An introduction to control networks based on

LONWORKSÒ Technology

Prepared by

EBV Elektronik GmbH & Co KG
Im Technologiepark 2-8, D-85586 Poing

Order number LONWORKS-DOC;21

Content: page

I The Echelon Business – An Executive Summary

The Echelon Corporation

A leader in control networks used by over 4000 OEMs with 3 million nodes installed worldwide that deliver efficiency, safety and productivity to business, home, and manufacturing environments.

The developer of the LONWORKS® control network family of software, hardware, and technology.

A company whose value proposition to end-users and integrators is lower cost of ownership and increased functionality and flexibility through open, inter-operable, multi-vendor control solutions.

A global leader in the building controls industry supported by leading suppliers in every facet of building automation – including access control, HVAC, security, elevators, CCTV, and lighting.

An emerging force in the transportation industry, with successful applications in aviation, rail transportation, luxury coaches, and emergency vehicle systems.

A partner with electric utilities worldwide in offering demand side management, automatic meter reading, appliance control, and other value-added services.

I The Echelon Business – An Executive Summary

Echelon's brand names (a subset)

LON abbreviation of **L**ocal **O**perating **N**etwork.
LonTalk the name of the firmware stored in a NEURON program memory.
LonWorks the system technology using NEURON and Echelon parts.
LNS(**L**onWorks **N**etwork **S**ervices) a SW to develop custom. applications to install, service, and deploy LonWorks networks.
LonMaker for Windows a turnkey SW to /design, install and deploy LonWorks networks.
***i*.LON1000** HW equipment manufactured by Echelon to route LonWorks telegrams from peer to peer by means of the TCP/IP protocol.
LonPoint HW equipment manufactured by Echelon to perform local or remote input/output functions (e.g. sensor/actor/controller).

Echelon's major investors/share holders

Mike Markkula (co-founder of Intel and Apple)
Ken Oshman (CEO of Echelon)
Detroit Edison
Motorola
ENEL
Rock Arthur
Oppenheimer Fund
The Soros Fund

Echelon's Intellectual Property

Echelon invented the Neuron chip technology and license it to CYPRESS and TOSHIBA for production.

Echelon has developed and released generic SW packages to design, install, service and maintain LonWorks control networks.

Echelon holds over 67 patents in network technology.

I The Echelon Business – An Executive Summary

Standardization of LonWorks

Accepted as (one of) the standards in BA.
(EIA 709.1/2/3)

Proposed for standardization in Home Automation.
(LonWorks & BACnet)

Accepted for standardization in Railway Automation.
(IEEE-1473-1999)

LonTalk protocol has been set as standard by EIA.
(ANSI/EIA 709.1-A-1999)

Echelon transceivers (FTT10A, PLT22) are compliant to worldwide standards in safety and EMI.

User Groups

Manage marketing and product validation activities, conferences as well as exhibitions and trade shows for their members.

- **LNO** – the German user group (150 members)
- **UKOSA** – the British user group (30 members)
- **LUF** – the French user group (50 members)
- **LonTech Thun** – the Swiss user group (30 members)
- **LonUsers Italia** – the Italian user group (30 members)
- **LonMark Association** (230 members)

Major technology benefits

Interoperability of HW products enable smart installation, service and maintenance while lowering cost of ownership.

Applications can be reconfigured and expanded without the need to reengineer an installation or even shut down the network.

Applications are independent from the physical transport media e.g. powered/unpowered power line, fiber optic twisted pair cable, wireless RF, COAX etc.

LonWorks supports multi-vendor installations without the need to create/manage application specific gateways and/or protocol converters.

I The Echelon Business – An Executive Summary

LonWorks supports multi-vendor installations using one single generic installation/service tool: e.g. LonMaker for Windows.

LonWorks is considered to be a front runner in Open System Technology in the international marketplace.

LonWorks supports LAN/WAN infranets. Using the i.LON1000, networked control systems can be monitored and controlled via Internet connections based on TCP/IP, RTC or ISDN lines.

Echelon SW packages are based on widely accepted programming standards like OOP, COM, OLE, ActiveX.

Echelon provides the complete set of products and tools needed to build interoperable networks. This approach further reduces expenses allocated to warehouse logistics and parts procurement.

Echelon's worldwide business results (as of end of 2000)

Echelon was founded in 1990 by Dr. Ken Oshman and Mike Markkula. In July 1998 Echelon became a public company (NASDAQ:ELON). Echelon employs 150 peoples worldwide.

- 1998 result 30 billion $.
- 1999 result 37 billion $
- 2000 result 47 billion $
- 2001 forecast 60 billion $

Echelon has a base of over 4000 OEM customers worldwide.

- 45% of Echelon's revenue are generated in the EU region
- 40% are generated in the Americas
- 15% are generated in the APAC region.

I The Echelon Business – An Executive Summary

Echelon's product portfolio (see complete catalogue on page 58)

Transceivers (FTT10A, LPT10, PLT22, FT31xx) interconnect Neuron chips with the communication media.

Control modules are generic customizable LonWorks platforms.

PC interface cards to connect networks with Windows OS.

Routers modules (LonPoint router, i.LON1000) to segment large networks and combine different communication media.

LonPoint modules ready-to-go HW for analog IO, digital IO, network controller that perform remote or local input/output functions.

Generic Software and Firmware that provide the middleware to deploy a LonWorks system. (LNS, LonMaker, ShortStack, gateway software, driver SW for Windows 95/98/2000/NT)

Test equipment for verification of data transmission (power line communication analyzer, protocol analyzer for LonWorks networks)

Echelon's product licensing policy

All software products (including LonTalk firmware) are made available to customers under the terms and conditions of software licenses that give customer the right to generate and use application code based on Echelon SW.

OEM customer agree to pay royalties to Echelon when redistributing parts of SW licensed from Echelon.

Echelon does not license the technology using in their transceivers, routers and HW development systems (LonBuilder, NodeBuilder) to 3rd parties.

The LonTalk protocol is a public specification (ANSI/EIA 709.1-A-1999) and can be embedded into any processor, from 8-bit microcontrollers to 32-bit microprocessors.

Customer support and training

Echelon maintains customer support & training centers in London, Tokyo and Sunnyvale/USA.

Echelon offers technical support and replacement/repair services for all of their hardware and software products. (e.g. lab and design review)

I The Echelon Business – An Executive Summary

Sales channels

- Distribution (thru EBV) in Europe
- Distribution in APAC region
- Direct sales in the Americas
- Distribution (thru Engenuity Systems) in US
- Network Integrators
- Direct sales to key accounts

Estimated sales channel performance (as per end of 2000)
(13 million Neuron chip based devices installed worldwide since ever)

- EBV: 13 b$
- Echelon EU: 7 b$
- Echelon Americas: 20 b$
- Echelon APAC: 7 b$

Major technology partners

- TOSHIBA (Neuron chip technology)
- CYPRESS (Neuron chip technology)
- CISCO (i.LON1000 router technology)

Echelon's important customers and early adopters

- EBV (distribution)
- ALSTOM (Railway)
- Bombardier (Railway)
- Honeywell (automation)
- Johnson controls (automation)
- Merloni (white ware)
- Whirlpool (white ware)
- SAMSUNG (white ware)
- SAMPO (home appliancies)
- Invensys Building Systems (automation)
- Bouygues (automation HVAC, lighting)
- Legrand (lighting)
- ENEL (energy distribution)
- EBM (clean room air conditioning)
- TAC (automation)
- Edwards High Vacuum
- Philips Lighting (lighting)
- Enermet (energy metering)
- Siemens Building Technology (automation)
- Trend
- Schindler

1 Introduction:

Networks are changing our lives. Everywhere we turn, they are used to collect and move data, connected to computers und run business.

In the past, network performed these functions locally. Today, the Internet allows that networks operate globally.

Now, another networking revolution will have an even greater impact than Internet: Echelon is extending the concept of networking into the world of control.

Control networks greatly expand the possibility of networking. When combined with data networks, control networks provide immediate and vital information on the enterprise, along with the means to act on it instantly.

Control networks link devices – replacing the central controllers and wiring harnesses of yesterday.

Although open systems are commonplace in data networks, control systems have traditionally been closed and proprietary architectures.

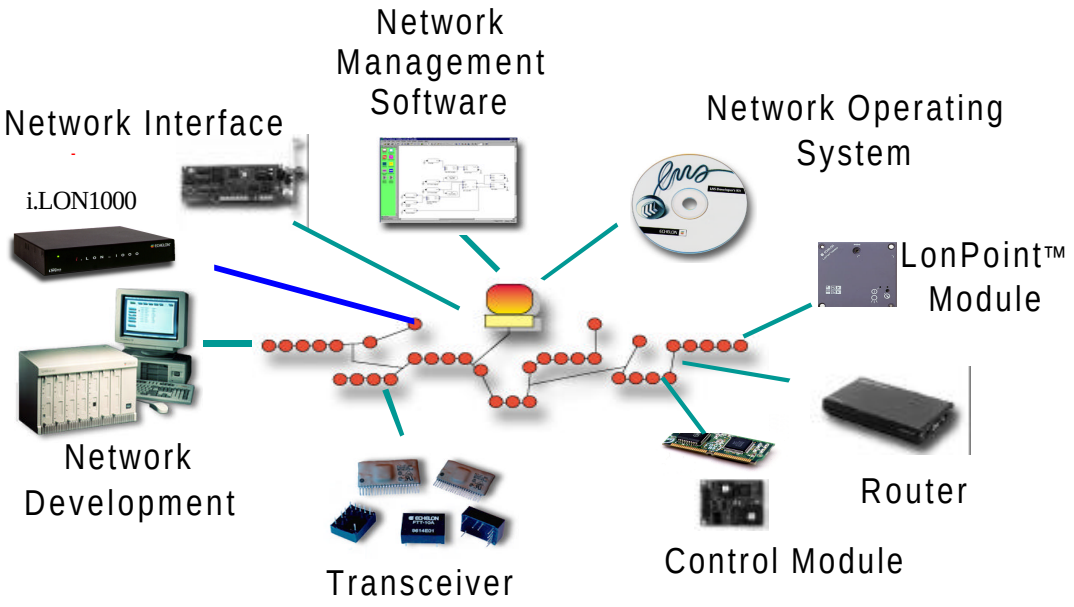
Echelon is the first and only networking company that provides a multi-vendor, open network architecture for control applications. This brings the benefit of reduced costs and enhanced flexibility to the world of controls.

Each device in the control network is smart and intelligent enough to function independent from a central super-visor system. Networked together, these smart devices communicate with each other to provide distributed monitoring and control.

Applications range from small networks embedded in a single machine to large networks with thousands of devices that monitor and control all functions in an entire building, transportation system or manufacturing operation.

This flexible approach eliminates the limits of traditional control technology and opens the way to a multitude of new applications and services.

Echelon's LONWORKS Technology provides a great variety of powerful HW and SW components that are used to build intelligent distributed LONWORKS networks.



The features of these components are presented in this paper. A complete documentation CDRom of all products described herein can be obtained free of charge from EBV Elektronik. (refer to /6/)

Echelon introduced the LONWORKS Technology in 1992. Since then, thousands of companies decided to use this technology. Today, more than 3000 products are available in the market.

The benefits for the user of this technology are obvious:

- Lower installation cost
- Improved reliability
- Increased flexibility
- Improved diagnostic capability
- Lower maintenance costs
- Lower cost of ownership

The most important standards to which LONWORKS complies:

- IFSF, CEN TC247, IEEE P1473.1 Rail Transit
- EIA 709.1 (LonTalk protocol)
- EIA 709.2 (FTT10 transceiver)
- EIA 709.2-A-2000 (PLT22 power line transceiver)

2 Basics of LONWORKS

Any LONWORKS hardware, called *node*, is based on a special microcontroller, called *Neuron* chip. The functional model of the Neuron chip as well as the *LonTalkÓ* protocol firmware have been defined by Echelon in 1990.

The Neuron chip matches the following requirements:

- It provides powerful I/O capabilities and communication functions needed in a distributed system.
- It uses an unique identifier, the *Neuron ID*, to be addressed within a network.
- It can be easily programmed in *Neuron C*, a structured language based on the ANSI C standard.
- It use a *media-independent communication* model: Network data may be transmitted using simple twisted pair wires, RF links, fibre optic links, power line, COAX cable etc.
- The LonTalk protocol firmware provides services to efficiently transport and route data from peer to peer.

Once a node is connected to a network management tool, powered-up and executing the LonTalk firmware, the user can control the operation mode of the node via network management commands. He might e.g.:

- download a programs into a node
- replace a program of a node
- change node configuration parameters
- put on- or off-line, reset a node
- get data from a node
- send data to a node
- bind a node into a network
- remove or replace a node in a network

Echelon and other 3rd party suppliers provide powerful network installation, service and maintenance software in order to fulfill the above tasks.

All basic functions and services required to manage a node are supplied by the firmware. This firmware provides an event-driven operating system to schedule and execute the application program, handle the data structures needed to communicate with other Neuron chips and operate the local 11-pin I/O block.

Each node in a LONWORKS network is identified by its unique Neuron ID that is stored in the Neuron chip. This write-protected identifier is 48 Bit wide and is stored in the on-chip EEPROM when the chip is manufactured.

Neuron chips communicate with each other by sending data telegrams over the network. Each telegram is formatted by the Neuron‘s firmware and contains address-, routing- & control information as well as the application data along with a checksum.

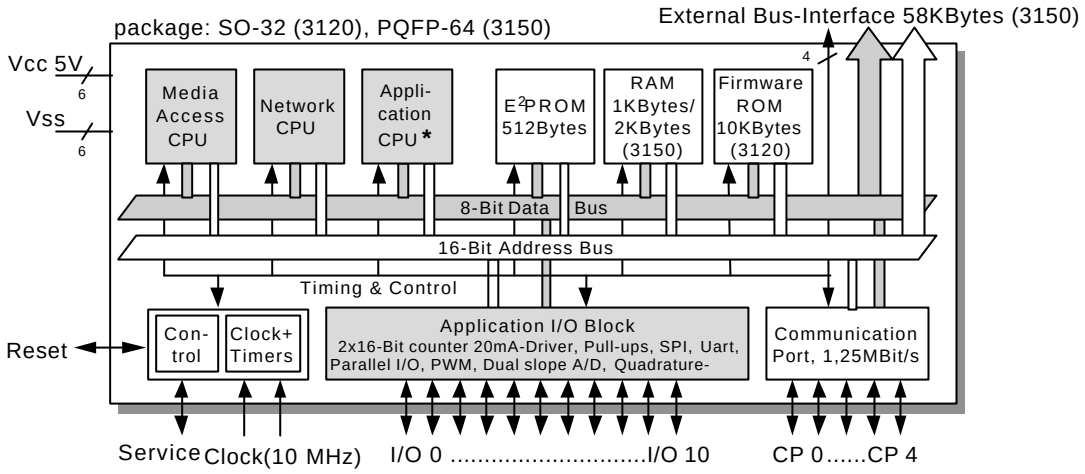
The data transmission is initiated und supervised by the Neuron‘s firmware. Each telegram may contain up to 229 bytes of data.

User/application data may either have the format of an *explicit message* or a *network variable*. Network variables provide the node with a structured data communication model and fully automated data send/receive handling operated by the LonTalk protocol.

Explicit messages provide a simple data send/receive handling operated under control of the node‘s application program.

3 Neuron Chip

The following picture shows the functional blocks of the NEURON IC.



TOSHIBA offer various Neuron IC models in different package types and memory sizes: The model 3120 is a single chip Neuron – no external memory is required; the 3150 is an equivalent to a 3120 with the exception of its external memory interface used to store the firmware, program and application data.

The 3120‘s internal non-volatile EEPROM contains both the user application program and communication parameters. The on-chip static RAM holds local program data and communication data buffers needed by the application program.

