



# Junction Box and Wiring Guideline for Twisted Pair LONWORKS® Networks

December 2010

LONWORKS Engineering Bulletin

## New Information

Revision P adds a new vendor, JJ-Lapp Cable, provides new listings for Connect-Air Wire and Cable, and includes Category 6 cable for the TP/FT-10 channel.

## Introduction

This bulletin identifies the different types of cabling and junction boxes that may be used in twisted pair LONWORKS networks. The recommendations presented herein are intended to assist network integrators, OEMs, electrical system designers, interconnection device manufacturers, and cable manufacturers, and are provided for informational purposes only.

For specific details on the operation and cabling requirements of the FT 3120®/FT 3150® Free Topology Smart Transceivers, TP/FT-10 (FTT-10A and LPT transceivers), TP/XF-78 (TPT/XF-78 transceiver), TP/XF-1250 (TPT/XF-1250 transceiver), and TP-RS485 (TP-RS485 control module) channels please refer to the pertinent user's guides. The guides can be downloaded from Echelon's web site at [www.echelon.com](http://www.echelon.com).

This document also includes specifications for twisted pair cabling for use in train braking applications compliant with the requirements of the Association of American Railroads. The AAR application uses the PL-20 channel (PLT-22 Power Line Transceiver or PL 3120 or PL 3150 Power Line Smart Transceiver) operating over a doubly terminated twisted pair power cable 3 kilometers in length. In such applications a special, non-standard coupling circuit and cable terminations are required, please contact Echelon for details.

## Network Cabling

### *TP/FT-10 Free Topology Channel*

Five cable types have been validated for the TP/FT-10 channel. These cable types are:

<b>Cable Type</b>	<b>AWG</b>	<b>Diameter</b>
TIA 568A Category 5 or Category 6 cable	24WAWG 0.5mm	
Belden 8471 (PVC jacket) or equivalent cable	16AWG 1.3mm	
Belden 85102 (Tefzel jacket) or equal cable	16AWG 1.3mm	
Level IV cable	22AWG	0.65mm
JY (st) Y 2x2x0.8	20.4AWG	0.8mm

The distance limitations, electrical characteristics, and suppliers of these cables follow. Link power applications have unique distance limitations based on power consumption. Please refer to the pertinent LPT user's guide for details.

### *TP/XF-78 Bus Topology Channel*

One cable type has been validated for the TP/XF-78 channel (for use with the TPT/XF-78 Bus Topology Transceiver). The only approved cable type is:

<b>Cable Type</b>	<b>AWG</b>	<b>Diameter</b>
Level IV cable	22AWG	0.65mm

The distance limitations, electrical characteristics, and suppliers of this cable are presented below.

### *TP/XF-1250 Bus Topology Channel*

Two cable types have been validated for the TP/XF-1250 channel (for use with the TPT/XF-1250 Bus Topology Transceiver). These cable types are:

<b>Cable Type</b>	<b>AWG</b>	<b>Diameter</b>
TIA 568A Category 5 cable	24AWG	0.5mm
Level IV cable	22AWG	0.65mm

The distance limitations, electrical characteristics, and suppliers of these cables are presented below.

### *TP-RS485 Channel*

Channels employing RS-485 transceivers should use only a shielded, twisted pair cable approved by the manufacturer for use with EIA RS-485 transceivers.

### *PL-20 Channel for Train Braking*

One cable type has been validated for use with the PL-20 channel for long distance signaling on S-4210 cable configured in a doubly terminated bus. This cable type is as follows:

<b>Cable Type</b>	<b>AWG</b>	<b>Diameter</b>
AAR S-4210 twin-axial, 50 Ohm cable	8WAWG 3.3mm	

## Cable Specifications

### *TIA 568A Category 5 or Category 6 Cable*

The specifications for Category 5 or Category 6 cabling are defined by the Telecommunications Industry Association standard 568A. The typical parameters of these cables are as follows:

Wire Diameter (mm/AWG)	Resistance Rloop $\Omega$ /km	Capacitance nF/km	Velocity of Propagation $V_{prop}$ % of c
0.51mm/24 168		46	58

Echelon has qualified cabling that meets the TIA 568A standard, and any cabling – from any manufacturer - that meets this standard is acceptable.

For the TP/FT-10 channel operating in a bus topology, the maximum bus length of TIA 568A Category 5 or Category 6 cabling is 900 meters, with a maximum stub length of 3 meters.

For the TP/FT-10 channel operating in free topology, the maximum length of TIA 568A Category 5 or Category 6 cabling is 250 meters maximum node-to-node distance, and 450 meters maximum total wire length.

For the TP/XF-1250 channel operating in a bus topology, the maximum bus length of TIA 568A Category 5 or Category 6 cabling is 130 meters, with a maximum stub length of 0.3 meters. There are topology restrictions associated with the use of this channel – refer to Chapter 5 of the *TPT Twisted Pair Transceiver User's Guide* **before** installing any cabling for this channel.

### *Belden 8471 Cable*

Belden 8471 16AWG (1.3mm) cable may be used only with the TP/FT-10 channel. Belden does not publish those 8471 cable parameters that affect signaling on TP/FT-10 channels, however, Echelon has measured the following important parameters:

Wire Diameter (mm/AWG)	Resistance Rloop $\Omega$ /km	Capacitance nF/km	Velocity of Propagation $V_{prop}$ % of c
1.3mm/16 28		72	55

For the TP/FT-10 channel operating in a bus topology, the maximum bus length of Belden 8471 cabling is 2700 meters, with a maximum stub length of 3 meters.

For the TP/FT-10 channel operating in free topology, the maximum length of Belden 8471 cabling is 400 meters maximum node-to-node distance, and 500 meters maximum total wire length.

### *Belden 85102 Cable*

Belden 85102 16AWG (1.3mm) cable may be used only with TP/FT-10 channels. Belden does not publish those 85102 cable parameters that affect signaling on TP/FT-10 channels, however, Echelon has analyzed this cable in some detail. The following specifications can be used by cable suppliers to produce an equivalent cable:

	<i>Minimum</i>	<i>Typical</i>	<i>Maximum</i>	<i>Units</i>	<i>Condition</i>
DC Resistance, each conductor	14.0 14.7		15.5	$\Omega$ /km	20°C per ASTM D 4566
DC Resistance Unbalance			5%		20°C per ASTM D 4566
Mutual Capacitance			55.9	nF/km	Per ASTM D 4566
Characteristic Impedance	92	100	108	$\Omega$	64kHz to 1MHz per ASTM D 4566
Attenuation 20kHz 64kHz 78kHz 156kHz 256kHz 512kHz 772kHz 1000kHz			1.3 1.9 2.2 3.0 4.8 8.1 11.3 13.7	dB/km	20°C per ASTM D 4566
Propagation Delay			5.6	nsec/m	78kHz

For the TP/FT-10 channel operating in a bus topology, the maximum bus length of Belden 85102 cabling is 2700 meters, with a maximum stub length of 3 meters.

For the TP/FT-10 channel operating in free topology, the maximum length of Belden 85102 cabling is 500 meters maximum node-to-node distance, and 500 meters maximum total wire length.

