Version 3.4
September 2005

LONMARK®
Layer 1 – 6 Interoperability Guidelines

Echelon, LON, 3120, 3150, LonBuilder, LonMaker, LonTalk, LONMARK, LONWORKS, Neuron, NodeBuilder, the Echelon logo, and the LONMARK logo are registered trademarks of Echelon Corporation. LonSupport is a trademark of Echelon Corporation. Other brand and product names are trademarks or registered trademarks of their respective holders.

ECHELON MAKES NO REPRESENTATION, WARRANTY, OR CONDITION OF ANY KIND, EXPRESS, IMPLIED, STATUTORY, OR OTHERWISE OR IN ANY COMMUNICATION WITH YOU, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, SATISFACTORY QUALITY, FITNESS FOR ANY PARTICULAR PURPOSE, NONINFRINGEMENT, AND THEIR EQUIVALENTS.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of Echelon Corporation.

Printed in the United States of America.

Copyright © 1992 – 2005 by Echelon Corporation.

Echelon Corporation

www.echelon.com

Contents

1 Introduction **5**
1.1. Introduction to the LONWORKS Platform 6
1.2. Audience 6
1.3. LONMARK Certification 6
1.4. Related Documentation 8

2 Layer 1 – The Physical Layer **9**
2.1. Standard Transceiver and Channel Types 10
2.1.1. Proposing New Channel Types 12
2.1.2. Performance Testing 13
2.2. TP/XF-78 and TP/XF-1250 Channel Types 13
2.2.1. Performance Specifications 13
2.2.2. Transceiver Schematic 14
2.2.3. Network Cabling and Connection 15
2.3. TP-RS485-39 Channel Type 16
2.3.1. Performance Specifications 17
2.3.2. Transceiver Schematic 17
2.3.3. Bus Termination 18
2.3.4. Grounding 18
2.4. PL-20(L-N) and PL-20(L-E) Channel Types 19
2.4.1. Performance Specifications 19
2.4.2. Transceiver Interface Specification 20
2.4.3. Coupling Circuits 20
2.4.4. Power Supply Requirements 21
2.5. PL-20A(L-N) Channel Type 22
2.5.1. Performance Specifications 22
2.5.2. Transceiver Interface Specification 22
2.5.3. Coupling Circuits 23
2.5.4. Power Supply Requirements 23
2.6. TP/FT-10 Channel Type 24
2.6.1. Performance Specifications 25
2.6.2. Link Power Supply Requirements 26
2.6.3. Passive Coupler Circuit Schematic 29
2.7. FO-20S Channel Type 30
2.7.1. Performance Specifications 30
2.8. FO-20L Channel Type 32
2.8.1. Performance Specifications 32
2.9. IP-852 Channel Type 33
2.9.1. Implementation Requirements 34

3 Layers 2 – 6 .... **37**
3.1. Layer 2: Link Layer 38
3.1.1. Channel Parameters 38
3.1.2. Network Buffers 40
3.2. Layer 3: Network Layer 41
3.3. Layers 4 & 5: Transport and Session Layers 42
3.4. Layer 6: Presentation Layer 44
Index **44**

1

Introduction

With thousands of application developers and millions of devices installed worldwide, the LONWORKS platform is the leading open solution for building and home automation, industrial, transportation, and public utility control networks. A control network is any group of devices working in a peer-to-peer fashion to monitor sensors, control actuators, communicate reliably, manage network operation, and provide local and remote access to network data. A LONWORKS network uses the ANSI/EIA/CEA-709.1 (EN14908-1) Control Network Protocol to accomplish these tasks. The ANSI/EIA/CEA-709.1 (EN14908-1) protocol is implemented by the firmware provided with Neuron® Chips and Echelon Smart Transceivers; this implementation is known as the *LonTalk® protocol*.

The standard protocol provided by the LONWORKS platform makes it possible to design open control systems using products from multiple vendors. The *LONMARK Interoperability Guidelines* provide guidelines, detailed explanations, and technical insight on how to design interoperable products based on the LONWORKS platform. All products that carry the LONMARK logo (“”) are certified to comply with these guidelines. The LONMARK guidelines are presented in separate volumes for ISO OSI Reference Model layers 1 – 6 and for layer 7 of the ANSI/EIA/CEA-709.1 (EN14908-1) protocol. This document provides layer 1 – 6 design guidelines. The *LONMARK Application-Layer Interoperability Guidelines* provides layer 7 guidelines, and also includes a glossary defining terms for both volumes.

1.1. Introduction to the LONWORKS Platform

A LONWORKS network consists of intelligent *devices*—such as sensors, actuators, and controllers—that communicate with each other using the ANSI/EIA/CEA-709.1 protocol over one or more *communications channels*. Network devices are sometimes also called *nodes*.

A device publishes information as instructed by the application that it is running. The applications on different devices are not synchronized, and it is possible that multiple devices may all try to communicate at the same time. Meaningful transfer of information between devices on a network, therefore, requires organization in the form of a set of rules and procedures. These rules and procedures are defined by the ANSI/EIA/CEA-709.1 (EN14908-1) protocol. The protocol defines the format of the messages being transmitted between devices and defines the actions expected when one device sends a message to another. The protocol implementation normally takes the form of embedded software or firmware code in each device on the network.

The LONMARK guidelines provide detailed information on how products based on the LONWORKS platform should be designed so that the device interface will support easy interoperation across a LONWORKS network. The actual application software and hardware behind the interface is outside the scope of these guidelines. The purpose of the guidelines is to ensure interoperability, but not interchangeability of devices. A major benefit to end-users of interoperable devices is the freedom to choose among suppliers for the devices as well as for the maintenance of those devices. The ability to choose a specific device is provided by public device interfaces that describe the function of the device and how it exchanges information with other devices on a LONWORKS network. The ability to choose among suppliers for system maintenance is realized by ensuring that interoperable devices do not require any private information to be successfully commissioned.

1.2. Audience

The information contained in the *LONMARK Layer 1–6 Interoperability Guidelines* is particularly pertinent to original-equipment manufacturers (OEMs) who plan to design interoperable LONWORKS products, but is also of interest to end-users and specifiers of LONMARK products.

1.3. LONMARK Certification

Products may be submitted to the LONMARK International for certification. A product that is certified by the LONMARK International as complying with the application-layer and layer 1–6 guidelines may carry the LONMARK logo to indicate that it is capable of being part of an interoperable LONWORKS network. The LONMARK logo is an indication to manufacturers, end users, and network integrators that a product can be easily linked with other products in a multi-vendor network. One of the logos in Figure 1 or Figure 2 must be used on the product documentation and/or product casing. If no casing is provided, the logo can be placed on a circuit board or equivalent. The logo cannot be used without at least the "3.3" designating this latest version of the LONMARK Interoperability Guidelines.

Figure 1. LONMARK Logos

One of the logos in Figure 1 must be used on the product documentation and/or product casing if the product does not conform with the ISI protocol as described in the *LONMARK Application-layer Guidelines*. If the product does conform with the ISI protocol, one of the logos in Figure 2 must be used.

Figure 2. LONMARK Logos with ISI

Contact the LONMARK International Principal Engineer at the following address for more information about LONMARK certification, or visit the LONMARK Web site for LONMARK certification details.

Principal Engineer - cert@lonmark.org
LONMARK International
550 Meridian Avenue
San Jose, CA 95126 USA
Tel: +1-408-938-5266, Fax: +1-408-790-3493

www.lonmark.org

1.4. Related Documentation

The following documents provide supplemental information to these guidelines. All documents listed here are available at www.lonmark.org unless noted otherwise.

- *ANSI/EIA/CEA-709.1-B-2000 Control Network Protocol .* Specifies the services available at each of the seven layers of the ANSI/EIA/CEA-709.1-B-2000 protocol. Copies of this document are available for purchase at www.global.ihs.com.
- *LONMARK Application-Layer Interoperability Guidelines.* Provides guidelines, detailed explanations, and technical insight on how to design applications for interoperable products based on the LONWORKS platform. These guidelines form the basis for obtaining the use of the LONMARK logo, which indicates that a product has been certified by the LONMARK International.
- *LONMARK Program Overview.* Describes the organizational structure and membership options of the LONMARK International, and rules for use of the LONMARK Logo.
- *Standard Transceiver Reference (StdXcvr.xml).* Describes the transceiver and channel parameters and properties of all LONMARK channel types as well as some channel types that are not LONMARK compliant. Development and network tools use this file for automatic validation and channel-type dependent calculations.

2

Layer 1 – The Physical Layer

The *physical layer* defines the transmission of raw bits over a communication channel. A *channel* is a physical transport medium for packets. Every device on a LONWORKS network is physically connected to a channel with a *transceiver* that implements the physical layer of the ANSI/EIA/CEA-709.1 (EN14908-1) protocol. The physical layer ensures that a 1 bit transmitted by a source device is received as a 1 bit by all destination devices. The ANSI/EIA/CEA 709.1 (EN14908-1) protocol is media independent; multiple physical layer protocols are supported depending on the communication medium. For example, twisted pair, power line, radio frequency (RF), infrared (IR), coaxial cable, fiber optic, and Internet-tunneling media may be used.

The physical form of a channel depends on the medium. For example, a twisted pair channel is a twisted pair of wires, an RF channel is a specific radio frequency, and a power line channel is a frequency band on power mains. The bit rate of a channel is dependent upon transceiver design and limits of the chosen medium. The bit rate is specified for each channel type. This chapter specifies guidelines for transceivers that can be used in certified devices.

2.1. Standard Transceiver and Channel Types

A standard network interconnection between products is necessary in order for certified devices made by different manufacturers to interoperate. The transceiver design plays an important role in allowing devices on a channel to interoperate reliably and predictably.

To facilitate and promote interoperability, the following sections include transceiver design references for a variety of media. These transceiver designs must be used as the physical layer for certified devices and is a requirement for passing the LONMARK Conformance Review. Products that use these transceiver designs automatically satisfy the stated layer-1 performance specifications, and no additional performance testing of the physical layer is required for the LONMARK Conformance Review.

