LynX-TOOLS^{tm} Users Manual
Version 1.01

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GETTING STARTED
Overview of LynX-TOOLS^{tm}

The LynX-TOOLS^{tm} suite was designed to aid in the installation of X-10 based current carrier systems as well as help developers' design and debug equipment that use X-10 technology. The tools are composed of hardware, a LynX-10^{tm} PLC, and software that monitors the X-10 signals transmitted over the power line. The signals received by the LynX-10^{tm} PLC are passed to a software package called LynX-VIEW^{tm}, which analyzes the information and displays the results to the user.

X-10 Theory of Operation

Power line carrier technology has been around for quite some time. British Sound Reproduction (BSR) commercialized the technology for the residential consumer in the early 1970s and named it X-10 (after the project numbering system used by the company – X8, X9, X10, etc). BSR sold the patent rights to X-10 USA, which still exists today (selling more than just X-10 equipment).

X-10 uses a 120 KHz sine wave carrier that is pulse position modulated using the power line 50 or 60 Hz sine wave zero crossing for synchronization. In other words, X-10 uses a radio signal that is below the AM band. The lowest frequency of the AM band ends around 450 KHz (kilohertz). This radio transmission is located specifically near the point at which the line voltage (110VAC in North America) is zero or where the current reverses direction. This is the most electrically quiet point in time on the power line. Dimmers and other power systems use this point as a method of control. Another and quite important reason to use this location is to provide a common reference for all devices to listen for the signal.

The 120KHz carrier is transmitted in bursts that are 1 millisecond (mS) long immediately following this zero crossing (rising and falling). The bits are formed using Manchester encoding to help with error detection and to indicate a start of frame. Manchester encoding uses two bits to represent one. That is a '01' is considered at '0' bit and a '10' sequence is a '1' bit. So in each single 60 Hz cycle, 2 bits or one symbol is transmitted bringing the effective bit rate to 60 bits per second. X-10 transmissions are not very fast, but adequate for controlling lights or other equipment. Violating the Manchester encoding denotes the start of a frame. This is done with the code '1110', which tells any listening X-10 device that a valid frame is about to begin. The data portion of the packet is made up of 9 symbols (encoded bits). A house code is denoted by the first 4 symbols and the address or command is formed by the remaining 5 symbols. The data is repeated twice to provide error correction and an EOF (end of frame) marker is made up of 6 consecutive zero crossing with no signal present.

The entire packet requires 23 symbols (2 used to form the start of frame marker, 18 data symbols, and 3 for the EOF marker). This accounts for almost 1/3 of a second for a single command! One symbol out of the command code is used to denote that the command field holds an address. This leaves four symbols for the address allowing 16 total. Combining the 4 bits of the house code provides a total of 256 unit addresses per

installation. BSR probably never envisioned a home with more than 16 devices, thus the idea of a house code.

For more information on X-10 theory, check the Marrick Limited web site at http://www.marrickltd.com/, which contains a more technical definition.

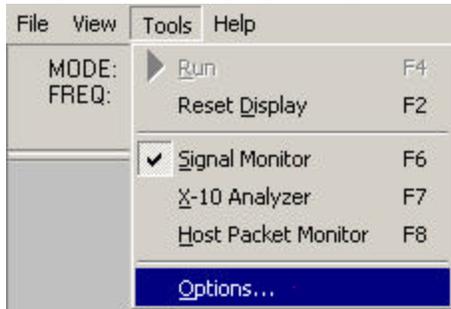## USING THE SOFTWARE
Installation
The software included in the LynX-TOOLS^{tm} package is called LynX-VIEW^{tm} and controls the LynX-10^{tm} PLC power line interface in such as way that allows the user to collect diagnostic data. The software was designed for all 32 bit versions of Windows which include Windows 98, ME, NT, 2000, and XP.

To install the software, place the LynX-VIEW^{tm} CD into the CD ROM drive. The installation software should automatically start. Follow the instructions presented on the screen and install the software into the appropriate directory. If the installation does not start automatically, open an explorer window for the CD ROM drive and double click on the **setup.exe** file. The installation should start at this point. Follow the menus to install the software where you want it. After installation is complete, the next step is to unlock the software with the key code provided.