### *Level 4 Cable*

Level 4 cables may be used with TP/FT-10, TP/XF-78, or TP/XF-1250 channels. The Level 4 cable specification used by Echelon and as originally defined by the National Electrical Manufacturers Association (NEMA) differs from the Category 4 specification proposed by the Electronic Industries Association/Telecommunication Industry Association (EIA/TIA). The following specifications can be used by cable suppliers to identify a compliant Level 4 cable – or produce an equivalent cable:

<b>Specifications apply to shielded or unshielded 22AWG (0.65mm) cable, 24AWG (0.5mm) cable shown in brackets [ ] if different</b>	
<b>D-C Resistance</b> (Ohms/1000 feet at 20°C) maximum for a single copper conductor regardless of whether it is solid or stranded and is or is not metal-coated.	18.0 [28.6]
<b>D-C Resistance Unbalance</b> (percent) maximum	5
<b>Mutual Capacitance of a Pair</b> (pF/foot) maximum	17
<b>Pair-to-Ground Capacitance Unbalance</b> (pF/1000 feet) maximum	1000
<b>Characteristic Impedance (Ohms)</b>	
772kHz 102±15%	
1.0MHz	100±15%
4.0MHz	100±15%
8.0MHz	100±15%
10.0MHz	100±15%
16.0MHz	100±15%
20.0MHz	100±15%
<b>Attenuation (dB/1000 feet at 20°C) maximum</b>	
772kHz 4.5	[5.7]
1.0MHz 5.5	[6.5]
4.0MHz 11.0	[13.0]
8.0MHz 15.0	[19.0]
10.0MHz 17.0	[22.0]
16.0MHz 22.0	[27.0]
20.0MHz 24.0	[31.0]
<b>Worst-Pair Near-End Crosstalk</b> (dB) minimum. Values are shown for information only. The minimum NEXT coupling loss for any pair combination at room temperature is to be greater than the value determined using the formula $NEXT (F_{MHz}) > NEXT(0.772) - 15 \log_{10}(F_{MHz}/0.772)$ for all frequencies in the range of 0.772MHz-20MHz for a length of 1000 feet.	
772kHz 58	
1.0MHz 56	
4.0MHz 47	
8.0MHz 42	
10.0MHz 41	
16.0MHz 38	
20.0MHz 36	

For the TP/FT-10 channel operating in a bus topology, the maximum bus length of Level 4 22AWG (0.65mm) cabling is 1400 meters, with a maximum stub length of 3 meters.

For the TP/FT-10 channel operating in free topology, the maximum length of Level 4 22AWG (0.65mm) cabling is 400 meters maximum node-to-node distance, and 500 meters maximum total wire length.

For the TP/XF-78 channel operating in a bus topology, the maximum bus length of 4 22AWG (0.65mm) cabling is 1400 meters, with a maximum stub length of 3 meters. There are topology

restrictions associated with the use of this channel – refer to Chapter 5 the *TPT Twisted Pair Transceiver User's Guide* **before** installing any cabling for this channel.

For the TP/XF-1250 channel operating in a bus topology, the maximum bus length of 4 22AWG (0.65mm) cabling is 130 meters, with a maximum stub length of 0.3 meters. There are topology restrictions associated with the use of this channel – refer to Chapter 5 of the *TPT Twisted Pair Transceiver User's Guide* **before** installing any cabling for this channel.

### *JY (st) Y 2x2x0.8 Cable*

JY (st) cable is available only in Europe, and may be used only with the TP/FT-10 channel. Cable parameters that affect signaling on TP/FT-10 channels are not published for this cable, however, Echelon has measured the following important parameters:

Wire Diameter (mm/AWG)	Resistance Rloop $\Omega$ /km	Capacitance nF/km	Velocity of Propagation $V_{prop}$ % of c
0.8mm/20.4 73		98	41

For the TP/FT-10 channel operating in a bus topology, the maximum bus length of JY (st) cabling is 900 meters, with a maximum stub length of 3 meters.

For the TP/FT-10 channel operating in free topology, the maximum bus length of JY (st) cabling is 320 meters maximum node-to-node distance, and 500 meters maximum total wire length.

### *S-4210 Cable for Train Braking on PL-20 Channel*

S-4210 cable is a two conductor, twinaxial cable for exclusive use with the PLT-22 Power Line Transceiver and PL 3120/PL 3150 Power Line Smart Transceivers. Specialized coupling and termination circuits are required for this application.

Wire Diameter (mm/AWG)	Conductors	Characteristic Impedance ( $\Omega$ )	Construction
3.3mm/8 2		50	Twinaxial

The PL-20 channel for train braking must be operated in a doubly terminated bus topology, and will function at distances of at least 3 kilometers with 160 PLT-22-based or smart transceiver devices, and no stubs. Contact your Echelon representative for details on coupling circuits.



Untwisted wires, or cables containing flat or parallel untwisted conductors must not be used on an LONWORKS twisted pair channel. The use of these wires/cables may result in improper network operation and could, under certain circumstances, result in damage to nodes connected to such a channel.

## Cable Suppliers

The following cable suppliers have stated that their listed cables comply with Echelon wire guidelines.

### Belden Wire & Cable Company

#### Corporate

2200 U.S. 27 South  
Richmond, Indiana 47374  
Phone: +1-765-983-5200  
Phone: 1-800-235-3361  
Fax: +1-765-983-5294  
Web: [www.belden.com](http://www.belden.com)

#### Europe

#### Head Office

Edisonstraat 9  
5928 PG Venlo  
The Netherlands  
Phone: +31 (0) 77 3878555  
Fax: +31 (0) 77 3878448

#### Asia/Pacific Head Office

100 Olympia Street  
Tottenham, Victoria 3012  
Australia Dubai,  
Phone: +61 (3) 9224 2800  
Fax: +61 (3) 9314 8515

#### Africa/ Middle East Head Office

P.O. Box 17308  
Jebel Ali  
U.A.E.  
Phone: +971 4 814723  
Fax: +971 4 814726

Cable Type	Number of Pairs	Details	Catalog Number
16AWG (1.3mm)	1	Unshielded High temperature	85102
16AWG (1.3mm)	1	Unshielded PVC jacket Non-plenum	8471
Category 5	Various	Various	Contact mfg.

## **BICCGeneral** **(BICC Cable, Brand-Rex, General Cable, Carol Cable)**

### **NORTH AMERICAN CORPORATE HEADQUARTERS**

4 Tesseneer Drive  
Highland Heights, KY 41076  
Phone: +1-859-572-8000  
Fax: +1-859-572-845  
info@generalcable.com  
Web: [www.biccgeneral.com](http://www.biccgeneral.com)

<b>Cable Type</b>	<b>Number of Pairs</b>	<b>Details</b>	<b>Catalog Number</b>
Level 4 22AWG (0.65mm)	1	Unshielded Plenum U.L. Type CMP	C8601
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	C8611
Level 4 22AWG (0.65mm)	1	Unshielded Non-plenum U.L. Type CM	C8641
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	C8651
16AWG (1.3mm)	1	Unshielded Plenum U.L. Type CMP	C8621
16AWG (1.3mm)	1	Unshielded Non-plenum U.L. Type CM	C8661
Category 5	Various	Various	Contact mfg.
S-4210 8AWG (3.3mm)	1	Twin-axial, 50 Ohm	Brand-Rex T-75128



## The Cable Company

498 Bonnie Lane  
 Elk Grove, Illinois 60007  
 U.S.A  
 Phone: 1-847-437-5267  
 Fax: +1-847-437-8820  
 Web: [www.thecableco.com](http://www.thecableco.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Unshielded Non-plenum U.L. Type CMR	0612ECH
Level 4 22AWG (0.65mm)	2	Unshielded Non-plenum U.L. Type CMR	0614ECH
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CMR	0732ECH
Level 4 22AWG (0.65mm)	2	Shielded Non-plenum U.L. Type CMR	0734ECH
Level 4 22AWG (0.65mm)	1	Unshielded Plenum U.L. Type CMP	5012ECH
Level 4 22AWG (0.65mm)	2	Unshielded Plenum U.L. Type CMP	5014ECH
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	5202ECH
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	5204ECH
16AWG (1.3mm)	1	Unshielded Non-plenum U.L. Type CMR	0652ECH
16AWG (1.3mm)	1	Unshielded Plenum U.L. Type CMP	5052ECH

