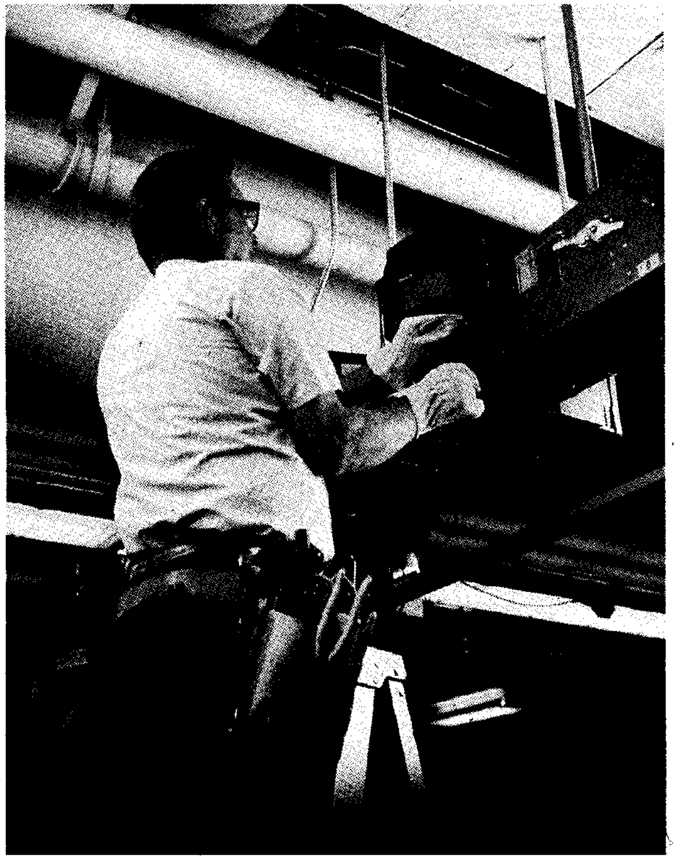

***When industrial control systems go wrong, grab a portable scope, and start troubleshooting!***

VAUGHN D. MARTIN

# Troubleshooting PLC Problems

ALL KINDS OF INDUSTRIAL PROCESSES are controlled electronically these days. The most common control device that an industrial technician is likely to encounter is the programmable logic controller (PLC). Troubleshooting PLC's can be tricky. However, when part of a manufacturing operation is shut down, the technician is under tremendous pressure to isolate the problem, fix it, and get the system up and running again. Last month's article, "All About PLC's", explained how PLCs work and how they are used. This article examines some real-world examples of PLC problems and how they are solved.

A portable oscilloscope is the most important instrument to have when troubleshooting industrial systems on the factory floor. New technology has reduced both the size and weight of the required test gear. For example, the Tektronix TekMeter is a dual-channel, auto-ranging portable scope plus a true rms multimeter in a compact lightweight package with an LCD screen. Although this article references the TekMeter exclusively, it is only one of a growing number of portable instruments in a competitive market. Fluke, for example, offers similar instruments that also target industrial technicians and engineers.

Most PLCs in industrial applications incorporate a variety of self-test features that verify correct sensor operation. However, they are not foolproof. Many electrical malfunctions can be solved only by using an oscilloscope together with your eyes. Take, for example, this case history where an optical sensor was used to count items passing over a conveyor belt.

### Too many counts

Figure 1 is a diagram of the packaging operation in which cans were counted as they travelled along a conveyer belt. As each can passed through the optical detector, it produced a pulse that was fed into a PLC's digital input port. The sensor output delivered one pulse for each can that passed by, providing an accurate cumulative total of the number of items.

When the new line was set into operation, it was expected to process 100 cans per minute, or 48,000 cans per eight-hour shift (100 cans per minute times 60 minutes per hour times 8 hours per shift = 48,000 cans.) However, at the end of the shift, the system had counted 50,000 cans, according to the PLC logging function. Nevertheless, there were exactly 2000, 24-can cases, verifying the original 48,000-can computation. Obviously, either the PLC counting program had been incorrectly programmed or the sensor input was receiving pulses for cans that weren't there.

The first step in troubleshooting was to check the counting program by connecting a pulse generator to the PLC input as in Fig. 2, and setting it to generate exactly 10 pulses. An oscilloscope was then connected across the pulse generator to verify proper operation. It showed 10 pulses, and the PLC logging program showed 10 counts. That indicated that the PLC program was probably not at fault, and pointed instead to the sensor or its cabling.

