LonWorks® PLCA-22

Power Line Communications Analyzer

User's Guide

Version 1

ECHELON®
Corporation

078-0176-01A

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Printed in the United States of America.

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Introduction

The PLCA-22 Power Line Communications Analyzer provides a simple, cost-effective method of field testing the operation of Echelon's multi-frequency, CENELEC EN50065-1 and EIA709.2 compliant, power mains communication technology. The PLCA-22 analyzers are used in pairs: one unit sends sequentially numbered packets whose length and protocol service type is set by the user and the other unit receives the packets and displays errors as a percentage of the total number of packets sent. A pair of calibrated receive signal strength meters also is provided. The user can select a transmit level of 1.7, 3.5, 7, or 10V peak-to-peak (p-p) with a current limit of 1 or 2A to assess the benefits of Echelon's high output signal transceivers and booster amplifiers. The user can also attenuate the transmit signal in discrete steps to determine system operating margin. A phase detector feature is provided to determine the relative distribution phase between a pair of power mains circuits.

The PLCA-22 analyzers automatically exchange test configuration information between one another, minimizing the need for a user to access both units during testing. Either unit can be programmed to be the Sender or the Receiver, and when one unit is set to be the Sender, the other automatically becomes the Receiver. At the end of a test, the packet error rate seen by the Receiver is automatically forwarded to the Sender for display, eliminating the need to physically observe the Receiver for test results.

To further extend their capabilities, each PLCA-22 analyzer includes an output only RS-232 communication port. This feature allows results to be logged on an external computer to create permanent time of day error logs.

The combined features of the PLCA-22 analyzer support rapid characterization of power mains-based LONWORKS networks. The PLCA-22 analyzer is also extremely useful as a troubleshooting and commissioning tool.

The PLCA-22 analyzer replaces the PLCA-21 analyzer, but in order to suport new features, the PLCA-22 analyzer functions are not compatible with those of the PLCA-21 analyzer. The PLCA-21 and PLCA-22 analyzers will not function as mixed pairs.

Echelon's Power Mains Technology

LONWORKS is a general purpose control network technology that can be used to monitor sensors and control outputs in a wide variety of applications. With the PLT-22 power line transceiver, control networks can be implemented through the same AC or DC mains wiring that powers the equipment under supervision. Power mains signaling eliminates the need for additional communications cabling and both reduces the expense and simplifies the task of retrofitting control networks in existing installations. The PLT-22 transceiver is based on powerful new Echelon custom integrated circuits and incorporates many technological innovations that enable reliable signaling on an otherwise hostile and noisy medium. Designed for world-wide application, the PLT-22 transceiver meets FCC, Industry Canada, CENELEC EN50065-1, and Japan MPT regulations for power mains signaling when used with recommended external components.

The PLT-22 power line transceiver is a backward-compatible replacement for Echelon's popular PLT-21, and earlier PLT-20, power line transceivers. While a PLT-22 can inter-communicate with PLT-20- and PLT-21-based nodes, it also incorporates a number of new features which allows it to communicate with other PLT-22 transceivers even when conditions block reliable signaling among earlier generation transceivers.

Power mains are generally optimized for supplying electrical power at low frequencies. They pose significant impediments to transmitting the signals necessary for high performance control applications. Power mains wiring inductance and the loading effects of electrical devices plugged into a power mains can easily result in the attenuation of a transmitted signal by 40dB (a factor of 100) to 60dB (a factor of 1,000). In addition, electrical equipment such as motors, light dimmers, switching power supplies, and fluorescent light ballasts inject noise that can mask low-level power mains control signals (figure 1.1). Worse yet, these electrical characteristics vary from instant to instant, presenting a continuously changing communication channel. Echelon's engineers have developed unique methods of signal processing and error correction in order to turn the power mains into a robust communication channel.

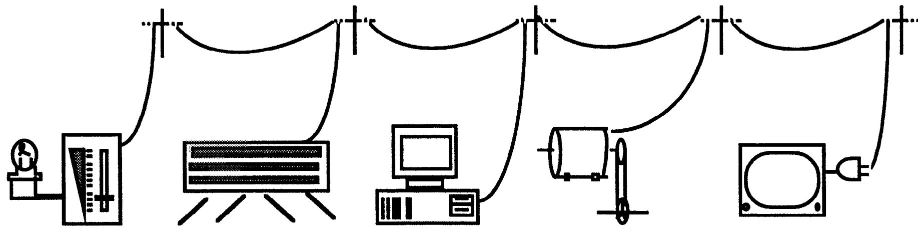


Figure 1.1 Typical Sources of Power Mains Noise and Attenuation

Reliable communication is further enhanced by the ability of the PLT-22 transceiver to automatically detect interference on its primary communication frequency and then dynamically switch to a secondary operating frequency. If the primary frequency is blocked by noise, the PLT-22 transceiver will automatically complete the transaction using its secondary frequency. The PLT-22 transceiver maintains backward compatibility with previously installed PLT-20- and PLT-21-based nodes by initiating all of its transactions using the primary frequency, which is common to all three transceiver versions.

With a change in crystal frequency the PLT-22 transceiver provides automatic dual frequency operation in the 70kHz to 95kHz portion of the European utility band (the CENELEC A-band). The PLCA-22 communication analyzer supports both crystal options via front panel selection of operating mode as shown in table 1.1.

Table 1.1 Transceiver Operating Frequencies by Application

Countries	***Applications***	***PLT-22 Crystal Frequency***	***PLCA-22 Mode Name***	***Primary Carrier Frequency***	***Secondary Carrier Frequency***
US, Canada, Japan (and all other non-CENELEC compliant countries)	All applications (EIA 709 compliant)	10.0000 MHz	C-band	132kHz	115kHz
European and all other CENELEC compliant countries	Consumer and all non-electricity supplier applications	10.0000 MHz	C-band	132kHz	115kHz
European and all other CENELEC compliant countries	Electricity supplier applications	6.5536 MHz	A-band	86kHz	75kHz

The PLT-22 transceiver meets the regulations for AC mains signaling of the FCC (Federal Communication Commission), Industry Canada (formerly DOC), CENELEC (European Committee for Electrotechnical Standardization), and Japanese Ministry of Post and Telecommunications (MPT).

Under FCC Section 15.107 "Limits for carrier current systems," as well as under Industry Canada guidelines, communication frequencies are allocated as shown in figure 1.2. To protect radio navigation systems operating between 190kHz and

525kHz, restrictions on power line communication above 185kHz are under consideration. The PLT-22 transceiver avoids interfering with these systems by signaling in the frequency range of 110kHz to 140kHz.

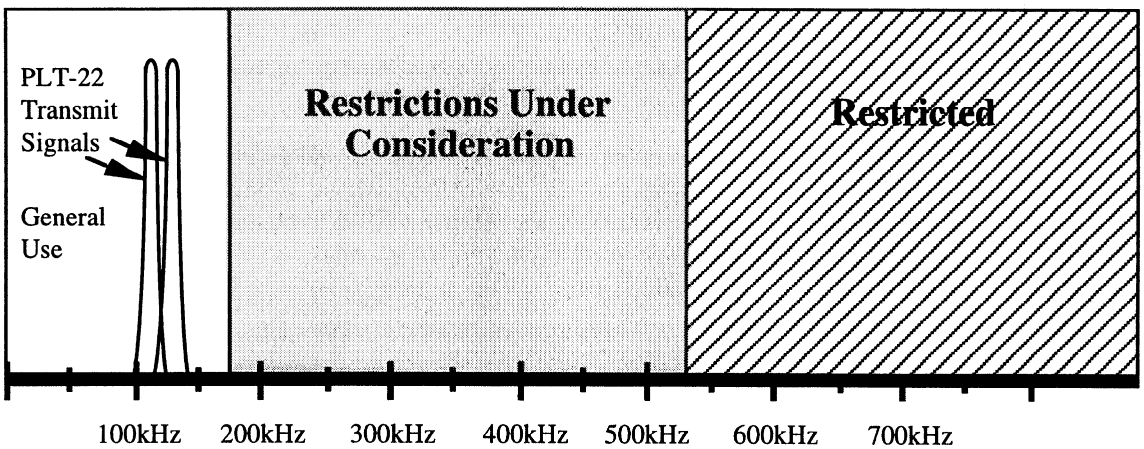


Figure 1.2 FCC and Industry Canada Frequency Allocation

Under CENELEC EN 50065-1 "Signaling on low-voltage electrical installations in the frequency range 3kHz to 148.5kHz" Part 1 "General requirements, frequency bands and electromagnetic disturbances," communication frequencies are allocated as shown in figure 1.3. When used with a 10MHz crystal, the PLT-22 transceiver signals in CENELEC C and B bands and implements the access protocol as specified in CENELEC EN 50065-1. (See *CENELEC Access Protocol Field* in Chapter 2 for more information.) When used with a 6.5536MHz crystal, both the primary and secondary operating frequencies of the PLT-22 are within the CENELEC A-band.

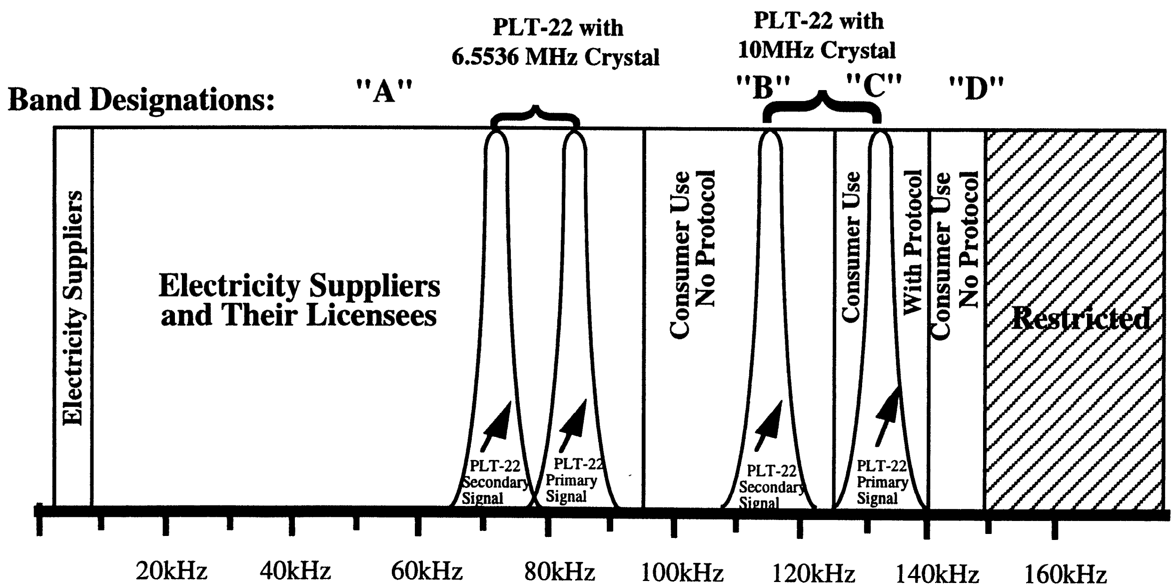


Figure 1.3 CENELEC Frequency Allocation

The PLT-22 transceiver is a 39mm x 19mm x 6mm (1.54" x 0.75" x 0.24") Single In-line Package (SIP) containing Echelon's dual carrier frequency power line integrated circuit, transmit and receive filters, and transmit amplifier (figure 1.4). This compact transceiver can be mounted on or inside of an OEM product and requires only the addition of a Neuron® 3120® or 3150® Chip, crystal, power mains coupling network, power supply, and application electronics to build a complete node.

