The 0- to 20-mA current loop is a reliable means of data communication in industrial applications. These circuits use a precision shunt in the receiver to convert the current signal into a voltage signal. Accidentally connecting the precision shunts to the current-loop power supply can cause damage, after which you must replace the shunt and recalibrate the system. To avoid that expense, you can use a microcontroller-controlled protection circuit (Figure 1).

With conventional techniques, you protect the shunt with a fast fuse or by turning off the loop with an automatic switch, which then turns back on after a specified period. The circuit in Figure 1 provides protection that is much faster than a fuse. IC₁, the slowest device in the circuit, switches off in less than 500 μsec. It offers a higher-precision switching threshold than a fuse, and, of course, there’s no fuse to replace. Rather than making you cycle power to restore the loop, the microcontroller provides control of the protection circuit. The microcontroller also logs the event, thereby providing a record that the system invoked the protection circuit.

The protection circuit has virtually no effect on the analog front end. The IC₂ buffer ensures an input current of less than 30 pA. The on-resistance of IC₁ is less than 2Ω. The circuit needs no additional isolated data channels or microcontroller-I/O ports, and it prevents damage during system installation or repair. It also turns off the loop after power-up and when no power is available.

You implement the protection algorithm with a power-fail comparator and a watchdog circuit, available as separate outputs on IC₃, together with IC₆, a D-type flip-flop.

At power-up, the flip-flop is in the reset state, and the current loop is open, due to a high-level reset signal from IC₃, driving IC₄, a NOR gate. After the first low-to-high transition on the SCK (clock-signal) line, a rising edge from IC₃’s WDQ (watchdog output) sets the flip-flop and pulls current through the solid-state relay, IC₁, thus connecting the input to the loop.

In the event of a loop-current overload greater than 27 mA, a high level from the PFC (power-fail-output) comparator on IC₃ resets the flip-flop and switches off IC₁. Thanks to the IC₅ gate, the microcontroller inputs ones at the MISO (master input/slave output), meaning overcurrent.

To again switch on the loop, the microcontroller must stop the SCK line for at least 2.4 sec. The next low-to-high transition on SCK then reconnects the current loop.