Pulse-width triggering with the Fluke 190 Series® ScopeMeter Test Tools

Application Note

Glitches. Timing jitters. System crashes. They're the bane of a field service engineer's existence, devilish problems that can hide in a network just out of reach of a conventional test tool. Sometimes you need a tool with a little something extra.

You need pulse-width triggering. Pulse-width triggering, sometimes called time-qualified triggering or glitch triggering, moves beyond measuring the edge of a pulse. It's a powerful way to capture a specific positive or negative pulse by triggering on the pulse duration rather than on its edge. That's important. In a logic circuit, for example, a glitch—say, a pulse much faster than the clock pulse—can be a serious source of problems. Measuring the edge simply isn't enough. The ability to trigger uniquely on the glitch, investigate what generated it and determine its effect on the rest of the system—all possible with pulse-width triggering—provides important diagnostic information.

Whether it's an error of synchronous logic, problems with a rotary encoder or a serial data transmission error, oscilloscopes with pulse-width triggering capability such as the powerful, handheld ScopeMeter® 190 Series help service technicians ferret out even the most troublesome buried problems. Handheld scopes offering pulse-width triggering are still a rarity, but because field service engineers are just as likely to need this capability as laboratory-based engineers, Fluke included pulse-width triggering in its advanced ScopeMeter 190 Series portable oscilloscope.

The ability to trigger uniquely on the glitch, investigate what generated it and determine its effect on the rest of the system provides the service engineer with an important diagnostic tool. In addition to glitches, many timing problems in circuits are caused by pulses that appear too long (which can, for example, indicate a missing pulse). To capture these, you can set a scope with pulse-width triggering capabilities to trigger on pulses longer than a given duration. Triggering on a long pulse also is useful in many bus protocols where a long pulse often occurs at the beginning of a data stream.

To contend with all likely eventualities, the pulse-width triggering function on the ScopeMeter 190 Series offers four time qualifiers: 'less than' ($< t$), 'greater than' ($> t$), 'equal to' ($= t$) and 'not equal to' ($\neq t$), where the time interval is selectable in minimum steps of 0.01 divisions or 50 ns. The scopes also offer a time delay of nine div pre-triggering and 1000 div post triggering. To be able to set the correct triggering conditions, however, it's necessary to know something about the signal you are looking for, such as the likely pulse duration, or whether the condition you're investigating is likely to lead to a glitch or a pulse longer than the normal signal (Figures 1 and 2).

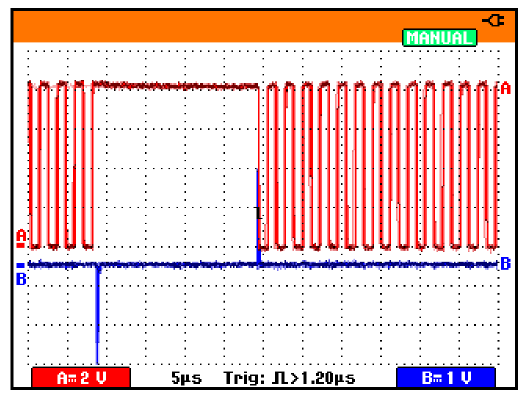

Figure 1. In this CMOS design, a 450 kHz control signal was showing irregular interruptions. It was found that the interruptions originated in a multiplexer that opened at incorrect times as the result of crosstalk. The red trace (top) shows the 450 kHz signal with the interruption. The blue trace (bottom) shows the crosstalk causing the incorrect switch operation. The oscilloscope was triggered on the signal interruption, which can be seen as a pulse much wider in duration than those building the desired signal. The 450 kHz squarewave comes with a pulsewidth of approximately 1.1 ms, therefore trigger set-up was chosen to trigger on pulses > 1.2 ms in duration, identifying erroneous pulses. Using pulsewidth triggering was vital to isolate the signal interruption from the main signal.