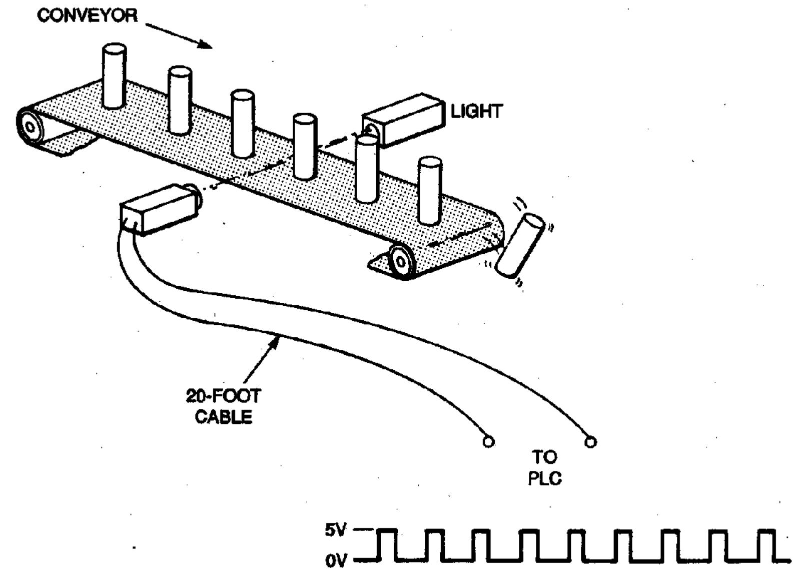


**FIG. 1—TYPICAL OPTICAL SENSOR SET UP TO COUNT items as they travel along a production line.**

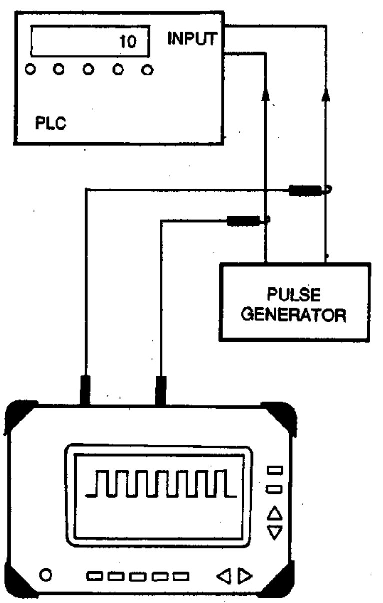


**FIG. 2—THIS INSTRUMENT HOOKUP is used to detect the extra, erroneous counts.**

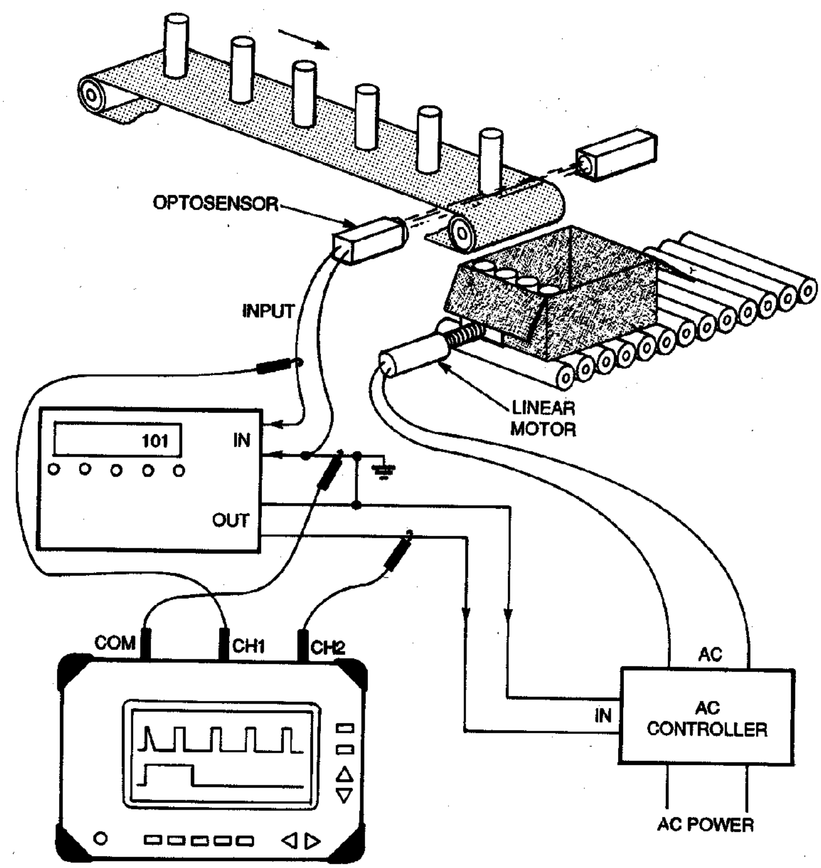


**FIG. 3—TROUBLESHOOTING THE PLC CONTROLLER. Connections between the PLC and the process are shown. We can also see how the scope was used to monitor the system.**

