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Introduction

Portions of this manual are printed with the permission of the Echelon Corporation and the National Electrical Contractors Association of the USA (NECA).

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The documentation in this manual is intended to provide you with comprehensive information on how to install and set up your LonWorks Option Card for communication over a LonWorks communication network.

For more specific information on installation and operation of the AFD refer to the VLT HVAC Instruction Manual.

About this manual

This manual is intended to be used both as an instructional and a reference manual. It only briefly touches on the basics of the LonWorks protocol whenever it is necessary for gaining an understanding of the LonWorks profile for drives and the LonWorks Option Card for the Danfoss VLT HVAC.

This manual is also intended to serve as a guideline when you specify and optimize your communication system. The list of contents is also a decision route that will guide you through the decisions you have to make before you set up your system.

Even if you are an experienced LonWorks programmer, we suggest that you read this manual in its entirety before you start programming, since important information can be found in all sections.

Assumptions

This manual assumes that you are using a LonWorks Option Card in conjunction with a Danfoss VLT HVAC 6000, with a control card that supports version 1.10 software or greater. It is also assumed that you have a controller node that supports the interfaces in this document and that all the requirements stipulated in the controller node as well as the VLT Adjustable Frequency Drive are strictly observed as well as all limitations therein.

What you should already know

The Danfoss LonWorks Option Card is designed to communicate with any controller node that supports the interfaces defined in this document.

It is assumed that you have full knowledge of the capabilities and limitations of the controller node.

LonWorks Overview

LonWorks is both an existing standard and physical hardware developed by Echelon Corporation.

Echelon's stated goal is to establish a commodity solution to the presently daunting problems of designing and building control networks.

Customers are currently using LonWorks for process control, building automation, engine control, elevator control, life safety systems, power distribution controls and similar intelligent building applications.

The Lon (Local Operating Network) Concept

The LonWorks communications structure is similar to that of a LAN in that messages are exchanged between a number of processors continually. LonWorks control devices are called nodes. The LonWorks systems are determined Local Operating Networks, or LONs. LON technology offers a means for implementing distributed systems that perform sensing, monitoring, control, and other applications.

A LON allows intelligent devices, such as actuators and sensors, to communicate with one another through an assortment of communications media using a standard protocol. LON technology supports distributed, peer-to-peer communications. That is, individual network devices can communicate directly with one another, and a central control system is not required. A LON is designed to move sense and control messages which are typically very short and which contain commands and status information that trigger actions. LON performance is viewed in terms of transactions completed per second and response time. The critical factor in LON technology is the assurance of correct signal transmission and verification. Control systems do not need vast amounts of data, but they do demand that the messages they send and receive are absolutely correct.

Applications

A key benefit of LonWorks networks is their ability to communicate across different types of transmission media in a single system. The NEURON chip's (the NEURON chip is the heart of the LonWorks system) communication port allows for the use of transceivers for other media (e.g. coax, fiber optic, etc.) to meet special needs.

With the proper design, the nodes become generic building blocks that can be applied in
various ways to control lighting (or any other task) in many different buildings using a variety of communications media. The tasks which the nodes perform in any given situation are determined by how they have been connected and configured. Because hardware design, software design, and network design are all independent in a LonWorks-based system, a node's function can be programmed without concern about the specifics of the networks in which they will be used.

Physically, each node will consist of a NEURON chip and a transceiver.

Node Arrangements

LonWorks nodes can be addressed either individually or in groups. A group can contain up to 64 nodes, and one LonWorks network can support up to 255 groups. Furthermore, any node can be part of up to 15 different groups. A subnet is very similar to a group, but can contain up to 127 nodes. A domain is the largest grouping of nodes. A single domain can handle up to 255 subnets. Thus a single domain can handle up to 32,385 separate nodes. A single node may be connected to no more than two domains.

The group structure has the advantage of allowing a number of nodes to be reached at only one address. This method keeps the record keeping inside each chip to a minimum, and allows for faster operating times. However, individual addressing can be done at all levels of a LonWorks system, with high efficiency. The address table of a node contains entries for the group type and size, and tells the node how many acknowledgments to expect when it sends a message. It also tells the NEURON chip which domain (the largest possible grouping of nodes) to use, what this node's group member number is, (to identify an acknowledgment as coming from this node), and contains a transmit timer, a repeat timer, a retry count, a receive timer, and the group ID.

Message Passing

There are a number of trade-offs between network efficiency, response time, security, and reliability. Generally, LonWorks defaults to the greatest degree of safety and verification for all communications over the LON network. The LonTalk protocol (the operating system that coordinates the LonWorks system and is built into the chips) offers four basic types of message service:

The most reliable service is "acknowledged," or end-to-end acknowledged service, where a message is sent to a node or group of nodes and individual acknowledgments are expected from each receiver. If an acknowledgment is not received from all destinations, the sender times out and re-tries the transaction. The number of retries and time-out are both selectable. Acknowledgments are generated by the network CPU without intervention of the application. Transaction IDs are used to keep track of messages and acknowledgments so that the application does not receive duplicate messages.

An equally reliable service is "request/ response," where a message is sent to a node or group of nodes and individual responses are expected from each receiver. Incoming messages are processed by the application on the receiving side before a response is generated. The same retry and time-out options are available as with acknowledged service. Responses may include data, so that this service is particularly suitable for remote procedure call, or client/server applications.

The next most reliable service is "unacknowledged repeated," where a message is sent to a node or a group of nodes multiple times, and no response is expected. This service is typically used when broadcasting to large groups of nodes and when traffic generated by all the responses would overload the network.

The least reliable method is "unacknowledged," where a message is sent once to a node or group of nodes and no response is expected. This option is typically used when the highest performance is required, network bandwidth is limited, and the application is not sensitive to the loss of a message.

Collision Detection

The LonTalk protocol uses a unique collision avoidance algorithm (a special mathematical equation) which allows an overloaded channel to carry close to its maximum capacity, rather than have its throughput reduced due to excessive collisions between messages. (Collisions are analogous to 10 people trying to talk all at once on a single telephone line. The messages are garbled and confused, and the contents of the messages are lost.) When using a communications medium that supports collision detection (twisted pair, for example), the LonTalk protocol can optionally cancel transmission of a packet as soon as a collision is detected by the transceiver. This option allows the node to immediately retransmit any packet that has been damaged by a collision. Without collision detection, the node would have to wait the duration of the retry time to notice that no acknowledgment was received, at which time it would retransmit the packet, assuming knowledge or request/response service. For unacknowledged service, an undetected collision means that the packet is not received and no retry is attempted.

Network Management

Depending on the level of a given application, a LonWorks network may or may not require the use of a Network Management node. A Network Management node is a node that has been specifically designated to perform network management functions, such as:

- Find unconfigured nodes and download their network addresses.
- Stop, start, and reset node applications.
- Access node communication statistics.
- Configure routers and bridges.
- Download new applications programs.
- Extract the topology of a running network.

