

AN-300 Simple Circuit Detects Loss of 4-20 mA Signal

ABSTRACT

Four-to-twenty milliamperere current loops are commonly used in the process control industry. They take advantage of the fact that a remote amplifier can be powered by the same 4-20 mA current that it controls as its output signal, thus using a single pair of wires for signal and power. Circuits for making 4-20 mA transmitters are found in the LM10, LM163, and LH0045 data sheets.

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While you could manually adjust R1 while observing the status of V3 output, this would be a coarse and awkward trim procedure. Figure 2 shows an improved test circuit which servos the current through the detector circuit, forcing it to be at the threshold value. Then that current can be monitored continuously, and the circuit can be trimmed easily. If the current through R107 starts out too small, the output of the 4N28 will be HIGH too much of the time, and the op amp output will integrate upwards until the current is at the actual threshold of the detector. The integrator's output will stop at the value where the duty cycle of the 4N28 output is exactly 50%. This occurs when the current through R107 is straddling the threshold value.

The positive feedback via R108 assures that the loop oscillates at approximately 50 cycles per second, with a small, well-controlled sawtooth wave at its output. This mode of operation was chosen to insure that the loop does not oscillate at some high, uncontrolled frequency, as it would be difficult in that case to be sure the duty cycle was exactly 50%. This test circuit is advantageous, because you can measure the trip point directly.