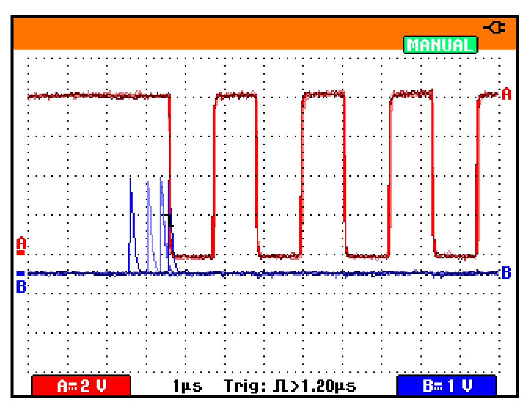

Figure 2. When using a higher timebase speed, it is obvious that the crosstalk is caused by a sub-system that is not in sync with the 450 kHz control signal. Thanks to Persistence mode, successive pulses are shown in a similar fashion as on an analog oscilloscope with display persistence.

Tracing errors in synchronous logic

A typical problem with synchronous logic systems is an unexpected timing delay caused by slow peripheral components in the signal path. On a microprocessor board, for example, a single clock controls all timing functions. Two clock-derived pulses passing simultaneously through a gate should generate an output pulse in sync with the clock pulse. Any unexpected delay in one of the signals caused by a faulty component or, even worse, by poor design, may result in an output pulse much shorter in duration than the clock pulse. This can lead to all manner of timing problems later in the circuit. If this type of problem is suspected, the ScopeMeter can be set to trigger on pulses shorter than the system's clock pulse. For example, with a clock pulse of 1 µs, setting the time qualifier on one channel of the ScopeMeter to trigger on $t < 1$ µs will reveal any signal parts, like glitches, that could be causing unexpected circuit behavior. You then can set the instrument's second channel to monitor other parts of the logic circuitry to determine which components are causing the glitch. What's more, the ScopeMeter's 9 x 12 divisions pre-trigger view and 1,000 divisions post-trigger view allow all circumstances surrounding the event to be captured and analyzed with excellent time resolution. And its proprietary *capture and replay* feature automatically records the event to allow the entire scenario to be played back later when perhaps there is more time to analyze the problem (Figure 3).

Keeping numerically-controlled machinery up and running

Rotary encoders are an essential element in virtually all numerically controlled industrial equipment and a potential source of trouble. The encoders are usually magnetic or optical; such as two sets of apertures positioned at right angles in a rotating drum, and the distance between the pulses generated is a direct measure of rotational speed. In some systems, the rotational motion is translated into linear motion. The encoder then provides a highly accurate measure of linear displacement. Such systems are found, for example, in precision grinding equipment for grinding the thickness of silicon wafers to within micron accuracy. The pulses from the rotary encoder are transmitted to a *positioning unit*, in effect an electronic pulse counter that counts down to a set point defined by, for example, a microcontroller or PLC. This controls the displacement of the movable machine parts and returns them to the zero position each time the set point is reached.

Trouble arises if dirt entering the system causes bad magnetic contact or, in the case of an optical encoder, blocks one or more of the apertures in the rotating drum. The missing pulses that result will lead to the transmission of erroneous data to the PLC with possibly catastrophic results. In the wafer grinder, for instance, missing pulses will cause the grinding tool to advance beyond its maximum limit, resulting in wafers that are too thin.

Detecting encoder errors is relatively easy using the ScopeMeter's pulse-width triggering function. A missing negative pulse can be interpreted as an abnormally long positive pulse, so you only need to set the time qualifier on one channel to trigger on positive pulses of durations longer than the expected pulse interval. In this case, it's only necessary to monitor the signals on the data bus between the encoder and the positioning unit to immediately reveal any decoder errors likely to cause equipment malfunction (Figures 4 and 5).

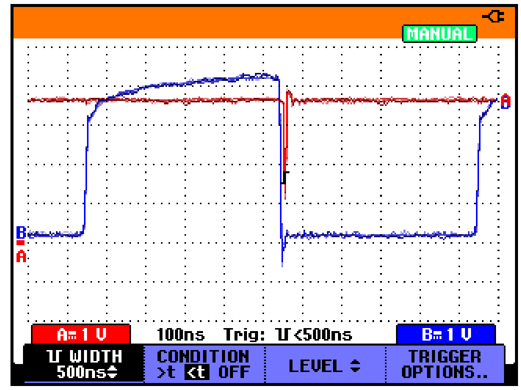

Figure 3. A pulse shorter than the clock pulse, captured using the ScopeMeter's pulse-width trigger function, is a sure sign that at least one peripheral component in this logic circuit is not operating correctly. The oscilloscope was triggered on negative going pulses shorter in duration than the system clock pulse of 500 ns.

