LonWorks®

LPI-10 Link Power Interface Module User's Guide

Version 1.2

ECHELON® Corporation

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Introduction

The LPI-10 Link Power Interface Module interconnects a 48VDC (nominal) power supply to a link power twisted pair network. The link power system eliminates the need to use a local power supply for each node since node power is sent from a central power supply over the same twisted wire pair that handles network communications. The LPI-10 module couples power to the network without interfering with network communications, and provides a termination for the twisted pair network. It also protects the power supply from overload conditions and faults on the network, and ensures that the network voltage does not exceed 42.4VDC as required by many safety agency guidelines.

The LPI-10 module can be used with power supplies with output voltages from 48 to 56VDC. The unit is designed to be mounted either on a bulkhead or baseplate, or on a DIN rail track. Wiring connections are made at screw terminals.

The LPI-10 module is designed to comply with both FCC and VDE requirements, minimizing time consuming and expensive laboratory transceiver testing. The LPI-10 module is a UL-Recognized component.

There are two versions of the LPI-10 interface: a simple, low-cost, inductor-based design intended for customers who are building power supplies, and an electronic LPI-10 interface designed for use with off-the-shelf 48VDC power supplies. The inductor-based design is described in detail in Appendix A, and the remainder of this document addresses the electronic interface. A design kit is available from Echelon which documents both versions.

Applications

A conventional control system using bus topology wiring (such as RS-485) consists of a network of sensors and control outputs that are interconnected using a shielded twisted wire pair. In accordance with EIA RS-485 guidelines, all of the devices must be wired in a bus topology to limit electrical reflections and ensure reliable communications. There is a high cost associated with installing and maintaining the cable plant that links together the many elements of an RS-485-based control system. Bus topology wiring is more time consuming and expensive to install because the installer is unable to branch or star the wiring where convenient: all devices must be connected directly to the main bus. The installation of local power supplies for each device is especially expensive since it usually involves an AC mains connection.

Installing separate data and power wiring also implies that a technician's time will be spent troubleshooting the wiring harness to isolate and repair cable faults. Moreover, each time a sensor is added or an actuator is moved, both data and power wiring must be changed accordingly, often resulting in network down time until the new connections can be established.

The best solution for reducing installation and maintenance costs and simplifying system modifications is a free topology communication system that combines power and data on a common twisted wire pair. Echelon's link power technology offers just such a solution, and provides an elegant and inexpensive method of interconnecting the different elements of a distributed control system.

The link power system sends power and data on a common twisted wire pair, and allows the user to wire the control devices with virtually no topology restrictions. Power is supplied by a customer-furnished nominal 48VDC power supply, and flows through an LPI-10 Power Supply Interface onto the twisted pair wire (figure 1.1). The LPI-10 module isolates the power supply from wiring faults on the twisted pair, couples power to the system wiring, and terminates the twisted pair network.

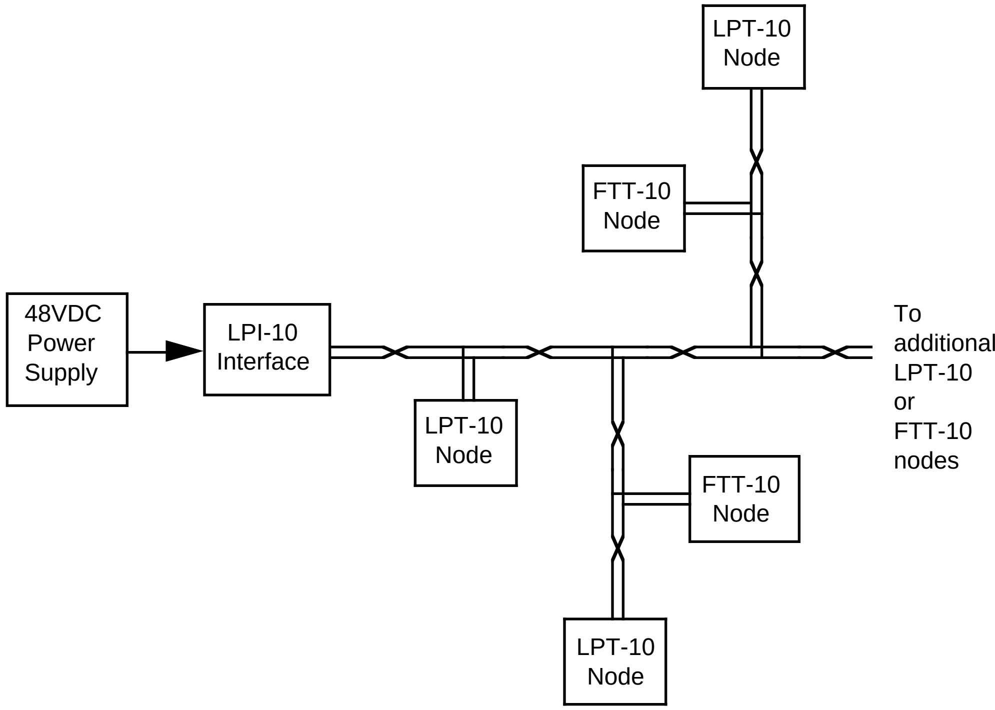

Figure 1.1 Free Topology Link Power System

LPT-10 Link Power Transceivers located along the twisted wire pair include integral switching power supplies. These supplies regulate the power on the twisted pair to +5VDC at currents up to 100mA for use by the Neuron® Chip and the various sensors, actuators, and displays. If a high current or high voltage device must be controlled, then the +5VDC power can be used to trigger an isolating high current triac, relay, or contactor.

The integral power supply does away with the need for a local AC-to-DC power supply, charging circuit, battery, and the related installation and labor expenses. The savings in money and time that results from eliminating the local power supply can be up to 20% of the total system cost: the larger the system, the greater the savings. Moreover, if standby batteries are used, then additional savings will be realized throughout the life of the system since only one set of batteries will require service.

The link power system uses a single point of ground, at the LPI-10 module, and all of the LPT-10 transceivers electrically float relative to ground. Differential transmission minimizes the effects of common mode noise on signal transmission. If grounded sensors or actuators are used, then either the communication port (CP) or the I/O lines of the Neuron Chip must be electrically isolated.

Unlike bus wiring designs, the link power system uses a free topology wiring scheme that supports star, loop, and/or bus wiring (figure 1.2). Free topology wiring has many advantages. First, the installer is free to select the method of wiring that best suits the installation, reducing the need for advanced planning and allowing last minute changes at the installation site. Second, if installers have been trained to use one style of wiring for all installations, link power technology can be introduced without requiring retraining. Third, retrofit installations with existing wiring plants can be accommodated with minimal, if any, rewiring. This capability ensures that link power technology can be adapted to both old and new projects, widening the potential market for link power-based products. Finally, free topology permits link power systems to be expanded in the future by simply tapping into the existing wiring where it is most convenient to do so. This reduces the time and expense of system expansion, and from the customer's perspective, keeps down the life cycle cost of the link power network.