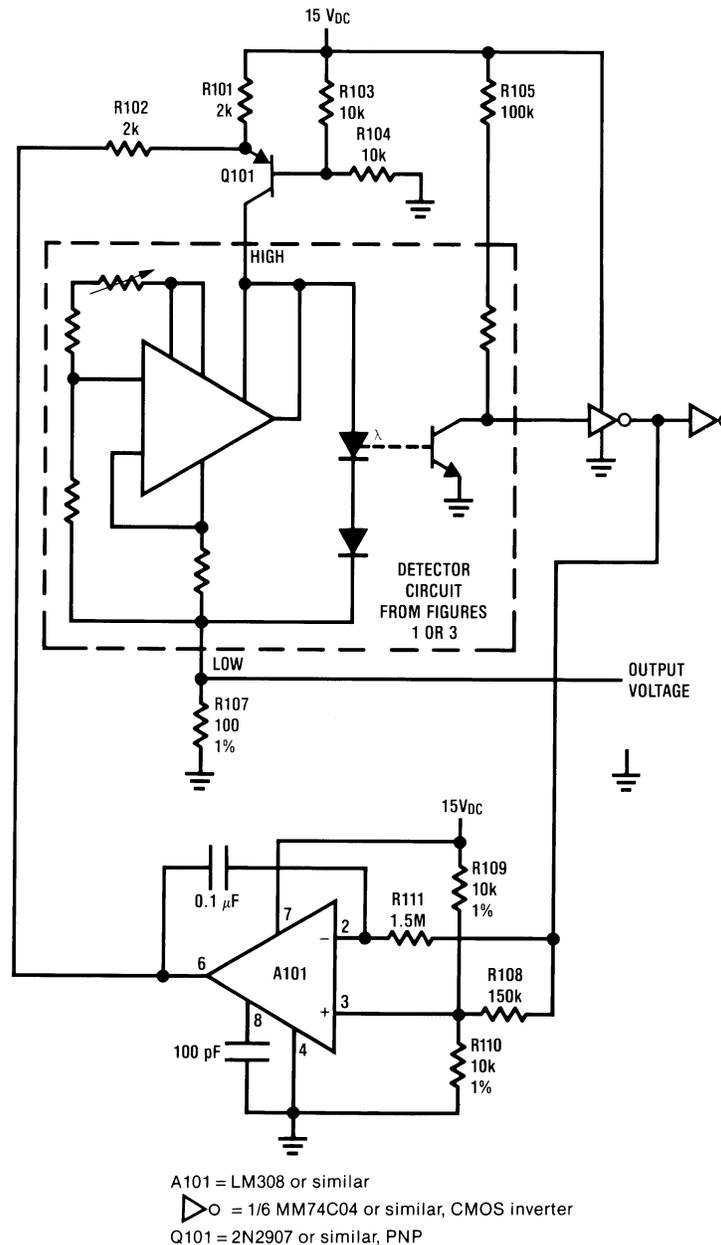


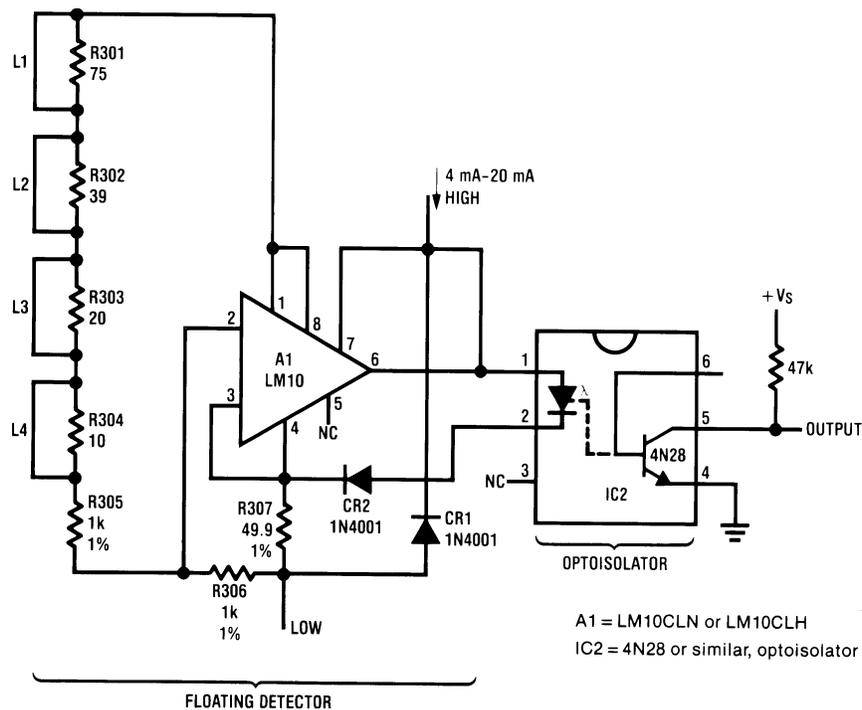
Figure 2. Test Circuit for Threshold Detector

The test circuit of [Figure 2](#) is necessary for trimming the detector in [Figure 3](#). This circuit does not have a trim pot, and thus avoids the problem of someone mis-adjusting the circuit after it is once trimmed correctly. It also avoids the compromises between good but expensive trim pots and cheap but unreliable, drifts trim pots. By opening one or more of the links, L1–L4, according to the following procedure, it is easy to trim the threshold level to be within 1% of 3.70 mA (or as desired).

- Observe the DC current through R107 in [Figure 2](#)
- If $I_{\text{THRESHOLD}}$ is larger than 3.950 mA, open link L1;
 - —if not, don't
- If $I_{\text{THRESHOLD}}$ is larger than 3.830 mA, open link L2;
 - —if not, don't
- If $I_{\text{THRESHOLD}}$ is larger than 3.760 mA, open link L3;
 - —if not, don't
- Then, if $I_{\text{THRESHOLD}}$ is larger than 3.720 mA, open link L4;
 - —if not, don't

This procedure provides a circuit trimmed to much better than 1% of 3.70 mA, without using any trim pots. Of course, this circuit can be used to detect drop-out of regulation of other floating signals, while maintaining high isolation from ground, good accuracy, low power dissipation (2 mA \times 2.5V typical) and low cost.

Other standard values of current loop are 1 mA–5 mA and 10 mA–50 mA. The version shown in [Figure 4](#) uses higher resistance values to trip at 0.85 mA. The circuit in [Figure 5](#) has an additional transistor, to accommodate currents as large as 50 mA without damage or loss of accuracy, and provide an 8.5 mA threshold.



