X-10 HISTORY RECORDER (MODES 4 & 5):

The **Power Line Signal Analyzer** is able to record in permanent memory up to 190 incoming X-10 codes along with their signal strength and an offset time (in hours) from when they occurred. Pressing the MODE button **5** times resets the History Recorder to the beginning by clearing all past recorded X-10 events and the internal Timer. The LCD screen will appear as below with the second line blank:

As X-10 codes are received, they are displayed in order along with their signal strength and the time (in hours) from when the History Recorder was reset.

In the example above, the LCD screen shows that 14 X-10 events have been recorded. The 14th event was **G OFF** which had a signal strength of 1.3 volts and occurred 8.7 hours since the History Recorder was reset.

If one has switched to another MODE, pressing the MODE button **4** times will continue the recording session from the point of the last recording without clearing or resetting any previously recorded events. If the power fails during a recording session, recording will continue upon restoration of power from where it left off except the internal Timer will be reset to 00.0.

NOTE: If a lot of noise spikes or "garbage X-10 codes" are on the AC power line, sorting out and displaying a good X-10 code is more accurate using Mode 1. Under such noisy conditions, BSC's are usually recorded when in Modes 4 or 5.

REVIEWING RECORDED EVENTS:

From any MODE except Mode 3 (Signal Dissect), pressing the NEXT or the BACK button on the front panel will display the total number of recorded X-10 events on the top line, and the last recorded event on the bottom.

In this example, 9 codes were recorded, the last event was **J DIM** which had a signal strength of 77 millivolts and occurred 16.3 hours since the History Recorder was reset. Pressing the BACK button displays the previously recorded event and the NEXT button displays the next recorded event. Hold the button down for rapid review. Note: to conserve memory when recording, only two Dim or Bright codes are recorded if more than two are received in a row.

MAINTENANCE: In case the **PLSA** is connected to voltage source greater than 130 volts AC, a **fuse** inside will blow; disconnect power and replace with the type: 2AG, 1/2 Amp. Also inside is a LCD **CONTRAST** adjustment; be careful not to touch any bare leads inside while adjusting the contrast with the power on.

MONTEREY INSTRUMENTS, A Division of Monterey Pool Products
Oceanside, CA. (760) 941-3666

Power Line *Signal Analyzer*

FOR COMPLETE ANALYSIS OF X-10 TYPE POWER LINE CARRIER SIGNALS

Instruction Manual

MONTEREY INSTRUMENTS, A Division of Monterey Pool Products
Oceanside, California (760) 941-3666

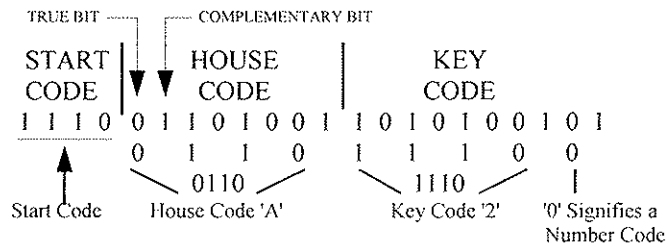
FEATURES:

- **IDENTIFIES ALL X-10 NUMBER & FUNCTION CODES**
- **DISPLAYS SIGNAL STRENGTHS OF ALL INCOMING CODES USING AN AUTO-RANGING VOLT-METER**
- **ANALYZES AC POWER LINE NOISE**
- **DISSECTS EACH X-10 CODE TO EXAMINE ALL BITS OF CODE**
- **RECORDS IN MEMORY UP TO 190 X-10 CODES FOR LATER REVIEW**
- **EXAMINE PRE-SET DIM, EXTENDED CODE & EXTENDED DATA COMMANDS**

CONTENTS

THE X-10 CODE TRANSMISSION THEORY IN BRIEF:

The AC power line voltage cycles from positive to negative 60 times a second thus crossing the zero voltage point 120 times/second. All X-10 transmissions are synchronized to this zero-crossing point. X-10 transmitting devices place a 120,000 hertz signal for a duration of 1 millisecond starting at this zero-crossing point to represent a binary 1; the absence of this 120 kHz signal represents a binary 0. A complete X-10 code transmission is composed of two identical blocks encompassing 11 power line cycles each, thus using a total of 22 cycles. The two 11 cycle blocks are transmitted back to back with no cycle gaps between them. The first 2 cycles (which contain 4 zero-crossings) of each block represent a Start Code which in binary form is: 1110. The next 4 cycles of each block represent the House Code and the last 5 cycles represent the Key Code. The House Code and Key Code transmit their true binary bit of code on the first zero-crossing of the cycle and a complementary (opposite) bit on the alternate half of the cycle. The Start Code (1110) is unique in that it is the only code that does not follow the true/complement bit relationship on alternate half cycles. If the fifth true bit of the Key Code is a 0, then the first 4 bits of the Key Code represent a Number Code; if the fifth bit is a 1, then the first 4 bits represent a Function Code. Table 1 shows the House Codes and Key Codes with their binary equivalent codes. Below is an example of how one block (11 cycles) of the X-10 code A2 is transmitted.