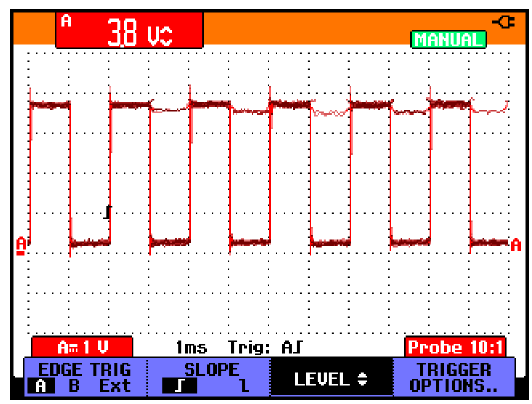

Figure 4. The output pulses from this rotary encoder show that the signal isn't a consistent squarewave, meaning some pulses have incorrect pulsewidth. The exact duration cannot be determined, though, due to waveform overlapping. Digital Persistence mode was used to capture signal anomalies over a longer timeframe.

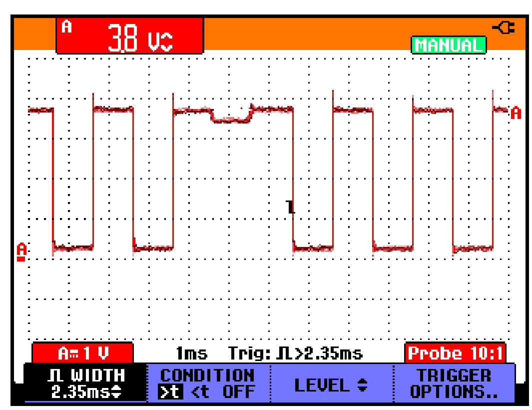

Figure 5. By selecting pulse width, triggering on pulses wider in duration than a normal encoder pulse, the signal demonstrates that occasionally an encoder 'slot' is overseen – leading to incorrect positioning information.

Serial data transmission errors

Errors in serial data transmission between a microcontroller and its peripherals are sometimes hard to pin down since they may be due to a faulty component, erroneous data generated by the microcontroller, or even errors on the serial data bus itself. Data streams transmitted by the bus comprise, in effect, a series of digital instructions plus the address of the peripheral device to which these instructions relate. An error in the instructions or address, such as incorrect logic levels or pulse lengths, will therefore result in the peripheral responding incorrectly or not at all.

Using the ScopeMeter's 'equal to'; i.e., t = xxx s PWT time qualifier and knowledge of the timing and communications protocol of the microcontroller and peripherals (from published specifications), the ScopeMeter can be set to trigger on the data stream's leading pulse (Figure 6).

While there's little doubt that a serial data analyzer would do this job more easily, specialized instruments like this aren't widely available outside development labs. So, this example provides a further illustration of the ScopeMeter 190 Series' incredible versatility and why it's fast becoming an indispensable tool for today's field service engineers.

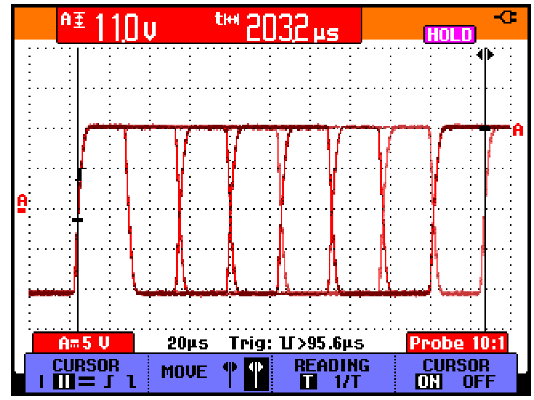

Figure 6. Using pulse-width triggering on the ScopeMeter 190C to analyze the signal quality on an RS-232 communication link. The scope was set up to trigger on the signal space preceding the data words. Using the cursors, the baudrate can easily be determined: it took 203 ms to transmit 8 bits, which equals 25.4 ms/bit. This equals a 39.4 kb/s baudrate.

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