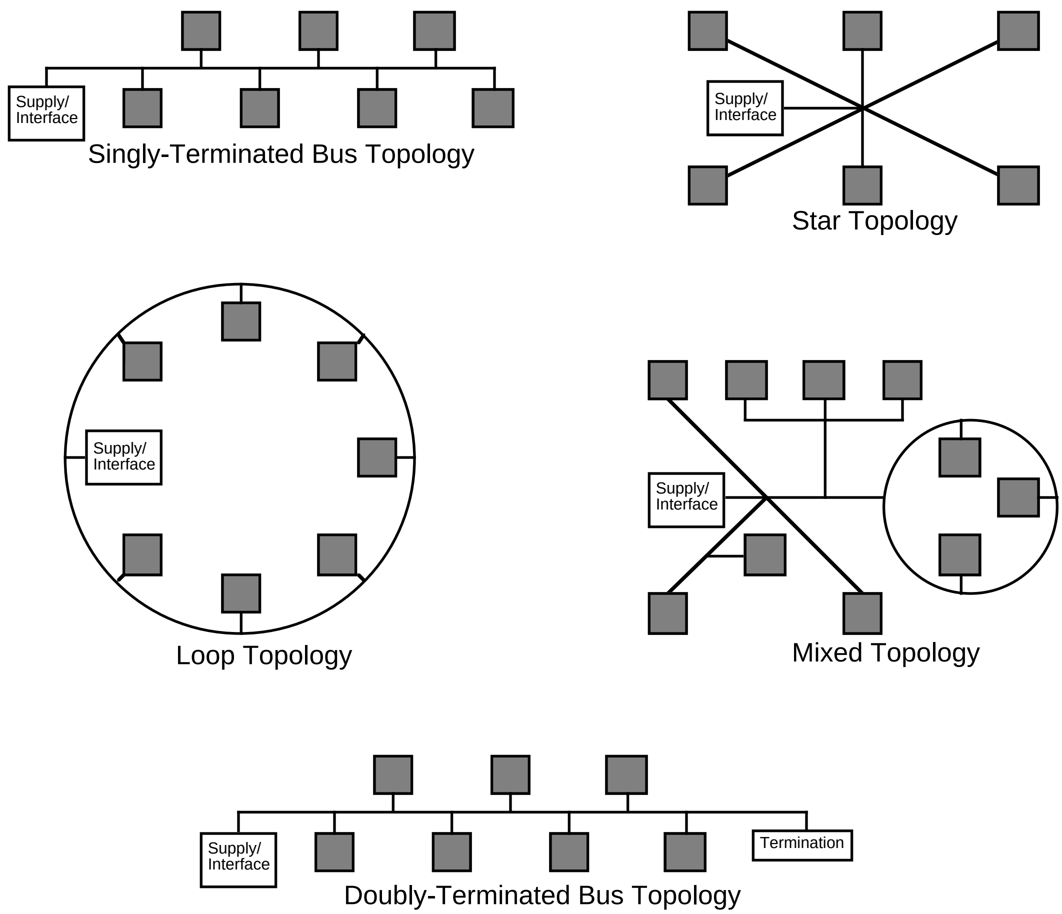

Figure 1.2   Typical Wiring Topologies Supported By the Link Power System

System expansion is simplified in another important way, too. Each link power transceiver incorporates a repeater function. If a link power system grows beyond the maximum number of transceivers or total wire distance, then additional link power systems can be added by interconnecting transceivers using the repeater function (figure 1.3). The repeaters will transfer LonTalk® data between the two systems, doubling the number of transceivers as well as the length of wire over which they communicate. The repeater function permits a link power system to grow as system needs expand, without retrofitting existing controllers or requiring the use of specialized bridges. Note that systems requiring high levels of network traffic may benefit from the use of LONWORKS routers which forward packets only when necessary.

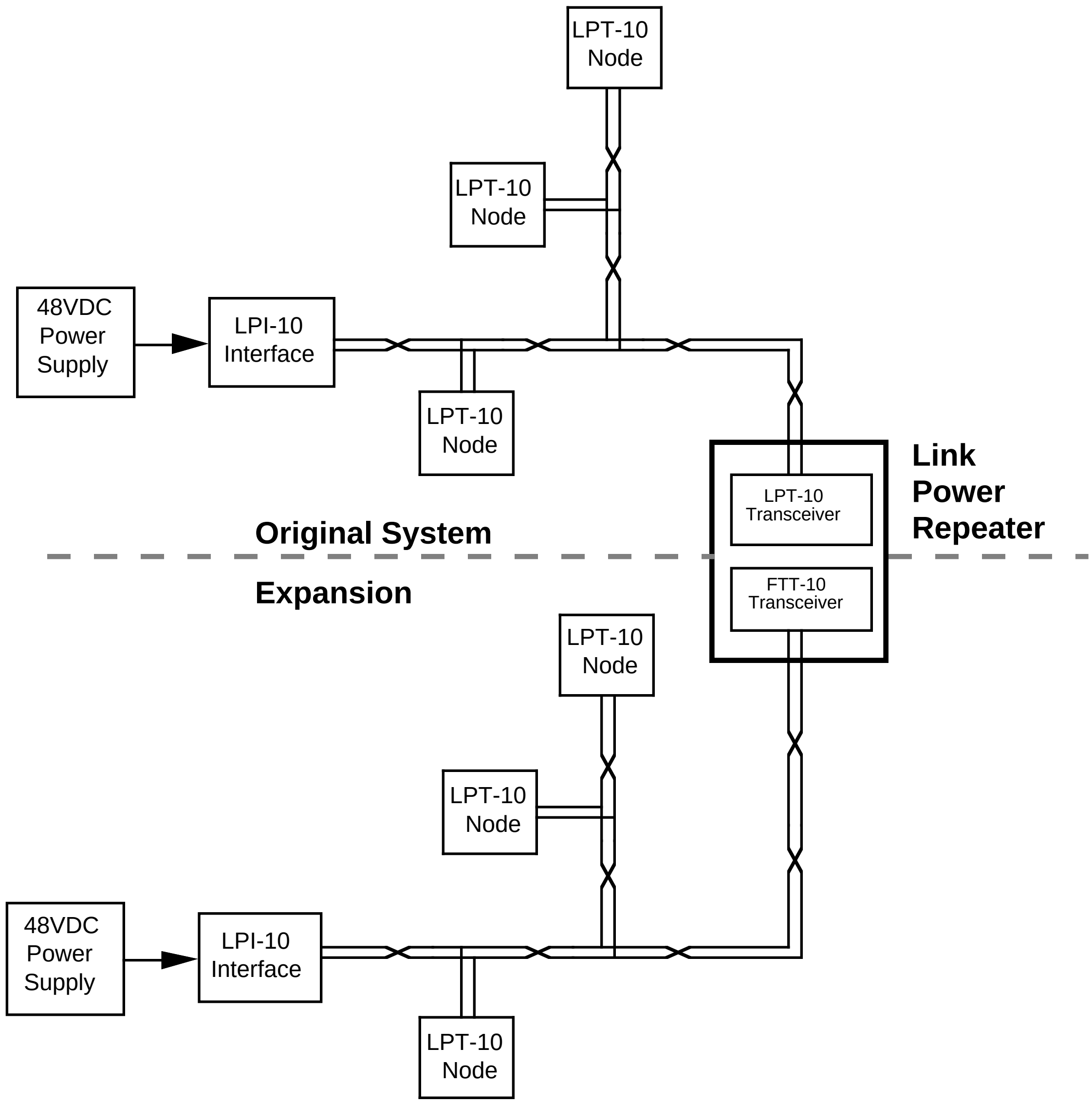

Figure 1.3 Link Power Repeater for System Expansion

Many link power applications, especially those utilizing battery-backed power supplies, will require that power consumption be minimized during normal operation. To accommodate these applications, the link power transceiver incorporates power management functions to reduce power consumption. Two methods of power management are provided:

(1) Sleep Mode–the transceiver can be put to sleep and awakened by Neuron Chip I/O activity;

(2) Neuron Chip Sleep Timer–the transceiver can awaken the Neuron Chip from its sleep mode on a timed basis by periodically triggering an input line on the Neuron Chip. This feature allows the Neuron Chip to awaken, sample its I/O lines, communicate with another controller, and then go to sleep again. This mode of operation is especially useful for applications where sensors are sampled from time-to-time, but where power consumption must be reduced between samples.

Audience

The *LONWORKS LPI-10 Power Supply Interface Module User's Guide* provides specifications and user instructions for customers who have purchased the LPI-10 module.

Content

This manual provides detailed technical specifications on the electrical and mechanical interfaces and operating environment characteristics for the LPI-10 Link Power Interface Module.

This document has a list of references in Chapter 5. Whenever a reference document is addressed, a superscript number corresponding to the reference has been placed in the text, e.g., Standler[9]. Whenever a specific chapter or section within a reference has been referred to, the reference is enclosed in brackets and the chapter is addressed by number, e.g., Reference [1], Chapter 5.

Related Documentation

The following Echelon documents are suggested reading:

LONWORKS LPT-10 Link Power Transceiver User's Guide (078-0105-01)

LONWORKS FTT-10 Free Topology Transceiver User's Guide (078-0114-01)

LONWORKS Products Databook

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Electrical Interface

The LPI-10 Link Power Interface Module interfaces to the customer-furnished power supply through connector P1 and to the twisted pair network through connector P2.

Connector Terminals

The P1 and P2 terminals blocks are Weidmüller GS-type screw-clamp connectors. Both terminal blocks accept wire sizes from 14AWG to 22AWG. The pinout of the power supply connector P1 is shown in table 2.1. The pinout of the twisted pair network P2 connector terminals is shown in table 2.2. The power supply must be rated for the system load and the current consumed by the LPI-10 module (see table 2.3). The LPI-10 module is the sole ground point for the link power system, and a good earth ground via a cold water pipe or earth stake (less than 10Ω resistance) is essential for reliable system operation and proper ESD performance.