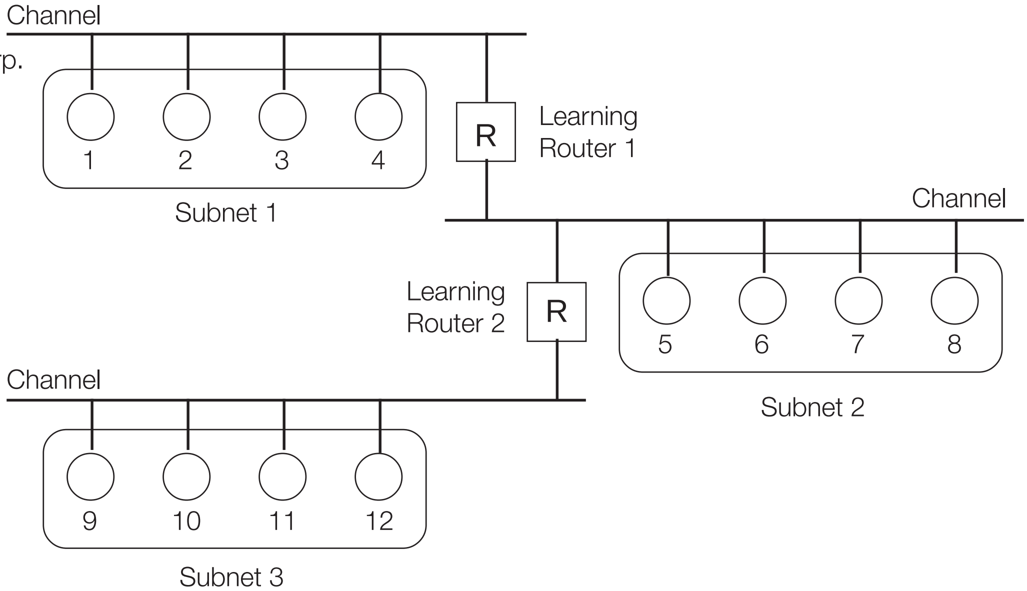
Routers and Bridges

A router (or bridge) is a special node that consists of two connected NEURON chips, each connected to a separate channel, see figure. Routers and bridges pass packets back and forth between these channels. There are four types of routers: A repeater is the simplest form of router, simply forwarding all packets between the two channels. Using a repeater, a subnet can exist across multiple channels. A bridge simply forwards all packets which match its domains between the two channels. Using a bridge, a subnet can exist across multiple channels. Like a learning router, a configured router selectively routes packets between channels by consulting internal routing tables. Unlike a learning router, the contents of the internal routing tables are specified using Network Management commands. A learning router monitors the network traffic and learns the network topology at the domain/subnet level. The learning router then uses its knowledge to selectively route packets between channels.

Initially, each router sets its internal routing tables to indicate that all subnets could lie on either side of the router. Referring to figure, suppose that node 6 generates a message bound for node 2. Learning router 1 initially picks up the message. Examining the source subnet field of the message, the learning router notes in its internal routing tables that subnet 2 lies below it. The router then compares the source and destination subnet IDs and since they are different, the message is passed on. Meanwhile, learning router 2 has also passed the message on, making an appropriate notation in its internal routing tables regarding the location of subnet 2.

Suppose now that node 2 generates an acknowledgment. This acknowledgment is picked up by learning router 1, which now notes the location of subnet 1. Learning router 1 examines its internal routing tables, and noting that subnet 2 lies below, passes the message on. When the message appears on subnet 2, it is noted by both node 6 (the destination node), and learning router 2, which does not pass it on but merely notes that subnet 1, like subnet 2, lies somewhere above. Learning router 2 will not learn of the existence or location of subnet 3 until a message is originated from there. Subnets cannot cross routers. While bridges and repeaters allow subnets to span multiple channels, the two sides of a router must belong to separate subnets. The fact that routers are selective about the packets they forward to each channel can be used to increase the total capacity of a system in terms of nodes and connections.

Learning Routers
Source: Echelon Corp.



VLT LonWorks Node

The VLT LonWorks option will perform as an integrated part of the VLT HVAC 6000. The VLT LonWorks option will provide unmatched control and flexibility of the VLT Adjustable Frequency Drive over a variety of LonWorks Networks.

The VLT LonWorks network interface consists only of SNVT's. The SNVT's support the HVAC LonUser motor controller profile along with VLT configuration, control and monitoring capabilities. Any combination of SNVT's can be used to operate the VLT.

Addressing nodes on the LonWorks network is performed at installation time by an installation tool or network management tool. Addressing requires the retrieval of a node's Neuron ID. The Neuron ID is a 48 bit number that uniquely identifies every manufactured Neuron chip. The VLT LonWorks option supports the three methods of addressing a node:

1. Query and Wink - The LonWorks option card is shipped with a domain of "0" and subnet of "1". Upon receiving the wink command, the VLT LonWorks option will flash the on-board Status LED so the installer can locate the node. The VLT LonWorks option will send out it's Neuron ID over the network in response to the query command .

2. Service Pin - When the on-board service switch is in the "service" position, the VLT LonWorks option will send out it's Neuron ID over the network.

3. Neuron ID Label - The VLT LonWorks option card has a Neuron ID label that displays the Neuron ID as a 12 digit hexadecimal number. The installer can manually enter the Neuron ID during installation.

Binding is the installation time process of logically connecting one node's output network variable to another node's input network variable. To support binding, the VLT LonWorks option includes the node's interface file (XIF). The VLT LonWorks option does not transmit network variables over the network which are not bound so there will be no added overhead on the network.

LonWorks supports many different types of transmission media. A LonWorks network physical layer can be: transformer coupled twisted pair (78 kbps and 1.25 Mbps), free topology, link power, power line, RF, RS-485, fiber optic, coaxial, and infrared.

The VLT LonWorks option supports four transmission media with three versions of the VLT LonWorks option card. The VLT LonWorks option card versions are:

1. 78 kbps transformer coupled twisted pair.

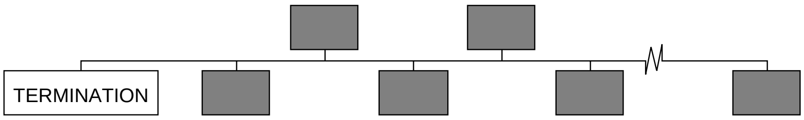
2. 1.25 Mbps transformer coupled twisted pair.

3. Free topology. The free topology node will also operate on a link power network.

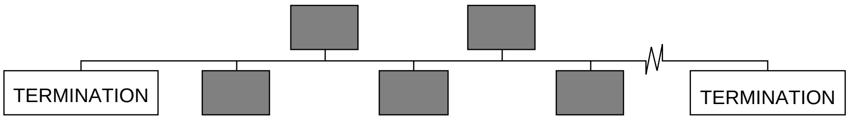
A router is required to interface to a LonWorks network that is not supported by the three option card versions.

The FTT system is designed to support free topology wiring, and will accommodate bus, star, loop or any combination of these topologies. FTT-10 transceivers can be located at any point along the network wiring capability simplifies system installation and makes it easy to add nodes should the system need to be expanded. The figures present five different network topologies.