Unlocking and Configuring the Software

The LynX-VIEW^{tm} software is copy protected by locking an encryption key to the serial number of the LynX-10^{tm} PLC unit shipped along with it. *The software will not function with any other unit until a new key is issued for the new unit's serial number.* To unlock your software, first select the OPTIONS menu item from the main menu as shown in figure 1. The OPTIONS dialog will appear as shown in figure 2. Next, enter the key (letters, numbers, and dashes exactly as shown in your key) into the ACCESS KEY edit box. Next, select the Communications tab and select your method of communication and appropriate port. Next hit OK and allow the software to communicate with the Marrick power line interface to retrieve the serial number. Once the software validates the key against the power line device, the software will unlock the RUN function allowing the software to function normally. You are now ready to use the LynX-VIEW^{tm} software to diagnose or monitor your X-10 network.

FIGURE 1 – OPTIONS MENU ITEM

LynX-VIEW^{tm} has many user configurable options. Just about every aspect of the user interface can be modified to suite the user's taste including object color and fonts. Figure 2 shows the GENERAL OPTIONS tab of the OPTIONS dialog box. This is the

FIGURE 2 – GENERAL OPTIONS
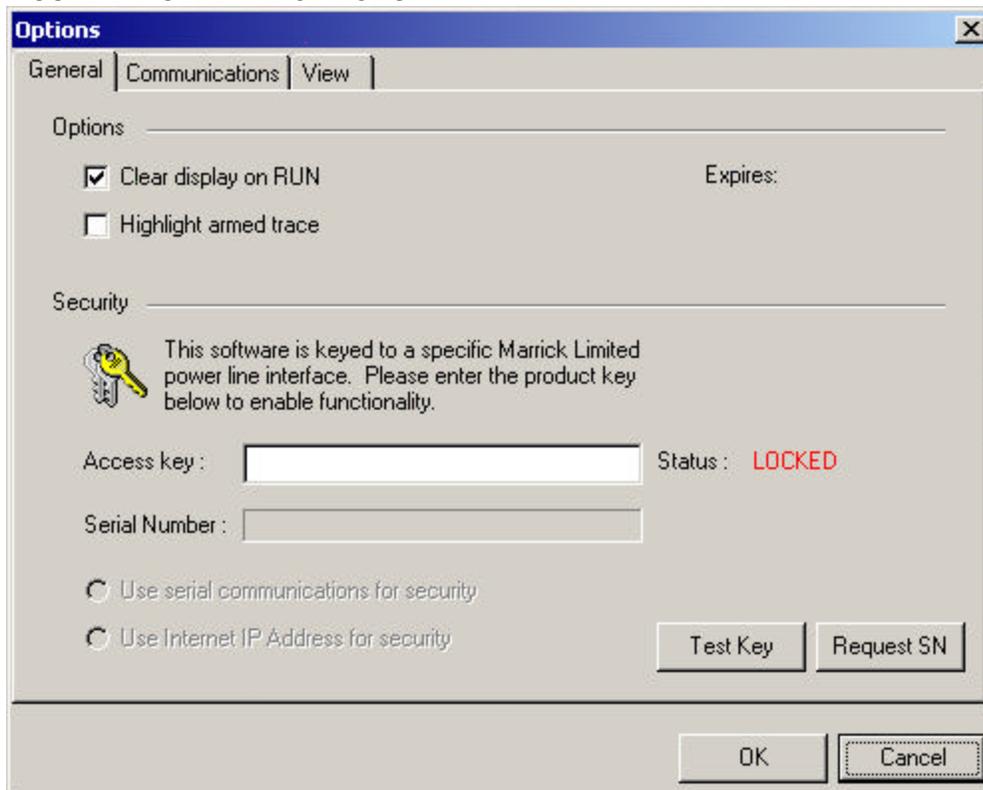
software security section as well as the main global options tab. The two global options here are CLEAR DISPLAY ON RUN and HIGHLIGHT ARMED TRACES. The CLEAR DISPLAY ON RUN option will automatically reset the display whenever the RUN button (or RUN menu item) is clicked. This will erase any information that is currently in the display window. If this option is not selected, then RUN will not affect the initial display and simply add to whatever is there.   The HIGHLIGHT ARMED TRACES option provides an indicator in the X-10 Packet Analyzer mode of which trace is next to be used. This can aid in watching the display for changes.