Care should be taken to ensure that proper polarity of the power supply is connected at the P1 terminals. If the incorrect input voltage polarity is applied to the LPI-10 module, it may be damaged. Use only a floating output power supply.

The wiring connections of the LPI-10 module are shown in figure 2.1.

Table 2.1 Source Power Supply Connector (P1)

Name	***Pin#***	***Function***
⊕	1	(+) Input
⏚	2	Earth ground
⊖	3	(–) Input

Table 2.2 Twisted Pair Network Connector (P2)

Name	***Pin#***	***Function***
Net+	1	Twisted pair network (+)
Net–	2	Twisted pair network (–)

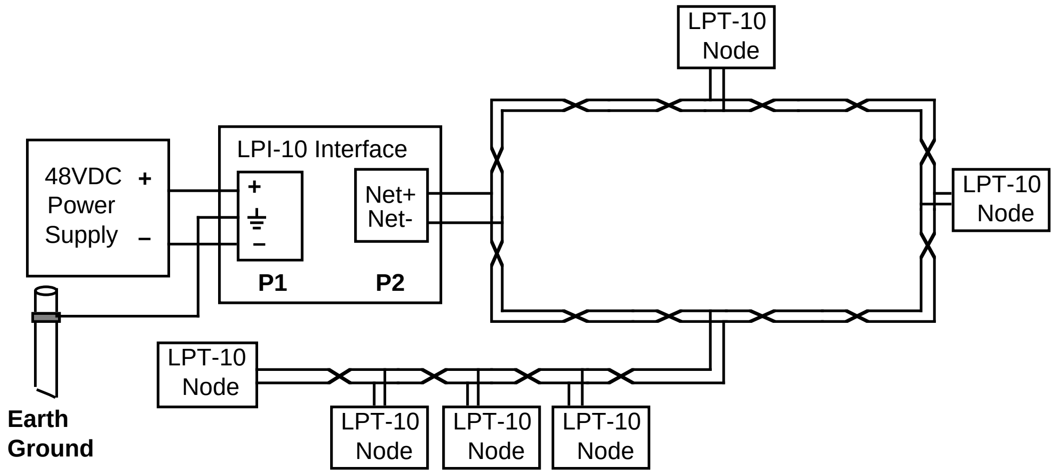

Figure 2.1 LPI-10 Module Interconnections

Network Connection

Transient protection may be required to protect the LPI-10 module against large transients such as lightning strikes. Since the link power system floats relative to ground, care must be taken when adding any transient suppressors to prevent capacitively loading the network differentially with more than 250pF.

Output Voltage and Regulation

When the LPI-10 module is powered from the floating output supply, the differential output voltage to the network will be approximately 42VDC and will be centered about earth ground; i.e., "Net+" ≈ +21 VDC and "Net–" ≈ –21 VDC.

The LPI-10 module will maintain output voltage regulation between 41.0 and 42.4VDC for an input power supply voltage from 48 to 56VDC with 0 to 1.5A network loading conditions. In the event the power supply voltage drops below 48VDC, the network will not operate to full system specifications. The LPI-10 module will continue to operate. However, if the supply voltage drops below 34VDC, the LPI-10 will shut off output power.

Selectable Current Limit

The LPI-10 module can be set to limit output (network) DC current to one of three settings: 1.5A, 1.0A, and 0.5A with appropriate positioning of jumper block JP2 (see figure 2.2).

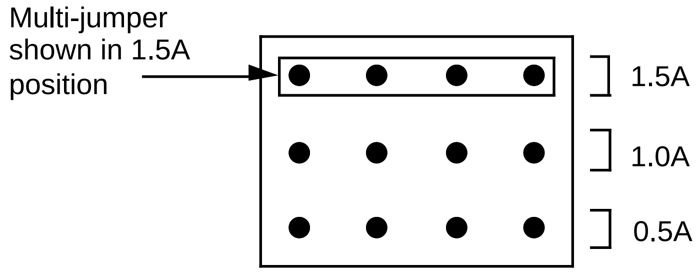

Figure 2.2 JP2 Jumper Settings

The markings for the positioning are clearly shown in the silkscreen of the LPI-10 module circuit board. Refer to the *LONWORKS LPT-10 Link Power Transceiver User's Guide* to determine the appropriate setting for your network.

Power Supply Requirements

The input power supply furnished by the customer must meet the specifications below for proper operation of the link power system. Improper start-up, erratic system behavior, or poor transmission performance may result from an inadequate power supply.

Table 2.3 Power Supply Specifications

Function	***Specification***	
Output Voltage	48 - 56VDC*	
Output Current	*Conditions*	*Minimum Continuous Output Supply Current*
	JP2 set to 0.5A JP2 set to 1.0A JP2 set to 1.5A	0.7A 1.25A 1.8A
Ripple**	*Conditions*	*Peak-to-Peak Voltage*
	Measured differentially at the LPI-10 connector P1 with desired system load based on JP2 jumper selection (See figure 2.3)	200mV max (10kHz<f<200kHz) 150mV max (200kHz <f<1MHz)
Spike Noise**	Measured differentially at the LPI-10 input connector P1 with desired system load based on JP2 jumper selection (See figure 2.3)	400mV max, 50MHz bandwidth
Zero Load Operation	Yes	
Floating Outputs with respect to Earth Ground	Yes	

* For output voltage exceeding 49VDC, supplemental cooling/heat sinking is required - see the section on "Thermal Considerations."

** See section on "Choosing a Source Power Supply."

Choosing a Power Supply

Power supply ripple voltage and spike noise are generally specified at rated current with a resistive load measured differentially at its output. While ripple and spike noise is usually negligible for linear power supplies, many commercial 5 volt to 48 volt switching power supplies have maximum peak-to-peak ratings of 1% ripple and 2% spike noise. Although ripple voltage may approach 1% for lower output voltage supplies (e.g., 5V outputs with 50mV maximum ripple), actual ripple voltage percent drops with increasing output voltage. For example, a 48V switching supply, so rated, may actually exhibit 100mV or less peak-to-peak ripple (0.2% of its output voltage). Further attenuation of this ripple voltage will occur as a result of the low impedance, capacitive load presented by the LPI-10 module (typically 0.25Ω at switching frequencies). Finally, any series inductance located between the power supply and the LPI-10 module will act in conjunction with the LPI-10 module's input capacitance to further attenuate the noise present at the LPI-10 module. The above principles apply to spike noise as well. Therefore, many 48V switching supplies with off-the-shelf ratings of 1% ripple voltage and 2% spike noise are acceptable for use with the LPI-10 module.

In the event a particular power supply alone does not meet the noise requirements, series choke(s) 0.5 - 1.0µH or a noise/EMI filter may be inserted between the supply and the LPI-10 module to attenuate the noise. Care must be taken when choosing the device to ensure that its current rating is adequate and that its DC resistance is acceptably low to give a negligible voltage drop across it under maximum current loading conditions.

EMI noise filters inserted between the power supply and the LPI-10 module which attenuate differential ripple above 50kHz by 15dB or more include:

CORCOM Type 2VB3 - 2 Ampere, EMI filter
CORCOM Type 1VB3 - 1 Ampere, EMI filter

In the event the switching frequency of the power supply under test is load dependent, testing should be done with loads spanning the range over which it is expected to operate. When confirming that the noise requirements are met, the measurement should be made with an adequate differential probe connected at the "+" and "–" inputs of the LPI-10 module. The differential probe should have good common-mode rejection (40dB-60dB minimum Common Mode Rejection Rate (CMRR) at desired frequencies) to ensure that the measurement is truly differential. For example, a 3V common-mode noise signal measured with differential probes with only 20 dB CMRR performance at the noise frequency will result in a faulty 300mV differential reading. To confirm that the common-mode noise does not affect the reading substantially, both probe tips can be connected at the same point. If the resultant reading is significant with respect to that when probe tips are differentially connected, the final measurement will be in error. One such acceptable differential probe is the Tektronix model P6046. Figure 2.3 depicts the proper connections for measuring differential noise at the LPI-10 module with a P6046 probe.