The LONMARK standard channel types are listed in Table 1. Ultimately, the transceiver used must be designed to fully support the channel specification.

Table 1. Standard Channel Types

Channel Type	*Medium*	*Bit Rate*	*Characteristics*	*Notes*
TP/XF-1250	Twisted pair cabling	1250kbps	Transformer-coupled	Bus topology
TP/XF-78	Twisted pair cabling	78kbps	Transformer-coupled	Bus topology
TP-RS485-39	Twisted pair cabling	39kbps	EIA RS-485 specifications	Bus topology
PL-10(L-N)[1]	Power line cabling	10kbps	100kHz – 450kHz, spread spectrum, line-to-neutral coupling.	FCC, Industry Canada compliant
PL-10(L-E)	Power line cabling	10kbps	100kHz – 450kHz, spread spectrum, line-to-earth coupling	FCC, Industry Canada compliant
PL-20(L-N)	Power line cabling	5kbps	125kHz – 140kHz, BPSK, line-to-neutral coupling, 50/60Hz mains frequency	Based on ANSI/EIA/ CEA 709.2-A; FCC, Industry Canada, CENELEC EN 50065-1 compliant

[1] This channel type has been replaced by the PL-20 channel type and should not be used for new designs.

Channel Type	Medium	Bit Rate	Characteristics	Notes
PL-20(L-E)	Power line cabling	5kbps	125kHz – 140kHz, BPSK, line-to-earth coupling, 50/60Hz mains frequency	Based on ANSI/EIA/ CEA 709.2-A; FCC, Industry Canada, CENELEC EN 50065-1 compliant
PL-20A(L-N)	Power line cabling	3600bps	70kHz – 95kHz, BPSK, line-to-neutral coupling, 50Hz mains frequency	CENELEC EN 50065-1 [2] compliant
PL-30(L-N)	Power line cabling	2 kbps	9kHz – 95kHz, spread-spectrum, Line-to-Neutral coupling.	FCC, Industry Canada, CENELEC, compliant
TP/FT-10	Twisted pair cabling	78 kbps	Free topology with optional link power	Based on ANSI/EIA/ CEA 709.3
FO-20S	Fiber optic cabling	1250 kbps	Bi-directional single-strand; up to 64 devices per segment	Based on ANSI/EIA/ CEA 709.4; active daisy-chain topology
FO-20L	Fiber optic cabling	1250 kbps	Bi-directional single-strand; up to 512 devices per segment	Based on ANSI/EIA/ CEA 709.4; active daisy-chain topology
IP-852	Internet protocol	Varying	UDP port 1628 recommended	Based on CEA-852 Annex A ; tunneling protocol

For each channel type, the performance specifications and the LONMARK International-approved transceiver schematics are provided or referenced. The ANSI/EIA/CEA-709.1 communication channel parameters for each transceiver are specified in this chapter. These parameters must be set correctly to ensure that all

[2] CENELEC EN 50065-1 "Signaling on low-voltage electrical installations in the frequency range 3kHz to 148.5kHz" Part 1 "General requirements, frequency bands and electromagnetic disturbances," Amendment AC. Reference: *EN 50065-1:1991/prAC:1994*.

devices on a channel will interoperate without requiring parameter adjustment prior to installation.

Guideline 2.1A:	A certified device shall implement a transceiver supporting one of the channel types listed in Table 1, with channel parameters as specified in Chapter 2.

Guideline 2.1B:	A certified device design shall follow referenced transceiver schematics exactly.

2.1.1. Proposing New Channel Types

Additional LONMARK International-approved channel types will be added as market requirements demand. The criteria used in adopting a channel as a standard include the following:

- Has a transceiver for the channel been thoroughly tested?
- Is channel design open and publicly available?
- Does this channel type have long-term, widespread applicability?

LONMARK International approval of additional channel types is handled separately from the LONMARK product certification. The LONMARK International will approve “standards-body” channel types only. Existing LONMARK channel types are exempt from this requirement. By “standards-body,” this means one that has become an official standard, or part of an official standard, by a formal standards-making body; or meets the requirements of formal industry regulations. Examples include, but are not limited to ISO/IEC, ANSI, DIN, IEEE, and EIA. Known-compliant transceivers for specified/referenced channels are listed in this document as examples only. Any transceiver meeting the specifications can be used. For more information on additional channels under consideration, or for information on how to submit a channel-design standard for LONMARK International approval, contact the LONMARK International Secretary at +1-408-938-5266 x1 or secretary@lonmark.org.

Products designed using a non-interoperable transceiver can be connected to an interoperable network via a router that uses an interoperable transceiver on one side; all other guidelines still apply. Certification can be granted to this product only if the router is considered part of the product, where the product cannot be sold without the router. This option is described in the *LONMARK Application-Layer Interoperability Guidelines*.

2.1.2. Performance Testing

Products submitted for certification are expected to comply with all applicable EMI and agency regulations of the markets they intend to serve. Examples include CE, UL, cUL, FCC, CSA, VDE, TÜV, and CENELEC, as appropriate.

2.2. TP/XF-78 and TP/XF-1250 Channel Types

The TP/XF-78 and TP/XF-1250 channel types use transformer-coupled transceivers on bus-topology twisted pair media. The TP/XF-78 channel type supports a 78kbps bit rate; the TP/XF-1250 channel type supports a 1.25Mbps bit rate.

2.2.1. Performance Specifications

Table 2 provides a summary of the performance specifications for the TP/XF-78 and TP/XF-1250 channel types. Echelon's TPT/XF-78 and TPT/XF-1250 transceivers meet the requirements of the TP/XF-78 and TP/XF-1250 channel types.

Table 2. TP/XF-78 and TP/XF-1250 Performance Specifications

Specification	*TP/XF-78*	*TP/XF-1250*
Transmission Speed	78kbps	1.25Mbps
Devices per Channel	64 (0 to +70°C) 44 (-40 to +85°C)	64 (0 to +70°C) 32 (-20 to +85°C) 20 (-40 to +85°C)
Device Distribution	Any	≤ 8 devices per 16m -section
Network Bus Wiring	UL Level IV, 22 AWG (0.65 mm) twisted pair	
Network Stub Wiring	UL Level IV, 22 or 24 AWG (0.5 mm) twisted pair	
Network Bus Length - Typical [3] - Worst-case [4]	 2000m 1330m	 500m 130m
Maximum Stub Length [5]	3m	0.3m
Network Terminators	Required at both ends of the network	

[3] Typical conditions are 20°C, 5.0 V supply voltage, normal wire temperature and 64 evenly distributed nodes
[4] Worst-case conditions are the combined effect of worst-case conditions of all the above parameters
[5] The stub length in Table 2 assumes a mutual capacitance of 17 pF/ft (56 pF/m) for the twisted pair stub cable.

Specification	TP/XF-78	TP/XF-1250
Temperature Operating	0 to +70°C (64-device load) -40 to +85°C (44-device load)	0 to +70°C (64-device load) -20 to +85°C (32-device load) -40 to +70°C (20-device load)
Electrostatic Discharge to Network Connectors No Errors No Hard Failures	 to 15kV to 20kV	 to 15kV to 20kV
Isolation between Network and I/O Connectors 0–60Hz (60 seconds) 0–60Hz (continuous)	 1000 VRMS 277 VRMS	 1000 VRMS 277 VRMS

Manufacturers of certified products are free to use any media connection or connector scheme customary in their industry.

2.2.2. Transceiver Schematic

Figure 3 shows the circuit that is required with Echelon's TPT/XF-78 and TPT/XF-1250 twisted pair modules. Each module contains the complete twisted pair transceiver, and can be mounted on a printed-circuit board (PCB) assembly either as a plug-in or soldered component.

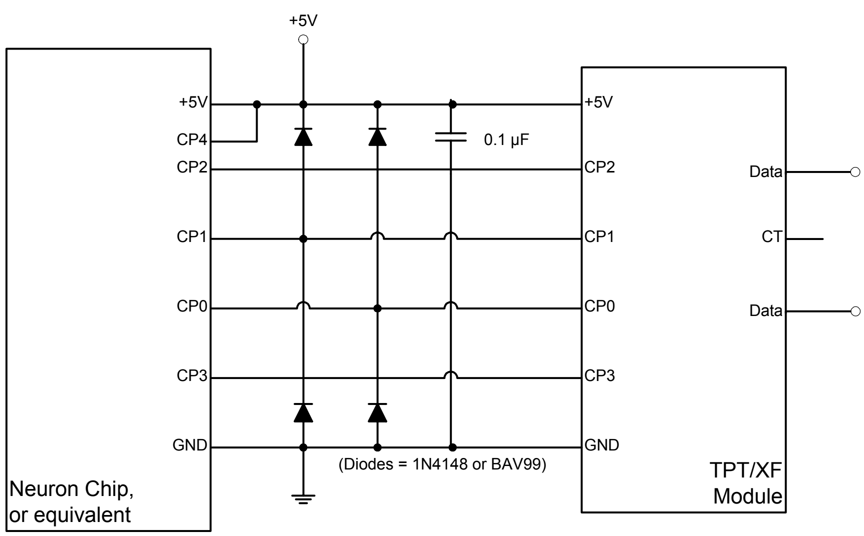

Figure 3. TPT/XF-78 or TPT/XF-1250 Transceiver Circuit

Using Echelon's TPT/XF-78 and TPT/XF-1250 Twisted pair Transceiver Modules (see Figure 3) minimizes circuit layout considerations, since most layout sensitive components are encased in the module. However, the following guidelines must be observed.

Guideline 2.2.2A:	If an Echelon Corporation TPT/XF module is used, then PCB trace lengths between the TPT/XF module P2 header and the twisted pair stub connector should be kept less than 5 cm for the TPT/XF-78 module and less than 2 cm for the TPT/XF-1250 module.

Guideline 2.2.2B:	If an Echelon Corporation TPT/XF module is used, then the total differential trace capacitance between CP0 and CP1 lines connecting the TPT/XF module and the Neuron Chip shall be ≤3pF.