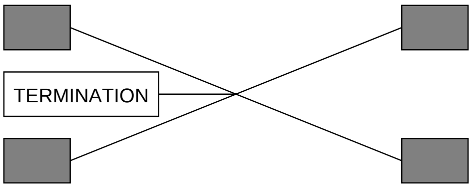
Singly Terminated Bus Loop



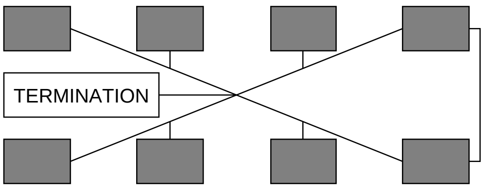
Doubly Terminated Bus Loop



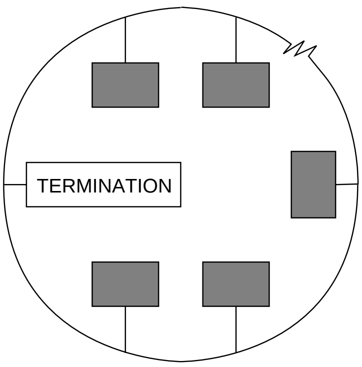
Star Topology



Loop Topology



Mixed Topology

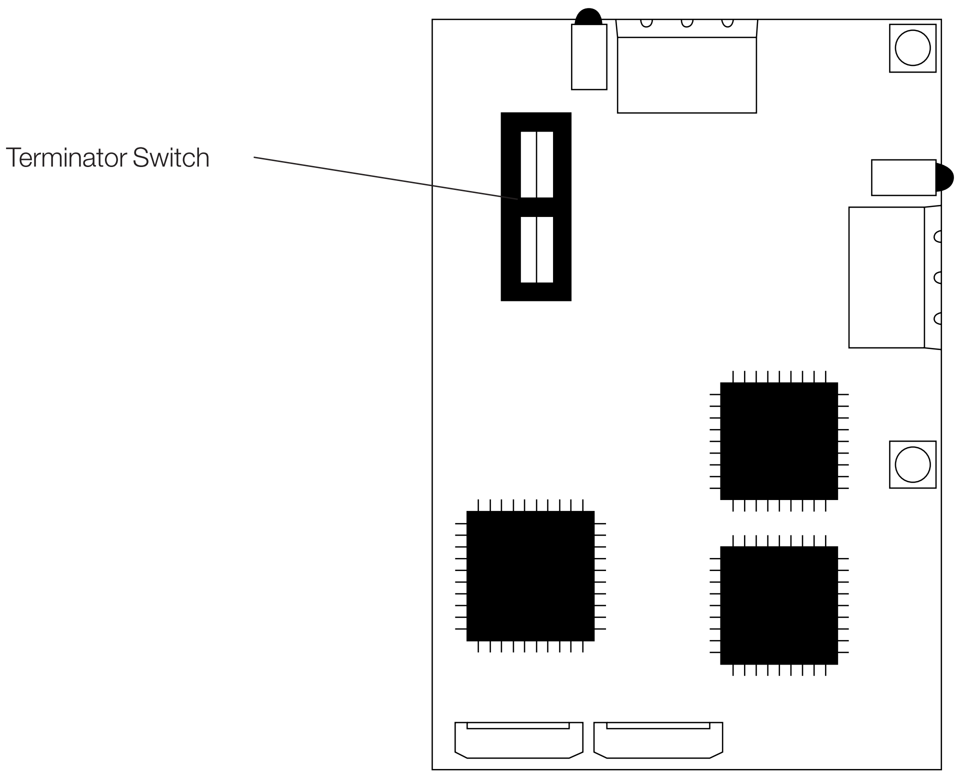


Free Topology Model

Termination	Pos 1	Pos 2
No termination	Net Term Off	Don't Care
Single termination	Net Term On	Net Term Off
Double termination	Net Term On	Net Term On

NOTE: Option cards are shipped from factory with double termination activated.

Terminator Switch



System Performance and Cable Selection

FTT-10 system and transmission specifications are outlined on the following pages. Both of these specifications should be met to ensure proper operation.

The system designer may choose a variety of cables, depending on cost, availability, and performance. Performance may vary with cable type. The transmission specification depends on such factors as resistance, mutual capacitance, and the velocity of propagation.

Echelon will characterize system performance on the following cable types. Electrical parameters shown in the table are typical.

Cable Parameters

Cable Type	Wire dia./AWG	Rloop ý/km	C nF.km	Vprop % of c
Belden 85102, single twisted pair, stranded 9/29, unshielded, plenum	1.3mm/16	28	56	62
Belden 8471, single twisted pair, stranded 9/29, unshielded, non-plenum	1.3mm/16	28	72	55
Level IV 22AWG, twisted pair, typically solid & unshielded	0.65mm/22	106	49	67
JY (St) Y 2x2x0.8, 4-wire helical twist, solid shielded	0.8 mm/20.4	73	98	41

Note that the following specifications are for one network segment. Multiple segments may be combined using repeaters to increase the number of nodes and distance.

System Specifications

- Up to 64 FTT-10 transceivers, or 128 LPT-10 transceivers are allowed per network segment.
- The average temperature of the wire must not exceed +55°C, although individual segments of wire may be as hot as +85°C.
- Both types of transceivers may be used on a given segment, provided that the following constraint is met: (2 x number of FTT-10 transceivers) + (1 x number of LPT-10 transceivers) - 128

Transmission Specifications

Free Topology nodes run at 78kbps transmission speeds.

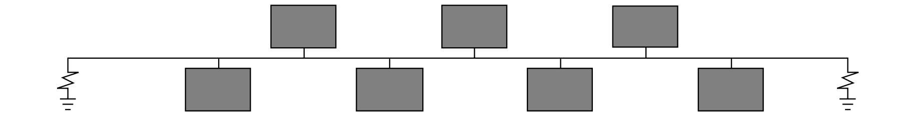
Doubly-Terminated Bus Topology Specifications

	Maximum bus length for segments with FTT-10 tranceivers only	Maximum bus length for segments with both FTT-10 and LPT-10 transceivers	Units
Belden 85102	2700	2200	meters
Belden 8471	2700	2200	
Level IV, 22AWG	1400	1150	
JY (St) Y 2x2x0.8	900	750	

Free Topology Specifications

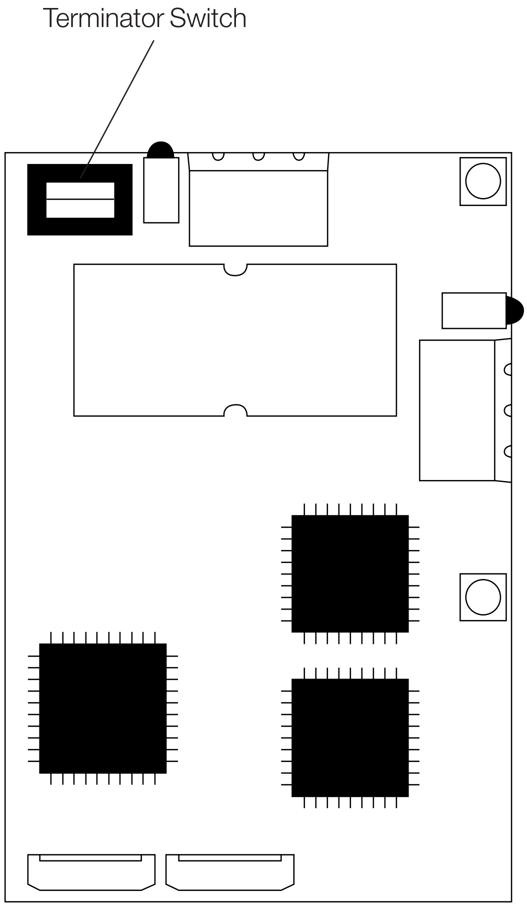
	Maximum node-to-node distance	Maximum total wire length	Units
Belden 85102	500	500	meters
Belden 8471	400	500	
LevelelV, 22AWG	400	500	
JY (St) Y 2x2x0.8	320	500	

Doubly Terminated Bus Topology



Terminator Switch

78 kbps or 1.25 Mbps Transformer Coupled Twisted Pair Model



Switch 1:

Net Term On
The VLT LonWorks node is terminated.
See network picture.

Net Term Off
The VLT LonWorks node is not terminated.

NOTE: Option cards are shipped from factory with network termination activated.

Performance Specification

The table provides a summary of the performance specifications for the 78 kbps and 1.25 Mbps transformer-coupled twisted pair channels.

