X10 and Compact Fluorescent or LED Bulbs

Jeff Volp (Revised 05/19/2014)

As we all know, incandescent lights are becoming a thing of the past. Most incandescent light production has already ceased, and we are being forced into using compact fluorescent (CFL) and newer LED lights. While these new lights are much more expensive, they should pay back their cost many times over by using much less energy over their lifetime. Unfortunately for X10 users, some of these new high efficiency lights generate powerline noise near the 120KHz X10 passband. As these lights proliferate throughout our homes, many X10 users are experiencing serious problems with their X10 systems. This document will cover some background, and how we can maintain reliable X10 communications when using CFL and LED lights.

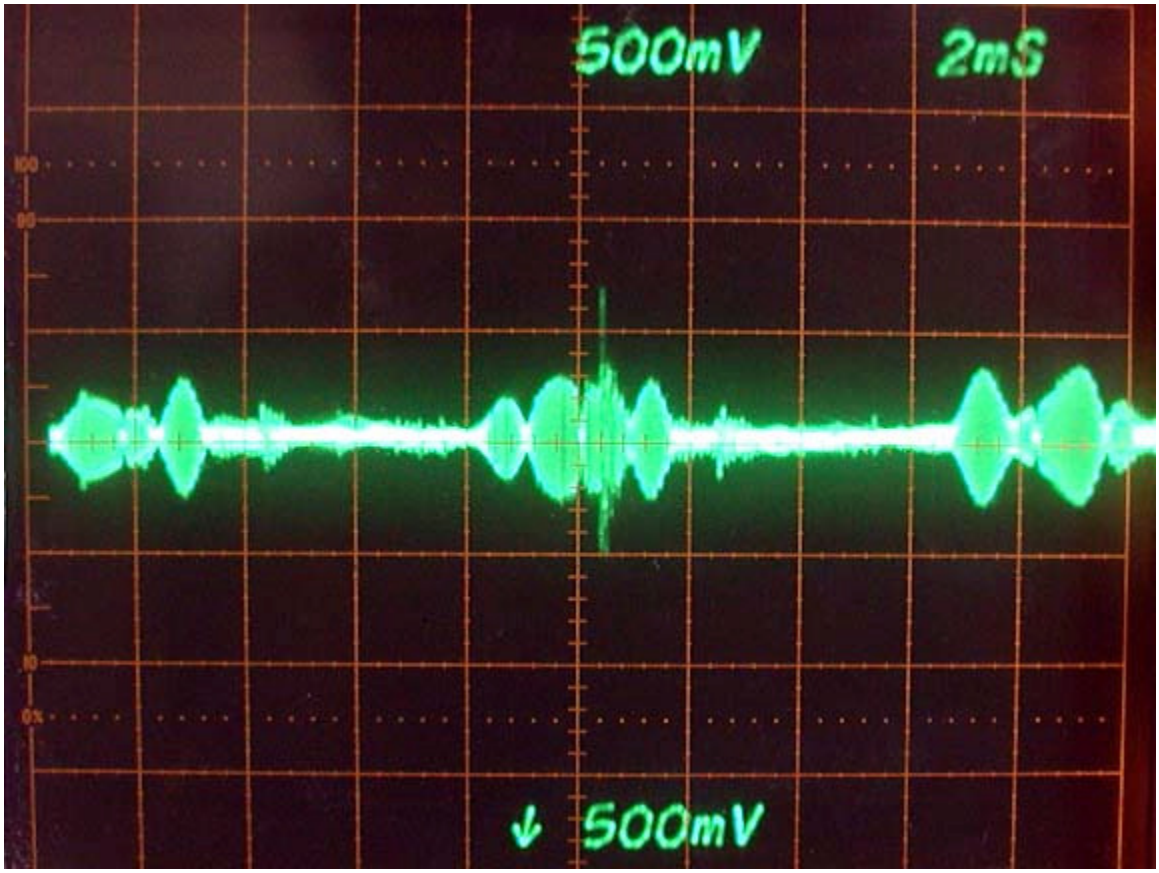
Being concerned about energy efficiency, we began using CFLs back in the mid-90's. We started with two brands – Philips "Earthlights" and a larger Lights of America unit with a replaceable bulb. Both were expensive compared with today's typical CFL, but were similar in price to newer high output LED lights.