This is achieved by keeping the total trace distance between the Neuron Chip CP lines and the TPT/XF module less than 2 cm. To achieve shielding and minimize capacitance, symmetrical layout guidelines must be followed for the communications port traces connecting the TPT/XF module with the Neuron Chip. CP0 and CP1 may be exchanged with one another. CP2 and CP3 also may be exchanged with one another independently of CP0 and CP1. Pins should be exchanged to optimize the PCB layout to eliminate crossovers. When routing CP traces from the Neuron Chip it is recommended that CP3 be routed directly underneath the Neuron Chip via the NC pin to achieve symmetry and shielding of the trace from the Neuron Chip to the module. On multi-layer boards, the use of a 25% crosshatch ground-plane underneath the CP lines will enhance the shielding while minimizing capacitance.

2.2.3. Network Cabling and Connection

2.2.3.1. Network Cable

The characteristics of the wire used to implement a channel will affect the overall system performance with respect to total distance, stub length, and total number of nodes supported on the channel. The channel performance is characterized for UL level IV, 22 AWG twisted pair cable for the network bus wiring as defined in UL's *LAN Cable Certification Program*, document number 200-120 20M/11/91. Level IV 22 or 24 AWG (0.5 mm) twisted pair cable may be used for the stub wiring.

Guideline 2.2.3.1:	A TP/XF-78 or TP/XF-1250 channel shall use UL Level IV, 22 AWG (0.65 mm) twisted pair cable.

2.2.3.2. Bus Termination

Guideline 2.2.3.2:	If the termination is provided with a certified TP/XF-78 or TP/XF-1250 device (attached or embedded), the termination circuit specified in 2.2.3.2 shall be used to terminate the channel.

It is necessary to terminate the ends of a twisted pair bus to minimize reflections. Failure to terminate the bus will degrade channel performance. Figure 4 details the circuit required to terminate TP/XF-1250 and TP/XF-78 channels.

Products do not need to include any network cable or bus termination. However, if they are provided, they must conform to these guidelines.

The following rated devices should be used:

Component	***Type***	***Rating***
Resistors	Metal Film	1%
Capacitors	Polyester	10%

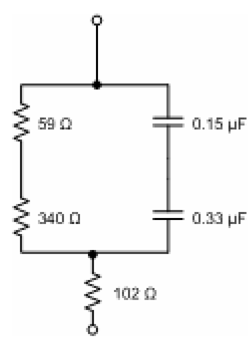

Figure 4. TP/XF-1250 and TP/XF-78 Bus Termination Circuit

2.3. TP-RS485-39 Channel Type

The TP-RS485-39 channel type uses transceivers that conform to the ANSI/TIA/EIA-485-A *Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems* specification on bus-topology twisted pair media and supports a 39kbps bit rate. A TP-RS485-39 transceiver (also known as an *RS-485 transceiver*) should operate at VDD = +5V, provide –7V to +12V common-mode range, and offer both short-circuit protection and a high-impedance output in the event of a local power failure. The ANSI/TIA/EIA-485-A standard allows for a continuum of bit rates. However, the TP-RS485-39 channel type specifies a single bit rate of 39kbps for interoperability.

2.3.1. Performance Specifications

Table 3 provides a summary of the performance specifications for the TP-RS485-39 channel type.

Table 3. TP-RS485-39 Performance Specifications

Performance Specification	***TP-RS485-39***
Transmission Speed	39kbps at listed bus length
Devices per Channel [6]	32
Network Stub Wiring	UL Level IV, 22 or 24 AWG twisted pair
Network Bus Wiring	UL Level IV, 22 AWG twisted pair
Maximum Stub Length	0m
Network Terminators	Required at both ends of network
Temperature Operating Non-operating	 0 to +70°C -40 to +85°C
Electrostatic Discharge to Network Connectors No Errors No Hard Failures	 to 15000V to 20000V
Maximum Channel Lengths	1200m per ANSI/TIA/EIA-485-A standard

2.3.2. Transceiver Schematic

The schematic for the TP-RS485-39 transceiver design is shown in Figure 4. Components for EMI, ESD, and transient protection should be added as needed. Unless otherwise noted, the following ratings apply to all devices on the schematic:

Component	***Type***	***Rating***		
Resistors	Metal film	5%	100 PPM per °C	1/8 watt

[6] These are standard specifications detailed in the ANSI/TIA/EIA-485-A Specification, Section 3, and entitled *Electrical Characteristics*.

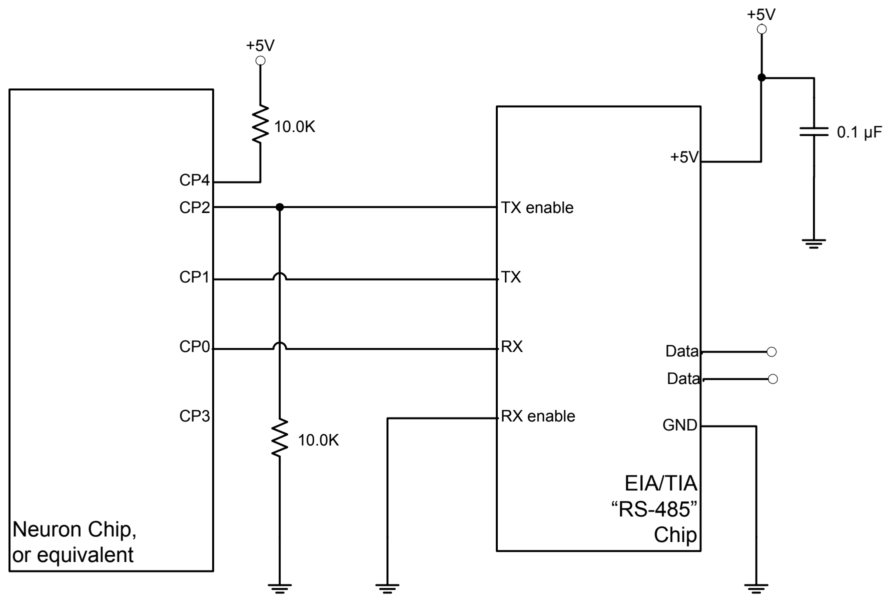

Figure 5. TP-RS485-39 Transceiver Circuit

2.3.3. Bus Termination

Guideline 2.3.3:	If the termination is provided with a certified TP-RS485-39 device (attached or embedded), the termination circuit specified in 2.3.3 shall be used to terminate the physical channels.

It is necessary to terminate the ends of a twisted pair bus to minimize reflections. Failure to terminate the bus will degrade network performance. Figure 6 details the circuit required to terminate the TP-RS485-39 physical channel. The TP/XF-78 and TP/XF-1250 termination circuit (see Figure 4) may be substituted for the one in Figure 6 if the one in Figure 6 in not available.

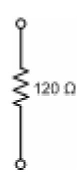

Figure 6. TP-RS485-39 Bus Termination Circuit

2.3.4. Grounding

A signal return path between the circuit grounds of devices on a TP-RS485-39 network must be provided. The ground reference may be established by a third conductor or by providing a connection to an earth reference at each device.

Guideline 2.3.4:	A certified TP-RS485-39 device shall comply with the grounding requirements of the ANSI/TIA/EIA-485-A standard Section A.3 entitled *Optional Grounding Arrangements*.

2.4. PL-20(L-N) and PL-20(L-E) Channel Types

The PL-20(L-N) and PL-20(L-E) channel types use transceivers that conform to the ANSI/EIA/CEA-709.2-A *Control Network Power Line (PL) Channel Specification*. These transceivers use narrow-band signaling over a 125kHz–140kHz frequency band on power mains media and support a 5kbps bit rate. The PL-20(L-N) channel type uses line-to-neutral signaling; the PL-20(L-E) channel type uses line-to-earth signaling.

2.4.1. Performance Specifications

Table 4 provides a summary of the specifications for the PL-20 channel types. Echelon's PL Smart Transceiver and PLT-22 transceiver meets the requirements of the PL-20 channel types.

Table 4. PL-20(L-N) and PL-20(L-E) Performance Specifications

Parameter	***PL-20(L-N)***	***PL-20(L-E)***
Coupling Technique	Line-to-neutral	Line-to-earth
Bit Rate	5kbps	
Transceiver Crystal	10MHz, 200ppm, 13pF, parallel resonant	
Modulation	BPSK	
Frequency Band	125kHz–140kHz	
Output Level	≤ 116dBμV per EN50065-1 for Class 116 EN50065-1 compliance ≥115dBμV per EN50065-1 otherwise	
Output Impedance	|Z|≤6Ω 129kHz–134kHz	|Z|≤8Ω, 120VAC |Z|≤15Ω, 240VAC 129kHz–134kHz
Input Impedance [7]	≥100Ω 125kHz–140kHz	

[7] Input impedance of transceiver and associated coupling circuit only. It does not include effect, if any, of system power supply. See the *ANSI/EIA-709.2-A Control Network Power Line (PL) Channel Specification* for guidelines. An additional resource of information, if you are using a PLT-22 transceiver, is Echelon's *LONWORKS PLT-22 Transceiver User's Guide*.

2.4.2. Transceiver Interface Specification

Figure 7 shows a typical PL-20 transceiver application block-diagram. The coupling circuit and power supply must be selected based upon the intended application.