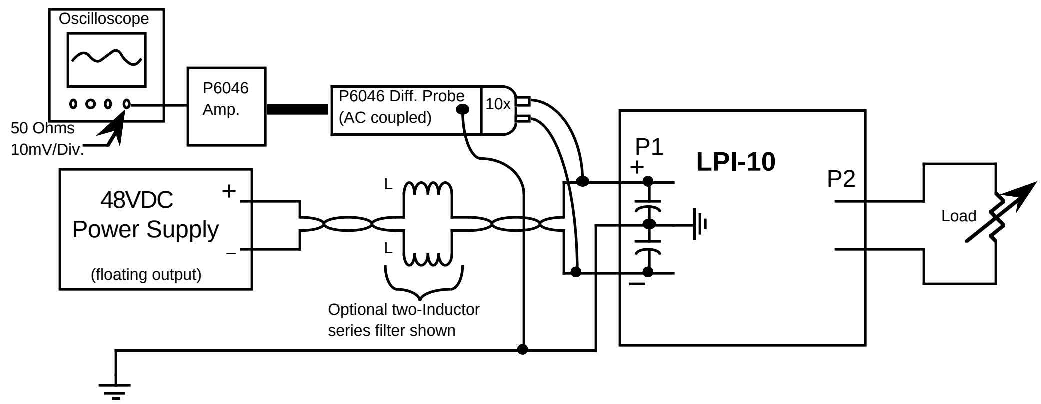

Figure 2.3 Differential Noise Measurement

Selectable Termination Impedance

A jumper selectable AC network termination setting is available with appropriate placement of multi-jumper JP1 located near the upper right corner of the LPI-10 module. JP1 should remain in its factory installed "1 CPLR" position shown below for free topology wiring configurations. When using the LPI-10 in a doubly-terminated bus topology, JP1 must be set in the "2 CPLR" position and an additional passive termination must be used at the far end of the bus. For more information on terminations, consult the *FTT-10 Free Topology User's Guide* and the *LPT-10 Link Power Transceiver User's Guide*.

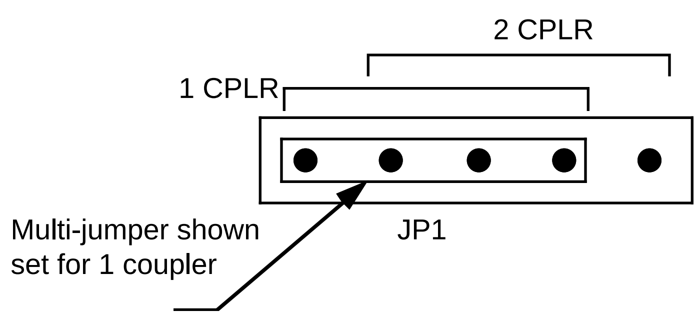

Figure 2.4 JP1 Jumper Settings

JP1 jumper set to "1 CPLR":	55 +/-2 Ohms (2 kHz < f < 200kHz)	factory setting
JP1 jumper set to "2 CPLR":	107 +/-2 Ohms (2 kHz < f < 200kHz)	

Start-up Behavior

When 48V power is first applied to the LPI-10 module input, the "input power" LED (next to connector P1) will be illuminated. Approximately six seconds will elapse before the LPI-10 module applies output power to the network. During this time the output LED (next to connector P2) will either illuminate dimly or not at all. Once power is applied successfully to the network, the output power LED will illuminate fully.

Overload and/or Short Circuit Behavior

In the event that the output of the LPI-10 module is loaded beyond the current limit for which it is set (JP2), its output power will switch off for approximately 6 seconds before restarting. If the fault persists when the LPI-10 module attempts its 750ms duration restart, the power-off cycle will repeat itself and the output LED will not illuminate fully. This off-on-off timing cycle will continue until the fault is removed.

Commissioning Procedure & Network Fault Isolation

Steps one through seven, outlined in the following sections, are recommended for network commissioning and fault isolation.

Connecting the Power Supply

The LPI-10 module may be damaged if the 48VDC input power has been miswired (polarity reversed) and power is applied. The LPI-10 module may be damaged if the power supply is not floating and a short circuit fault exists at its output. Therefore, exercise care to ensure that the proper polarity wires are used when connecting the floating output power supply to the LPI-10 module P1 input connector. Attach the earth ground wire only to the middle terminal of the P1 connector. Prior to attaching the twisted pair network cable to the "Net+" and "Net-" P2 terminals of the LPI-10 module, it is important to verify that the LPI-10 module is operating correctly. This can be accomplished by measuring the differential output voltage from "Net+" to "Net-" and the voltage drop between each of the output terminals "Net+", "Net-" and earth. The "Net+" and "Net-" conductor voltages of a properly functioning link power network will be symmetric (balanced) with respect to earth. An unbalanced (non-floating) network will result in degraded communication performance and should be corrected.

Check for Proper Power Supply and LPI-10 Operation

1. Set the meter to the DC Voltage scale. Connect the meter (+) lead to the "Net+" connector of P2. Connect the meter (-) lead to the "Net-" connector of P2. With 48V power applied to the LPI-10 module, you should observe a reading between 41.0V and 42.4V - see figure 2.5 below. Note that the full differential output voltage cannot be observed until approximately six seconds following input power application. A reading outside of these limits indicates that the network is shorted or that the LPI-10 module has failed. If necessary, disconnect the network at P2 and observe the resulting voltage.

2. Connect the meter (+) lead to the "Net+" connector of P2. Connect the meter (-) lead to the "GND" connector of P1. A reading between 19V and 22V should result. Likewise, with the meter (+) lead connected to the "Net-" connector of P2 and the meter (-) lead connected to the "GND" connector of P1, a reading between -19V and -22V should result - see figure 2.5. A reading outside of these limits indicates that the power supply output is not floating, the LPI-10 module is damaged, or that the network, if connected, is unbalanced (not floating). If possible, disconnect the network at P2 and observe the resulting voltage.

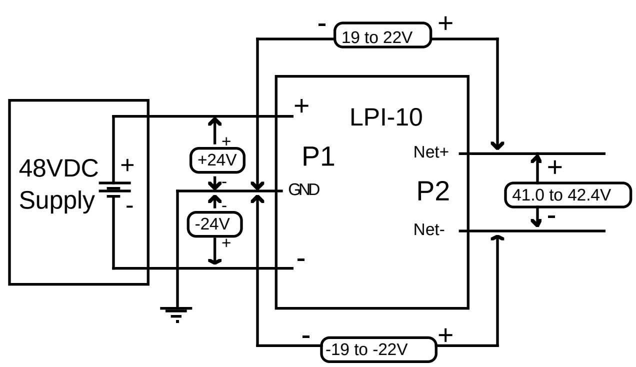

Figure 2.5 Normal LPI-10 Terminal Voltages

Once it has been established that the power supply and LPI-10 module are functioning properly, confirm that the network is balanced by repeating step (2) with the network connected. An unbalanced condition may be the result of either cable faults to earth or node faults to earth. Cable wiring faults can be located using two methods. The first method requires that the network be disconnected from the LPI-10 module and is described in (3) and (4) below. If network power cannot be removed during troubleshooting, method (5) can be used. To isolate node-based earth faults, network power must be applied - see (6) and (7).

Isolating Network Cable Wiring Faults (Network Disconnected from LPI-10)

Before connecting the twisted pair network wires to the LPI-10 module, confirm that there are no conductive paths between the network twisted pair wires or from either of the wires to earth.

3. With the meter set to "Ohms" measure the resistance across the twisted pair conductors. The reading should indicate an open circuit or resistance greater than 500kΩ. If the reading is less than 500kΩ the fault should be corrected prior to connecting the network cable to the LPI-10 module. To find the location of a low impedance fault, use a sensitive Ohmmeter with 4.5 digits accuracy to find the point along the network cable with the minimum resistance between the faulty twisted pair conductors. Otherwise use a process of elimination to determine the faulty cable section by systematically disconnecting sections of the cable from the network.

4. Connect one of the resistance probes to earth and the other probe to either of the twisted pair conductors. The reading should indicate an open circuit or resistance greater than 500kΩ. If the reading is less than 500kΩ, an earth fault to either of the conductors is indicated and the fault should be corrected prior to connecting the network cable to the LPI-10 module. Using techniques similar to those suggested in (3) above will help isolate the location of the fault.

Isolating Network Cable Wiring Faults (Network Connected With Power Applied)

This method can be used to isolate the network cabling if one of the twisted pair conductors is suspected to have shorted to earth.