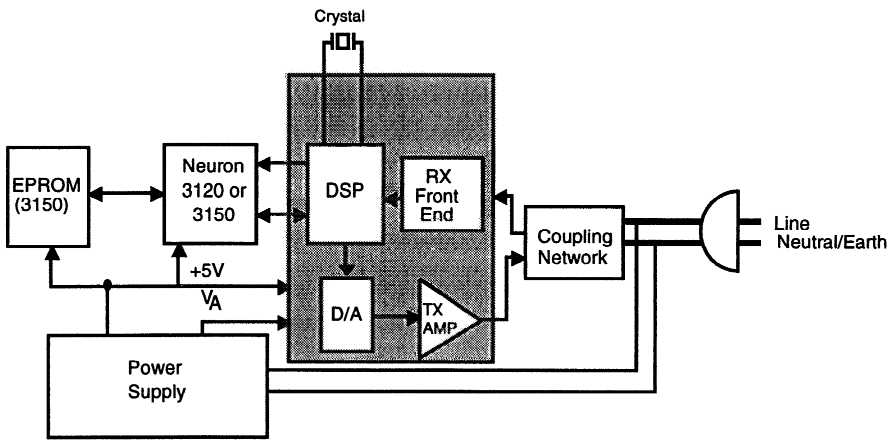


Figure 1.4 PLT-22 Transceiver Block Diagram (transceiver shown in shaded area)

The PLT-22 transceiver supports different output signal levels depending on the application. Table 1.2 summarizes the output signal levels for both Line-to-Neutral (L-to-N) and Line-to-Earth (L-to-E) coupling circuits. The PLCA-22 analyzer supports all of the signaling levels and coupling types listed in table 1.2.

Table 1.2 Transceiver Maximum Voltage and Coupling Options

Device Type	***Coupling Type***	***Primary Communication Frequency***	***Maximum Transmit Voltage***	
			PLT-22	***PLT-22 with PLA-21 Booster Amplifier***
Residential FCC and Industry Canada	L-to-N	132kHz (C-band)	7V p-p	10V p-p
Commercial FCC and Industry Canada	L-to-E	132kHz (C-band)	7V p-p	10V p-p
All Japanese MPT	L-to-N	132kHz (C-band)	7V p-p	7V p-p
CENELEC C-band Class 116	L-to-N	132kHz (C-band)	3.5V p-p	3.5V p-p
CENELEC C-band Class 134	L-to-N	132kHz (C-band)	7V p-p	7V p-p
CENELEC A-band	L-to-N	86kHz (A-band)	7V p-p	7V p-p

The PLT-22 transceiver also may be used with an Echelon PLA-21 Booster Amplifier that provides 10Vp-p/2Ap-p output signals when used with a 15V power supply. The PLT-22 transceiver is able to drive up to 1A peak-to-peak (p-p) into low impedance loads. The PLA-21 booster amplifier is able to drive up to 2Ap-p. The current limits of the PLT-22 transceiver and booster amplifier are electronically controlled so that any load, including a short circuit, may be driven indefinitely without damage to the transceiver. The PLCA-22 analyzer supports 1.7, 3.5, 7, and 10V p-p signal output levels at both 1A and 2A current limits for emulating the operation of the PLT-22 transceiver or the PLA-21 booster amplifier.

The PLT-22 transceiver interfaces directly with the Neuron Chip and requires a minimum number of external components. When operating in the C-band, the transceiver provides a selectable 1.25, 2.5, 5, or 10 MHz clock output to drive the Neuron Chip, eliminating the need for a separate Neuron Chip crystal. It also provides packet detect and band-in-use outputs that are suitable for directly driving low power light emitting diodes (LEDs). The transceiver communicates at a raw bit rate of 5.5kbps when operated in the C-band and at 3.6kbps when operating in the A-band.

The PLT-22 transceiver can be used to couple LONWORKS control signals to virtually any two- or three-wire AC or DC power mains, regardless of voltage, as well as to any un-powered wire pair. The transceivers are suitable for wave soldering in a standard through-hole-component manufacturing process.

Audience

The *LONWORKS PLCA-22 Power Line Communications Analyzer User's Guide* provides specifications and user instructions for the power line communication's analyzer, and is required reading before operating the units.

Content

This manual provides detailed operating instructions for the PLCA.

Related Documentation

The following Echelon documents are suggested reading:

LONWORKS PLT-22 Power Line Transceiver Module User's Guide (078-0175-01)

PLA-21 Power Line Amplifier Specification and User's Guide (078-0161-01)

Centralized Commercial Building Applications with LONWORKS PLT-21 Power Line Transceiver (005-0056-01)

Demand Side Management with the LONWORKS PLT-21 Power Line Transceiver (005-0070-01)

2

Getting Started

This chapter guides the user through a brief set of step-by-step instructions on the use of the PLCA-22 analyzers.

Simple Step-by-Step Instructions for Getting Started

To use the PLCA-22 Analyzers, first connect both analyzers to the power mains by plugging them into AC receptacles. The first time that a PLCA-22 analyzer is powered, the display will briefly present the Set-up Mode screen and will then show the following:

R	e	c	v		A	c	k	d	4	t	r	y		C	-	b	a	n	d
P	k	t	s	:							T	x	V	p	p	:	7	V	
R	c	v	d	:	0						A	t	t	n	:	0	d	B	
L	o	s	t	:							E	r	r	:					

For a quick initial test, both units should be connected to the same wall outlet and the START key pressed on either of the two units. The other unit will automatically change from Receive mode to Send mode and will start sending packets to the first unit. The two displays will look something like this:

Receiver:

R	e	c	v		A	c	k	d	4	t	r	y		C	-	b	a	n	d
P	k	t	s	:							T	x	V	p	p	:	7	V	
R	c	v	d	←	1	2	3				A	t	t	n	:	0	d	B	
L	o	s	t	:	0						E	r	r	:		0	.	0	%

Sender:

S	e	n	d		A	c	k	d	4	t	r	y		C	-	b	a	n	d
P	k	t	s	:	0	0	0	1	k		T	x	V	p	p	:	7	V	
S	e	n	t	→	1	2	3				A	t	t	n	:	0	d	B	
L	o	s	t	:							E	r	r	:					

On the Receiver, the number of lost packets and the error rate are updated in real time. The statistics shown on the Sender are updated only after a Pause or Stop command, or upon completion of a test.

"Ackd4try" indicates that the analyzer is set to communicate using acknowledged service with each message being allowed a maximum of four tries to be completed. "C-band" indicates that the analyzer is set to use 132kHz as its "primary" carrier frequency while using 115kHz as a "secondary" carrier frequency for the last two attempts (if needed).

On the Sender, the upper-left corner of the display changed from Recv to Send, indicating the mode change. The "0001" and "k" fields indicate that the Sender will send 1000 packets. The "TxVpp" and "Attn" fields indicate that the transmit level is 7Vp-p with 0dB of added transmit attenuation. The left side of the third line shows the number of packets that have been sent.

The words REMOTE READY appear momentarily on the fourth line after pressing the Start key, and indicate that the Sender was able to successfully communicate with the Receiver at the start of the test. Then the fourth line appears as shown above.

After the analyzers have sent about 500 packets, press the Pause key on the Sender. The Sender will stop transmitting and retrieve the test statistics from the Receiver. The displays will look something like this (ignoring the REMOTE READY message that briefly appears on the Sender's display):

S	e	n	d		A	c	k	d	4	t	r	y		P	a	u	s	e	d
P	k	t	s	:	0	0	0	1	k		T	x	V	p	p	:	7	V	
S	e	n	t	:	5	0	0				A	t	t	n	:	0	d	B	
L	o	s	t	:	0						E	r	r	:		0	.	0	%

The Receiver's display will look like this:

R	e	c	v		A	c	k	d	4	t	r	y		P	a	u	s	e	d
P	k	t	s	:							T	x	V	p	p	:	7	V	
R	c	v	d	:	5	0	0				A	t	t	n	:	0	d	B	
L	o	s	t	:	0						E	r	r	:		0	.	0	%

Note that the fourth line of the Sender has changed to show statistics in the two fields Lost and Err. The Lost field displays the number of packets that were lost during the test. The Err field displays the packet error rate, calculated as the percentage of lost packets and rounded to the nearest one-tenth percent.

Press the Pause key again on either analyzer. The third line on both units will again increment as packets are sent. The fourth line on the Receiver will continue to be updated, but the fourth line on the Sender will remain unchanged unless Pause is pressed again. This is because the Sender must query the Receiver before it can update this line, and the query will not take place unless the Pause key or the Stop key is pressed, or until the test completes when the selected number of packets has been sent.

Experiment by starting, pausing, and stopping tests from each analyzer, and by changing the direction of the test from either analyzer. Note that tests may be started, paused, and/or stopped from either analyzer. Whenever two analyzers lose communication (e.g., if one temporarily loses power while a test is running), they can be re-initialized by pressing the Stop key followed by the Start key. Note also that when one analyzer is changed from Recv to Send, or vice-versa, the other unit changes to the opposite mode as soon as the Enter key is pressed on the local unit.

3

PLCA-22 Analyzer Functions

This chapter describes how to use a PLCA-22 system comprised of two PLCA-22 analyzers.

How the PLCA-22 Analyzer Tests the Power Mains

The PLCA-22 analyzers carefully emulate "real" nodes by using the same hardware as a control node based on a PLT-22 power line transceiver. During a test, one PLCA-22 analyzer (the Sender) sends packets while the other unit (the Receiver) receives packets. Three communication service modes are provided. In the first mode, **Unacknowledged Primary mode (UnackPri)**, each message is sent unacknowledged using only the primary frequency with zero repeats. This provides an ideal mechanism to test the suitability of the power mains circuit as a physical medium. In the second mode, **Acknowledged service mode (Ack4try)**, each message is sent acknowledged with three retries. In this mode, the first two attempts are made at the primary carrier frequency of the transceiver, while the secondary carrier frequency is used for the last two tries. This mode allows the user to see how signaling performance is improved with the benefit of the LonTalk protocol services and the dual carrier frequency capability of the PLT-22 transceiver.

The third communication service mode, **Unacknowledged Secondary mode (UnackSec),** provides a way to separately evaluate the communication performance of the PLT-22 transceiver at its secondary operating frequency, without the benefits of any retries. Each of these communication service options is supported for both C-band and A-band operating modes. From a setup screen, the user can select between C-band or A-band operation. This selection will be indicated on the main screen in the upper right-hand corner of the display. In each case the messages consist of two-byte sequenced values, plus random data totaling 12 to 76 bytes per packet, including overhead. The Receiver looks for the packets in sequence, and if there is a gap, the missing packets are counted as lost. The result of the test is reported as a packet error rate, which is the percentage of packets lost versus total packets transmitted.

Unacknowledged service testing is indicated by the letters UnackPri or UackSec in the middle of the top row of the display. Acknowledged service mode testing is indicated by the letters Ackd4try in the same position on the display. Placing one unit in Send mode automatically causes the other unit to go into Recv mode, and vice-versa. The Phase mode detects and displays the electrical phase of the mains connection. From the setup screen, the user can control whether testing is performed with the CENELEC EN50065-1 access protocol enabled or disabled.

The PLCA-22 analyzers are designed so that the network can be tested in both directions from either analyzer. At the completion of a test, a Sender automatically polls the remote PLCA-22 Receiver for lost packet information and displays the results on the local PLCA-22 LCD display.

Due to the periodic status information sent between the two PLCA-22 analyzers, the packet throughput of the PLCA-22 is **not** indicative of the throughput of the PLT-22 transceiver.