## Calvert Wire and Cable Corporation

5091 West 164th Street  
 Brook Park, OH. 44142  
 USA  
 Phone: +1-216-433-7600  
 Fax: +1-216-433-7614  
 Web: [www.calvert-wire.com](http://www.calvert-wire.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1 Stranded	Unshielded Non-plenum U.L. Type CMR	RD3001-LON
Level 4 22AWG (0.65mm)	2 Stranded	Unshielded Non-plenum U.L. Type CMR	RD2P3001-LON
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Non-plenum U.L. Type CMR	RD3011-LON
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Non-plenum U.L. Type CMR	RD2P3011-LON
Level 4 22AWG (0.65mm)	1 Stranded	Unshielded Plenum U.L. Type CMP	MDC3001-LON
Level 4 22AWG (0.65mm)	2 Stranded	Unshielded Plenum U.L. Type CMP	DMC2P3001-LON
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Plenum UL CMP	DMC3011-LON
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Plenum U.L. Type CMP	DMC2P3011-LON
Level 4 24AWG (0.5mm)	1 Stranded	Shielded Plenum U.L. Type CMP	402-241PFBSB
Level 4 24AWG (0.5mm)	2 Stranded	Shielded Plenum U.L. Type CMP	402-242PFBSO
Level 4 24AWG (0.5mm)	1 Stranded	Shielded Non-plenum U.L. Type CMR	401-241PFBSBW

## Communication Supply Corporation (CSC)

Low Voltage Division Headquarters

5950 Office Boulevard, N.E.

Albuquerque, NM 87108

USA

Phone: 1-505-344-3400, 1-800-334-2150

Fax: +1-505-345-3862

Web: [www.qocsc.com](http://www.qocsc.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1 Stranded	Unshielded Non-plenum U.L. Type CM	CSC 588547
Level 4 22AWG (0.65mm)	2 Stranded	Unshielded Non-plenum U.L. Type CM	CSC 588548
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Non-plenum U.L. Type CM	CSC 588549
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Non-plenum U.L. Type CM	CSC 588550
Level 4 22AWG (0.65mm)	1 Stranded	Unshielded Plenum U.L. Type CMP	CSC 583783
Level 4 22AWG (0.65mm)	2 Stranded	Unshielded Plenum U.L. Type CMP	CSC 588544
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Plenum U.L. Type CMP	CSC 588545
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Plenum U.L. Type CMP	CSC 588546

## ConnectAir International

4240 B Street N.W.  
 Auburn, Washington 98001  
 Phone: +1-253-813-5599  
 Phone: 1-800-247-1978  
 Fax: +1-253-813-5699  
 Web: [www.connect-air.com](http://www.connect-air.com)

Direct burial and aerial messenger cables also available. The two new listings (W161P-2130SG and W161P-2130FEP) are Level 4 Echelon cables. See the Connect-Air web site for data sheet details.

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 16AWG (1.3mm)	1	Stranded BC Plenum U.L. Type CMP	W161P-2130SG
Level 4 16AWG (1.3mm)	1	Stranded BC FEP (Teflon) Plenum U.L. Type CMP	W161P-2130FEP
Level 4 22AWG (0.65mm)	1	Unshielded Plenum U.L. Type CMP	W221P-2001
Level 4 22AWG (0.65mm)	2	Unshielded Plenum U.L. Type CMP	W222P-2003
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	W221P-2002
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	W222P-2004
Level 4 22AWG (0.65mm)	1	Unshielded Non-plenum U.L. Type CM	W221P-1002
Level 4 22AWG (0.65mm)	2	Unshielded Non-plenum U.L. Type CM	W222P-1004
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	P221P-1003
Level 4 22AWG (0.65mm)	2	Shielded Non-plenum U.L. Type CM	P222P-1005
Category 5	Various	Various	Contact mfg.
Composite			
Level 4 22 AWG (0.65mm)	1	Unshielded	W22162P-1820
16 AWG (1.3mm)	1	Unshielded Non-plenum Standard U.L. Type CM	

## Eastman Wire & Cable

International Sales Office

1085 Thomas Busch Highway  
 Pennsauken, New Jersey 08110  
 Phone: +1-609-488-8800  
 Phone: 1-800-257-7940  
 Fax: +1-609-488-8899  
 Web: [www.eastmanwire.com](http://www.eastmanwire.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Unshielded Plenum	LEV4221P725
Level 4 22AWG (0.65mm)	2	Unshielded Plenum	LEV4222P725
Level 4 22AWG (0.65mm)	1	Shielded Plenum	LEV4221PSJ725
Level 4 22AWG (0.65mm)	2	Shielded Plenum	LEV4222PSJ725
Level 4 22AWG (0.65mm)	1	Unshielded PVC jacket Non-plenum	LEV4221P
Level 4 22AWG (0.65mm)	2	Unshielded PVC jacket Non-plenum	LEV4222P
Level 4 22AWG (0.65mm)	1	Shielded PVC jacket Non-plenum	LEV4221PSJ
Level 4 22AWG (0.65mm)	2	Shielded PVC jacket Non-plenum	LEV4222PSJ
16AWG (1.3mm)	1	Unshielded Plenum	725-5705
16AWG (1.3mm)	1	Unshielded Plenum High temperature Radiation resistant	725-5705SP
16AWG (1.3mm)	1	Unshielded PVC jacket Non-plenum	5705
Category 5 24AWG (0.5mm)	4 Unshielded	Plenum	800-244CAT5 EZM
Category 5 24AWG (0.5mm)	4 Unshielded	Non-plenum	244CAT5 BL EZM
Category 5	Various	Various	Contact mfg.

## General Wire Products

International Sales Office

425 Shrewsbury Street  
 Worcester, Massachusetts 01604  
 Phone: +1-508-752-8260  
 Fax: +1-508-753-2173  
 Web: [www.generalwireproducts.com](http://www.generalwireproducts.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Unshielded Solid Plenum	030-21890
Level 4 22AWG (0.65mm)	2	Unshielded Solid Plenum	030-42102
Level 4 22AWG (0.65mm)	1	Shielded Solid Plenum	030-42701
Level 4 22AWG (0.65mm)	2	Shielded Stranded Plenum	030-21891
Level 4 22AWG (0.65mm)	1	Unshielded Stranded Plenum	030-21851
Level 4 22AWG (0.65mm)	2	Unshielded Stranded Plenum	030-52902-S
Level 4 22AWG (0.65mm)	1	Shielded Stranded Plenum	030-21892
Level 4 22AWG (0.65mm)	2	Shielded Solid Plenum	030-42702
16AWG (1.3mm)	1	Unshielded Stranded High temperature Harsh environment	030-84952
16AWG (1.3mm)	1	Unshielded Stranded PVC jacket Non-plenum	030-8321

## Great Lakes Wire and Cable, Incorporated

International & Domestic Sales Office

32400 Howard Street  
 Madison Heights, MI 48071  
 Phone: +1-248-616-0022  
 Phone: 1-888-833-4592  
 Fax: +1-248-616-9118  
 Web: [www.greatwire.com](http://www.greatwire.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1 solid	Unshielded plenum, U.L. Type CMP	70002
Level 4 22AWG (0.65mm)	2 solid	Unshielded plenum, U.L. Type CMP	70003
Level 4 22AWG (0.65mm)	1 solid	Shielded plenum, U.L. Type CMP	70004
Level 4 22AWG (0.65mm)	2 solid	Shielded plenum, U.L. Type CMP	70005
Level 4 22AWG (0.65mm)	1 stranded	Unshielded plenum, U.L. Type CMP	70006
Level 4 22AWG (0.65mm)	2 stranded	Unshielded plenum, U.L. Type CMP	70007
Level 4 22AWG (0.65mm)	1 stranded	Shielded plenum, U.L. Type CMP	70008
Level 4 22AWG (0.65mm)	2 stranded	Shielded plenum, U.L. Type CMP	70009
16AWG (1.3mm)	1 stranded	Unshielded plenum, U.L. Type CMP	70010
16AWG (1.3mm)	1 stranded	Unshielded Non-plenum, U.L. Type CMP	70011
16AWG (1.3mm)	1 stranded	Unshielded Plenum, U.L. Type CMP Harsh Environment High Temperature Radiation Resistant	70012
Category 5	Various	Various	Contact mfg.