5. Attach the network wires to the LPI-10 module P2 connector and apply 48V input power. With the meter set to DC Volts, repeat the procedure in step (2) above. If an unbalance condition exists with the "Net+" conductor voltage closer to earth potential, then it is likely the "Net+" conductor is at fault. Locate the fault by finding the point along of this conductor with the minimum voltage with respect to earth. Otherwise use a process of elimination to determine the faulty cable section by systematically disconnecting sections of the cable from the network. See Fault "A" in figure 2.6.

If the "Net-" conductor is closer to earth, locating the fault with a voltmeter can be accomplished in a similar fashion. See Fault "C" in figure 2.6. However, be aware that node-based faults described in (7) below will also result in the "Net-" voltage approaching earth potential.

Isolating Node-based Faults (Network Connected With Power Applied)

After having ascertained that the power supply and LPI-10 module are properly functioning and that there are no network cable faults, one can apply power to the network and isolate node related faults. Step (6) concerns faults and overload conditions seen differentially across the two twisted pair conductors introduced by the resident nodes themselves. Step (7) concerns faults to earth of LPT-10 nodes' local ground.

6. Attach the network wires to the LPI-10 module P2 connector and apply 48V input power. With the meter set to DC Volts, repeat the procedure in step (1) above to measure the LPI-10 module's differential output voltage. In this case, however, if the reading is less than 41V, a network overload condition is indicated. The following are causes of overload conditions and tips to isolate them:

a) The power supply may not be able to feed adequate 48V power to the LPI-10 module. Confirm with the meter that 48VDC is present at the LPI-10 module P1 input connector. Replace the power supply if necessary;

b) The LPI-10 module's current limit jumper, JP2, may be inappropriately set causing it to prematurely limit output power. Check for the proper JP2 setting. For more information refer to the section on "Power Supply Requirements";

c) The total application current to all the link power nodes on the twisted pair segment may exceed the maximum allowed by the system specifications. For more information see the section on "Network Cabling and Connection" in the *LPT-10 Link Power Transceiver User's Guide*;

d) One or more of the nodes residing on the twisted pair segment may be faulty. Both LPT-10 transceiver-based nodes and FTT-10 transceiver-based nodes may reside on the link power network. Although either of these node types may be at fault, it is less likely that an FTT-10 transceiver-based node is the culprit. Use a process of elimination by disconnecting sections of the cable or individual nodes to isolate the fault.

7. If the "Net+" and "Net-" voltages are not centered (especially after having passed step 4 and the "Net-" conductor voltage is close to earth), a fault to earth of one of the LPT-10 transceiver-based nodes is indicated. Local +5V power and ground generated by each LPT-10 node must be isolated from earth for correct operation. A node's "Net-" conductor is at a potential of approximately -3VDC with respect to its local ground. Therefore, if its local ground is directly shorted to earth, the "Net-" conductor at the faulty node will be at a potential of -3VDC with respect to earth. If the twisted pair segment at resident nodes together with an earth conductor are easily accessible, measuring the voltage with respect to earth of the more negative twisted pair conductor can help in locating the vicinity of the culprit LPT-10 node. Otherwise, use a process of elimination to isolate the faulty node by systematically disconnecting sections of the cable or individual nodes from the network. See figure 2.6 "Fault B" for a depiction of the expected network voltage distribution for this situation.

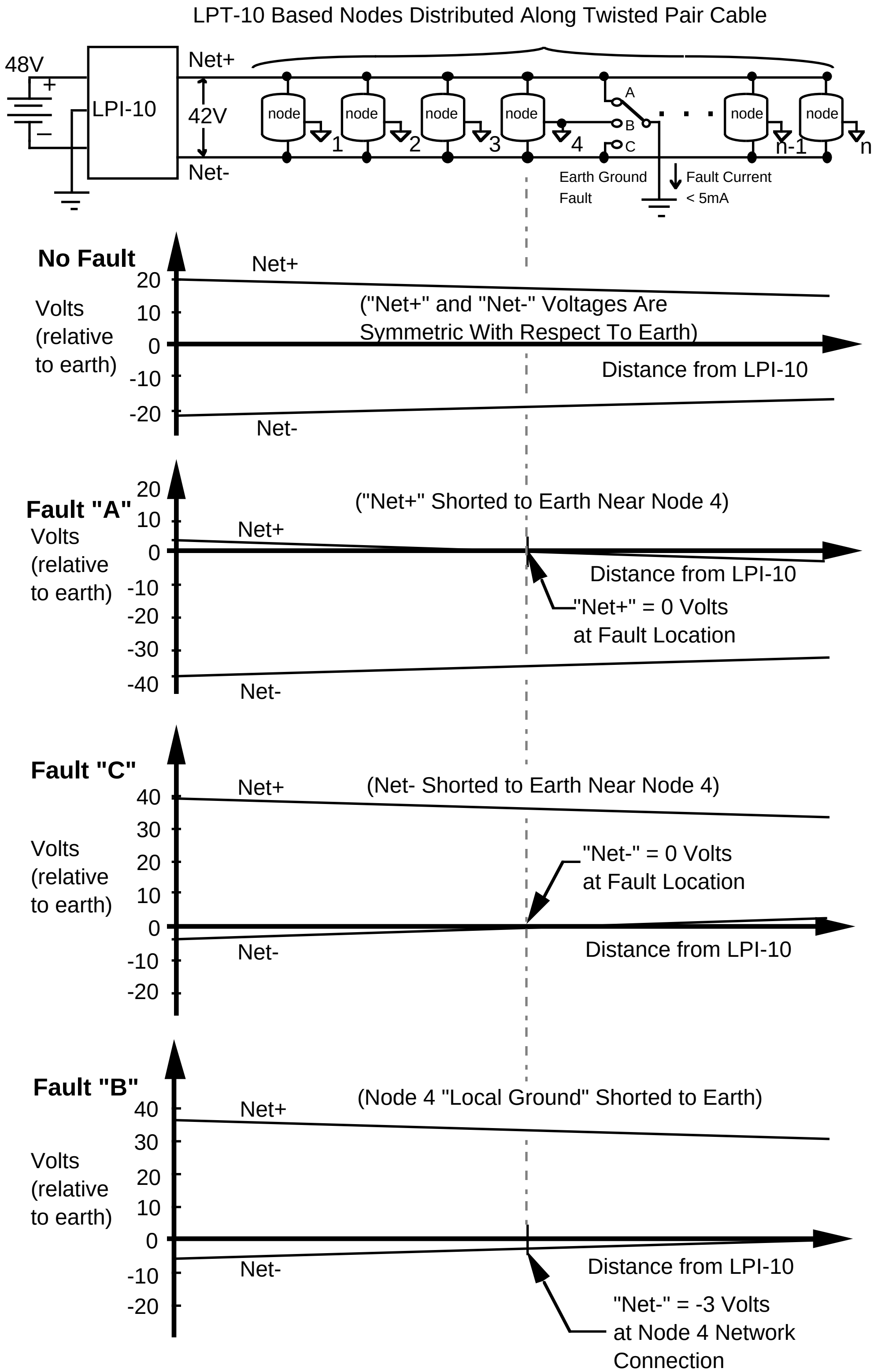

Figure 2.6 Ground Fault Network Voltage Distributions

3

Mechanical Considerations

This chapter discusses the mechanical footprint and connectors of the LPI-10 Link Power Interface Module. Details of temperature limitations as they apply to enclosure selection are also discussed.

Module Mounting and Thermal Considerations

The LPI-10 module mechanical dimensions are shown in table 3.1, and the footprint and connectors are shown in figure 3.1. The LPI-10 module can be mounted in any of three ways: DIN rail, baseplate, or bulkhead.

The DIN rail mounting track is designed to accommodate 72.4mm (2.85") wide circuit boards, and is intended for use on 32mm or 35mm DIN rails (Altech RS series or equivalent). DIN rail mounting provides a neat, professional appearance and is especially desirable when other DIN rail-mounted devices will be used in the same enclosure.

Four circuit board mounting holes are provided for mounting the LPI-10 module on an enclosure wall or baseplate panel (Hoffman JIC and NEMA panels or equal), or on another printed circuit board. The mounting holes accommodate #6 screws.

If the +50˚C ambient free air thermal rating of the LPI-10 module is exceeded due to self-heating, the enclosure will require either a cooling fan, air vents, or bulkhead mounting of the LPI-10 heat sink to permit proper cooling.