Description of the PLCA-22 Unit

Figure 3.1 presents the front panel of the PLCA-22 analyzer, and the function of the controls and displays are described below.

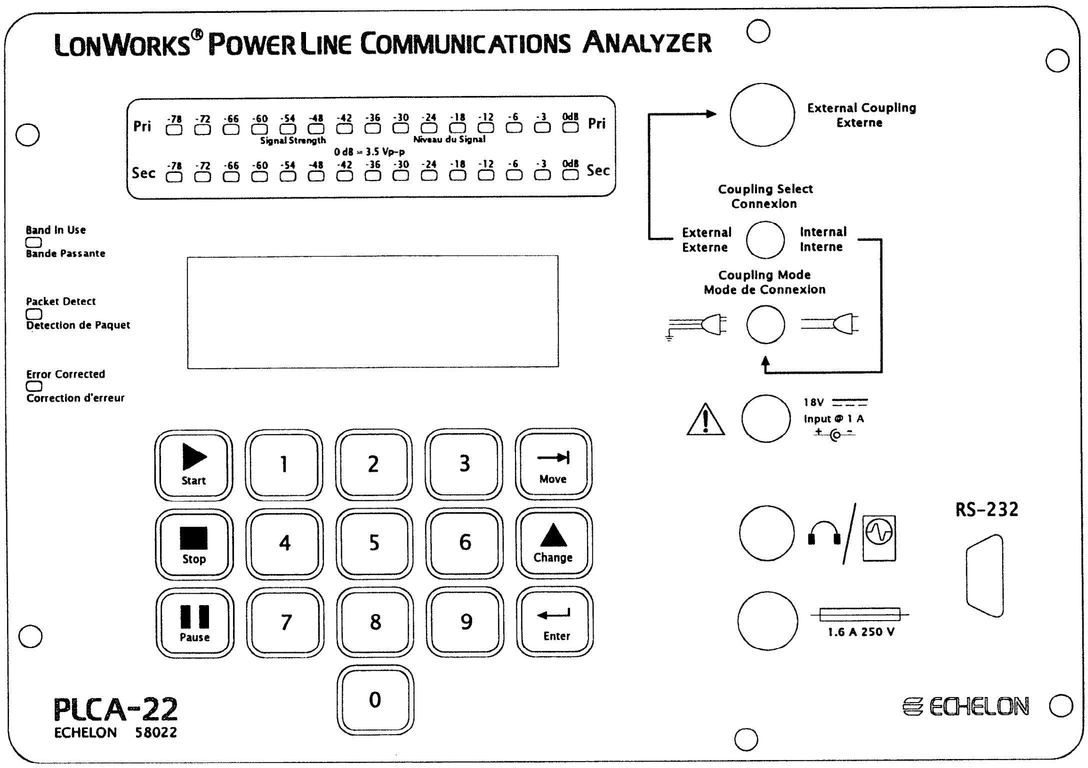
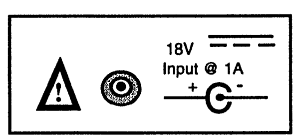
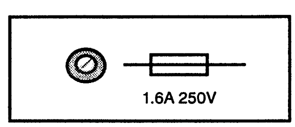


Figure 3.1 PLCA-22 Analyzer Front Panel

Input Power



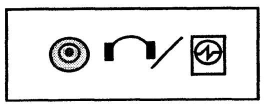
IEC Receptacle



The PLCA-22 analyzer can be powered either from the AC mains via the IEC-320 line cord or from 18VDC @ 1A via the front panel miniature 2.1mm x 5.5mm plug (Shogyo SPY1812 or equal). AC mains voltage operation is auto-ranging, and the unit adapts automatically to input voltages from 100 to 240VAC, 50/60Hz.

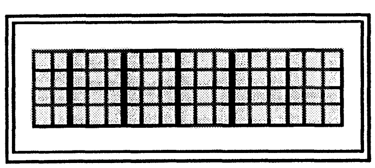
The 18VDC input is intended for use with external battery power sources where 100-240VAC at 50/60Hz is not available. A user-replaceable fast-blow input power fuse is provided on the front panel. Should this fuse require replacement, only a fuse of identical size and rating should be used. (See Chapter 6.)

Headphone/Oscilloscope Output



The PLCA-22 analyzer provides a two channel output of its baseband received signal. Available via a standard 3-conductor 1/4" phone plug (Switchcraft 60 or equal), the output can be monitored on audio headphones or displayed on an oscilloscope. This feature provides for an audible and/or visual indication of the characteristics of a received signal when a test is in progress. Likewise, the characteristics of noise on the power mains can be heard/seen. This feature allows for rapid field analysis of signal impairments without additional expensive or bulky equipment. When the analyzer is in UnackPri mode, the right and left headphone outputs are the two baseband signals from the primary frequency receiver. When UnackSec is selected, the right and left headphone outputs are the baseband signals for the secondary operating frequency. When Ack4try is selected, the left headphone signal is from the primary frequency while the right signal is from the secondary frequency. Note that the signal present at the headphone jack is not updated until the first time a test is started following a mode change (or after entering and exiting the setup screen). The headphone/oscilloscope output jack is only for connection to cables and equipment which have no accessible live parts.

LCD Display



The LCD display indicates the status of the PLCA-22 analyzer, and provides a simple means of displaying new commands prior to their execution by the unit. The LCD display includes a backlight with an adjustable intensity control. The backlight enables the PLCA-22 analyzer to be used in dimly lit rooms, and can be turned off to conserve power, or turned up to improve legibility. The backlight level is adjusted using the LCD "Lt" display field of the set-up screen.

The PLCA-22 analyzer configuration Set-up mode (figure 3.2) is used to configure parameters that are unlikely to change during a test. These parameters include the size of the packets, CENELEC protocol configuration, A or C-band primary carrier frequency and the transmit current limit. In addition, the Set-up mode screen briefly displays the software revision of the analyzer each time the unit is repowered. The other modes display parameters that are of consequence during a test, and allow programming of those fields that are likely to be changed in the course of testing. Figure 3.3 presents the send mode of operation.

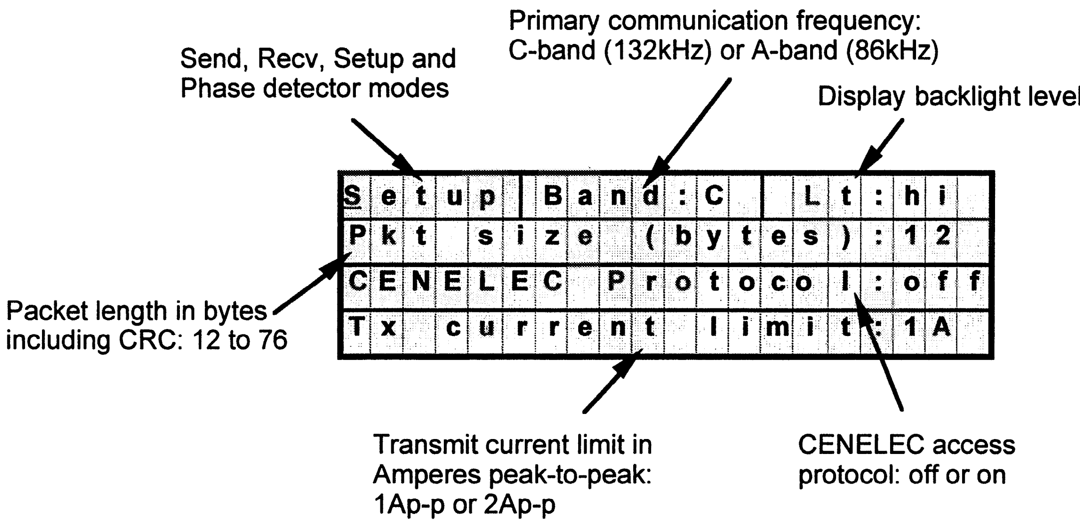


Figure 3.2 LCD Display Fields - Set-up Mode

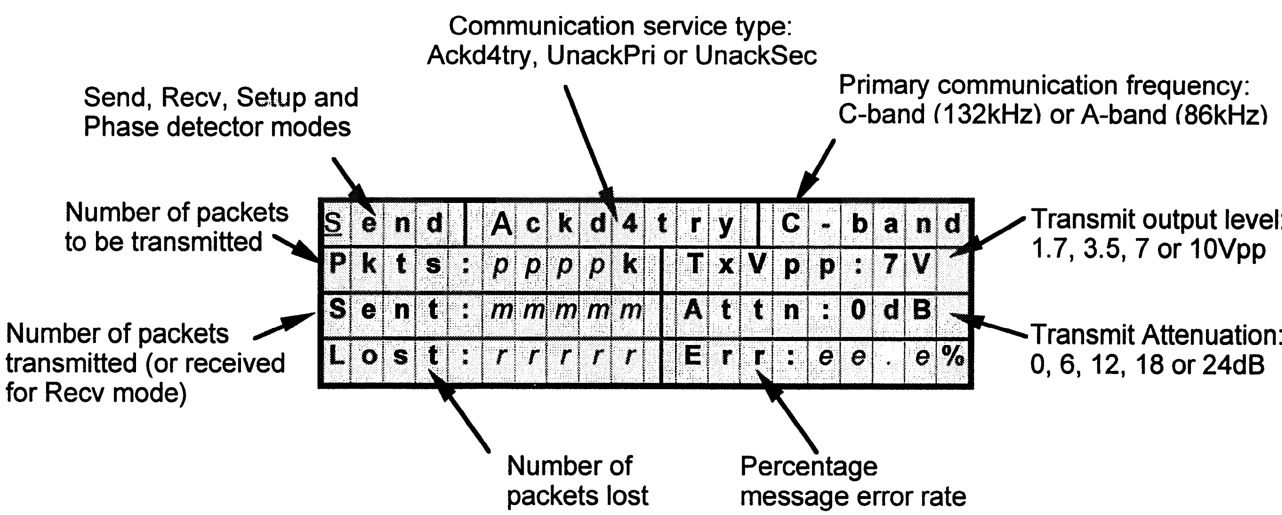
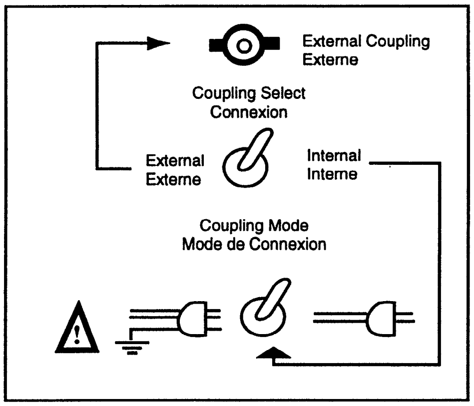


Figure 3.3 LCD Display Fields - Send Mode

Coupling Circuits



A locking toggle switch (pull to switch) on the PLCA-22 analyzer selects between Line-to-Neutral (2-wire) and Line-to-Earth (3-wire) coupling to 100 - 240 VAC power mains. Line-to-Neutral coupling uses the Line and Neutral power mains for signal transmission, and should be used for two wire AC circuits in which a ground is not present. Line-to-Neutral mode coupling is also intended for applications in which more than one PLT-21 or PLT-22 transceiver will be installed on a single circuit using a low current (<4 mA) Residual Current Device/Ground Fault Interrupter (RCD/GFI).

Line-to-Earth coupling signals on Line relative to Ground, and should be used where three wire (Line, Neutral, and Ground) AC circuits are available. Line-to-Earth coupling provides the best performance in electrically noisy environments, and is ideal for commercial installations in which a reliable ground connection is available.