## Honeywell Cable

### Honeywell Cable Products

7701 95th Street

Pleasant Prairie, WI 53158-2716

Phone: +1-262-947-0720 / +1-800-222-0060

Fax: +1-262-947-0724

Web: [www.honeywell.com](http://www.honeywell.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22 AWG (0.65mm)	1, stranded	Unshielded, CL2	1061
Level 4 22 AWG (0.65mm)	2, stranded	Unshielded, CL2	1062
Level 4 22 AWG (0.65mm)	1, stranded	Shielded, CL2	1063
Level 4 22 AWG (0.65mm)	2, stranded	Shielded, CL2	1064
Level 4 22 AWG (0.65mm)	1, stranded	Unshielded CL2P	3252
Level 4 22 AWG (0.65mm)	2, stranded	Unshielded, CL2P	3253
Level 4 22 AWG (0.65mm)	1, stranded	Shielded, CL2P	3254
Level 4 22 AWG (0.65mm)	2, stranded	Shielded, CL2P	3255



## JJ-Lapp Cable

**JJ-Lapp Cable Pte Ltd**

9 Tuas South Street

Singapore 63807

Phone: +65 65086206

Fax: +65 68631271

Web: [www.jj-lappcable.com](http://www.jj-lappcable.com)

<b>Cable Type</b>	<b>Number of Pairs</b>	<b>Details</b>	<b>Catalog Number</b>
Level 4 22 AWG (0.65mm)	1	Shielded, FRNC	3140160001
Level 4 22 AWG (0.65mm)	2	Shielded, FRNC	3140160002

## Keystone Electric Wire and Cable Company, Ltd.

Head Office      China

Factory

#110.D.D83      Ye  
Kwan Tri North Village  
Fanling, N.T.      Guangdong,  
Hong Kong      Postal

Sha Management District  
Shatin, Dongguan City  
P.R. China  
Code: 523998

Phone: +852-2691 7183

Phone: +86-769-886 7234

Fax: +852-2695 9738      Fax:

+86-769-886 1696

Web: [www.keystonecable.com](http://www.keystonecable.com)

Web:

[www.dgkeystone.com](http://www.dgkeystone.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Unshielded PVC jacket	H4-22Ax1
Level 4 22AWG (0.65mm)	2	Unshielded PVC jacket	H4-22Ax2
16AWG (1.3mm)	1	Unshielded PVC jacket	H4-16Ax1
Category 5, 24AWG	2	UTP, CM	H5-24Ax2
Category 5e, 24AWG	4	UTP, CM, CMX, CMR	H5-24Ax4
Category 5, 24AWG	12	UTP, CM, CMR	H5-24Ax12
Category 5, 24AWG	20	UTP, CM, CMR	H5-24Ax20
Category 5, 24AWG	25	UTP, CM, CMR	H5-24Ax25

**Lake Cable, LLC**

2020 North Austin Avenue  
 Chicago, IL. 60639  
 USA  
 Phone: +1-773-385-8700  
 Fax: +1-773-385-8770  
 Web: [www.lakecable.com](http://www.lakecable.com)

<b>Cable Type</b>	<b>Number of Pairs</b>	<b>Details</b>	<b>Catalog Number</b>
Level 4 22AWG (0.65mm)	1	Unshielded Plenum U.L. Type CMP	PF222C-ECH
Level 4 22AWG (0.65mm)	2	Unshielded Plenum U.L. Type CMP	PF222PRC-ECH
Level 4 22AWG (0.65mm)	1	Unshielded Plenum U.L. Type CMP	PF222C1-ECH
Level 4 22AWG (0.65mm)	2	Unshielded Plenum U.L. Type CMP	F222PRC1-ECH
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	PFF222PRCS-ECH
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	PFF222CS-ECH
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	222CSFPP-ECH
Level 4 22 AWG (0.65mm)	1	Unshielded Non-plenum U.L. Type CM	222PRC-ECH
Level 4 22 AWG (0.65mm)	1	Unshielded Non-plenum U.L. Type CM	222C-ECH

## Lucent Technologies

This product is now available through Systimax.

The FTT-10A Free Topology Transceiver is qualified for use SYSTIMAX Structured Cabling Systems.

Request information at [www.systimax.com](http://www.systimax.com).

<b>Cable Type</b>	<b>Number of Pairs</b>	<b>Details</b>	<b>Catalog Number</b>
Category 5 - Systimax	4	Non-plenum	1061
Category 5 - Systimax	4	Plenum	2061
Category 5 - Systimax	Various	Various	Contact mfg.

## Magnum Cable Corporation

International Sales Office

5250 Naiman Parkway  
 Solon, Ohio 44139 USA  
 Phone: +1-440-519-3333  
 Fax: +1-440-519-3334  
 Web: [www.magnumcable.com](http://www.magnumcable.com)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Unshielded Plenum	A3001LON
Level 4 22AWG (0.65mm)	2	Unshielded Plenum	A3004LON
Level 4 22AWG (0.65mm)	1	Shielded Plenum	A30016LON
Level 4 22AWG (0.65mm)	2	Shielded Plenum	A30018LON
Level 4 22AWG (0.65mm)	1	Unshielded PVC jacket Non-plenum	A20001LON
Level 4 22AWG (0.65mm)	2	Unshielded PVC jacket Non-plenum	A20003LON
Level 4 22AWG (0.65mm)	1	Shielded PVC jacket Non-plenum	A20050LON
Level 4 22AWG (0.65mm)	2	Shielded PVC jacket Non-plenum	A20052LON
16AWG (1.3mm)	1	Unshielded Plenum	A30013LON
16AWG (1.3mm)	1	Unshielded Plenum High Temperature Radiation Resistant	KA30013LON
16AWG (1.3mm)	1	Unshielded PVC jacket Non-plenum	A20032LON
Category 5 24AWG (0.5mm)	4 Unshielded	Plenum	A50588LON
Category 5 24AWG (0.5mm)	4 Unshielded	Non-plenum	A50069LON
Category 5	Various	Various	Contact mfg.