The Earthlights worked perfectly on X10 lamp modules, and could even be dimmed to about half intensity before they finally blinked off. We still had several Earthlights in daily service when I first created this document, but the last was finally retired when it began to flicker after almost two decades of use. One downside of most CFLs is that it takes several minutes after turn-on before they reach their full light output. That problem does not exist with the newer LED lights, which come on at full brightness.

The original Lights of America CFL did turn on at full brightness, but it was not X10 friendly. It had a large base that could be snapped open. Inside was a bypass capacitor directly across the AC power input. That prevented it from radiating noise out onto the powerline, but it also shunted the X10 signal on its circuit to ground. There was room inside the base to add a 1000uH Miller "Hash Choke" in series with the center contact to prevent it from attenuating the X10 signal. Those Lights of America CFLs were not dimmable, but they worked well with X10 appliance modules after the modification.

In this house we planned to install CFLs in many of the ceiling cans. Because of the possible problems caused by certain brands of CFLs, I installed a Leviton 6287 in-line filter for every set of ceiling cans controlled by an X10 switch. And I used Leviton X10 switches with a neutral connection so any incandescent, CFL, or LED bulb can be used in those fixtures. Even with the large number of CFLs in this house, X10 communications has been virtually 100% reliable. Unfortunately, Leviton discontinued the 6287 filter, and it is now virtually impossible to find. That restricts the options available for those who are fighting noise problems from CFL or LED lights.

The CFLs in my workshop are not controlled by an X10 switch, and I did not isolate them with a Leviton 6287 filter. Those CFLs were purchased at deep discount through the utility company. While working on the XTB-II AGC loop, I discovered how difficult it is to deal with noise generated by some compact fluorescent bulbs. The photograph below shows the signal received after passing through the bandpass filter in the XTB-II. The 60Hz AC waveform has been removed, and this is the signal that is sent on to the envelope detector for decoding X10 signals. The XTB-II bandpass filter is not high-Q to prevent too much ringing, but it does attenuate out-of-band signals.



Noise from 4 CFLs Beating Together

This testing was done in my workshop, which is on a non-X10 circuit powered through an Arc-Fault breaker. Zero crossings are at dead center of the trace, and 8.3mS on either side. The transient in center X10 reception window is on our powerline at all times, and is not related to the noise created by the CFLs. As you can see, these particular CF bulbs generate a burst of noise centered around each zero crossing, which is when Insteon and X10 signals are transmitted.

To further complicate matters, the noise varies in amplitude from cycle to cycle. This “pulsation” is apparently due to the high frequency choppers in the various bulbs running at slightly different frequencies. As the noise produced by the choppers beats together, it can either sum to produce a stronger net signal, or cancel each other out. Note in the above photo how the character of the noise bursts at the three zero crossings differ. The strongest noise burst on the far right is square in the middle of an X10 reception window, and would likely have been detected as a logic “1” by any X10 modules that received it. The CF bulb causing this havoc was the TCP ESN18. I did confirm the noise pulsation is due to beating between the bulbs by removing all but one.

One of the reasons this noise is particularly difficult to deal with is that it does pulsate. So a module with AGC can sample the background noise near a null, and the noise can rise to a peak in the middle of the next X10 reception window. In fact I saw extra "1"s received when that happened. It resulted in a reported collision, and a rejected message.

These particular CFLs have a relatively small base so they will fit into most light fixtures. There is not much room for the high-frequency chopper that produces the electromagnetic field that lights the bulb. While I have not disassembled one to confirm, I suspect rectified line voltage is supplied directly to the high-frequency chopper. That could cause its frequency to vary throughout each half cycle of the 60Hz waveform. It so happens that the chopper frequency of these particular CFLs falls into the 120KHz X10 bandpass as the line voltage approaches zero, which is right when X10 signals are transmitted.

The bottom line is that some CFL and LED lights can cause problems for X10 signal transmissions. If you experience problems with your X10 system when using these bulbs, it may be necessary to isolate some of them with filters. The X10 XPPF is an excellent plug-in filter for CFL and LED lights. It is a low-pass filter that significantly attenuates all noise near the X10 passband. It is also effective at isolating "signal suckers" should the CFL or LED bulb include a capacitor directly across the power input.