to operate X-10 devices. In most cases when the signal is dissected, the codes bits (those translated as binary 1's) in the second block will have a higher signal strength reading than those in the first block.

In MODE 1, the **Power Line Signal Analyzer** takes its signal strength reading from this second block to reflect any amplification.

NOTE: If the first block received by the **Power Line Signal Analyzer** is too weak in signal strength (below the threshold) to register but the second block has sufficient signal strength due to amplification, the received code will still be displayed on the LCD screen but the House Code letter will be in lower case. This is to indicate that only one block of the block pair was received. In such a case, dissecting the signal will reveal code bits from the 2nd block in cycles 1-11 but none in cycles 12-22.

PRE-SET DIM COMMANDS:

Pre-Set Dim codes can be deciphered easily using the Signal Dissect Mode. The Pre-Set Dim command contains within itself 5 bits to give a total of 32 possible dimming levels (two to the fifth power). Looking at Table 1, the "X" in the Pre-Set Dim command will be either a 1 or a 0 to represent the most significant bit (MSB) of the 5 bits. The 4 least significant bits (LSB) are actually the house code of the Pre-Set Dim command.

The format of the Pre-Set Dim command is as follows:

HOUSE CODE				KEY CODE				
L1	L2	L3	L4	1	0	1	L5	1

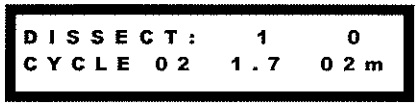
L5 represents the MSB of 5 Level bits and L1 represents the LSB. The 5 Level bits range from full ON (11111) to full OFF (00000). For example, if the X-10 codes **B7** then **EPD** were received on the LCD screen, this would show that a light set to **B 7** was to accept the Pre-Set Dim command. According to Table 1, House Code **E** is 0001 and if dissecting the code shows L5=0 (at cycles 10 & 21), this would mean L5,L4,L3,L2,L1=01000 (the binary equivalent to the decimal 8) and the light would dim to 25% (8/32).

EXTENDED CODE AND DATA COMMANDS:

The X-10 transmission format allows for additional data or codes to be sent after an Extended Data or Extended Code command. The X-10 format calls for no cycle 'gaps' between the command and the data that follows. The **Power Line Signal Analyzer** can record in memory up to 7 bytes (56 cycles) of extended code or data for later review. This data or code is viewed in the true bit/complement bit manner. After receiving an Extended Data or Extended Code command, dissecting the signal (MODE 3) displays only the additional code or data and **not** the command itself.

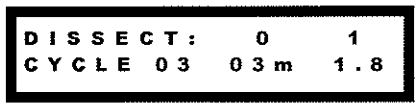
DISSECTING X-10 CODES (MODE 3):

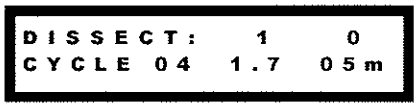
All signal strengths of the 22 cycles of the last X-10 code received (while in MODE 1) are permanently stored in memory for review later. Press the MODE button **1** time to enter MODE 1. After an X-10 code is received and displayed on the LCD screen, press the MODE button **3** times to examine in detail (dissect) the last code received as shown in the example below:

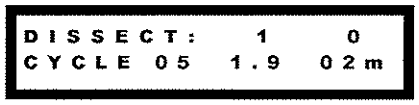


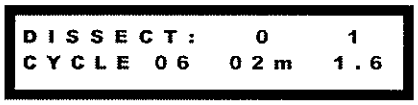
As mentioned in the section under X-10 Transmission Theory, each X-10 code is transmitted in groups of two identical 11 cycle blocks using a total of 22 power line cycles. Each X-10 code can be dissected to display the information of both code bits of each cycle. The true bit is displayed first followed by it's complementary bit with their signal strengths displayed directly below. Cycles 1&2 and cycles 12&13 contain the Start Code bits 1110. Above, Cycle 1 is dissected to show a 1.7 volt signal (or binary 1) in it's first zero-crossing and a 1.8 volt signal (binary 1) in the alternate half. Cycle 2 shows a 1.7 volt signal (binary 1) in it's first zero-crossing and a 2 millivolt signal (binary 0) in the alternate half thus forming the binary Start Code: 1110 .

