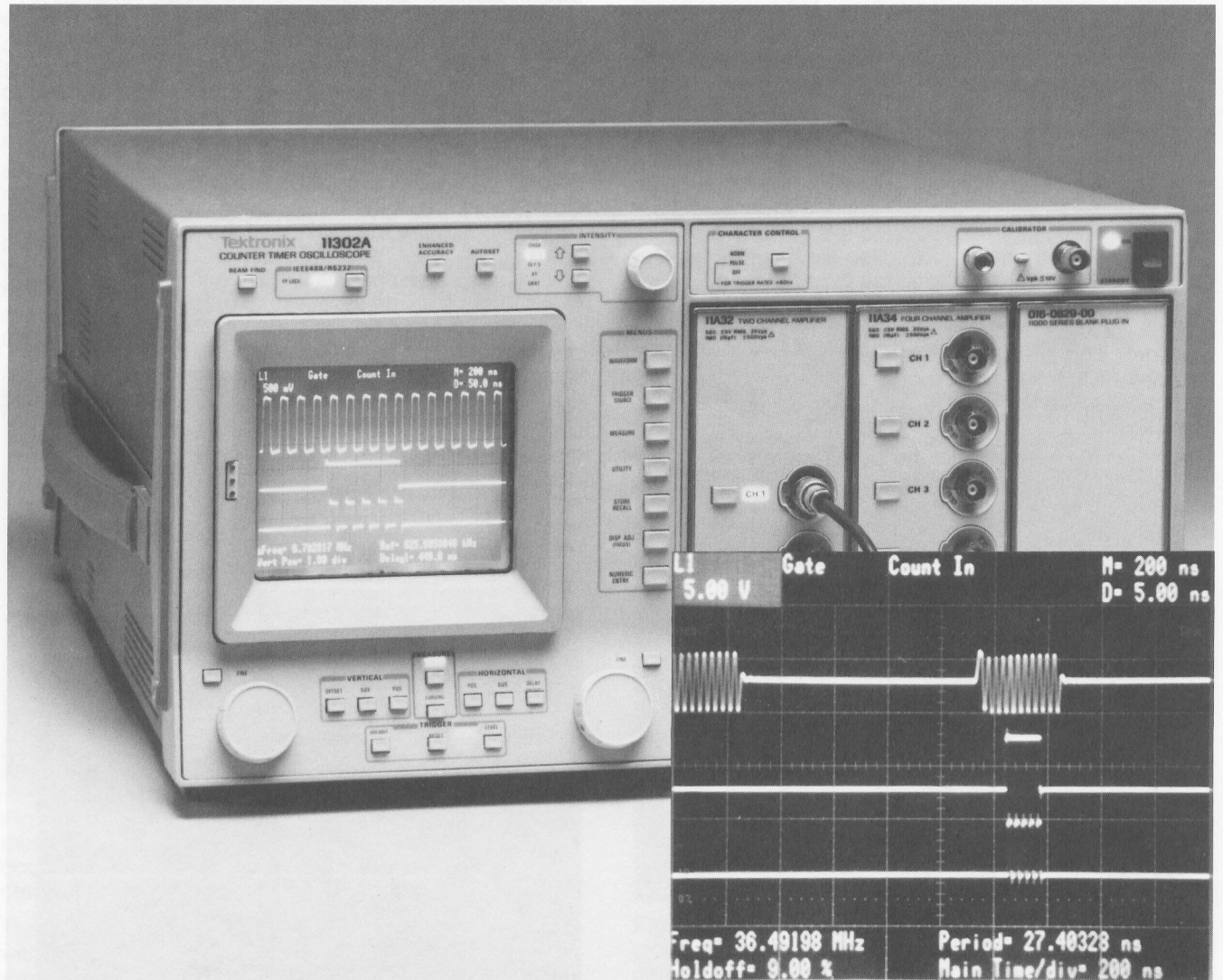


DELTA FREQUENCY MEASUREMENTS WITH THE TEK 11300A SERIES OSCILLOSCOPES



Tektronix' 11300A Series Oscilloscopes' gated frequency measurement capabilities enables you to select, isolate and measure any selected pulse or burst in a complex sequence of events. With their built-in 750 MHz 10 digit precision counter/frequency measurement capabilities, these oscilloscopes enable single-instrument test setups to replace the gated counter and oscilloscope combinations that were previously required for such measurements. Such test setups were unwieldy at best and sometimes gave inaccurate results because it was difficult to determine the exact event measured by the counter. Using the precision timing capabilities of the 11300A Series oscilloscopes virtually eliminates ambiguities.

Because the 11300A Oscilloscopes integrate the controls for both the counter and the gating into one instrument, and because all of the controls are visible to the operator, there is far less risk of operator error in setting up the gating of the counter. And because results can be averaged over thousands, or even millions of repetitions, very high resolution can be achieved.