## Metro Wire and Cable Corporation

6636 Metro Pkwy  
 Sterling Heights, MI 48312  
 Phone: 1-586-264-3050  
 Phone: 1-800-633-1432  
 Fax: 1-586-264-7390  
 Email: [metro@metrowire.net](mailto:metro@metrowire.net) Fax:  
 Email:  
 2802 Independence Road  
 Iowa City, IA 52240  
 Phone: 1-319-337-9473  
 Phone: 1-800-633-1432  
 Fax: 1-319-834-1050  
 Email: [metro@metrowire.net](mailto:metro@metrowire.net)

2105 Newpoint Place  
 Suite 400  
 Lawrenceville, GA 30043  
 Phone: 1-770-995-3700  
 Phone 1-800-633-1432  
 1-770-995-3735  
[metro@metrowire.net](mailto:metro@metrowire.net)

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Unshielded Plenum U.L. Type CMP	MWC-1000
Level 4 22AWG (0.65mm)	2	Unshielded Plenum U.L. Type CMP	MWC-1001
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	MWC-1002
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	MWC-1003
Category 5, 24AWG	4	Unshielded Plenum	MWC-5456
Category 5, 24AWG	4	Unshielded Non-plenum	MWC-1728

## Paige Electric

1160 Springfield Road  
 P.O. Box 368  
 Union, New Jersey 07083-0368 USA  
 Phone: +1-908-687-7820  
 Phone: +1-800-327-2443  
 Fax: +1-908-687-8860  
 Web: [www.paigewire.com](http://www.paigewire.com)

<b>Cable Type</b>	<b>Number of Pairs</b>	<b>Details</b>	<b>Catalog Number</b>
Level 4 22AWG (0.65mm)	1	Unshielded Stranded Plenum U.L. Type CMP	AK3797
Level 4 22AWG (0.65mm)	2	Unshielded Stranded Plenum U.L. Type CMP	AK3799
Level 4 22AWG (0.65mm)	1	Unshielded Stranded Non-plenum U.L. Type CMR	AK3798

**Showa Electric Wire and Cable Co. Ltd. (Japan)**

No. 26 Chuo Building  
29-5, Nishi-Shinbashi 2-chome  
Minato-ku  
Tokyo

Phone: +81-03-3437-7301

Fax: +81-03-3437-7323

Web: <http://www.swcc.co.jp/eng/products/index.htm> or [www.swcc.co.jp](http://www.swcc.co.jp)

<b>Cable Type</b>	<b>Number of Pairs</b>	<b>Details</b>	<b>Catalog Number</b>
Level 4 22AWG (0.65mm)	1	Unshielded Non-plenum	LW221
Level 4 22AWG (0.65mm)	2	Unshielded Non-plenum	LW222
16AWG (1.3mm)	1	Unshielded Non-plenum	LW161



## The Siemon Company

Asia/Pacific

Room B1512  
Vantone New World Plaza  
No. 2 Fu Cheng Men Wai Avenue  
Xicheng District, Beijing  
100037 China  
Phone: +86-10-6858-7358  
Fax: +86-10-6858-7361  
Web: [www.siemon.com](http://www.siemon.com)

The Siemon Company has qualified Echelon's FTT-10A Free Topology Transceiver for use on Siemon's TBIC Total Building Integration Cabling system. At the time of publication of this document, TBIC is available only in the Asia/Pacific market. Please contact Siemon or check [www.siemon.com](http://www.siemon.com) for the availability of TBIC in other markets.

<b>Cable Type</b>	<b>Number of Pairs</b>	<b>Details</b>	<b>Catalog Number</b>
Category 5 - TBIC	Various	Various	Contact mfg.

**Wieland Electric Ltd.**

Europe Office

Riverside Business Center  
 Walnut Tree Close  
 Guildford  
 Surrey GUI 4UG  
 Phone: +44 (0) 1483-531213  
 Fax: +44 (0) 1483-505029  
 Web: [www.wieland.co.uk/buslynx](http://www.wieland.co.uk/buslynx)

Cable Type	Number of Pairs	Details	Catalog Number
Composite 16AWG (1.3mm)	2	Two unshielded 16AWG (1.3mm) twisted pairs for network signaling.	BusLynx
16AWG (1.3mm)	2	Two unshielded 16AWG (1.3mm) twisted pairs for low voltage, low current power distribution.	

Wieland cables employing parallel (non-twisted) high voltage power conductors may not be used with LONWORKS networks due to the potential for noise coupling.

## Windy City Wire

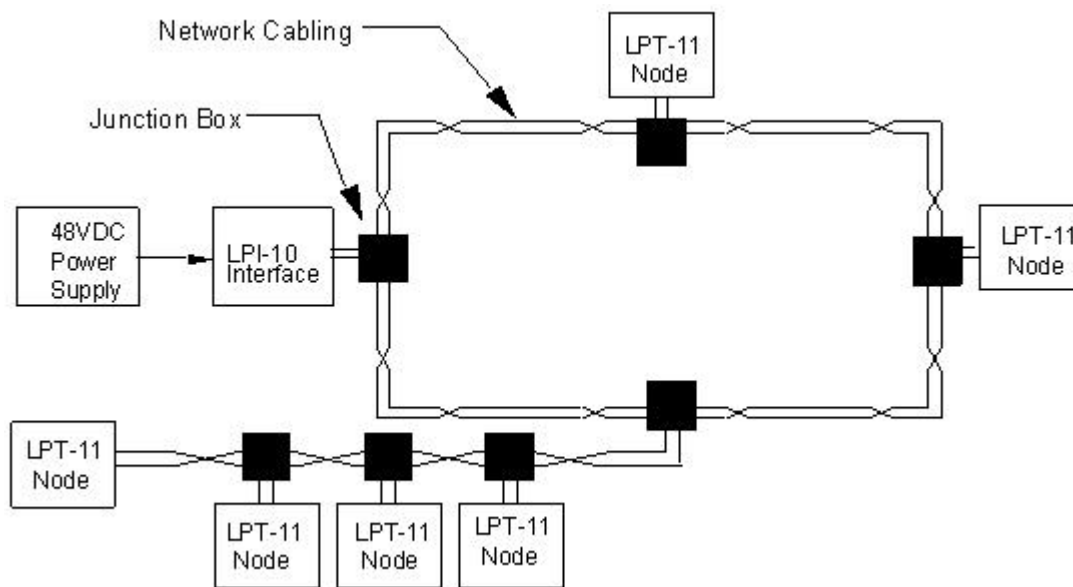
515 South Figueroa Street  
 Los Angeles, CA 90071  
 Phone: +1-310-795-1824  
 Phone: 1-800-379-1191  
 Fax: +1-213-955-4993  
 Web: [www.smartwire.com](http://www.smartwire.com)

386 Internationale Drive, Suite H  
 Bolingbrook, Illinois 60440  
 Phone: +1-800-379-1191  
 Fax: +1-630-296-8100

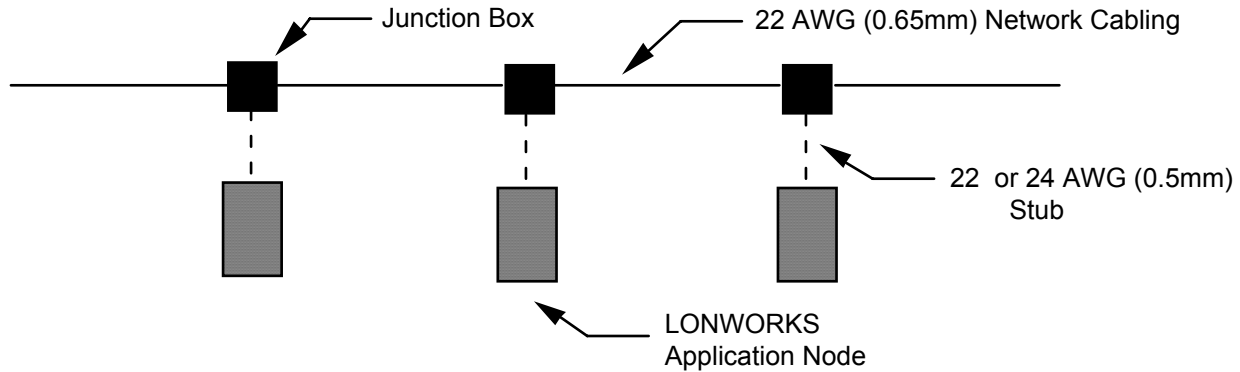
Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Unshielded Plenum U.L. Type CMP	105500 – Blue jacket 105530 – Yellow jacket 105540 – Orange jacket 105550 – Purple jacket 105580 – Pink jacket
Level 4 22AWG (0.65mm)	2	Unshielded Plenum U.L. Type CMP	105600 – Blue jacket
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	106500- Blue jacket 106502 – Orange jacket 106503 – Yellow jacket 106540 – Purple jacket
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	106600 – Blue jacket
Level 4 22AWG (0.65mm)	1	Unshielded Non-plenum U.L. Type CM	107500 – Blue jacket
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	108500 – Blue jacket
Level 4 22AWG (0.65mm)	2	Shielded Non-plenum U.L. Type CM	108600 – Blue jacket
16AWG (1.3mm)	1	Unshielded Plenum U.L. Type CMP	104500 – White jacket 104560 – Green jacket 105580 – Pink jacket
16AWG (1.3mm)	1	Unshielded Non-plenum U.L. Types CMR or CL2R	103500 – Gray jacket
Category 5	Various	Various	Contact mfg.