Software Communications
The communications options tab allows the user to configure how the software communicates with the Marrick power line interface. The two main options are serially through a COMx port, or via TCP/IP (IP address and port number). To configure a serial port, simply select SERIAL COMMUNICATIONS on the communications tab and, using the serial port drop down box, select a communications port. To configure the software to communicate via a network connection to a remote Marrick power line interface, select INTERNET PROTOCOL and type an IP Address and port number into their associated edit boxes. The IP address must be in the form **X.X.X.X** where X is a number between 0 and 255. The port number must be an integer between 0 and 65535 (a valid IP port number). When completed, click the CONNECT button to connect to the LynX-10[tm] PLC.

FIGURE 3 – COMMUNICATIONS OPTIONS
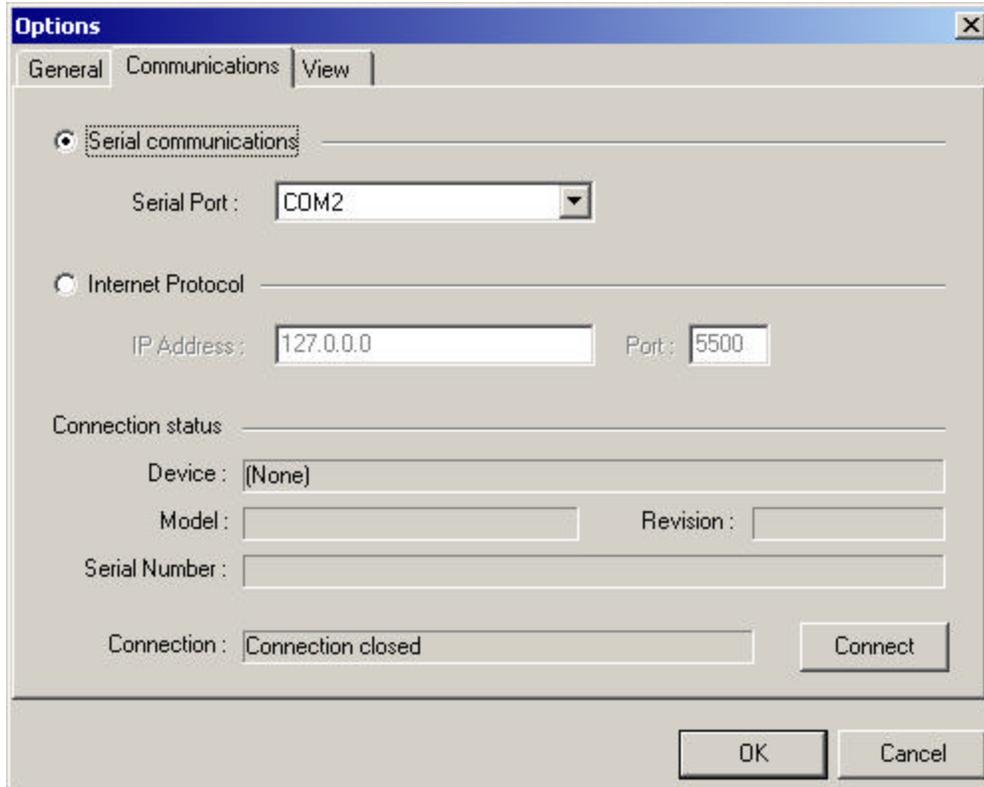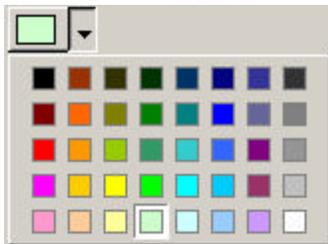
Changing the User Interface

The LynX-VIEW^{tm} software allows the user to change the way the information is displayed. Individuals may find a different group of colors and font easier to see or more readable. The VIEW tab of the options dialog provides the user with these controls. Figure 4 below shows this dialog box.

