XTBM-Pro X10 Signal Analyzer Operation

JV Digital Engineering

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The XTBM-Pro is an advanced X10 signal analyzer for home automation systems. It is an enhanced version of the basic XTBM. Both can display signal voltage, carrier frequency, and line noise, but the additional features of the Pro can help solve the most difficult X-10 control problems.

Both meters will display the peak-to-peak signal level of each decoded X10 command in the form Xx.xx (Vpp). Resolution is 10mV. Valid decoded commands are displayed, as are any errors that corrupt X10 communication.

Some installations contain a repeater, such as the X10 XPCR or XTB-IIR. Both XTBM versions contain a transmitter, and will briefly check for a repeater whenever they are first plugged into a receptacle. The strength of the repeated signal will be displayed if one is active in the system. This feature allows signal levels to be quickly checked throughout a home by merely plugging the XTBM into each receptacle for just a few seconds. The Pro also includes the ability to recheck the repeater signal by just pressing a button. When monitoring normal X10 traffic with a repeater active, the signal strength of the source is flashed onto the LCD for a fraction of a second before being replaced by the strength of the repeated signal.

The carrier frequency of X10 transmissions is displayed in the form Fxxx (KHz), and should normally be near 120KHz. The meter can sample the range from 100KHz to 140KHz. Readings outside that range could mean the signal is too weak to be measured accurately, or it may not completely fill the X10 sample window (such as with the XTB-IIR delayed transmit option).

X10 transmissions consist of 1mS long bursts of 120 KHz on the powerline just after each zero crossing of the 60Hz AC waveform. The X10 reception window is slightly shorter, and centered inside the transmission window.

The XTBM-Pro samples noise in three windows: before, during, and after the X10 reception window. It displays maximum noise in the form N.xx (Vpp). The frequency of strong in-band noise will also be displayed. Any noise near 120KHz should be tracked down and isolated with a suitable filter

The XTBM-Pro adds a number of enhancements to the basic XTBM X10 signal meter, which are listed below:

0) Default X10 powerline monitor mode (same as the basic XTBM)
1) Non-volatile prior history of the most recently received command
2) Expanded noise display with additional pre and post sample windows
3) Bargraph showing signal and noise levels in a clearly visible format
4) Bitmap with bit status and voltage for the entire 44-bit command
5) Logging history of the last 100 valid X10 commands

Pressing the left switch steps though the modes in the order listed. In modes 1-3, the right switch can move up to the previous mode. In the bitmap and logging modes the switches scroll through the data. Pressing both switches for 1/2 second returns to the default X10 monitor mode. Holding down the switch(es) when changing modes will display that mode function. Returning the cursor to zero in the bitmap mode enables stepping to the logging mode at the next ½ second press of the left switch. The repeater check can be re-run in the powerline monitor mode with a ½ second press of the right switch.

X10 Powerline Monitor – This default mode displays X10 signal level, transmitter frequency, background noise level, and the last decoded X10 command. It also will display a number of different error messages.

```
X8.91 F120k N.01
P01 OFF  MONITOR
```

Here the most recent X10 signal level was 8.91Vpp at 120KHz, present background noise is .01Vpp, and the last received command was P1 OFF.

Prior history – This is a non-volatile storage of the last X10 reading taken before the XTBM-Pro was unplugged. This can be handy to check changes in signal and noise levels as you move around from outlet to outlet. The prior history shows both signal and noise level, and also whether the last command was the result of an XTBM repeater check.

```
X5.54 F120k N.01
RPT CHK  *PRIOR*
```

In this case the last command was a repeater check sent by the XTBM-Pro. The received X10 signal was 5.54Vpp at 120KHz. Noise was .01Vpp.

Pre and Post Noise – In addition to continually monitoring the background noise level in the middle of the X10 sample window, this mode also samples noise at the very beginning and very end of the window. High noise at the beginning is indicative of a noise source that is transmitting constantly, such as a wireless intercom. High noise near the end may cause a problem if that noise movers further into the window. An example would be noise from a dimmer set near max brightness. The XTBM-Pro will try to identify the type of noise, and it will display either the average frequency or the number of noise cycles it recorded during the X10 sample window.

```
 [#[NOISE]#] RNDM
.05 .88 .99 58CY
```

This is an example of the noise produced by one extremely noisy LED light. The pre, mid, and post windows read .05Vpp, .88Vpp, and .99Vpp or higher. It is producing random noise, with 58 cycles in the X10 reception window.

Bargraph – This provides a quick graphic indication of the X10 signal and noise levels. When the two halves of the doublet are different amplitudes, the stronger half will be displayed. However, the XTBM will ignore its own transmitter output when sending a repeater status check.

```
X4.27:▮▮▮▮▮▮▮▮▮▮▮▮
N.03: ▮
```

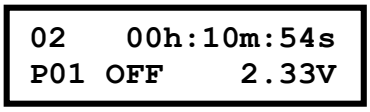
The X10 signal level is 10Vpp full scale, and noise is 1Vpp full scale. The bargraph uses a pseudo-log scale for higher resolution at the low end.