Line-to-Earth coupling is not permitted in some countries. The user is advised to consult with local safety and regulatory agencies before using Line-to-Earth coupling.

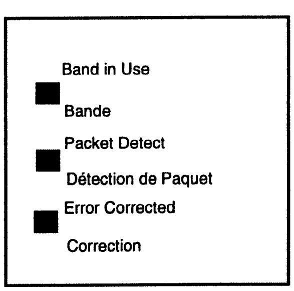
Any combination of coupling circuit and transmit signal levels may be used for FCC and Industry Canada applications. For applications that require compliance with CENELEC EN50065-1 regulations the limits shown in Table 3.1 must be observed. Note that the L-to-E signal coupling is not permitted in most CENELEC countries. Class 134 operation may require prior notification to, or consent of, the appropriate authorities.

Table 3.1 Transceiver Maximum Voltage and Coupling Options

Device Type	Coupling Type	Primary Communication Frequency	Maximum Transmit Voltage	
			PLT-22	PLT-22 with PLA-21 Booster Amplifier
Residential FCC and Industry Canada	L-to-N	132kHz (C-band)	7V p-p	10V p-p
Commercial FCC and Industry Canada	L-to-E	132kHz (C-band)	7V p-p	10V p-p
All Japanese MPT	L-to-N	132kHz (C-band)	7V p-p	7V p-p
CENELEC C-band Class 116	L-to-N	132kHz (C-band)	3.5V p-p	3.5V p-p
CENELEC C-band Class 134	L-to-N	132kHz (C-band)	7V p-p	7V p-p
CENELEC A-band	L-to-N	86kHz (A-band)	7V p-p	7V p-p

A separate locking toggle switch selects between internal or external coupling. Internal coupling routes the communications signal through the AC mains line cord and is intended for all AC voltages from 100 to 240VAC, 50/60Hz; power is then provided either via the line cord or the 18VDC input jack. External coupling routes the power mains signaling through the BNC connector on the front panel of the PLCA-22 analyzer, and power is again provided either via the line cord or the 18VDC input jack. External coupling should be used to couple to AC circuits with voltages less than 100VAC, AC voltages greater than 240VAC, AC line frequencies other than 50 to 60Hz, as well as any DC power mains or unpowered lines including twisted pair and unconditioned telephone lines. Refer to the *LONWORKS PLT-22 Transceiver User's Guide* and related PLT-21/22 engineering bulletins for coupling circuit recommendations. See Appendix A for details of the external coupling circuit interface. Note that the external coupling jack should be connected to a powered line only through an appropriate line coupling circuit.

Status LEDs



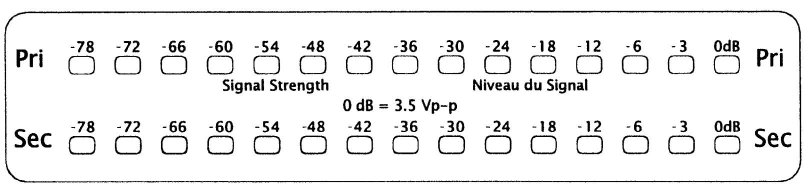
Three LED indicators on the front panel provide real-time status indications of the following functions:

- Band-In-Use: green LED that is defined in CENELEC EN50065-1 to be active whenever a signal that exceeds 80dBµVrms within the selected band (86.2kHz to 87.5kHz in the A-band or 131.5kHz to 133.5kHz in the C-band) is present for at least 4ms. The green Band-In-Use LED illuminates when this condition is met.

- Packet Detect: bicolor LED that turns green whenever a valid LonTalk packet is received on the primary frequency and yellow when a valid LonTalk packet is received on the secondary frequency. Note that the PLCA-22 analyzer's receive sensitivity is considerably greater than that of the BIU indicator. The PLCA-22 analyzer can receive a packet, as indicated by the packet detect LED, whose signal level is as small as 30dBµV rms. Thus it is not uncommon for the packet detect indicator to signal that a packet is present without the Band-In Use indicator turning on. This occurs for cases where the received packet signal strength is less than 80dBµV and greater than 30dBµV.

- Error Corrected: yellow LED that indicates that the error correction algorithm of the PLCA-22 analyzer is attempting to correct one or more packet errors, as a PLT-22 based node would under the same conditions.

Signal Strength Meter



A set of 15 green LEDs indicates the relative signal level (during packet activity) and noise level (during packet free times) in the primary carrier band. A second set of yellow LEDs indicates the corresponding levels in the secondary carrier band. The signal strength meter has LEDs for -78, -72, -66, -60, -54, -48, -42, -36, -30, -24, -18, -12, -6, -3, and 0 dB, relative to a 3.5Vp-p signal on the power mains. Note that the reference level is always 3.5V and does not change as the TxVpp field is changed (see TxVpp).

The LEDs can be used to make a quick estimate of signal-to-noise ratio at the Receiver by using the Pause key on the Receiver to pause transmissions (checking the background noise level) and then checking the indicated receive signal level after pressing Pause again to restart the Sender.

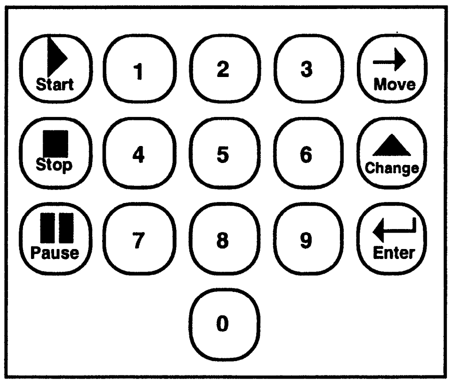
When used as a noise indicator, only signals whose frequency or noise characteristics affect power mains signaling are displayed; other noise sources that do not affect power mains signaling are ignored.

RS-232 Communication Port

The PLCA-22 provides an output-only serial port for use in monitoring and data logging applications. During operation, the contents of the LCD screen are sent to the serial port. Using a VT100 terminal emulation program, the LCD screen can be displayed on a PC. The data from the serial port may be captured and processed using a program on the PC to provide error rate versus time or other measurements.

Devices using the serial port should be configured for 9600 baud, 8 data bits, no parity, and 1 stop bit (8-N-1). The PLCA-22 analyzer does not support flow control so the device connected to the serial port should be able to receive data at 9600 baud without losing bytes. For the format of the serial port data, refer to the Echelon web site at www.echelon.com/toolbox.

16-Key Keypad



The 16-key keypad includes the following functions (these are described in more detail in the next section):

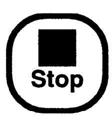
0-9	Numeric keys for entering programming values;
Start	Initiates packet transmissions and clears statistics shown on the LCD display;
Stop	Stops packet transmissions and updates the statistics shown on the LCD display;
Pause	Temporarily halts packet transmissions and updates the statistics shown on the LCD display;
Move	Moves the cursor on the LCD display to the next field;
Change	Changes the value of the parameter at the current cursor position;
Enter	Stores the new value entered via the numeric or Change buttons.

Keyboard Operation

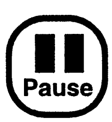
The PLCA-22 analyzer is controlled by the 16-key keypad. Six of the sixteen keys are control keys (Start, Stop, Pause, Move, Change, Enter), and the other ten are numeric keys. The operation of the keyboard is described below.

Pressing Start at either the Sender or Receiver will cause initialization packets to be sent between the two units, after which the test will commence. While the initialization process is taking place, the message COMMUNICATING will appear in the lower left corner of the display. After initialization, the message will change to REMOTE READY, and will finally be replaced by the Lost and Err fields, after which packet transmission will commence. If the Receiver's start button was pressed and initialization fails, the message NO REMOTE UNIT FOUND will appear and the test will be aborted. If the Sender's Start button was pressed and initialization fails, the sender will begin sending packets even though no remote unit was found.

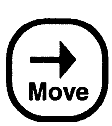
If the Start key is pressed in the middle of a test, or while the analyzer is paused, then the active or paused test will be terminated, the current statistics will be cleared, and a new test will be started.



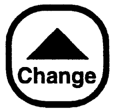
The Stop key terminates a test in progress. The test may be stopped by pressing the Stop key on either the Sender or Receiver. After pressing the Stop key, the test statistics will be displayed on the LCD displays at both the Sender and Receiver PLCA-22 analyzers. Once a test has been stopped, a new test may be started by pressing the Start key.



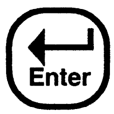
The Pause key halts a test once it is running. The test may be paused by pressing the Pause key on either the Sender or Receiver. Pressing the Pause key will update the test statistics at both analyzers. Pressing the Pause key again on either analyzer will cause the test to resume from the point at which it was halted.



The Move key moves the cursor to the next programming field on the LCD display. The cursor only moves to fields that can be modified either via the Change key or the numeric keys. Fields that are displayed but cannot be programmed are skipped by the Move command. The Move key is only active when the PLCA-22 analyzer is in the IDLE state: when an analyzer test is Active or Paused, the cursor is frozen at the transmit attenuation field.

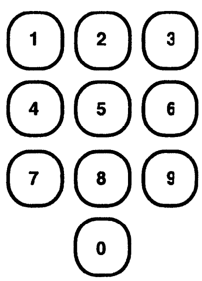


The Change key sequentially displays the options for each non-numeric input field. Except for the backlight control field, Change key inputs do not take effect until the Enter key is pressed.



The Enter key stores the new value entered via the numeric keys or the Change key. If the input is numeric, the Enter key terminates the input and posts it to the selected field. When the input is selected by the Change key, the Enter key causes the change to take effect. (Note: the exception to this rule is the backlight control field. Any changes in this field take effect immediately.) If the cursor is moved from a modified field without the Enter key being pressed, the field will revert to its previous, unmodified value.

When a field has been changed, but Enter has not yet been pressed, the field will flash. Once Enter is pressed, the field will steadily display the value.



The keys 0-9 are used to alter numeric fields. The numeric keys are active only when the unit is in an idle state. Numeric inputs do not take effect until the Enter key is pressed. The numeric keys are active only on the Sender or in the Set-up mode.

Display Operation - Set-up screen Fields

The following section describes the LCD display fields that are used for the programming set-up screen options of the PLCA-22 analyzer.

Function Mode Field

```
Setup Band:C  Lt:hi
Pkt size (bytes):12
CENELEC Protocol:off
Tx current limit:1A
```

The mode of the PLCA-22 analyzer can be changed from Set-Up to one of three function modes (Send/Recv/Phase) using the Function Mode Field.

Frequency Field

```
Setup Band:C  Lt:hi
Pkt size (bytes):12
CENELEC Protocol:off
Tx current limit:1A
```

The frequency field of the set-up screen can be selected to either C-band (132kHz as the primary frequency with 115kHz as the secondary frequency) or A-band (86kHz as the primary frequency with 75kHz as the secondary frequency). A-band or C-band operation can be selected from the set-up screen using the Move and Enter keys. Note that the selected band also is displayed on the main screen in a report-only field. This setting is stored in non-volatile memory.

Backlight Intensity Field

```
Setup Band:C  Lt:hi
Pkt size (bytes):12
CENELEC Protocol:off
Tx current limit:1A
```

The backlight intensity field indicates the brightness of the LCD display backlight. The field may be changed to off, low, med, or hi with the Change key (the Enter key is not required). This setting is stored in non-volatile memory.