Communication on TP/XF-78 and TP/XF-1250 channels;

Performance Specifications	TP/XF-78	TP/XF-1250
Transmission Speed	78kbps	1.25Mbps
Nodes per Channel	64 (0 to +70°C)	64 (0 to +70°C)
Network Bus Wiring	UL Level IV, 22 AWG (0.65 mm) twisted pair	
Network Stub Wiring	UL Level IV, 22 or 24 AWG (0.5 mm) twisted pair	
Network Bus Length Typical [1] Worst case [2]	 2000m 1330m	 500m 125m
Maximum Stub Length [3]	3m	0.3m (0 to 70°C)
Network Terminators	Required at both ends of the network	
Temperature Operating Non-operating	 0 to +70°C (64 node load) –40 to +85°C (44 node load)	 0 to +70°C (64 node load) –20 to +85°C (32 node load) –40 to +70°C (20 node load)
Electrostatic Discharge to Network Connectors No Errors No Hard Failures	 to 15,000V to 20,000V	 to 15,000V to 20,000V
Isolation between Network and I/O Connectors 0 - 60Hz (60 seconds) 0 - 60Hz (continuous)	 1,000 VRMS 277 VRMS	 1,000 VRMS 277 VRMS

1 Typical conditions are 20°C, +5VDC supply voltage, normal wire temperature, and 64 evenly distributed nodes.

2 Worst case conditions are the combined effect of worst case conditions of all the above performance parameters — nodes per channel, network bus length, stub length, temperature, etc.

3 The stub length in the table assumes a mutual capacitance of 17 pF/ft (56 pF/m) for the twisted pair stub cable. Actual lengths may be shorter or longer depending on the actual, measured value.

NOTE:
It is necessary to terminate the ends of a TP/XF-78 or TP/XF-1250 twisted pair bus to minimize refelections. Failure to terminate the bus will degrade network performance.

Level 4 Cable Specifications

The Level 4 cable specification used by Echelon and as originally defined by the National Electrical Manufacturers Association of the USA (NEMA) differs from the Category IV specification proposed by the Electronic Industries Association/Telecommunication Industry Association (EIA/TIA). The Level 4 cable specifications used by Echelon are presented below, and are followed by a list of Level 4 cable suppliers.

Specifications apply to shielded or unshielded 22AWG (0.65mm) cable 24AWG (0.5mm) cable shown in brackets [ ] if different	
DC Resistance (Ohms/1000 feet at 20°C) maximum for a single copper conductor regardless of whether it is solid or stranded and is or is not metal-coated.	18.0 [28.6]
DC Resistance Unbalance (percent) maximum	5
Mutual Capacitance of a Pair (pF/foot) maximum	17
Pair-to-Ground Capacitance Unbalance (pF/1000 feet) maximum	1000
Impedance (Ohms)	
772kHz	102 ±15% (87-117)
1.0MHz	100 ±15% (85-115)
4.0MHz	100 ±15% (85-115)
8.0MHz	100 ±15% (85-115)
10.0MHz	100 ±15% (85-115)
16.0MHz	100 ±15% (85-115)
20.0MHz	100 ±15% (85-115)
Attenuation (dB/1000 feet at 20°C) maximum	
772kHz	4.5 [5.7]
1.0MHz	5.5 [6.5]
4.0MHz	11.0 [13.0]
8.0MHz	15.0 [19.0]
10.0MHz	17.0 [22.0]
16.0MHz	22.0 [27.0]
20.0MHz	24.0 [31.0]
Worst-Pair Near-End Crosstalk (dB) minimum. Values are shown for information only. The minimum next coupling loss for any pair combination at room temperature is to be greater than the value determined using the formula NEXT (F_{MHz}) > NEXT (0.772) – 15_{log10} (F_{MHz}/0.772) for all frequencies in the range of 0.772MHz – 20MHz for a length of 1000 feet	
772kHz	58
1.0MHz	56
4.0MHz	47
8.0MHz	42
10.0MHz	41
16.0MHz	38
20.0MHz	36

Level 4 Cable Suppliers

Anixter
4711 Golf Road
Skokie, IL 60076

Ph: 708-677-2600
FAX: 708-677-2668

Anixter stocks the following cables which they will cut to size.

Part No.	Description
9D220150	22 AWG (0.65mm) / 1 pair solid, unshielded, PVC
9F220150	22 AWG (0.65mm) / 1 pair solid, shielded, PVC
9D220250	22 AWG (0.65mm) / 2 pair solid, unshielded, PVC
9F220254	22 AWG (0.65mm) / 2 pair solid, shielded, PVC
9H2201504	22 AWG (0.65mm) / 1 pair solid, unshielded, plenum
9J2201544	22 AWG (0.65mm) / 1 pair solid, shielded, plenum
9H2202504	22 AWG (0.65mm) / 2 pair solid, unshielded, plenum
9J2202544	22 AWG (0.65mm) / 2 pair solid, shielded, plenum

Connect-Air
International, Inc.
50-37th Street N.E.
Auburn, WA 98002

Ph: 206-813-5599
FAX: 206-813-5699

The following table lists cables stocked by Connect-Air.

Part No.	Description
W221P-1002	22 AWG (0.65mm) / 1 pair strand, unshielded, PVC
W222P-1004	22 AWG (0.65mm) / 2 pair strand, unshielded, PVC
W221P-1003	22 AWG (0.65mm) / 1 pair strand, shielded, PVC
W222P-1005	22 AWG (0.65mm) / 2 pair strand, shielded, PVC
W221P-2001	22 AWG (0.65mm) / 1 pair strand, unshielded, plenum
W221P-2003	22 AWG (0.65mm) / 2 pair strand, unshielded, plenum
W221P-2002	22 AWG (0.65mm) / 1 pair strand, shielded, plenum
W222P-2004	22 AWG (0.65mm) / 2 pair strand, shielded, plenum

Link Power/ Free Topology Cable Suppliers

Level 4 22AWG (0.65mm) cables may also be used.

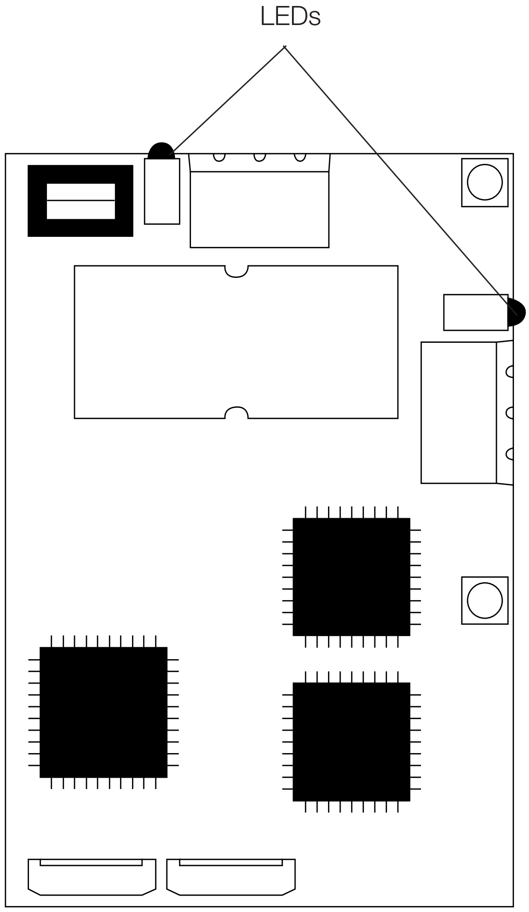
Belden
P.O. Box 1980
Richmond, IN 47375

Ph: 206-813-5599

Part No.	Description
8471	16 AWG (1.3mm) / 1 pair strand, unshielded, PVC
85102	16 AWG (1.3mm) / 1 pair strand, unshielded, plenum

Status LED

The VLT LonWorks Option card includes two LED's to display the communication status of the VLT LonWorks option, display the state of the Neuron chip, and respond to the network management "wink" command. The on board LEDs are the Service LED (LED 1, red) and the Status LED (LED 2, green).



