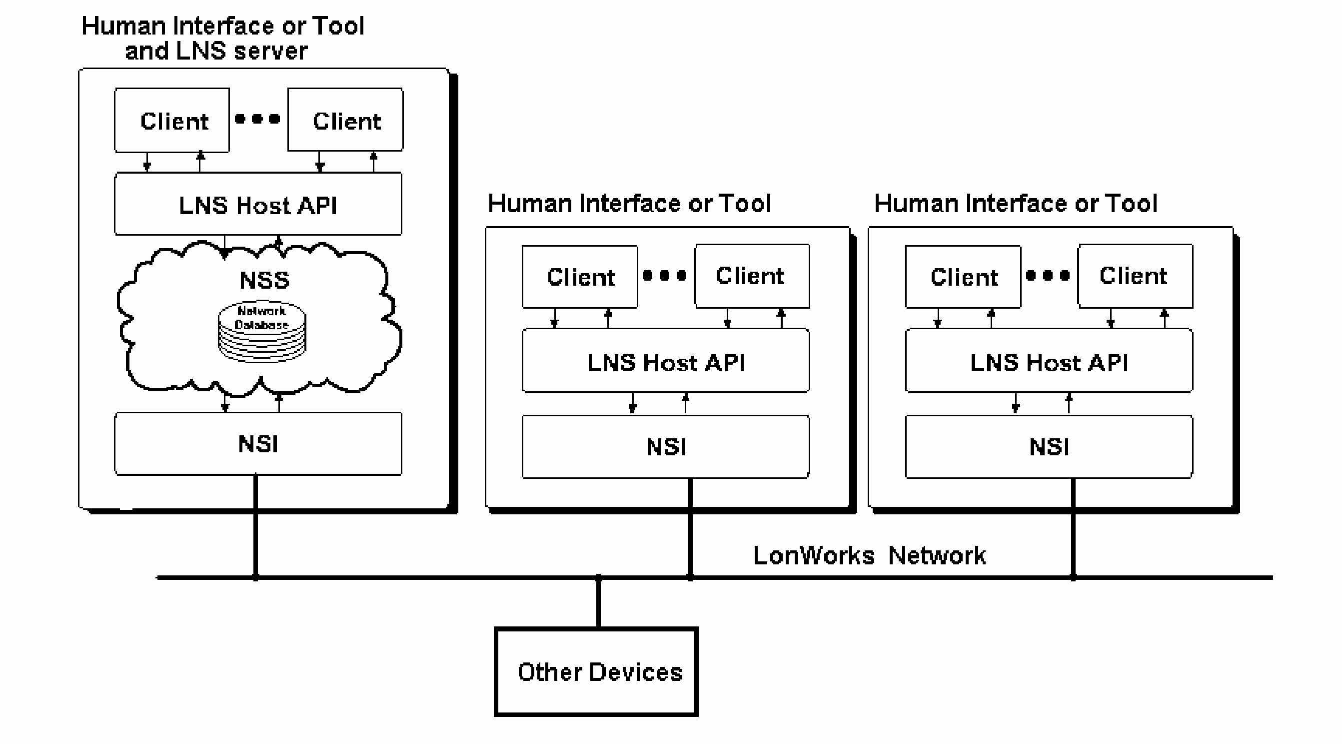
- Retrieve network topology, network address, connections, configuration parameter information from a functioning system and store the information in an LNS data base. Not all the desired information may reside in the system but basic information can be retrieved.

- Other functions to automate system design and maintenance.

The LNS server contains two major components. The Network Services Server (NSS) processes standard network services, maintains the network data base and enables and coordinates multiple points of access to its services and data. The Network Services Interface (NSI) provides the physical interface to the LonWorks network and manages transactions with the NSS and application servers. In addition the NSS interfaces to local client applications through the LNS Host API. When the host is a PC, then clients interface using Microsoft OLE automation.

The LNS architecture allows many human interfaces or tools to exist on the LonWorks network at the same time. Only one Network Services Server (NSS) is allowed to exist in the network at a time. All tools and human interfaces are clients and communicate with the NSS (via NSS and Host LNS API). The NSS coordinates the activities of the various clients and ensures consistent information across all clients, the database, and the devices on the network.

Clients may have director (navigator), installation, maintenance, diagnostics, monitor, field programming, device specific configuration, or job specific functions. Directors allow the user to choose the clients (and devices or objects) to display and modify.



What is LonMaker?

LonMaker is an integration tool for designing, installing, maintaining, and operating a multi-vendor, open, interoperable LonWorks network. Based on Echelon's LNS network operating system, the LonMaker tool combines the client – server architecture with an easy to use Microsoft Visio user interface. The result is a tool that is sophisticated enough to design and commission a distributed control network but that can be left behind as an operations and maintenance tool. The LonMaker tool takes full advantage of LonMark features such as standard functional profiles, configuration properties, and resource files.

Users are provided with a familiar, CAD-like environment for designing a control system. LonMaker includes a number of smart shapes for LonWorks networks, and users can create new custom shapes. Shapes may be single device, functional block, or connection. Custom shapes may be a complete subsystem with nested subsystems and predefined devices, functional blocks, and connections between them. Using custom subsystem shapes, additional subsystems can be created by simply dragging a custom subsystem shape from a stencil to the drawing.

LonMaker performs the following functions with the aid of the behind the scenes LNS data base and the VISIO user interface:

- Installation of devices using service pin, bar code scanning, winking, manual entry, or automatic discovery
- Recover network design from an existing network
- Merge networks into one integrated system
- Test a device
- Configure of a device
- Manual operation of a device
- Browse a device or a functional block
- Display and allow users to change any network variable(s) in any device
- Compatible with LNS DDE server for a variety of third-party operator interface packages
- Supports multiple users
- Supports Plug-ins (custom user interfaces for specific device types or specific functions)

What is needed for system integration?

The following items are needed to integrate the BIC into an LNS based system.

- Either LNS version 3.xx or LonMaker version 3.xx installed on your PC. LNS and LonMaker are Echelon products.

- Network interface to connect your PC to the LonWorks network. Any of the NSI supported interfaces may be used for system integration. Generally network interfaces are available from Echelon.

- Resource files available in BIC. ZIP archive. BIC.ZIP is available from Lochinvar.
  - ✓ BIC.XIF – device interface
  - ✓ BIC.XFO and BIC.XFB – binary device interface files
  - ✓ BIC.DEF – source definition resource file
  - ✓ BIC.TYP – custom data structures
  - ✓ BIC.FPT – functional profile for BIC
  - ✓ BIC.ENU – United States English language text strings
  - ✓ BICUS.FMT– data format with United States units
  - ✓ BICSI.FMT – data format with metric units
  - ✓ README.TXT – instructions for resource files installation into LonMaker / LNS – It is recommended that you read the README.TXT file for details on the installation of the resource files. There may be current issues with LonMaker / LNS that you should know.

- WinZip or other program that can extract the resource files from the BIC.ZIP archive and place them in the appropriate directories.

- You will need a browser to display and modify BIC information. LonMaker comes with a browser that shows the values and allows you to change those that can be changed, but the format is not user friendly. Your custom browser or graphics package can display the BIC information in a more user friendly format.

Step by step integration

The details of how to integrate a BIC system into a LonMaker system are presented below. The general steps are:

Ordering and Unit Installation Task

- Order the units per the usual Lochinvar ordering process.
- Install the units

System Integrator Task - Add BIC system to building network (Offnet)

Note: This task should be done at the office without being connected to the LonWorks network.

- Install the resource files into the appropriate directories
- Register the resource files in the resource catalog
- Back up any existing network before making any major changes to an existing network.
- Add BICs (sequencer and units) and dummy CDs to either a new or existing LNS network
- Configure the LNS data base so that the BIC uses a device specific resource file
- Add boiler function blocks (objects) for the sequencer and each of the units to the network
- Bind the Sequencer BIC to the Unit BICs for normal sequencer operation
- Order replacement CDs
- Make custom graphical user interfaces to display system status

Note: Do not add or delete BICs from the network after ordering replacement CDs.

Reprogramming CDs Task

- Using information provided by System Integrator, the Lochinvar factory programs replacement CDs with the new subnet/node address of the BICs, and ships them to the system integrator.

Prepare to connect LonWorks Network wire to the BIC System Task

- Run the building LonWorks network wire to the BIC system but do not connect the BIC system to building LonWorks network.

System Integrator Task – Final Integration (OnNet)

Note: The final task of integration is performed after replacement CDs arrive.

- Shut down the boiler system
- Remove the CDs from the boiler system
- Connect the BIC System to the building LonWorks Network
- Commission the BICs
- Install the replacement CDs
- Return the boiler system to operation
- Test any network functions

The step by step process is long, involved, and somewhat tedious. Do not rush through the process, or skip any steps. Check your work before you go on to the next step. Refer to this step by step guide on every step.

It is **not** recommended that you use the LonMaker network recovery and merge facilities with BICs or CDs. The recovery process is prone to recovery errors and can leave the BICs in a non-functional state. For example: The recovery process does not recover BIC bindings completely and the merge facility changes the subnet / node address of all the BICs.

After the BICs have been integrated into a system it is recommended that the LonMaker merge facility **not** be used on the network. The CDs contain a table of BIC subnet / node addresses and if the merge facility changes a BICs subnet / node address, the CD will no longer be able communicate with BICs.

Ordering and Unit Installation Task

Order the units using the standard Lochinvar ordering process. Install and connect the units into a boiler (heater) system interconnecting the BICs and CDs with a LonWorks network. Turn on and test the system. The system should be working before it is integrated into the rest of the building automation system.

System Integrator Task - Add BIC system to building network (Offnet)

The steps in this task should be done at the office by the system integrator without being connected to the LonWorks network. At the end of this task, the BICs and CDs have been added to the network data base but the units are still running as a non integrated subsystem. This task takes a skilled person about 30 minutes (not including custom graphics). Do not add or delete BICs from the network after ordering replacement CDs.

Install the resource files into the appropriate directories

Extract the resource files from the BIC.ZIP archive and install them into the directories shown below.

File	Directory (note 1)	Comments
BIC.XIF	\LonWorks\import\Lochinvar\Bic	
BIC.XFB	\LonWorks\import\Lochinvar\Bic	
BIC.XFO	\LonWorks\import\Lochinvar\Bic	
BIC.TYP	\LonWorks\types\User\Lochinvar\Bic	
BIC.ENU	\LonWorks\types\User\Lochinvar\Bic	
BIC.FPT	\LonWorks\types\User\Lochinvar\Bic	
BicUS.fmt	\LonWorks\types\User\Lochinvar\Bic	Note 2
BicSI.fmt	\LonWorks\types\User\Lochinvar\Bic	Note 2

Note 1: Directory path names are typical. It is assumed that the default LonMaker directory scheme is in use.

Note 2: BicUS.fmt is for U.S. default units. BicSI.fmt is for metric units. Copy either BicUS.fmt or BicSI.fmt to the type directory as required by your regional use of units.

Register the resource files in the resource catalog

It is assumed that the LNS user is able to use the resource catalog facility (ldrfcat.exe) and no other instructions are given here.

Back up any existing network before making any major changes to an existing network

If, the BICs will be connected to an existing network, backup the network using the LonMaker back up facility. In case there is a fatal error made, you will be able to recover using this backup.

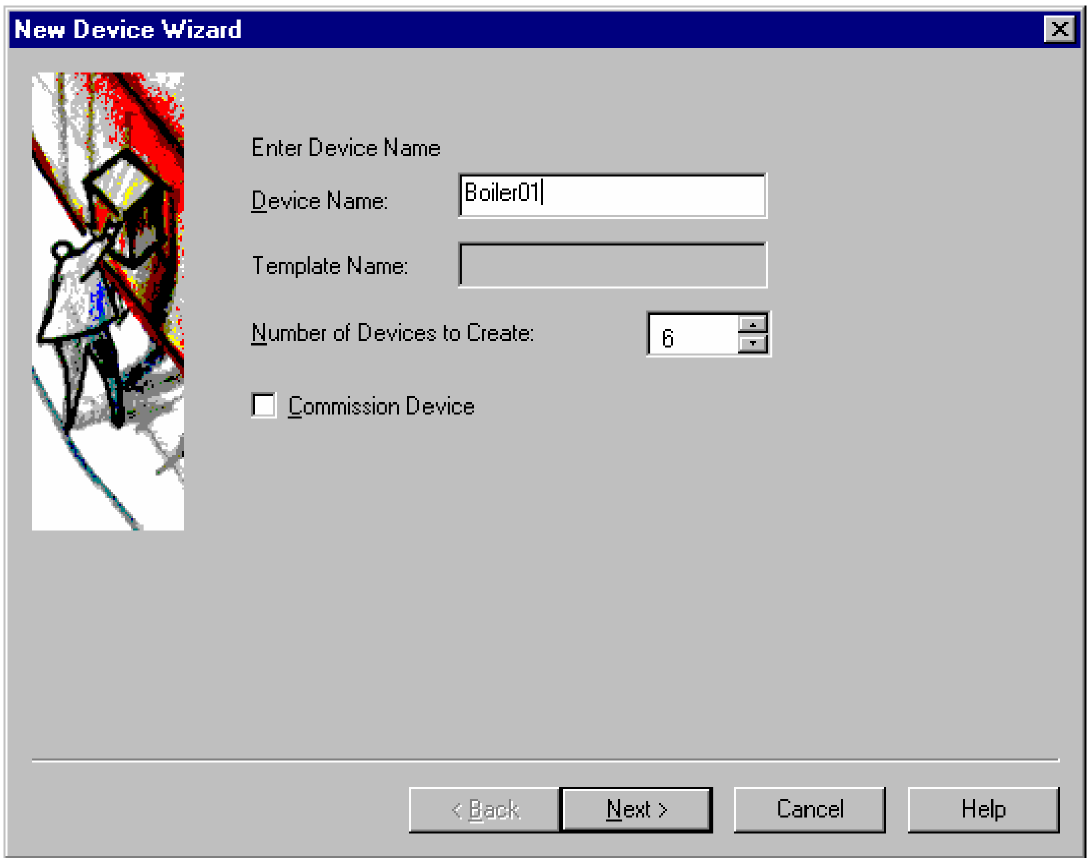
Add BICs (sequencer and units) and dummy CDs to either a new or existing LNS network

In this step you will create devices in the network for your BICs and CDs. CDs will not be commissioned under LNS but their subnet / node address must be "reserved". By creating dummy CDs, their address will be reserved. For every CD, create an extra BIC and give it the name of a CD.