FIGURE 4 – VIEW OPTIONS
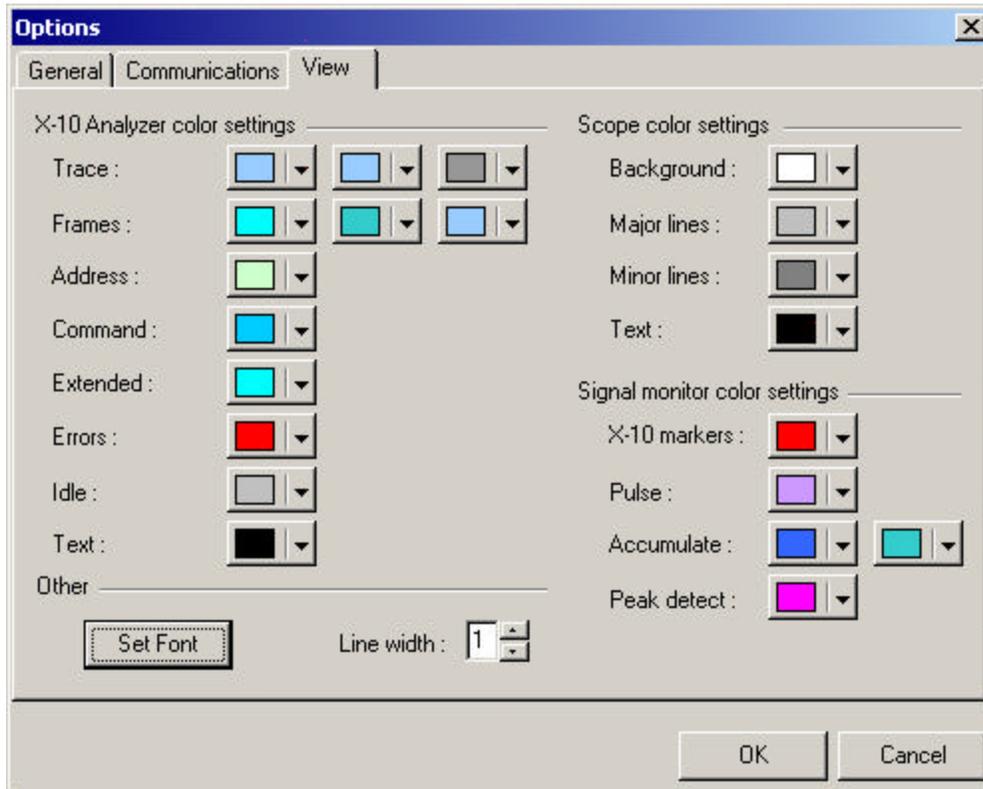
Certain objects displayed on the screen have multiple colors associated with them. To find out which color control associates with what object, simply place the cursor over the control for 1 second, and a pop-up help message will display the full meaning of the control. Each color control provides a drop down color palette to select from. Figure 5 shows a color picker control in the *selected* mode. Simply click on the desired color to change it. If you desire a color that is not on the palette, simply click the color box (left of down arrow) and a full color selector dialog will appear. You can then select a custom color for that object. *Note: these colors require a 24 bit color graphics mode to be displayed properly.*

FIGURE 5 – COLORS

Modes of Operation

The LynX-VIEW^{tm} software collects data directly from the power line when the LynX-10^{tm} PLC is in diagnostic mode. This data is presented in several ways depending on the settings. The idea is to look at various aspects of the power line transmission to determine if the all the criteria are being met for proper operation. The software provides three methods of looking at the data. Those are the signal analyzer, the packet analyzer, and the packet monitor. Each of these presents the data coming from the LynX-10^{tm} PLC in a different way.

The signal analyzer mode looks at the actual carrier signal and other signals that look like an X-10 carrier – also known as in-band noise. If the LynX-10^{tm} PLC can detect the signal (the minimum signal level is around 10mV for detection), it will display the position in time relative to the zero crossing of the power line. This is important - if noise (or non X-10 signals) appears outside the 1mS window that is used for X-10, the transmission will be unaffected. A normal noise monitor will tell you that you have a certain level noise or signal, but not where it is located in time.