Bulkhead mounting should be used if the enclosure temperature will exceed the rating of the LPI-10 module, or if the input voltage exceeds 49VDC with the JP2 current select jumper set for either 1.0A or 1.5A limiting. Bulkhead mounting is accomplished by using the four heat sink mounting screw holes to physically couple the LPI-10 module heat sink to the metal enclosure wall. Metal wall enclosure construction is necessary as other enclosure materials may not provide adequate thermal dissipation. The heat sink is not electrically connected to on-board circuitry and therefore may make contact with a grounded conductive surface. To verify that the applied supplemental cooling measure is adequate when using a power supply exceeding 49VDC, the case temperature of either output transistor Q1 or Q9 should not exceed 60°C rise above ambient with a 1.5A continuous network load.

Regardless of the mounting method selected, care should be taken to leave adequate room for routing power supply and network wiring to the P1 and P2 connectors. Care should also be taken to avoid contact with LPI-10 module power transistors and the heat sink since these parts generate heat when operating or a fault occurs.

Table 3.1 LPI-10 Interface Module PCB Mechanical Dimensions

Dimensions in cm (inches)	***Nominal***	***Maximum***
Length	12.7 (5.0)	
Height		3.78 (1.49)
Width	7.24 (2.85)	

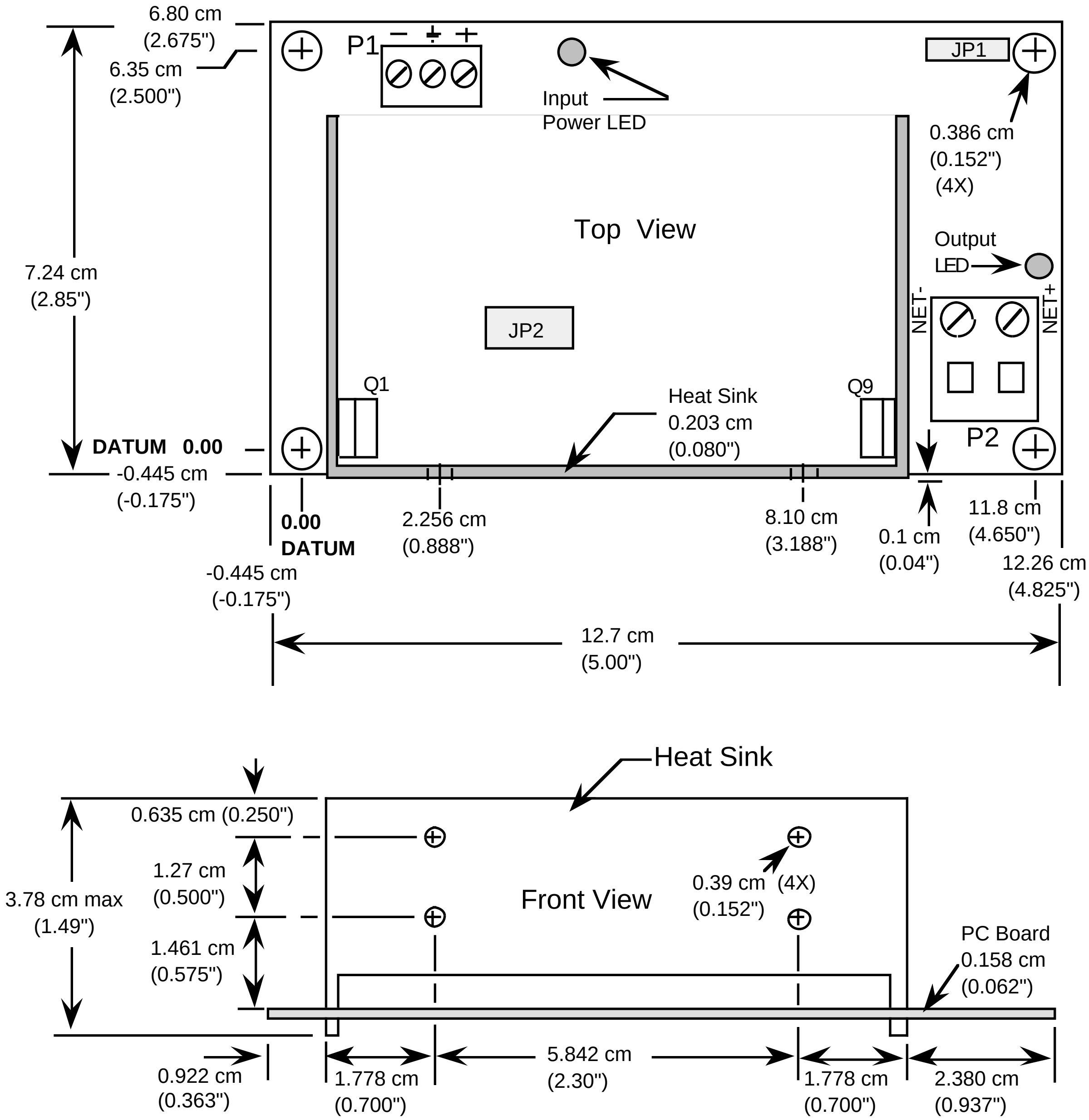

Figure 3.1 LPI-10 Module Dimensions

4

Design Issues

This chapter looks at design issues, and includes a discussion of Electromagnetic Interference (EMI) and Electrostatic Discharge (ESD).

EMI Design Issues

The high-speed digital signals associated with microcontroller designs can generate unintentional Electromagnetic Interference (EMI). High-speed voltage changes generate Radio Frequency (RF) currents that can cause radiation from a product if a length of wire or piece of metal can serve as an antenna.

Systems that use the LPI-10 module will generally need to demonstrate compliance with EMI limits enforced by various regulatory agencies. In the USA, the FCC[1] requires that unintentional radiators comply with Part 15 level "A" for industrial systems, and level "B" for systems that can be used in residential environments. Similar regulations are imposed in most countries throughout the world[2,3].

Designing Systems for EMC (Electromagnetic Compatibility)

Careful design of application electronics is important to guarantee that a system that incorporates an LPI-10 module will achieve the desired EMC. Information on designing products for EMC is available in several forms including books,[4,5] seminars, and consulting services. This section provides useful design tips for EMC.

EMC Design Tips

- Much of the RF noise originates in the customer-furnished input power supply, especially if it is a switching power supply.
- Most of the EMI is radiated by the network cable.
- The LPI-10 module must be well grounded ($\leq 10\Omega$ maximum to earth ground) to ensure that its built-in EMI filtering works properly.
- Additional EMI filtering may be required between the power supply and the LPI-10 module.
- To meet level 2 of IEC 801-3 RF susceptibility testing, it may be necessary to run two turns of the network cable through a ferrite core, e.g., Fair Rite #2643804502, at the output of the LPI-10 module.
- Early EMI testing of prototype link power devices at a certified outdoor range is an extremely important step in the design of level "B" products. This testing ensures that grounding and enclosure design questions are addressed early enough to avoid most last-minute changes and their associated schedule delays.

ESD Design Issues

Electrostatic Discharge (ESD) is encountered frequently in industrial and commercial use of electronic systems[6]. Reliable system designs must consider the effects of ESD and take steps to protect sensitive components. Static discharges occur frequently in low-humidity environments when operators touch electronic equipment. The static voltages generated by humans can exceed 10kV. Keyboards, connectors, and enclosures provide paths for static discharges to reach ESD sensitive components. Care also should be taken during installation to avoid exposing the LPI-10 module to static discharges during handling. Once installed, the LPI-10 module provides ESD protection at the wiring terminals provided that it is properly earth grounded at the P1 ground terminal.

Since some of the ESD energy is passed by the LPI-10 module to its power supply, the power supply itself must be capable of withstanding comparable ESD hits directly to its output connector without resulting in voltage droops longer than 50µS.

5

References

This section provides a list of the reference material used in the preparation of this manual.

Reference Documentation

[1] 47CFR15, Subpart B (Unintentional Radiators), *U.S. Code of Federal Regulations*, (formerly known as FCC Part 15, Subpart J).

[2] *VDE 0871*, Class "B", tested per VFG1046/1984.

[3] *CISPR Publication 22*, proposed new EC EMC Standard.

[4] *Noise Reduction Techniques in Electronic Systems*, 2nd ed., by Henry W. Ott, John Wiley & Sons, 1988.

[5] *Protection of Electronic Circuits from Overvoltages*, by Ronald B. Standler, John Wiley & Sons, 1989.

[6] *Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment, Part 2: Electrostatic Discharge Requirements*, IEC 801-2, 1991-04, draft.