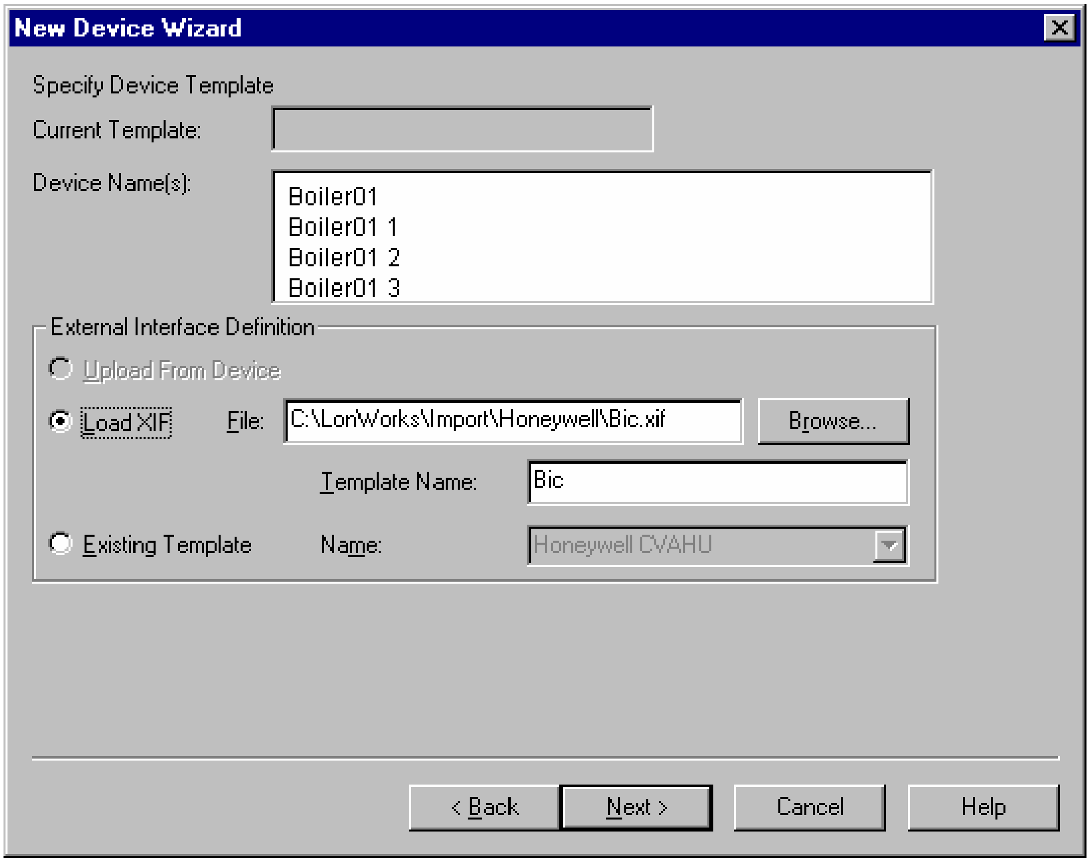
If there is more than one group in the network create one group of units at a time. For example, a group is one sequencer, several units, and one CD.

- Start LonMaker and either create a new network or open an existing network. You should have backed up an existing network in the previous step. You should **not check the OnNet** Radio Button in the Network Open Wizard. Work should be done without communicating the changes to the any nodes at this time.

- Drag a Device template onto the drawing which launches the "New Device Wizard". Give the device a name such as BOILER 01, and create one device for every BIC (sequencer and units) and one device for every CD. In this case there are 6 devices. Do not commission the devices at this time. Go to the next step.

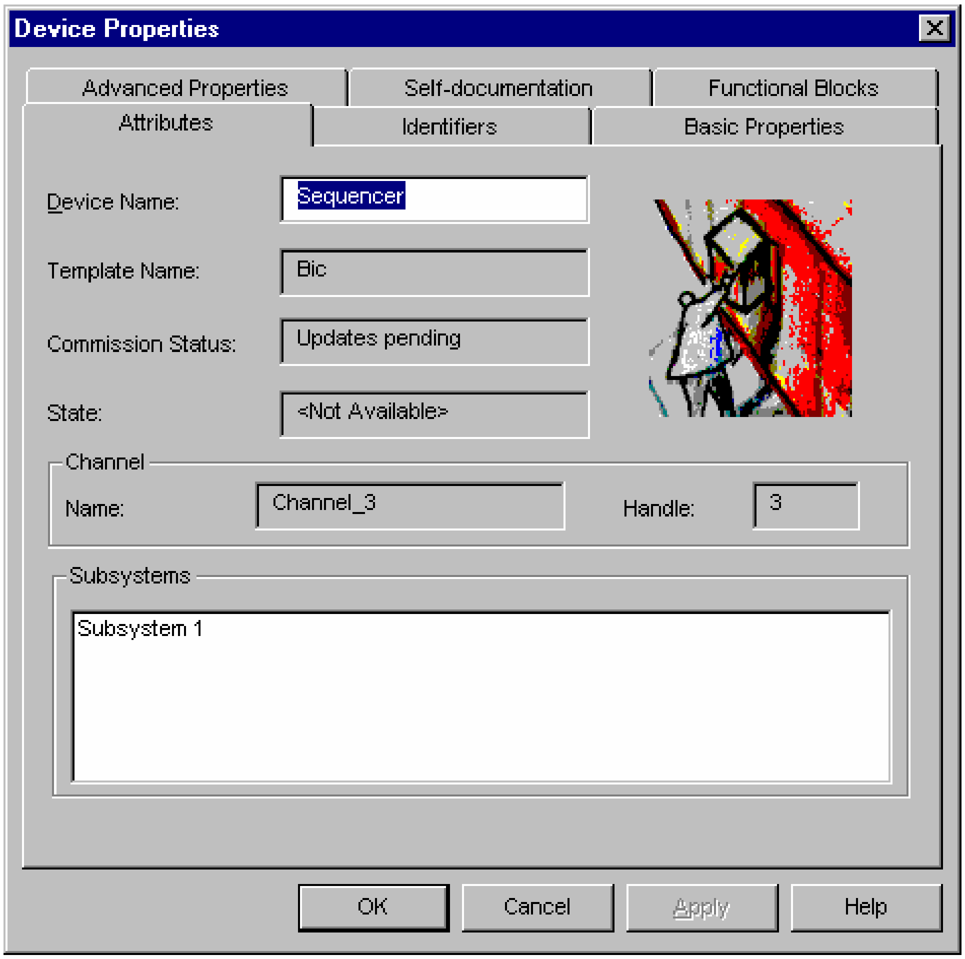


- Load the BIC.XIF file for all the devices, and proceed through the other wizard screens with the default values. The XIF file **should not** be Uploaded from the device. Some device versions may not have up to date self documentation. Ignore the “Configuration Properties Warning” if it appears. Assign the devices to the channel that will be used to connect the boiler system to the network. “Finish the New Device Wizard”.



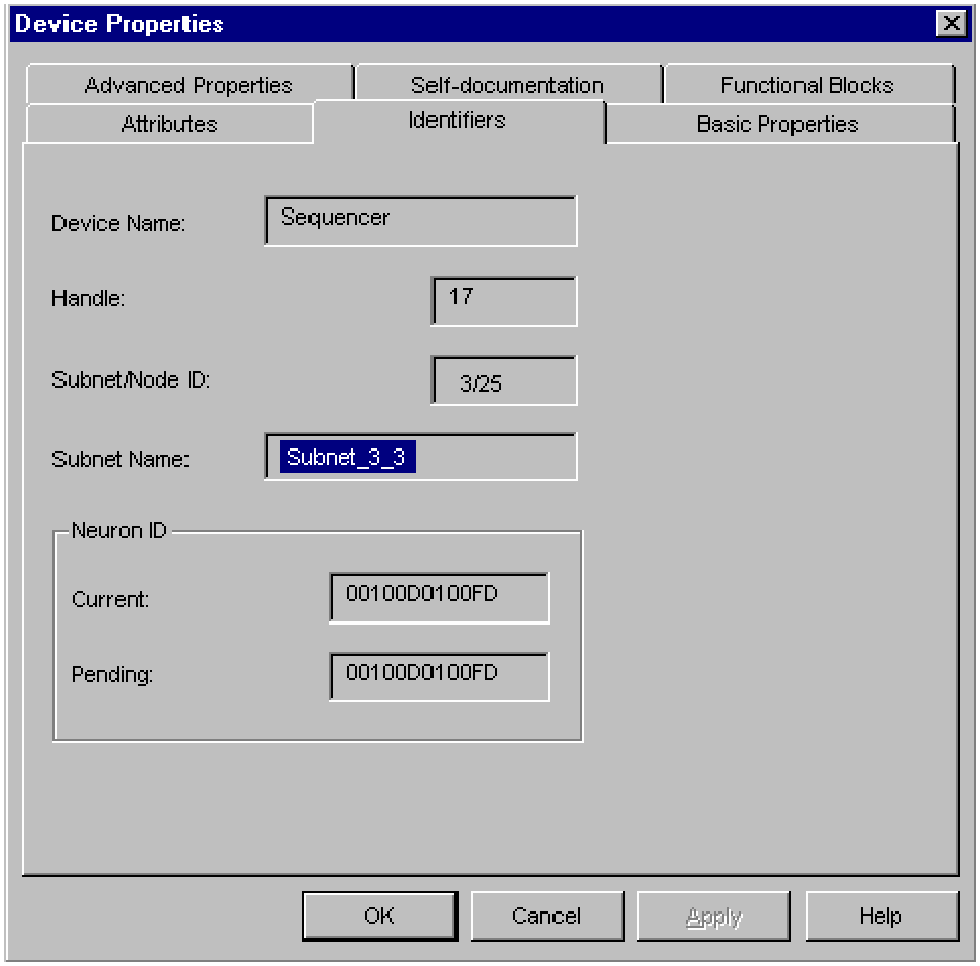
- On the drawing, select (click) each device, and open the "Device Properties" dialog box by selecting properties from the drop down menu. Change the name of each device to an appropriate name. The order of the names is not important at this time. The Device Name given in "Device Properties" will appear on the drawing, is saved in the LNS data base, and may be used on custom graphics. The names will not appear on the CD. The CD will display the names given during configuration at the factory. The names displayed by CD are saved in each BIC. The names saved in BICs may be changed by Intelli-Station.

  Select the "Device Properties" Identifiers tab and note what subnet/ node ID has been assigned to the device. Make a list of devices containing,: "CD Name"(named displayed by CD); "Device Name" (from LNS data base – Device Properties dialog); Subnet, Node, Neuron Id, and Device Type. An example of a list of devices is shown below. Enter this information on the **REPLACEMNT CD ORDER** FORM found a few pages later in this book and as a separate file bundled with this document in electronic form. The Neuron Id can be found on the bar code labels of the units.

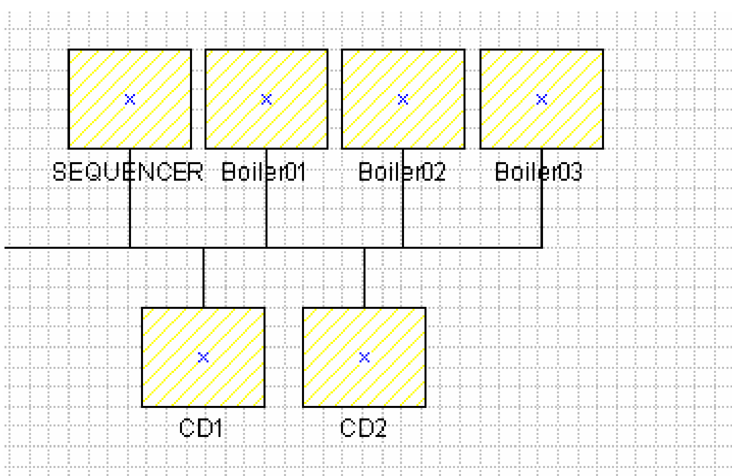


Example device list compiled from the CD bar code labels, and the Device Properties dialog box. This list is used to order replacement CDs custom loaded for your network.