## Examining the evidence

Since more cans were counted than were packed, it seemed that some stray pulses had slipped into the optical sensor cable that fed the PLC input. Some 2000 stray pulses, to be exact (50,000 − 48,000). That number proved to be a clue in itself because a little deduction showed that it wasn't a random number. Divide the number of expected cans by the excess pulse error count (48,000 ÷ 2000) and the result is 24. That didn't seem to mean anything at first, but it was the exact number of cans that are in each carton. So now we decided to examine if anything happened in the process only once each carton-filling cycle. We noticed that a small linear motor was energized after each carton was filled to push the carton off the conveyor belt and onto a sealing roller line. Naturally, our investigation then turned to this new suspect.

We reconnected the PLC to the process line and the optical sensor, and connected our scope's channel 1 (CH1) input to the optical sensor output. Then we connected the scope's channel 2 (CH2) input to the linear push motor's control line (ahead of the AC relay or triac controller) as shown in Fig. 3. Then we started the line and set the scope's trigger for the positive edge on CH2; the resulting waveform is shown in Fig. 4. What we discovered is that a stray pulse was being inserted into the optical sensor line each time the linear push motor was activated. Not only did the heightened pulse look different from the can-count pulses, it had a different timing delay than that of the 100 can-per-second pulses. But the PLC logged the pulse just as though there were a 25th can in each box.

### Diagnose the problem

Using the same scope connections, with the line still running, we attempted to eliminate the extraneous pulse. As we examined the physical layout of the plant floor, we found that the optical sensor cable passed by and directly over the housing of the linear motor. Immediately we suspected that magnetic coupling between the motor and the sensor output line leading to the PLC was causing the extra pulse. As we watched the scope display we tried rerouting the sensor cable. As we did so we noted that the decaying pulse on the sensor line disappeard, eliminating the problem. Then we had a fully operational—and correctly functioning—packing line.

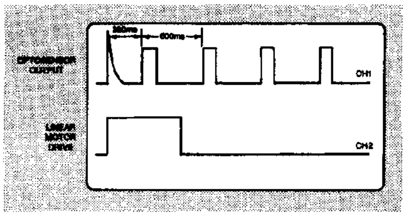


**FIG. 4—WAVEFORMS ON THE SCOPE SCREEN quickly identified the problem as an extra spurious pulse.**

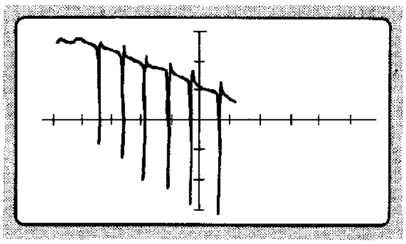

**FIG. 5—WAVEFORM OF THE COOL-DOWN thermal output as it appeared on the scope display.**

### Taking the heat off

Another case history where an oscilloscope saved the day was in solving a problem in an annealing furnace. It had been producing perfect coil springs for two months, but it suddenly began producing weak springs that failed and were being returned by customers as defective. Quality control verified the problem, and they agreed: The springs were weak and lacking proper tensile strength. We immediately suspected some change in the cycle of the annealing furnace. We looked back at the annealing logs for the past few weeks and found that the annealing cycle had been shortened from the original 18 hours to 16 hours. The log revealed that the two-hour change took place during the night when no workers were in the plant, and no one noticed the change. When the crew arrived the next morning they incorrectly assumed that the coils had been properly tempered overnight.

### Checking out timers

This time there were two puzzles to solve. First we had to find out why the process failed. Then we had to reset the PLC to provide the correct timing cycle. Most of the cycle was controlled by timers. The only exception was the cooling phase, in which the coils remained in the oven until they cooled to less than 400 degrees Fahrenheit.

Obviously, we checked the timers first, and found that they were all operating correctly. That pointed to a possible cool-down cycle problem. As we examined the PLC operating logs from the past two-week's cool-down cycles, we found that cool-downs were running only about one to two hours, or two hours shorter than what would be normal. Aha! That is where the problem was hiding!

