X10 Automation Reliability

Jeff Volp (revised 10-01-2013)

Many of you probably know that the X10 protocol was developed back in the 70's by a Scottish firm called Pico Electronics. Back then, homes contained relatively few electronic devices. Things like computers and switching power supplies were barely on the horizon. There was very little to interfere with X10 powerline communication in an average home, and those early BSR modules worked well.

Fast-forward a few decades. Our homes are becoming filled with more and more electronic devices. We have computers, media systems, flat-panel televisions, electronic gaming systems, electronically-controlled major appliances, compact fluorescent lights, and even new LED lights. Many of these new devices incorporate switching power supplies. The powerline environment has vastly changed, but the X10 protocol is the same. Because of that, X10 devices don't always work correctly "out of the box".

Some people quickly throw in the towel and criticize X10 devices for being junk. Actually, they are the same devices that worked very well when they were developed several decades ago. All we have to do today to achieve that same level of reliability is to provide a similar environment for their powerline communications. Below is an overview of the steps to be taken to achieve reliable X10 operation. Other documents will go into each of these steps in much greater detail.

X10 signals are transmitted over the AC powerline as short bursts of 120KHz low-frequency radio signals just after the zero crossing of the AC power waveform. The presence of a 1mS burst signifies a logic "1", and the absence a logic "0". The amplitude of the 120KHz bursts produced by most X10 transmitters is in the 5-10Vpp range. That level quickly decreases as the signal propagates away from the transmitter and encounters obstacles in its path.

The AC power distribution in a typical home is a very complex network at 120KHz. It can have resonant peaks and nodes due to distributed inductance and capacitance. Add to that the obstacles created by random "Signal Suckers" and "Noise Generators" spread throughout the system. To further complicate things, most homes have split-phase power distribution. A typical transmitter drives only one phase. The signal on the second phase must rely on coupling through the utility company's power distribution transformer after perhaps hundreds of feet of cable. It is not surprising that little X10 signal makes it to the second phase through this circuitous path.

So, with all these complications, how do X10 powerline devices work at all? They can indeed work very well if one invests some time and effort up front. The first step in solving reliability problems is to obtain some sort of X10 signal level meter. Previously I recommended the ESM1 signal meter as a troubleshooting tool. That and the other low-cost meters have been discontinued, and I designed the XTBM and XTBM-Pro as affordable alternatives. After mapping out your circuits, check the signal strength on all circuits that power X10 devices with some sort of repetitive transmit signal. I use a PalmPad to trigger signals through a RR501 connected near the distribution panel. While some X10 modules may still work below 50mV, any circuit that reads less than 100mV is a candidate for reliability problems.

You may need a signal coupler if many of your circuits read low. As previously mentioned, most X10 transmitters drive a single phase. If X10 devices are used on both phases, then it is strongly recommended that a good tuned-circuit passive coupler, such as the X10 XPCP, be installed adjacent to the main distribution panel. There are simpler approaches, such as couplers that plug into a dryer receptacle. If that receptacle is fed from the main distribution panel, and the run is relatively short, a dryer coupler can work pretty well. In our case, all 240V electrical appliances are fed from another panel located where power comes into the house. It is a long run from that panel to our main distribution panel, which is centrally located in the basement. If we used a dryer coupler, signals would have to propagate from the transmitter to the main panel, then to the entrance panel, then to the dryer coupler, back to the entrance panel, and finally back to the main panel before they could be distributed to circuits on the opposite phase. The hundreds of feet of wire would significantly reduce the effectiveness of a dryer coupler.

Many electronic devices today contain high frequency switching circuitry. FCC regulations on conducted interference limit the amount of that energy that can leave the device. An inexpensive way for manufacturers to meet these FCC regulations is to place a filter capacitor directly across the AC power input. That effectively shunts the interference signal to ground. Unfortunately, any X10 signals on the same circuit will also be shunted to ground. As a result, the remaining signal level may be too low for X10 modules on that circuit to operate reliably. Devices that most often act as these "Signal Suckers" are computers and monitors, some TVs and other A/V equipment, UPSs, some surge-protector power strips, and even simple things like LED night lights. Compact fluorescent bulbs are often "Noise Generators", but some may actually be "Signal Suckers" if the manufacturer tried to prevent them from radiating noise.

When checking signal levels throughout the house, any circuit that reads significantly lower than other circuits should be checked for potential signal suckers. The easiest way to do that is to unplug all electronic devices on that circuit. Assuming that the signal level increases with all of the devices removed, plug them back in one-at-a-time, while rechecking signal levels. When the signal level drops again, you have found a "Signal Sucker" that should be isolated by an X10 filter, such as the XPPF.

"Noise Generators" are another problem for X10 signal propagation. Some can produce enough "in band" background noise so that a transmitted logic "0" is actually detected as a logic "1". The culprits are similar to the "Signal Suckers": switching power supplies, CFL and LED light bulbs, electronically-controlled appliances, and wireless communication devices, such as intercoms and baby monitors. Some signal monitors, like the XTBM, will also indicate background noise level. While doing the signal level test, if the noise level increases substantially when a device is turned on, you have identified a "Noise Generator". The fix for "Noise Generators" is the same as for "Signal Suckers" – isolate them with filters. Or you could try the XTB-ANR Active Noise Reducer.

After you have installed a coupler and isolated your problem loads, you should have much stronger signals throughout your home. Unless you have a very large house with a large number of circuits and electronic loads, your signal levels should be adequate for reliable operation. If you still have X10 devices that do not operate reliably, there remain a couple more things you can do. One is to move the primary X10 transmitter as close to the main distribution panel as possible. That will reduce the line inductance, and a stronger signal will reach the panel for distribution on the other circuits. The other option is to add some sort of signal amplifier either at the output of your transmitter or at the main distribution panel. The X10 XPCR is an inexpensive repeater. Our own XTBR and XTB-IIR are much more powerful repeaters that can produce strong signal levels through even large size homes.

If you invest some effort, the reliability of your X10 system can approach 100%.