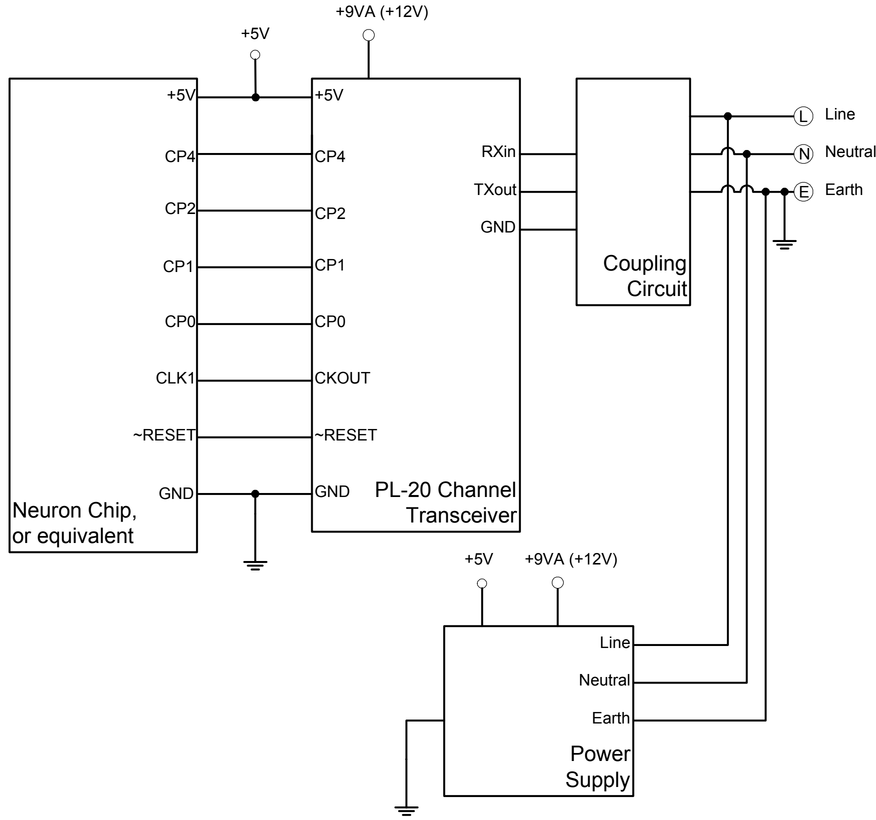

Figure 7. PL-20 Transceiver Sample Circuit

2.4.3. Coupling Circuits

The two methods of coupling to the power line, *line-to-neutral* coupling and *line-to-earth* coupling, define two different power line channels referred to as PL-20(L-N) and PL-20(L-E), respectively. Most installations will consist of devices that use only one channel type in order to achieve maximum communication reliability. However, L-N and L-E devices may be mixed within an installation with the possibility of significant loss (2 – 20dB) of communication margin between L-N and L-E devices depending on physical location and power line environment.

2.4.3.1. Line-to-Neutral Coupling

The PL-20(L-N) channel type specifies coupling circuits that transmit and receive the power-line communications signals between the line and neutral mains conductors. Line-to-neutral coupling is used in power-mains circuits where a ground is not available, or where low ground-leakage is required.

2.4.3.2. Line-to-Earth Coupling

The PL-20(L-E) channel type specifies coupling circuits that transmit and receive the power-line communications signals between the line and earth mains conductors. Line-to-earth coupling is used in power-mains circuits where an earth conductor is available.

Specific coupling circuits for use with Echelon's PLT-22 transceivers are described in the *ANSI/EIA/CEA-709.2-A Control Network Power Line (PL) Channel Specification*. An additional resource of information is Echelon's *LONWORKS PLT-22 Transceiver User's Guide*.

2.4.4. Power Supply Requirements

Most linear power supplies do not load the transmitted signal, nor do they generate significant electrical noise. Switching power supplies may load the transmitted signal, or generate significant electrical noise; either of which will limit system performance. The following guidelines must be met to avoid attenuation of the transmit signal and coupling of noise directly into the input of a receiver.

2.4.4.1. Attenuation

Guideline 2.4.4.1:	When connecting the input (line side) of a switching power supply directly to the coupling circuit of a certified PL-20 device, the guidelines for preventing the switching supply from attenuating the communications signal, as outlined in the *ANSI/EIA/CEA-709.2 Control Network Power Line (PL) Channel Specification*, shall be followed.

2.4.4.2. Noise

Guideline 2.4.4.2:	When connecting the input (line side) of a switching power supply directly to the coupling circuit of a certified PL-20 device, the guidelines for preventing the switching supply from conducting excessive noise onto the communications channel, as outlined in the *ANSI/EIA/CEA-709.2-A Control Network Power Line (PL) Channel Specification*, shall be followed.

2.5. PL-20A(L-N) Channel Type

The PL-20A(L-N) channel type uses transceivers that conform to the CENELEC EN 50065-1 power line channel specification. These transceivers use line-to-neutral narrow-band signaling over a 70kHz – 95kHz frequency band on power mains media and support a 3600bps bit rate.

2.5.1. Performance Specifications

Table 5 provides a summary of the specifications for the PL-20A channel type. Echelon's PL Smart Transceiver and PLT-22 transceiver meets the requirements of the PL-20A channel type when connected to a 6.5536 MHz crystal clock.

Table 5. PL-20A(L-N) Performance Specifications

Parameter	*PL-20A*
Coupling Technique	Line-to-neutral
Transmission Speed	3600bps
Transceiver Crystal	6.5536MHz, 200ppm, 16pF, parallel resonant
Modulation	BPSK
Frequency Band	70kHz–95kHz
Output Level	≤ 116dBµV per EN50065-1 for Class 116 EN50065-1 compliance ≥115dBµV per EN50065-1 otherwise
Output Impedance	|Z|≤1.1Ω 70kHz–95kHz
Input Impedance [8]	≥500Ω 70kHz–95kHz

2.5.2. Transceiver Interface Specification

Figure 8 shows a typical PL-20A transceiver application block-diagram. The coupling circuit and power supply must be selected based on the intended application.

[8] Input impedance of transceiver and associated coupling circuit only. It does not include effect, if any, of system power supply. See the CENELEC *EN 50065-1:1991/prAC:1994* document for restrictions, and Echelon's *Using the LONWORKS PLT-22 Power Line Transceiver in European Utility Applications* guide for additional details of this power line channel specification.

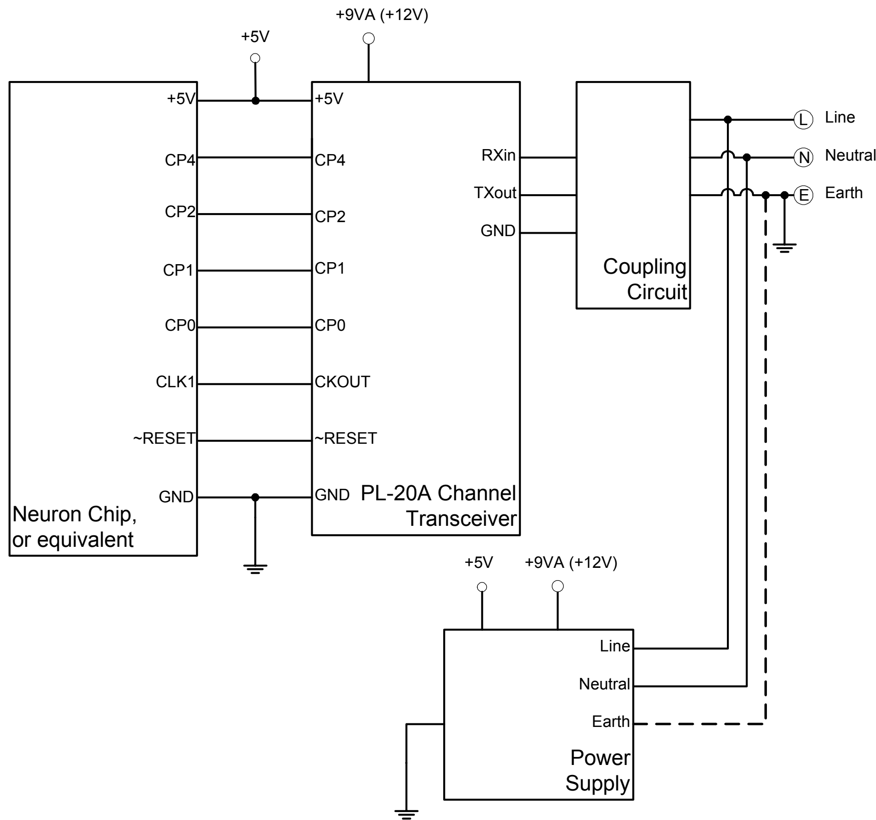

Figure 8. PL-20A Transceiver Sample Circuit

2.5.3. Coupling Circuits

The PL-20A(L-N) channel type specifies coupling circuits that transmit and receive the power line communications signals between the line and neutral mains conductors. Line-to-neutral coupling is always used for the PL-20A channel.

Specific coupling circuits for use with PL-20A transceivers should be obtained from the transceiver manufacturer.

2.5.4. Power Supply Requirements

Most linear power supplies do not load the transmitted signal, nor do they generate significant electrical noise. Switching power supplies may load the transmitted signal, or generate significant electrical noise; either of which will limit system performance. The following guidelines must be met to avoid attenuation of the transmit signal and coupling of noise directly into the input of a receiver.

2.5.4.1. Attenuation

Guideline 2.5.4.1:	When connecting the input (line side) of a switching power supply directly to the coupling circuit of a certified PL-20A device, the guidelines for preventing the switching supply from attenuating the communications signal, as outlined in Echelon's *Using the LONWORKS PLT-22 Power Line Transceiver in European Utility Applications* guide, shall be followed.

2.5.4.2. Noise

Guideline 2.5.4.2:	When connecting the input (line side) of a switching power supply directly to the coupling circuit of a certified PL-20A device, the guidelines for preventing the switching supply from conducting excessive noise onto the communications channel, as outlined in Echelon's *Using the LONWORKS PLT-22 Power Line Transceiver in European Utility Applications* guide, shall be followed.

2.6. TP/FT-10 Channel Type

The TP/FT-10 channel type uses transceivers that conform to the ANSI/EIA/CEA 709.3-A *Free-Topology Twisted Pair Channel Specification* on free-topology twisted pair media and supports a 78 125bps bit rate. These transceivers encode data using differential Manchester encoding, which is polarity insensitive. A TP/FT-10 channel consists of up to 64 devices on a single network segment; or 128 devices along with a link power source, which supplies DC power to the devices on the channel. The free topology wiring supported by the TP/FT-10 channel type accommodates bus, star, loop, or several combinations of these topologies. The total network length and number of devices may be extended by use of ANSI/EIA/CEA-709.1 routers, and/or one TP/FT-10 physical-layer repeater. Devices can be either locally powered or link powered. A link powered device derives its polarity-insensitive power from the network.