The 3150‘s external bus interface is used to interface the IC with SRAM, NVRAM, EEPROM and/or memory mapped I/O.

The 3150 stores the application program and firmware on external memory whereas the 3120 uses on-chip memory resources to store the firmware and the application program.

Both models of the Neuron allows for program download and application parameterization via its communication port by means of the embedded LonTalk protocol firmware.

Each of the three CPU's of the Neuron execute a dedicated job:

- the ***media access CPU*** handles all serial I/O on the communications port.
- the ***network CPU*** supplies protocol data handling services, timing services used in various states of the data processing within the Neuron IC and provides subroutines to drive the local application IO block.
- the ***application CPU*** runs the application program. The application program is edited, compiled and linked by means of an Neuron-C program development system. The program itself might be downloaded via the communication port or supplied as external memory.

The user/programmer has access to only the application CPU. He may, if necessary, control the operating modes of the other CPUs by supplying them appropriate parameters.

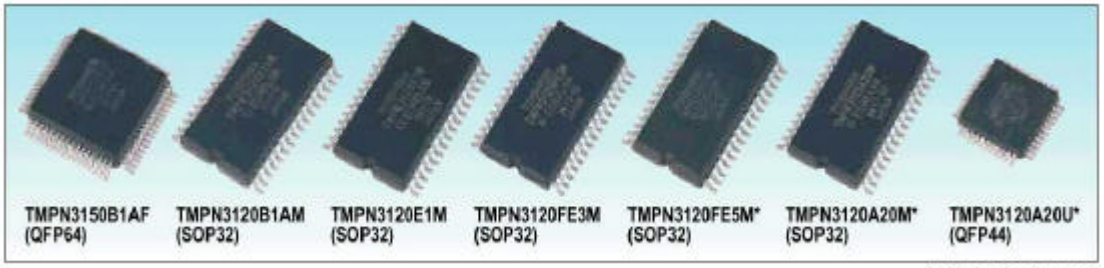
The network communication port is software-configurable to run at bus clock speeds from 600 baud up to 1.25 Mbps. The hardware designer of a node connects this port to an external transceiver in order to decouple and electrically isolate the Neuron IC from the bus wiring. The node may use whatever transceiver is appropriate to match the application requirement: RS485, transformer, fiber optic, infrared, power line, COAX cable, radio frequency etc. Adapting the Neuron chip communications port to these transceivers is just a matter of software parameterization of the node: the application program is independent from the type of transceiver used to connect the node to the network.

Unlike other microprocessors, the Neuron chip does not provide an external interrupt pin. All hand-shaking between the Neuron chip and it's external H/W is controlled by S/W. Signals applied to the IO application block must be stable for at least 200ns(for a 10MHz Neuron chip) in order to be correctly sampled by the internal firmware.

The bidirectional service-pin is provided to:

- monitor the internal firmware state
- make the Neuron chip sending its Neuron ID.

The following table shows currently available and future versions of Neuron chips manufactured by TOSHIBA.



* : Under development

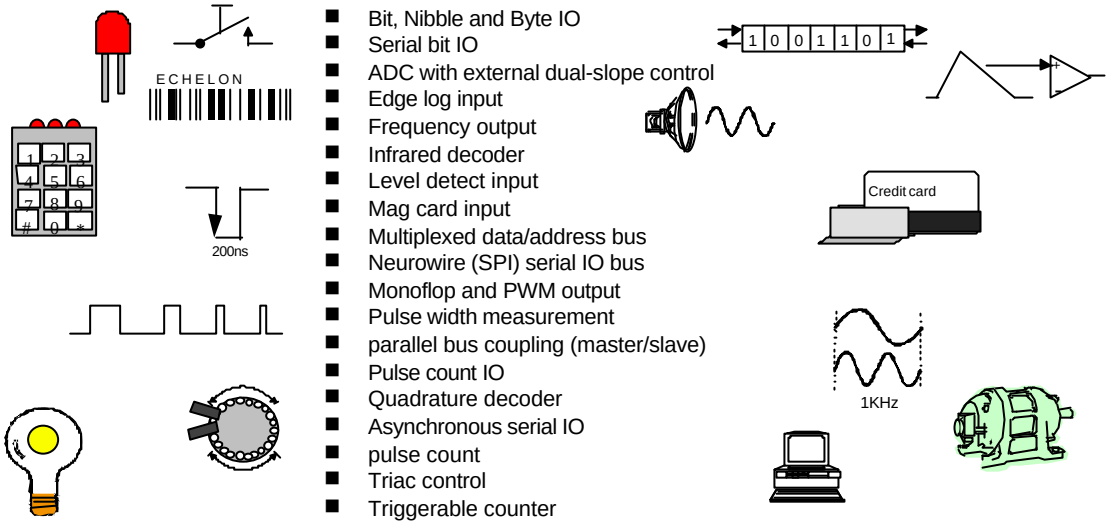
Table 10. Comparison of TOSHIBA Neuron® Chip

Product No.	EEPROM (in bytes)	RAM (in bytes)	ROM (in bytes)	8-bit CPU	External memory I/F	16-bit timer/ counter	A/D CONVERTER	Maximum operation Frequency (MHz)	Package
TMPN3150B1AF	512	2K	No	3	Available	2 ch	-	10	QFP64-P-1414 -0.80A
TMPN3120B1AM	512	1K	10K	3	No	2 ch	-		SOP32-P-525 -1.27
TMPN3120E1M	1K	1K	10K	3	No	2 ch	-		SOP32-P525 -1.27
*TMPN3120A20U	1K	1K	16K	3	No	2 ch	3 ch	20	QFP44-P-1010 -0.80
*TMPN3120A20M									SOP32-P-525 -1.27
TMPN3120FE3M	2K	2K	16K	3	No	2 ch	-		SOP32-P-525 -1.27
*TMPN3150FE5M	3K	4K	16K	3	No	2 ch	3 ch		SOP32-P-525 -1.27

* Under development

4 Neuron Chip I/O Models

The Neuron may be connected to one or more physical I/O devices. Examples of simple I/O devices include temperature and position sensors, valves, switches and LED displays. Neuron chips can also be connected to other microprocessors. The Neuron chip firmware implements I/O objects that manage the physical interface of external devices of a Neuron C application. The next picture shows some of the available I/O objects:



- Bit, Nibble and Byte IO
- Serial bit IO
- ADC with external dual-slope control
- Edge log input
- Frequency output
- Infrared decoder
- Level detect input
- Mag card input
- Multiplexed data/address bus
- Neurowire (SPI) serial IO bus
- Monoflop and PWM output
- Pulse width measurement
- parallel bus coupling (master/slave)
- Pulse count IO
- Quadrature decoder
- Asynchronous serial IO
- pulse count
- Triac control
- Triggerable counter

The programming model of the Neuron C language allows the programmer to declare one or more pins as I/O objects. These declarations can be thought of as written firmware routines in ROM that are accessed by the application program. The application program refers to these objects in *io_in* and *io_out* system calls to perform the actual input/output function during execution of the program.

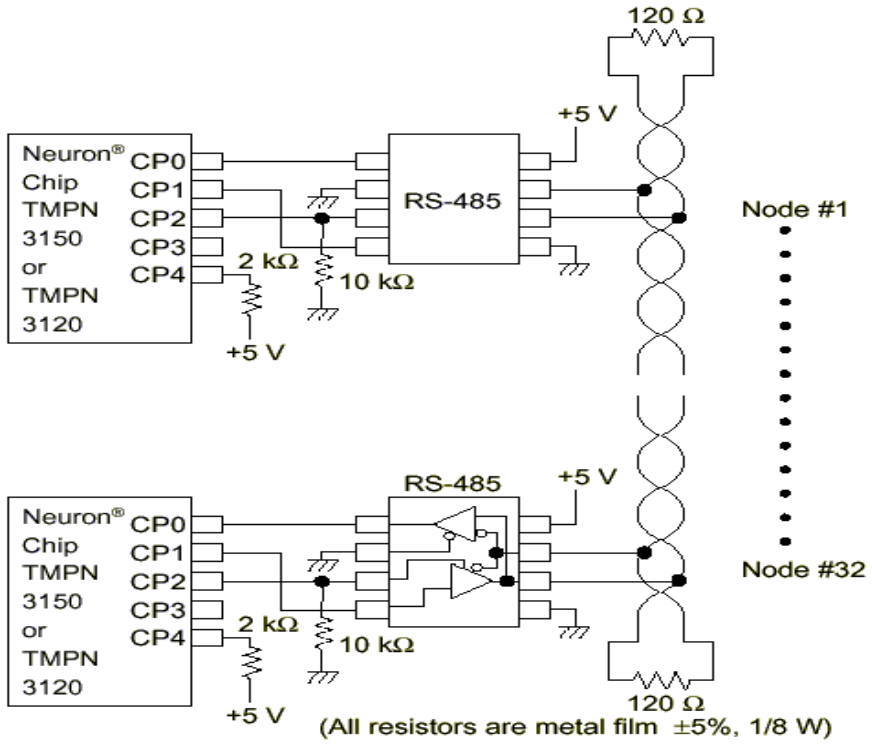
There are 34 different I/O objects available in the 3150 Neuron firmware. Most are available in the 3120 Neuron internal ROM. The additional objects can be loaded into the 3120 EEPROM if needed.

The Neuron has two on-chip 16Bit timer/counters. The input to timer/counter 1, also called the *multiplexed timer/counter,* is selectable among pins IO4 through IO7 via a programmable multiplexer and its output may be connected to pin IO0. The input to timer/counter 2, also called the *dedicated timer/counter,* may be connected to pin IO4 and its output to pin IO1.

5 Transceiver

The Neuron chip provides a very versatile communications port. It consists of five pins that can be configured to interface to a variety of network transceivers and operate over a wide range communication rates. The communications port can be configured to operate in one of three modes: single-ended, differential, or special purpose mode.

The following schematic shows a simple RS485-based network interface between the Neuron chip and the LON using the single ended mode.



*All chips ground level must be within ±7 V.

Opto-isolators can be added to increase the common mode voltage range. EIA-485 transceivers allow for cost performance/size advantages compared to other solutions. Data rates of up to 1.25 Mbps are supported.

Transformer coupled networks work well for applications that require higher performance, high common mode rejection and noise immunity between nodes. Transformer coupled transceiver designs can operate up to 1.25 Mbps and achieve common mode ranges of +/- 277Vrms. The most widely used transformers are the LPT10, FTT10A and the PLT22 which are manufactured by Echelon.

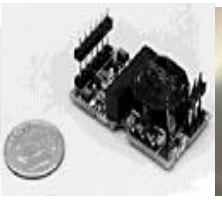
Echelon‘s power line transceiver PLT22 provides a simple and cost-effective method of adding LONWORKS power line technology to any control system. Network data are broadcast through the power mains, eliminating the need for dedicated wiring and greatly reduce wiring costs. The PLT22 transceiver is designed to be used with an OEM‘s own power supply, a custom coupling circuit and a Neuron chip.

Echelon‘s transceivers are designed to directly interface to the communications port of a Neuron chip.

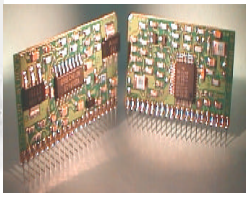
FTT10A

FT3120/50

LPT10



TP/XF1250



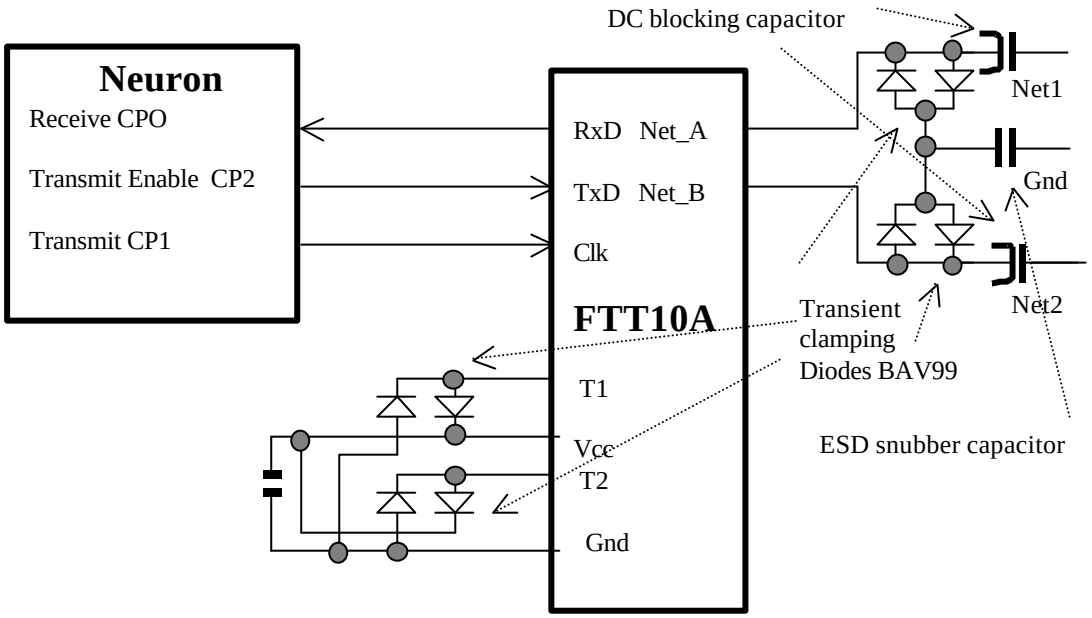
PLT22

78kbit transceiver	**78kbit transceiver**	**78kbit transceiver**	**1.25Mbit transceiver**	**4.8kbit transceiver**
requ. 5VDC power supply	requ. 5VDC power supply	requ. 48VDC “Linkpower” power supply	requ. 5VDC power supply	requ. 5V/9V DC power supply and mains coupling circuitry
supports bus, loop and star topology	supports bus, loop and star topology interoperable with FTT10A and LPT-10	supports bus, loop and star topology interoperable with FTT10A and FT3120/50	supports bus topology	supports bus, loop and star topology

5.1 FTT10A Free Topology Transceiver

Echelons FTT10A transceiver provide many advantages over a RS485 transceiver. Since the FTT10A is basically a transformer that electrically isolates the Neuron chip from the network, thus preventing the Neuron chip or the custom device being damaged due to ESD, cable short circuits or by over-voltage imported from the cabling.

Part of the preferred interconnection between the FTT10A transceiver and a Neuron chip is shown below.



The network connection (NET1 and NET2) is polarity insensitive and therefore either of the two twisted pair wires can be connected to either of these two network connections.

The FTT10A receives its clock input from the Neuron chip. The input clock may be 5, 10 or 20 MHz. It automatically detects the clock rate and configures internal circuitry appropriately.

