SAFETECH™ INTERNATIONAL, INC.

S3000
APPLICATION NOTE
AN-S3K-01A

SLC LOOPS AND CAPACITANCE

First of all, here is what we spec in our manual:

Any wire type may be acceptable (solid, stranded, twisted pair, untwisted, shielded, unshielded), as long as it complies with the following specifications:

14-18 gauge
Limit of 0.3uF capacitance over entire line
Limit of 50 Ohms resistance over entire loop (from panel to farthest point and back)
Complies with NEC standard 760-51 for power limited, fire protective signaling cable

Capacitance is a very big issue. A capacitor essentially sucks up and holds any voltage that come its way. Data is sent over a line in the form of a square wave. When there is a source of capacitance across an SLC loop, it will suck up enough of the voltage to round off the edges of the square wave containing the information. To the chip on the ACM that receives this rounded wave form, the information sounds like gibberish, so it reports a communication (COMM) trouble. If you have an oscilloscope and would like to see the wave yourself, try the following test:

1. Hook Channel 1 of your oscilloscope to B+ of SLC 2; connect ground to B-. When you do this, the CP3 will display a positive ground fault. This is normal; just hit the Silence button so you don't have to listen to the buzzer. Set the scope to trigger off the rising edge at 30V. You should see a square wave with the high point being about 37V, and low being about 28V. Our time base is 2ms/division. The wave should have sharp, clean edges. If any of the edges are rounded off, there is a lot of capacitance on the line. If you have a storage scope, you can set it up for single sweep and capture the pattern.
2. Channel 2 should be hooked to TP104. This is a test point on the ACM board, located between C124 and R142. This is a very small square wave of about .5V. This should also have very sharp, clean edges. If there is a large amount of capacitance on the line, there will be a lot of noise at this test point.

What can cause capacitance over a line? Well, just having shielding on the line can cause capacitance. To illustrate, Belden wire part number 9580 is unshielded and typically has about 27pF/ft on the line. Part number 9581 is the same wire, but shielded, and the capacitance level on the line is 55pF/ft. That's twice as much capacitance just from the shielding! Grounding one side of the shield can add capacitance as well, although if you have to do this, it is better to ground the side closest to the op-amp (on the circuit board), as this apparently lessens the capacitance you do add. If you ground both sides of the shielding, your wire becomes a conductor for magnetic interference. This opens a whole new batch of problems!

It is also important to consider the protective jacket around the wire. Most twisted-pair wiring made for signaling circuits come in a PVC jacket. The color of the jacket describes the quality of the jacket. A red jacket, which is the most common, is strictly for indoor use. It is by nature very flexible, and, very porous. This means that if the wire is lying near moisture, the jacket will soak up the moisture, just like a sponge. Water will of course cause capacitance. This quality makes it unsuitable for burial underground. The other type of PVC jacket is black. The carbon in the black jacket will protect against UV rays, making the wire suitable for outside installation; however, the material is still porous, and thus would be inappropriate for direct burial.

So, in looking for a wire to go underground, you must find one made of a non-porous material, such as an FEP Teflon jacket. Below are some examples of companies that make cabling for direct burial.

Belden
P/n 83752 14 gauge only / shielded only / capacitance rating: 30pF/ft (acceptable)
Web site: www.belden.com

West Penn Wire / CDT
P/n TC2994 (14 gauge)
TC2990 (16 gauge)
TC2980 (18 gauge)
All above are unshielded, and will have different ratings of capacitance. Most spec sheets will state the capacitance in pF/ft (picofarads per foot).

To determine if the capacitance levels are acceptable, use the following formulas:

Total Capacitance = L * C * 10^{-12}

Where: L = Total length of wire on B+ line
C = Capacitance per foot, in picofarads [10^{-12} = pico (10 to the negative 12th)]
(Note: L is the distance to the farthest point on the line, including the length of all branches. L does not include the length of the line to the farthest point and back; it is only the length of one side.)

This will give you the total capacitance for a given length of wire.

Example: Given wire is 10,000 feet in length.
Total Capacitance = 10,000ft * 30 * 10^{-12}
Total Capacitance = 0.3µF

Maximum Length = $\frac{\text{Total Capacitance}}{C * 10^{-12}}$

This will give you the maximum length that wire can be before the capacitance levels violate spec. If the length is less than what you need to complete your project, the capacitance level is too high. We generally recommend wire that is rated 30pF/ft or less.

Example: Given wire is rated 30pF/ft. Total Capacitance = 0.3µF
Maximum Length = $\frac{0.3\mu F}{30pF} = \frac{0.3 * 10^{-6}}{30 * 10^{-12}} = \frac{0.0000003}{0.000000000030}$ = 10,000ft

If you find that there is too much capacitance across your loop, you can trim up the noise by turning the unit off and placing a 1K Ohm resistor (must by rated at least 2-3 Watts, preferably 5-10 Watts) across the line at the farthest end of the loop. Turn the unit on. If any Comm Errors still pop up, attach another resistor of the same value in parallel with the first. Adding one 1K Ohm resistor adds about a 30mA load to the loop; adding two 1K resistors in parallel adds about a 60mA load to the loop.

If a Comm Error still persists, there may be other causes. Further documentation will cover these situations.