The Status LED patterns are:

ON;
There is power on the board but there has not been any communication to an input network variable in the last 2 seconds.

Flashing 10 times per second;
There is regular network communication to the VLT's input network variables.

Flashing intermittently;
There is network communication to the VLT's input network variables but input network variables are received at a period greater than 2 seconds.

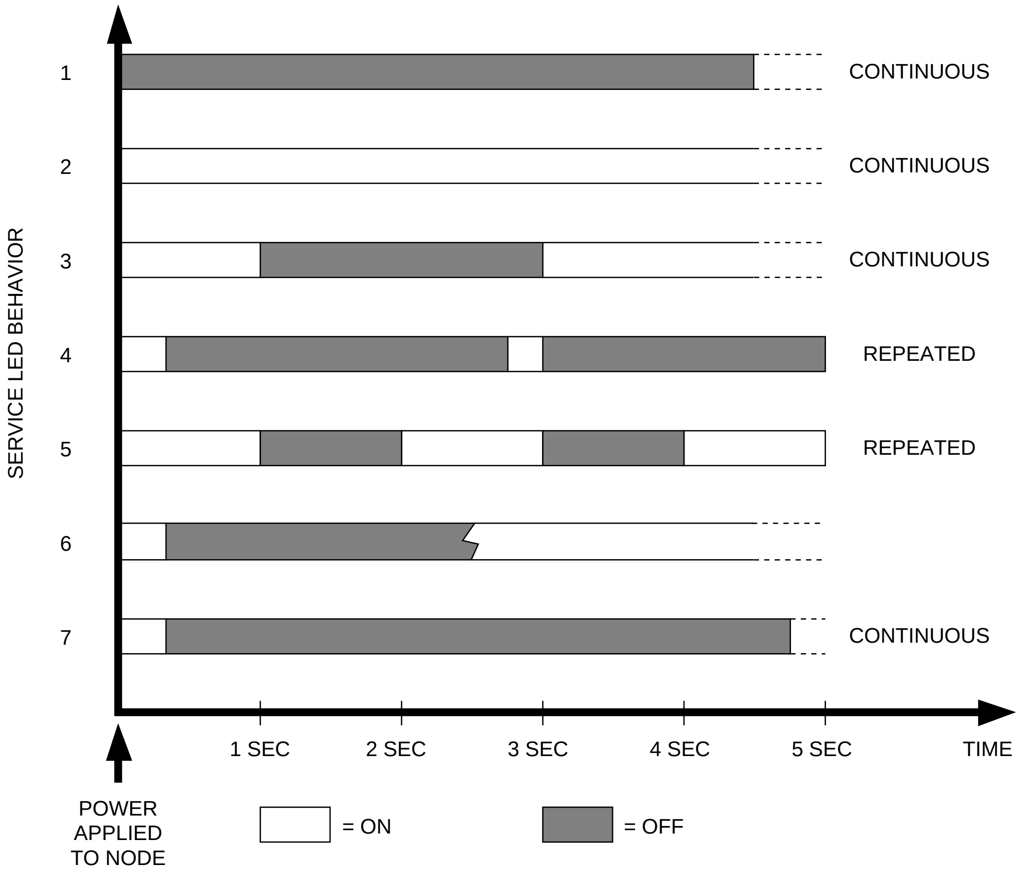
Flashing 5 times per second;
The response to the network management "Wink" command. The VLT LonWorks node must be reset to leave the wink state.

OFF;
No power on board or hardware fault.

Service LED

The Service LED will display the state of the Neuron chip. The figure below shows the Service LED patterns and the table on the following page explains the patterns.

Possible Service LED behaviors showing different duty cycles



Service LED

Explanation of the service LED behaviors shown in preceding figure.

Table 3.1

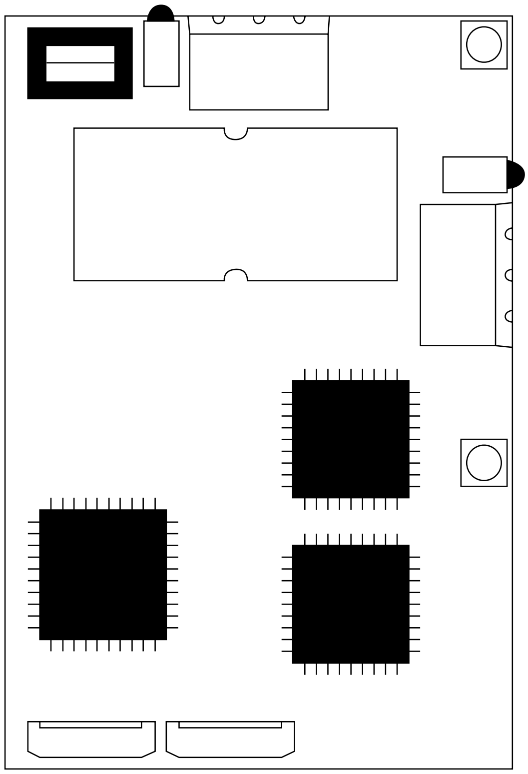
Behavior	Context	Likely Explanation
1	Power-up of a Neuron 3120xx Chip-based node, or a Neuron 3150 Chip-based node with any Prom	Bad node hardware
2	Power-up of a Neuron 3120xx Chip-based node, or a Neuron 3150 Chip-based node with any PROM	Bad node hardware
3	Power-up/Reset	Node is applicationless May be caused by the Neuron Chip firmware when a mismatch occurs on application checksum
4	Anytime	Watchdog timer resets occuring Possible corrupt EEPROM For a Neuron 3150 Chip-based node, use a newly programmed PROM, or EEBLANK and follow bringing up procedure
5	Anytime	Node is unconfigured but has an application. Procede with loading the node.
6	Using EEBLANK on a Neuron 3150 Chip-based custom node	The OFF duration is approximately 10 seconds. After this OFF time the service LED should turn ON and stay ON, indicating the completion of the blanking process.
6	First power-up with a new PROM on a Neuron 3150 Chip-based custom node. Applicatless firmware state exported	The OFF duration is approximately 1 second. Service LED should then turn ON and stay ON indicating an applicationless state.
6	First power-up with a new PROM on a Neuron 3150 Chip-based custom node. Unconfigured firmware state exported	The OFF duration is approximately 1-15 seconds depending on the application size and system clock. Service LED should then begin flashing as in behavior 5 indicating an unconfigured state
6	First power-up with a new PROM on a Neuron 3150 Chip-based custom node. Configured firmware state exported	The OFF duration is indefinite (1-15 seconds to load internal EEPROM; stays OFF indicating configured state.)
7	Anytime	Node is configured and running normally

Service Switch

The Service Switch supports one of the addressing methods used to retrieve the Neuron ID.

When the service switch is in the "service" position, the VLT LonWorks option continually sends it's Neuron ID over the network.

For normal network operation, the Service Switch should be in the "normal" position.