CD Name (Given at Lochinvar Factory)	LNS Device Name (Given by System Integrator)	LNS Subnet	LNS Node	NeuronID	Node Type
SEQUENCER	SEQUENCER	3	25	010031F24E00	BIC
BOILER01	Boiler01	3	26	010031F20C00	BIC
BOILER02	Boiler02	3	27	010029B81200	BIC
BOILER03	Boiler03	3	28	010029B91900	BIC
CD01	CD1	3	29	010053EEDE00	Command Display
CD02	CD2	3	30	010038C92D00	Command Display



The drawing should look like this when all of the BICs and dummy CDs have been added to network and given appropriate names.



Configure the LNS data base so that the BIC uses a device specific resource file

There is a bug in LonMaker/LNS that causes all user defined objects to be assigned to LonMark resource file scope 3 resource files (one resource file for each manufacturer) by default. For large organizations it is impractical to have one resource file for all node types. For large organizations it is more convenient to use resource file scope 6 (one resource file for each node type). Furthermore LonMaker does not currently search for resource file by scope. LonMark envisions that tools search for resource files starting with scope 6 and proceeding to scope 5, the scope 4, etc until profiles, data types, and formats are found in a resource file. LonMaker does allow the scope of each object to be changed manually using the LNS Object Browser (LNSObjectBrowser.exe). See the "LonMark Resource File Developer's Guide" and "LonMark Application Layer Interoperability Guidelines" for more detailed information on "Scope".

In some future version (hopefully a service pack or minor version update) of LNS/LonMaker, this bug may be fixed and the step given below will then not be necessary.

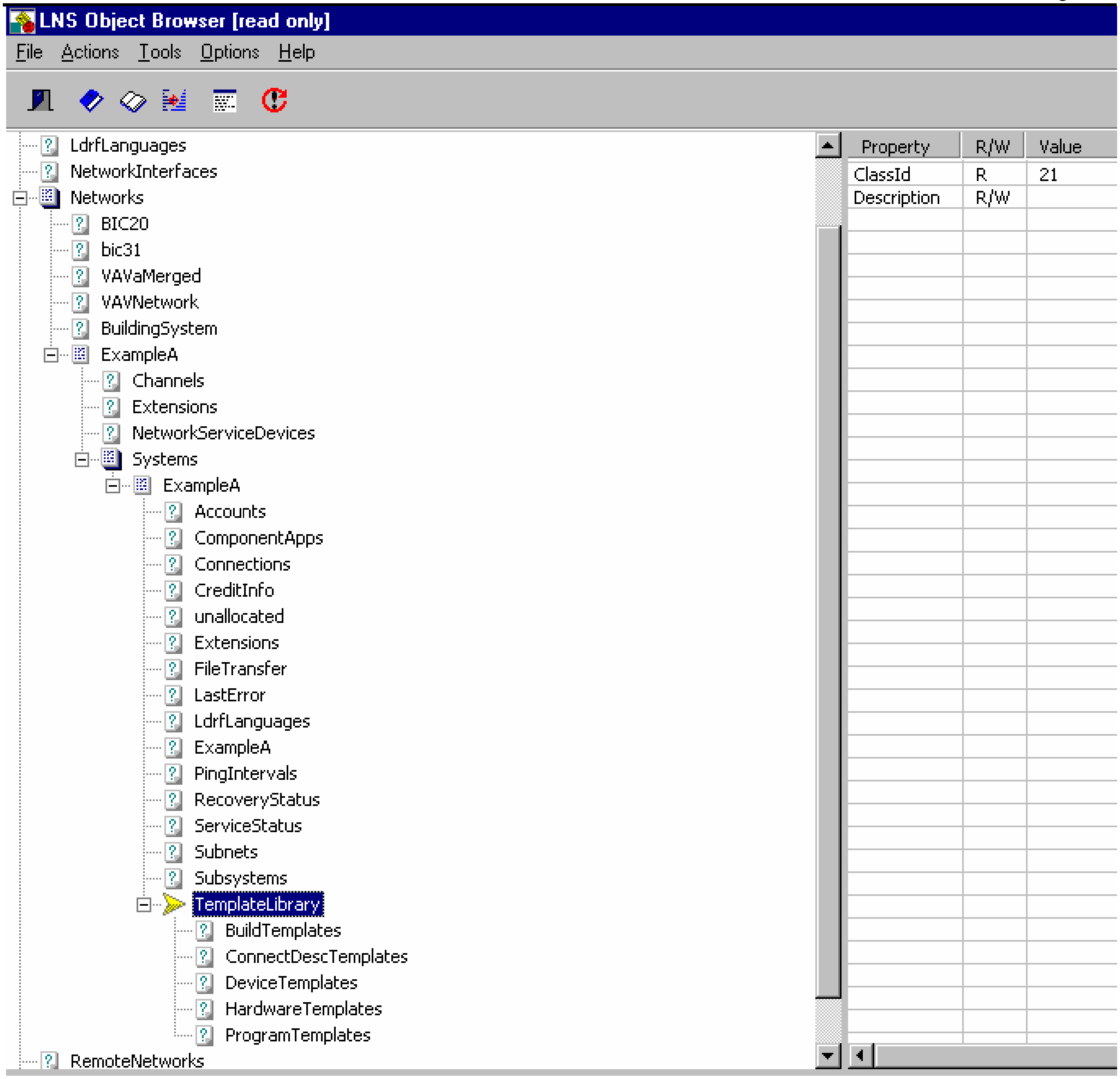
The procedure below changes the resource file "Scope" of all installed devices using the BIC resource files, providing no function blocks (objects) have yet been created on a drawing.

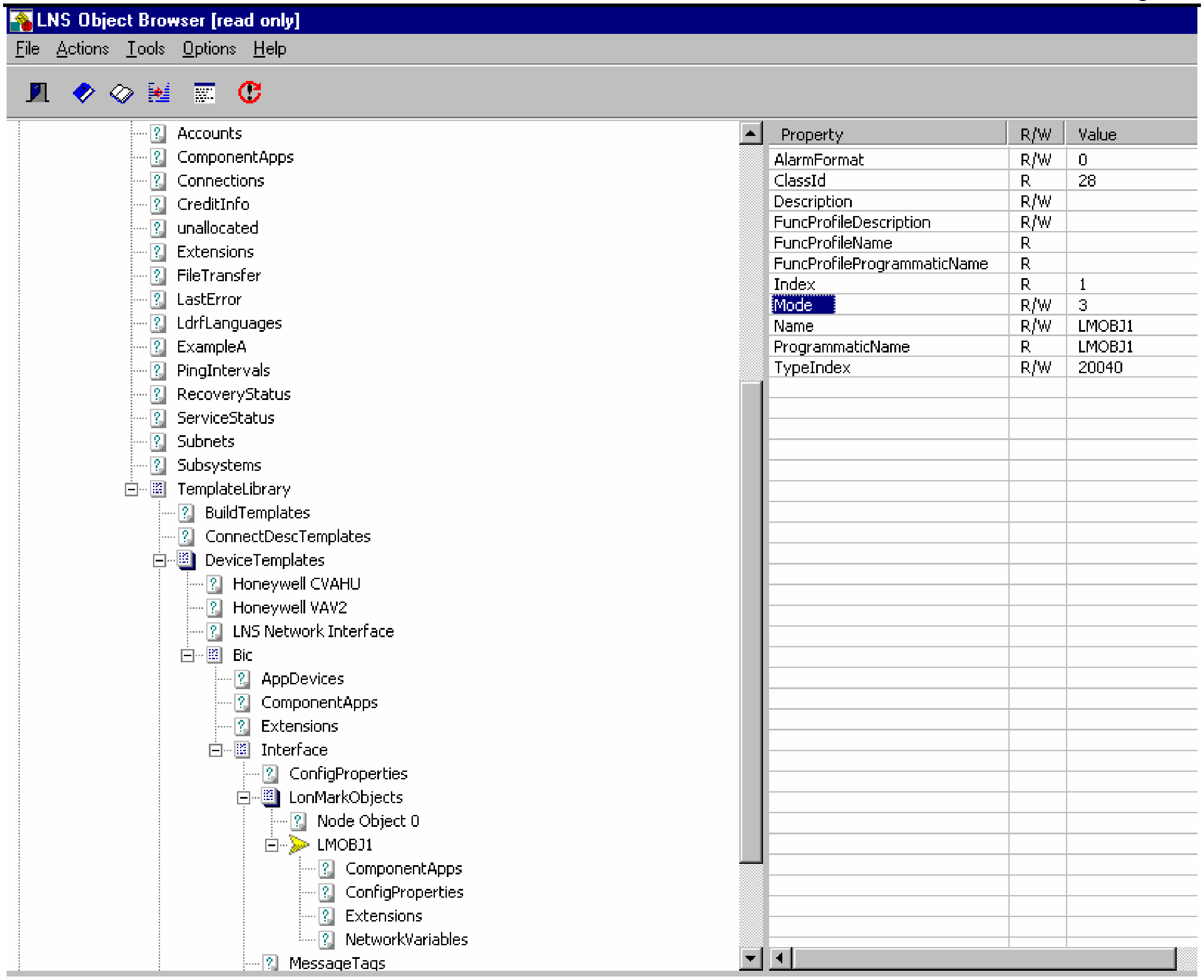
- Exit LonMaker (to avoid conflicts between LonMaker and the LNS Object Browser).

- Start the LNS Object Browser. This program comes with LNS and LonMaker and allows a skilled person to change certain parameters in the LNS data base.

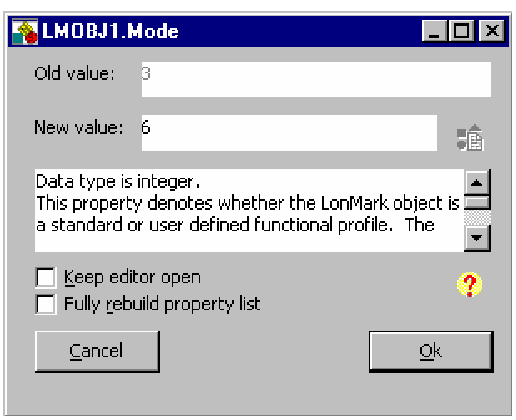
- Navigate the tree as shown in the tree below and also depicted in the screens below:

```
ObjectServer
  Networks
    <NetworkName>    for example: ExampleA
      Systems
        <SystemName>  often the same as the Network Name, For example: ExampleA
          TemplateLibrary
            DeviceTemplates
              BIC
                Interface
                  LonMarkObjects
                    <ObjectTypeName>   may be LMOBJ or BoilerObject or similar
```


LNS Object Browser [read only]
File Actions Tools Options Help
LdrfLanguages
NetworkInterfaces
Networks
BIC20
bic31
VAVaMerged
VAVNetwork
BuildingSystem
ExampleA
Channels
Extensions
NetworkServiceDevices
Systems
ExampleA
Accounts
ComponentApps
Connections
CreditInfo
unallocated
Extensions
FileTransfer
LastError
LdrfLanguages
ExampleA
PingIntervals
RecoveryStatus
ServiceStatus
Subnets
Subsystems
TemplateLibrary
BuildTemplates
ConnectDescTemplates
DeviceTemplates
HardwareTemplates
ProgramTemplates
RemoteNetworks
Property
R/W
Value
ClassId
R
21
Description
R/W



- From the LNS Object Browser menu, first elect "Options" and then select "Allow Modifications". Then double click on Mode in the right window. The dialog box below appears. Enter 6 in the “New Value’ box and click on “OK”



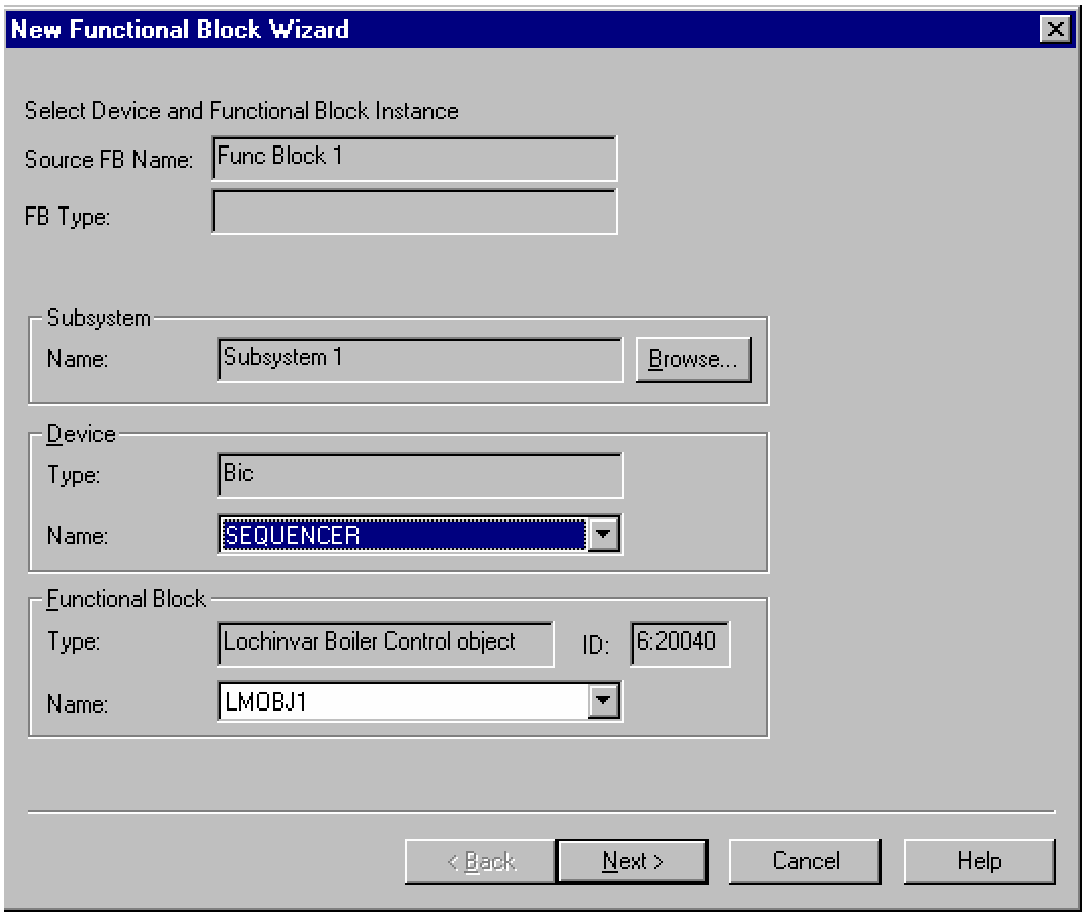
- Exit the LNS Object Browser. Now the “Scope” of all the boiler objects that will be created later is 6 and matches the resource files.