Packet Size Field

```
Setup Band:C  Lt:hi
Pkt size (bytes):12
CENELEC Protocol:off
Tx current limit:1A
```

The packet size field controls the size of the packets being sent, in bytes. This field is modified with the numeric keys and the Enter key. Valid values are 12 through 76, inclusive. If more than two digits are entered, the oldest digits are discarded. If an illegal number is entered and the Enter key is pressed, the original, unmodified value is restored. This setting is stored in non-volatile memory.

The size of the packet (Packet Size) sent during a test is determined by the value in the Packet Size field on the Sender - not the Receiver. Since the Packet Size field must be manually set on each analyzer, care must be exercised to ensure that the Sender is programmed with the desired packet size.

CENELEC C-Band Access Protocol Field

```
Setup Band:C  Lt:hi
Pkt size (bytes):12
CENELEC Protocol:off
Tx current limit:1A
```

The CENELEC protocol field allows the user to either enable the CENELEC EN50065-1 defined access protocol (ON) or disable the protocol (OFF). A third option (ON8) enables the CENELEC protocol and allows transmission for 8 seconds each time a false band-in-use condition is detected. (A false band-in-use condition is defined as band-in-use being true for 1.1 seconds without any gap greater than 80ms.) Check the status of current CENELEC regulations to see if this mode is required for C-band use in your country. Changing this field on one analyzer automatically updates the other analyzer when the Set-up mode is exited or when the test is started.

When the access protocol is enabled and a test is started, the PLCA-22 analyzer will transmit packets until the 1 second time limit is reached, pause for 125ms, then resume transmission. The 1 second time limit is imposed even if a test packet is in the process of being transmitted. When this occurs the Neuron Chip in the PLCA-22 will re-transmit the truncated packet after the 125ms pause. A truncated packet will often cause the Error Corrected LED to light on a receiver. The truncated packet will not be logged as a bad packet in the receiver's statistics.

The CENELEC access protocol only is required when operating in the C-band in CENELEC compliant countries. The CENELEC access protocol is not required when operating in the A-band in CENELEC compliant countries. It is recommended that the CENELEC protocol be disabled for other uses.

Tx Current Limit Field

```
Setup Band:C    Lt:hi
Pkt size (bytes):12
CENELEC Protocol:off
Tx current limit:1A
```

The Tx current limit field sets the maximum transmit current to either 1 or 2 Amperes peak-to-peak. The 1A setting should be used to assess expected performance with a PLT-22 transceiver. The 2A option allows the user to assess the potential benefits of using a higher current limit as provided with a PLA-21 booster amplifier. The corresponding open circuit voltage is set using the TxVpp field on the main screen. The Tx current limit must be set individually on each analyzer and is not automatically synchronized at the start of a test; this allows the user to emulate performance of a node pair with different current limits. This setting is stored in non-volatile memory.

Display Operation - Main Screen Fields

Function Mode Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V
Sent:mmmmm Attn:0dB
Lost:rrrrr Err:ee.e%
```

The operation of the PLCA-22 analyzer can be changed to one of four modes using the Function Mode field: Send (Sender mode), Recv (Receiver mode), Phase (Phase Detector mode, see Chapter 4), or Setup. This field can be modified using the Change and Enter keys. This setting is stored in non-volatile memory.

Communication Service Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V
Sent:mmmmm Attn:0dB
Lost:rrrrr Err:ee.e%
```

The communication service field provides options for testing to be done in any one of three communication service modes. When set for "Ackd4try" the analyzer uses acknowledged service and up to 4 tries (3 retries) for each test message. In this mode the primary frequency is used for the first and second attempts. The secondary frequency is then used if a third or fourth try is required. The Ackd4try mode should be used to evaluate the message error rate PLT-22 based nodes would have when their retry count is set as recommended to three.

When "UnackPri" is selected, each test message is sent only one time (i.e., with no retries) at the primary operating frequency. This mode allows the performance of "first try" packets to be tested with the benefits of the LonTalk protocol effectively turned off.

When "UnackSec" is selected, each test message is sent only one time at the secondary operating frequency. This allows performance of the "later try" packets to be tested independent of the LonTalk protocol.

Frequency Band Field

S	e	n	d		A	c	k	d	4	t	r	y		C	-	b	a	n	d
P	k	t	s	:	*p*	*p*	*p*	*p*	k		T	x	V	p	p	:	7	V	
S	e	n	t	:	*m*	*m*	*m*	*m*	*m*		A	t	t	n	:	0	d	B	
L	o	s	t	:	*r*	*r*	*r*	*r*	*r*		E	r	r	:	*e*	*e*	.	*e*	%

The frequency band field on this screen is a display only field. The primary frequency band of the analyzer is set from the set-up screen as described earlier. When the unit is in a paused state the band designation is replaced by the word “Paused”.

Transmit Packet Fields

S	e	n	d		A	c	k	d	4	t	r	y		C	-	b	a	n	d
P	k	t	s	:	*p*	*p*	*p*	*p*	k		T	x	V	p	p	:	7	V	
S	e	n	t	:	*m*	*m*	*m*	*m*	*m*		A	t	t	n	:	0	d	B	
L	o	s	t	:	*r*	*r*	*r*	*r*	*r*		E	r	r	:	*e*	*e*	.	*e*	%

The transmit packet fields indicate the number of test packets that will be sent during a test (not including acknowledgements in acknowledged service mode). The two fields include a packet number and a multiplier (packet number x 1 or x 1000 ‘k’) which together determine the total number of packets that will be sent during a test.

The transmit packet fields appear only on the Sender and may be modified only when the unit is in the idle state. The fields can be modified by moving the cursor using the Move key, entering a number from 1 to 9999 (or pressing the Change key for the multiplier field), and pressing the Enter key. Entering zero is not permitted, and results in the original number being restored. If more than four digits are entered, the most recently added digits are used and the other digits are discarded. This operation permits the user to correct typing errors by simply re-entering the four digits. This setting is stored in non-volatile memory. At a rate of twelve 12-byte packets per second, 9,999,000 packets (the maximum number) is equal to approximately 230 hours (about 10 days) of continuous test time.

Transmit Voltage Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V 
Sent:mmmmm Attn:0dB 
Lost:rrrrr Err:ee.e%
```

The transmit voltage field sets the output voltage level of the Sender to either 1.7V, 3.5V, 7V, or 10Vp-p. This feature allows the user to assess the performance trade-off among different transceiver and booster amplifier options (see Chapter 5 for details). The TxVpp field appears on both the Sender and Receiver and may be modified only when the unit is in the idle state. At the start of a test, the setting of the TxVpp field on the analyzer from which the test was started is forwarded to the remote unit, which synchronizes its TxVpp field. This setting is stored in non-volatile memory.

Packet Count Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V 
Sent:mmmmm Attn:0dB 
Lost:rrrrr Err:ee.e%
```

The packets field indicates the number of packets that have been sent. This is a report field only, and cannot be modified. It will automatically reset to zero when a new transmission is started, (i.e., when the **Start** button is pressed) or when the PLCA-22 analyzer is powered up. When the number of packets sent exceeds 99,999, the number of thousands of packets sent is displayed with "k" multiplier to the right of the number.

Analyzer Status Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V 
Sent:mmmmm Attn:0dB 
Lost:rrrrr Err:ee.e%
```

The analyzer status indicator field is a report-only field showing the current test status of the analyzer. Possible indications include a solid colon (:), a flashing send arrow (->), a flashing receive arrow (<-), alternating send and receive arrows (->/<-) and a flashing question mark (?). A solid colon in this field indicates that the analyzer is in idle mode (neither sending nor receiving any packets) or paused.

The send arrow (->) indicates that the analyzer is sending test packets in either UnackPri or UnackSec modes. The receive arrow (<-) indicates that the analyzer is receiving unacknowledged primary or secondary frequency packets. The alternating send/receive arrows (->/<-) signify two way communication associated with acknowledged service messaging. If a break in communication occurs while a test is in progress, a flashing question mark (?) will be displayed.

Transmit Attenuation Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V
Sent:mmmmm Attn:0dB
Lost:rrrrr Err:ee.e%
```

The reason for attenuating the transmitted signal level is to determine the operating margin of a power mains communications path (see *Margin Testing* in Chapter 5 for additional details). Attenuation values of 0, 6, 12, 18, or 24 dB can be selected. Only test packets are attenuated: control messages are not attenuated.

Both PLCA-22 analyzers normally display the current transmit attenuation setting. This function allows the user to look at the display of the Receiver and know how much the transmitted signal had been attenuated. During a test (active or paused), the cursor remains in the transmit attenuation field. The transmit attenuation can be changed from either a Sender or a Receiver at any time during the test by using the Change/Enter keys. When the Enter key is pressed, the new attenuation value is sent from the local Sender to the remote Receiver, (or vice versa if changed from the Receiver) and the test resumes with the new attenuation. Functionally, the operation is similar to pressing the Pause key twice, changing the transmit attenuation between the two Pause key events. Upon powering the unit, this field is reset to 0dB.

Lost Packets Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V
Sent:mmmmm Attn:0dB
Lost:rrrrr Err:ee.e%
```

The lost packets field is a report of the number of packets lost during a test. This field is updated in real time if the analyzer is a Receiver; a Sender is updated when either the Pause key or the Stop key is pressed, or when the test ends after all of the packets have been sent.

Error Rate Field

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V
Sent:mmmmm Attn:0dB
Lost:rrrrr Err:ee.e%
```

The error rate field represents the calculated error rate. The equation for the error rate is:

$$Err\% = \frac{\text{Packets Lost x 100}}{\text{Packets Sent}}$$

This field is updated in real time on a Receiver; while on a Sender the field is updated when either the Pause key or the Stop key is pressed, or when the test ends after all of the packets have been sent. The percentage error rate is rounded to one decimal place. If the test was interrupted, e.g., by the Receiver losing power, --.- will be displayed.

PLCA-22 Analyzer Initialization

```
Send Ackd4try C-band
Pkts:ppppk TxVpp:7V
Sent:mmmmm Attn:0dB
COMMUNICATING
```

During their operation, the Sender and Receiver make use of control messages to communicate with each other to coordinate their activity. Communication between the analyzers can be monitored by observing the fourth line of the display, which will show one of five status messages: COMMUNICATING, PENDING, REMOTE READY, or NO REMOTE UNIT FOUND. Another message that can appear in special cases is ??.?, which replaces the numbers after the Err field on the fourth line of the display. If initialization is successful, then these messages will be replaced by the normal test statistics on the fourth line of the display. Each of these messages is discussed below.

Communicating

The word COMMUNICATING indicates that the local unit is trying to establish communication with the remote unit. When the communication attempt is successful, it is usually completed so quickly that the word COMMUNICATING will not be seen before it is overwritten by the message REMOTE READY. If the communication attempt is unsuccessful, the word COMMUNICATING will flash for up to twenty-five seconds before the local unit aborts initialization and displays NO REMOTE UNIT FOUND.

The following keypad actions cause the word COMMUNICATING to appear (briefly or continuously) on the fourth line of the LED display:

- Changing operating mode: Send, Recv, Phase, Setup;
- Pressing the Start key;
- Pressing the Pause key to temporarily halt a test;
- Pressing the Pause key to restart a test;
- Pressing the Stop key.

Remote Ready

The message REMOTE READY indicates that a communication attempt was successful. In most cases, this message is soon overwritten by test statistics. The PLCA-22 analyzer adds a pause in this case so that the message can be seen.

No Remote Unit Found

The message NO REMOTE UNIT FOUND indicates that a communication attempt failed. This could be because the network connection is too poor or because the remote analyzer is not connected.