Interoperability refers to the ability of independent nodes to operate together over the LonWorks network. The LonMark program was developed to address interoperability issues. The VLT Lonworks option supports the following LonMark activities to improve interoperability:

1. Standard Network Variable Types (SNVT's); SNVT's define the units, limits and resolution of network variables so that nodes have a common platform for representing data items. The VLT LonWorks option only uses SNVT's to transmit and receive data over the LonWorks network.

2. Standard Objects;
   Standard Objects are a collection of SNVT's to perform a function. The VLT LonWorks option supports the node object and a controller standard object as defined in the LonMark Interoperability guidelines 2.0. The controller object contains the adjustable frequency motor controller profile along with the other features included in the VLT LonWorks option.

3. LonMark Interoperability Association Tast Groups (LonUsers Groups); Tast groups define SNVT's and standard objects to create standards and models to be used by particular applications. Danfoss is active in defining standards for LonUser groups.

This section will group the SNVT's into five functions: drive control, drive feedback, drive configuration, network configuration and standard object support.

To support a variety of controllers, the VLT LonWorks option offers multiple SNVT's for selected drive functions. Reference 1, 2, or 3 can be used to send a frequency reference to the VLT. Drive output 1, 2 or 3 can be used to determine the output frequency of the VLT. Controlword or Start/Stop/Reset fault can be used to control the operation of the drive. Statusword, Drive status, or Object status can be used to monitor the state of the drive and motor. Alarm or Object alarm can be used to determine that a fault condition exists in the drive.

NB!
In order to optimize network performance and to insure correct VLT operation, only one SNVT should be used for the drive control, frequency reference, and frequency output functions.

A controller node can support any number of VLT SNVT's and any combination of SNVT's (note the above exceptions) can be used. The degree of control and flexibility of the VLT over the network depends on the capabilities built into the controller node.

Drive Control

The VLT LonWorks option supports the following SNVT's for flexible speed and operational control of the VLT over the LonWorks network. Table 4.1 refers to the control network variables that are supported by the VLT LonWorks option.

Reference 1 is an output frequency reference command. The network variable nviRefPcnt, is a signed value in percentage of maximum frequency (PNU 202).

Drive control is limited to start/stop and reset fault. For complete operational control of the VLT, the Controlword should be used.

The function Max receive time can be used to determine the health of the controller/VLT connection. The VLT can be programmed to react in a pre-determined manner (PNU 824) if an input network signal is not received in the time specified by the Max receive time.

Start/stop and reset fault use SNVT_lev_disc ST_OFF is interpreted as low or"0". ST_LOW,ST_MED,ST_HIGH, and ST_ON are interpreted as high or"1".

Reference 2 is a frequency reference command. The network variable nviRef Rads, is a signed value in rad/second.

Reference 3 is a frequency reference command. The network variable nviRefHz is an unsigned value in Hz.

The input network variable nviControlword is a commanded 16-bit word that provides full operation control of the drive such as start/stop, reverse, reset fault, quick stop etc.

The Controlword is defined in Chapter 5, Parameter Description.

Table 4.1 Network Variable Inputs to the VLT

Function	SNVT type	Variable Name	Units	Max	Min
Control word	SNVT_state	nviControlword	16 Boolean	NA	NA
Reference 2	SNVT_angle_vel	nviRefRads	0.1 rad/sec	3276.7	–3276.8
Reference 3	SNVT_freq_hz	nviRefHz	0.1 Hz	6553.5	0
Start/Stop	SNVT_lev_disc	nviStartstop	Boolean	Start	Stop
Reference 1	SNVT_lev_percent	nviRefPcnt	0.005%	163.835	–163.840
Reset fault*	SNVT_lev_disc	nviResetFault	Boolean	Reset	Enable

* Reset on a transition from 0 to 1. A "0" must be sent after reset to enable the next reset.

Drive Feedback

The VLT LonWorks option provides 16 output network variables containing important drive and motor feedback data. Feedback network variables are output on a change in value with transmission rates limited by Min send time. The Min send time function specifies the minimum time between transmissions of a feedback network variable. The VLT LonWorks option will only transmit "bound" feedback network variables.

Drive output 1, 2, or 3 will have a maximum time between transmission limit set by the Max send time. The function Max send time can be set to allow a controller node to determine the health of the controller/ VLT connection.

Table 4.2 refers to the network variables supported by the VLT LonWorks option.

1. Drive Status represents the status of the VLT. nvoDrvStatus is a feedback network variable that represents the condition of the VLT. The four defined drive states (0/1) are: No fault/Drive tripped (bit 15), No warning/Warning (bit 14), Not running/Running (bit 13), and Auto/Manual control (bit 12). If a more descriptive drive status message is required then Status word should be used.

2. The network variables that represent Drive Status, Current, Energy, and Power will be output on a change in value. The output rate for each network variable will be limited by the Min send time function.

3. Drive output 1 is output frequency of the VLT. The network variable nvoOutputPcnt is a signed value in percentage of Max frequency (PNU 202). Drive output 1 (or Drive output 2 or 3) can be used by the controller node to determine the health of the controller/VLT connection. The network variables that represent output frequency will be transmitted as described above, but with a maximum transmission rate defined by Max send time. The maximum send time function is disabled when the network variable nciMaxsendT is not configured or set to "0".

4. The network variable nvoStatusword represents the status of the VLT and motor. Statusword is defined in Chapter 5, Parameter Description.

5. Drive output 2 and Drive output 3 are the output frequency of the VLT. The network variable nvoOutputRads is a signed value in rad/sec.
   The network variable nvoOutputHz is an unsigned value in Hz.

6. The network variables that represent Statusword, Output voltage, Digital input, Alarm, Warning 1, Warning 2, DC voltage, Motor temperature, and Inverter temperature are transmitted over the network on a change in value. The output rate for each network variable is limited by Min send time.

7. The network variables that represent Drive output 2 and Drive output 3 are transmitted as described above but with a maximum time between transmissions set by Max send time. The Max send time function is disabled when the configuration network variable nciMaxsendT is not configured or is set to "0".

Table 4.2 Network Variable Outputs from the VLT

Function	SNVT type	Variable Name	Units	Max	Min
Drive status	SNVT_state	nvoDrvStatus	16 Boolean	NA	NA
Drive output 1	SNVT_lev_percent	nvoOutputPcnt	0.005%	163.835	-163.840
Current	SNVT_amp	nvoDrvCurnt	0.1 amps	3276.7	–3276.8
Energy	SNVT_elec_kwh	nvoDrvEnrg	1 kWH	65,535	0
Power	SNVT_power_kilo	nvoDrvPwr	0.1 kW	6553.5	0
Statusword	SNVT_state	nvoStatusword	16 Boolean	NA	NA
Drive output 2	SNVT_angle_vel	nvoOutputRads	0.1 rad/sec	3276.7	–3276.8
Drive output 3	SNVT_freq_hz	nvoOutputHz	0.1 Hz	6553.5	0
Output voltage	SNVT_volt	nvoVoltage	0.1 V	3276.7	–3276.8
Digital input	SNVT_state	nvoDigitlInput	16 Boolean	NA	NA
Alarm	SNVT_state	nvoAlarmword	16 Boolean	NA	NA
Warning 1	SNVT_state	nvoWarning1	16 Boolean	NA	NA
Warning 2	SNVT_state	nvoWarning2	16 Boolean	NA	NA
DC voltage	SNVT_volt	nvoDCVolt	0.1 V	3276.7	–3276.8
Motor temp	SNVT_lev_cont	nvoTempMtr	0.5 %	100	0
Inverter temp	SNVT_lev_cont	nvoTempInvrtr	0.5 %	100	0

Network Configuration

The configuration parameters are network variable inputs to the VLT. Configuratioin parameters only need to be set one time, usually at installation. Table 4.3 refers to the configuration network variables supported by the VLT LonWorks option.