The packet analyzer mode uses the actual bit positions detected by the LynX-10^{tm} PLC to reconstruct the coding monitored on the power line. This removes any error correction or decoding normally done by the LynX-10^{tm} PLC and represents the actual bits, right or wrong, seen by other X-10 equipment. This is important since many sources of noise are sporadic and only interfere with a small portion of the X-10 signal. Since the addresses and commands are all sent twice within a packet, an error due to a single incorrect bit will normally not affect the transmission. However, it may point to a problem that could cause worse issues at a later date. Another issue shown by this mode is incorrectly designed X-10 equipment that codes the signals improperly. This mode can pin point a piece of equipment that is not completely X-10 compliant which may cause a real mystery when trouble shooting. Developers of X-10 equipment can also use this mode to verify proper operation and compliance of their equipment during development.

The final option is the packet monitor mode. This mode uses the error correction and decoding of the LynX-10^{tm} PLC to display the actual X-10 commands seen on the power line. This is helpful when the first two modes have not identified an obvious problem. This can be caused by a programming error in a script, a rogue piece of equipment randomly sending commands, or a neighbor who might also be using X-10 equipment on the same addresses. This mode logs the reception of the X-10 address or command and allows the user to filter the packets to look for abnormal transmissions.

Diagnosing an X-10 Network

The next chapter discusses using the various modes to diagnose X-10 problems in a step-by-step process. The LynX-VIEW^{tm} software was designed to ease this process and flows easily from one mode to the next. The following sections define each type of problem and the method for detecting and correcting it. They are broken into an overview which is a synopsis of the section, a detailed description of the mode, and a "how to use" section which defines how each mode is used to correctly analyze the problem.

Mode 1 – Signal Analyzer

Overview: This is used to find signals that can interfere with X-10 traffic. It should be the first mode used when diagnosing troubled X-10 installations. Use this mode to find possible signals interfering with normal X-10 traffic.

Detail: This mode uses the LynX-10^{tm} PLC to monitor the power line for signals that fall within the X-10 transmission frequencies. This is done by sampling the power line many times each cycle and looking for receptions. The information gathered by the LynX-VIEW^{tm} software is then displayed in several methods, all of which show not only the presence of a signal, but the time it occurred within the cycle. As mentioned in the theory of operation, X-10 signals are transmitted immediately following the zero crossing of the power line current and last only 1 mS. If noise is present outside of that window, there will be no interference with normal X-10 signals.

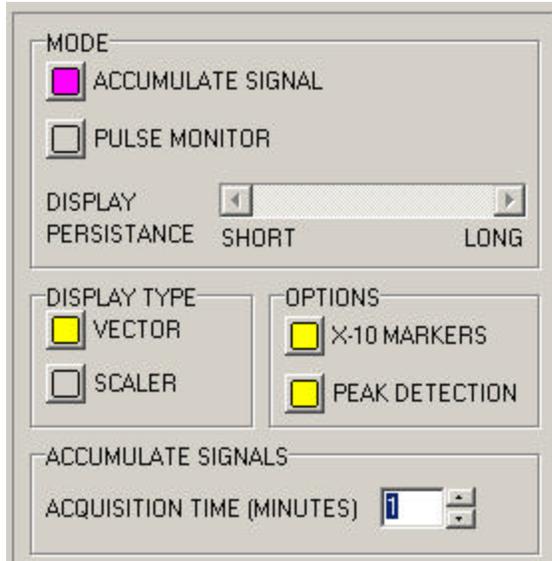FIGURE 6 – SIGNAL MONITOR CONTROLS

Figure 6 (left) shows the controls for the Signal Analyzer mode. There are two major modes of operation. First is the ACCUMULATE SIGNAL mode. This mode collects or "accumulates" these signals over a period of time set by the ACQUISITION TIME (in minutes). The second mode is the PULSE MONITOR mode, which monitors for sporadic signals on the power line. Both of these modes can display information in either a VECTOR or SCALER display. That is, the information can be displayed in a circular pattern that represents the rotation through 360 degrees of a single power cycle (which occurs 60 times a second), which is the vector mode, or relative to the beginning of a cycle plotted with time increasing to the right, which is the scalar mode. These modes can be used to detect the presence of signals that are either true X-10 signals or noise that falls within the X-10 detection band (120KHz +/- 10KHz). A set of lines called X-10 MARKERS can be turned on which will denote the X-10 transmission window. If any signal detected falls within that region, it will be considered an X-10 signal and operate or interfere with X-10 equipment. If the signal falls outside of the window, it will not interfere with X-10 traffic, however it may be

