HART Loop Resistor: Why?

Introduction

You just received one of the new technology HART communicators that use your smart phone. You connect the modem to your HART instrument, launch the App and… nothing happens - "Error connecting to device". What is going on?!

Your loop is missing a vital element of HART - the Loop Resistor. Per the HART specification HCF_SPEC-054, FSK Physical Layer Specification, the resistor is essential to HART communications. The resistor serves two purposes. One, it is needed to convert the current based HART signal to a voltage signal. Second, it prevents the Loop Power Supply from canceling out the HART signal. Figure 1 shows the placement of the Loop Resistor in the loop and where the modem connections can be made. Connect your modem at A-B or C-D.

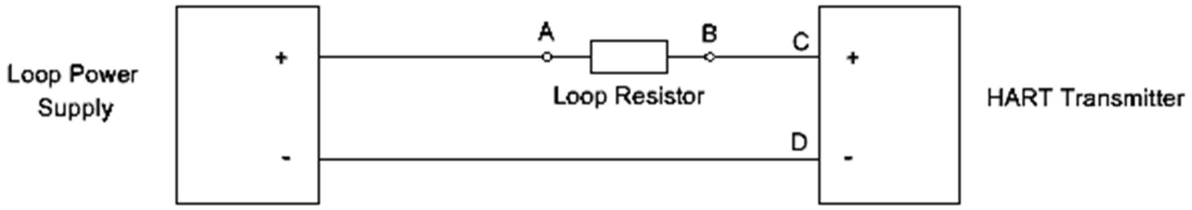

Figure 1. Loop Resistor Placement in the Loop

Resistance Value

The HART specification defines the Loop Resistor value to be in the range of 230 ohms to 600 ohms. Typically, 250 ohms is used. This value provides an easy conversion from a current value to a voltage value used in some control systems. In this case 4mA through a 250 ohm resistor is 1Vdc and 20mA is 5 Vdc.

Resistor Location in the Plant

So where should I put the resistor? Well, it depends. It can be anywhere in series in the loop. An obvious and convenient place is in the PLC I/O card itself. For instance the Allen-Bradley model 1756-IF8 I/O card has a built-in loop resistor.

If your PLC does not have a built-in resistor, you can place it in the marshaling cabinet. Often, cable is run from the control room to the plant floor to a marshaling cabinet. The cabinet provides a convenient place to insert a resistor into the loop.

The worse option for loops in service, because it means the loop must be interrupted, is to place the resistor at the HART instrument. Simply lift one of the loop connections from the instrument, connect a resistor in its place and the other end of resistor connects to the cable lead. There may be enough room in the instrument enclosure so you can refasten the cover, keeping the resistor in the loop for the next time you need to connect.

Resistor Location on the Bench

When working with a HART device on in the lab, more options are available. The first option is to simply connect a resistor to one of the instrument loop connections. Then connect the power supply to the instrument and to the other end of the resistor. Figure 2 is an example.

Figure 2. Correct Loop Resistor Connection

If a loop calibrator is available, it may have a built-in loop resistor function. For example on the Fluke 789, the resistor can be easily enabled. So in this case the loop calibrator is simply connected to the loop connections on the instrument. The loop resistor is enabled on the calibrator. Figure 3 shows the calibrator screen with the loop resistor enabled.

Figure 3. Loop Resistor enabled in Loop Calibrator

Modern HART modems now have the ability to power an instrument and often contain a built in loop resistor also. This makes powering a device and communicating with it very simple.

Why Don't I Need a Resistor on Some Loops?
First off, remember that the loop resistor is a HART specification requirement. However, loops with long cable runs may have enough loop resistance for HART communications to occur. The likelihood of successful HART communications in low resistance loops is increased when your HART modem output and sensitivity exceeds the HART specs. This means the modem can receive lower voltage signals and can transmit at higher voltage levels. This means long cable runs will likely provide enough wire resistance so that a dedicated loop resistor is not necessary. However, modems with more sensitive inputs are more susceptible to noise which will reduce communication reliability.

Common Loop Resistor Mistakes
As simple as the loop resistor requirement is, connection mistakes still occur. A common one is put the modem connection in series with the loop. See example.

Figure 4. Wrong! Modem in Series with Loop Power

Another mistake is to put the resistor across the terminals of the instrument. This removes the instrument from the loop and creates a fixed current output. See example.

Figure 5. Wrong! Loop Resistor Across Device Input Connections

Remember, the loop resistor is in **SERIES** with the power to the instrument.

The Future
HART is always going to require a loop resistor. You may have heard of PSK (Phased Shift Keying, aka High Speed HART) that is now starting to be deployed. Does this physical layer also need a loop resistor? YES! The wiring is no different between FSK (Frequency Shift Keying, aka standard HART) and PSK.

Conclusion
The loop resistor is a HART requirement. Yes, some loops MAY work without it, but the tradeoff is with reliability. Noise will be more prevalent and command retries will occur more often, slowing down communications.

Put that loop resistor in the loop on your next shutdown. Or better yet, put it in during the design phase. Your instrument techs will thank you for it!

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