**Figure 3. Fault Detector with Low-Cost Trim Scheme
(To be trimmed in the circuit of [Figure 2](#))**

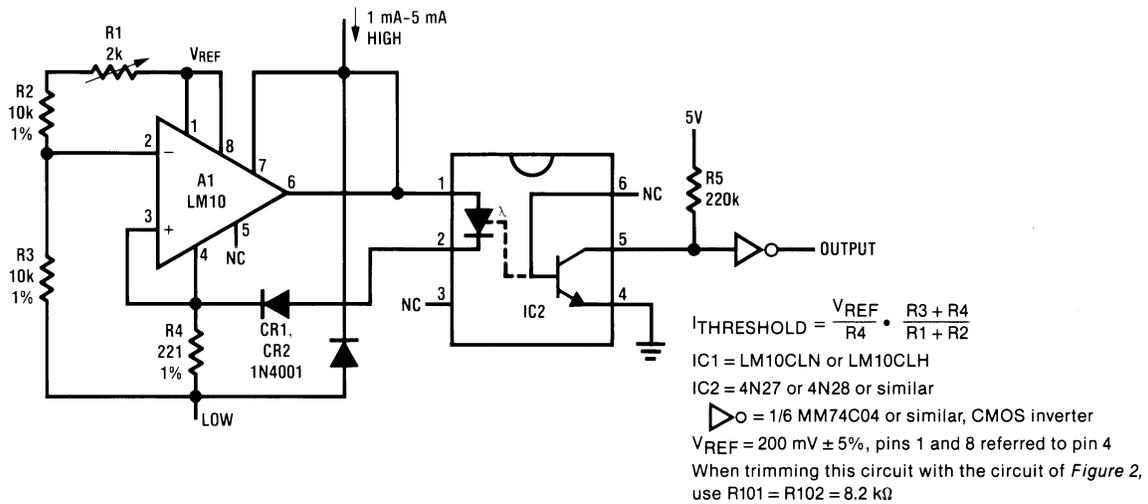


Figure 4. Current Loop Fault Detector
 ($I_{\text{THRESHOLD}} = 0.85 \text{ mA}$ for 1 mA–5 mA Current Loops)

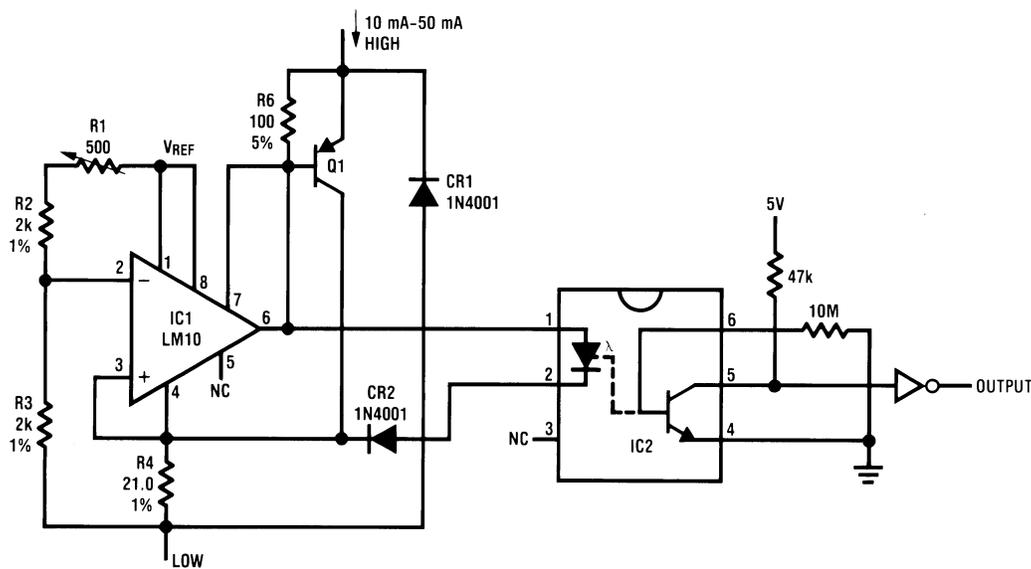


Figure 5. Current Loop Fault Detector
 ($I_{\text{THRESHOLD}} = 8.5 \text{ mA}$, for 10 mA–50 mA Current Loops)

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