## Junction Boxes

A junction box provides an interface between the twisted pair cable and one or more LONWORKS application nodes. The twisted pair cabling used between junction boxes will depend on the type of transceiver being installed. For free topology twisted pair systems, including the FT 3120/FT 3150 Free Topology Smart Transceiver, FTT-10A Free Topology Transceiver, LPT-11 Link Power Transceiver (figure 1), the PLT-22 Power Line Transceiver, and the PL 3150/PL 3120 Power Line Smart Transceiver, the wiring is typically specified separately for each transceiver. For systems using TP/XF-78, TP/XF-1250, TP-RS485, TPT/XF-78, or TPT/XF-1250 modules the bus wiring is 22AWG (0.65mm), while either 22 or 24AWG (0.5mm) cabling may be used on the stub between the junction box and the LONWORKS application node (figure 2).



**Figure 1** Typical Network Topology for Free Topology Networks  
(LPT-11 Link Power Transceiver shown)



**Figure 2** Typical Network Topology for Bus-Topology Networks

A Pass-Through Junction Box is intended to be a splice point only and does not include interconnections for a local node. A Stub Junction Box provides both a stub for a local node and a convenient splice point for cables passing to the previous and next junction boxes. A Local Loop Terminal Junction Box provides terminals for a local loop and a splice point for cables passing to the previous and next junction boxes. These two junction boxes are intended to be used when the distance between the junction box and the local node exceeds the allowed stub length, or when a loop-style architecture is desirable.

The connector that will be used to connect the twisted wire pair to the application node is typically defined by the industry application.

For the purposes of the discussion about junction box design that follows, we need to establish a common definition of terms. These terms, and their definitions, are presented below.

Color Code	The color of the LONWORKS network cable conductors. In systems using a single twisted wire pair (two wire), the colors will be white/blue (W/B) and blue (B). In systems using a dual twisted wire pair (four wire), the colors will be white/blue (W/B), blue (B), white/orange (W/O), and orange (O). A shield drain wire (S) may be provided in either single or dual twisted wire pair networks, and will be clearly designated by color coding or other markings as being a shield or drain wire.
IN	Wiring that originates at the previous node.
Insulation Displacement Terminal	A connector arrangement in which wiring is affixed to insulation displacement terminals. Multiple wires can be attached to a single connector bus either by permitting two conductors to be inserted in the same displacement terminal or by providing two or more displacement terminals on a common bus.
Local Loop	A loop of bus cable that exits from a junction box, interconnects with a node, and returns to the junction box.
Local Power	A power source that provides operating power to a locally powered node.

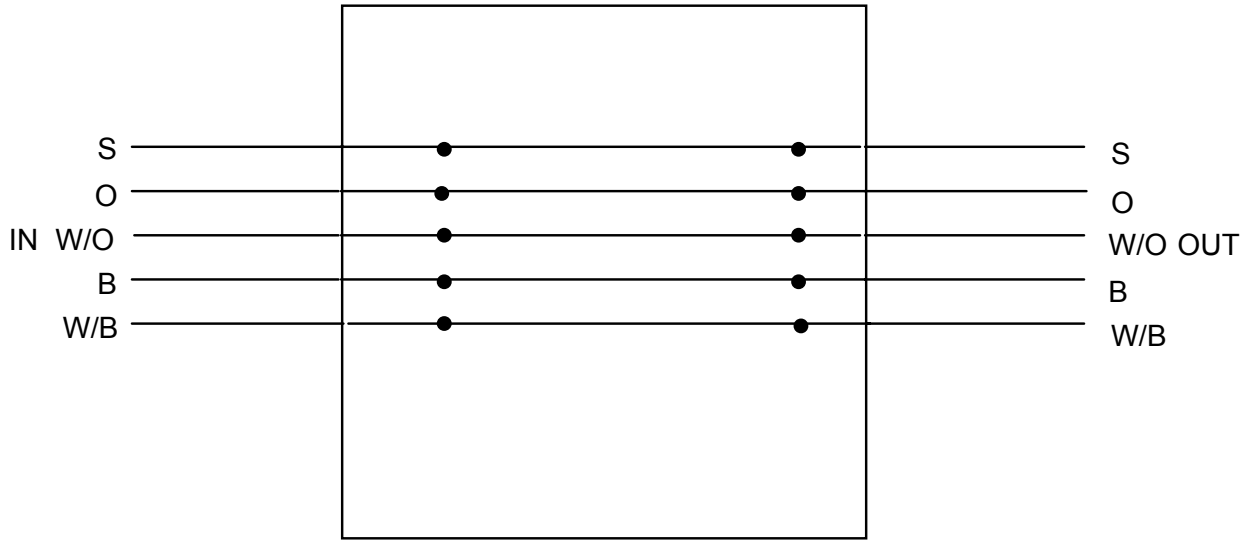
OUT	Wiring that originates at the current node.
Pass-Thru	A junction box at which wires are spliced, and to which no nodes are connected.
Screw Terminal	A connector arrangement in which wiring is affixed to screw terminals. Washers are provided to separate multiple conductors attached to a single screw.
Stub	A T-tap from a bus cable that originates at a junction box and terminates at a node.
2-Wire Link Power	2-wire link power permits the transmission of both node power and LonTalk® network data on a common pair of wires. Link power nodes may or may not require local power depending on the system topology and local power consumption levels.

## Pass-Thru Junction Box

A pass-thru junction box provides a convenient point at which to splice two cables. No nodes or connectors are provided at a pass-thru junction box. There are three primary methods of implementing a splice at a pass-thru junction box:

1. **Screw Terminals:** IN and OUT wires are stripped and wrapped around screw terminals, which are tightened to retain the wires and make a secure electrical contact. Each screw is supplied with two or more washers. The washers separate conductors where multiple wires are landed at one screw, thereby preventing wires from being ejected as the screw is tightened. IN terminals 1-5 are connected directly by buses, circuit card traces, or wire jumpers, to OUT terminals 1-5, respectively. These connections provide the "pass-thru" function by routing the incoming signals to the outgoing terminals.
2. **Insulation Displacement Terminals:** IN and OUT wires are punched down on barrel or telco insulation displacement terminals. IN terminals 1-5 are connected directly by buses, circuit card traces, or wire jumpers, to OUT terminals 1-5, respectively. These connections provide the "pass-thru" function by routing the incoming signals to the outgoing terminals.
3. **Crimp Connectors:** IN and OUT wires are spliced together using crimp connectors. The connectors are then fitted inside the junction box, which itself contains no terminals.