Add boiler function blocks (objects) for the sequencer and each of the units to the network

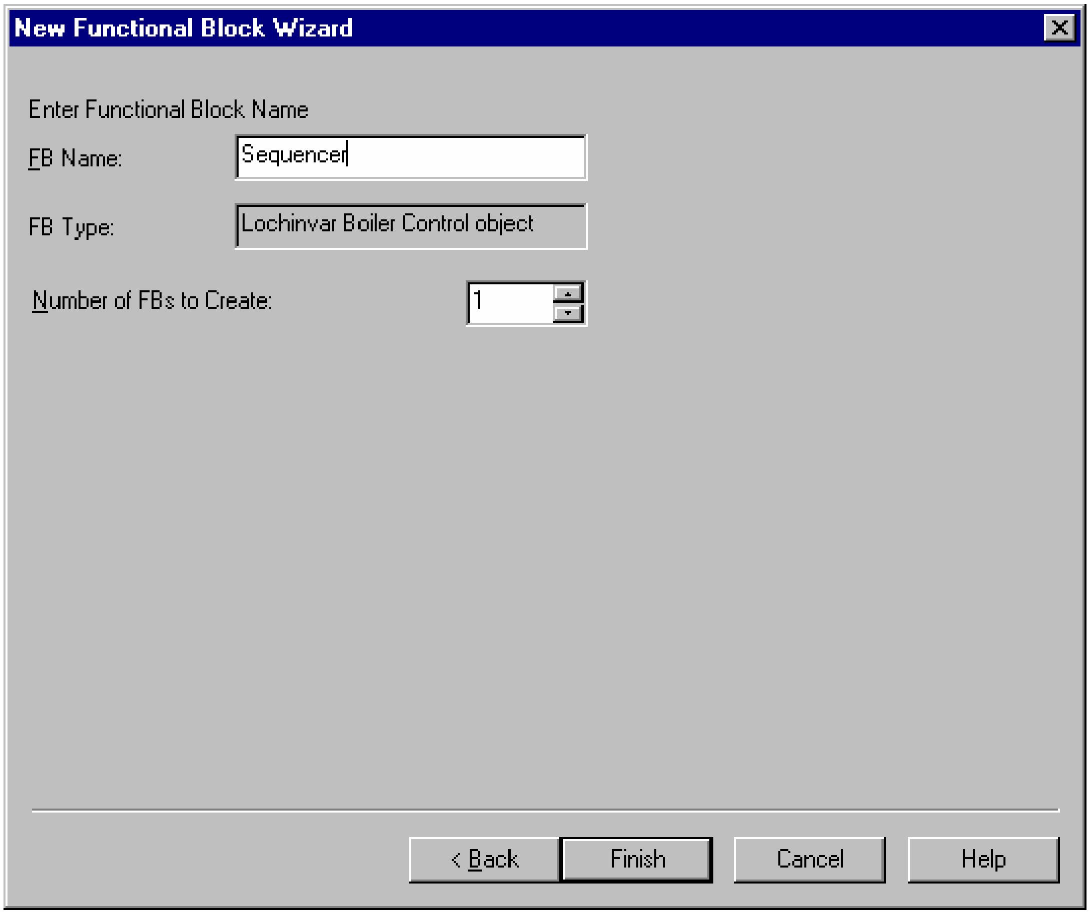
Connections between the sequencer and units must be added to the network. In LonMaker the connections are made between functional block objects. Boiler Objects (LMOBJ1) must be added to the drawing before the connections (binding) can be made. The steps below show how to add objects to the drawing.

- Drag the "Functional Block" template to the drawing, causing the "New Functional Block Wizard" to run. Select the device Name and Functional Block Name (LMOBJ1) to be added to the drawing.

Note: For BICs the ID is 6:20040. 6 is the resource file scope and 20040 is the resource file user defined object type that has been assigned to BICs. If the scope is not 6, the resource file will not be found by LNS and device data will not be parsed and formatted correctly in the LonMaker browser and other user interfaces that use LNS resource files. If the scope is not 6, the scope can be changed manually for every BIC - LMOBJ1 using the LNS Object Browser.



- Give the Functional Block (FB) a meaningful name. Press Finished to place the object on the drawing. Repeat for all the BICs. Do not make any functional blocks for the CDs.



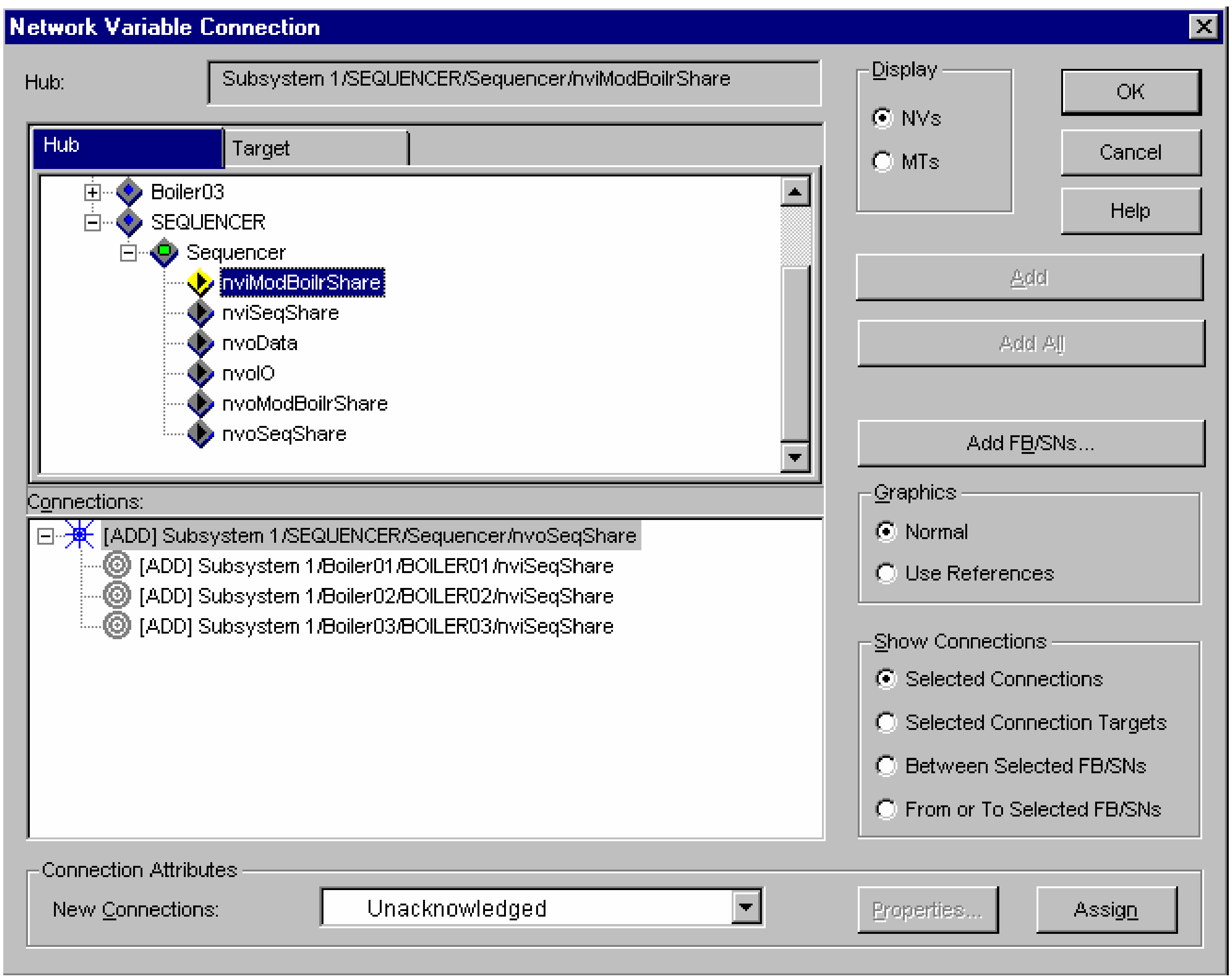
Bind the Sequencer BIC to the Unit BICs for normal sequencer operation

The variables nvoSeqShare, nviSeqShare, nvoModBoilrShare and nviModBoilrShare, are used to share information between the sequencer BIC and the unit BICs. Specifically the SEQUENCER uses nvoSeqShare connected (bound) to the UNITS nviSeqShare to request and modulate unit heat. Feedback from the UNITS nvoModBoilrShare connected (bound) to the SEQUENCER nviModBoilrShare reports the actual unit response to the request. *Note: If there is no sequencer, then there is no binding required.*

- In LonMaker, on the drawing, select the sequencer BIC function block. Right Click and select "Connect" from the drop down menu.
- **<u>Before making any connections select "Unacknowledged" in the "New Connections" drop down box.</u>**
- Then make the following two connections with the Hub and Targets and "Add" them as listed below:

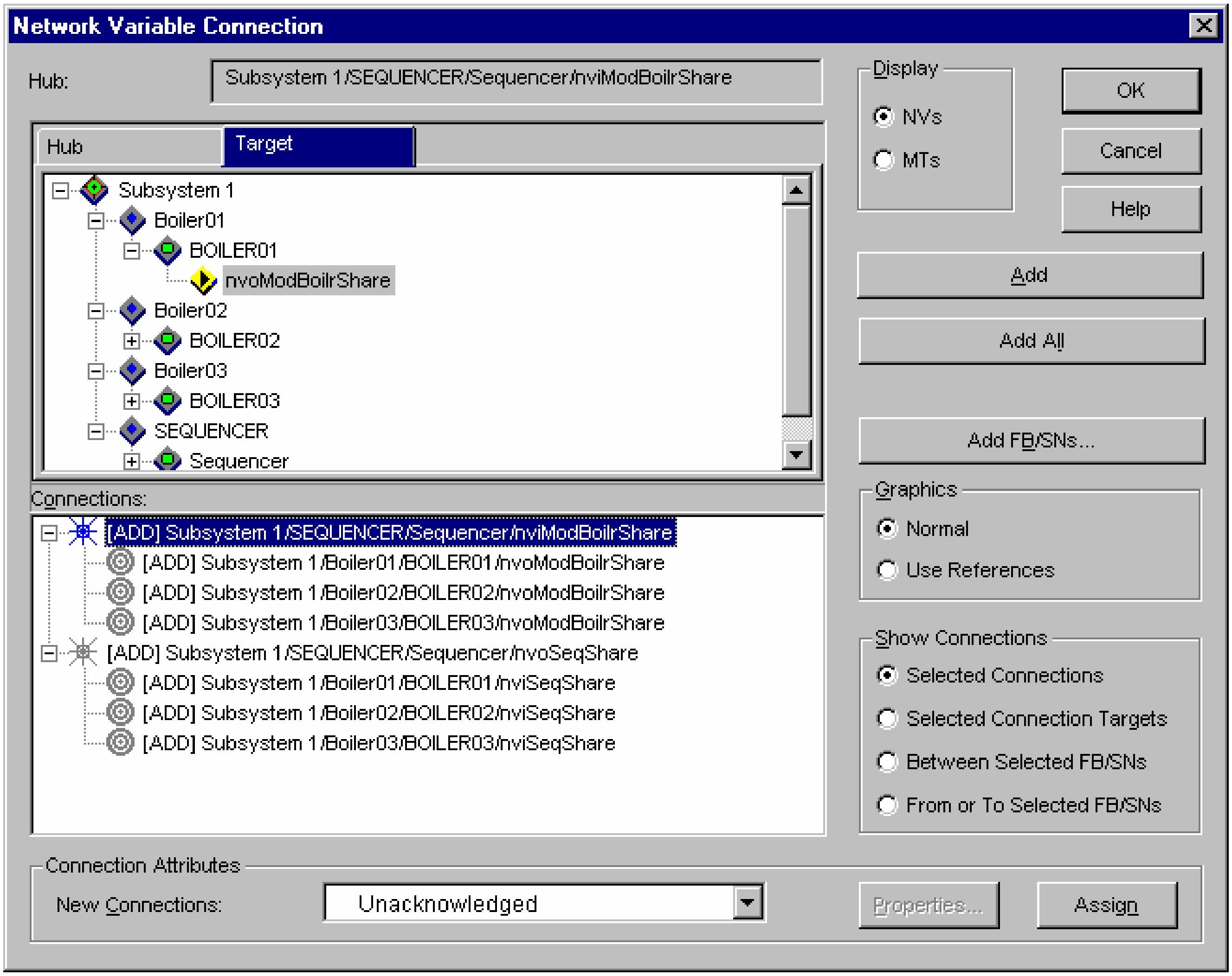
Hub	Target(s)	Note
SEQUENCER -> nvoSeqShare	All UnitBIC -> nviSeqShare	Do not include SEQUENCER in the target List
SEQUENCER -> nviModBoilrShare	All UnitBIC -> nvoModBoilrShare	Do not include SEQUENCER in the target list