Since we knew that the cool-down time was controlled by the thermocouple reading, we connected a portable scope to the PLC thermocouple input and watched as the furnace switched from its soak to its cool-down phase.

We connected the scope's CH1 to the thermocouple output, selected the autorange mode, and set the sweep to its slowest speed—1 minute per division on the TekMeter. This made ten minutes of cool-down visible at any time. After about six minutes of cool-down we saw the scope trace in Fig. 5. The spikes on the line were abnormal, so we watched closely and noticed that they occurred about once

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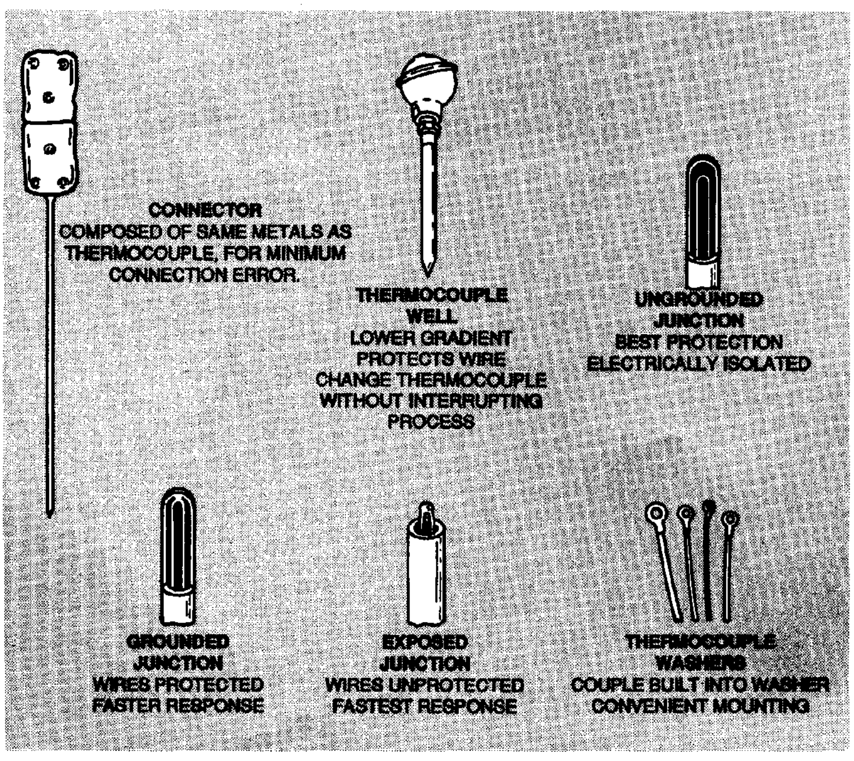
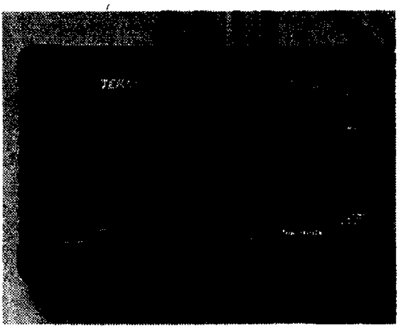



**FIG. 6—TYPICAL THERMOCOUPLE CONFIGURATIONS that we will encounter in industrial applications.**

## TROUBLESHOOTING

*continued from page 38*

each minute. As we listened to the machinery and watched the pulses, we heard a cooling fan switching just as each new spike occurred. Then we realized that the problem was the spike. It was fooling the PLC, and making it think that the temperature had dropped below threshold during one of the spikes, when the temperature dropped near 400 degrees.



**THE TEKMETER saved the day!**

### Now it's so obvious

A visual inspection of the thermocouple cables revealed that a portion of its shield had been worn away because of the vibration of a nearby cooling fan. Figure 6 shows some typical thermocouple hardware for those who are not already familiar with them. Replacing the cable got the annealing cycle back to normal, and the springs were springy again! We and our portable scope found and eliminated a costly factory problem.

The preceding examples illustrate just a few of the ways that a portable scope can be used to find and cure factory process problems. In addition to these simple cases, we can use the DVM and oscilloscope functions to find power-quality problems caused by dirty AC, bad power factors, and unbalanced phase power. We can also evaluate SCR- and triac-based motor controls for voltage, phase, and frequency conditions, factors governing efficiency. Finally, we can detect and cure sensor signal degradation with the simplicity of using a pocket DMM. Ω