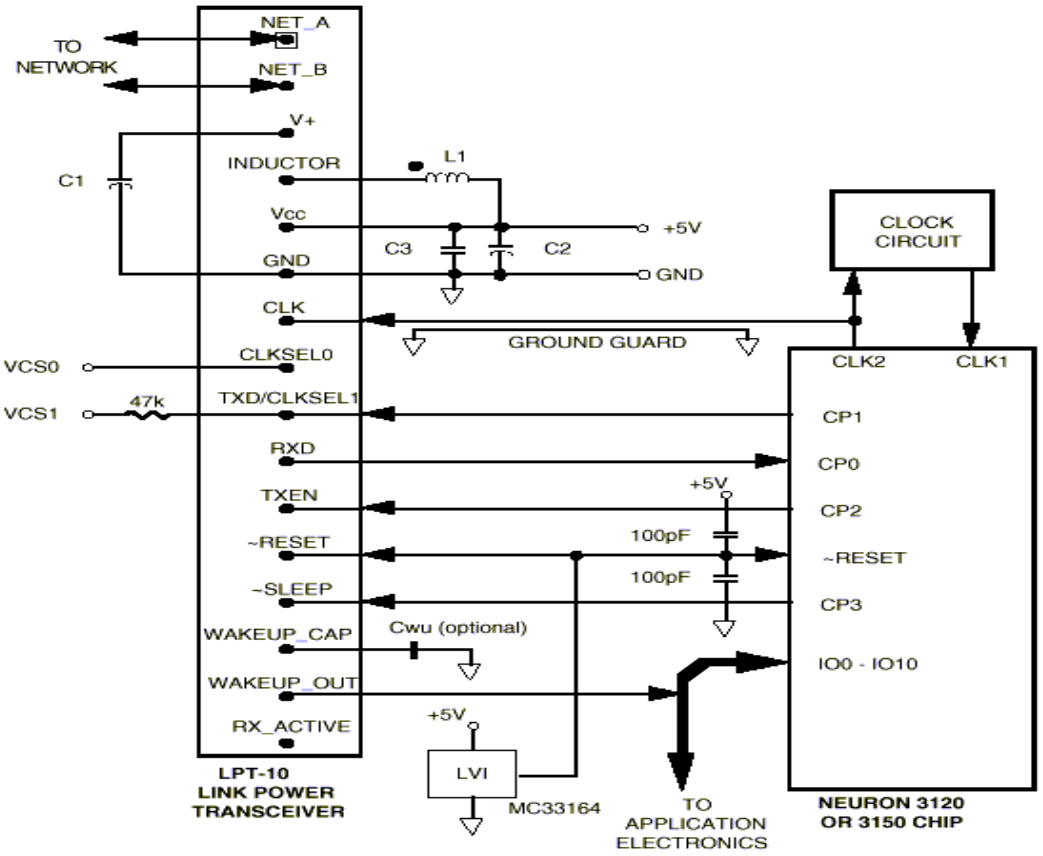
The FTT10A transceiver has a fixed bit transmission rate of 78Kbps. This transceiver allows free topology wiring, which reduces the time and expense of system installation by allowing the wiring to be installed in the most expeditious manner. It also simplifies network expansion by eliminating restrictions on wire routing, splicing, and node replacement.

5.2 LPT-10 Link Power Transceiver

The LPT-10 Link Power Twisted Pair Transceiver combines power and data on a single 2-wire twisted pair cable, and allows the user to wire LPT-10 transceivers with virtually no topology restrictions. The LPT-10 provides a regulated +5VDC@100mA for the node from the power sent via the twisted pair, eliminating the need to use a local power supply.

The LPT10 is compatible with the FTT10A and these transceivers can communicate with each other on a single twisted pair cable.

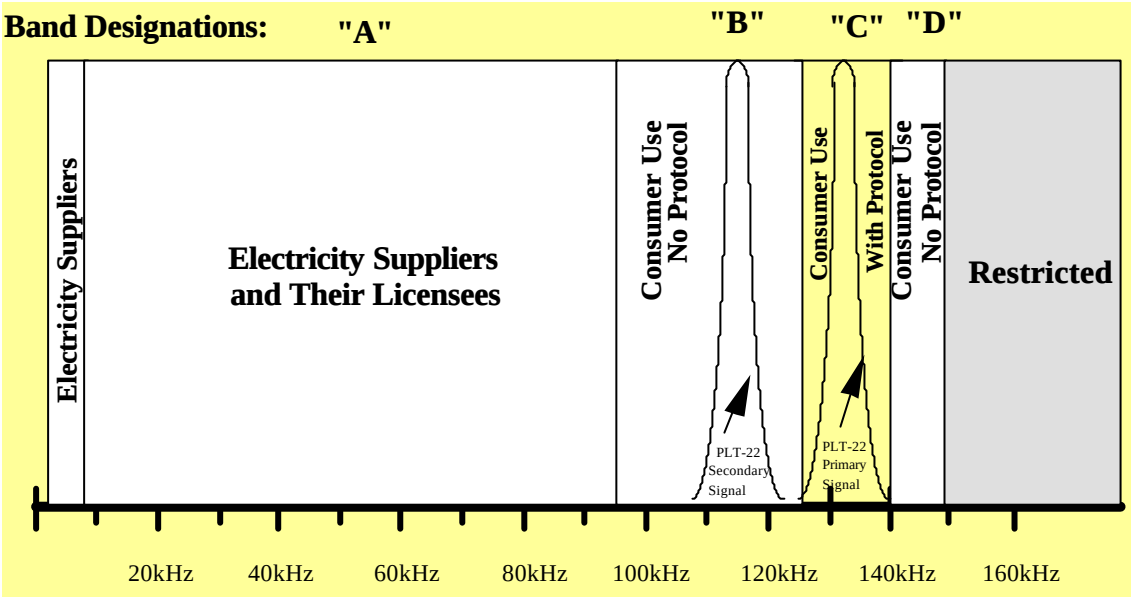
The following drawing shows the typical LPT-10 to Neuron interface:



5.3 PLT-22 Powerline Transceiver (EIA 709.2-A-2000 Standard)

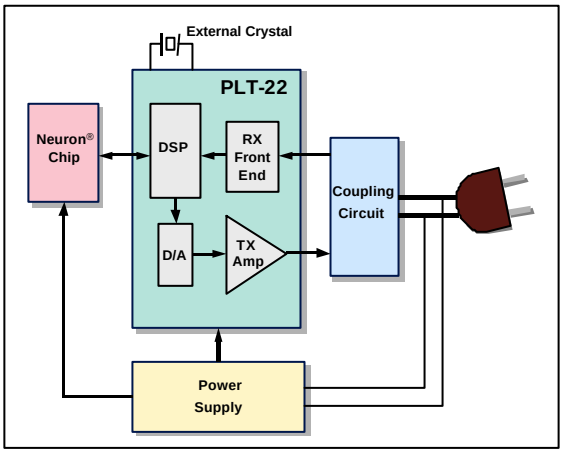
The PLT-22 is designed for all building, home, industrial, and demand side management signaling applications worldwide.

The PLT-22 is drop-in compatible with its predecessors PLT-20 and PLT-21. It is the only commercially available power line communications device that complies with the Ministry of Post and Telecommunications (Japan), FCC (US) Industry Canada (Canada, CEN (Europe) and ANSI regulations for applications worldwide.



CENELEC frequency allocation

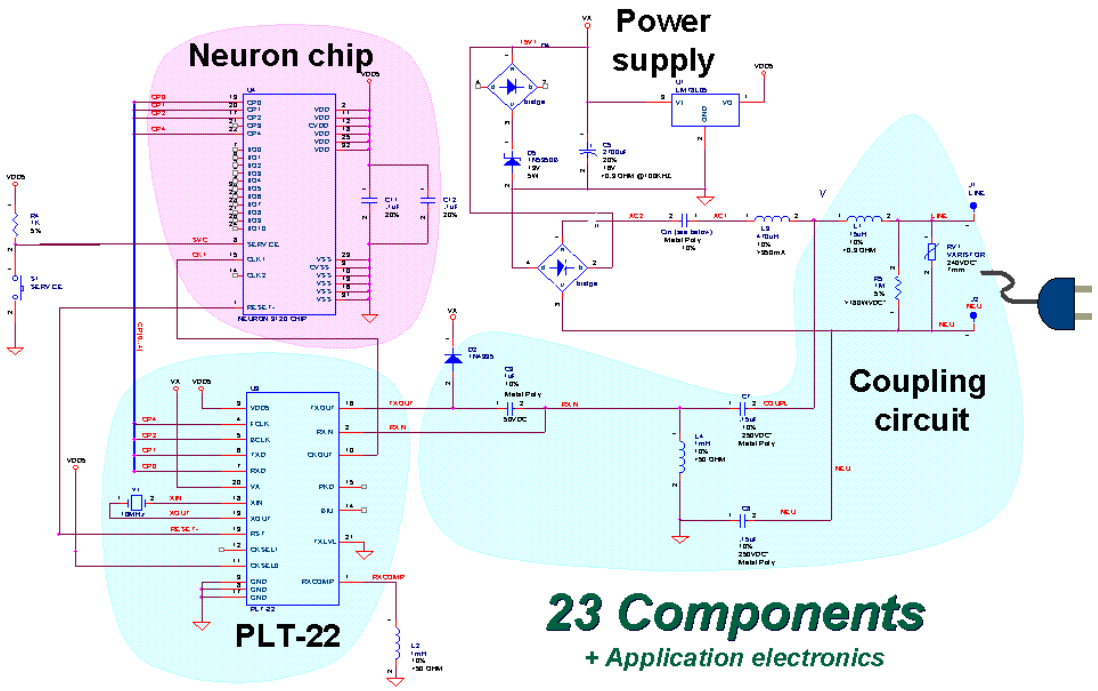
The PLT-22 transceiver with its DSP+ digital signal processing is a miniature Single In-Line (SIP) Pack-age containing Echelon's narrow band power line integrated circuits, receive front end, and transmitter amplifier and filter.



This transceiver complies with both FCC and European CENELEC EN50065-1 regulations for signaling in the 125kHz to 140kHz line frequency band, and implements the CENELEC access protocol that allows in the 125kHz to 140kHz line frequency band, and implements the

CENELEC compatible access protocol that allows multiple power line devices from different manufacturers to operate on a common mains circuit.

The following picture shows a typical, non-isolated interface between a NEURON chip and the mains power



5.4 FT31 series Free Topology Transceiver

The FT 3120 combines a Neuron chip core, 4K bytes of Flash for application code, 2K bytes of RAM and 12K bytes of ROM, and an enhanced free topology transceiver.

The FT3120 and FT3150 are supplied with a patented external communication transformer that enables operation in the presence of high frequency common mode noise on unshielded twisted pair networks. Properly designed nodes can meet the rigorous Level 3 of EN 61000-4-6 requirements without then need for a network isolation choke.

Ideal for use in sensors, actuators, switches, lamps, and motors, the FT 3120 operates at up to 40MHz and is offered in both a 32- lead SOIC package and a compact 44-lead TQFP package.

The FT 3120 device can be programmed by an extensive range of off-the-shelf universal device programmers from major program-ming equipment vendors.

The FT 3150 combines a Neuron chip core, an external memory bus that addresses up to 58K bytes of external memory, and an enhanced free topology transceiver.

Ideal for use in devices with larger application programs or more input/output (I/O), the FT 3150 operates at up to 20MHz and is offered in a 64-lead TQFP package.

The FT3120 is pin compatible with the Neuron 3120 chips while the FT3150 is pin compatible with the Neuron 3150 chips from Motorola and Toshiba.

Samples of the FT 3120 and FT 3150 will be available in May 2001, with volume production scheduled for August 2001.

Product number	Max.Frequ. (MHz)	Flash (bytes) on chip	RAM (Kb) On chip	ROM (Kb) On chip	External memory	IC package type
FT3120-F4S40	40	4094	2	12	No	SOIC32
FT3120-F4P40	40	4096	2	12	No	TQFP44
FT3150-P20	20	512	2	N/A	Yes	TQFP64

6 The LonTalk Protocol (EIA 709.1 Standard)

The Neuron chip implements a complete networking protocol using the media access CPU and the network CPU. This networking protocol is designed according to the ISO OSI reference model for network protocols. It allows programs running on the application CPU to communicate with applications running on other Neuron chip nodes elsewhere on the same network. The protocol services are invoked by application level objects called network variables and explicit messages.

The main features of the LonTalk protocol are:

multiple media support:

- twisted pair, transformer coupled, power-line, RF, COAX, infrared, fibre optic and others.

support for multiple communications channels:

- a channel is a physical transport medium for data telegrams (packets) and can contain up to 32.385 nodes. A network may consist of one or more channels. Packets are transferred from one channel to another by using routers.

The next table resumes the services and functions provided by the 7 layers of the LonTalk protocol.

OSI Layer	Purpose	Services
Application	Application Program	Standard objects & types, config props, file xfer, network services
Presentation	Data Interpretation	Network variables, application messages, foreign frames
Session	Remote Actions	Dialog, remote procedure calls, connection recovery
Transport	End-to-End Reliability	End-to-End acks, service type, pkt sequencing, duplicate detect
Network	Destination Addressing	Unicast & multicast, destination addressing, packet routing
Data Link	Media Access & Framing	Framing, data encoding, CRC, media access, collision detect
Physical	Electrical Interconnect	Media specific details, xceiver type, physical connect

Nodes talk to each other by sending messages. The message concept is used to even transport data which the application program refers to as network variables.

The LonTalk protocol offers four basic types of message service:

- *Acknowledged* (or end-to-end acknowledged) service: a message is sent to a node or a group of nodes and individual. Acknowledgements are expected from each receiver. If an acknowledgement is not received from all destinations, the sender times out and re-tries the transaction. The number of re-tries and the time-out are both selectable. The acknowledgements are automatically generated by the network CPU. Transactions Ids are used to keep track of messages and acknowledgements so that the application does not receive duplicate messages.

- *Request/response* service is used to send a message to a node or a group of nodes from which individual responses are expected. The incoming message is 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. Response data may include data, so that this service is particularly suitable for remote procedure calls, or client/server applications.

- *Repeated* (or unacknowledged repeated) service sends a message to a node or group of nodes multiple times, and does not expect a response from the receiving nodes. This service is typically used when broadcasting to large groups of nodes, in which the traffic generated by all the responses would overload the network.

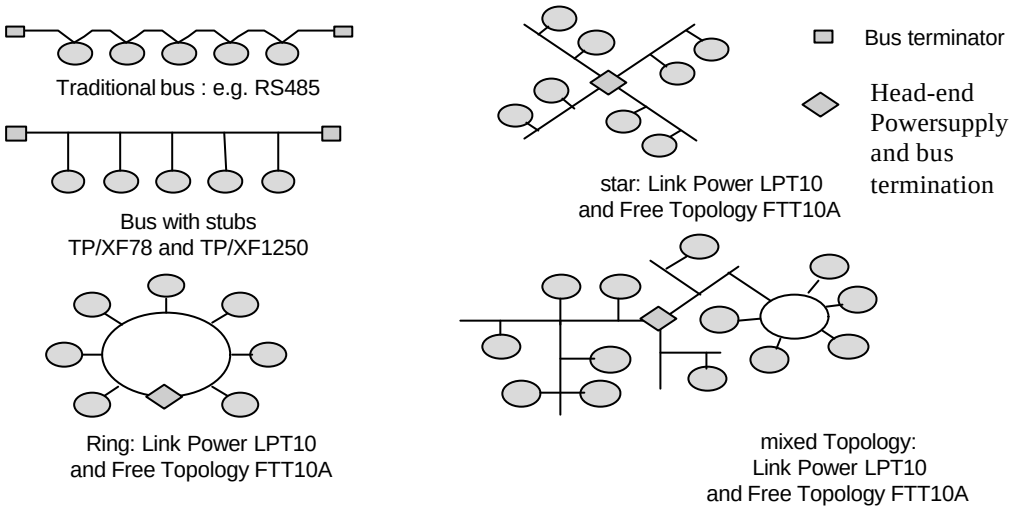
- *Unacknowledged* service sends a message to a node or a group of nodes once and does not expect a response. This service is typically used when highest network performance is required, when network bandwith is limited or when the application is not sensitive to the loss of a message.

The LonTalk protocol also supports authenticated messages; the receiver of an authenticated message checks if the sender is authorized to send that message. This method prevent unauthorized access to nodes or their applications. The use of authentification is configured individually for each network variable. Network manage-ment transactions may also be optionally authentificated.

7 Bus Topologies

LONWORKS provides support for multiple communications channels. A channel is a physical transport medium for data telegrams (packets) and can contain up to 32.385 nodes. A network may consist of one or more channels. Packets are transferred from on channel to another by using routers.