Hub selection

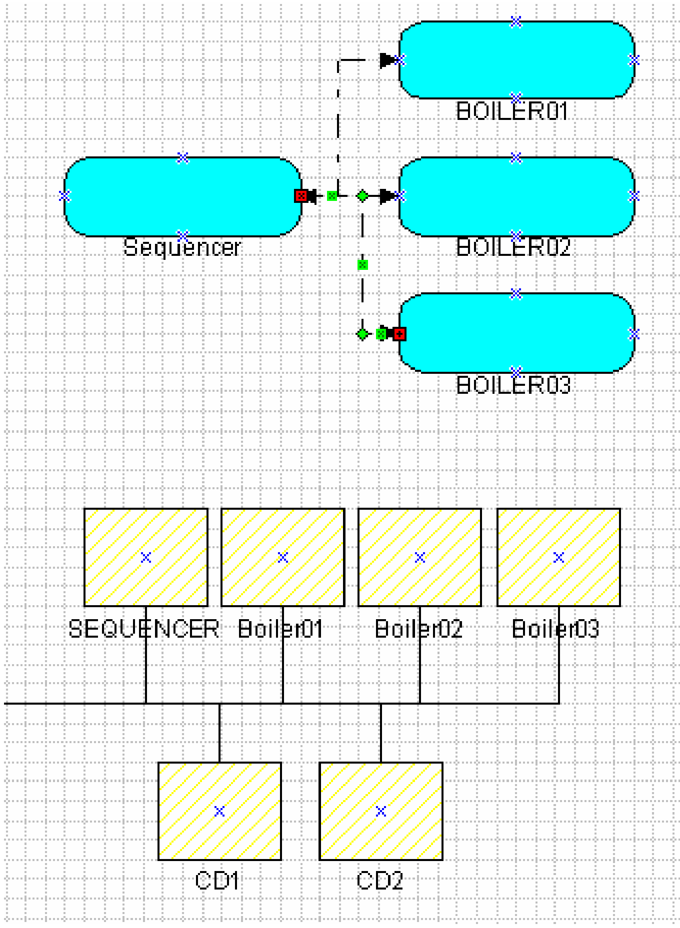


Use the Add FB/SN button to add target devices to the list of targets. Then use Add All to simplify adding targets. The view below shows target selection and final results.

Sometimes, the wizard tries to connect between a sequencer input and output network variable. Be sure to delete the connection between the sequencer input and output network variables, by first selecting the sequencer to sequencer connection in the Connections window and then pressing the delete button.



The drawing should look like this when objects and connections have been added.



Order replacement CDs

Request replacement CDs from Lochinvar using the **REPLACEMNT CD ORDER FORM** shown below. The REPLACEMENT CD ORDER FORM is also included in a separate file. It is preferred that you fill out the form electronically and send it to Lochinvar as an electronic file.

The form includes a space for the network domain. The network domain can be found in a tab under LonMaker Network Properties (activated from the LonMaker Properties menu item). The domain length must be one byte long.

************ CRITICAL INFORMATION !!!! ************

The BICs and CDs are configured at the factory. The factory sets the network image (domain, subnet, node, and bindings) so that BICs can communicate with one another and CDs can display BIC status.

Integration into an LNS system changes the BIC network image to one that has been created for your network during the task of adding BICs to the building network.

Replacement CDs will be programmed according to the subnet node address listed in the REPLACEMNT CD ORDER FORM. It is important to send the correct information to the factory.

************ CRITICAL INFORMATION!!!! ************

REPLACEMNT CD ORDER FORM

SITE (where BICs will be installed): ____

CUSTOMER:

Company:____

Contact:____

Phone:____

FAX:____

E-Mail:____

SHIPPING ADDRESS:

Address:____

____

City, State, Zip:____

Country:____

DOMAIN: ______ Hexadecimal (only one byte domain lengths are allowed)

CD Name (Given at Lochinvar Factory)	LNS Device Name (Given by System Integrator)	LNS Subnet	LNS Node	NeuronID	Node Type
SEQUENCER					BIC - Sequencer
BOILER01					BIC
BOILER02					BIC
BOILER03					BIC
BOILER04					BIC
BOILER05					BIC
BOILER06					BIC
BOILER07					BIC
BOILER08					BIC
BOILER09					BIC
BOILER10					BIC
BOILER11					BIC
BOILER12					BIC
BOILER13					BIC
BOILER14					BIC
BOILER15					BIC
BOILER16					BIC
CD01				Don’t Care	Command Display
CD02				Don’t Care	Command Display
CD03				Don’t Care	Command Display
CD04				Don’t Care	Command Display

Note: It is expected that the CDs will display all boilers in this group and that the CD passwords are the default values. If this is not the case, specify which CDs should display which BICs and list the level 1, level 2, and level 3 passwords on the next page.

Make custom graphical user interfaces to display system status

Graphical user interfaces can be created to display any of the parameters listed in the BIC details section. It is the business of system integrators to provide workstations with custom graphics. Only the items listed in BIC details may be displayed and /or changed by custom graphic user interfaces.

Reprogramming CDs Task

Using the REPLACEMENT CD form, the Lochinvar factory programs replacement CDs with the new subnet/node address of the BICs, and ships them to the system integrator. Lochinvar will ship a copy of the REPLACEMNT CD ORDER FORM with the CDs so you will have a list of the devices and their neuron ids available during the final integration task.

Prepare to connect LonWorks Network wire to the BIC System Task

At the site, run the building LonWorks network wire to the BIC system but **do not** connect the LonWorks bus to the BIC system. This task can be performed at any time. Use the standard LonWorks bus wire and LonWorks topology to include the BIC system in the building automation system.

See "Junction Box and Wiring Guideline for Twisted Pair LonWorks Networks" by Echelon Corporation for more information on the standard wiring LonWorks bus wiring practices.

System Integrator Task – Final Integration (OnNet)

In a previous task, a network containing the BICs and CDs were created. Since CDs cannot presently be programmed by LNS tools, the replacement CDs where programmed at the Lochinvar factory. When the replacement CDs arrive, the final integration task can be completed.

Before starting the final integration task, it must be pointed out that the boiler system is now working. It is possible, through error, to cause the boiler system to no longer function. Follow the warnings given below.

Shut down the boiler system

Shut down the boiler system by placing all the RUN / STOP switches in the STOP position.

Remove the CDs from the system

The CDs are mounted on the units using a sub base. A CD can be removed by lifting the bottom of the CD away from the sub base. When the bottom of the CD is disconnected from the sub base, rotate the CD further until the plastic tabs at the top of the CD allow the CD to be removed from the sub base.

Package the removed CDs for return to the Lochinvar factory.

Connect the BIC System to the building LonWorks Network

Connect the LonWorks network to the building network. LonMaker / LNS must be connected to the LonWorks network to complete this installation. LonMaker must be able to communicate with the BICs.

Commission the BICs

In this step the BICs will be commissioned. The process of commissioning is a three step process.

- Assign the neuron id to a device in the network drawing.
- LonMaker reads the configuration parameters from the device
- LonMaker down loads the network image to the device

CDs are not commissioned by LNS / LonMaker. Do not try to commission CDs.

************ WARNING !!!! ************

The BICs and CDs are configured at the factory. The system integrator must not change any of the BIC or CD configurations.

The system integrator must protect the configuration of the BIC and CD made in the factory. During installation, the system integrator must read the configuration parameters from the BICs into the tool data base (LNS data base) before trying to monitor or change anything in the BICs.

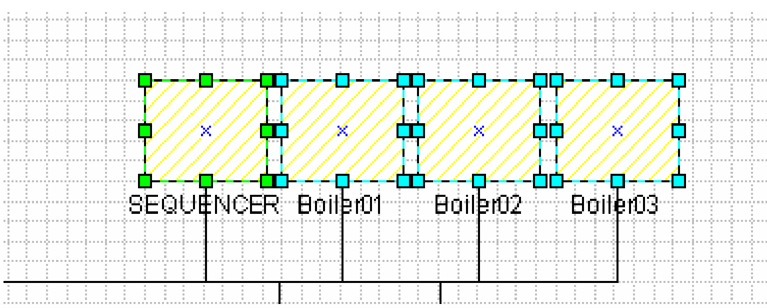
Failure to read the configuration parameters from the BICs will allow LonMaker to set the configuration parameters to incorrect values. The BIC system will no longer function properly.

The mistake of writing configuration parameters instead of reading configuration parameters is not easily recovered.

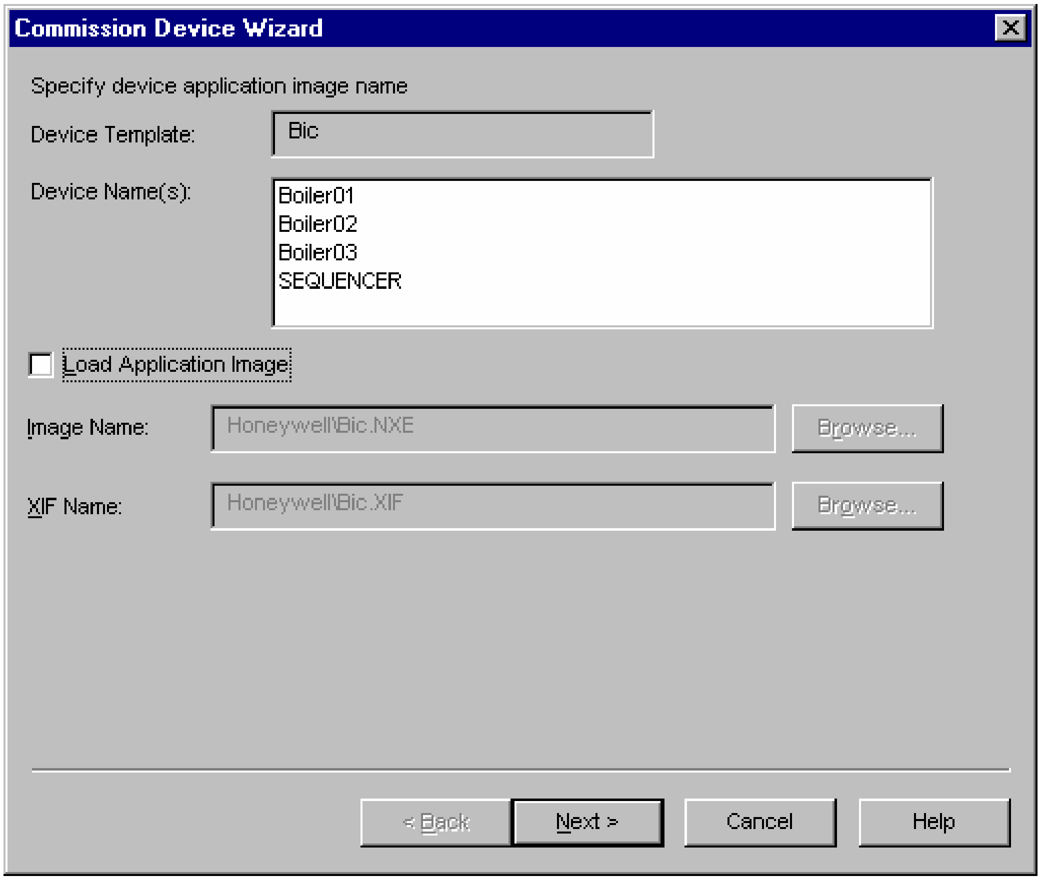
************ WARNING !!!! ************

- Start LonMaker and open the network. **Check the OnNet** Radio Button in the Network Open Wizard. In this step LonMaker will communicate with device on the LonWorks network.

- On the network drawing, select all the BICs to be commissioned. Do not select any CDs.