The easiest approach to troubleshooting is to use an X10 signal meter that can monitor signal level and powerline noise. The Elk ESM1 could do that, but it has long been out of production. I developed the XTBM with much better resolution as an affordable alternative.

First unplug or switch off all CFL or LED lights. Then reconnect them one-by-one while monitoring signal and noise levels. Any time the background noise level increases or there is a large decrease in signal level when a CFL or LED light is switched on, that bulb should either be replaced or isolated with an appropriate filter.

If you are handy, an inexpensive solution for many table lamps is to install a 1000uH Miller 5258-RC "Hash Choke" in series with the hot lead. Double insulate it with shrink sleeving. While the 1000uH inductor is rated 1 amp (100 watt bulb), I recommend the higher current 250uH 5254-RC if you will ever use a high-wattage incandescent bulb in that lamp. Electronic supply houses such as Digikey and Mouser carry the chokes and suitable shrink sleeving.

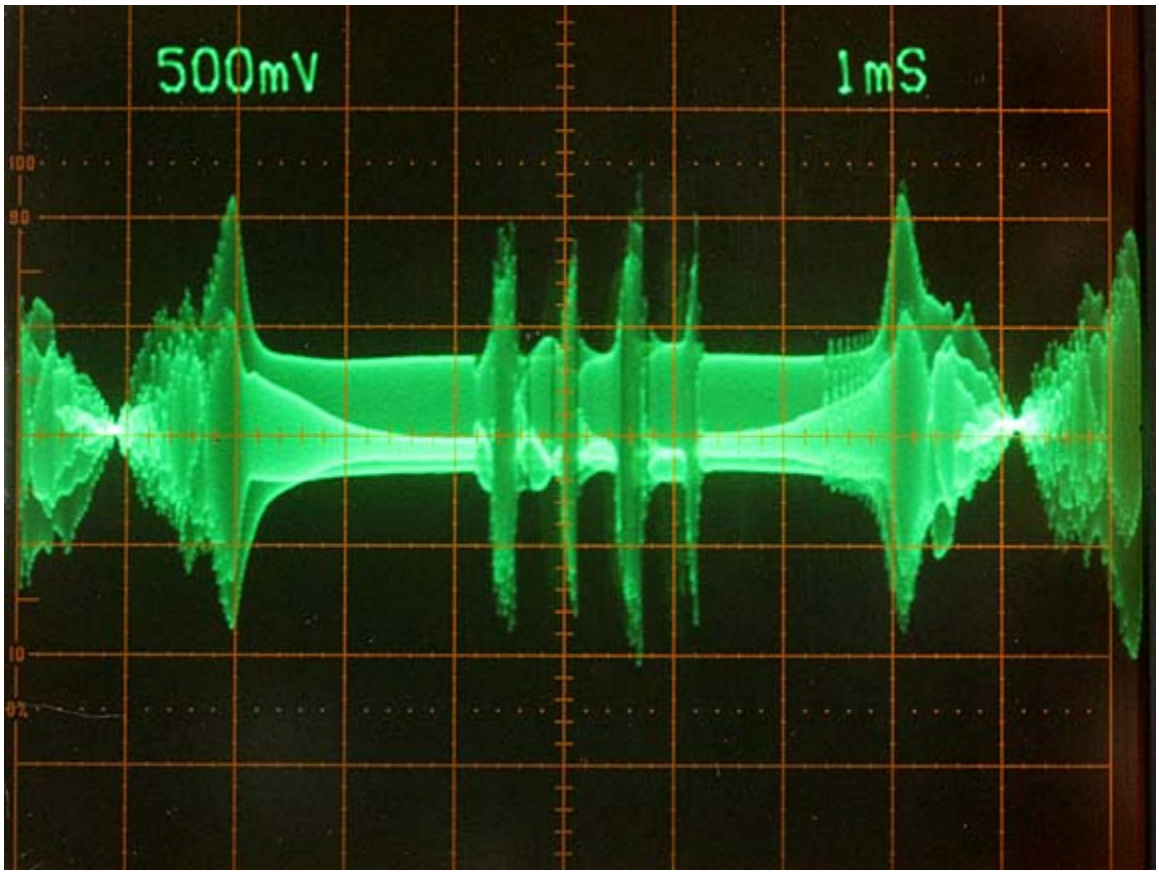
In 2013 we replaced many of our ceiling CFLs with Feit BR30 and PAR30 LED bulbs. Those are compatible with X10 systems, causing no reduction in signal level, and generating no measurable noise at all. An early LED light made by Lumoform generated a horrendous amount of noise, and even prevented Leviton switches (which incorporate AGC) on its circuit from responding to X10 commands when it was on. The hope that other manufacturers will join Feit in manufacturing bulbs that are compatible with X10 powerline control systems.