LONWORKS supports bus, loop and star topologies. The design of the transceiver determines the number of nodes in one channel as well as the maximum transmission distance between nodes in one channel.



The following table lists the characteristics of some frequently used transceiver:

Transceiver Product name	Network speed	Bus topology	Nodes per channel	Distance between nodes	Type of Isolation from Neuron	Typical Application fields
RS485	<= 1Mbps	Line	32	1400m	custom	Ind.
TP/XF1250	1.25Mbps	Line	64	130m	transformer	Ind. & Build.
TP/XF78	78kbps	Line	64	1400m	transformer	Ind. & Build.
FTT10A	78kbps	Line	64	2700m	transformer	Ind. & Build.
FTT10A	78kbps	Free	64	500m	transformer	Ind. & Build.
LPT10	78kbps	Line	128	2200m	transformer	Ind. & Build.
PLT22	4.8kbps	Free	varies	Up to 5km	custom	varies

8 Network Addressing

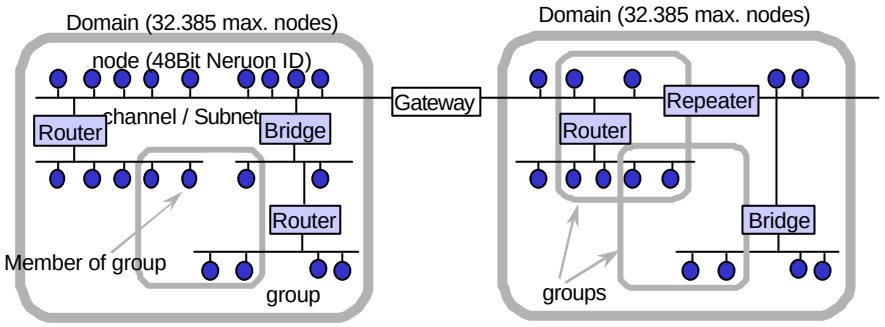
LONWORKS uses an efficient 3-level addressing hierarchy to identify nodes in a network.

The 1st level addressing of the hierarchy is the domain. The domain identifier has a selectable length of 0,1,3 or 6 bytes. A single node can be a member of up to two domains.

The 2nd level of addressing is the subnet. There may be up to 255 subnets per domain. A subnet is a logical grouping of nodes from one or more channels. Routers operate at the subnet level, determines which subnet lie on which side of it and forward packets accordingly.

The 3rd level of addressing is the node. There may be up to 127 nodes per subnet. Thus a maximum of 255 x 127 = 32.385 nodes may reside in a single domain. Any node may be a member of one or two domains, allowing a node to serve as an inter-domain gateway. This also allows, e.g., a single sensor node to transmit its data into two different domains.

Nodes may also be grouped. Groups of nodes may span several subnets within a domain. The channel does not affect the way a node is addressed. Domains can contain several channels. Subnets and groups of nodes may also span several channels.



Router: selectively forwards packets between two channels of same or different physical media. (e.g. RS485 to FTT10A).

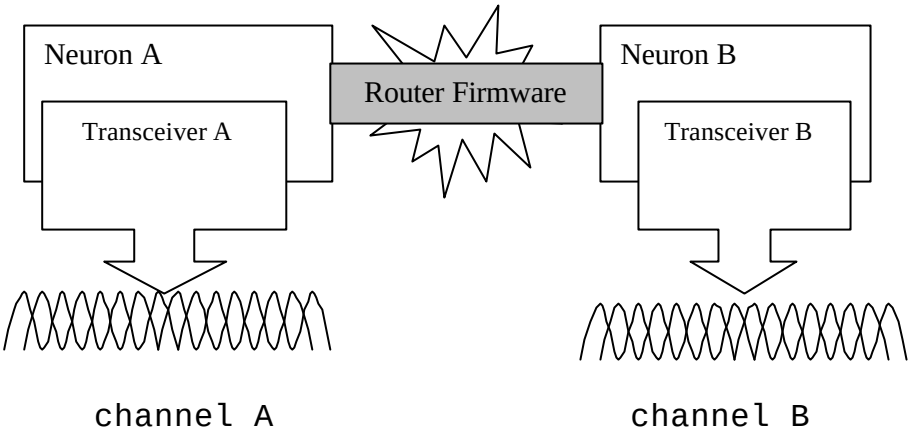
Repeater: forwards all packets between two channel of same phy. media. (e.g. RS485 to RS485, FTT10A to FTT10A).

Gateway: connects one channel in the 1st domain to another channel in the 2nd domain.

Bridge: forwards all packets between two channels of same or different physical media. (e.g. FTT10A to FTT10A). Both channels must reside in the same domain.

9 Router

A LONWORKS router basically consists of two Neuron chips and two transceivers. Both Neuron chips communicate with each other via their application port. A copy of the router firmware runs in both Neuron chips and forward packets from one channel to another channel controlled by routing tables. These tables are either pre-programmed during network configuration/installation or configured to be self-learning.



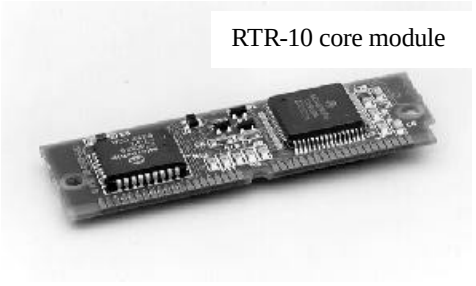
Routers are used to optimise packet traffic on channels. Packets generated on one channel are selectively forwarded to another channel if the packet contains address information referencing the receiver channel.

Routers can also be configured to operate as bus repeaters. This application mode is especially useful where the distance between nodes exceeds the constraints specified by the transceiver designer.

Echelon offers both ready-to-use router (model LPR-10) and router core OEM module (model RTR-10). The LPR-10 is available with FTT10A, TP/XF78 and TP/XF1250 transceivers. The RTR-10 SIP module only needs two external transceivers to build a custom router.

Routers are configured at system set-up/installation time.

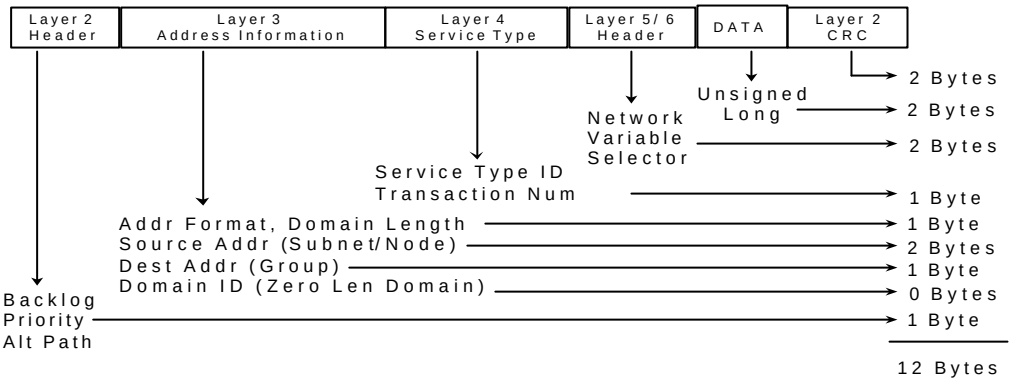

LonPoint LPR-10
Router module


RTR-10 core module

10 LonTalk Packets

LonTalk nodes communicate with each other by sending and receiving data telegrams that carries many types of information needed to operate the control network in a reliable and consistent way.

The following table details the individual components of a LonTalk protocol telegram frame:



The data field may be up to 228 bytes long. The domain ID field may be 0, 1, 3 or 6 bytes long. In general, the protocol overhead is of constant length of 10 bytes.

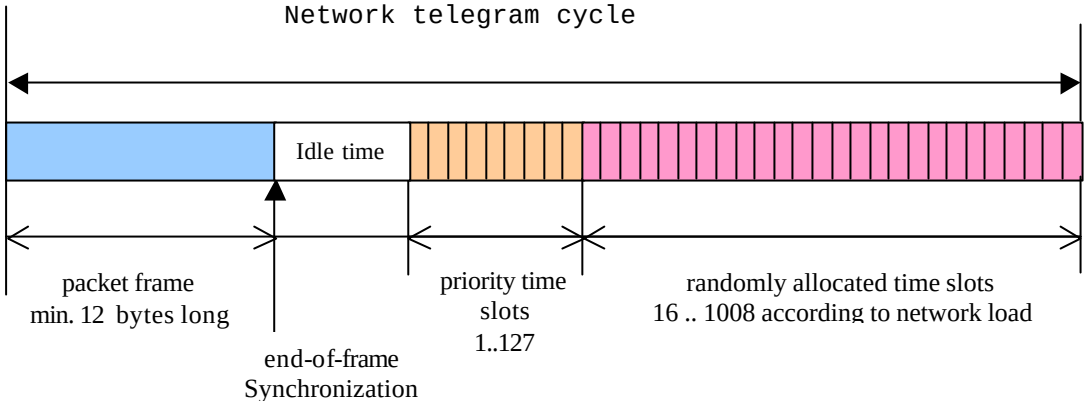
The frame handling is done by the media access CPU and the network CPU. The application program only have to provide the content of the DATA field. This content is referenced within the application program either as a *network variable* or a *message field.*

The following table summarizes the channel throughput capability measured for a 10MHz clocked 3150 Neuron using a direct connect transceiver sending 12 Bytes long telegrams:

Bitrate in kBd	Channel throughput in packets / second
9,8	100
19,5	192
39,1	337
78,1	410
156,3	508
312,5	615
625	696
1250	1021

11 LonTalk Media Access

The LonTalk firmware provides a CSMA/CA algorithm to manage the transmission of telegram frames. To do so, the media access CPU enters into a bus access phase after the network is in idle state, which is the case when the media access CPU of a sending node has sent the *end-of-frame* synchronization byte.



Each node on a network channel is limited to a single outgoing transaction at a time. The LonTalk protocol implements a mechanism to avoid that access to the network is denied indefinitely. To do so, the time when the transmission of a telegram frame should start is calculated using a randomly generated time slot. This start time calculation can be overridden by assigning a priority time slot to each node on a channel. In this case, all nodes waiting to send a frame would then start sending in the order they have been priorized. The priority feature uses separate buffers within each node allowing outgoing priority packets to get in front of non-priority packets that have already been queued up for transmission. Additionally, the priority feature uses dedicated bandwith at the end of each packet that eliminates contention for the communications medium after the transmission of a packet.

For even higher performance applications, transceivers may be implemented which perform collision resolution by hardware. These transceivers are most useful when the channel bandwith is limited and/or there is a need to run the network at its maximum capacity for a sustained time.

12 Network Variables

A network variable is an object on one node that can be connected to one or more network variables on one or more additional nodes.

A node's network variables define its inputs and outputs from a network point of view and allow sharing of data in a distributed application. Whenever a program writes into one of its ***output network variables***, the new value of the network variable is propagated across the network to all nodes with ***input network variables*** connected to that output network variable. Although the propagation of network variables occurs through LonTalk messages, these messages are sent transparently. The application program does not need explicit instructions for sending and receiving network variable updates.

Network variables greatly simplify the process of developing and installing distributed systems because nodes can be defined individually, then connected and reconnected easily into new LONWORKS applications.

Network variables promote interoperability between nodes by providing a well-defined interface that nodes use to communicate. Interoperability simplifies installation of nodes into different types of networks by keeping the network configuration independent of the node's application. A node may be installed in a network and logically connected to other nodes in the network as long as the data types (e.g. *int* or *long*) match.

To further promote interoperability, the LonTalk protocol provides ***Standard Network Variable Types*** (SNVTs). SNVTs are a set of predefined types with associated units, such as degree C, volts, meters, seconds. The following table shows some of currently defined SNVTs:

Name	Unit	bits	Value range
SNTV_lev_cont	Continous value	8	0..100
SNTV_lev_disc	discrete value	8	On,off,high,low,med
SNTV_temp	Temperature	16	-273,2..+6279,0
SNTV_power	power	16	0..65535
SNTV_date_time	Time HH:MM:SS	24	00:00:00..23:59:59
SNTV_str_asc	ASCII string	248	30 characters

A network management tool can use LonTalk network management messages to determine the type of every network variable declared as a SNVT.

Network variables also provide for *Self-Documentation* (SD), a feature that the application programmer can use to create a text string including a network variable name, special installation instructions, etc. This information is stored with the application program on the node.

Network variables are first declared within the program that runs on an individual Neuron chip. The complete syntax for declaring a network variable object is one of the following:
/see section 26 for additional literature/

```
network input|output [netvar-modifier][class] type
     [connection info] identifier [=initial value];

network input|output [netvar-modifier][class] type
     [connection info] array-bound [=initializer list];
```

Up to 62 network variables (including array elements) may be declared on a node in a Neuron C program. Up to 4096 network variables can be declared when using a LONWORKS network interface connected to a host processor.

The maximum size of a network variable is 31 bytes. In the case of a network variable array, each element is limited to a size of 31 bytes.

Examples of network variable:

```
network input SNVT_temp temp_set_point;
network output SNVT_lev_disc heater_command;
network output int current_temp;
```

Examples of priority network variable:

```
network output boolean bind_info(priority)
           fire_alarm;
network output boolean bind_info(priority(nonconfig))
          fire_alarm;
```

Example of network variable using unacknowledged service:

```
network input SNVT_lev_cont bind_info(unackd)
           control_dial;
```

13 Explicit Messages and Foreign Frames

Applications requiring a different data interpretation model than the network variable concept is offering can send and receive explicit messages. Explicit messages use the messaging services of the LonTalk protocol with minimal data interpretation. Each explicit message contains a message code that the application can use to determine the type of interpretation to be used on the content of the message.

For Neuron hosted nodes, explicit messages are transmitted by assigning the message code and message contents to a special output object used for transmitting explicit messages. Explicit messages are received in another special input object that contains the message code and contents.

A special range of message codes is reserved for foreign frame transmission. Up to 228 bytes of data may be embedded in a message packet and transmitted like any other message. The LonTalk protocol applies no special processing to foreign frames – they are treated as a simple array of bytes. The application program may interpret the data in the way it wishes.

Foreign frame messages are sent and received by both Neuron chip-hosted nodes and host-based nodes using the same techniques as explicit messages, except that a different range of message codes is used.

An outgoing message is defined in the Neuron C program as follows:

```
typedef enum{FALSE,TRUE} boolean;
typedef enum{ackd,unackd_RPT,UNACKD,REQUEST} service_type;

struct { boolean priority_on;     // TRUE if priority message
         msg_tag tag;             // message tag identifier
         int code;                // message code
         int data[MAXDATA];       // message data 0..228 bytes
         boolean authenticated;   // TRUE to be authenticated
         service_type service;    // default ACKD
         msg_out_addr dest_addr;  // optional dest. address
       } msg_out;
```

14 Network Management Messages

In addition to application message services, the LonTalk protocol provides network management services for installation and configuration of nodes, downloading of application programs, and diagnosis of the network.

A system may be configured so that critical network management messages are subject to authentification pro-tection. This means that only authorized network manager nodes may execute these functions. Some of the available network management messages are listed below:

- The ***request-to-query*** message is designed for use during installation when unconfigured nodes are asked to identify themselves.

- The ***security*** message is used to transmit incremental changes in the authentification key over the network. The key itself is never transmitted, thus protecting the authentification scheme against misuse.

- The ***modify-address-table*** message and ***modify-net-variable*** messages may be used to dynamically bind network variables and message tags. This is used during installation and reconfiguration to estab-lish the addressing information needed to route message and network variable updates between nodes.

- The ***write-memory*** message may be used to download a new application program into a node over the network.