the symptom of a potential future problem and should be addressed for best X-10 reliability. When in accumulate mode, an option is available to monitor where in time the peak signals occur. That is, when signals are accumulated or summed as they are detected, there may be a point relative to the zero crossing of the power line that collects more energy. A defective dimmer, or any equipment that uses the zero crossing of the power line for operation may cause this to occur. The peak detect option may be useful in identifying the cause of the signals by providing additional information on the position of the signal relative to the zero crossing. One additional option is used in conjunction with the pulse monitor, which is a slider used to adjust the persistence of the display during detection.

How to use: Place the LynX-VIEW^{tm} software into the signal monitor mode by selecting the SIGNAL MONITOR button shown in figure 7. It will turn magenta in color when selected. The display will change to show either a circular or scalar graph, which is

FIGURE 7 – SIGNAL MONITOR
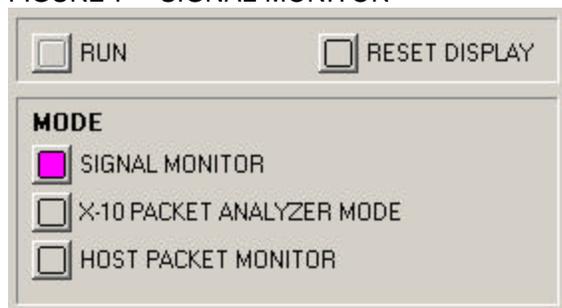
where the information will be displayed. Select whichever options are desired (as shown in figure 6) and click the RUN button shown in figure 7 (left). A large flashing "RUNNING" will appear in the upper right hand side of the display. If ACCUMULATE mode is selected, a timer will appear in the upper left corner to indicate how much time is left while signals are collected. Watch the display for out of the ordinary activity. In pulse mode, flashes of color will appear when signals are detected. If these signals fall within the X-10 detection window (1mS after the power zero crossing), it will be detected by or interfere with other X-10 equipment. If nothing is immediately found, try switching to the accumulate mode and using a 5 minute detection window. This will monitor for any activity and save it in a graph of it's position relative to the power line zero crossing. If there are any strange lobes forming in the display, noise or some other signal is present in the X-10 frequency range.
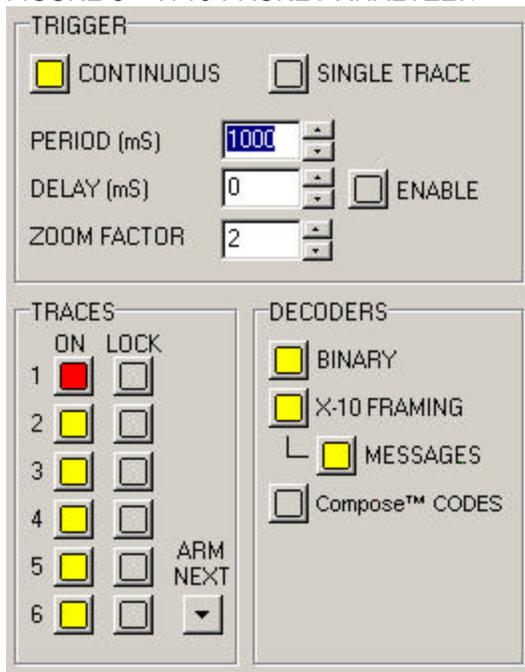
If these signals are detected, try finding the cause by eliminating suspects. That is, turn off breakers in the load center of the dwelling and monitor if the signals disappear. Once isolated, use the mode on the suspect circuit to narrow in on the cause. Various causes of noise or extraneous signals could be baby monitors (some use current carrier techniques like X-10), electrostatic precipitators used in high-end air handlers, solid-state ballasts used in modern florescent lighting and high efficiency light bulbs (**note: many new screw base florescent bulbs cause this problem**), defective dimmers, fan motor controls, or poorly operating motors.