Below is an example of Cycles 3, 4, 5 & 6 of the X-10 code **A2**:









This shows that Cycle 3's true bit of code is a binary 0 (3 millivolts) and it's complementary bit as a binary 1 (1.8 volts). Cycle 4's true bit is a binary 1 (1.7 volts), Cycle 5's true bit is a binary 1 (1.9 volts) and Cycle 6's true bit is a binary 0 (2 millivolts). From their true bits, Cycles 3,4,5,6 form the House Code 0110 representing the letter **A** (see Table 1). Dissecting the signal further would reveal the Key Code: 1110 0 in Cycles 7,8,9,10,11 representing the Number Code **2**. The next 11 cycles would be identical with Cycles 12,13 being the Start Code, Cycles 14,15,16,17 being the House Code and Cycles 18,19,20,21,22 being the Key Code. On the back of the **Power Line Signal Analyzer**, a code chart is provided for easy reference.

Coupler/repeaters: MODE 3 (Signal Dissect) is useful when seeing the effects on the X-10 signal strength after installing a coupler/repeater such as the Leviton 6201 signal amplifier. The Leviton 6201 receives the first 11 cycle block of the X-10 code and then amplifies the second 11 cycle block. This works fine since only one of the blocks from the block pair needs to be received

HOUSE CODES		KEY CODES			
		NUMBER CODES		FUNCTION CODES	
A	0110	1	0110	All Units Off	0000
B	1110	2	1110	All Lights On	0001
C	0010	3	0010	On	0010
D	1010	4	1010	Off	0011
E	0001	5	0001	Dim	0100
F	1001	6	1001	Bright	0101
G	0101	7	0101	All Lights Off	0110
H	1101	8	1101	Extended Code	0111
I	0111	9	0111	Hail Request	1000
J	1111	10	1111	Hail Acknowledge	1001
K	0011	11	0011	Pre-Set Dim	101X
L	1011	12	1011	Extended Data	1100
M	0000	13	0000	Status=On	1101
N	1000	14	1000	Status=Off	1110
O	0100	15	0100	Status Request	1111
P	1100	16	1100		

TABLE 1: X-10 Binary Code Equivalents For House Codes And Key Codes

The **Power Line Signal Analyzer (PLSA)** calculates a threshold signal strength value in which all code bits with signal strengths greater to this threshold are translated as binary 1's. Any signal equal to or lower than the threshold is translated as a binary 0. This threshold voltage varies between 8 and 25 millivolts depending on noise level on the AC power line.

X-10 codes are always transmitted two identical blocks at a time with no cycle gaps between these identical blocks, using 22 cycles. When another code is to be transmitted, at least 3 'silent' power line cycles occur between these block pairs. For example, if an X-10 module set to **A2** is to be turned **ON**, then the X-10 code **A2** consisting of two identical 11 cycle blocks would be sent, followed by at least 3 cycles of silence (no X-10 signals present on the power line), followed by the X-10 code **A ON** consisting of two identical 11 cycle blocks. Exceptions to this rule are: 1) Dim and Bright codes which are transmitted continuously with no gaps between same codes and 2) Extended Code and Extended Data which are transmitted with no gaps between the function code and the data that follows. For more detailed information, see the *Technical Note* on the PL513 & TW523 Power Line Interfaces from X-10, Inc., telephone: (201) 784-9700.

MODE BUTTON OPERATION: The MODE button on the front panel is used to switch to one of 5 different modes. After pressing the button the prescribed number of times, as described in the MODE box on the front panel, wait about 1 second and the **PLSA** will switch to that mode.

X-10 SIGNAL IDENTIFIER & SIGNAL STRENGTH INDICATOR (Mode 1):

When the **Power Line Signal Analyzer** is plugged into any 120 VAC outlet, the LCD screen should appear as below; if not, press the MODE button once.

```
      X-10  CODE:
SIGNAL STRENGTH:
```

Any X-10 code now received will be displayed on the top line and it's signal strength in volts or millivolts displayed directly underneath. As each code is received, the entire LCD display shifts from right to left. The X-10 code on the top line consists of 3 characters: the first representing the House Code and the next 2 representing the Key Code. For example, if an X-10 module set to **F 12** was turned **ON**, the LCD screen will appear as below:

```
10 CODE: F12 FON
TRENGTH:  .46  .46
```

This shows that an X-10 code **F 12** was received first followed by the X-10 code **F ON**. The '**F**' indicates House Code **F** while the **12** indicates the Number Key Code and the **ON** indicates the Function Key Code. The legend for all X-10 functions are on the back of the meter for easy reference.