- The ***wink*** message is used during installation to instruct nodes to identify themselves physically (e.g. by flashing a LED indicator)

- The ***service-pin*** message is an unsolicited message used during installation so that a node may identify itself on the network by sending its unique 48Bit Neuron ID.

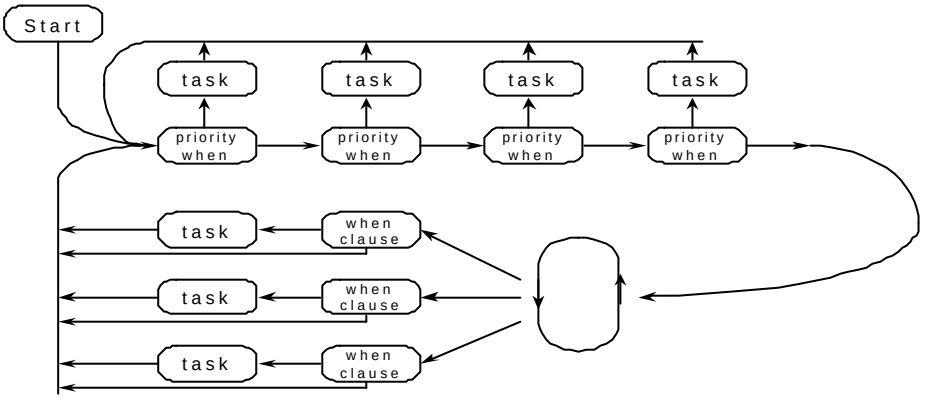
15 Neuron C Programming

Neuron chips are programmed using the Neuron C language. The Neuron chip can not be programmed in assembler.

A Neuron C program is composed of a collection of tasks. A task consists of the special syntax *when* followed by the body of that task.

```
[priority] when (condition)
{
     < task body>
}
```

Tasks may run on either of two priority levels: *normal* or *priority*. The task scheduler provided with the LonTalk firmware executes the task if the *condition* is met.



task scheduler for when statements

The Neuron C language syntax supports different classes of events, which are expressed by the *condition* clause.

IO event	A transition at IOx pin occured A HW-timer has terminated.
Communication event	A network variable or message update occured.
Software timer event	A network communication time-out occured. One of the 15 S/W- 16Bit timer has expired.
Special event	The Neuron chip has changed its state. (e.g. RESET, ONLINE, OFFLINE etc.) A network manage-ment message was received.
User defined events	Every programmed C expression which evaluates > 0.

The use of any of the 11 pins of the Neuron chip must be declared as an IO object in the program before that IO pin can be controlled within the application program.

e.g.
```
IO_4 input bit switch;  // IO object declaration
when (io_update_occurs(switch))
{
      status = io_in(switch);
}
```

The primary communication mechanism of LonTalk nodes are network variables. These variables transport values which a program can either read or write. The name of a network variable must be declared as an communication object in the program before it can be used.

The following code segments illustrates some program syntax available with Neuron C:

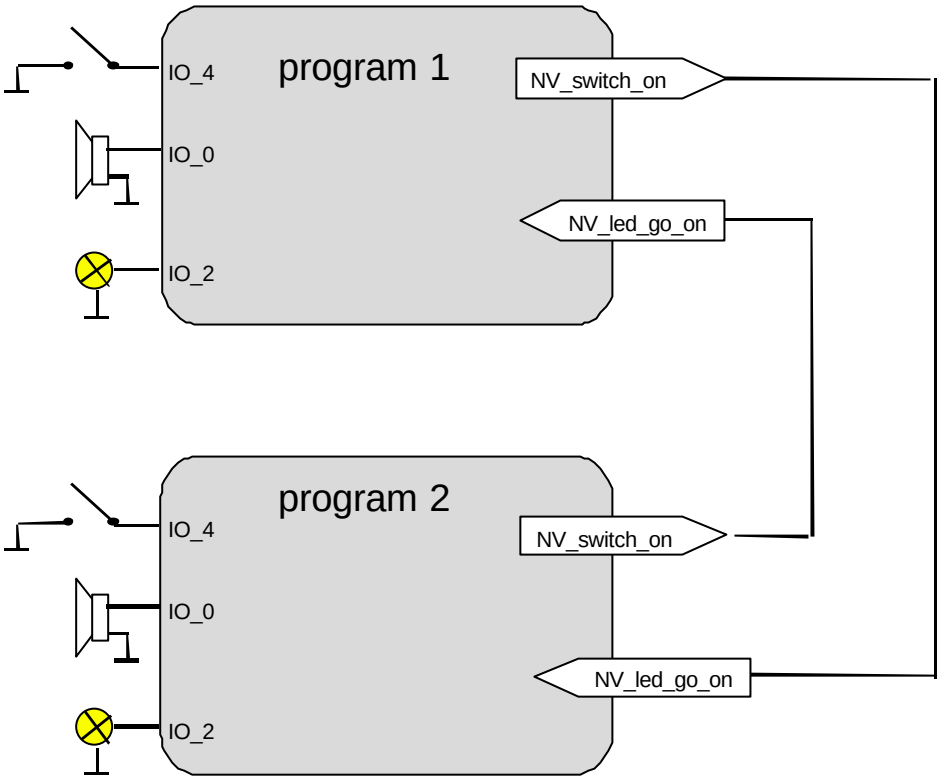
```
// program 1
// outputs the status of switch in a network variable
// to turn on the LED controlled by program 2

IO_4 input bit switch;  // IO object declaration
Int status;             // local variable
network output int led_go_on; // network variable declar.
when (io_update_occurs(switch))
{
      status = io_in(switch); // read data from IO_4
      led_go_on  = status;    // update network variable
}

// program 2
IO_2 output bit led;    // IO object declaration
network input int switch_on; // network variable declar.
when (nv_update_occurs(switch_on)) // NV was updated
{
      io_out(led,switch_on); // use NV value
}
```

Note that the application program does not establish the communication links between individual network variables.

LONWORKS sharply distinguish between the programming of a node and its installation in the network. The program stored in the node only provides a S/W interface to the network.

The communication links between individual variables of different nodes are created on-site, at network installa-tion time. The process of creating the communication links between nodes is called *binding*.

The graphical representation of the above program is given by the following picture:



In order for both nodes to communicate, the network variables must be connected together using a network management tool /see section 22/. The network management tool is also needed to identify both nodes by sending network management messages to the nodes which would themselve reply by sending their Neuron ID‘.

Using this ID and a device installation table which maps the Neuron ID to a user-selected 3-level address scheme /see section 8/, the network management tool can than set up the Neuron‘s internal configuration.

The network variable selector entry stored in the EEProm-table in the Neuron chip is used to reference the name of an individual network variable. It is this selector which is actually transmitted in the packet /see section 10/ when a network variable is updated.

16 LonMark Compliancy

The LonMark association is an independent member organization of producers, consumers and consultants of LONWORKS-based products and services. The LonMark association specifies and publishes recommendations and S/W implementation guidelines describing the operating modes of devices and services by means of objects and functional profiles.

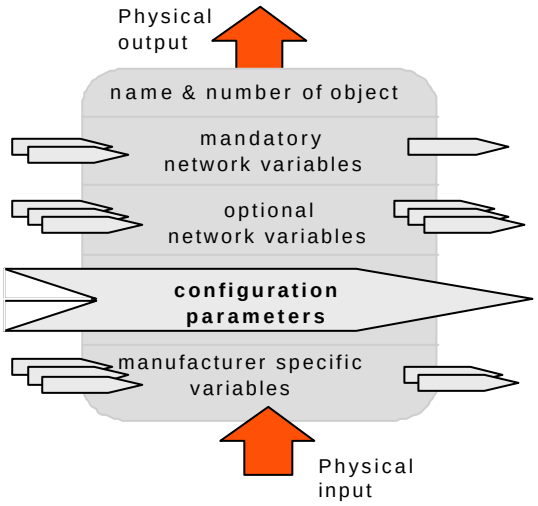
Functional profiles are prototype representations of devices which functionality can be described by generic objects such as actor, sensor and controller.

LonMark objects form the base of interoperability at the OSI application layer level. The LonMark objects describe standard formats for how information is input and/or output from a node and shared with other nodes on the network.

LonMark objects are defined as a set of one or more standard network variables /see section 12/ with semantic definitions relating the behaviour of the object to the network variable values, in addition to a set of configuration properties.

To provide for future expansion and to enable manufac-turer differentiation, the LonMark object definitions comprise both mandatory and optional network variables as well as configuration sections.

The following picture shows the graphical representation of a prototype model for a node‘s application layer interface.



17 LonBuilderÒ Development System

The LonBuilder developer‘s Workbench is an integrated H/W and S/W development environment which combines three development tools:

- o a multi-node development system
- o a network manager
- o a LonTalk protocol analyser.

The network manager installs and configures nodes during development, making them easy to define, build and bind. The protocol analyser monitors the network and interprets its activity.

The LonBuilder development workbench contains the following H/W components:

High-speed ISA-bus/Network Control Station interface and cable

PC interface card with removable transceiver and network management F/W. (NSI compatible)

Two emulator units with Neuron 3150/10MHz with 64 KB emulation RAM and removable transceivers.

One network management unit with removable transceivers.

One Router unit with removable transceivers. (PLT-22 versions only)

I/O application board to evaluate the Neuron IO models.

The LonBuilder development workbench contains the following S/W tools:

Neuron C Compiler (edit-compile-go)

Neuron C multi-node source code debugger

application builder (loader)

network variable and message tag binder

network driver library for various Echelon OEM products (router, gateways, interfaces etc.)

Windows 16Bit DDE server

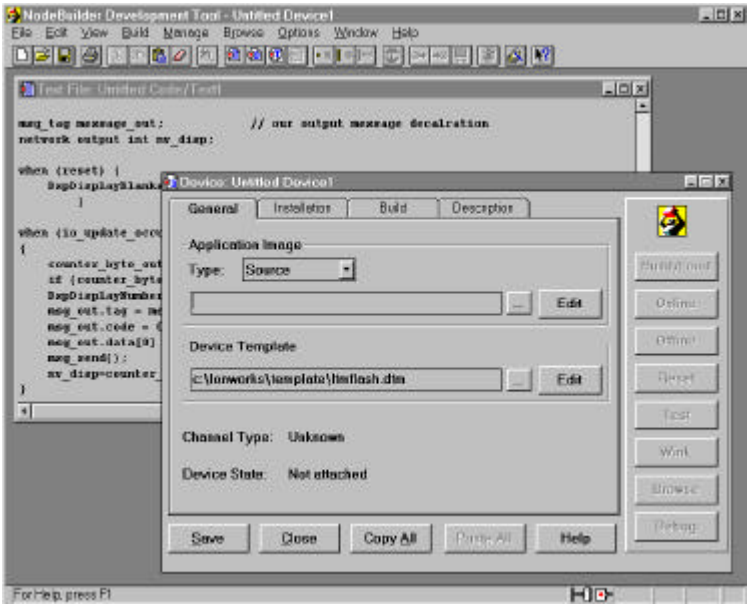
LonTalk protocol analyser

18 NodeBuilderÒ Development System

The NodeBuilder Developer's Workbench is an integrated single-node low-cost* development system (without network manager S/W and protocol analyser). The S/W tools supplied with the NodeBuilder include:

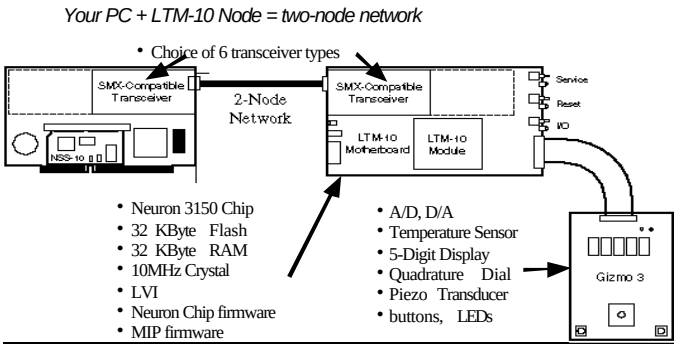
- Neuron C Compiler (edit-compile-go)
- Neuron C single-node source code debugger
- Network variables and message browser
- application builder and program loader
- Windows® 16Bit DDE server S/W
- Node configuration utility

Nodebuilder H/W
(Monitor not supplied)



Screen shot of the NodeBuilder's multi-window environment

The NodeBuilder editor also include a code generator wizard that help the programmer to structure its application program according to the LonMark interoperability guidelines /see section 16/.



H/W components included in NodeBuilder:

ISAbus PC interface and emulation node with two SMX transceivers

(SMX transceivers options: FTM10, TP/XF1520, RS485 PL-22)

*) requires separate network management software (e.g. LonMaker for Windows) to install nodes into a LonWorks network und bind variables.

19 EBV HOSS-200 Evaluation Kit

The HOSS-200 (**H**ands **O**n **S**tarter **S**et) is designed to provide an easy-to-handle evaluation tool for the LONWORKS technology. The hardware is implemented as a three-node network using prototype nodes populated with Neuron chip, 32KBytes flash memory, FTT10A transceivers, overvoltage protected I/O circuitry and two I/O evaluation boards. The user may connect its own peri-pherals to the IO connector provided on each node.

For installation, configuration and management purposes the network can be connected to any Windows-95 based host computer using the PCC-10 LonTalk adapter (PCMCIA-II interface), supplied with the HOSS-200.

The user can download compiled application programs into selected nodes, manage these nodes and bind network variables that are declared in these nodes.

The HOSS-200 provides a Windows-9x based GUI* that let the user:

- find a node connected to the network
- manage a node (Reset, Online, Offline etc.)
- download an application program into nodes
- bind network variables and message tags
- change value of network variables and messages
- install user-supplied routers

In addition to the above node management SW, the HOSS-200 also provides a Windows-9x compatible 32-Bit DDE server software to monitor the 3-node-network using 3rd party SCADA S/W. This S/W is an evaluation version of Echelon's LNS DDE server. /see section 23/

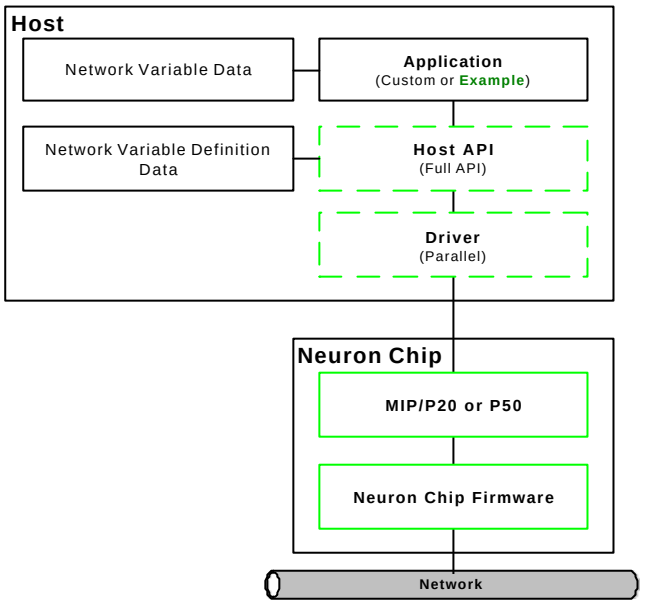
The HOSS-200 is an ideal extension o
the NodeBuilder development syste
The combi-nation of both tools give
the application designer and/or pr
grammer a versatile multi-no
workbench needed to create applicati
programs, install nodes, bind netwo
variables and deploy the network.

*) **GUI** **G**raphical **U**ser **I**nterface restricted to work with 4 nodes

20 MIP - Microprocessor Interface Program

The Microprocessor Interface Program (MIP) is a firmware library that transforms the Neuron chip into a communi-cations coprocessor for an attached host processor. MIP is recommended to implement complex application SW that is too large to run on a Neuron chip, or applications that already run on other host processors.