Bitmap – This displays the full 44-bit pattern for a standard X10 doublet command. Except for the 1110 start pattern, all other bits should be complimentary pairs. “11” pairs indicate noise or a collision, and “00” pairs a very weak signal. The voltage level for each bit pair underlined by the cursor is displayed. The switches move the cursor back and forth to display the voltages for all 44 bits. The value for the first start bit for each half of the doublet will not be displayed if it is above 2V

because of the gain change necessary to read higher signal levels. The display is locked when the cursor is moved off zero, and can be unlocked by briefly pressing both switches. A "*" is displayed when the display is locked, and "#" when the data is stale.

This is a typical bitmap showing both halves of the 44-bit doublet with the voltages for each bit of the underlined bit pair.

Command Log – A history of the most recent 100 commands received since the unit was plugged in is retained in RAM along with the signal level for those commands. This can help you track down control problems. The XTBM repeater check command is not logged because that is not a normal control function. The switches scroll back and forth through the log file. Holding down either switch jumps in 5 step increments. When the log index is at zero it will display commands as they arrive. An index higher than zero will track that command as new commands arrive. The index will increment to indicate its new position in the log. The time stamp is the elapsed time from when the XTBM was plugged in. It overflows at 7 days.



Command Log, with the index, time stamp, command, and signal voltage.

The command log is intended for diagnosing control problems, and does not have the same X10 signal resolution as the Powerline Monitor mode. Very weak signals may read 0.00. While the XTBM-Pro is capable of decoding very weak signals, some X10 modules will not receive them reliably.

As a further aid in diagnosing control problems, the logging mode will display the data associated with an extended command as 4 hexadecimal characters in the form H01_XcABCD, where H is the house code.

The XTBM-Pro also includes a signal reporting capability that can monitor the output of two-way modules like the RR501 that respond to the X10 Status Request command. When enabled, the XTBM will watch for any Status_ON or Status_OFF commands, and will report the received signal strength as a P pre-set dim command in a pseudo log scale. To identify different modules, the unit code for the module sending the status will be used for the P pre-set dim command. The signal strength of the source is of interest, and a repeated second half of the doublet will be ignored. This may give unexpected results if the incoming first half is too weak to receive because only the strength of the repeated second half will be reported. In the example below, your controller issues the status request to the remote A6 module, and the XTBM converts its status signal strength to the pre-set dim:

A6, A_Status_Request → A_Status_ON → P6, Pre-set_Dim XX%

Status Report Pre-set dim conversion chart:

00% -> 0.00 - 0.03 V	25% -> 0.32 - 0.39 V	50% -> 1.26 - 1.56 V	75% -> 5.01 - 5.63 V
03% -> 0.04 - 0.07 V	28% -> 0.40 - 0.47 V	53% -> 1.57 - 1.88 V	78% -> 5.64 - 6.25 V
06% -> 0.08 - 0.11 V	31% -> 0.48 - 0.55 V	56% -> 1.89 - 2.19 V	81% -> 6.26 - 6.88 V
09% -> 0.12 - 0.15 V	34% -> 0.56 - 0.63 V	59% -> 2.20 - 2.50 V	84% -> 6.89 - 7.50 V
12% -> 0.16 - 0.19 V	37% -> 0.64 - 0.78 V	62% -> 2.51 - 3.13 V	87% -> 7.51 - 8.13 V
15% -> 0.20 - 0.23 V	40% -> 0.79 - 0.94 V	65% -> 3.14 - 3.75 V	90% -> 8.14 - 8.75 V
18% -> 0.24 - 0.27 V	43% -> 0.95 - 1.09 V	68% -> 3.76 - 4.38 V	93% -> 8.76 - 9.38 V
21% -> 0.28 - 0.31 V	46% -> 1.10 - 1.25 V	71% -> 4.39 - 5.00 V	96% -> 9.39 - 9.99 V

This capability allows you to monitor the overall health of your system by placing two-way X10 modules on critical circuits. Have your controller issue the Status_Request periodically, and check the reported signal levels against some predetermined minimum. Like with the P1 noise alert, your controller can then issue a warning when the signal level drops too low.

Both the powerline noise alert and the status signal monitor are enabled and disabled through housecode P commands being sent continuously as the XTBM-Pro is plugged in. As in the basic XTBM, the P_ON and P_OFF commands will enable and disable the noise alert. In a similar manner, P_Bright and P_Dim commands control the status signal monitor. And as in the basic XTBM, P_ALL_OFF being transmitted as the unit is plugged in returns it to the factory default configuration, with both monitors disabled.

Plugging the unit in with both switches held down will do a complete reset except for disabling the noise alert and status signal monitor. The complete reset clears the prior history log and re-runs the self-test, which checks the functionality by monitoring its own transmitter output. A nearby signal sucker may attenuate the transmitter output enough that the self-test will not pass. In that case, try a different outlet away from potential signal suckers. Once self-test has passed, it will not run again until a complete reset is done.

Debugging with the XTBM-Pro

Inadequate signal strength and powerline noise often cause X10 reliability problems. X10 commands are sent as a series of signal bursts coupled to the powerline. Presence of a burst signifies a logic "1", and absence a logic "0". Noise near the X10 carrier frequency can fill in those blank frames, making it impossible for a receiving module to decode the command unless it includes some form of Automatic Gain Control (AGC) to raise its detection threshold above the background noise level.