Echelon's FTT-10A, LPT-10, LPT-11, and FT Smart Transceivers meet the requirements of the TP/FT-10 channel type.

2.6.1. Performance Specifications

The TP/FT-10 channel type supports a maximum bit error rate of 1 in 100 000. Both link power and locally powered devices can be supported on a given segment, provided that the following constraint is met:

(1 x LinkPoweredDeviceCount) + (2 x LocallyPoweredDeviceCount) ≤ 128

Transmission performance varies with the type of network cable used. Network performance has been characterized for several cable types as detailed below. Table 6 shows the maximum bus length for a doubly terminated topology network using TIA 568A Category 5 cabling.

Table 7 shows the maximum device-to-device distance and maximum wire length for a singly terminated free-topology network using Category 5 cabling. The distance from each device to each of the other devices, and to the link power source, shall not exceed the maximum device-to-device distance. If multiple paths exist, *e.g.*, a loop topology, then the longest path shall be used for the calculations. The maximum wire length is the total amount of wire connected to a network segment.

Table 6. Doubly-Terminated Bus-Topology Specifications

Cable [9]	*Maximum Bus Length*	*Maximum Stub Length*
TIA 568A Category 5 cable/24AWG (0.5mm)	900 meters	3 meters

Table 7. Free-Topology Specifications

Cable [10]	*Maximum Device-to-Device Distance*	*Maximum Total Wire Length*
TIA 568A Category 5 cable/24AWG (0.5mm)	250 meters	450 meters

Guideline 2.6.1: A certified TP/FT-10 device shall meet all requirements set-forth in the *ANSI/EIA/CEA 709.3-A Free-Topology Twisted Pair Channel Specification*.

[9] Detailed cable specifications are provided in the *ANSI/TIA/EIA-568-A-1995, Commercial Building Telecommunications Cabling Standard*.

[10] Detailed cable specifications are provided in the *ANSI/TIA/EIA-568-A-1995, Commercial Building Telecommunications Cabling Standard*.

2.6.2. Link Power Supply Requirements

A link power supply is required if any link powered devices are installed on a TP/FT-10 channel. The power supply specifications listed in Table 8 and Table 9 shall be met over all combinations of the following conditions:

- ❑ $T_{ambient}$ 0 to 50˚C
- ❑ Specified coupling circuit connected
- ❑ Line input voltage over full range per specification
- ❑ Network output load = 0 to 1.5 DC amperes

Table 8. Power Supply Requirements

Description	***Conditions***	***Specification***
Line input voltage & indicator	• Measured at "A"	Line voltage as required by application. Input power applied indicator required (LED or equivalent)
Output voltage	• Measured at "B"	42.4VDC maximum 42.08VDC minimum
Output voltage regulation response	• Measured at "B" • 50% step change in load	Output voltage must recover to within 1% of its final value in less than 1ms of step change in load
Output reference	• Measured at "B" • Coupling circuit disconnected	Floating with respect to earth
Output ripple voltage (differential)	• Measured at "B"	Reference Figure 9
Spike noise (differential)	• Measured at "B" • 50MHz bandwidth	400mVpeak-to-peak maximum
Output common-mode noise	• Measured at "B" with respect to earth	100mVpeak-to-peak maximum
Continuous output current capability	• Measured at "B"	0–1.5ADC
Output startup interval behavior	• Startup or recovery from output short circuit or overcurrent fault • Measured at "B"	Reference Figure 10

Description	Conditions	Specification
Short-circuit output protection	• Continuous short circuit at output for any duration	Must recover after fault is cleared according to "Output startup interval behavior" specification
Single fault tolerance	• Any single component failure as open or short • Measured at "B"	"V_{in+}" – "V_{in-}" ≤ 42.4V |"V_{in+}" to earth| ≤ 42.4V |"V_{in-}" to earth| ≤ 42.4V

Notes and definitions for Table 8 and Table 9:

- "A" is the line input to the link power supply.
- "B" is the floating output of the link power supply. This is also the input to the power supply coupler.
- "C" is the network connection of the power supply coupler.

Table 9. Power Supply Environmental Requirements

Description	Conditions	Specification
Ambient temperature	• Operating • Storage	0–50˚C -40–85˚C
IEC 801-2 ESD immunity	• Air discharge at "C" to either "Net+" or "Net-" terminal	+/- 15kV (Level 4) Output voltage must recover within 10ms following an ESD discharge
IEC 801-3 Radiated susceptibility (Continuous RF excitation with 80% AM)	• Twisted pair cable connected at "C"	10 V/m (Level 3) All specifications contained herein must be met
IEC 801-4 Burst immunity	• Capacitive clamp discharge to twisted pair cable connected at "C" according to IEC 801-4	2kV (Level 4) Output voltage must recover within 10ms following each burst
IEC 801-5 Surge immunity	• 1.2/50 µs - 8/20 µs combination wave surge waveform • Coupling circuit – see figure 11, IEC 801-5, line-to-ground coupling • Discharged at "C" to either "Net+" or "Net-"	+/- 2kV (Level 3) Output voltage must recover within 10ms following a surge discharge
Earth reference terminal		Required if coupling network is not grounded via power supply

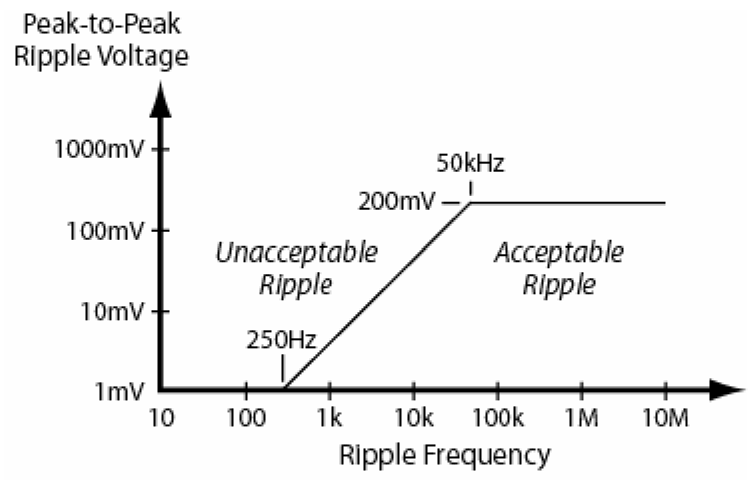

Figure 9. Power Supply Output Ripple Voltage Requirement

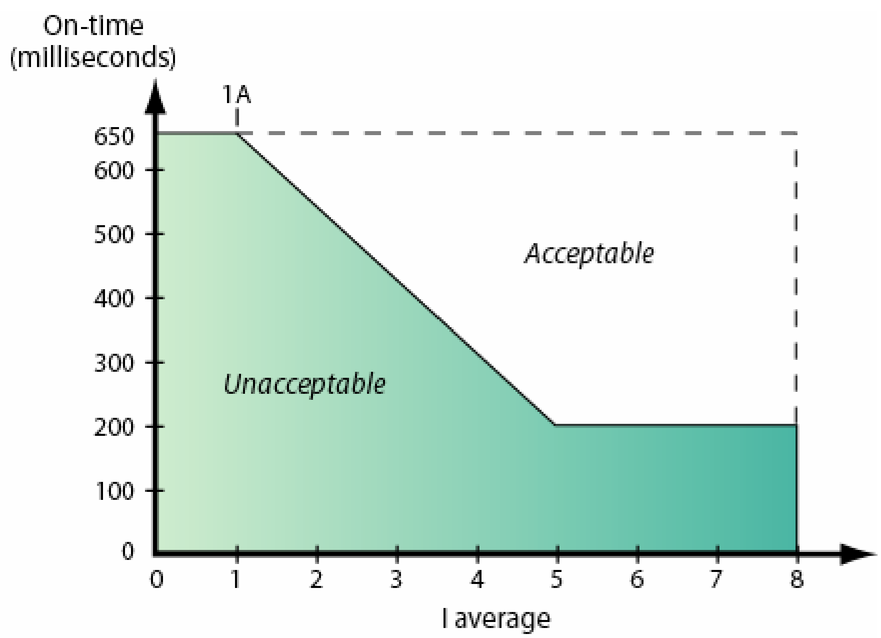

Figure 10. Power Supply Startup Interval Behavior

Notes and definitions for Figure 10:

- On-time is defined as the time for the source power supply to charge the network from 0V to 42VDC for a given average output current.
- $I_{average}$ is the average output current available from the source power supply when charging the network from 0 to 42 VDC. Once the output voltage has reached 42V, the output current capability must be at least 1.5 amperes.

2.6.3. Passive Coupler Circuit Schematic

The schematic for a TP/FT-10 link power supply passive coupler is shown in Figure 11, with referenced components listed in Table 10.