??.? (Question Marks)

It is possible, though very unlikely, for a receiver to lose a packet because of an overflow in the PLCA-22 analyzer's application code rather than as a result of a network problem. Fortunately, the PLCA-22 analyzer is able to detect that this has happened, although it cannot determine how many packets were lost. Since the test results are indeterminate in this situation, both analyzers change the error percentage numbers after the Err field on the fourth line to ??.?. This change occurs immediately on the Receiver, and after the test has stopped or is paused on the Sender.

Error Handling

The sections that follow describe some of the more common events that cause errors to occur during testing, as well as how these errors are handled by the PLCA-22 analyzer.

Sender Interrupted

If during a test the Sender is unplugged, the Receiver will stop receiving packets. When this happens, the Receiver's display freezes with no incoming packets, and the arrows next to the "Rcvd" changes to display a flashing question mark. Press Stop to unfreeze the unit. After an unsuccessful attempt to communicate with the Sender, the Receiver will display NO REMOTE UNIT FOUND on the fourth line of its display and return to the idle state.

If the Sender loses power and is then re-powered, the Sender will have returned to the idle state instead of the active state, and the Receiver will still be frozen. When the Receiver's Stop button is pressed to unfreeze it, the receiver will communicate with the Sender and find that it is in the idle state. As a result of this, the Receiver will change the Err field to be --.-, to indicate that the test results are invalid.

Receiver Interrupted

If the Receiver loses power during a test, the Sender will continue to send packets over the network. If the Stop button is pressed at this point, the Sender will attempt to communicate with the Receiver and will fail. The message NO REMOTE UNIT FOUND will appear on the fourth line of the display, and the analyzer will return to an idle state.

If the remote Receiver's power is interrupted during a test, restoration of power will cause it to enter the idle state. When the Sender completes the test, or when the Stop button is pressed, the remote Receiver will respond that it is in the idle state. Both units will indicate this state by showing three hyphens (---) in the Sent/Rcvd field and three hyphens (--.-) in the Err field.

Attenuation Change During Test with no Remote Unit

If the Attn field is changed with no remote unit on-line, the test will be aborted and the local unit will return to the idle state. The message NO REMOTE UNIT FOUND will be displayed on the fourth line.

Interfering with Residual Current Device Protectors

When using the PLCA-22 analyzer with Line-to Earth coupling, care must be taken when transmitting on circuits protected by residual current devices (RCDs), also known as Ground Fault Interruptors (GFIs). Line-to-Earth communication currents can cause a ground fault detection. A single PLCA-22 analyzer will generate about 3mA of current, which is usually not enough current to trigger an RCD protector, however, two PLCA-22 analyzers almost always trigger a low current (4mA trip level) RCD protector. Therefore, no more than one PLCA-22 analyzer should be used on a circuit protected by a single RCD device.

Residual Coupling

The high sensitivity of the PLCA-22 analyzer can result in the reception of packets via the AC mains power cord due to parasitic coupling, even when the external coupling circuit is selected. For this reason, if external coupling is used while powering the PLCA-22 analyzer from the AC mains, care must be taken to ensure that there are no active power line transceivers on the mains circuit. If this is not possible, a commercially-available EMC filter should be used between the AC mains and the PLCA-22 analyzer.

4

Phase Detector Operation

This chapter describes how to use two PLCA-22 analyzers to determine the relative power phase between a pair of electrical circuits.

Multi-Phase Power Systems and Power Mains Communications

In commercial and residential AC mains electrical power networks it is very common to supply electricity via a distribution transformer whose secondary side is configured to provide two or three different, isolated, AC voltage outputs. Each of these outputs has the same nominal rms voltage value and each has a different phase. Each output of the distribution transformer produces a sinusoidal waveform that is offset in time by some percentage of a 50/60Hz period relative to the other phases. The time difference in the waveforms can be described as a phase angle between 0 and 360 degrees. Figure 3.1 shows the AC voltage waveforms of a three phase power system.

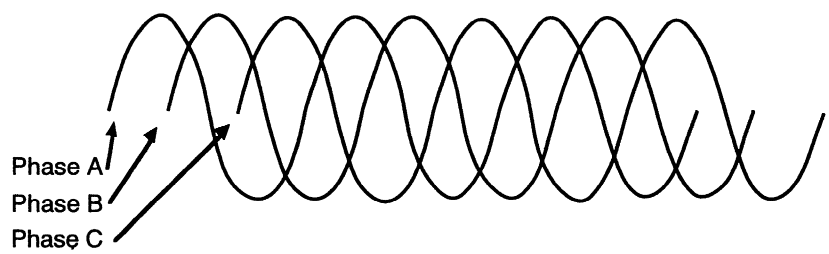


Figure 4.1 Three-Phase Power System Voltage Wave Forms

In the example above, the three phases are offset in time in 120 degree increments. This is typical for a three phase power distribution system. Some distribution systems, such as those used for North American residences, distribute two hot lines which are 180 degrees out of phase with each other. For our present purposes we will refer to such systems as “two phase” systems.

In the case of the three phase system, any particular phase can be said to either lead or lag the other two phases by 120 degrees. Put another way, if one could measure the relative phase angle of two phases they would be either 0 degrees (same phase), +120 degrees, or -120 degrees. In the case of a two phase system the choices are 0 degrees and 180 degrees. One further permutation exists when accidental wiring polarity inversions are present. For three phase systems a wiring error can result in three more possible phases which can be described as phase inversions of the 0,-120, and +120 cases. For two phase and three phase systems, the inverted 0 degree case is equivalent to 180 degree relative phase.

The concern with power phases in power mains communication systems comes from the nature of the distribution transformers used to step down medium voltage AC power (typically distributed at around 4kV) to working voltages of 100-277VAC. For residential service, distribution transformers are usually shared among multiple homes or apartments. In commercial installations one or more distribution transformers frequently are dedicated to a particular building. In all of these cases, the distribution transformers have the effect of blocking power mains communication frequencies between primary and secondary sides of the transformer and attenuating communication signals between the multiple phase outputs of the transformer. This attenuation between phases is mitigated somewhat by the natural parasitic capacitive and inductive coupling that occurs between power phases due to wire proximity. However, the effective attenuation of a power mains signal as it crosses from one phase to another can be very significant. Attenuation caused by phase crossing can account for as much as one-third of the total attenuation of a power mains communication signal as it traverses a building.

The above discussion points out that in some power mains communication network installations it may be very useful to know the relative power phase between two locations within a building's mains wiring. The knowledge of relative phase can be used to either avoid the attenuation or to demonstrate the need for some kind of building conditioning which reduces the effective attenuation due to crossing phases. Refer to engineering bulletin 005-0056-1 or 005-0070-1 for detailed recommendations on mitigating the effects of signal loss from crossing phases. These bulletins are available from the Echelon web site at www.echelon.com.

Using the PLCA-22 Analyzer In Phase Detector Mode

The phase detector mode of the PLCA-22 analyzer provides a simple way to determine the relative phase of a 50/60Hz AC mains circuit operating at 100-240V. Operation of the Phase Detector function is limited to 100-240V 50/60Hz power mains when the PLCA-22 units are connected to the power mains via the IEC-320 line cord. The Phase Detector function is not available when operating the PLCA-22 analyzers via external coupling.

Two PLCA-22 analyzers are required to perform a phase test. After entering phase detector mode, one unit is configured as a Sender and is connected to a mains circuit which is chosen to be the reference phase. The second PLCA-22 analyzer is configured as a Receiver and connected to a mains circuit whose phase relative to the transmitter is to be measured. Both units will automatically determine if the line frequency is either 50Hz or 60Hz. The transmitter will immediately begin transmitting special packets that will indicate to the receiver the reference phase. The receiver compares its phase with that of the transmitter's phase over an averaging period of a few seconds, and then indicates whether the receiver's phase is 0 degrees, +120 degrees, -120 degrees, or 180 degrees (0 degrees inverted) relative to the reference. Should a wiring inversion be present in a three phase system, the receiver will indicate that this is the case. By moving the receive unit from outlet to outlet the user can create a map of which locations are connected to which phases.

Note that in a two-phase system such as a North American residence, in-phase locations will be reported as “0 degrees,” and 180 degree out-of-phase locations will be reported as “180 degrees.” In two phase systems a wiring inverson (Line and Neutral reversed) is reported as 180 degrees when both PLCA-22 analyzers are connected to the same phase.

Getting Started: Simple Step-by-Step Instructions

This section guides the user through a brief set of step-by-step instructions on the use of the PLCA-22 analyzers in phase detector mode. For a quick initial test both units should be connected to the same wall outlet. The first time that a PLCA-22 analyzer is powered, the display looks like this:

```
Recv Ackd4try C-band
Pkts       TxVpp:7V 
Rcvd:      Attn:0dB 
Lost:      Err:     
```

First verify that the Mode field is selected via the Move button as shown above. Press the Change button until the Phase mode appears then press the Enter button to enter the Phase Detector mode. The other unit will automatically change to Phase Detector mode as well. The two displays will now look something like this:

Receiver:

```
Phase detect  Lt:hi 
Direction:Receiver  
Frequency:60Hz      
Phase:0°            
```

Sender:

```
Phase detect  Lt:hi 
Direction:Sender    
Frequency:60Hz      
                    
```

The first line on both displays indicates that the PLCA-22 analyzers are in the Phase Detector mode. This is a selectable field that can be moved to with the Move key, then changed with the Change key to Send/Recv/Setup which takes effect when the Enter key is pressed.

A one hour time-out is built into the Sender which stops transmission if the analyzer is left unattended for more than an hour. Should the Receiver lose communication with the Sender, the words IN PROGRESS will appear on the fourth line of the display.

Both displays will indicate whether the mains line frequency is 50Hz or 60Hz.

Finally, the Receiver will indicate the phase difference between the Sender and the Receiver.

At this point the user can move the Receiver to different locations and test the phase relative to the Sender. Depending on the size of the facility being characterized, there may be locations at which the Receiver cannot "hear" the Sender. If this happens, the Sender can be moved to a location that has already been tested and where the phase is already known, provided that the location is "closer" to the Receiver. By using this "leap-frog" method, a facility of any size can be analyzed. This process works well for facilities where there is only one distribution transformer present. Should the facility be wired with multiple distribution transformers, it will usually be impossible to communicate between circuits connected to different distribution transformers.

5

PLCA-22 Analyzer Test Methodology

This chapter discusses techniques for using a pair of PLCA-22 analyzers for evaluating the physical layer performance of the PLT-22 transceiver.

Configuring PLCA-22 Analyzers Before Testing

The PLCA-22 analyzers can emulate many different PLT-21 and PLT-22 transceiver configurations and options, and therefore it is important that the analyzers be properly configured for the intended application prior to testing.

Applications that must employ the CENELEC EN50065-1 media access protocol require that the CENELEC Protocol field be turned on at both analyzers (see Chapter 3). In most instances the CENELEC access protocol is used only for applications in Europe. For all other applications the CENELEC Protocol field should be turned off to increase throughput. Note that both analyzers automatically synchronize the CENELEC access protocol status to the setting of the analyzer from which a test is started.

If PLA-21 booster amplifier emulation is needed then the Tx Current Limit field must be set to 2A to match the current limit of the booster amplifier. Otherwise the Tx Current Limit field should be set to 1A, which is the internal current limit on both the PLT-21 and PLT-22 transceivers. The Tx Current Limit must be set individually on each analyzer - this parameter is not automatically synchronized between the two analyzers at the start of a test.

The TxVpp field also requires configuration to ensure that the nominal value matches the selected transceiver configuration. Table 5.1 summarizes the TxVpp setting for typical applications. The TxVpp field of the analyzer from which the test is started determines the TxVpp to be used during the test: the TxVpp field is automatically synchronized between the two analyzers at the start of a test.