**Pass-Thru Terminal Junction Box**



**Terminal Legend**

<u>Terminal</u>	<u>Wire Color</u>	<u>Function</u>
1	White/Blue	Data comm. or + for 2-wire link power
2	Blue	Data comm. or - for 2-wire link power
3	White/Orange	Power + if locally powered
4	Orange	Power GND if locally powered
5	S - Shield	Cable shield if used



## Stub Junction Box

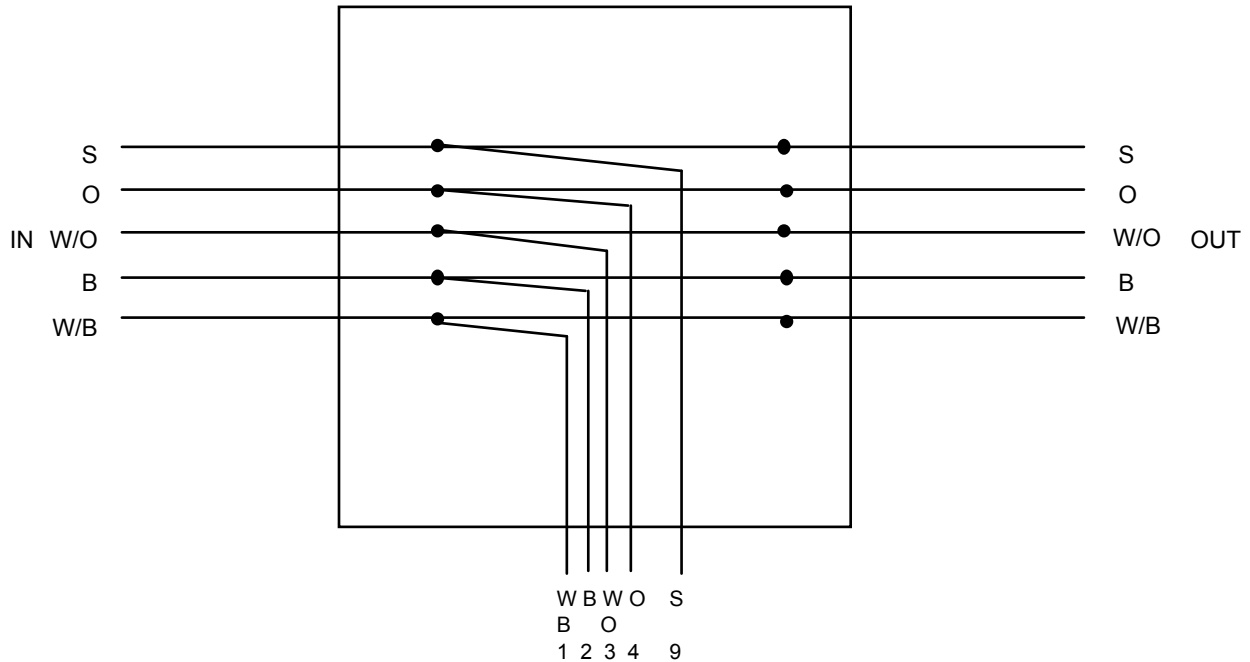
A stub junction box provides a convenient point at which to splice two cables and provide a stub for servicing a local node. There are two primary methods of implementing a stub connector junction box:

1. **Screw Terminal 10 Wire Pin Connector:** IN and OUT wires are stripped and wrapped around screw terminals, which are tightened to retain the wires and make a secure electrical contact. Each screw is supplied with two or more washers. The washers separate conductors where multiple wires are landed at one screw, thereby preventing wires from being ejected as the screw is tightened.
2. **Insulation Displacement 10 Wire Pin Connector:** IN and OUT wires are punched down on barrel or telco insulation displacement terminals. Both stranded and solid conductor wires are supported.

The following section applies to both versions of a stub connector junction box.

IN terminals 1-5 are connected directly by buses, circuit card traces, or wire jumpers, to OUT terminals 1-5, respectively. These connections provide the "pass-thru" function by routing the incoming signals to the outgoing terminals.

**Stub Junction Box**



**Terminal Legend**

<u>Terminal</u>	<u>Wire Color</u>	<u>Function</u>
1	White/Blue	Data comm. or + for 2-wire link power
2	Blue	Data comm. or - for 2-wire link power
3	White/Orange	Power + if locally powered
4	Orange	Power - if locally powered
5	S - Shield	Cable shield if used

**Tap Legend**

<u>Terminal</u>	<u>Wire Color</u>	<u>Function</u>
1	White/Blue	IN Data comm. or + for 2-wire link power
2	Blue	IN Data comm. or - for 2-wire link power
3	White/Orange	IN Power + if locally powered
4	Orange	IN Power GND if locally powered
5-8	Not used	
9	S - Shield	IN Cable shield
10	Not used	

## Local Loop Terminal Junction Box

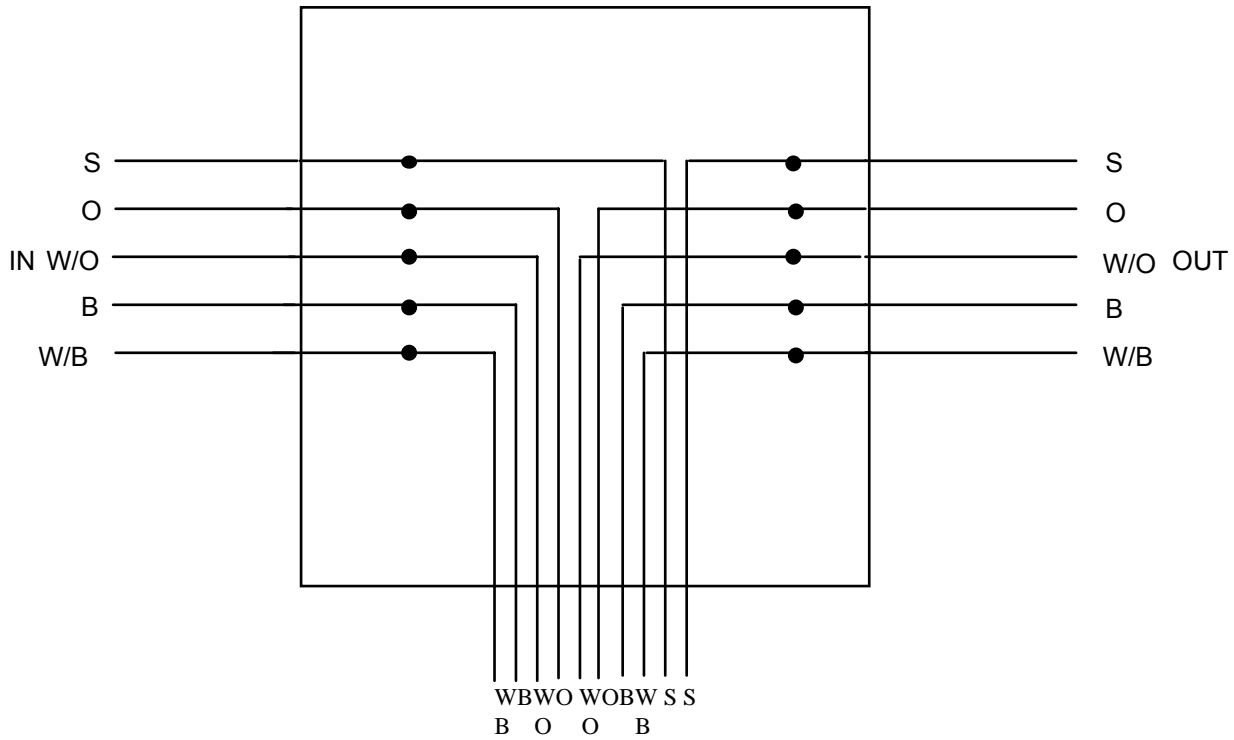
A local loop terminal junction box provides a convenient point at which to terminate two cables and provide a wiring loop for servicing a local node. There are two primary methods of implementing a local loop terminal junction box:

1. **Screw Terminal 10 Wire:** IN and OUT wires are stripped and wrapped around screw terminals, which are tightened to retain the wires and make a secure electrical contact. Each screw is supplied with two or more washers. The washers separate conductors where multiple wires are landed at one screw, thereby preventing wires from being ejected as the screw is tightened. The local node is wired directly to the In and OUT terminals.
2. **Insulation Displacement 10 Wire:** IN and OUT wires are punched down on barrel or telco insulation displacement terminals. The local node is wired directly to the In and OUT terminals.