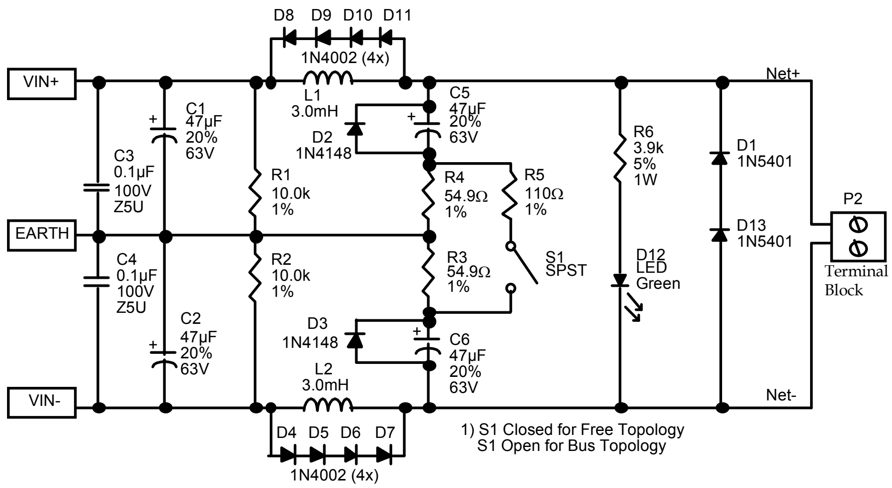

Figure 11. Passive Coupler Circuit

Table 10. Coupler Circuit Bill of Materials

Item	Quantity	Reference	Description
1	4	C1, C2, C5, C6	Capacitor, Aluminum Electrolytic, 47µF, 20%, 63V
2	2	C3, C4	Capacitor, Ceramic, 0.1µF, 100V, Z5U
3	2	D1, D13	Diode, 1N5401, 3 ampere, 100V
4	2	D2, D3	Diode, 1N4148 or equivalent
5	8	D4, D5, D6, D7, D8, D9, D10, D11	Diode, 1N4002, 1 ampere, 100V
6	1	D12	LED, Green, Hewlett Packard HLMP-3502 or equivalent
7	2	L1, L2	Inductor, 3.0mH, Ferrite Core, 1.5 ampere, RDC≤0,36Ω,
8	1	P2	Terminal block, 2 conductor, accepts conductor size AWG 24 – 14 (0.5mm – 2.05mm)
9	2	R1, R2	10.0kΩ, 1%, 1/4W
10	2	R3, R4	54.9Ω, 1%, 1/4W

Item	Quantity	Reference	Description
11	1	R5	110Ω, 1%, 1/4W
12	1	R6	3.9kΩ, 5%, 1W
13	1	S1	Switch, SPST or equivalent jumper

2.7. FO-20S Channel Type

The FO-20S channel type uses transceivers that conform to the ANSI/EIA/CEA-709.4 *Fiber Optic Channel Specification*, Type 1A, on a single, active daisy-chained (point-to-point) single-strand fiber optic cable and supports a 1.25Mbps bit rate. These transceivers encode data by amplitude modulating the carrier frequency using differential Manchester encoding. An FO-20S channel supports up to 64 devices on a single network segment. Each transceiver contains two channel connectors. Multiple devices may be interconnected in a point-to-multipoint fashion provided that the transceiver in one of the devices supports three or more channel connections. Connecting the last device on a string (point-to-point series of strands) to the first device results in a ring topology. This is an active ring in that the transceivers at each device in the ring must be powered in order to maintain data propagation from one link to the next link. With an active ring topology, each device in the ring receives and regenerates all incoming message packets. Regeneration reshapes the received signal and restores the power level of the outgoing signal.

2.7.1. Performance Specifications

The FO-20S channel type is specified to support a ring topology but will accommodate a bus topology with loss of redundancy. The total network length and number of devices may be extended by use of ANSI/EIA/CEA-709.1 routers equipped with FO-20S transceivers.

Table 11. FO-20S Standard Cable Type Specifications

Cable [11]	Maximum Device-to-Device Distance	Maximum Stub Length
ANSI\TIA\EIA 492AAAA-A Class 1a graded-index, multi-mode, glass optical fibers; Core Diameter 62.5 µm, Cladding Diameter 125 µm	25 meters	3 meters

[11] Detailed cable specifications for the FO-20S are provided in *ANSI\TIA\EIA 492AAAA-A*. Glass fiber optic cable connectors should be installed in a manner that meets Annex A of *ANSI/TIA/EIA 570-A Optical Fiber Connector Performance Specifications*.

Table 12. FO-20S Transmission Performance Specification

Parameter	*Value*
Optical parameters	62.5/125 fiber cable
Attenuation at 850 nm	< 3.5 dB/km

Table 13. FO-20S Communications Parameters

Parameter	*Value*
Communication mode	Single-ended
Bit rate	1250kbps
Device priorities	0
Channel priorities	16
Clock rate	10MHz minimum
Preamble length, at 10MHz	221.4–229.8 μsec
Packet cycle, at 10MHz	4020 μsec
Beta 2 time, at 10MHz	132 μsec
Interpacket delays (Tx/Rx)	None/None
Collision detection	No
Bit-synchronization threshold	4 bits

Guideline 2.6.2: A certified FO-20S device shall meet all requirements set-forth in the *ANSI/EIA/CEA-709.4 Fiber Optic Channel Specification*, Type 1A.

2.8. FO-20L Channel Type

The FO-20L channel type uses transceivers that conform to the ANSI/EIA/CEA-709.4 *Fiber Optic Channel Specification*, Type 1B, on a single, active daisy-chained (point-to-point) single-strand fiber optic cable and supports a 1.25Mbps bit rate. These transceivers encode data by amplitude modulating the carrier frequency using differential Manchester encoding. An FO-20L channel supports up to 512 devices on a single network segment. Each transceiver contains two channel connectors. Multiple devices may be interconnected in a point-to-multipoint fashion provided that the transceiver in one of the devices supports three or more channel connections. Connecting the last device on a string (point-to-point series of strands) to the first device results in a ring topology. This is an active ring in that the transceivers at each device in the ring must be powered in order to maintain data propagation from one link to the next link. With an active ring topology, each device in the ring receives and regenerates all incoming message packets. Regeneration reshapes the received signal and restores the power level of the outgoing signal.

2.8.1. Performance Specifications

The FO-20L channel type is specified to support a ring topology but will accommodate a bus topology with loss of redundancy. The total network length and number of devices may be extended by use of ANSI/EIA/CEA-709.1 routers equipped with FO-20L transceivers.

Table 14. FO-20L Standard Cable Types Specifications

Cable [12]	***Maximum Device-to-Device Distance***	***Maximum Stub Length***
ANSI\TIA\EIA 492AAAA-A Class 1a graded-index, multi-mode, glass optical fibers; Core Diameter 62.5 µm, Cladding Diameter 125 µm	25 meters	3 meters

Table 15. FO-20L Transmission Performance Specification

Parameter	***Value***
Optical parameters	62.5/125 Fiber Cable
Attenuation at 850 nm	< 3.5 dB/km

[12] Detailed cable specifications for the FO-20S are provided in *ANSI\TIA\EIA 492AAAA-A*. Glass fiber optic cable connectors should be installed in a manner that meets Annex A of *ANSI/TIA/EIA 570-A Optical Fiber Connector Performance Specifications*.

Table 16. FO-20L Communications Parameters

Parameter	***Value***
Communication mode	Single-ended
Communication rate	1250kbps
Node priorities	0
Channel priorities	16
Clock rate	10MHz minimum
Preamble length, at 10MHz	221.4–229.8 µsec
Packet cycle, at 10MHz	4020 µsec
Beta 2 time, at 10MHz	1056 µsec
Interpacket delays (Tx/Rx)	None/None
Collision detection	No
Bit-synchronization threshold	4 bits

Guideline 2.8.1:	A certified FO-20L device shall meet all requirements set-forth in the *ANSI/EIA/CEA-709.4 Fiber Optic Channel Specification*, Type 1B.

2.9. IP-852 Channel Type

The IP-852 channel type uses Internet-tunneling transceivers that conform to the CEA-852 or CEA-852-A *Tunneling of Component Network Data Over IP Channels* specification, Annex A. This channel type allows for communications between LONWORKS devices over a private or public Internet Protocol (IP) network by tunneling the ANSI/EIA/CEA-709.1 (EN14908-1) protocol inside the structure of the Internet Protocol. Tunneling is a way of carrying the messages of one protocol—in their original packet shape—in the data section of another protocol's packet. Figure 12 demonstrates the concept of packaging the content of the message. Figure 13 demonstrates the concept of tunneling packets.