Mode 2 – X-10 Packet Analyzer Mode

Overview: This mode is used look at signals received on the power line within the normal X-10 transmission window and to compile them into messages. These messages can then be analyzed by the software to determine if they are coded correctly.

Detail: This mode monitors for X-10 carrier signals in the 1 mS window immediately following the power line zero crossing (the X-10 window). Bits received in that window are then captured by the LynX-10^{tm} PLC and sent directly to the LynX-VIEW^{tm} software without any processing. The software then displays the results as well as provides various methods of analysis to determine the validity of the packet. This type of analysis is valuable for diagnosing tough X-10 problems where equipment may not be operating correctly. It is also useful to developers who are working on creating X-10 compliant equipment and want to ensure proper interoperation.

FIGURE 8 – X-10 PACKET ANALYZER

Figure 8 shows the control panel for this mode. There are two main operating methods. The first is CONTINUOUS mode and the second is SINGLE TRACE mode. Continuous mode will provide constant arming of the triggers. Every time a trace completes after being triggered the next available trace will be used on the next trigger and the system remains in the RUN mode. In single trace mode, only the currently armed and selected trace (indicated by the TRACE ON button turning red as shown above) will be used. After triggering, the system will drop out of RUN mode. Single trace mode is useful if you want to capture only a single packet. The TRACES portion of the control panel allows you to selectively view and arm various traces – up to 6. You can also LOCK a trace while viewing it by clicking the LOCK button to the right of the ON button. If locked, the trace will not be used while triggering. This is handy for comparing two traces – perhaps a known good packet and additional suspect packets. Once captured, the raw binary data can be analyzed by using several of the available DECODERS. The actual binary ones and zeros can be viewed to look for correct Manchester encoding. The X-10 packet framing can be analyzed to see if there are the correct number of framing bits surrounding the binary data and if those bits are correctly formed. The actual X-10 message can also be decoded and viewed to make sure there are no violations in the coding. This can be caused by poorly designed equipment, or incorrect commands coming from automation software. This is one of the most powerful features of the LynX-VIEW^{tm} software. Additionally, for users working with Lightolier Compose^{tm} Codes, Preset Dim codes can be automatically mapped to the correct Compose^{tm} Codes for visual analysis.

How to use: Place the LynX-VIEW^{tm} software into the X-10 Packet Analyzer Mode by selecting the X-10 PACKET ANALYZER MODE shown in figure 9. It will turn magenta in color when selected. The display area will change to show a time grid in milliseconds. This indicates how much time has passed since the event trigger has