- Right click the selected device(s) to display the drop down menu. From the drop down menu , select Commission to launch the Commission Device Wizard. There is no application image to load. Next step.



- Select the following :

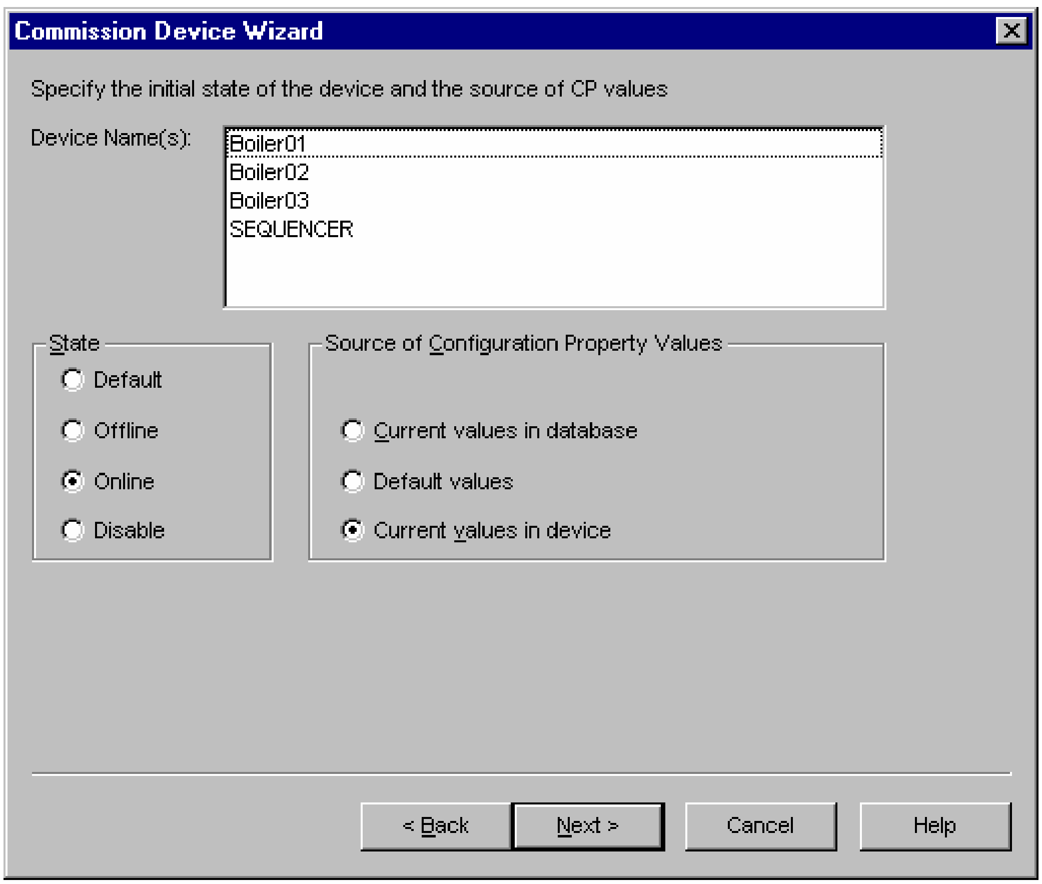
  State = OnLine
  Source of Configuration Property Values = Current values in device

************* WARNING !!!! ************
THIS IS A CRITICAL STEP.

"OnLine" and "Current Values In Device" must be selected.

Failure to select these items will result in a non-functioning BIC system and you cannot recover the system without outside help.

************* WARNING!!!! ************



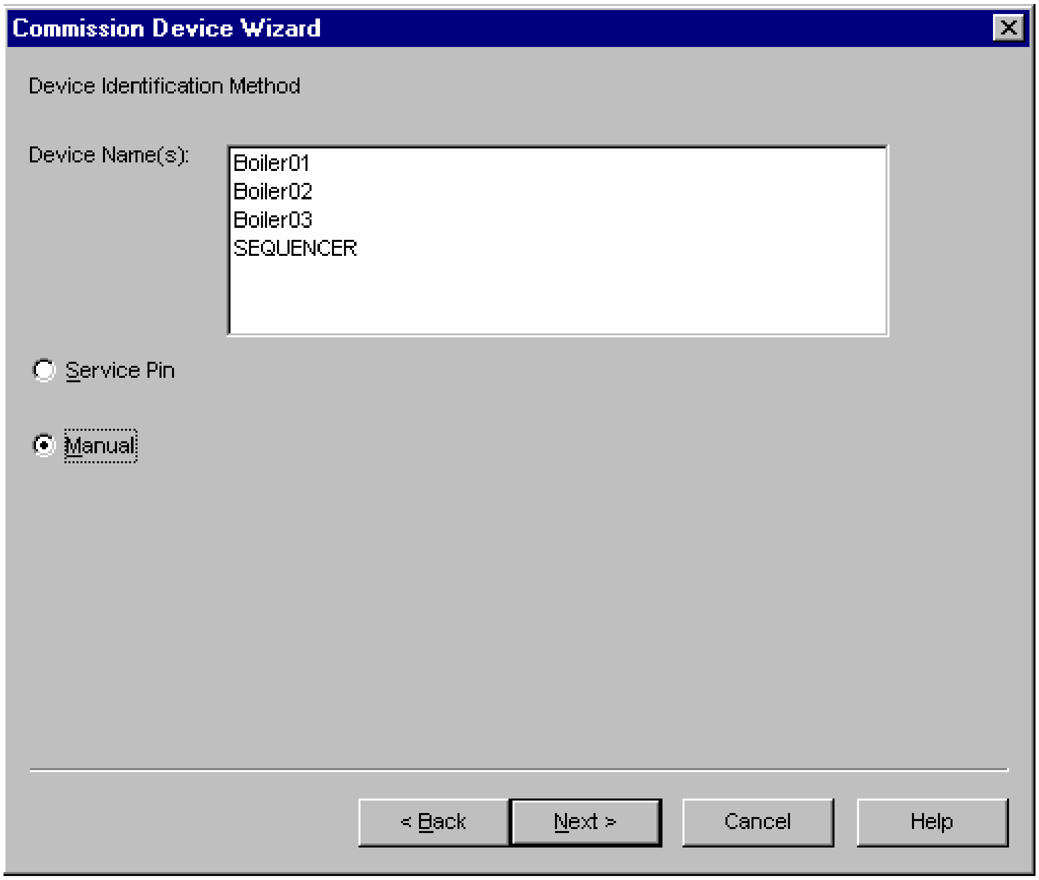
************* CHECK YOUR WORK!!!! ************

"OnLine" and "Current Values In Device" must be selected.

************* CHECK YOUR WORK!!!! ************

- Next Step

- The Manual method of Device Identification is preferred . Typically the LNS workstation is not located near the units, it may be easier and more accurate to manually enter the neuron ids. If you do use the service pin method, the service pin button is on one side of the BICs. Next Step.



- Enter the neuron ids of the BICs from a copy of the REPLACEMNT CD ORDER FORM. Finish. During this step, the BICs will be loaded with an updated network image (domain / subnet / node address and the bindings) you have created for this project.

************ WARNING!!!! ************

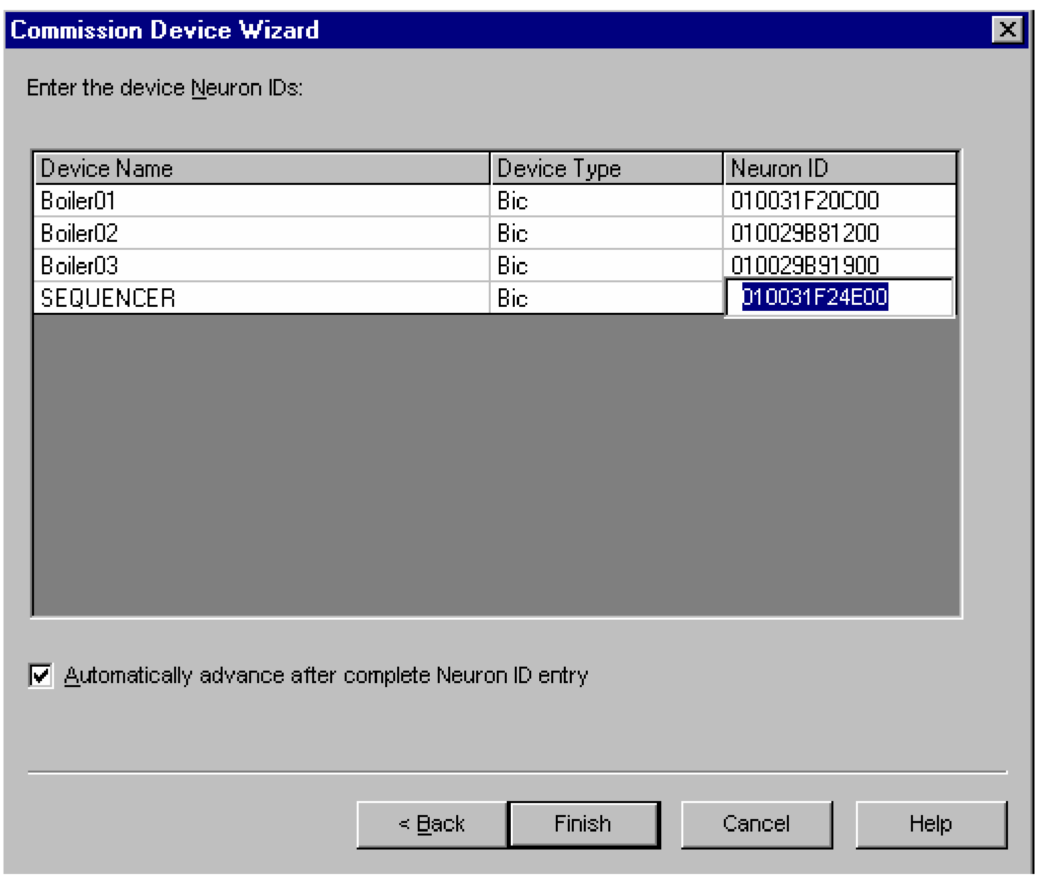
Failure to match the Neuron Id with the correct BIC, will require that you delete the function blocks and bindings from your project, rename the BICs according to the correct name for each neuron id, and create function blocks and bindings again.

DO NOT DE-COMMISION BICs

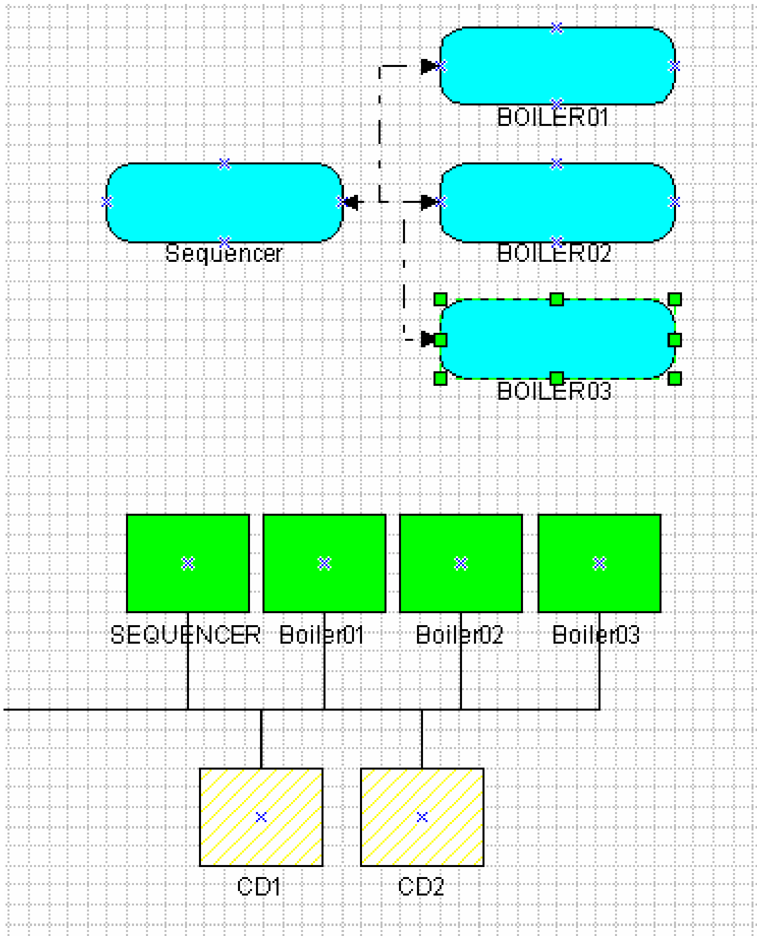
DE-COMMISIONING RESETS CONFIGURATION PARAMETERS and the factory set parameters will be lost.

In addition, De-Commissioning sets the node offline, and the BIC no longer will control a UNIT.

************ WARNING!!!! ************



- The look of commissioned BICs. Do not commission CDs



Install the replacement CDs

Install the replacement CDs on their sub bases. Line up the upper tabs first and gently rotate the CD onto the connections at the bottom. After a few minutes, the CDs should be displaying BIC status.