Appendix A

Passive Link Power Interface

This section describes a passive link power interface that can be used with the LPT-10 Link Power Transceiver in lieu of the LPI-10 Link Power Interface. A schematic is included together with a parts list and a detailed specification of the special power supply requirements of the passive interface.

Passive Coupler Interface

Echelon's link power system sends power and data on a common twisted wire pair, and allows the user to wire link power nodes with virtually no topology restrictions. DC voltage from a power supply is supplied to the network via an appropriate electrical interface. The interface isolates the power supply from the communications signals and provides a proper termination impedance for these signals. Special features for proper system operation must be included either in the power supply itself or in the interface. These features include requirements for system startup behavior, tolerance to network wiring faults, and 42.4VDC output voltage regulation for compliance with Echelon link power transceivers and safety agency low voltage requirements. The simple passive coupler interface described requires integration with a power supply that is modified to incorporate the special features. It is assumed throughout this document that the referenced schematics, parts lists, and related technical documentation are followed exactly, without deviation.

The passive coupler is intended for use with a power supply having special attributes, and together the combination coupler/power supply provides a cost-effective alternative to the LPI-10 interface. The combination coupler/power supply is shown in the figure A.1 below.

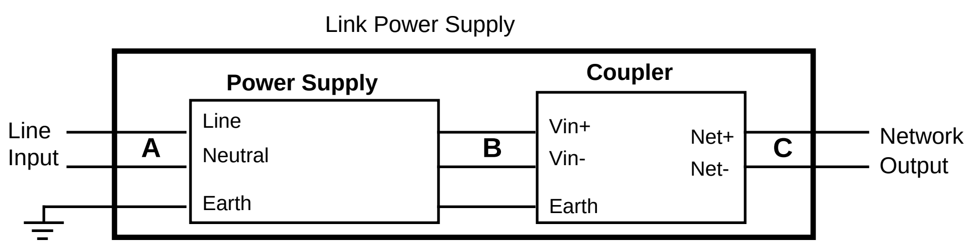

Figure A.1 Link Power Supply

Power Supply and Inductor Design Parameters

The passive coupler passes DC current from a floating output 42VDC supply (B) to the link power network (C), isolates communications signals on the network from the supply via two inductors and provides a selectable termination impedance for balanced data communications.

The requirements for the power supply for proper system operation include its startup behavior, tolerance to direct shorts across its output, and 42.4VDC output voltage regulation for compliance with Echelon's LPT-10 Link Power Transceiver and safety agency low voltage requirements.

LED indicators for the presence of input line power and output network power aid in troubleshooting the source of problems on the link power network. Some applications may require two source power supplies to be resident on the same twisted pair segment either for redundancy or for load sharing. The outputs of both units must be wired to the network with the same polarity. Reverse polarity protection is provided to prevent damage due to incorrect wiring. Source power supplies capable of load sharing (optional) must meet additional requirements to ensure proper network startup synchronization behavior.

The coupler "centers" the output voltage with respect to earth ground resulting in +21V and -21V outputs at "Net+" and "Net-" respectively. If one of the network wires experiences a single ground fault, the 42V output voltage is no longer centered about earth. In this case data communications may be degraded as the AC signal will be unbalanced and attenuated up to 3.5dB depending on the relative location of the fault.

Unless otherwise specified, the following power supply specifications must be met over all combinations of the following conditions as shown in the tables and figures below:

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

Description	***Conditions***	***Specification***
Line input voltage & indicator	• Measured at "A"	Line voltage as required by customer. 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 A.2
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[1]
Output startup interval behavior	• Startup or recovery from output short circuit or overcurrent fault • Measured at "B"	Reference figure A.3

continued

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
Redundancy fault tolerance[3]	• Two source power supplies connected in parallel with one or both operational	Functional behavior of operational unit(s). Non-operational unit shall not load the network.
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

Environmental Specifications[2]		
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"	10V/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	• 1.2/50µs - 8/20µs 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

Notes:

(1) It is recommended that the continuous output current be limited to less than 2.3 Amperes since some applications may require a safety agency continuous output power limitation of 100VA (non-redundant applications). In all cases, the continuous output power must be limited to 120 VA (2.8A) to satisfy UL-1950/IEC-950 240VA limits for redundant applications.

(2) Stricter or more extensive environmental specifications may be required by customers.

(3) For applications requiring redundant source power supplies for load sharing (optional), it is necessary that during startup both supplies apply continuous power to the network simultaneously. Depending on its design, the source power supply may require the ability to synchronize its startup to that of the redundant unit. This is especially applicable to units which use "burp" mode to handle overload conditions.

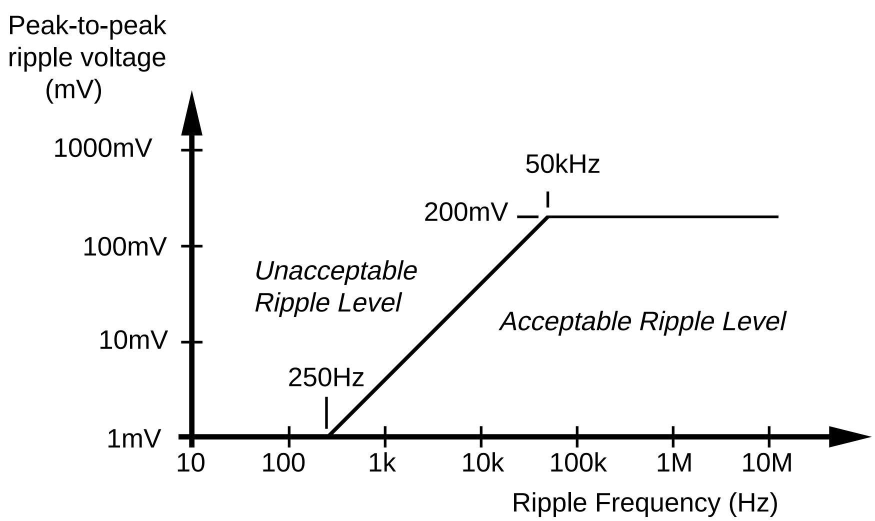

Figure A.2 Power Supply Output Ripple Voltage Requirement

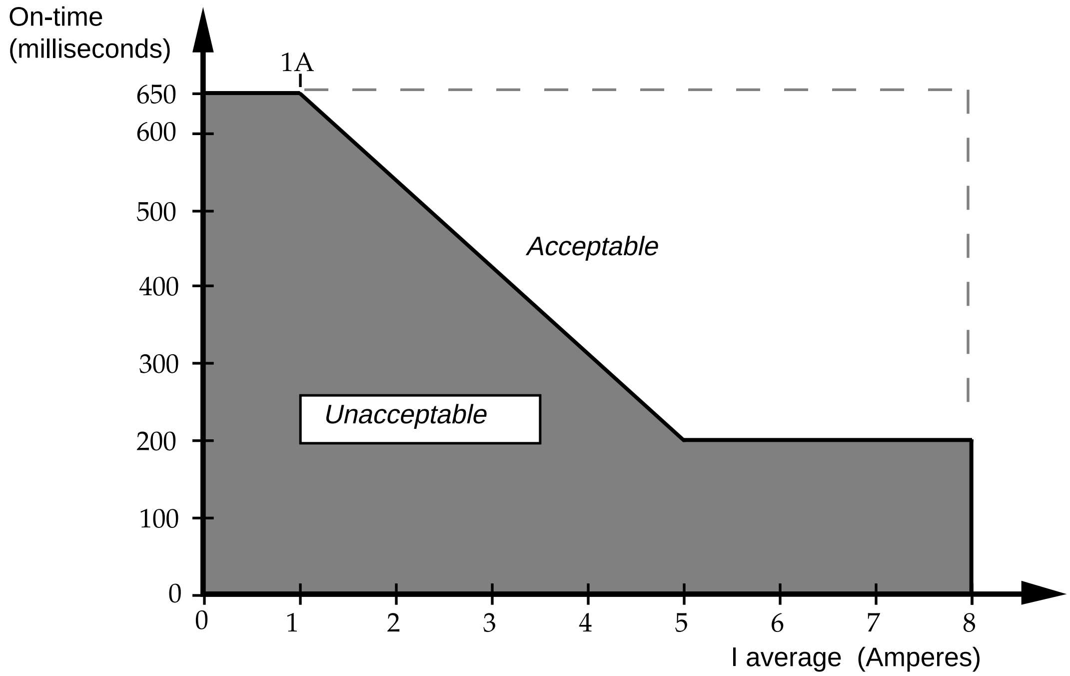

Figure A.3 Power Supply Startup Interval Behavior

Notes and definitions for Power Supply Startup Interval Behavior:

(1) 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.