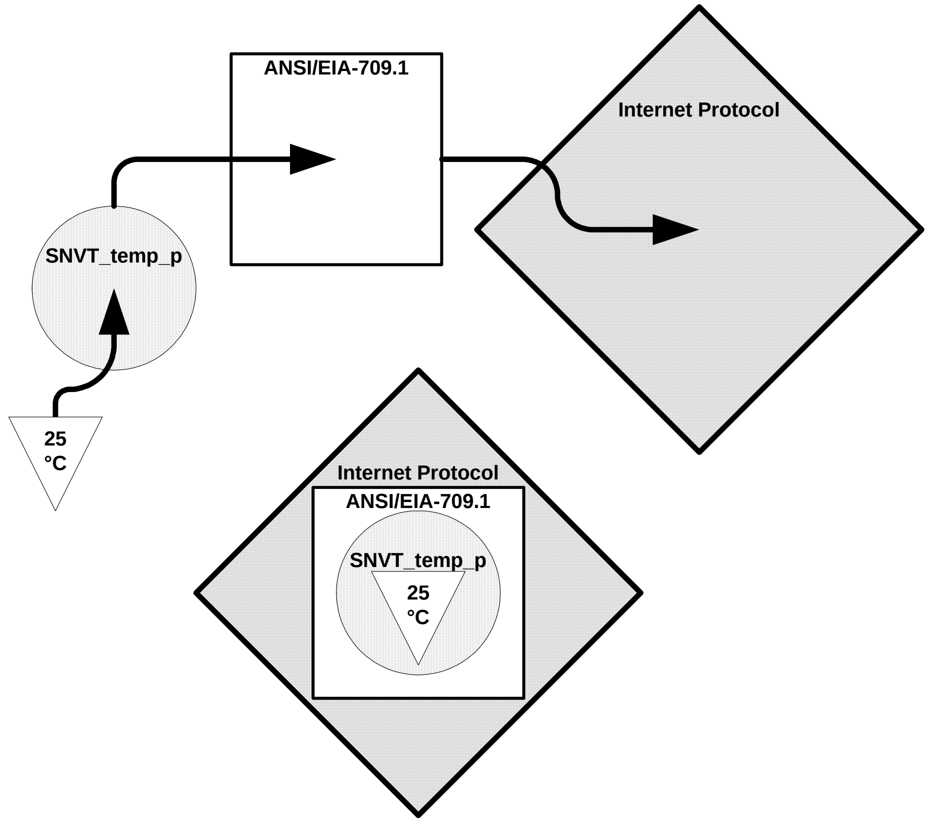

Figure 12. Value, Container, and 709.1 Protocol Packaging in IP

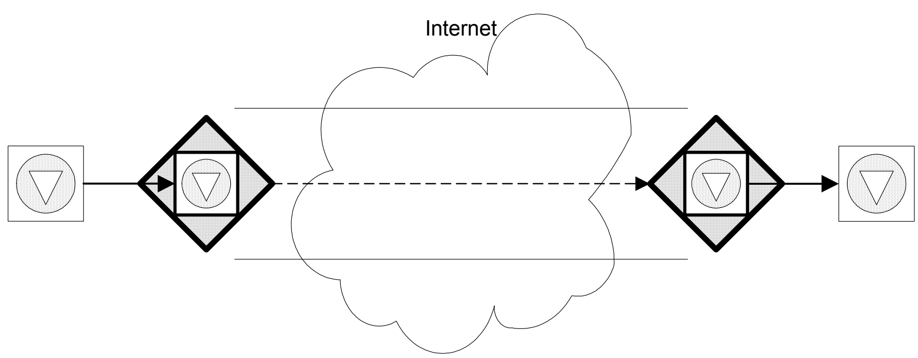

Figure 13. Packing, Tunneling, and Unpacking 709.1 Protocol

2.9.1. Implementation Requirements

The format of the IP-852 packets encapsulated by the IP tunnel include the Level 2 Header (L2Hdr) field through the cyclical-redundancy-check (CRC) field, inclusively. It does not include the Preamble, BitSync, or ByteSync fields, nor does it include the Line-Code Violation bits from the ANSI/EIA/CEA-709.1 (EN14908-1) protocol specification.

All devices must support User Datagram Protocol (UDP). Support for Transmission Control Protocol (TCP) is optional for certain types of messages, but in addition to UDP.

IP-852 devices may optionally use the following port numbers, which have been assigned by the IANA[13]. Use of these port numbers is not required. Port 1628 is recommended as the default for normal traffic.

- lontalk-norm 1628/udp LonTalk normal
- lontalk-norm 1628/tcp LonTalk normal
- lontalk-urgnt 1629/udp LonTalk urgent
- lontalk-urgnt 1629/tcp LonTalk urgent

Guideline 2.9.1:	A certified IP-852 device shall meet all requirements set-forth in the *CEA-852 (or CEA-852-A) Tunneling of Component Network Data over IP Channels* specification.

[13] The Internet Assigned Numbers Authority (IANA) maintains a list of registered TCP and UDP ports at the following link: www.iana.org/assignments/port-numbers

3

Layers 2 – 6

In addition to having the appropriate transceiver connected to the communication port of a Neuron Chip or equivalent processor, there must be appropriate channel settings present in the memory of the processor to enable the ANSI/EIA/CEA-709.1 (EN14908-1) protocol to send out and receive messages in the correct format to allow interoperability. Compliance with these LONMARK Guidelines for Layers 2 – 6 of the ANSI/EIA/CEA-709.1 (EN14908-1) protocol is easily accomplished by making selections within development tool software. For example, these settings may be selected using Neuron C compiler directives (#**pragma**) when developing applications using the Neuron C programming language, and many of these settings are automatic if the compiler directives are not specified.

3.1. Layer 2: Link Layer

The *link layer* defines media access methods and data encoding to ensure efficient use of a single communications channel. The raw bits of the physical layer are broken up into data frames. The link layer defines when a source device can transmit a data frame, and defines how destination devices receive the data frames and detect transmission errors. A priority mechanism is also defined to ensure delivery of important messages.

3.1.1. Channel Parameters

The Neuron Chip communications port supports a number of parameters that allow the Neuron Chip to communicate over different media, depending on how they are configured. These parameters govern the low-level communication characteristics. On each communications channel, a unique combination of settings provides optimum communications. The collections of settings used for a particular physical communication medium is called the medium's *channel parameters*.

The Neuron Chip communications port, used in direct mode, encodes and decodes data using differential Manchester or bi-phase space coding. A *preamble* is transmitted at the beginning of a packet to allow the other devices on the channel to synchronize their receiver clocks. An idle period called the *beta 1* time is provided after each packet to allow devices on a channel to synchronize to the end of a packet. Another important characteristic of a message is the *beta 2* time, which defines the width of the randomizing slots. The lengths of the preamble, beta 1, and beta 2 times are configurable by the LONWORKS network designer independently of the transceiver design. In order for a set of devices to interoperate, the channel parameters that control the preamble, beta 1, and beta 2 times must match. If a processor other than a Neuron Chip is used for communications, that processor must provide support for emulating the same communications provided by the Neuron Chip. For more information about channel parameters see the ANSI/EIA/CEA-709.1 protocol specification.

> Guideline 3.1.1A: To be interoperable, all of the devices on a channel must be configured with the same channel parameters, and the parameters must be for one of the approved LONMARK channels types.

The channel parameters corresponding to each of the approved LONMARK channel types are shown in Table 17. If you are using one of Echelon Corporation's development systems, for example, then the correct channel parameters are automatically loaded.

Table 17. Channel Parameters

Channel	Comm Port Mode	Bit Rate	Maximum Number of Priority Slots	Minimum Clock Rate (MHz)	Oscillator Accuracy	Average Packet Size
TP-RS485-39	Single-ended	39kbps	4	5	200ppm	15 bytes
TP/XF-78	Differential	78kbps	4	5	200ppm	15 bytes
TP/XF-1250	Differential	1.25Mbps	16	10	200ppm	15 bytes
TP/FT-10	Single-ended	78kbps	4	5	200ppm	15 bytes
PL-10 (L-E)	Special purpose	10kbps	8	5	200ppm	15 bytes
PL-20 (L-N)	Special purpose	5kbps	8	1.25	200ppm	15 bytes
PL-20A (L-N)	Special purpose	3.6kbps	8	1.25	200ppm	15 bytes
PL-20 (L-E)	Special purpose	5kbps	8	1.25	200ppm	15 bytes
PL-30 (L-N)	Special purpose	2kbps	8	5	200ppm	15 bytes
FO-20S	Single-ended	1.25Mbps	16	10	200ppm	15 bytes
FO-20L	Single-ended	1.25Mbps	16	10	200ppm	15 bytes

Note: The FO-20S channel has replaced the FO-10 channel's XID (24), and the parameters are not the same.

The ANSI/EIA/CEA-709.1 (EN14908-1) protocol supports communication between devices running at different clock speeds by lengthening the preamble for all devices on a channel to accommodate the device with the slowest clock speed on the channel. However, there is a penalty on channel throughput as the preamble is lengthened. All devices on the channel share this channel performance penalty—including the devices whose clocks run at the maximum clock speed possible. In order to provide some flexibility, but also sustain good channel performance, all interoperable devices must adhere to the minimum clock speed values indicated in Table 17.

> Guideline 3.1.1B: A certified device shall implement the minimum acceptable clock rate as indicated in Table 17.

The oscillator accuracy of all the devices on a channel directly affects the throughput of the channel by affecting the width of the priority and randomizing slots that may be supported. The accuracy of the oscillator has the largest effect on channel throughput of all of the parameters discussed. In order to not degrade channel throughput and also to support a reasonable number of priority slots per channel, all interoperable devices must include an oscillator with an accuracy of at least 0.02% over the complete temperature range within which the device is operated. This means that crystals must be used rather than ceramic resonators.

Guideline 3.1.1C:	A certified device shall use an oscillator with an accuracy of 0.02% (200ppm), or better.

The ANSI/EIA/CEA-709.1 protocol permits a network tool to optionally allocate priority time slots on a channel to particular devices. These priority time slots come before the non-priority time slots. The network tool can ensure that one-and-only-one device is assigned to a particular priority slot on the channel. Because there is no contention for the medium during the priority portion of a packet cycle, devices configured with priority have better response time than non-priority devices when the channel is heavily utilized (when traffic is high).

All devices sharing the same channel must be configured with the same maximum number of priority slots so that they can reliably exchange messages and so that priority messages gain priority access to the channel. Each priority time slot on a channel adds a minimum of two bit times to the transmission of every message. The amount of overhead associated with priority messaging varies based upon the bit rate, oscillator accuracy, and transceiver characteristics of devices on the channel.

The default maximum number of priority slots is kept small to minimize effects on throughput, but may be increased at installation time by a network tool. By requiring a higher-accuracy oscillator, the effect of each priority slot on throughput is also minimized.

Guideline 3.1.1D:	A certified device shall be configured with a default maximum number of priority slots as shown in Table 17.

Guideline 3.1.1E:	A certified application device shall not use priority slot 1—it is reserved for use by network tools.

3.1.2. Network Buffers

The network I/O buffer sizes are configurable within the application program on a device. There are three buffer sizes and counts to configure: network output buffers, network output priority buffers, and network input buffers.

The network input buffers in a device must be at least 66 bytes to allow the device to receive all network management messages. The Neuron C compiler uses this default for a Neuron C application if the application does not explicitly set the network input buffer size.

> Guideline 3.1.2A: The network input buffers in a certified device shall be at least 66 bytes.

The network output buffers in a device must be large enough to send the longest packet that the device application can generate. However, a minimum size of 42 bytes is required to support all network management responses. This length includes not only the application information, but also the worst-case addressing overhead for the packet, which is 22 bytes. Addressing overhead is partly dependent on the domain length chosen for a network at installation time. The Neuron C compiler uses these defaults for a Neuron C application if the application does not explicitly set the network output buffer size.

> Guideline 3.1.2B: The network output buffers in a certified device shall be at least 42 bytes; or 22 bytes larger than the largest network variable, application message, or response message sent by the device application, whichever is larger.

A device must have network output priority buffers if the device can be installed to use priority messaging. The same sizing and count rules apply for priority buffers as for ordinary network output buffers. A Neuron C application can use the **nonpriority nonconfig** declaration for network variables (or not set the priority field for explicit messages) to ensure that no priority can be assigned on the device. In that case, priority network output buffers are not required.

