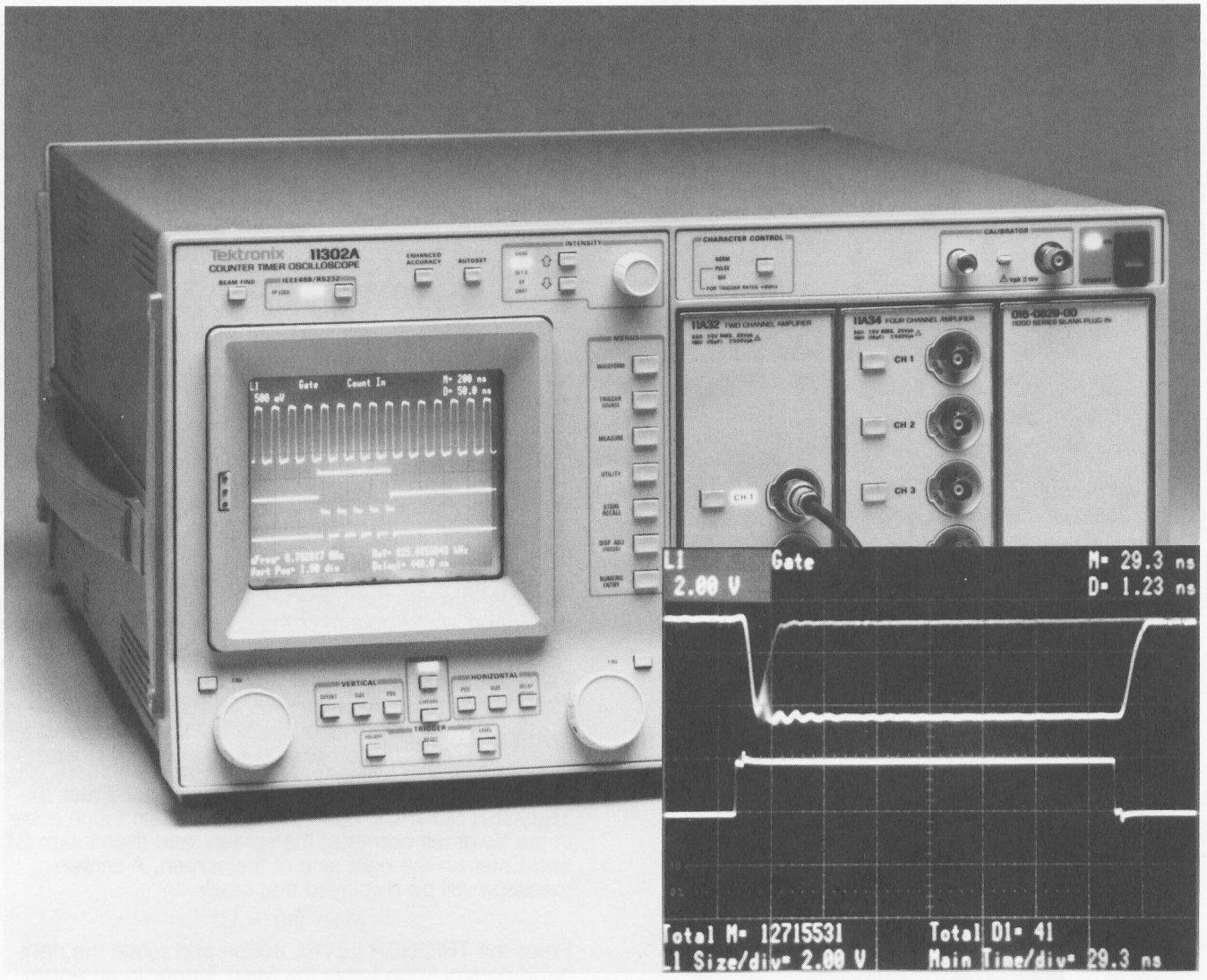
TROUBLESHOOTING METASTABLE EVENTS USING THE GATED TOTALIZE COUNTER FEATURE OF THE TEKTRONIX 11300A SERIES OSCILLOSCOPE



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Metastable Events

One of the toughest kinds of faults to troubleshoot in digital logic is intermittent component failures or other factors that result in "metastable events" — erroneous, random transitions in logic levels. Metastable events may be most familiar in data communications, where they can be triggered by noise, but they can also corrupt signals on memory and control buses and can create anomalous behavior in any kind of digital circuit. The problem in troubleshooting them is that their unpredictability makes them difficult even to see, much less to quantify.