(2) $I_{average}$ is the average output current available from the source power supply when charging the network from 0V to 42VDC. Once the output voltage has reached 42V, the output current capability must be at least 1.5 Amperes.

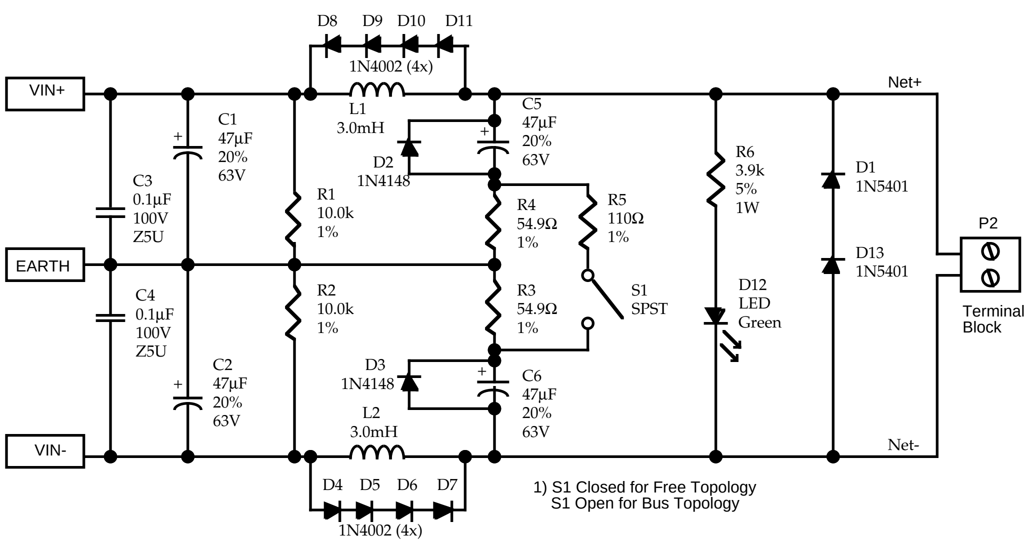

Figure A.4 Echelon Passive Coupler Schematic

Passive 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, Custom[1]
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
11	1	R5	110Ω, 1%, 1/4W
12	1	R6	3.9kΩ, 5%, 1W
13	1	S1	Switch, SPST or equivalent jumper

Inductor notes:

(1) Two design recipes for the custom 3.0mH inductors (L1, L2) are described below. While both designs are electrically equivalent, their different form factors allow the designer to meet various height and area requirements. Inductors are available from:

Precision Components Inc.
400 West Davy Lane
Wilmington, Illinois 60481 USA
Tel. (708) 543-6448
Fax (708) 543-6484

TNI Inc.
1001 Steeple Square Court
Knightdale, NC 27545
Tel. (919) 266-4411
Fax (919) 266-6008

3.0mH Inductor Recipe A		
Form Factor W x D x H = 40.5 x 30.2 x 35.8 (mm)		**PCI # 0505-0633**
Component	***Description***	***Manufacturer #***
Bobbin	Bobbin for TDK EE-40 core	TDK # BE-40-1112CP or equivalent
Winding	105 turns #20AWG (0.81mm) heavy build magnet wire terminated at pins 2 and 6.	Belden Trade No. 8076 or equivalent
Tape (windings)	130˚C polyester film tape meets flame retardancy requirements of UL-510. 2 wraps minimum applied over winding.	3M type 1350Y or equivalent
Core	Ferrite material TDK PC30, EE40, center leg gapped to A_L = 270nH/N^2 ±3%.	TDK # PC30EE40A0270±3%
Tape	130˚C polyester film tape meets flame retardancy requirements of UL-510. 2 wraps applied around core halves.	3M type 1350Y or equivalent (Adequate for clamping core halves)
Varnish	Varnish dip the assembly to cover windings and core. Varnish is cured and clear of PCB pins.	UL Class 130˚C minimum, UL 94V-0

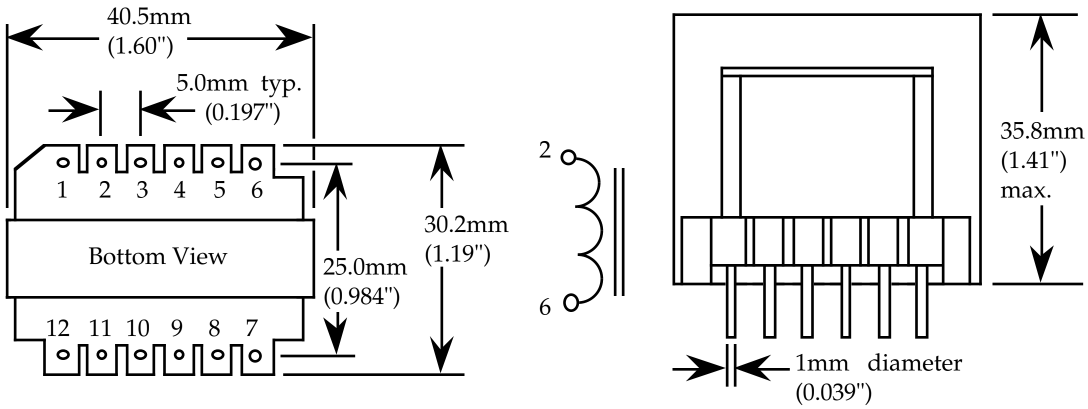

Figure A.5 Mechanical Dimensions for Inductor (Recipe "A")

3.0mH Inductor Recipe B		
Form Factor W x D x H = 43.2 x 35.6 x 27.2 (mm)		**PCI # 0505-0634**
Component	***Description***	***Manufacturer #***
Bobbin	Custom Bobbin for TDK EE/41/33B core 94V-0 Material	PCI # 0700-0240
Winding	105 turns #20AWG (0.81mm) heavy build magnet wire terminated at pins 2 and 6.	Belden Trade No. 8076 or equivalent
Tape (windings)	130˚C polyester film tape meets flame retardancy requirements of UL-510. 2 wraps minimum applied over winding.	3M type 1350Y or equivalent
Core	Ferrite material TDK PC30, EE41/33B, center leg gapped to A_L = 270nH/N^2 ±3%.	TDK # PC30EE41/33BA0270±3%
Tape	130˚C polyester film tape meets flame retardancy requirements of UL-510. 2 wraps applied around core halves.	3M type 1350Y or equivalent (Adequate for clamping core halves)
Varnish	Varnish dip the assembly to cover windings and core. Varnish is cured and clear of PCB pins.	UL Class 130˚C minimum, UL 94V-0

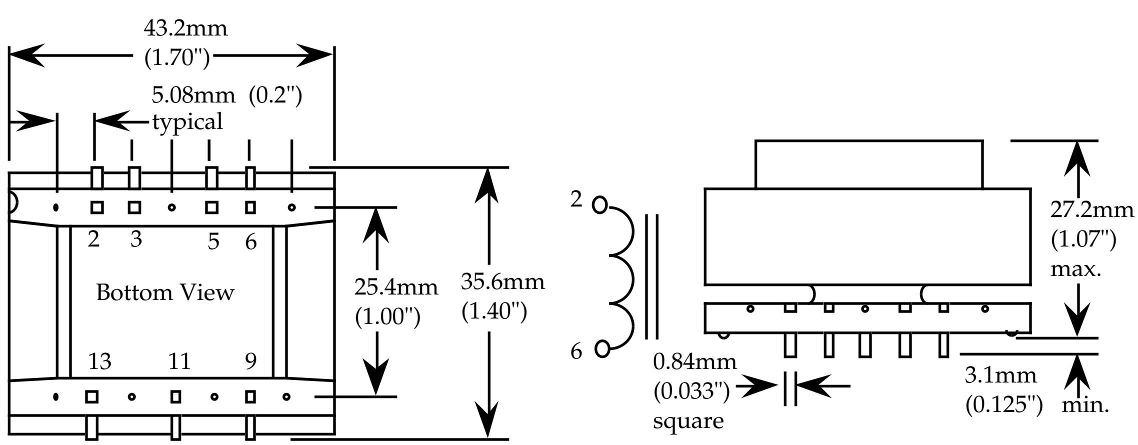

Figure A.6 Mechanical Dimensions for Inductor (Recipe "B")