

Pulse-width triggering with the Fluke Color ScopeMeter®

Application Note

With its advanced pulse-width triggering capabilities, the Color ScopeMeter 190C handheld oscilloscope series from Fluke puts all the diagnostic power of a top-flight bench-top instrument into the hands of today's field service engineers. In this Application Note it will be explained how pulse-width triggering can be used to diagnose a host of problems that simple edge triggering is unable to handle.

To capture events such as glitches, missing bits, timing jitter, system crashes and network problems, an oscilloscope needs much more sophisticated triggering capabilities than are found in conventional instruments. Yet even with today's highly sophisticated scopes, most dual-channel instruments offer only an edge-triggering function, and the handheld scope offering a more advanced *pulse-width triggering* capability is still a rarity. Appreciating that field service engineers are just as likely to need this capability as laboratory-based engineers, Fluke incorporated it into the advanced Color ScopeMeter 190C handheld oscilloscope series.

Pulse-width triggering (PWT), sometimes called *time-qualified triggering* or *glitch triggering*, is a powerful means of capturing a specific positive- or negative-going pulse by trig-

gering on the pulse duration rather than on the edge of a pulse. In a logic circuit, for example, a glitch (i.e. a pulse much faster than the clock pulse) can be a serious source of problems. 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.

Besides 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 the scope to trigger on pulses longer than a given duration. Triggering on a long pulse is also 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 Color ScopeMeter 190C 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 scope also offers a time delay of 12 div pre-triggering and 1000 div post-triggering. To be able to set the right triggering conditions, however, it's necessary to know something of the signal you are looking for, i.e. 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.

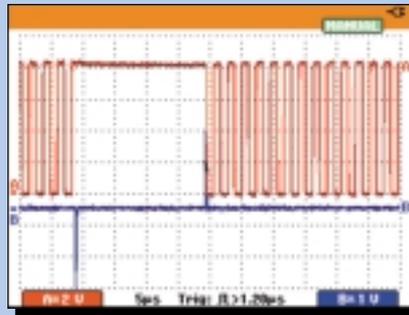


Figure 1

In this CMOS design, a 450 kHz control signal showed irregular interruptions. It was found that the interruptions originated in a multiplexer that, due to crosstalk, opened at incorrect points in time. 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 square wave comes with a pulse width of approximately 1.1 μ s, therefore trigger setup was chosen to trigger on pulses $>1.2 \mu$ s duration, identifying erroneous pulses. Here, pulse width triggering was vital to isolate the signal interruption from the main signal.

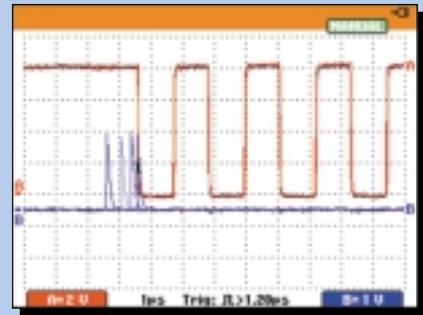


Figure 2

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 the ScopeMeter's Digital Persistence mode, successive pulses are shown in a similar fashion as on an analog oscilloscope with display persistence.

Tracing errors in synchronous logic

Typical problems that occur in synchronous logic systems are unexpected timing delays 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 say 1 μ s, setting the time qualifier on one channel of the ScopeMeter to trigger on $t < 1 \mu$ s will reveal any signal parts, like glitches, that could be causing unexpected circuit behaviour. You can then 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 12 divisions pre-trigger view and 1000 divisions post-trigger

view allows the whole circumstances surrounding the event to be captured and analyzed with excellent time resolution. And its proprietary *capture and replay* feature automatically stores copies of 100 screens exactly as these are displayed, providing the opportunity to 're-live' the last 100 recordings of disruptions or glitches.

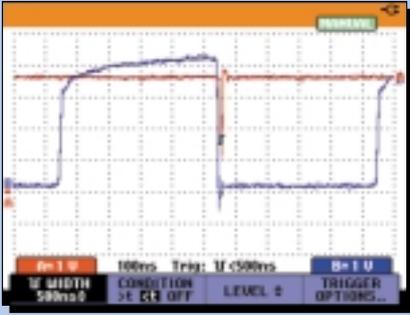


Figure 3

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.

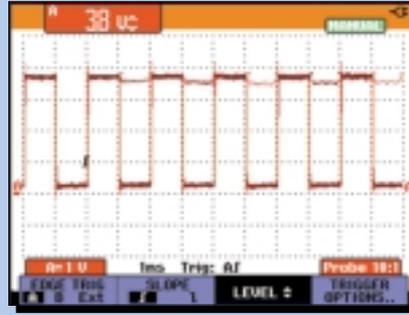


Figure 4

The output pulses from this rotary encoder shows that the signal isn't a consistent square wave – meaning some pulses have incorrect pulse width. The exact duration cannot be determined, however, owing to waveforms overlapping. The Digital Persistence mode was used to capture signal anomalies over a longer timeframe.

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 duration 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.

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 (e.g. 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 and 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 accuracies. 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 (e.g. the grinding head) and returns them to the zero position each time the set point is reached. Trouble comes 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

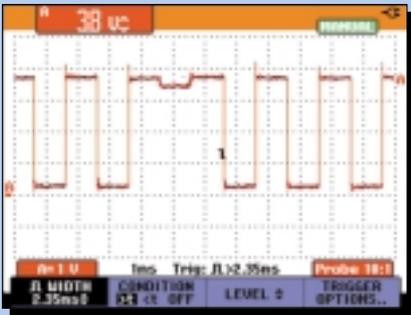


Figure 5

By selecting pulse-width triggering on pulses wider in duration than a normal encoder pulse, it can be seen that occasionally an encoder 'slot' is overseen – leading to incorrect positioning information.

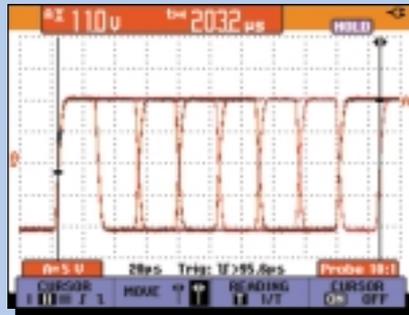


Figure 6

Using pulse-width triggering on the Color 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 baud rate can easily be determined: it took 203 µs to transmit 8 bits, which equals about 25 µs/bit. This corresponds with a 38k4 b/s baud rate.

Serial data transmission errors

Errors in serial data transmission between say 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 e.g. 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.

Whilst 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 Color ScopeMeter 190C's incredible versatility and why it's fast becoming an indispensable tool for today's field service engineers.

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