1. The Min send time function sets the minimum period between transmissions for all output network variables using the network variable nciMinSendT.

2. The Max receive time function performs the communications watchdog function for the VLT using the configuration network variable nciMaxReceiveT. The LonWorks option will initiate bus-timeout activities when the Max receive time has expired without receiving an input network variable. The action taken by the VLT depends on the setting of VLT parameter 824.

   The communication watchdog function is disabled when the network variable nciMax ReceiveT is not configured or set to "0".

3. The Max send time function sets the maximum time between transmissions for the feedback network variables representing Drive output 1, 2, or 3 using the configuration network variable nciMaxSendT. This function can be used by the controller to monitor the health of the VLT and controller connection.

   The Max send time function is disabled when nciMaxSendT is not configured or set to "0".

Table 4.3 Network Variable Configuration Inputs to the VLT

Function	SNVT type	Variable Name	Units	Max	Min	Default
Min send time	SNVT _elapsed _tm	nciMin-SendT	time	0 days 0 hours 1 min 5 sec 535 msec	0 days 0 hours 0 min 0 sec 100 msec[1] 30 msec[2]	0 days 0 hours 0 min 0 sec 500 msec
Max receive time	SNVT _elapsed _tm	nciMax-ReceiveT	time	0 days 18 hours 12 min 15 sec 0 msec	0 days 0 hours 0 min 1 sec 0 msec	0 days 0 hours 0 min 0 sec 0 msec (Off)
Max send time	SNVT _elapsed _tm	nciMax-SendT	time	0 days 0 hours 1 min 5 sec 535 msec	0 days 0 hours 0 min 0 sec 100 msec[1] 30 msec[2]	0 days 0 hours 0 min 0 sec 0 msec (Off)

[1] for 78 kbps Transformer coupled twisted pair and 78 Kbps free topology transceiver models
[2] for 1.25 Mbps Transformer coupled twisted pair transceiver model.

VLT Configuration

A controller node can monitor or modify any defined VLT parameter by supporting the Parameter access command and the Parameter access response functions. These functions allow a controller complete control of the drive, access to all of the features of the VLT, and the ability to configure drives with pre-defined settings using the network variables nviParamCmd and nvoParamResp.

The following definitions describe how the fields of SNVT_preset are used by the VLT LonWorks option:

1. Learn
   This field contains the function code for the VLT. The enumeration definitions for this field are:
   LN_RECALL (0),
   LN_LEARN_CURRENT (1),
   LN_LEARN_VALUE (2), and
   LN_REPORT_VALUE (3).
   LN_RECALL (0) and
   LN_REPORT_VALUE (3)
   are interpreted as read commands.
   LN_LEARN_CURRENT (1) and
   LN_LEARN_VALUE (2)
   are interpreted as write commands.

Any other value in this field will result in an error message in the Parameter access response.

2. Selector
   This field contains the VLT parameter number that is to be written or read. Requests for undefined parameters will result in an error message in the Parameter access response. The controlling device should check the parameter number of the response message to the requested parameter number to determine that the information received is the requested information and not a response to another controller or from another VLT.

3. Value
   This 4 byte array contains the parameter information to and from the VLT. All VLT parameters use 16 bit signed or unsigned values except for the ramp times. Ramp times, PNU 215 to PNU 218, are 32 bit unsigned. For 16 bit values, the most significant byte of data will be stored in value [2] and the least significant byte of data will be stored in value [3]. For drive parameters 215, 216, 217, and 218, the most significant byte of data will be stored in value [0] and the least significant byte will be stored in value [3]. In the event of an error message, the VLT will send 0xff in value [0] and an error code in value [3]. The error codes are defined in table 4.6.

VLT Configuration (continued)

4. Day, Hour, Minute, Second, Millisecond The time fields will not be supported by the VLT LonWorks option. The VLT will respond to parameter access requests as soon as they are received. Any values in the time fields of the Parameter access command will be ignored. All time fields will be set to "0" in the Parameter access response.

Table 4.4 Network Variable Input to the VLT

Function	SNVT type	Variable Name
Parameter access command	SNVT_preset	nviParamCmd

Table 4.5 Network Variable Output from the VLT

Function	SNVT type	Variable Name
Parameter access response	SNVT_preset	nvoParamResp

Table 4.6 Parameter Access Error Codes

Exception Code	Interpretation
1	Illegal function for the addressed node
2	Illegal data address (i.e. illegal parameter number)
3	Illegal data value
6	Busy

For the following examples, the controller node has a Parameter access command SNVT_preset called nvoParamCmd and a Parameter access response SNVT_preset called nviParamResp.

Example 1:

A controller node writes 40 Hz to the Bus Jog parameter (PNU 511) of the VLT.
NOTE: The value 400 equals 40.0 Hz.

Time 0 - Controller node sends the following parameter write request to the VLT.

nvoParamCmd.learn = 1.*
nvoParamCmd.selector = 511.
nvoParamCmd.value[0] = 0.
nvoParamCmd.value[1] = 0.
nvoParamCmd.value[2] = 1 hex.
nvoParamCmd.value[3] = 90 hex.

* Note: 2 could have been used.

Time 1 - The controller node receives the following parameter access response from the VLT.

nviParamResp.learn = 1.
nviParamResp.selector = 511.
nviParamResp.value[0] = 0.
nviParamResp.value[1] = 0.
nviParamResp.value[2] = 1 hex.
nviParamResp.value[3] = 90 hex.
nviParamResp.day = 0.
nviParamResp.hour = 0.
nviParamResp.minute = 0.
nviParamResp.second = 0.
nviParamResp.millisecond = 0.

Example 2:

The controller node writes 3600.00 seconds to the Ramp time up parameter (PNU 215) of the VLT.
NOTE: The value 360000 equals 3600.00 seconds and is the maximum value for the ramp times.

Time 0 - Controller node sends the following parameter write request to the VLT.

nvoParamCmd.learn = 1.*
nvoParamCmd.selector = 215.
nvoParamCmd.value[0] = 0.
nvoParamCmd.value[1] = 5 hex.
nvoParamCmd.value[2] = 7E hex.
nvoParamCmd.value[3] = 40 hex.

* Note: 2 could have been used.

Time 1 - The controller node receives the following parameter access response from the VLT.

nviParamResp.learn = 1.
nviParamResp.selector = 215.
nviParamResp.value[0] = 0.
nviParamResp.value[1] = 5 hex.
nviParamResp.value[2] = 7E hex.
nviParamResp.value[3] = 40 hex.
nviParamResp.day = 0.
nviParamResp.hour = 0.
nviParamResp.minute = 0.
nviParamResp.second = 0.
nviParamResp.millisecond = 0.

Example 3:

A controller node writes 600 Hz to the Bus Jog 1 parameter (PNU 511) of the VLT.
NOTE: 6000 (600.0 Hz) exceeds the parameter limits.

Time 0 - Controller node sends the following parameter write request to the VLT.

nvoParamCmd.learn = 1.*
nvoParamCmd.selector = 511.
nvoParamCmd.value[0] = 0.
nvoParamCmd.value[1] = 0.
nvoParamCmd.value[2] = 17 hex.
nvoParamCmd.value[3] = 70 hex.

* Note: 2 could have been used.