Return the boiler system to operation

Set all the RUN/STOP switches to RUN. Create a demand for heat. The units should stage on (BURNER ON) one at a time over a period of several minutes between units. It may be difficult to create enough demand in a large system and mild weather so that all units stage on (BURNER ON). If the temperature is especially mild, the outside air lock out temperature may prevent any units from staging on.

> *Comment: Intell- Station can be useful during this integration process if the last step fails. Also an on site SLTA and modem can be used to restore the BICs to a functioning boiler system. The Lochinvar factory can restore the BIC to the original condition if the integration effort fails.*

Test any network functions

Test any graphical user interfaces you have created to display or control BICs.

Appendix A – Network variable description

************ WARNING !!!! ************

The BIC contains network variables and configuration parameters other than the ones described here. The system integrator should not attempt to bind to the unspecified network variables or attempt to change them since some of the network variables may present safety issues, except as specified in the section on binding between the sequencer and unit BICs.

************ WARNING !!!! ************

The LonMark XIF and resource files for BICs includes machine readable definitions of the exposed network variables. For systems that do not read LonMark files, a detailed description of the exposed network variables is given below for manual entry into non-LNS systems.

The following BIC network variables are available for use by system integrators. The BIC contains other network variables, but they are intended for communications between sequencer and units, factory configuration, or for future enhancements. Changing or binding to network variables that are not described below could cause safety problems and therefore the system integrator should not attempt to change the unspecified network variables or bind to the unspecified network variables.

Network variable name (NvName)	NvIndex	Class	Mechanism	Data Structure	SNVT type	Comment
nviRequest	0	IN	in	SNVT_obj_request	92	Node object – request
noStatus	1	OUT	out	SNVT_obj_status	93	Node object – status
nroPgmVer	19	CONST	polled	UNVT_pgm_id	0	The node_type field is used by some tools to identify the fact that this node is a BIC.
nvoData	27	OUT	polled	UNVT_ctl_data	0	
nciConfigSr	37	CONFIG	in	SNVT_config_src	69	Node object – Network image self configuration flag
nciOAReset	38	CONFIG	in	UNVT_oa_reset	0	
nvoIO	40	OUT	polled	UNVT_io	0	

Where:

- NvName is the assigned name of the network variable.
- NvIndex is the assigned network variable index of the network variable.

Class:

Class	Node Stores This Variable In	Direction From / To Node
CONST	(P)ROM	Output
CONFIG	EEPROM (EEPROM life is limited to 10K writes and should not be written frequently	Input
OUT	RAM	Output
IN	RAM	Input

Mechanisms:

Mechanism	Full meaning
Out	Output
In	Input
polled	Polled output

- Data Structure: The data structure specifies the fields of the network variable. See the definitions given below:
- SNVT type is the standard network variable type number assigned to this network variable type by LonMark

Some of the network variables are data structures having several fields or pieces of data in them. The network variable fields are shown below.

NvName	NvField	Field Number	Units	C-Software Data Type	SNVT type	Display Data Type	Byte-Offset	Bit-Offset	Length	Scale10	Scale Offset
nviRequest	object_id	1		unsigned long		UNSIGNED	0	0	2	1	0
nviRequest	object_request	2		object_request_t		object_request_t	2	0	1	1	0
nvoStatus	object_id	1		unsigned long		UNSIGNED	0	0	2	1	0
nvoStatus	invalid_id	2		unsigned :1		&BOOLEAN	2	7	1	1	0
nvoStatus	invalid_request	3		unsigned :1		&BOOLEAN	2	6	1	1	0
nvoStatus	disabled	4		unsigned :1		&BOOLEAN	2	5	1	1	0
nvoStatus	out_of_limits	5		unsigned :1		&BOOLEAN	2	4	1	1	0
nvoStatus	open_circuit	6		unsigned :1		&BOOLEAN	2	3	1	1	0
nvoStatus	out_of_service	7		unsigned :1		&BOOLEAN	2	2	1	1	0
nvoStatus	mechanical_fault	8		unsigned :1		&BOOLEAN	2	1	1	1	0
nvoStatus	feedback_failure	9		unsigned :1		&BOOLEAN	2	0	1	1	0
nvoStatus	over_range	10		unsigned :1		&BOOLEAN	3	7	1	1	0
nvoStatus	under_range	11		unsigned :1		&BOOLEAN	3	6	1	1	0
nvoStatus	electrical_fault	12		unsigned :1		&BOOLEAN	3	5	1	1	0
nvoStatus	unable_to_measure	13		unsigned :1		&BOOLEAN	3	4	1	1	0
nvoStatus	comm_failure	14		unsigned :1		&BOOLEAN	3	3	1	1	0
nvoStatus	fail_self_test	15		unsigned :1		&BOOLEAN	3	2	1	1	0
nvoStatus	self_test_in_progress	16		unsigned :1		&BOOLEAN	3	1	1	1	0
nvoStatus	locked_out	17		unsigned :1		&BOOLEAN	3	0	1	1	0
nvoStatus	manual_control	18		unsigned :1		&BOOLEAN	4	7	1	1	0
nvoStatus	in_alarm	19		unsigned :1		&BOOLEAN	4	6	1	1	0
nvoStatus	in_override	20		unsigned :1		&BOOLEAN	4	5	1	1	0
nvoStatus	report_mask	21		unsigned :1		&BOOLEAN	4	4	1	1	0
nvoStatus	programming_mode	22		unsigned :1		&BOOLEAN	4	3	1	1	0
nvoStatus	programming_fail	23		unsigned :1		&BOOLEAN	4	2	1	1	0
nvoStatus	alarm_notify_disabled	24		unsigned :1		&BOOLEAN	4	1	1	1	0
nvoStatus	reserved1	25		unsigned :1		&BOOLEAN	4	0	1	1	0
nvoStatus	reserved2	26		unsigned :8		UNSIGNED	5	0	1	1	0
nroPgmVer	reserved1	1		char		UNSIGNED	0	0	1	1	0
nroPgmVer	reserved2	2		char		UNSIGNED	1	0	1	1	0
nroPgmVer	reserved3	3		char		UNSIGNED	2	0	1	1	0
nroPgmVer	reserved4	4		char		UNSIGNED	3	0	1	1	0
nroPgmVer	reserved5	5		unsigned short		UNSIGNED	4	0	1	1	0
nroPgmVer	reserved6	6		unsigned short		UNSIGNED	4	0	1	1	0
nroPgmVer	reserved7	7		unsigned short		UNSIGNED	5	0	1	1	0
nroPgmVer	reserved6	8		unsigned short		UNSIGNED	6	0	1	1	0
nroPgmVer	node_type	9		unsigned short		UNSIGNED	7	0	1	1	0
nvoData	Mode	1		stmd_type		stmd_type	0	0	1	1	0
nvoData	EffectOcc	2		SNVT_occupancy	109	SNVT_occupancy	1	0	1	1	0
nvoData	OverRideOcc	3		SNVT_occupancy	109	SNVT_occupancy	2	0	1	1	0
nvoData	SchedOcc	4		SNVT_occupancy	109	SNVT_occupancy	3	0	1	1	0
nvoData	ManualOcc	5		SNVT_occupancy	109	SNVT_occupancy	4	0	1	1	0
nvoData	SensorOcc	6		SNVT_occupancy	109	SNVT_occupancy	5	0	1	1	0
nvoData	TempControlPt	7	deg C	SNVT_temp_p	105	SIGNED	6	0	2	.01	0
nvoData	InletWaterTemp	8	deg C	SNVT_temp_p	105	SIGNED	8	0	2	.01	0
nvoData	OutletWaterTemp	9	deg C	SNVT_temp_p	105	SIGNED	10	0	2	.01	0
nvoData	DeltaTemp	10	DD C	SNVT_temp_p	105	SIGNED	12	0	2	.01	0
nvoData	CalcWaterFlow	11	liter/sec	SNVT_flow	15	UNSIGNED	14	0	2	1	0
nvoData	BypassTemp	12	deg C	SNVT_temp_p	105	SIGNED	16	0	2	.01	0
nvoData	OutsideAirTemp	13	deg C	SNVT_temp_p	105	SIGNED	18	0	2	.01	0
nvoData	VFDPos	14	percent	SNVT_lev_percent	81	SIGNED	20	0	2	.005	0
nvoData	HeatStages	15		unsigned short		UNSIGNED	22	0	1	1	0
nvoData	PrimaryPmp	16		unsigned :1		&BOOLEAN	23	7	1	1	0
nvoData	SecondaryPmp	17		unsigned :1		&BOOLEAN	23	6	1	1	0
nvoData	IgnitEnab	18		unsigned :1		&BOOLEAN	23	5	1	1	0
nvoData	LocalAlarm	19		unsigned :1		&BOOLEAN	23	4	1	1	0
nvoData	DialOutAlarm	20		unsigned :1		&BOOLEAN	23	3	1	1	0
nvoData	AuxCallHeat	21		unsigned :1		&BOOLEAN	23	2	1	1	0
nvoData	Out7	22		unsigned :1		&BOOLEAN	23	1	1	1	0
nvoData	SeqControllerCfg	23		unsigned :1		&BOOLEAN	23	0	1	1	0
nvoData	ManDisableIn	24		unsigned :1		&BOOLEAN	24	7	1	1	0
nvoData	GlowBarOnIn	25		unsigned :1		&BOOLEAN	24	6	1	1	0
nvoData	GasValveOnIn	26		unsigned :1		&BOOLEAN	24	5	1	1	0

NvName	NvField	Field Number	Units	C-Software Data Type	SNVT type	Display Data Type	Byte-Offset	Bit-Offset	Length	Scale10	Scale Offset
nvoData	LowWaterFlowIn	27		unsigned :1		&BOOLEAN	24	4	1	1	0
nvoData	FlameFailIn	28		unsigned :1		&BOOLEAN	24	3	1	1	0
nvoData	LowAirIn	29		unsigned :1		&BOOLEAN	24	2	1	1	0
nvoData	BlockDrainIn	30		unsigned :1		&BOOLEAN	24	1	1	1	0
nvoData	LowGasIn	31		unsigned :1		&BOOLEAN	24	0	1	1	0
nvoData	BlockFlueIn	32		unsigned :1		&BOOLEAN	25	7	1	1	0
nvoData	LEDOut	33		unsigned :1		&BOOLEAN	25	6	1	1	0
nvoData	Spare	34		unsigned :6		UNSIGNED	25	0	6	1	0
nvoData	ModeTimer	35	seconds	unsigned long		UNSIGNED	26	0	2	1	0
nvoData	BypassPos	36	percent	SNVT_lev_percent	81	SIGNED	28	0	2	.005	0
nciConfigSrc				SNVT_config_src	69	config_source_t	0	0	1	1	0
nciOAReset	MaxSetpoint	1	deg C	SNVT_temp_p	105	SIGNED	0	0	2	0.01	0
nciOAReset	SetbackAmt	2	deg C	SNVT_temp_p	105	SIGNED	2	0	2	0.01	0
nciOAReset	Setpoint	3	deg C	SNVT_temp_p	105	SIGNED	4	0	2	0.01	0
nciOAReset	EmergSetpoint	4	deg C	SNVT_temp_p	105	SIGNED	6	0	2	0.01	0
nciOAReset	OaMinSetpoint	5	deg C	SNVT_temp_p	105	SIGNED	8	0	2	0.01	0
nciOAReset	OaMaxSetpoint	6	deg C	SNVT_temp_p	105	SIGNED	10	0	2	0.01	0
nciOAReset	OaHtgLockout	7	deg C	SNVT_temp_p	105	SIGNED	12	0	2	0.01	0
nciOAReset	AbsMaxSetp	8	deg C	SNVT_temp_p	105	SIGNED	14	0	2	0.01	0
nciOAReset	AbsMinSetp	9	deg C	SNVT_temp_p	105	SIGNED	16	0	2	0.01	0
nvoIO	BlrTotRtHr		hour	unsigned long		UNSIGNED	15	0	2	1	0

Where the table headings and the information in the columns are shown below:

- NvName: The network variable name
- NvField: The name of the field for network variable NvName.
- Field Number: Field number for those tools that count fields from the beginning of the data string communicated to or from the device. This number is based on the information in the XIF file.
- Units: The engineering units of the field as displayed by an operator interface when the scale factors given below are used.
- Software Data Type is the way the field is declared in the software code (Neuron-C).
- SNVT type is the standard network variable type number assigned by the LonMark to this field
- Display Data Type:

DataType	Comments	BitOffset Column	Length Column
SIGNED	Signed Analog Value	Don't Care	Number of Bytes
UNSIGNED	Unsigned Analog Value	Don't Care	Number of Bytes
FLOAT	Floating point	Don't Care	Number of Bytes
ASCII	Text	Don't Care	Number of Bytes
HEX	Hexadecimal Value	Don't Care	Number of Bytes
BIT	Bit Field	First Bit in the field	Number of Bits
&other	Enumerated value based on a bit fields	First Bit in the field	Number of Bits
other	Enumerated value based on a byte	Don't Care	Number of Bytes (must be one)

Note: "other" is any word combination referring to an enumerated type name. For example if DataType is "ENUM_TYPE", the data is an enumerated type whose values are listed under EnumType ENUM_TYPE.