FIGURE 9 – X-10 PACKET ANALYZER MODE
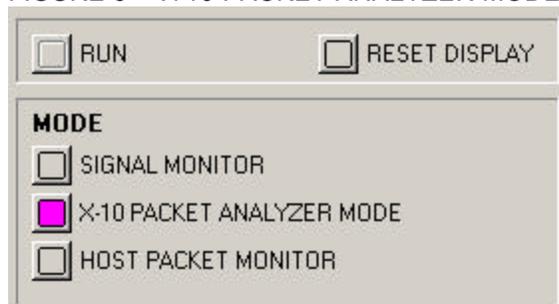
begun. A normal X-10 message will take about 300 mS to complete. There are usually two messages for a complete command – an address message and a command message. The total time will be around 600 mS or 2/3rd of a second (a fairly long time). Select whichever options are desired (as shown in figure 8) and click the RUN button shown in figure 9 (left). The large flashing "RUNNING" will appear again in the upper right hand side of the display. If CONTINUOUS mode is selected, the system will remain in run mode indefinitely. This will allow you to monitor traffic as it occurs and translate the packets with the selected decoders. If SINGLE TRACE mode is selected, the system will drop out of RUN mode after the first trigger is received. A trigger is caused by the detection of an X-10 signal within the X-10 window.
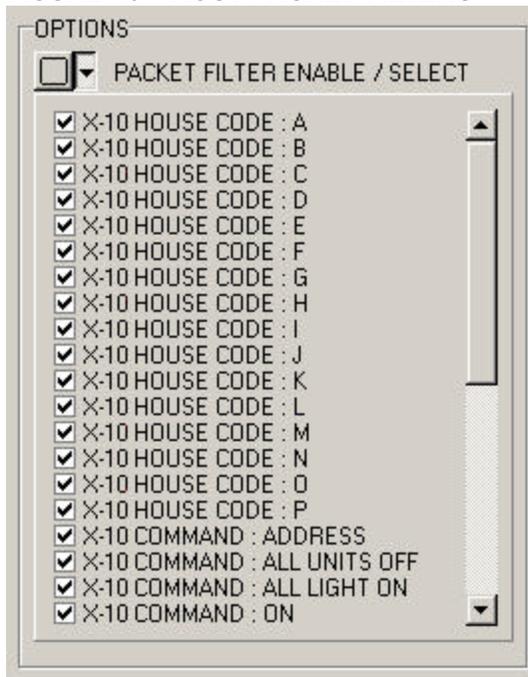
Use this mode to verify that the packets are correctly formed. If a component of the packet is malformed or fragmented, it will be highlighted by the LynX-VIEW^{tm} software to note the error. Also, verify that the packets are correct in meaning and that they carry the correct command. This mode handles all standard and extended codes as well as extensions for Lightolier Compose^{tm} Codes.

Mode 3 – Host Packet Monitor
Overview: This mode is used to monitor packet traffic detected on the power line by the LynX-10[tm] PLC. It uses the internal state machines of the LynX-10[tm] PLC to decode the traffic and send it to the LynX-VIEW[tm] software for display.

Detail: This mode monitors X-10 traffic on the power line and records the packets complete with a time and date stamp. The packet list can be filtered as shown below in figure 10. By enabling the PACKET FILTER and un-checking any type of information that is not to be displayed, the list can be dramatically shortened. This makes it quite easy to find rogue packets or incorrect commands being transmitted on the power line by automation software or modules. Entire house codes can be eliminated allowing an installer to look for packets coming from neighboring houses or apartments. Sometime the problem is not the local installation, but one next door.

FIGURE 10 – HOST PACKET FILTERS

How to use: Place the LynX-VIEW[tm] software into the X-10 Packet Analyzer Mode by selecting the X-10 PACKET ANALYZER MODE shown in figure 11. It will turn magenta in color when selected. The display area will change to a list structure showing the NETWORK the packet was detected, a TIME STAMP showing the time of arrival, and PACKET column showing the meaning of the packet. Select whichever filter and decoder options are desired (as shown in figure 10) and click the RUN button shown in figure 11 (below). The large flashing "RUNNING" will appear again in the upper right hand side of the display. The software is now monitoring for X-10 traffic on the power line. Even if a filter is selected, all packets are recorded. This enables the user to change views dynamically even as data is being recorded.

FIGURE 11 – HOST PACKET MONITOR MODE
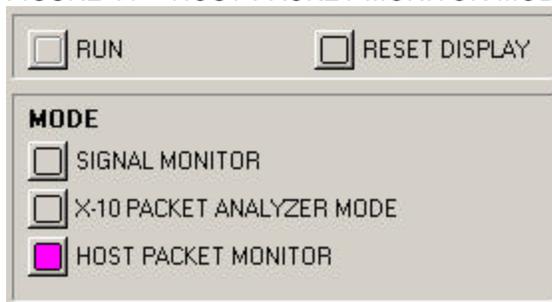
Use this mode to correlate strange X-10 behavior with packets received. That is, if a light turns on or off when it normally should not, check the log and see what commands corresponded with the change. If nothing is found in the log, it is possible that the device is triggering incorrectly from of power line noise. This can be verified by using the SIGNAL MONITOR MODE and watching for excessive noise arriving in the

X-10 window.   Other strange behavior might be due to a neighboring house or apartment running an X-10 based system, incorrectly programmed schedules or macros running on automation software, rogue equipment behavior, and malfunctioning light or appliance modules.