The XTB-ANR – an alternate way to deal with powerline noise.

With CFLs and LED lights proliferating, isolating all noise generators with filters can be cumbersome, and I developed the XTB-ANR (Active Noise Reducer) as an alternate approach. The XTB-ANR will significantly reduce even in-band powerline noise.

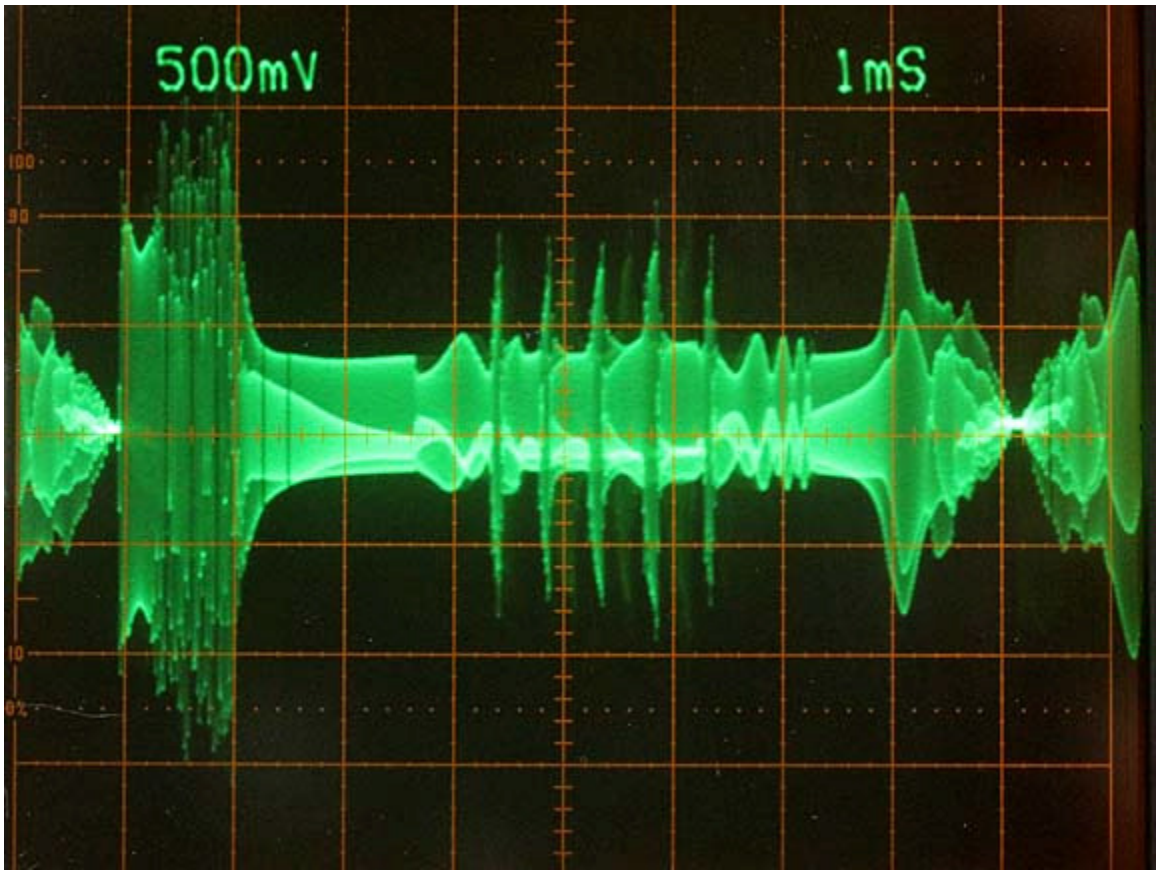
I finally took some time to record what the XTB-ANR can do to powerline noise. Below are a series of photos showing how the XTB-ANR deals with the noise produced by the Lumoform LED light that is the worst powerline noise generator I have encountered.