- ByteOffset: This parameter locates the beginning of the field in the network variable and specifies the first byte of the field. The first data byte sent or received in a network variable is number "0". The second byte is byte "1", etc. For example, if ByteOffset is 10, then the first byte of the field is the eleventh byte sent or received.
- BitOffset: When the DataType is "BIT" or "&other", this parameter locates the first bit in a bit field. The least significant bit of the field, where 0 is the least significant bit of the byte. Bit fields are not allowed to go over a byte boundary.
- Length: The length of the field. If the DataType is SIGNED, UNSIGNED, ASCII, HEX, FLOAT, or "other", the length is the number of bytes in the field. If the DataType is BIT or "&other", the length is the number of bits in the field (1 through 7 bits). Bit fields are not allowed to go over a byte boundary. An operator interface always uses a length of one for an "other" data type regardless of the value of Length. An operator interface always uses a length of four for a FLOAT data type regardless of Length.
- Scale10, ScaleOffset: When the DataType is SIGNED, UNSIGNED, or FLOAT these parameters are used to convert the scaled field value to an engineering units value.

The analog value in engineering units for SIGNED or UNSIGNED or FLOAT is:
Engineering_Units_Value = FieldValue * (Scale10) + ScaleOffset

When the data type is an enumerated data type, the table below lists the text displayed for each enumerated value

DataType	EnumText	EnumValue
object_request_t	RQ_NORMAL	0
object_request_t	RQ_DISALBED	1
object_request_t	RQ_UPDATE_STATUS	2
object_request_t	RQ_SELF_TEST	3
object_request_t	RQ_UPDATE_ALARM	4
object_request_t	RQ_REPORT_MASK	5
object_request_t	RQ_OVERRIDE	6
object_request_t	RQ_ENABLE	7
object_request_t	RQ_RMV_OVERRIDE	8
object_request_t	RQ_CLEAR_STATUS	9
object_request_t	RQ_CLEAR_ALARM	10
object_request_t	RQ_ALARM_NOTIFY_ENABLED	11
object_request_t	RQ_ALARM_NOTIFY_DISABLED	12
object_request_t	RQ_MANUAL_CTRL	13
object_request_t	RQ_REMOTE_CTRL	14
object_request_t	RQ_PROGRAM	15
object_request_t	RQ_NUL	-1
SNVT_occupancy	OC_OCCUPIED	0
SNVT_occupancy	OC_UNOCCUPIED	1
SNVT_occupancy	OC_BYPASS	2
SNVT_occupancy	OC_STANDBY	3
SNVT_occupancy	OC_NUL	-1
config_source_t	CFG_LOCAL	0
config_source_t	CFG_EXTERNAL	1
config_source_t	CFG_NULL	-1
BOOLEAN	TRUE	1
BOOLEAN	FALSE	0
stmd_type	START_UP_WAIT	0
stmd_type	IDLE	1
stmd_type	WATER_FLOW_EVAL	2
stmd_type	AIR_PRES_EVAL	3
stmd_type	BLOCK_DRAIN_EVAL	4
stmd_type	LOW_GAS_PRESS_EVAL	5
stmd_type	PRE_PURGE	6
stmd_type	IGNITION_EVAL	7
stmd_type	BOILER_ON_EVAL	8
stmd_type	HEAT	9
stmd_type	WATER_FLOW_FAIL_MODE	10
stmd_type	AIR_PRESS_FAIL_MODE	11
stmd_type	BLOCK_DRAIN_FAIL_MODE	12
stmd_type	BLOCK_FLUE_FAIL_MODE	13
stmd_type	LOW_GAS_PRESS_FAIL_MODE	14
stmd_type	FLAME_FAILURE_MODE	15
stmd_type	SOFT_LOCK_OUT_FAIL_MODE	16
stmd_type	HEAT_MOD_FAIL_MODE	17
stmd_type	MANUAL	18
stmd_type	FACTORY_TEST	19
stmd_type	PUMP_ONLY	20
stmd_type	EMERGENCY_MODE	21
stmd_type	DISABLED_MODE	22
stmd_type	HIGH_TEMP_MODE	23
stmd_type	OFF_MODE	24
stmd_type	SMOKE_EMERGENCY	25
stmd_type	POST_PURGE	26
stmd_type	FREEZE_PROTECT_MODE	27
stmd_type	POST_PURGE_PREPARE	28
stmd_type	FLOAT_OUT_SYNC	29
stmd_type	IDLE_MIN_DELAY	30
stmd_type	SPARE_MODE2	31
stmd_type	SEQ_HEAT_0STGS	32

DataType	EnumText	EnumValue
stmd_type	SEQ_HEAT_1STGS	33
stmd_type	SEQ_HEAT_2STGS	34
stmd_type	SEQ_HEAT_3STGS	35
stmd_type	SEQ_HEAT_4STGS	36
stmd_type	SEQ_HEAT_5STGS	37
stmd_type	SEQ_HEAT_6STGS	38
stmd_type	SEQ_HEAT_7STGS	39
stmd_type	SEQ_HEAT_8STGS	40
stmd_type	SEQ_HEAT_9STGS	41
stmd_type	SEQ_HEAT_10STGS	42
stmd_type	SEQ_HEAT_11STGS	43
stmd_type	SEQ_HEAT_12STGS	44
stmd_type	SEQ_HEAT_13STGS	45
stmd_type	SEQ_HEAT_14STGS	46
stmd_type	SEQ_HEAT_15STGS	47
stmd_type	SEQ_HEAT_16STGS	48

The table headings and the information in the columns are:

- DataType: The Enumerated Data Type specified for the field
- EnumText: The text displayed by an Operator Interface for the EnumValue
- EnumValue: The numeric value of the field

```
=========================================================================
Network Variable Field Definitions in Neuron-C:


====== NOTES:
The fields defined here are for the big-endian (Motorola-style)Neuron processor.
Bit fields are allocated left-to-right within a byte.  The first bit field is the
most significant bit.

The data type, long, is a two byte field with the most significant byte entered into
the lower address in memory and the least significant byte entered at the higher
memory address.  The long data type may be either signed or unsigned.

The data type, short is a one byte field.  The short data type may be either signed
or unsigned.

The data type char is a one byte field.

SNVT data types are defined by Echelon in the "SNVT Master List and Programmers
Guide"


===========
THE STANDARD PROGRAM ID IS SET ACCORDING THE FOLLOWING NEURON-C PRAGMA
#pragma set_std_prog_id 90:00:0C:83:00:03:04:18

//    Standard ID       = 8 (LonMark)  or  9 (Pre-LonMark)
//    Honeywell         = 0:00:0C:
//    hvac controller   = 83:00
//    Commercial        = 03:
//    TP/FT-10          = 04:
//    Version 1         = 18  hex (same as 24 decimal)


===========
// file: UNVTstmd.h   Created: 01/09/2001  Revised: 01/15/2001
// Neuron - C network variable type header
// Copyright (c) -  Honeywell  2001
```

```
#ifndef _UNVTstmd
#define _UNVTstmd

// This file defines the enumeration to be used with stmd_type  in UNVT_ctl_data

typedef enum  stmd_type {
   /* 0   */  START_UP_WAIT,
   /* 1   */  IDLE,
   /* 2   */  WATER_FLOW_EVAL,
   /* 3   */  AIR_PRES_EVAL,
   /* 4   */  BLOCK_DRAIN_EVAL,
   /* 5   */  LOW_GAS_PRESS_EVAL,
   /* 6   */  PRE_PURGE,
   /* 7   */  IGNITION_EVAL,
   /* 8   */  BOILER_ON_EVAL,
   /* 9   */  HEAT,
   /* 10  */  WATER_FLOW_FAIL_MODE,
   /* 11  */  AIR_PRESS_FAIL_MODE,
   /* 12  */  BLOCK_DRAIN_FAIL_MODE,
   /* 13 */  BLOCK_FLUE_FAIL_MODE,
   /* 14  */  LOW_GAS_PRESS_FAIL_MODE,
   /* 15  */  FLAME_FAILURE_MODE,
   /* 16  */  SOFT_LOCK_OUT_FAIL_MODE,
   /* 17  */  HEAT_MOD_FAIL_MODE,
   /* 18  */  MANUAL,
   /* 19  */  FACTORY_TEST,
   /* 20  */  PUMP_ONLY,
   /* 21  */  EMERGENCY_MODE,
   /* 22  */  DISABLED_MODE,
   /* 23  */  HIGH_TEMP_MODE,
   /* 24  */  OFF_MODE,
   /* 25  */  SMOKE_EMERGENCY,
   /* 26  */  POST_PURGE,
   /* 27  */  FREEZE_PROTECT_MODE,
   /* 28  */  POST_PURGE_PREPARE,
   /* 29  */  FLOAT_OUT_SYNC,
   /* 30  */  IDLE_MIN_DELAY,
   /* 31  */  SPARE_MODE2,
   /* 32  */  SEQ_HEAT_0STGS,
   /* 33  */  SEQ_HEAT_1STGS,
   /* 34  */  SEQ_HEAT_2STGS,
   /* 35  */  SEQ_HEAT_3STGS,
   /* 36  */  SEQ_HEAT_4STGS,
   /* 37  */  SEQ_HEAT_5STGS,
   /* 38  */  SEQ_HEAT_6STGS,
   /* 39  */  SEQ_HEAT_7STGS,
   /* 40  */  SEQ_HEAT_8STGS,
   /* 41  */  SEQ_HEAT_9STGS,
   /* 42  */  SEQ_HEAT_10STGS,
   /* 43  */  SEQ_HEAT_11STGS,
   /* 44  */  SEQ_HEAT_12STGS,
   /* 45  */  SEQ_HEAT_13STGS,
   /* 46  */  SEQ_HEAT_14STGS,
   /* 47  */  SEQ_HEAT_15STGS,
   /* 48  */  SEQ_HEAT_16STGS,
   }  stmd_type;

// End of UNVTstmd.h
#endif
```

```
===========
//File: BICTypes.h   Created: 1/9/2001 Revised:  01/15/2001
//    type definitions for BIC

typedef struct  {
   char reserved1;
   char reserved2;
   char reserved3;
   char reserved4;
   unsigned short reserved5;
   unsigned short reserved6;
   unsigned short reserved7;
   unsigned short node_type;  // node_type is set to 24 (or 18H) in BICs
   }  UNVT_pgm_id;

typedef struct {
  stmd_type        Mode;

  SNVT_occupancy   EffectOcc;
  SNVT_occupancy   OverRideOcc;
  SNVT_occupancy   SchedOcc;
  SNVT_occupancy   ManualOcc;
  SNVT_occupancy   SensorOcc;
  SNVT_temp_p      TempControlPt;
  SNVT_temp_p      InletWaterTemp;
  SNVT_temp_p      OutletWaterTemp;
  SNVT_temp_p      DeltaTemp;
  SNVT_flow        CalcWaterFlow;
  SNVT_temp_p      BypassTemp;
  SNVT_temp_p      OutsideAirTemp;
  SNVT_lev_percent VFDPos;
  unsigned short   HeatStages;

  unsigned PrimaryPmp       :1;    // Bit fields  - Most significant Bit
  unsigned SecondaryPmp     :1;    //
  unsigned IgnitEnab        :1;    //
  unsigned LocalAlarm       :1;    //
  unsigned DialOutAlarm     :1;    //
  unsigned AuxCallHeat      :1;    //
  unsigned Out7             :1;    //
  unsigned SeqControllerCfg :1;    //least significant Bit

  unsigned ManDisableIn     :1;    // Bit fields  - Most significant Bit
  unsigned GlowBarOnIn      :1;    //
  unsigned GasValveOnIn     :1;    //
  unsigned LowWaterFlowIn   :1;    //
  unsigned FlameFailIn      :1;    //
  unsigned LowAirIn         :1;    //
  unsigned BlockDrainIn     :1;    //
  unsigned LowGasIn         :1;    // least significant Bit

  unsigned BlockFlueIn      :1;    // Bit fields  - Most significant Bit
  unsigned LEDOut           :1;    //
  unsigned Spare            :6;    // least significant Bits

  unsigned long    ModeTimer;
  SNVT_lev_percent BypassPos;
  } UNVT_ctl_data;


typedef struct {
```

```
   SNVT_temp_p MaxSetpoint;
   SNVT_temp_p SetbackAmt;
   SNVT_temp_p Setpoint;
   SNVT_temp_p EmergSetpoint;
   SNVT_temp_p OaMinSetpoint;
   SNVT_temp_p OaMaxSetpoint;
   SNVT_temp_p OaHtgLockout;
   SNVT_temp_p AbsMaxSetp;
   SNVT_temp_p AbsMinSetp;
   } UNVT_oa_reset;

typedef struct  {
   SNVT_temp_p    Reserve1;
   SNVT_temp_p    Reserved2;
   SNVT_temp_p    Reserved3;
   SNVT_temp_p    Reserved4;
   signed long    Reserved5;
   signed long    Reserved6;
   unsigned short Reserved7;
   unsigned short Reserved8;

   unsigned       Reserved9:   1;   // Bit fields - most significant bit
   unsigned       Reserved10:  7;   // least significant bits

   unsigned long  BlrTotRtHr;

   unsigned long  Reserved11;
   unsigned long  Reserved12;
   }  UNVT_io;
```