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Current controlled loop testing with the Fluke 120 Series Industrial ScopeMeter®

Application Note

Within the process industry, current loops are widely used to monitor parameters such as temperature, pressure, levels and flow of fluids, as well as for controlling actuators like valve positioners. An invaluable tool for testing such current loops is the Fluke 120 Series of Industrial ScopeMeters.

Current controlled loops basics

The essential part of a current controlled loop is a sensor that controls or dictates the magnitude of a DC-current in an electrical circuit loop, whereby the actual value of the current depends only on the parameter that the sensor measures. As a rough approximation, one may think of such a sensor as a variable resistor, where the measured parameter sets the value of the resistance.
A better approach is to think of the sensor as a current source that is set up to allow a current of accurately controlled magnitude to pass, although this current source doesn't supply the current itself.
In a similar way, actuators are used that respond accurately to the magnitude of a current and, for instance, open a valve proportionally to the magnitude of the current.

Current loops have the advantage over voltage controlled loops of being virtually immune from stray influences from surrounding wiring. As these control loops consist of a single, closed electrical circuit loop, the current that is 'controlled' by the sensor must flow at all points throughout the loop and must have equal magnitude at all places.
For that reason, each current loop is kept fully isolated from any other electrical circuit.
Voltage controlled loops, on the other hand, are far more sensitive to stray voltages and "hum"-pick-up, and suffer from voltage drops due to the resistance of the wiring.
Both errors may lead to erroneous readings and misinterpretation of the process status, which may potentially lead to the process running out of control.

The current controlled loop is preferred because it is far less sensitive to these kinds of interference.

Current loop components

The current loop is an electrical circuit loop consisting of the following elements:

- a supply voltage source, usually providing 24 V
- the electronic sensor, also referred to as 'the transmitter' as it transmits (by wire) the measured value
- a read-out device or a process controller to interpret the reading
- the wiring between read-out and the remote sensor.

If it is an actuator loop, the process controller provides an output current at an output port that is connected to the actuator.

The driving voltage may be internally supplied by the process controller, or as an additional supply source.

The wiring is an essential part of these control loops. The distance between sensor and read-out can be as long as several hundred meters (or yards), yet the voltage drop that results from the resistance of the wiring has no effect on the magnitude of the current. Therefore, the current loop requires only relatively simple low-voltage wiring.

Nevertheless, the wiring of each loop must be laid out independently and fully isolated from any other loops, to avoid loops influencing each other.
Sensors for these current controlled loops are widely identified as "4...20 mA loop compatible".
For instance, a temperature sensor may be described as having the following characteristics: "temperature range: 0°...+50° C, output current: 4...20 mA."

This specification means that this sensor will continuously draw a minimum current of 4 mA, independent of the temperature it experiences. This current is used to power the sensor's internal electronics. On top of this, an additional current is drawn that is proportional to the temperature that the sensor detects. This additional current is then 0 at 0° C, and ranges up to an additional 16 mA (or 20 mA in total) at +50° C. Other sensors may have different temperature ranges or respond to different parameters but the current is always within the range 4....20 mA. An interruption of the 4 mA basic current can also be seen as an indication of a defect, for example a broken wire, a wiring interrupt or a defective part.

Actuators such as valve positioners and motors require an additional power source to power their prime operation, although control is accomplished using a current in the range 4....20 mA. Here, again, the main reason for using the current controlled loop is in the virtual immunity from stray voltages and from voltage losses in the control wiring that may result from wire resistance.

Checking current controlled loops

A basic check on control loop currents can be done with a multimeter. More convenient is the use of dedicated loop testers and loop calibrators like the Fluke 707 and 715. Not only can these instruments measure the current in the loop, they can also be set up to supply the control current for checking an actuator, while the device is temporarily disconnected from the loop, or to supply the control current in a loop as if it were a sensor.
The Fluke ScopeMeters are also able to measure this current and display it as a numerical value on screen, see Figure 1. The ScopeMeter can actually be used as a dual multimeter, measuring two currents or a current and a voltage, as can be seen in Figure 2.
The instantaneous value of the loop current could be one of these measurements, but as the processes are generally slow in nature, changes in process parameters may take from minutes to days before becoming noticeable.

Figure 1 *– The ScopeMeter measures the current in the control loop and presents it as a numerical value*

Therefore monitoring the process and the behavior of sensors during normal operation requires measurement tools that can also record the current over a longer time span.
This is one area where the unique qualities of the Fluke ScopeMeters come into their own.
These instruments can be used to measure the current and give a reading of the instantaneous value of the current, as seen above. Moreover, they can be used to measure two currents simultaneously, and give a dual current reading (see Figure 2), or to measure a current and a voltage simultaneously.
The most direct way to measure the current on the ScopeMeter is to show

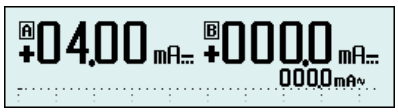

Figure 2 *– Fluke 120-series ScopeMeter offers dual multimeter readings*

the numerical value, as seen above. At the same time, however, the instrument also gives a graphical representation of the loop current, using the oscilloscope section of the instrument.
This allows you to find any low- or high-frequency signals disturbing the control current, and to take advantage of the instrument's broad (20 MHz or more) bandwidth – which is particularly advantageous for fault-finding in electronic circuits such as current converters.
For slower current changes, typical of the process industry, the ScopeMeters can be used to record measurements over a longer period