The MIP moves the upper layers of the LonTalk protocol from the Neuron chip to the attached host, extending the reach of LONWORKS technology to a variety of hosts including PCs, workstations, embedded controllers and µControllers.



MIP is delivered as an API package called MIP developer's Kit. It contains a Neuron C library that extends the LonBuilder or NodeBuilder software to include system calls for the MIP. The LonBuilder or NodeBuilder develop-ment system is needed to create a ROM image which executes on a Neuron chip.

MIP also includes a sample host application which illustrates how a host can send and receive network variables and explicit messages using the supplied network driver.

Using MIP, any host processor can handle up to 4096 network variables. The algorithm which map network variables into host addressable variables is included in the SW package.

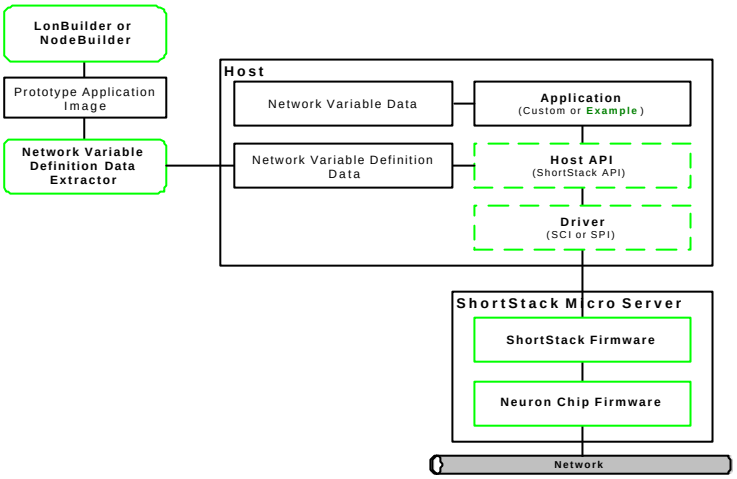
MIP provides a full network management and explicite message addressing support.

21 ShortStack Micro Server

The ShortStack Micro Server is a software that enables any microcontroller based hardware platform to quickly and inexpensively become a networked, Internet-accessible device.

Limited only by the imagination, the type of device can range from simple home appliances, thermostats, and security systems to sophisticated factory-floor or building control equipment.

ShortStack Application Architecture



By leveraging the existing 8, 16, or 32-bit microcontroller and software inside a device and adding only a tiny amount (less than 2.5K) of additional code, Echelon's ShortStack™ software enables manufacturers to add substantial new functionality to their products while preserving their past development investment. With ShortStack software, devices can communicate with other smart devices over the Internet and across LonWorks® networks

ShortStack software is delivered as a developer's Kit. It contains ANSI C source code for the ShortStack API, a SW driver, an example application and documentation.

The software is royalty-free for developers when used with Echelon's FTT-10, FT31xx or PLT-22 transceivers.

ShortStack provides a limited network management support and can handle up to 62 network variables. It also provide support for defining network variables.

22 LonTalk Adapter

Host processor interfaces are frequently called LonTalk adapters. Such an interface provides, together with the processing power of the host, additional features and functionality to the host. Echelon offers both H/W and S/W products to built custom LonTalk adapters.

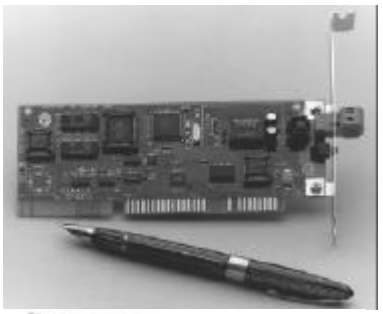
For networks with 62 nodes or less, *NSS-10's* are available. The NSS-10 is a miniature SIM that is embedded within an OEM's product along with an attached µController. The host treats the NSS-10 module as an intelligent peripheral device that provides both the H/W and the S/W resources needed to enable network management services. The NSS-10 OEM license from Echelon allows developers to build custom NSS H/W with built-in NSS-10 functionality.

A NSI interface can be used to address all nodes in one domain (max. 32385 nodes). The NSI also provides FW to access the services provided by an LNS server /see section 24/ , which is used to configure all devices on a network and maintain a directory of available devices and services on the network. NSIs are typically provided in operator interface panels, system monitors, data loggers, gateways, installation tools, maintenance tools and diagnostic tools.

The most widely used LonTalk interfaces are:

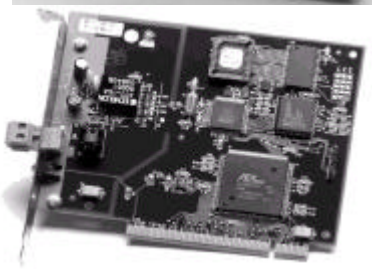
Product	Transceiver	Host system	driver S/W	features
PCLTA-10	FTT10A,TP78, TP1250	ISA-Bus	WIN Emulate DOS	Downloadable F/W NSI support
PCLTA-20	FTT10A,TP78, TP1250 or RS485	PCI-Bus	WIN Emulate DOS	Downloadable F/W NSI support
SLTA-10	FTT10A,TP78, TP1250 or RS485	RS232	WIN Emulate DOS	Downloadable F/W NSI support
PCC-10	FTT10A	PCCard	DOS,WIN	Downloadable F/W NSI support
NSS-10	User supplied	Any 8 Bit µController	Custom, User supplied	Includes on-borad Network mngnt F/W No NSI support
NSI-10	User supplied	Any 8 Bit µController	Custom, User supplied	Includes on-board Network mngnt F/W NSI support
PSG-20	User supplied	RS232	Custom, User supplied	Custom F/W can be implemented No NSI support
PSG-3	FTT10A,TP78, TP1250 or RS485	RS232	Custom, User supplied	Custom F/W can be implemented No NSI support

Beside the product choice offered by Echelon, a wide variety of 3rd part products is available, allowing LONWORKS networks to be accessed from hosts whose interface H/W is either a bi-directional printer port, VMEbus, USB, PC/104, Ethernet, etc.



The PCLTA-10 interface for use on ISAbus PCs is available with FTT10A or TP/XF1250 (1.25Mbps) transceivers.

The PCLTA-10 is NSI compatible.



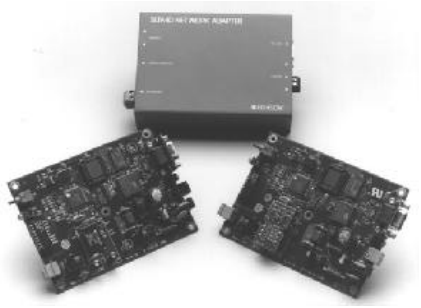
The PCLTA-20 interface for use on PCIbus PCs is available with FTT10A ,TP/XF1250 or RS485 transceivers.

The PCLTA-20 is NSI compatible

The LonDongle (3rd party product) provides an NSI compatible interface for FTT10A-based networks.

The LonDongle interfaces to the PC or Laptop via the bidirectional printer port. The printer port is a transparent function of the LonDongle.

The PCC-10 is an NSI-compatible LonTalk interface with integrated FTT10A transceiver. The PCC-10 plugs into an PCCard slot. Optionally available connection pods allows interface of custom transceivers like TP/XF1250, PLT-22, infrared, COAX etc.



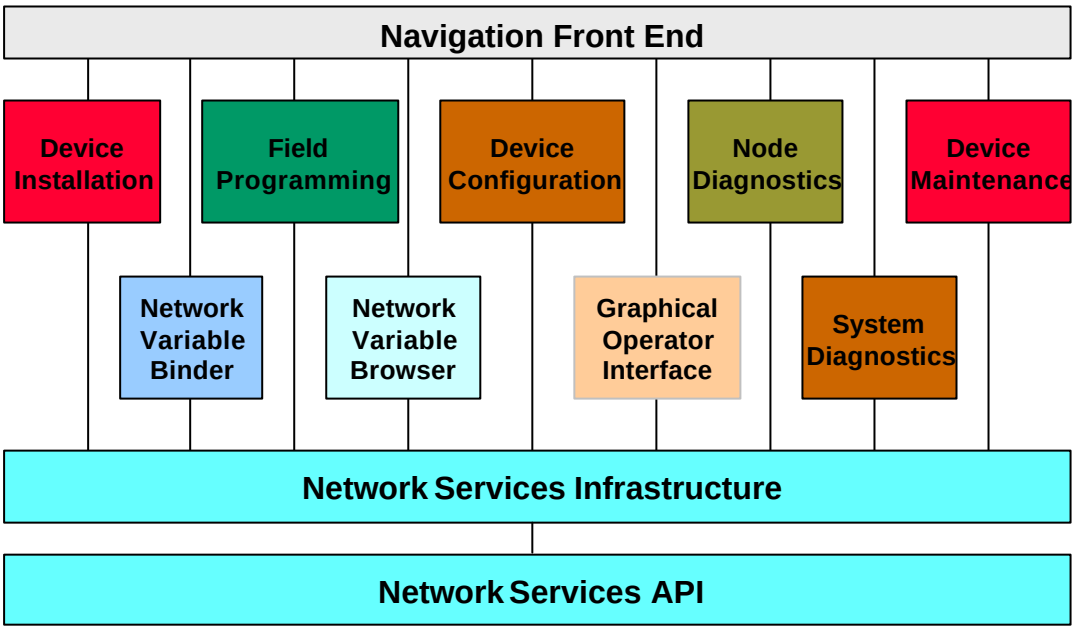
The SLTA-10 is a NSI-compatible LonTalk adapter with a RS232 interface to the host computer.

The SLTA-10 is available with either FTT10A or TP/XF1250 transceiver.

The RS232 interface supports baud rates of up to 115kbps.

23 LNS - LONWORKS Network Service

LNS is a network operating system for LONWORKS networks. It provides the essential directory, installation, management, monitoring and control services needed to efficiently master complex LONWORKS networks.



LNS provides a compact, object-oriented programming model that reduces development time, host code space, and host processing requirements. LNS represent the network as a hierarchy of objects that provide a set of services, contain a number of properties, and that report changes with events. To simplify development wherever possible, LNS automates common system tasks. E.g., it automatically discovers the presence of new unconfigured nodes on the network – without a tool's host having to do anything. LNS manages the network, freeing developers to focus on their application.

The LNS consists of two major components:

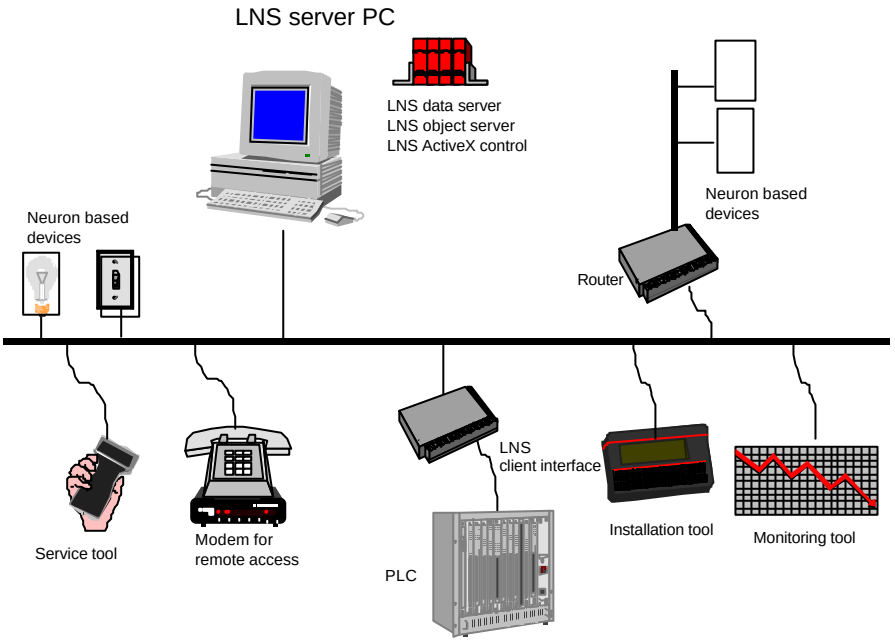
the *Network Service Server* (NSS)
the *Network Service Interface* (NSI).

The NSS hosts and processes network services. It maintains a network database. It enables and coordinates multiple points of access to its services and data. It also maintains a directory of all network and application service providers and event sources.

Clients speak to servers via a hardware component called Network Service Interface (NSI). NSIs provide the physical connection to the network and the messaging connection to the NSS. They automatically consult the NSS as needed to determine which server provide a given service and route the request transparently.

LNS is a client/server operating system with a single LNS server that supports many interoperating client appli-cations. The LNS server S/W can run as a stand-alone application on a PC attached to the LONWORKS network. Clients on other PCs (called remote clients) can log into a LNS server to access the shared LNS database.

All nodes in a LONWORKS network are classified together as devices. Every device has local processing and input-output hardware. Each device can communicate with other devices using the LonTalk protocol.



LNS based network tools are available in various forms:

- embedded tools: NSI-10
- LonMaker for Windows Version 3
- LNS Version 2 DDE server for Windows
- LNS Verison 3 application development kit for Windows (95/98/2000/NT)

24 The LNS DDE Server Software

The LNS DDE server is a software package that allows any DDE-compatible Microsoft Windows application to monitor and control LONWORKS control networks – without any additional programming. Typical applications for the LNS DDE server include interfaces for HMI applications, data logging and trending applications, and graphical process displays.

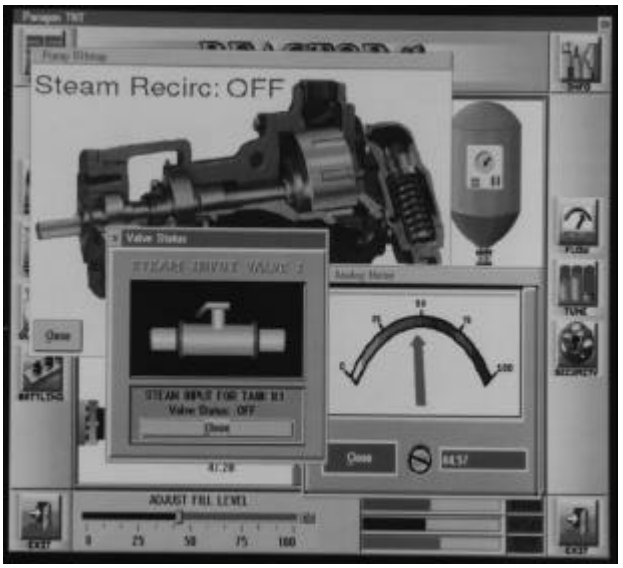
Using the LNS DDE server S/W and a NSI-compatible LonTalk adapter connected to a LONWORKS network, a PC may:

- read, monitor, and modify the value of any network variable.
- Supervise and change the configuration of nodes.
- Send and receive application messages.
- Test, enable, disable and override LonMark objects.
- Test, wink, and control devices.

The S/W is compatible with Wonderware's *InTouch*, Microsoft's *Excel* and Microsoft's *Visual Basic* and other widely used programming environments. It also supports Wonderware's *FastDDE* protocol for improved performance with InTouch.

No separate configuration step is required to use the LNS DDE server – LNS ensures that all of the required information is retrieved from the LNS data base.

Multiple PCs running the LNS DDE server may simul-taneously access the same network, allowing several HMIs and maintenance tools to run at the same time.



Screen shot of a LONWORKS network monitoring SW based on the LNS DDE server

25 The LNS Application Developer's Kit

The LNS Application Developer's Kit for Windows is a S/W development tool for designing and deploying open, interoperable LNS network tools for LONWORKS control networks. This product also provides the ability to redistribute the LNS network operating system as part of the developer's LNS network tool product.