The unique combination of a micro-channel plate (MCP) CRT and gated counting capability in Tektronix' Model 11302A Counter/Timer Oscilloscope provides engineers with a new tool with which to study and measure metastable events.

Both of these features play important roles. The MCP display has sufficient writing speed (about 1000 times brighter than a conventional CRT) to show very fast single-shot events brightly enough for viewing in normal room lighting. Yet the brightness saturates at a level that allows these events to be seen in the presence of repetitive signals. This helps you to isolate the context in which the event is occurring. Figure 1 is a multi-sweep CRT photograph of a single metastable event occurring in the middle of a string of pulses.

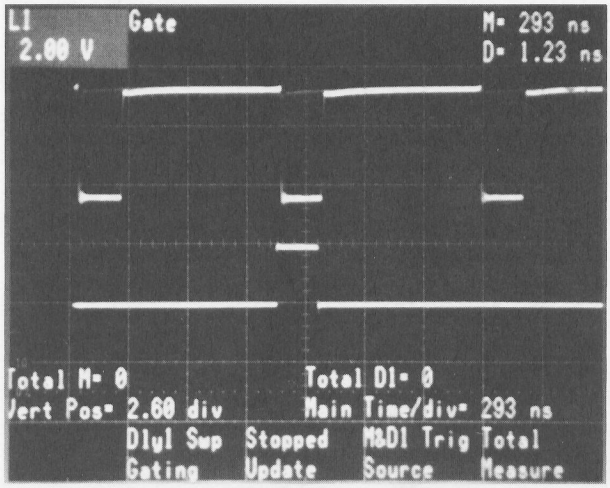

Figure 1. Faulty flip-flop failing to latch in low state (upper trace) as evidenced by the thin trace between two normal highs. To measure these metastable events, use gated totalize mode, position the counter gate so it starts before the normal negative transition and ends before the normal positive transition.

Because the scope's internal counter can be "gated" to count only events in predetermined time windows, it is possible to totalize the number of metastable events over a given time period. Counting metastable events can be useful in isolating a bad component, because you can see whether the number of events increases or decreases when you change the component temperatures or other stresses in a suspect component for example.

Before Tek's 11300A Series scopes, with their integrated 750 MHz 10 digit precision counters, gated measurements were difficult to make because you had to use additional test equipment including a separate oscilloscope to supply and synchronize the necessary external gate. Now, only a single piece of test equipment is required. Further, because all of the 11302A Oscilloscope's controls are visible to the operator, there are minimal risk of operator error in setting up the measurement.

Finally, the 11300A Series scopes enable you to store test setups and to automate both the control and data recording measured at the test station. This can be done with an inexpensive personal computer linked by either the GPIB bus or an RS-232 serial port. This setup enables you to "can" a test procedure that can be later carried out by relatively inexperienced personnel.

Connecting the Scope to the Circuit under Test

Plug-in bays in the Tek 11302A Oscilloscope are designated L, C, and R, for Left, Center and Right, and vertical amplifier channels are designated numerically. Thus channel L1 refers to channel 1 of the vertical amplifier in the leftmost bay, C1 refers to channel 1 of the amplifier in the center bay, etc. Assume for this test that you will be using cannel L1 on selected test points and that channel C1 will be connected to the circuit clock in order to provide a stable trigger.

For initial setup, connect both probes to the clock signal. Initialize the scope from the Utility Menu by pressing the Init button. Once the scope has been initialized, turn the Utility Menu off and Autoset the scope either by pushing the buttons at the probe tips or by pressing the Channel L1 and Autoset buttons and then the Channel C1 and Autoset buttons.

When the "Autoset Complete" message appears on the screen, press the Vertical Size and C1 buttons, and rotate the left-hand knob to set the clock signal display to a convenient amplitude. Then press the Vertical Pos button and rotate the same knob until the waveform is positioned at the bottom of the screen.

Repeat this procedure to position to L1 signal near the top of the display. Then rotate the right-hand control knob to set the Main Time/div to a convenient setting.