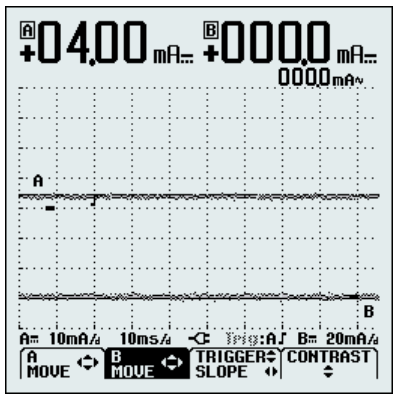

Figure 3 *– ScopeMeter measures loop current on two inputs simultaneously, it displays the measured values and gives the oscilloscope display of each current*

of time. In this mode, the current is measured as before, and the numerical values are plotted in a graph, as on a graphical recorder.

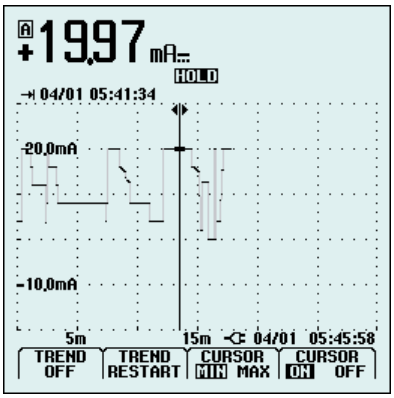

Figure 4 *– TrendPlot makes a graphical recording of the current measurements. Here also an interruption of the current was recorded, inidicating a wiring problem*

In Figure 4 we see a recording that was made over about 18 minutes. In this TrendPlot, we can see the changes of sensor current, and we can see that an interrupt of the current occurred about 16 minutes after the start of the recording, where the current temporarily drops to zero. In the TrendPlot-mode, the instrument automatically compresses the timescale to keep space available to add new measurement results. This way, you can see trends in process parameters that may take a few minutes, or as long as 16 days. When using the Fluke 124, the cursor and the real-time clock can also help you analyze recorded phenomena.

Making the connections

The actual measurement of the control loop current requires you to open up the current loop, and to insert the current meter into it. As the ScopeMeter basically measures voltages, a current shunt should be added to create a low-impedance current input. For that purpose, Fluke offers the CS20MA Current Shunt as an optional accessory. It matches the input connectors of the 120 Series ScopeMeters directly, and accommodates 4 mm banana-plugs as found on standard test leads. The ScopeMeter itself can be set up to work with this shunt, and to take the 10 Ω resistance value into account, as is shown in Figure 5.

If the control loop itself has a fixed resistor included, this may also be used to measure the current, using the STL120 standard test leads. No additional current shunt is then needed.
And because the ScopeMeters are all 2-channel instruments, one can easily measure both a current directly using the shunt and a voltage at some point in the circuit using the test leads, for instance when investigating a suspect component in the loop. Figure 6 gives the correct way of making such a set-up, taking into account the common reference point found on the two inputs.
Once it comes to analysing malfunctioning components, the ScopeMeter also doubles as a component tester, measuring resistors, diodes and capacitors directly.

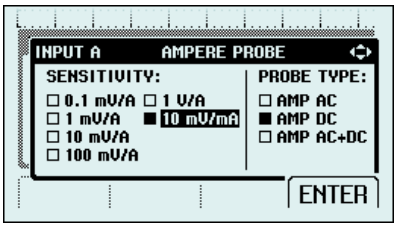

Figure 5 *– When using the CS20MA Current Shunt, the instrument can take the resistance value into account and give the proper current readings automatically*

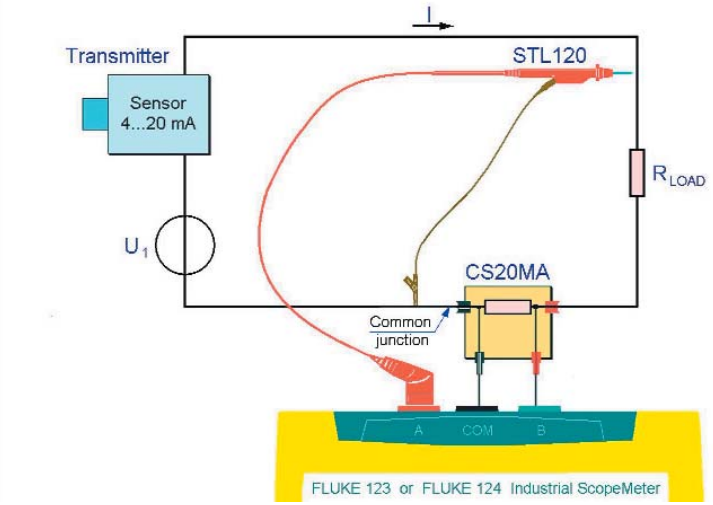

Figure 6 *– Connecting the current sensor CS20MA and a voltage probe to the Fluke 120-series ScopeMeter the proper way, using a common reference junction*

Conclusion

Current controlled loops are widely used in the process industry. Testing the loops during normal operation requires tools that can handle the current levels and that can cover the time spans involved in the process industry. The ScopeMeter 120 Series are compact, handheld test tools that are ideal for the electrical tests of the control loops and of the electronic components found in those loops.

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