The first photo shows the raw powerline signal measured through an X10 Pro XPCP passive coupler. You can see the noise peaks at almost 2Vpp. Zero crossings of the AC waveform are at the two points on the left and right of the trace where the noise level drops to zero.



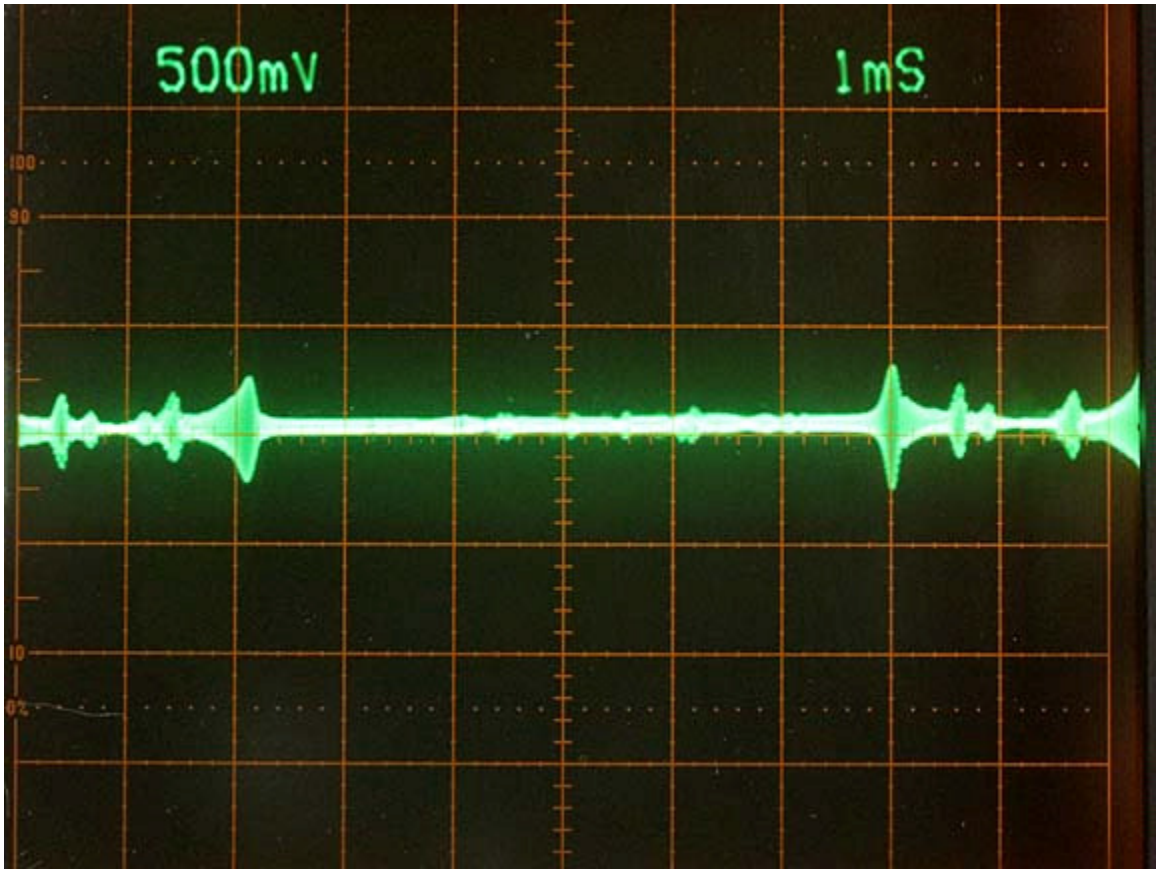
Noise from Lumoform 4W 120V LED bulb

The second photo shows a 2Vpp X10 signal being added to the powerline. You can see it begins just after the left zero crossing. The variation in amplitude is due to the noise and the X10 signal summing together. Even with a signal this strong, there is virtually no way an X10 device could extract that signal.