The following section applies to both versions of a local loop connector junction box.

IN terminals and OUT terminals are isolated from each other: this junction box does not perform a "pass-thru" function.

**Local Loop Terminal Junction Box**



**Terminal Legend**

<u>Terminal</u>	<u>Wire Color</u>	<u>Function</u>
1	White/Blue	Data comm. or + for 2-wire link power
2	Blue	Data comm. or - for 2-wire link power
3	White/Orange	Power + if locally powered
4	Orange	Power GND if locally powered
5	S - Shield	Cable shield if used

**Local Loop Legend**

<u>Terminal</u>	<u>Wire Color</u>	<u>Function</u>
1	White/Blue	IN Data comm. or + for 2-wire link power
2	Blue	IN Data comm. or - for 2-wire link power
3	White/Orange	IN Power + if locally powered
4	Orange	IN Power GND if locally powered
5	White/Orange	OUT Power + if locally powered
6	Orange	OUT Power GND if locally powered
7	Blue	OUT Data comm. or - for 2-wire link power
8	White/Blue	OUT Data comm. or + for 2-wire link power
9	S - Shield	IN Cable shield
10	S - Shield	OUT Cable shield

## **Appendix A**

### **Application for Cable Approval**

This Appendix is intended for use by vendors who manufacture electrical cables and would like those cables approved by Echelon for use on one or more LONWORKS channels. Echelon approves cables based on information supplied by the cable vendor: the vendors self-certify that their products comply with Echelon's published specifications, and the responsibility to meet and adhere to these specifications reside solely and exclusively with the cable vendors. Echelon will not test any cables or validate the electrical characteristics of the submitted cables. Echelon relies exclusively on the veracity of the information provided by the cable vendors.

To submit a cable for approval, please complete the vendor information for each geographic area in which your products are sold.

For each cable being submitted for approval, please complete the pertinent cable type form. You must include entries for every blank space in the table. Failure to fill out the form completely will result in the rejection of your application. One form must be completed for each cable submitted for your approval. For reference purposes, the mandated specifications are shown in italicized type in each table.

Send or fax your completed application to:

Echelon  
550 Meridian Avenue  
San Jose, CA 95126 USA  
Attn: Echelon Support

Fax number: +1-408-790-3801 (attention Echelon Support)

---

### Vendor Information

#### Vendor Information – Americas

<i>Company Name</i>	
<i>Address (including country and postal code)</i>	
<i>Phone Number</i>	
<i>Facsimile Number</i>	
<i>E-Mail Address</i>	
<i>Web Site URL</i>	

#### Vendor Information – Asia/Pacific

<i>Company Name</i>	
<i>Address (including country and postal code)</i>	
<i>Phone Number</i>	
<i>Facsimile Number</i>	
<i>E-Mail Address</i>	
<i>Web Site URL</i>	

#### Vendor Information – Europe, Middle East, Africa

<i>Company Name</i>	
<i>Address (including country and postal code)</i>	
<i>Phone Number</i>	
<i>Facsimile Number</i>	
<i>E-Mail Address</i>	
<i>Web Site URL</i>	

### Cable Type Forms

#### Belden 8471 Equivalent Cable

---

Cable model number Number of pairs Plenum/Non-plenum Special features, i.e., aerial or direct burial	
---	--

Wire Diameter (mm/AWG)	Resistance Rloop $\Omega$ /km	Capacitance nF/km	Velocity of Propagation Vprop % of c

**Belden 85102 Equivalent Cable**

Cable model number Number of pairs Plenum/Non-plenum Special features, i.e., aerial or direct burial	
---	--

	Minimum	Typical	Maximum	Units	Condition
DC Resistance, each conductor				$\Omega$ /km	20°C per ASTM D 4566
DC Resistance Unbalance				%	20°C per ASTM D 4566
Mutual Capacitance				nF/km	Per ASTM D 4566
Characteristic Impedance				$\Omega$	64kHz to 1MHz per ASTM D 4566
Attenuation 20kHz 64kHz 78kHz 156kHz 256kHz 512kHz 772kHz 1000kHz				dB/km	20°C per ASTM D 4566
Propagation Delay				nsec/m	78kHz

**Level 4 Cable**

Cable model number Number of pairs Plenum/Non-plenum Special features, i.e., aerial or direct burial	
Specifications apply to shielded or unshielded 22AWG (0.65mm) cable, 24AWG (0.5mm) cable shown in brackets [ ] if different	
<b>D-C Resistance</b> (Ohms/1000 feet at 20°C) maximum for a single copper conductor regardless of whether it is solid or stranded and is or is not metal-coated.	
<b>D-C Resistance Unbalance</b> (percent) maximum	
<b>Mutual Capacitance of a Pair</b> (pF/foot) maximum	
<b>Pair-to-Ground Capacitance Unbalance</b> (pF/1000 feet) maximum	
<b>Characteristic Impedance (Ohms)</b>	
772kHz	
1.0MHz	
4.0MHz	
8.0MHz	
10.0MHz	
16.0MHz	
20.0MHz	
<b>Attenuation (dB/1000 feet at 20°C) maximum</b>	
772kHz	
1.0MHz	
4.0MHz	
8.0MHz	
10.0MHz	
16.0MHz	
20.0MHz	
<b>Worst-Pair Near-End Crosstalk (dB) minimum.</b> Values are shown for information only. The minimum NEXT coupling loss for any pair combination at room temperature is to be greater than the value determined using the formula $NEXT (F_{MHz}) > NEXT(0.772) - 15 \log_{10}(F_{MHz}/0.772)$ for all frequencies in the range of 0.772MHz-20MHz for a length of 1000 feet.	
772kHz	
1.0MHz	
4.0MHz	
8.0MHz	
10.0MHz	
16.0MHz	
20.0MHz	



**JY (st) 2x2x0.8 Equivalent Cable**

<i>Cable model number</i>			
<i>Number of pairs</i>			
<i>Plenum/Non-plenum</i>			
<i>Special features, i.e., aerial or direct burial</i>			
<i>Wire Diameter (mm/AWG)</i>	<i>Resistance Rloop <math>\Omega</math>/km</i>	<i>Capacitance nF/km</i>	<i>Velocity of Propagation Vprop % of c</i>

**S-4210 Equivalent Cable**

<i>Cable model number</i>			
<i>Number of pairs</i>			
<i>Plenum/Non-plenum</i>			
<i>Special features, i.e., aerial or direct burial</i>			
<i>Wire Diameter (mm/AWG)</i>	<i>Conductors</i>	<i>Characteristic Impedance (<math>\Omega</math>)</i>	<i>Construction</i>

**Category 5 Cable**

<i>Cable model number</i>			
<i>Number of pairs</i>			
<i>Plenum/Non-plenum</i>			
<i>Special features, i.e., aerial or direct burial</i>			

**Disclaimer**

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