Table 5.1 TxVpp by Application

Device Type	***Coupling Type***	***Primary Communication Frequency***	***Maximum Transmit Voltage***	
			PLT-22	***PLT-22 with PLA-21 Booster Amplifier***
Residential FCC and Industry Canada	L-to-N	132kHz (C-band)	7V p-p	10V p-p
Commercial FCC and Industry Canada	L-to-E	132kHz (C-band)	7V p-p	10V p-p
All Japanese MPT	L-to-N	132kHz (C-band)	7V p-p	7V p-p
CENELEC C-band Class 116	L-to-N	132kHz (C-band)	3.5V p-p	3.5V p-p
CENELEC C-band Class 134	L-to-N	132kHz (C-band)	7V p-p	7V p-p
CENELEC A-band	L-to-N	86kHz (A-band)	7V p-p	7V p-p

Packet Error Rates

The most basic information provided by the PLCA-22 analyzer is the packet error rate of the signals transmitted on a given power mains. Two types of error rate measurements are supported by the PLCA-22 analyzer: Physical Layer Packet Error Rate (UnackPri/UnackSec) and Acknowledged Service Error Rate (Ackd4try). The physical layer test mode uses unacknowledged non-repeated service, wherein the PLCA-22 analyzers make no attempt to re-transmit packets that are lost or unreadable - they are simply counted as errors. The acknowledged service mode causes each message to be sent acknowledged with three retries. The first two attempts are made using the primary carrier frequency, while the last two tries use the secondary frequency. If the packet is not received after the fourth attempt, an error is registered.

It is recommended that most power mains testing be performed in the acknowledged service mode (Ack4try) since this mode will model more closely error rates seen in an actual application. Testing using UnackPri and UnackSec can then be used if a more detailed analysis is required.

Margin Testing

The PLCA-22 analyzers allow the user to quickly characterize a power mains communication environment. The characterization process can be broken into two parts: margin testing and impairment identification.

Before using the PLCA-22 analyzers, it is important to verify that no other LONWORKS power mains communication systems are being used on the power mains under test. The presence of such devices can be easily detected by observing the Packet Detect LED on a PLCA-22 analyzer when no packets are being transmitted. The Packet Detect LED will flash when a LONWORKS power mains packet is received.

Margin testing is performed by using the transmit attenuation feature of the PLCA-22 analyzer. Start by testing a communication path initially without transmit attenuation (Attn=0dB). Then, after establishing that the packet error rate is acceptable, increase the transmit attenuation from 0 to 6, 12, 18, and then 24dB until the packet error rate is no longer acceptable. Note that the Attn field can be changed during a test by pressing the Change key followed by the Enter key while the test is running. This feature is useful for quickly establishing communication margin when observing the packet error rate at the Receiver unit and incrementing the Attn field until the error rate jumps. The greater the attenuation level required to reach the error rate limit, the greater the operating margin.

Transmit attenuation testing combines signal attenuation testing and noise level testing into one simple, practical test. Note that power mains communication reliability is not symmetrical, so that the ability to communicate from Sender to Receiver is not indicative of the ability to reliably communicate from Receiver to Sender. For this reason it is important to perform margin testing in both directions.

A powered line should have at least 6dB of margin, preferably 12dB. For applications on unpowered wire pairs (twisted pair wire or unpowered telephone lines), 6dB of margin is usually adequate.

Impairment Identification & Test Methodology

After using margin testing to identify a problematic communication path, the next step is to identify the nature of the communication impairment. Unreliable communications on a power mains is generally the result of a combination of three electrical effects, any one of which may be the dominant factor impairing communication. These effects include *signal attenuation* due to transmission losses and loading of the power mains, *noise* as seen by the Receiver due to electrical equipment operating on the power mains, and *distortion* of the transmitted packet. The PLCA-22 analyzer has features designed to help determine which of these effects is most responsible for impaired communications. Once the nature of the impairment has been identified, proper corrective action can be taken.

The signal strength meter of the PLCA-22 analyzer is the primary tool used for identifying the nature of impairments. Two measurements are necessary for isolating the type of impairment: the signal level at the Receiver when packets are being transmitted, and the signal at the Receiver when no packets are being transmitted (also referred to as the noise level). The arithmetic difference between these numbers is the signal-to-noise ratio (S/N) at the Receiver. The S/N ratio is calculated as the signal level at the Receiver minus the noise level at the Receiver. For example, in an environment with a good communications margin, the signal level at the Receiver might be -24dB while the noise level at the Receiver might be -42dB, yielding a S/N of +18dB. Note that packet signal strength measurements are only valid for the type of packet being transmitted, even though there is some packet signal level indicated on both bar graph meters. Thus, UnackPri mode should be used to measure signal strength of primary frequency packets, and UnackSec must be used to measure secondary packet strength. The PLT-22 transceiver typically requires +6 to +9dB of S/N on either its primary or secondary frequency to operate reliably. In cases where an inadequate S/N is present, communication can usually be made reliable by either increasing the transmit signal level or decreasing the noise level or reducing the signal path attenuation by the use of conditioning devices.

The PLCA-22 analyzer allows the user to quickly verify the benefits of increased transmit signal level via the TxVpp field. For example the difference in communication performance between a PLT-22 transceiver with 3.5Vp-p output (pin 21 open) versus 7Vp-p output (pin 21 grounded) can be quickly tested using the TxVpp feature of the PLCA-22 analyzer.

Another method of effectively increasing the transmit signal level is to minimize the effects of signal injection loss by using a booster amplifier to provide higher drive capability than that of the PLT-22 transceiver. Excessive signal injection loss can occur when transmitting into very low impedance (<1Ω) loads. Signal injection loss can be easily measured by connecting two PLCA-22 analyzers at the same test location and starting a test. Note the signal strength on the Receiver. The signal strength on the Receiver is a direct measurement of the injection loss relative to 3.5V p-p.

In "typical" locations a loss of 3-6dB relative to the nominal TxVpp is normal. Thus for a TxVpp of 3.5Vp-p the injection loss relative to the 3.5Vp-p can be read directly from the Receiver's signal strength meter. For a TxVpp of 7Vp-p, 6dB should be subtracted from the signal strength meter reading to get the actual injection loss relative to 7Vp-p. For example if TxVpp is set to 7V and the Receiver is reading -12dB, the actual injection loss is -18dB (-12dB minus 6dB). Similarly if TxVpp is set for 10Vp-p, 9dB should be subtracted from the Receiver signal strength meter reading. If signal injection loss is significant then a PLA-21 booster amplifier may improve the communication margin. By changing the TxVpp to 10V and the Tx Current Limit field to 2A on the PLCA-22 analyzer located at the low impedance location, the benefits of using a PLA-21 booster amplifier can be quickly quantified. Note that the Tx Current Limit is not automatically synchronized between analyzers and must be set individually on each PLCA-22 analyzer using the Set-Up mode screen.

In some cases it may be appropriate to consider reducing the noise level at the Receiver. If there is a large observed noise level at the Receiver (-24dB to -6dB) when no packets are present, and the S/N is less than or equal to 12dB, then a noise source close to the Receiver is likely the dominant impairment. If the S/N is still good (>12dB) on one of the two communication frequencies, then a pair of PLT-22 based nodes can overcome the noise by automatically selecting the best communication frequency. (Note that this dynamic frequency selection feature requires the use of new PL-20 standard transceiver parameters in the Neuron Chip of the node. A PLT-22 based node loaded with older PL-20 standard transceiver parameters will only transmit at the primary frequency and never at the secondary frequency. Refer to Chapter 3 of the PLT-22 User's Guide for more details). If it is necessary to lower the noise, then a suitable filter may need to be added between the noise source and power mains.

In rare cases communication may be impaired when a S/N greater than 12dB is observed at the Receiver. The existence of a high signal-to-noise ratio in conjunction with impaired communications is indicative of packet distortion caused by a power mains transmission anomaly. If this does occur, it will typically only impair communication at the primary operating frequency. Communication at the secondary operating frequency is generally immune to this type of distortion due to the exceptionally robust signal processing and error correction provided at that frequency. If it is ever necessary to reduce the effects of distortion this can be accomplished by adding a suitable filter between the source of the distortion and the power mains.

It is best to conduct PLCA-22 analyzer testing in a methodical manner, ensuring that test results are properly documented. Table 5.2 presents a format for recording test results. You may photocopy this table and use it to record your test results.

Table 5.2 PLCA-22 Analyzer Test Report Form

Tested by:	**Frequency Band**	**TxVpp**	**Tx Current**	**CENELEC protocol**	**Packet Size**
		1.7V			
	C-Band	3.5V	1A	Off	
Date:	A-band	7V	2A	On	
		10V			

Send Location	**Receive Location**	**TXATT**	**Ackd4try**	**Pri Noise @ RX**	**UnackPri**		**Sec Noise @ RX**	**UnackSec**		**Phase Check**	**Injection Loss @ TX**
			%Err		**Signal @ RX**	**%Err**		**Signal @ RX**	**%Err**		
		0dB									
		6dB									
		12dB									
		18dB									
		24dB									
		0dB									
		6dB									
Reverse direction from above		12dB									
		18dB									
		24dB									
		0dB									
		6dB									
		12dB									
		18dB									
		24dB									
		0dB									
		6dB									
Reverse direction from above		12dB									
		18dB									
		24dB									

Corrective Actions

This section describes some of the system solutions that may improve the reliability of communications on a power mains known to have an impairment described in the previous section.

Signal Attenuation as the Dominant Impairment

If signal attenuation has been identified as the dominant impairment it may be due to one of the following factors:

- **Signal injection loss when transmitting into a very low impedance location.** The PLT-22 transceiver is optimized to efficiently inject communication signals into power mains impedances in the range of 2 to 50Ω. This range of impedances covers the vast majority of AC mains outlets found in commercial buildings and homes. However, locations such as power distribution breaker panels may have impedances as low as 0.25Ω due to the multiplicity of parallel circuits, each with impedances in the 5 to 50Ω range, that converge at these locations. In these situations injection losses of 12-18 dB are not uncommon.

  Solution: Using a PLA-21 booster amplifier with a 10Vp-p output and 2A current limit to buffer the PLT-22 transceiver at these locations will recover a significant percentage of the injection loss as compared to an unbuffered PLT-22 transceiver. In most cases, the booster amplifier will be necessary at a relatively small number of low impedance locations. The effectiveness of a booster amplifier can be easily determined using the PLCA-22 analyzers.

- **Signal loss due to very long transmission paths.** In larger commercial installations there may be locations that are too far away from each other for reliable communications with a given transmit signal level. In these cases the communication signal is impeded due to wire line loss and signal loading loss which results in insufficient S/N for reliable communications.

  Solution: Increasing the transmit signal level by changing from 3.5Vpp to 7Vpp by grounding the TXLVL pin of the PLT-22 (pin 21) may provide sufficient additional S/N for reliable communication (provided this level is permitted in the country of use). The next option is to use a PLA-21 booster amplifier with a 10Vp-p output and a 2A current limit to buffer the PLT-22 transceiver at these locations and thereby maximize the possible transmission distance. The effectiveness of these options can be easily determined using the PLCA-22 analyzers.

- **Communications are blocked by a distribution transformers or signals are highly attenuated as a result of crossing from one power phase to another.**

  Solution: See Echelon's engineering bulletin *Centralized Commercial Building Applications with the LonWorks ® PLT-21 Power Line Transceiver* (part no. 005-0070-01) for recommended system solutions. The recommendations contained in this document apply to both the PLT-21 and PLT-22 transceivers. This document is available from Echelon's website at www.echelon.com.