Both codes had a signal strength (peak-to-peak voltage of the 120 kHz X-10 signal) of .46 volts (460 millivolts). The signal strength volt-meter is auto-ranging from 0 millivolts to 4.1 volts. All voltage readouts are in Volts unless the signal strength is lower than .1 volts (100 millivolts) in which a "m" will appear in the readout to indicate millivolts. For example, "72m" indicates 72 millivolts. If the voltage received is greater than 4.1 volts, "4.÷" is displayed.

The **Power Line Signal Analyzer** calculates a threshold signal strength value in which all incoming X-10 code bits are compared to. Code bits with signal strengths greater to this threshold are translated as binary 1's. Any signal equal to or lower than the threshold is translated as a binary 0. This threshold voltage varies between 8 and 25 millivolts depending on noise level on the AC power line. If a signal is too weak to be displayed on the LCD screen (meaning all code bits have signal strengths lower than this threshold), it may still operate an X-10 device since some devices can to respond to signal strengths of less than 8 millivolts.

ERROR CODES are displayed on the LCD screen when either a received X-10 code is corrupted or "noise" spikes are present . Remember, most X-10 devices will still respond even if one of the Start Codes or one of the two identical code blocks is damaged.

"BSC", Bad Start Code: Before processing an X-10 code, the **PLSA** looks for a valid Start Code (1110) at the beginning of the first code block. If this Start Code is corrupted, "**BSC**" will appear on the LCD screen. This often occurs when a noise spike at a frequency of 110 kHz or greater on the AC power line is strong enough to translate as a binary 1 at one zero-crossing but is absent at the next. In this case, "dissecting" the Start Code (using Mode 3) would reveal a 1000 in cycles 1 &2. Bad Start Codes can also occur when weak signals are on the threshold of being translated as a binary 1 or a 0; or when two codes, transmitted at the same time, collide to create a garbage code.

"BBK", Bad Block, is displayed on the LCD screen when an X-10 code with a good Start Code is received but either the two 11 cycle blocks of the code are not identical or a true bit and its complementary bit in a block are not the opposite. "Dissecting" the signal bit by bit (Mode 3), will help determine what part of the code is corrupted.

"BCY", Bad Cycle Gap, is displayed on the LCD screen when the gap or 'silent' period between two different X-10 codes is less than 3 complete cycles (it does not matter if the first X-10 code is good or bad) . The X-10 transmission format calls for at least 3 'silent' AC power cycles between each code transmitted.

Lower Case House Code Letter: if only **one** good Start Code and **one** good Block (of the two identical blocks) are received from an X-10 transmission, the House Code letter will appear on the LCD screen in lower case. For example, instead of **F12**, the LCD screen will display **f12.** This often occurs when a coupler/repeater such as the Leviton 6201 is installed on a system and the first code Block is too weak to register (see the *note* in the Coupler/ Repeater section, page 6). It can also occur when the second Start Code is corrupted and the rest of the code is thus translated as garbage.

DISPLAYING AC POWER LINE NOISE (MODE 2):

Press the MODE switch twice, wait about 1 second, the LCD screen will appear as below indicating noise levels on the AC power line within the first millisecond after zero-crossing:

```
NOISE: .5ms: 05m
   .2 to .9ms: 07m
```

In this mode, the peak voltage or highest amplitude of noise with frequencies of 110 kHz or greater, that occurred during the previous second, is displayed on the LCD screen. The screen is updated once a second. Since most X-10 devices sample the AC power line for the presence a signal about half way into the 1 millisecond 120 kHz frequency burst (.5ms after zero-crossing), the LCD screen shows noise levels for this time period on the first line; and in addition, it shows all noise occurring between .2ms and .9ms after zero-crossing on the second line. In the example screen above, the highest noise voltage received during the last second occurring at .5 milliseconds after zero-crossing is 5 millivolts. The highest noise occurring between .2 milliseconds to .9 milliseconds after zero-crossing is 7 millivolts. This mode can also be used to display the signal strengths of X-10 codes that would not normally be displayed using Mode 1 due to their signal strengths being less than the calculated threshold value. From field testing, **acceptable noise levels** seem to be about 15 millivolts ("15m") or less.