Time 1 - The controller node receives the following parameter access response from the VLT.

nviParamResp.learn = 1.
nviParamResp.selector = 511.
nviParamResp.value[0] = FF hex.
nviParamResp.value[1] = 0.
nviParamResp.value[2] = 0.
nviParamResp.value[3] = 3 hex.
nviParamResp.day = 0.
nviParamResp.hour = 0.
nviParamResp.minute = 0.
nviParamResp.second = 0.
nviParamResp.millisecond = 0.

Example 4:

A controller node reads the value of the Bus Jog 1 parameter (PNU 511) in the VLT.
NOTE: 400 (40.0 Hz) is the value stored in parameter 511.

Time 0 - Controller node sends the following parameter read request to the VLT.

nvoParamCmd.learn = 0.*
nvoParamCmd.selector = 511.
nvoParamCmd.value[0] = 0.**
nvoParamCmd.value[1] = 0.
nvoParamCmd.value[2] = 0.
nvoParamCmd.value[3] = 0.

* Note: 3 could have been used
** Note : Any values in the value fields are ignored by the VLT for a read command.

Time 1 - The controller node receives the following parameter access response from the VLT.

nviParamResp.learn = 0.
nviParamResp.selector = 511.
nviParamResp.value[0] = 0.
nviParamResp.value[1] = 0.
nviParamResp.value[2] = 1 hex.
nviParamResp.value[3] = 90 hex.
nviParamResp.day = 0.
nviParamResp.hour = 0.
nviParamResp.minute = 0.
nviParamResp.second = 0.
nviParamResp.millisecond = 0.

Standard Object Support

The VLT LonWorks option supports two standard objects and three SNVT's to support the LonMark standard object philosophy. The standard objects are the node object containing the Object request, Object status, and Object alarm and the controller object containing the network variables described in the preceding sections. The object request is a LonMark device used to obtain status and alarm information from a node.

It is not necessary for a controller to support these network variables. The Object request, Object status and Object alarm provide status and alarm information for controllers that only support this type of functionality. The status and alarm functions described in the preceeding sections contain more drive specific information than Object status and Object alarm.

1. The VLT sends an Object status containing drive status information and an Object alarm containing fault information in response to the following Object requests: RQ_NORMAL, RQ_UPDATE_STATUS, and RQ_UPDATE_ALARM. The nviRequest.object_id should be set to "1" (controller node). nviRequest, nvoStatus and nvoAlarm are the network variables used for these functions.

2. The VLT sends an Object status containing a bit map of supported status fields in response to all other Object requests including undefined requests.

3. The VLT Object status supports the following status fields: invalid_id, invalid_request,open_circuit, out_of_service, electrical_fault, comm_failure, manual_control, and in_alarm. All other fields are always set to "0".

4. The VLT sends an Object alarm following any set or reset of a drive fault condition.

Table 4.7 Network Variables for Node Object and Standard Object support

Function	SNVT type	Variable Name	Input/Output
Object request	SNVT_obj_request	nviRequest	Input
Object status	SNVT_obj_status	nvoStatus	Output
Object alarm	SNVT_alarm	nvoAlarm	Output

PNU	Parameter Description	Default Value	Range	Size Index	Conversion Index	Data Type
812	Digital input			0	0	5
813	Analog input			0	0	3
814	Analog input			0	0	3
815	Position			0	0	6
817	Relay 01 function	NO FUNC. (0)	0 - 2	0	0	5
818	Relay 04 function	NO FUNC. (0)	0 - 2	0	0	5
824	Time-out function	FREEZE (0)	0 - 4	4	0	5
927	Parameter write access	With PROFIBUS (1)	0-1	0	0	6
928	Process control access	With PROFIBUS (1)	0-1	0	0	6
970	Setup select programming	SETUP = P001	0-6	0	0	5
971^{S}	Store data values	OFF (0)	ON/OFF	0	0	5**

812-815 Data read-out	812 Digital input 813 Analog input 814 Analog input 815 Position	binary code 10 V 20 mA counter value	These values can be read only. The master may ask for a value from a PNU between 812 and 815. No local access.
817 Relay 01 function (RELAY FUNC. 01)	Data Value: ★ No action OFF ON	 [0] [1] [2]	Is used for controlling the relay 01 from the master. If "no action" is selected, the relay will function according to the setting of parameter 325.
818 Relay 04 function (RELAY FUNC. 04)	Data Value: ★ No action OFF ON	 [0] [1] [2]	Is used for controlling the relay 04 from the master. If "no action" is selected, the relay will function according to the setting of parameter 326.
824 Time-out function (TIME-OUT FUNC.)	Data Value: ★Freeze Stop Jog Max. Run normal	 [0] [1] [2] [3] [4]	The setting of this parameter determines the behavior of the VLT following a bus time-out. Parameters 502-508 must be set. Freeze: The actual speed reference will be frozen. Stop: The motor will stop Jog: The motor will run with Jog speed (parameter 213) if start signals are present. Max: The motor will run with max. speed (parameter 205) if start signals are present. Run normal: The control word will be set to 043F HEX, which makes it possible to control the VLT via the terminals, depending on the setting of parameters 502-508. Warning: The VLT will resume normal operation when the communication is ok, this means that the motor can start or change speed without warning.

927 Access to parameter change (ACC PARA WRITE)	Data Value: No LONWORKS [0] ★ With LONWORKS [1]	This parameter lets you determine from which place parameters may be altered.
928 Access to process control (ACC PROC CTRL)	Data Value: No LONWORKS [0] ★ With LONWORKS [1]	This parameter lets you determine from which place control authority may be exercised.
970 Setup selection, Programming (SETUP PROGRAM)	Data Value: Preprogrammed(FACTORY SET) [0] Setup 1 (SETUP 1) [1] Setup 2 (SETUP 2) [2] Setup 3 (SETUP 3) [3] Setup 4 (SETUP 4) [4] ★ Setup = Par. 001(SETUP = P001) [5]	
971 Store data values	Data Value: ★ OFF [0] ON [1]	When the parameter is set to "ON" the downloaded parameters are stored. When finished, it automatically returns to "OFF". Do not switch off the AC line before the value changes to "OFF" (app. 15 sec.) otherwise all changes are lost. When using the keypad the function is activated when "MENU" is pressed. The function can only be activated with the VLT in stop-mode and may not be activated cyclically.

Control word

Data Value:
16 bits Unsigned

No local access.

	CONTROL WORD															
0 / 1	NO ACTION/REVERSE	SETUP SELECT 2	SETUP SELECT 1	NO ACTION/CATCH-UP	NO ACTION/SLOW-DOWN	CTR DATA NOT VALID/VALID	JOG 2 OFF/ON	JOG 1 OFF/ON	NO ACTION/RESET	RAMP STOP/START	ALWAYS = 1	QUICK STOP/RAMP ON	MOTOR COASTING/ENABLE	ALWAYS = 1	ALWAYS = 1	ALWAYS = 1
	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
	VALUE [2]								VALUE [3]							

Status word

Data Value:
16 Bits Unsigned

No local access.

	STATUS WORD															
0 / 1	TIMER OK/LIMIT	CURRENT OK/LIMIT	VOLTAGE OK/LIMIT	INVERTER OK/STALL AUTOSTART	NOT RUNNING/RUNNING	OUT OF RANGE/FREQ IN RANGE	LOCAL CONTROL/BUS CONTROL	NOT ON REFERENCE/ON REFERENCE	NO WARNING/WARNING	ALWAYS = 0	ALWAYS = 0	ALWAYS = 0	NO FAULT/TRIPPED	NOT ENABLED/ENABLED	UNIT NOT READY/READY	CTR NOT READY/READY
	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
	VALUE [2]								VALUE [3]							