- **Attempting to communicate *through* an EMC filter.** Many power strips have built-in filters that can block communications with devices that are not on the same power strip.

  Solution: Remove the EMC filter or connect the PLCA-22 analyzer on the other side of the filter.

Noise as the Dominant Impairment

If noise has been identified as the dominant impairment it may be due to one of the following conditions:

- **Presence of another power mains communication system on the power mains.**

  Solution: Most power mains communications systems interfere with one another during transmission. Two incompatible systems transmitting at the same time will most likely prevent reliable communications by either system. This will not be the case if both power mains communication systems enforce the CENELEC access protocol or are designed to operate simultaneously.

- **Presence of an unusual noise source.** Echelon's power line communication technology is robust with respect to common power mains noise sources, but some equipment generates sufficient noise to impair communications when connected to the power mains.

  Solution: Find the offending noise source using the PLCA-22 analyzer signal strength meter and insert a commercially available noise isolation filter between the noise source and the power mains. The selected filter must not present a low impedance to the communication side or excessive signal attenuation may be introduced. Leviton Manufacturing makes a number of suitable filters such as the plug-in model #6288. A suitable filter can also be built using the circuit at figure 5.9 from the PLT-22 user's guide (except eliminating the series 3.3 Ohm resistor).

Signal Distortion as the Dominant Impairment

If signal distortion has been identified as the dominant impairment it may be due to the following condition:

- **Extreme, time-varying frequency resonances on the power mains producing large amounts of phase modulation.** This relatively rare condition is usually caused by a particular electronic device connected to the power mains near the Receiver.

  Solution: The same filters that are effective in blocking noise at the operating frequencies of the PLT-22 transceivers are very effective in isolating equipment that causes these unusual levels of distortion.

6

PLCA-22 Analyzer Maintenance

This chapter discusses the method for replacing fuses on the PLCA-22 analyzer, as well as typical preventive maintenance procedures.

Changing the AC Mains Fuses

The AC mains fuses are located on the IEC-320 connector on the rear of the PLCA-22 analyzer (figure 6.1). These fuses will blow if an internal fault causes the PLCA-22 analyzer to draw too much current. When these fuses have blown, the PLCA-22 analyzer will not operate from AC mains power, although it may still be able to function using 18VDC power via the front panel 18VDC input connector in conjunction with an external coupling circuit.

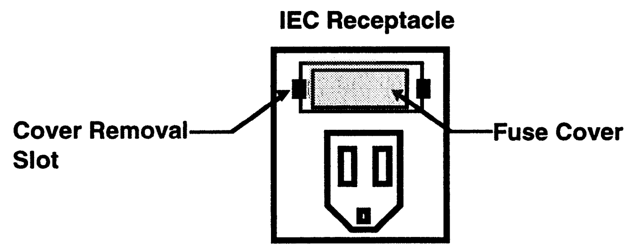


Figure 6.1 PLCA-22 Analyzer AC Mains Fuses on the IEC Connector

To replace the fuses, first disconnect the AC mains power cord from the IEC-320 connector. Also disconnect the 18VDC external power source (if used) from the front panel 18VDC Input connector. Use two small screwdrivers to pry the fuse cover off the IEC connector, ensuring that the screwdrivers are inserted in the cover removal slots. After removing the cover, replace the two AC mains fuses with identical fuses, Buss GDC 13•15AL250V (5X20mm 3.15A time delay), or equivalent. Replace the cover and press it into the fuse holder until a click is heard and the assembly is locked in place.

Changing the 18VDC Fuse

The 18VDC fuse is located on the front panel of the PLCA-22 analyzer (figure 6.2). This fuse will blow if an internal fault causes the PLCA-22 analyzer to draw too much current from the 18VDC supply. If this fuse has blown, the PLCA-22 analyzer will not operate from 18VDC power.

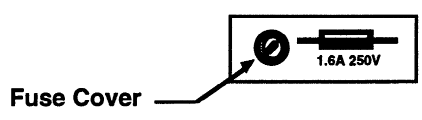


Figure 6.2 PLCA-22 Analyzer 18VDC Fuse on the Front Panel

To replace the fuse, first disconnect the AC mains power cord (if used) from the IEC-320 connector. Also disconnect the 18VDC external power source from the front panel 18VDC Input connector. Use a small screwdriver to push in and turn the 18VDC fuse cover counterclockwise 1/4 turn until the fuse holder can be removed.

After removing the cover, replace the DC fuse with an identical fuse, Buss GDB 1.6A, 250V, fast -blow, or equal. Then replace the cover and, pressing down lightly on the screwdriver, gently rotate the fuse cover clockwise until it stops.

Cleaning the Unit

The front panel and exterior case of the PLCA-22 analyzer is made of durable plastic materials that will provide years of use without discoloring or breaking. However, it may be necessary to clean the front panel from time to time depending on the frequency of usage. Before cleaning the unit, disconnect both AC and 18VDC power from the unit. Use a lightly moistened, clean soft towel and gently wipe the front panel and outer case. Be certain not to apply pressure when cleaning the LCD display window or the window may be stretched or broken. After cleaning, gently dry the unit with a clean, dry soft towel.

Appendix A

External Coupling Circuits

The PLCA-22 analyzer includes switchable coupling circuits that can be used for Line-to-Neutral (L-to-N) or Line-to-Earth (L-to-E) coupling to 100 - 240 VAC, 50/60Hz power mains. The PLCA-22 analyzers can communicate over virtually any other AC or DC power mains - even over unpowered wire - by using a suitable external coupling circuit.

External Coupling Circuit Operation

Use these steps to connect the PLCA-22 analyzer external coupling BNC connector to an external coupling circuit if any of the following circumstances apply:

- AC power line voltage is less than 100VAC or greater than 240VAC;
- AC power line frequency is less than 50Hz or greater than 60Hz;
- DC power line at any voltage;
- Communications medium is an unpowered copper wire pair such as twisted wire or an unconditioned telephone circuit.

The steps in using an external coupling circuit are as follows:

1 Turn off power to the PLCA units.

2 Set the Coupling Select switch to the external position.

3 Connect the communications medium to the PLCA-22 analyzer's external coupling BNC connector using Echelon's 78200-Series Power Line Couplers or a user-supplied coupling circuit. A detailed description of the coupling circuit design is contained in the *LONWORKS PLT-21 Power Line Transceiver Module User's Guide* (the coupling circuits are identical for both the PLT-21 and PLT-22 transceivers) and *PLT-22 Power Line Transceiver Module User's Guide*. For reference, figure A.1 below shows the circuitry internal to the PLCA-22 analyzer that is connected to the external coupling BNC.

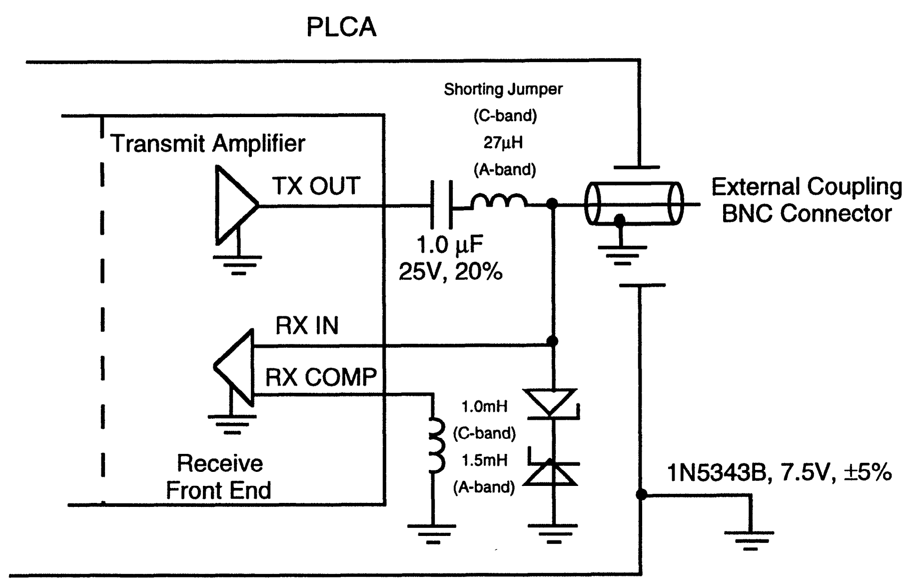


Figure A.1 PLCA -22 Analyzer External Coupling Functional Schematic

4 Connect power to the analyzer using either the IEC-320 line cord or the +18VDC input jack.

Appendix B

Specifications

This appendix provides the specifications for the PLCA-22 analyzer.

Technical Specifications

Microprocessor	Neuron 3150 Chip
Packet Size	Adjustable via keypad, 12-76 bytes (including CRC)
Power Supply Type	Internal 100-120/240 VAC switching supply or external DC power supply, fused
External DC Power Supply (supply not included)	18VDC @ 1A
Power Supply Consumption	9W maximum transmit, 3W typical receive
External Power Supply Input	Miniature jack, 2.1mm x 5.5mm plug (Shogyo SPY 1812 or equal)
Headphone/Oscilloscope Output	Standard 1/4" (6.4mm) jack
Coupling Type	Internal or external, switch selectable. Line-to-Earth mode and Line-to-Neutral mode, switch selectable
Electrostatic Discharge to Network Connector or Case	No hard failures to 20,000V
Regulatory Compliance	Complies with FCC power line carrier requirements for conducted emissions, and FCC/VDE Level B for radiated emissions. Complies with both CE Mark requirements and CENELEC EN50065-1 specifications for low-voltage signaling.
Safety Certified	UL 3111-1, c-UL to CSA C22.2 No. 1010.1, TÜV EN-61010-1
Transceiver Bit Rate	5.5kbps (C-band mode) 3.6kbps (A-band mode)
Transmission Technique	BPSK 110kHz-140kHz (C-band mode) BPSK 70kHz-95kHz (A-band mode)
Nominal Line Input Voltages	100-120/240VAC
Line Input Voltage Tolerance	+6, –10%
Output Voltage	1.7V to 10Vp-p
Power Line Connector	IEC-320 compatible line cord
Operating Altitude	4572m (15,000 feet) Max.
Non-operating Altitude	7620m (25,000 feet) Max.
Installation categories (over voltage categories)	II
Pollution Degree	2
Operating Temperature	0 to +40°C
Non-operating Temperature	–20 to +65°C
Operating Humidity (non-condensing)	25 to 90% RH @ +40°C
Non-operating Humidity (non-condensing)	90% RH @ +60°C
Dimensions	184 mm x 237 mm x 102mm (7.2" x 9.3" x 4.0") excluding case handle

ECHELON

DECLARATION OF CONFORMITY

Power Line Communications Analyzer PLCA-22

Application of Council Directive:	89/23/EEC, 89/337/EEC
Manufacturer's Name:	Echelon Corporation
Manufacturer's Address:	4015 Miranda Avenue Palo Alto, CA 94304 USA
Manufacturer's Address: in Europe	Echelon BV Printerweg 3 3821 AP Amersfoort The Netherlands
Product Model Number:	58022
Type of Equipment:	Test and Measurement Equipment
Standards to which: Conformity is Declared	EN 61010:1992; EN 55022:1994/A1 EN 61000-4-2 EN 61000-4-3 EN 61000-4-5 EN 61000-4-8 EN 50065-1/A1 EN 50082-1:1997 ENV 50204 EN 61000-4-4 EN 61000-4-6 EN 61000-4-11

I, Paul Smith, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Place: Amersfoort, The Netherlands Date: Position: Controller, Echelon BV