The LNS network operating system can be used to design networks offsite (known as engineered systems), with device and router commissioning occurring later when the LNS Server is brought onsite. In addition, the LNS Server can be removed from the network after commissioning the network. This feature is especially desirable for smaller networks where an onsite management server is not required.

In order to optimise performance and minimize network traffic, remote Windows-based client applications can cache directory information received from the LNS Server. These applications can then perform monitoring and control functions directly without interaction with the LNS Server. Client applications can read network variables using polled or event-driven updates, and can optionally filter redundant updates to minimize application overhead. Client applications can request that the LNS Server notify them if any of the cached information changes, ensuring consistency between the database and the caches. In addition, monitoring and control applications can continue to function if the LNS Server is not available.

Network variable and configuration property values on devices can be automatically converted to and from formatted strings to simplify user interaction. Formatting can be based on standard resource files for standard network variable types and standard configuration property types, or manufacturer-specific resource files for user-defined network variable and configuration property types.

LNS include comprehensive support for the latest version of the LONMARK Interoperability Guidelines. LNS is able to manage certified and prototype LONMARK devices as well as other LONWORKS devices. The LONMARK objects on LONMARK devices can be easily controlled, allowing LNS applications to override, enable, test, or disable individual objects on a device.

Network variables can be accessed either by their device name or by their member name within a LONMARK object.

LONMARK configuration properties can be accessed as easily as network variables, even if the configuration properties are stored in the device's memory and not exposed as network variables.

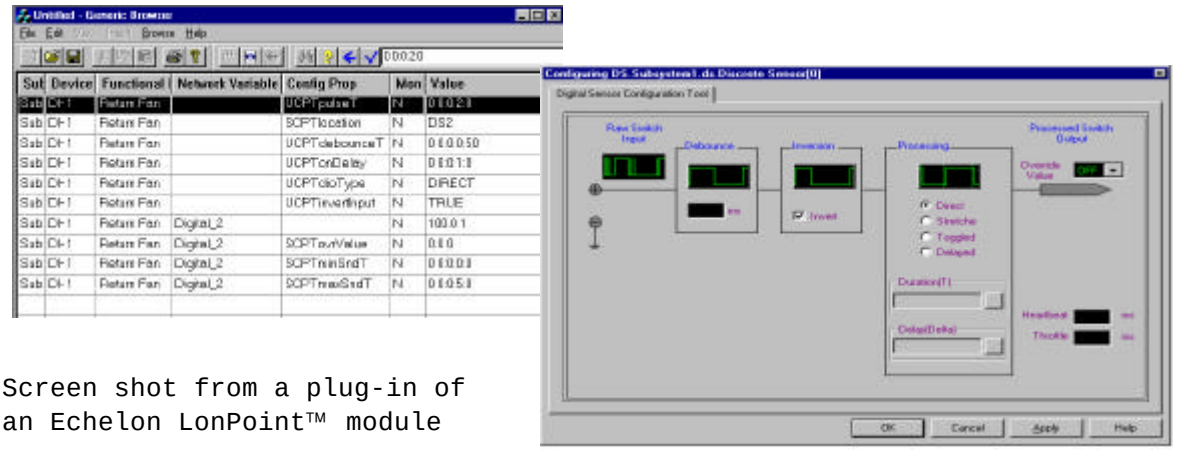
Plug-in Component Standard

To provide interoperability between LNS applications from different vendors, LNS defines and supports a standard plug-in architecture where an LNS application can invoke the services of any other LNS application on the same PC.
The LNS plug-in standard allows a single user interface or installation tool application to navigate or manage all the devices in a network, and then invoke device-specific applications (known as LNS Device Plug-ins) for any device on the network. LNS Device specific applications will typically be developed by device manufacturers to simplify the installation, configu-ration, or operation of their devices.

LNS Device Plug-ins serve the function of being the "device expert" in order that the network integrator need not be. Especially in multi-vendor, interoperable LONWORKS control networks, it is not possible or too costly to train the network integrator to understand all of the device types. The LNS Device Plug-in for each of the device types serves as the automatic calibrator, the instructor or the troubleshooter.

LNS Device Plug-ins are invoked by LNS applications that implement the LNS Plug-in Standard. The LNS Plug-in Standard allows a single user interface or installation tool application to navigate or manage all the devices in a network, and then invoke device-specific applications (known as LNS Device Plug-ins) for any device on the network. LNS Device Plug-ins will typically be developed by device manufacturers to simplify the installation, configuration, or operation of their devices. There are a number of LNS Plug-in aware applications; one of them is Echelon's LonMaker® for Windows Integration Tool. Part of the value of LNS Plug-ins is that they can be written once, and then used by every network integrator who uses LNS-based tools.

A listing of currently available LNS plug-ins is published at www.echelon.com/plugins.



Screen shot from a plug-in of an Echelon LonPoint™ module

The LNS plug-in standard supports a component application to be invoked on any type of object in the LNS Object Hierarchy, allowing such plug-ins as system plug-ins, subsystem plug-ins, channel plug-ins, Plug-in applications can also be developed for general purpose applications such as device drivers for HMI or SCADA applications.

A listing of currently available LNS plug-ins is published at www.echelon.com/plugins.

Example Applications

Example applications are included which demonstrate how to use the LNS Object Server ActiveX Control. The examples offer a range of complexity, starting with simple tutorial examples written in Microsoft Visual C++, Microsoft Visual Basic, and Borland Delphi. Additional example LNS example applications are available on the LNS home page at http://www.echelon.com/lns.

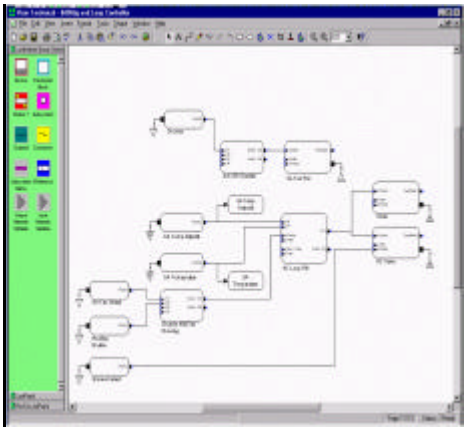
Licensing

A license to distribute copies of the LNS Servers and LNS Remote Client must be purchased separately (product # 34312). A flexible royalty structure allows royalty payments based on the number of LNS Device Credits that are distributed with each LNS Server. One LNS Device Credit is required for each device managed by an LNS Server.

26 The LonMaker for Windows

The LonMaker for Windows integration tool is a software package for designing, installing and maintaining multi-vendor, open, interoperable LONWORKS control networks.

Based on Echelon's LONWORKS network control services (LNS) operating system, the LonMaker tool combines a powerful client /server architecture with a Visio® user interface. The result is a tool that is sophisticated enough to design, commission, and maintain a distributed control network, yet economical enough to be left on-site as a maintenance tool.



The LNS network operating system provides a standard platform for supporting interoperable applications on LONWORKS networks. LNS permit multiple applications and users to manage and interact simultaneously with a ped with a LonMaker tool to commission devices on the network at the same time.

The LonMaker tool provides comprehensive support for LonMark® certified devices as well as other LONWORKS devices. The tool takes full advantage of LonMark features such as functional profiles, configuration properties, resource files, and network variable aliases.

LonMark functional profiles are exposed as graphical function blocks within a LonMaker drawing, making it easy to visualize and document the logic of a control system.

For engineered systems, network design is usually done off-site, without the LonMaker tool attached to the network. However, network design may also take place on-site, with the tool connected to a commissioned network. This feature is especially desirable for smaller net-works where adds, moves, and changes are a regular occurrence.

Users are provided with a familiar, CAD-like environment in which to design a control network. Visio's smart shape drawing feature provides an intuitive, simple means for creating devices. The LonMaker tool includes a number of smart shapes for LONWORKS networks, and users can create new custom shapes. Custom shapes may be as simple as a single device or a functional block, or as complex as a complete subsystem with predefined devices, function blocks, and connections between them.

Using custom subsystem shapes, additional subsystems can be created by simply dragging the shape to a new page of the drawing, a timesaving feature when designing complex systems.

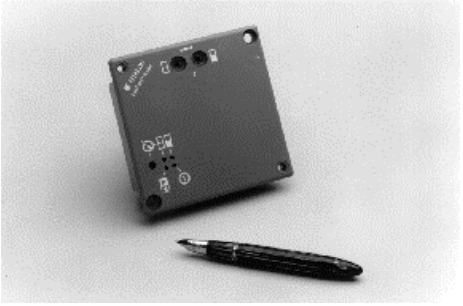
Network installation time is minimized by the ability of the installer to commission multiple devices at the same time. Devices can be identified by service pin, bar code scanning Neuron chip IDs, or manually entering the IDs. Testing and device configuration is simplified by an integrated application for browsing network variables and configuration properties. A management window is provided to test, enable/disable, or override individual function blocks within a device – or to test, wink, or set online and offline states for devices.

The LonMaker tool is the first installation tool to conform to the LNS plug-in standard. This standard allows LONWORKS device manufactures to provide customized applications for their products. These applications are automatically integrated into the LonMaker tool, making it easy for system engineers and technicians to define, commission, maintain, and test the associated devices.

For monitoring and control applications, the LonMaker tool is compatible with a variety of 3rd party products including operator interface packages such as Wonderware's InTouch® and National Instruments' LabView® and BridgeView® . In addition, the LonMaker tool can both import and export AutoCAD® files and generate as-built documentation. An integrated generator can also be used to generate a detailed report of the network configu-ration.

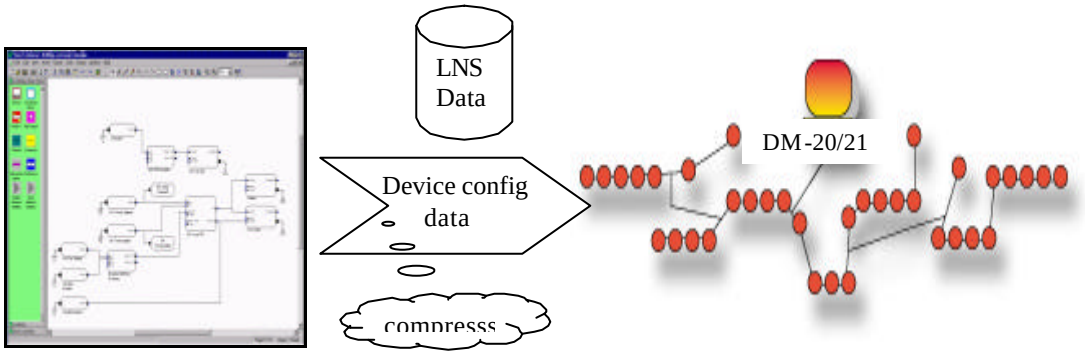
27 DM-21 embedded network management device

The DM-20 and DM-21 Device Manager modules are embedded network management devices. The DM-20 is shipped as a printed circuit board suitable for mounting on a mother-board. The DM-21 is completely packaged with plastic face plate and mounting hardware.



The DM-20/21 Device managers main features:

- Provides automatic installation, fault detection, and device replacement of a LON with up to 128 devices and one router.
- Uses the FTT10A free topology transceiver.
- Runs by itself without a local PC after a database created with the LonMaker for Windows integration tool is loaded by the DM20/21 compression utility.
- Records system activity using an internal FLASH-based event logger
- Cuts installation time and cost with a two-piece design.
- Support LonMark 3.0 objects and configuration properties.
- Supports network variables and message tags.



The above diagram illustrates the three steps necessary to successfully use the DM-21/21 to manage your network:

1) create your network using the LonMaker for Windows.
2) export the managed device list(s) to the DM-20/21 using the DM-20/21 compression utility.
3) attach the DM-20/21 module to your network.

Once attached, the DM-20/21 will automatically find and commission all the devices defined in the compressed LNS data base.

28 *i*.LON™ 1000 Internet Server

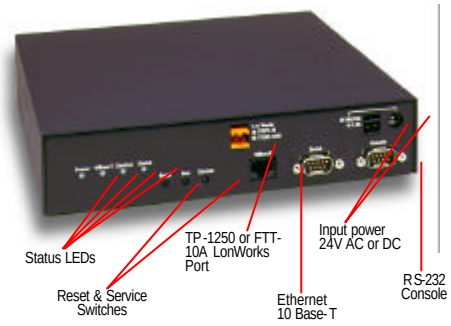
The *i*.LON™ 1000 Internet server provides seamless connectivity between LONWORKS control networks and Internet protocol (IP) based data networks. This capa-bility allows the *i*.LON™ 1000 to create virtual private control networks for a wide variety of applications, including:

- linking of LONWORKS networks on different floors of a multistore building via a high speed Ethernet backbone;
- connecting the manufacturing pods of a production plant to a corporate LAN;
- sending information from retail stores to a corporate maintenance center via a WAN to the Internet;
- accessing an automation system over the Internet with a browser;
- displaying the status of remote devices via a wireless LAN.

The *i*.LON™ 1000 offers unparalleled performance and reliability. Certified under the CISCO *NetworksÔ* pro-gram, the *i*.LON™ 1000 integrates Echelon's routing and networking expertise together with CISCO's *Network Foundation Technologies*. The result is a Layer 3 LonTalk router that offers lightning, fast throughput for demanding process control, utility, transportation, and telecom applications.

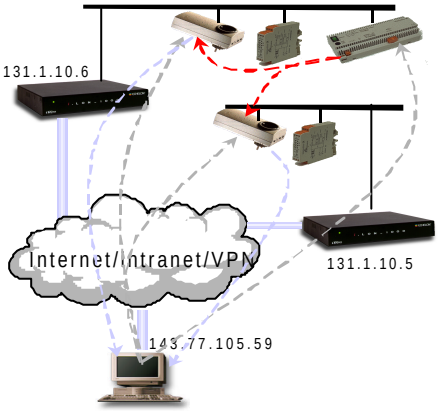
The *i*.LON™ 1000's built-in web server allows control network information (such as network variables and messages) to be accessed easily via a web browser. This password-controlled feature provides access to LONWORKS monitoring and control data from anywhere – without the need for special software tools – over LAN, WAN or the Internet. Whether for remote diagnostics, equipment calibration, alarm monitoring, or maintenance, the integral web server makes it simple to access any part of the control system.

The *i*.LON™ 1000 is unique in its ability to support both peer-to-peer and master-slave network communications. This powerful feature allows remotely located devices to communicate over IP networks in the same way they would if they were co-located. Devices on different floors of a building, scattered across different manufacturing pods, or located in retail branches across the world can be seamlessly and transparently linked together.



rear view of the i.LON1000

The impressive performance of the *i*.LON™ 1000 is due to a combination of a powerful 32-bit RISC processor and Echelon's *Virtual Network Interfaces* (VNI) software architecture. The result – very high packet throughput in control networks with large numbers of nodes and/or very fast monitoring and display requirements.



LonWorks telegrams are tunneled using TCP/IP telegrams. Each i.LON1000 has its own host address

The *i*.LON™ 1000 can be installed using standard LONWORKS installation tools such as *Lonmaker for Windows*™. From the perspective of the IT network, the *i*.LON™ 1000 is viewed as a typical IP host. Like other IP hosts, the *i*.LON™ 1000 supports standard internetworking protocols: TCP/IP, UDP, DHCP, SNMP, (MIB II), ICMP, SNMP, TOS, MD5, and FTP. In addition, packet aggregation, parameters, addressing, IP bandwith utilization, and security can all be adjusted via the IP network.