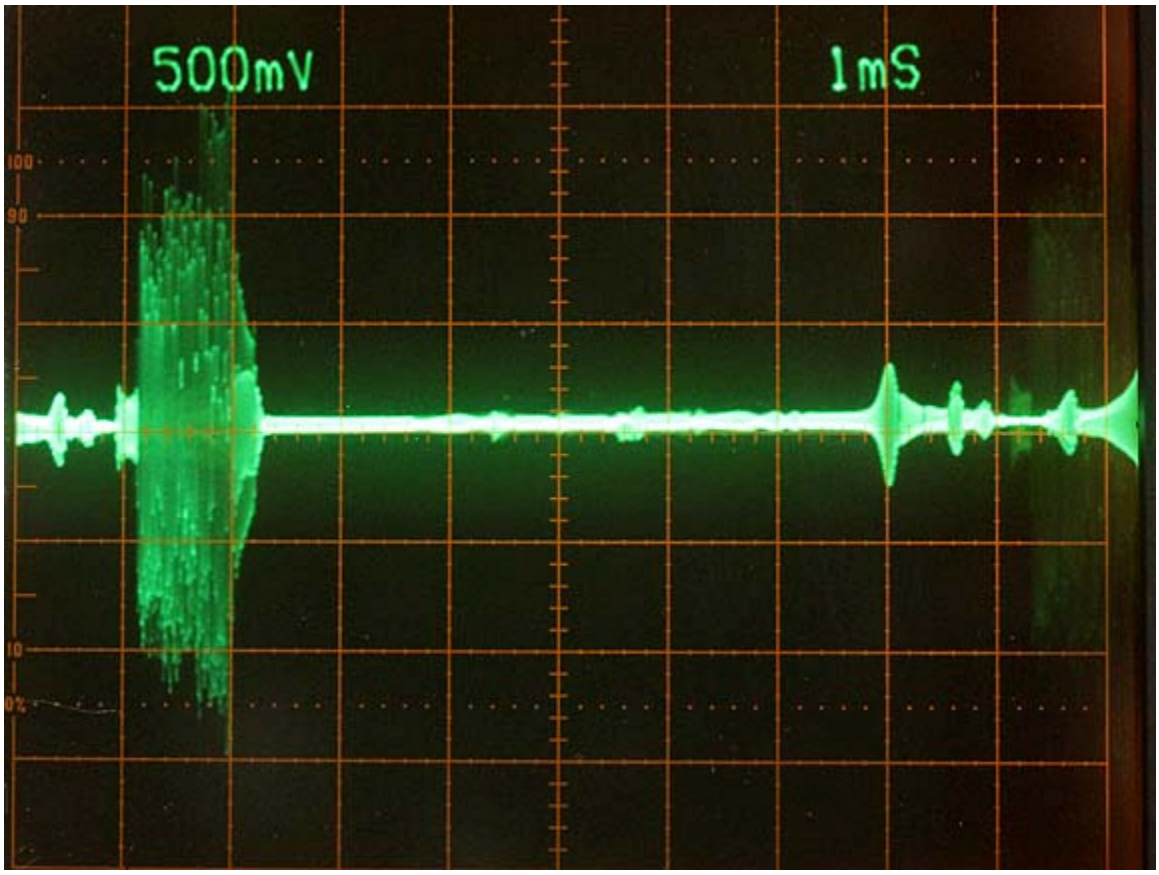
X10 signal added to noise from Lumoform 4W 120V LED bulb

The third photo shows the noise level with the XTB-ANR plugged into the powerline. Clearly there has been a significant reduction in noise level. While it can reduce typical powerline noise by about a factor of ten, it only does about a factor of five in this example due to strength of the noise source.



XTB-ANR reducing noise from Lumoform LED bulb

The forth photo shows the X10 signal again added to the powerline. You can see that the first portion of the X10 signal burst is attenuated until the XTB-ANR recognizes it is a valid X10 signal. At that point it switches off the attenuation, allowing the full X10 signal to come through. As in the second photo, the variation in amplitude is do to the noise and the X10 signal summing together.



XTB-ANR passing X10 signal while reducing noise

Here the difference between a logic "0" (no signal burst) and a logic "1" (with the burst) is almost a factor of ten. An X10 module incorporating AGC should have no trouble detecting this signal. It might be marginal for a standard X10 module if the noise frequency is near the X10 passband. But remember, this is the worst noise source I have found. Noise from a more typical noise source is reduced even more.

I hope sharing my experience in these tutorials will help others obtain the same level of reliability that we have here. X10 has been with us for 3 decades. Its low cost and rich selection of devices still makes it a cost-effective solution. Installations today can certainly be more challenging than they were decades ago, but investing some time and effort up front will give a big payoff in the years to come.