The XTBM makes it easy to identify “signal suckers” and major noise sources. If the house has a repeater, just plugging in the XTBM will give a measurement of the signal level at that receptacle. The strength of the repeated signal can be checked multiple times by using the repeater check command. There will be some fluctuation in the signal level as the original transmission and the repeated output sum together.

Without a repeater, some signal source is necessary. You can use a TM751 or RR501 plugged into a receptacle near your main controller, and triggered with a PalmPad. With the XTBM plugged into the receptacle under test, send a few commands, and the XTBM should display the signal amplitude and decode the commands.

X10 reliability begins to suffer at signal levels below 100mV. If you have a circuit with low signal levels, the resolution of the XTBM should make it easy to identify the cause(s). Devices that cause a significant change in signal level when unplugged should be isolated with X10 filters. The X10 XPPF is good for several amps, and the XTB-F10/F15 for higher currents.

Powerline noise is also a major problem for many X10 installations today because of the proliferation of switching electronics in CFLs, LED lights, and modular power supplies. It is possible for “in band” noise of only 50mV to cause serious reliability problems for X10 modules that do not have AGC.
Noise readings above .03V, a cycle count approaching 40, or multiple ERR BSC messages indicate problems that need troubleshooting. Move around testing other outlets on that circuit looking for the highest noise level. If that points toward the breaker panel, the noise source may be on another circuit.

Some types of interference may prevent X10 commands from being properly decoded, causing them to look like noise. That is likely if the noise reading jumps significantly as X10 commands are sent. You can use the technique described above to track down the offending noisy device(s).

Insteon commands straddle the zero crossing, and the XTBM will try to identify them as being different from other background noise. Since the XTBM does not decode the data, strong noise near 130KHz straddling the zero crossing may also be identified as an Insteon command. The average level of an Insteon command is displayed in the form Ix.xx (Vpp).

The XTBM includes a noise alert system to warn of a sudden increase in the background noise level. When enabled, the XTBM will transmit “P1 ON” when the noise suddenly increases, and “P1 OFF” when it falls back to a safe level. A slight delay prevents momentary transients from causing an alert. The noise alert system is intended to identify individual devices that generate a lot of noise, and the ON or OFF may not be issued for gradual changes.

An X10 chime or lamp module can be used for the P1 noise alert indicator. Since the noise may corrupt nearby X10 communication, the XTBM should be plugged into the circuit with the suspected noise source, but the alert indicator should be located on a different circuit for reliable operation.

The noise alert system can be enabled or disabled by plugging the XTBM in while holding down the key of a manual controller sending “P ON” or “P OFF”. The state of the noise alert system is only displayed when it is changed. Performing a complete reset with a “P ALL_OFF” at power-up disables both the noise alert system and the status signal monitor. The states of both of these functions are stored in non-volatile memory, and are only changed with the appropriate “P” commands.

Hundreds of hours of development have gone into making the XTBM-Pro the best tool we can offer to help troubleshoot X10 automation systems and maintain them at peak operating reliability. We appreciate any feedback you may have to further enhance its capabilities. Simply swapping the PIC microcontroller will maintain your instrument at the latest version should any firmware updates be issued.

Decoded commands:

Label	Code	X10 Function	Label	Code	X10 Function
AOFF	0000	ALL Units OFF	HReq	1000	Hail Request
ALON	0001	ALL Lights ON	HAck	1001	Hail Acknowledge
ON	0010	ON	PDim	1010	Preset Dim "0" bit
OFF	0011	OFF	PDim	1011	Preset Dim "1" bit
DIM	0100	DIM	Xdat	1100	Extended Data
BRT	0101	BRIGHT	StON	1101	Status ON
LOFF	0110	ALL Lights OFF	StOF	1110	Status OFF
Xcod	0111	Extended code	StRq	1111	Status Request

Status indications:

MONITOR	The unit is monitoring the powerline.
<VALID>	A valid X10 command has been decoded (displayed 2 seconds).
ERR RCV	An error was detected while trying to decode an X10 command.
ERR BSC	A bad start code was received.
ERR COL	A collision was detected while decoding an X10 command.
^NOISE^	Noise may be corrupting weaker X10 signals.
INSTEON	Noise may be due to an Insteon transmission.

Full line messages:

HIGH NOISE LEVEL	Background noise suddenly increased to a high enough level to corrupt X10 transmissions.
NOISE DECREASE	Background noise has suddenly decreased to an acceptable level.
NOISE ALERT ON	The P1 ON/OFF noise alert system is enabled.
NOISE ALERT OFF	The P1 ON/OFF noise alert system is disabled.
STATUS LEVEL ON	The STATUS ON/OFF level monitor is enabled.
STATUS LEVEL OFF	The STATUS ON/OFF level monitor is disabled.
LOW OUTPUT LEVEL	Self-test is marginal due to a low transmitter output, possibly due to a nearby signal sucker.
FAIL SELF TEST	Something is causing it to read back a very low or entirely absent transmitter output.