> Guideline 3.1.2C: A certified device shall implement priority network output buffers if the device can send priority messages or priority network variables.

3.2. Layer 3: Network Layer

The *network layer* defines how message packets are routed from a source device to one or more destination devices. This layer defines naming and addressing of devices to ensure the correct delivery of packets. This layer also defines how messages are routed between the source and destination device when these devices are on different channels.

A *name* is an identifier that uniquely identifies a single object within an object class. A name is assigned when an object is created and does not change over its lifetime. To ensure that every ANSI/EIA/CEA-709.1 device can be uniquely distinguished from every other ANSI/EIA/CEA-709.1 device, every ANSI/EIA/CEA-709.1 (EN14908-1) device includes a unique 48-bit name called the *Neuron ID*. This ID will always be unique for every ANSI/EIA/CEA-709.1 device and does not change over the lifetime of the ANSI/EIA/CEA-709.1 device. The Neuron ID is also called the *unique node ID*.

An *address* is an identifier that uniquely identifies an object or group of objects within an object class. Unlike a name, an address may be assigned and changed any time after an object is created.

ANSI/EIA/CEA-709.1 addresses uniquely identify the source device and destination device or devices of an ANSI/EIA/CEA-709.1 (EN14908-1) packet. Routers may use these addresses to selectively pass packets between two channels.

A Neuron ID may be used as an address. However, the Neuron ID is not used as the sole form of addressing in the ANSI/EIA/CEA-709.1 (EN14908-1) protocol because such addressing only supports one-to-one transactions (i.e., no groups), and would require excessively large routing tables to optimize network traffic. As a result, this addressing mode is used only for installation, configuration, and diagnostics since it allows communications with a device before the device has been assigned an address, and is useful for detecting duplicate network addresses.

To simplify routing, the ANSI/EIA/CEA-709.1 (EN14908-1) protocol defines a dynamically-assigned hierarchical form of addressing using three address components: the *domain*, *subnet*, and *node* addresses. This form of addressing can be used to address an individual device or collections of devices sharing common subnet or domain address components. To further facilitate the addressing of multiple dispersed devices, the ANSI/EIA/CEA-709.1 (EN14908-1) protocol defines another class of dynamic addresses using domain and *group* addresses. The dynamic addresses for a device are called the *network address*.

The use of a dynamically assigned address instead of a fixed name simplifies replacement of devices in a functioning network. A network tools assigns a replacement device the same network address as the device it replaces. Thus all references to this device from elsewhere on the network do not need to be modified, as would be the case if Neuron ID addressing was used.

A device may assign its own network address. This form of addressing is called *self-installation*. Self-installation requires knowledge of other devices in a network. Self-installation is typically only used for simple networks where a hardware input controlled by an integrator or other hardware means can be used to manually assign a network address to a device. It must be possible to disable self-installation to allow a self-installed device to be used in a network where the network addresses are assigned by a network tool. See *Self-Installed Devices* in the *LONMARK Application-Layer Interoperability Guidelines* for guidelines on implementing self-installed devices.

3.3. Layers 4 & 5: Transport and Session Layers

The *transport layer* ensures reliable delivery of message packets. Messages can be exchanged using an acknowledged service, where the sending device waits for an acknowledgement from the receiver and resends the message if the acknowledgement is not received. This is called the *acknowledged message service*. The transport layer also defines how duplicate messages are detected and rejected if a message is re-sent due to a lost acknowledgement.

The *session layer* adds control to the data exchanged by the lower layers. It supports remote actions so that a client may make a request to a remote server and receive a response to this request. Remote actions are implemented using the *request message service*. It also defines an authentication protocol that enables receivers of a message to determine if the sender is authorized to send the message.

The acknowledged or request message services are not permitted when the packet to be sent requires a network output buffer greater than 66 bytes. The reason for this is that all devices on a channel must receive every message in order to maintain the correct estimate of the channel backlog. If an incoming message is longer than the network input buffer allocated to hold it, the message will fail the CRC and will be discarded prior to extracting the backlog information from it. Since unacknowledged packets always have a backlog increment of zero, there is no problem sending longer packets using one of the unacknowledged message services provided by the ANSI/EIA/CEA-709.1 (EN14908-1) protocol. All devices must therefore use unacknowledged message services when transmitting packets that require output buffers longer than 66 bytes.

Guideline 3.3A:	A certified device shall not use the acknowledged or request message services for packets requiring a network output buffer greater than 66 bytes.

A *receive transaction entry* is required on a device to manage outstanding time-outs for any incoming message that uses either a repeated, acknowledged, or request message service. No receive transaction entries are required for an incoming message using an unacknowledged message service. A receive transaction entry is required for each unique source address/destination address/priority attribute. Each receive transaction entry contains a current transaction number. A message is considered to be a duplicate if its source address, destination address, and priority attribute vector into an existing receive transaction and the message's transaction number matches the entry's transaction number.

The *receive transaction count* is the maximum number of simultaneous receive transaction entries that are be supported by a device. The receive transaction count must be large enough to support the maximum number of outstanding receive transaction entries likely to be required for the device in a network installation. At a minimum, the receive transaction count for a certified device that receives application or foreign-frame messages must be equal to the following value:

ReceiveTransactionCount = max(8, min (16, NonConfigInputNvCount + 2))

At a minimum, the receive transaction count for a certified device that does not receive application or foreign-frame messages must be equal to the following value:

ReceiveTransactionCount = min(16, NonConfigInputNvCount + 2)

The Neuron C compiler uses these defaults for a Neuron C application if the application does not explicitly set the receive transaction count.

Guideline 3.3B:	A certified device shall implement a receive transaction count equal to or greater than the value calculated by the formulas in 3.3.

3.4. Layer 6: Presentation Layer

The *presentation layer* adds structure to the data exchanged by the lower layers by defining the encoding of message data. Messages may be encoded as network variables, configuration properties, application messages, or foreign frames. Interoperable encoding of network variables and configuration properties is provided with standard network-variable types (SNVTs) and standard configuration-property types (SCPTs). The *LONMARK Application-Layer Interoperability Guidelines* specify guidelines for use of network variables, configuration properties, and messaging.

Index

A

acknowledged message service, 45
ANSI/EIA/CEA 709.1 Control Network Protocol
  defined, 5, 6
  reference, 8
ANSI/EIA-709.2-A. *See* PL-20(L-N) and PL-20(L-E)
ANSI/EIA-709.3-A. *See* TP/FT-10
ANSI/EIA-709.4. *See* FO-20S and FO-20L
ANSI/TIA/EIA-485-A. *See* TP-RS485-39
authentication, 45
average packets sizes, 40

B

beta 1, 40
beta 2, 40
bit rates, 40
buffers
  network, 42

C

CENELEC EN 50065-1. *See* PL-20A(L-N)
channel parameters, 13, 40
channel types
  FO-20L. *See* FO-20L
  FO-20S. *See* FO-20S
  IP-852. *See* IP-852
  PL-20(L-E). *See* PL-20(L-E)
  PL-20(L-N). *See* PL-20(L-N)
  PL-20A(L-N). *See* PL-20A(L-N)
  proposing new, 14
  standard, 12
  TP/FT-10. *See* TP/FT-10
  TP/XF-1250. *See* TP/XF-1250
  TP/XF-78. *See* TP/XF-78
  TP-RS485-39. *See* TP-RS485-39
channels
  defined, 6, 11

clock rates, 40
communications channels. *See* channels
control network
defined, 5

D

devices
defined, 6

E

EIA/CEA-852. *See* IP-852

F

FO-20L
defined, 34
network cabling, 34
performance specifications, 34
FO-20S
defined, 32
network cabling, 32
performance specifications, 32

I

IP-852
defined, 35
implementation requirements, 36

L

layer 2. *See* link layer
layer 3. *See* network layer
layer 4. *See* transport layer
layer 5. *See* session layer
layer 6. *See* presentation layer
line-to-earth coupling
PL-20(L-E), 22
line-to-neutral coupling
PL-20(L-N), 22
PL-20A(L-N), 25
link layer
chanel parameters, 40
defined, 40
LONMARK Application-Layer Interoperability Guidelines
reference, 8
LONMARK Association Principal Engineer, 8
LONMARK certification, 6, 7
LONMARK Interoperability Guidelines
defined, 5
LONMARK logo, 5, 6
LONMARK Program Overview, 9
LonTalk protocol, 5
LONWORKS platform, 5

N

network buffers, 42
network layer
acknowledged message service, 45
addressing, 44
defined, 43
naming, 43
nodes. *See* devices

O

oscillator accuracy, 40

P

packet sizes, 40
performance testing, 15
physical layer
defined, 11
PL-20(L-E)
coupling circuits, 22
defined, 21
performance specifications, 21
power supplies, 23
transceiver interface specifications, 22
PL-20(L-N)
coupling circuits, 22
defined, 21
performance specifications, 21
power supplies, 23
transceiver interface specifications, 22
PL-20A(L-N)

coupling circuits, 25
defined, 24
performance specifications, 24
power supplies, 25
transceiver interface specifications, 24
preamble, 40
presentation layer
defined, 46
priority slots, 40

R

receive transaction counts, 45
receive transaction entries, 45
request message service, 45

S

session layer
authentication, 45
defined, 45
request message service, 45
standard channel types. *See* channel types
Standard Transceiver Reference, 9
StdXcvr.xml, 9

T

TP/FT-10
bit error rate, 27
defined, 26
link power supply requirements, 28
network cabling, 27
passive coupler, 31
performance specifications, 27
repeaters, 26
TP/XF-1250
bus termination, 18
defined, 15
network cabling, 17
performance specifications, 15
transceiver schematic, 16
TP/XF-78
bus termination, 18
defined, 15
network cabling, 17
performance specifications, 15
transceiver schematic, 16
TP-RS485-39
bus termination, 20
defined, 18
grounding, 20
performance specifications, 19
transceiver schematic, 19
transceivers
defined, 11
transport layer
defined, 44
tunneling, 35