Additional Information

/1/ **Echelon** LONWORKS Products Catalogue

/2/ **Echelon** Neuron C Reference Guide

/3/ **Echelon** Neuron C Programmer's Guide

/4/ **Echelon** LonMaker for Windows User's Guide

/5/ **Echelon** LNS DDE Server User' Guide

/6/ **Echelon** Documentation CD 2001 (part # CDROM-ECH2)

/7/ **Echelon** The LONWORKS Network Services (LNS) Architecture Technical Overview

/8/ **LonMark** Application Layer Interoperability Guidelines Rev. 3.1

/9/ **F.Tiersch** LonWorks Technology – An Introduction DESOTRON Verlagsgesellschaft, Erfurt 2000 ISBN 3-932875-11-7

/9/ www.echelon.com

/10/ www.ebv.com

/11/ www.toshiba.com

/12/ www.lonmark.org

/13/ www.netscape.com search for keyword „LONWORKS"

/14/ www.lontech.ch Swiss Lonuser's home page

/15/ www.lonuser.asso.fr French Lonuser's home page

/16/ www.lno.de German Lonuser's home page

/17/ www.ukosa.com British Lonuser's home page

/18/ www.ansi.org to obtain the ANSI/EIA 709.1 protocol specification

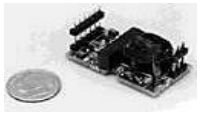
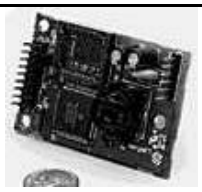
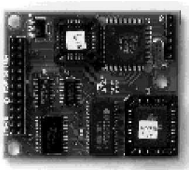
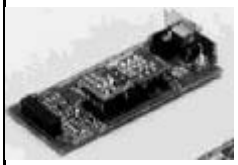
September 2001 ECHELON Resale Price List

Product	Ref.	Description	Resale price (USD)	Comments
DEVELOPMENT TOOLS				
	10010-142 10010-21-172	NodeBuilder FTT10A Node Builder Power Line Line- Neutral 220V	**$4945** **$4945**	Single node development tool: Include : 1 evaluation node (LTM10 based) 1 compiler/linker/debugger/ browser 1 PCNSS card 1 DDE server incident based technical support 220VAC EU power supply **shrink wrap SW licence**
	20311-142 20311-21-172	LonBuilder FTT10A LonBuilder Power Line Phase/Neutral coupling 220V	**$21995** **$21995**	Multi node system development tool : Include : 2 emulators 1 compiler/linker/debugger/ browser 1 PCNSI card 1 DDE server 1 protocol analyser 1 variable binder incident based technical support 1 router (with x-21-172 version only) 220VAC EU power supply **shrink wrap SW licence**
Release 3  **LNS application Deveoper's kit**	34309	LNS 3.0 Application development kit	**$2745**	Used to develop and deploy all types of LNS applications, including LNS tools that commission, configure, monitor, control, diagnose and maintain LonWorks networks, as well as any type of LNS plug-in. Includes LNS server, LNS plug-in wizard Device drivers, example applications, utilities For systems running Windows 95/98/NT/2000 Requires one of the following interface HW 7200x, 73200, 7335x, 7340x or 7440x **Customer must sign SW licence "LNS-A"**
Release 3  **LNS redistribution licence**	34312	LNS 3.0 redistribution kit	**$2745** customer should contact Echelon sales office for the purchase of LNS "Software License Generator" (part no 34311). The Echelon sales office provides the 34311 free of charge with a minimum purchase of 1,000 Model 34410 LNS Administrator Credits	Optional add-on for the 34309 Application Development kit. This kit permits the developer to redistribute LNS server and LNS remote client SW with their LNS Applications. Customer must quarterly report to Echelon/USA the number of LNS servers, LNS remote clients and LNS device credits he has shipped. **Customer must sign SW licence "LNS-A"**
Release 3  **LonMaker for Windows**	37000	LonMaker for Windows Includes 64 device credits	**$985** to install more than 64 devices, the licensee agree to pay $5 device credit per installed device to Echelon. Such additional device credits are sold exclusively by Echelon sales offices!	**LNS based software for installation and** maintenance of LonWorks networks For systems running Windows 95/98/NT/2000 Requires one of the following interface HW: 7200x, 73200, 7335x, 7340x or 7440x **shrink wrap SW licence**

September 2001 — ECHELON Resale Price List

Product	Ref.	Description	Resale price (USD)	Comments
DEVELOPMENT TOOLS				
Upgrade  **LNS application Developer's kit**	34319	LNS 3.0 Application development kit Upgrade	**$1.095**	Upgrade to Release 3 Upgrade license from earlier versions of the LNS development kit for Windows (model 34303) to the Release 3 of LNS. **This license does not include the right to redistribute the LNS server and/or client SW linked into the application code.** **The « LNS redistribution license » is required to obtain this right.**
Upgrade  **LonMaker for Windows**	37011	LonMaker for Windows Upgrade	**$545**	Upgrade to Release 3 Upgrade license from earlier versions of the LonMaker for Windows to the the Release 3 LonMaker for Windows **shrink wrap SW licence**
Upgrade  **LNS for Windows**	34313	LNS 3.0 Developers kit Upgrade	**$2.195**	Upgrade to Release 3 Upgrade license from earlier versions of the LNS application development kit to the Release 3 LNS application development kit **Customer must sign SW licence "LNS-A-UP"**
TRANSCEIVERS				
	50051	FTT-10A	*<500* **$16** *<1000* **$15,20** *<2500* **$14,10** *<5000* **$13,60**	Isolated transceiver for twisted pair cable : Speed : 78Kb/s Distance : 500m (free topology) 2700m (bus topology)
	14210-500	FT3120-F4S40 SOIC32 package	$19	$17,50	$17,10	$16,20	FT3120 smart transceiver for twisted pair transformer isolated free topology networks of 78Kb/s transmission speed. 40MHz, 4KB EEprom, 2KB RAM, 12KB ROM only for use with external FT-X1 transformer
	14220-900	FT3120-E4P40 TQFP44 package	$19.60	$18	$17.60	$16,70	FT3120 smart transceiver for twisted pair transformer isolated free topology networks of 78Kb/s transmission speed. 40MHz, 4KB EEprom, 2KB RAM, 12KB ROM only for use with external FT-X1 transformer
	14230-800	FT3150-P20 TQFP64 package	$19.60	$18	$17.60	$16,70	FT3150 smart transceiver for twisted pair transformer isolated free topology networks of 78Kb/s transmission speed. 40MHz, 0,5KB EEProm, 2KB RAM,, no ROM only for use with external FT-X1 transformer
	14240	FT-X1 transformer for use with FT31 Smart transceiver	$1.80	$1.65	$1.60	$1.50	isolation transceiver for twisted pair free topology networks of 78Kb/s transmission speed.
No picture	51001	FTT-10A Magnetic shield	**$3,30**	$3,00	$2,80	$2,65	Two piece assembly magnetic shield for FTT10A transceiver

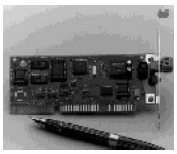
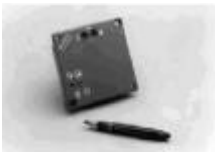
September 2001 — ECHELON Resale Price List

Product	Ref.	Description	Resale price (USD)				Comments
Transceiverfs							
	50040-01	LPT-10	*<500* **$19**	*<1000* **$17,50**	*<2500* **$17,10**	*<2500* **$16,20**	Link power transceiver for twisted pair cable. Speed : 78Kb/s Distance : 500m (free topology) 2700m (bus topology)
	50020-10	TP/XF -1250	**$21**	**$19,70**	**$17,40**	**$16,80**	Isolated transceiver for twisted pair cable. Speed : 1,25Mb/s Distance :130m (support only bus topology)
	50090-03	PLT-22	**$33**	**$30,60**	**$29,70**	**$28,00**	Dual Band Power Line transceiver : Speed : 5 kb/s Distance : depend on media quality (115kHz & 132kHz CENELEC compliant) free or bus topology; supports power lines and unpowered twisted pair
Control Modules							
	55010-00 55010-10	TP/XF78 control module TP/XF78 FLASH control module	*<500* **$64** **$74**		*500+* **$60,80** **$70,30**		Control module with TPXF -78 + ROM socket Control module with TPXF -78 + FLASH socket (Does not include the memory chip)
	55020-01 55020-10	FTT-10A control module FTT-10A FLASH control module	*<500* **$64** **$74**		*500+* **$60,80** **$70,30**		Control module with FTT10A + ROM socket Control module with FTT10A + FLASH socket (Does not include the memory chip)
	65100-100	LTM-10	**$109**				Control module with: - 3150 Neuron chip - 32k RAM - 32k FLASH - MIP firmware (requ. extra transceiver)
	65120	LTM-10 Motherboard	**$164**				LTM10 motherboard with on board 5VDC power supply, SMX & LTM10 connectors. Include also Reset, Service and IO4 button and leds.
SMX transceiver modules and special transceiver adapters							
	77010 77030 77040 77050	SMX TPXF -78 SMX TP-1250 SMX FTM10 SMX-RS485	**$105** **$105** **$66** **$77**				transceiver board for use with PC interface cards or development tools.

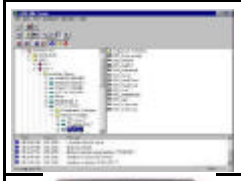
September 2001 ECHELON Resale Price List

Product	Ref.	Description	Resale price (USD)	Comments
Transceiverfs				
	77162	SMX PLT-22	**$193**	PL transceiver board for use with PC interface cards or development tools.
	78200-221	PL-20 L-N 240V	**$83**	Coupler to connect SMX transceivers to mains electrical network. Includes cable to connect to SMX PLT22 adapter. Coupling mode: Line to neutral
LonTalk interfaces ---------- download Windows device driver SW from www.echelon.com ----------				
	73381 73382 73383 73384	PSG-3 FTT10 PSG-3 TP78 PSG-3 TP1250 PSG-3RS485	**$407** **$407** **$407** **$407**	User programmable serial Lontalk Adapter (not NSI/LNS compliant). Supports application program downloaded in PROM or Flash. PSG firmware library included with the NodeBuilder development tool or available for Free download from www.echelon.com. RS232 input: 1200Bd up to 115,2kBd Requ. 16-30V AC or DC power supply
	73351 73352 73353 73354 73370 73371	SLTA/10 FTT10 SLTA/10 TP78 SLTA/10 TP1250 SLTA/10 RS485 PROM/RS485/78k PROM/RS485/635K	**$407** **$407** **$407** **$407** **$28** **$28**	Serial Lontalk Adapter (NSI/LNS compliant). Requ. 16-30V AC or DC power supply Firmware PROM to support 78Kb/s speed. Firmware PROM to support 635Kb/s speed.
	76000	PL-SLTA	**$200**	Serial Lontalk Adapter with PLT22 power line Transceiver (NSI/LNS compliant).
	65202	LTS-20	**$182**	Serial Lontalk core module (NSI/LNS compliant). Requ. external transceivers
	73390	PSG-20	**$182**	User programmable Serial Lontalk core module (not NSI/LNS compliant). Supports application program download into Flash PSG firmware library included with the NodeBuilder development tool or available for Free download from www.echelon.com Requ. external transceivers

September 2001 — ECHELON Resale Price List

Product	Ref.	Description	Resale price (USD)	Comments
Interface Modules				
	73401 73402 73403	PCLTA-10 /FT-10 PCLTA-10/TP-78 PCLTA-10/TP1250	**$286** **$286** **$286**	PnP ISA Host Adapter Board Run with Windows 95, NT (LNS software and DOS emulation).
	73200 78302 78301 73250 73251	PCC-10 2 wire cable 15 wire cable POD TP78 POD TP1250	**$275** **$28** **$44** **$165** **$165**	PCMCIA type II card (5V only) : Built in FTT10A transceiver. (connect custom transceivers via external POD) download device driver for Windows 95/98, NT from www.echelon.com
	74401 74402 74403 74404 74405	PCLTA-20/FTT PCLTA-20/TP78 PCLTA-20/1250 PCLTA-20/RS485 PCLTA-20/SMX (order SMX transceiver separately)	**$286** **$286** **$286** **$286** **$286**	PCI Host Lontalk Adapter Board On board transceiver (except for PCLTA-20/SMX) download device driver for Windows 95/98, NT from www.echelon.com
LonPoint Router modules				
	42100 42101 42102 42103 42104 42105	LonPoint Router FTT-FTT FTT-TP78 FTT-TP1250 TP78-TP78 TP78-TP1250 TP1250-TP1250	**$385** **$440** **$413** **$440** **$440** **$440**	Integrated router with 2 transceivers. Requ. extra power supply 16-30V AC or DC
	48222	DIN Rail plate for Router	**$22**	DIN rail plate for fitting one LonPoint Router module
	61000-100	RTR-10	**$165**	Router SIM core module. Firmware included (no software development required) Requ. two external transceivers
Test & Programming equipment				
Non Echelon product 	3120Prog	3120 programmer	**$725**	Neuron Chip 3120XXX programmer One SOP32 programming socket and One QFP44 for replacement of SOP32 programming socket RS232 interface and FTT10A interface with 9V/220VAC power external powers supply Includes special RS232 cable to connect to PC
Non Echelon product 	HSPA-10	FTT10A Protocol Analyser	**$550**	Stand alone protocol analyser for FTT10 networks Filter/trigger/store functions, 100ns time stamp Include Software for Windows 95/98/NT/2000 with 9V/220VAC power external power supply

September 2001 ECHELON Resale Price List

Product	Ref.	Description	Resale price (USD)	Comments
PLT-22 network analyser				
	58022-2	PLT-22 Power Line communication Analyser	**$5495 / pair**	PLT-22 network analyser Include power meter, LCD display, external coupling possibility and RS232 port for data logging
System Level Products				
	37200-20	LNS DDE Server OEM edition	**$875**	Software to link Windows application to LonWorks network using standard Microsoft DDE protocol. Requires one of the following interface HW: 7200x, 73200, 7335x, 7340x or 7440x shrink wrap SW licence
	43202 48111	DM-21 Din Rail Plate for DM-21	**$539** **$22**	Embedded module for installing and maintaining up to 127 nodes and one router in a network. Use a LNS database. On board FTT-10A.
	72001 72002 72951 72901-2	*i*.LON™ 1000 FTT10 *i*.LON™ 1000 TPXF1250 19" mount brackets power supply 24V	**$1315** **$1315** **$24** **$55**	LonWorks – IP gateway. Features a 100% transparent Lon (FTT10A / TPXF1250) to Ethernet 10baseT router. Also Include a WEB server to monitor the Lon devices with an internet browser. (24V power supply required). Configuration with serial port and/or FTP. Brackets to mount one i.LON in a 19" enclosure 220VAC to 24VDC@250mA power supply *i*.LON™ 1000
	TLON-HOSS200	HOSS-200 LonWorks Evaluation system	**$1260**	Complete kit for evaluating LonWorks - One 3150/FTT10 flash control module - One 3120/FTT10 control module - One MCM/FTT10 control module - One PCC-10 card with two-wire cable - Two GIZMO I/O boards - S/W for Windows 95/98 - With SW to download into Neuron chip - 200VAC/9VDC power supply

September 2001 ECHELON Resale Price List

Product	Ref.	Description	Resale price (USD)	Comments
Idocumentation & Training				
Documentation 	CDROM-ECH2	April 2001 edition	**Free of charge**	Web browser based collection of complete set of data sheets, user manuals, engineering bulletins and application notes.
	LONWORKS-EBV	Introduction to LonWorks By Prof.Dr. Tiersch	**$15**	Comprehensive introduction to the LonWorks Technology, LonMark objects, programming etc. ISBN 3-932875-11-7
	LONWORKS-DOC	Introduction to LonWorks by EBV Elektronik	**$5**	Condensed survey on the LonWorks Technology Includes Echelon Product Documentation CDRom
	training	LonMaker for Windows LonWorks Network design LNS Network Development Internet Connectivity Introduction to Device and network design		Contact www.echelon.com/support/training for Training class schedule and prices