Setting the Trigger

Now that both signals are displayed on the screen, you must direct the C1 signal to the main trigger. Press the TRIGGER SOURCE button, touch the Main touch zone in the lower left corner of the screen, and then touch C1 and Enter on the right side of the screen. A screen message will be displayed that reads,

Main Trig = C1

Press the TRIGGER LEVEL button and rotate the right-hand control knob to set the Main Trigger to an appropriate level. If necessary, touch the Slope touch zone to set the trigger slope to positive (+) or negative (–).

Remove the Trigger Source menu from the screen by pressing the TRIGGER SOURCE button again.

Bright Display Simplifies Snooping

At this point, you are ready to start "snooping" for metastable events. This is largely a matter of intelligent probing. You'll have to understand how the circuit under test operates, and you'll have to know the conditions under which the fault occurs. This means that you may have to set up the test conditions so that the same event occurs repetitively. Doing this may be fairly simple. For example, you might press a computer keyboard key repeatedly while looking for key bounce. Alternatively, it may take some planning. If you were looking for glitches on a memory bus, for instance, you might have to write a short program that repeatedly reads or writes to a file.

Once you have found an abnormal event, try to follow it backward through the circuit, using your schematic. The stage in which you have found it may not be the stage in which it is generated.

To help you see these infrequent events, increase the CRT brightness. This will produce a rather bright display of the repetitive waveforms, but it will not harm the CRT. The scope has protective circuitry that will shut down the CRT before damage occurs. (Even so, don't make a habit of going off for coffee with the brightness at maximum, or you will reduce the useful life of the tube.)

With a bright display, it should easily be possible to observe metastable events as signal transitions that occur randomly in between repetitive transitions. Once you have found such an event and traced it back as closely as possible to its source, you will want to count how often these events occur.

Counting Metastable Events

Press the Counter button and tap the Measure touch zone on the screen until it reads "Counter" and touch the Gating touch zone to set it to "Dly1 Swp Gating". The size and position of the gate signal are controlled by the size and position of the delayed sweep. Set source to M & D1 Trig.

Press the Waveform menu button, and touch the following in this order: View; Gate; and Enter. You will now have a second trace, with a positive gate positioned at the left edge. Now press the Waveform button again to remove the menu.

Press the Horizontal Size button and touch the "Time Base" touch zone until it reads Dly'd Time Base, then rotate the right-hand control knob to position the gate to the time interval in which the event occurs. Use the left-hand control knob to increase or decrease the gate width. Your objective should be to position the left edge of the gate just before the last transition before the metastable event occurs, and the right edge of the gate just before the next transition, as in Figure 2. That way, metastable events will be counted only during the gated period.

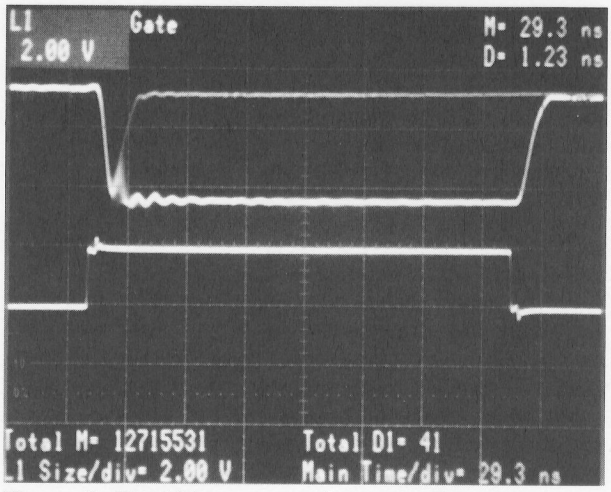

Figure 2. Total M are normal events. Total D1 are metastable events.

With the main trigger set to – slope (to totalize normal events), and the delayed trigger set to + slope (to totalize metastable events), run the counter briefly. The ratio of normal events to metastable events can be calculated from the M and D1 totals, in this case

$$\frac{12715531}{41} = \text{one metastable event per 310134 normal events.}$$

Now you can quantify the signal quality. You will be able to see the effect that changes have to your devise under test have.

The Tektronix 11302A Oscilloscope simplifies the troubleshooting of metastable events. Its MCP CRT makes it easy to see these glitches against a background of regular pulses, and its gated counter makes it possible to count them.

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