The ability to store specific test setups in memory and to automate both the control and the data recording measured at the test station on inexpensive micro-computers, over either the GPIB bus or an RS-232 serial port, offers significant cost savings while performance is enhanced.

Setting Windows

The ability to gate the measurement window, to arm the counter, for example, at a particular place on a waveform, and to disarm it again at another specific time means that you can cover a wide range of testing applications with the high 10 digit accuracy and resolution.

As long as the frequency of the signal you are investigating is relatively stable, a gated counter and an oscilloscope will yield adequate information. But frequency shifting is now commonly designed into many radar, secure voice communications and data communications systems. Worse, it commonly occurs and causes problems in more conventional systems where it isn't supposed to.

As example of one area where such problems can show themselves is in the gated master clock signal shown in figure 1. Since this signal is provided to several other circuits, it may be susceptible to excess loading at times, and bears checking in critical applications.

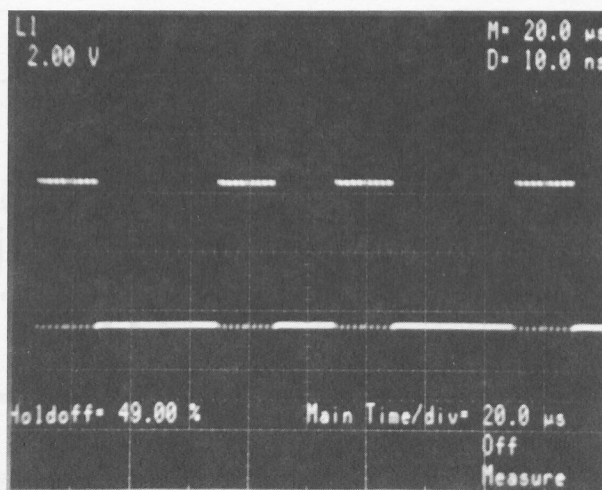


Figure 1. A system master clock pulse, gated to sub-systems can vary beyond design limits due to inconsistent loading, temperature variations of defective components.

The First Steps

Before you begin the detailed measurements of this clock signal, press the Utility button (to the right of the screen) to initialize the settings of the 11300A Series oscilloscope. After the initialization process is completed, attach the channel L1 probe to the appropriate place to observe the clock signal bursts, and Autoset the scope by pressing the button at the probe tip or by pressing the front panel Autoset button found above the screen.

Now rotate the right-hand control knob to a convenient Main Time/div setting, one that will display several of the clock frequency bursts across the CRT. Check for double or false triggering of the signal by checking the bottom of the pulses. If they appear to jump occasionally as shown in figure 2, then press the Holdoff button and rotate the left-hand control knob to give a steady display and eliminate the false triggering.

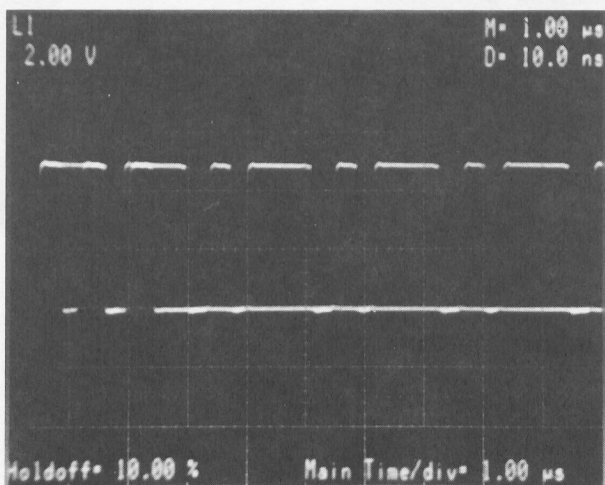


Figure 2. Double triggering of the signal can be detected here by observing the lower portion of the pulses, and removed by adjusting the holdoff.

Next, press the Vertical Size button and rotate the left-hand control knob to set the L1 trace to a convenient Size/div setting on the screen. When the size is set, push the Vertical Pos button and rotate the left-hand control knob to move the displayed waveform to the top half of the screen. Then press the Counter button and touch the "Measure" touch zone on the scope face one time to set it to Frequency.

Caution: at this point you will observe that the counter is reading a frequency that is not meaningful, since it is an average figure and includes the time in which the clock pulse is not present. Before you can take an accurate frequency measurement you must properly get the gate pulse for the counter.

Setting Up The Counter

Touch the "Gating" touch zone and set it to Dly1 Swp Gating and press the Waveform button and then in order: Count View; Gate; and Enter. You will now have a second trace on the scope display, 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 counterclockwise until the gate is more than half as wide as the clock pulse burst on the top trace. Do not make the gate wider than the burst or you will introduce inaccuracies into your readings. The exact width of the gate is not critical, but it is good practice to set this to approximately three-quarters of the clock burst you are measuring.

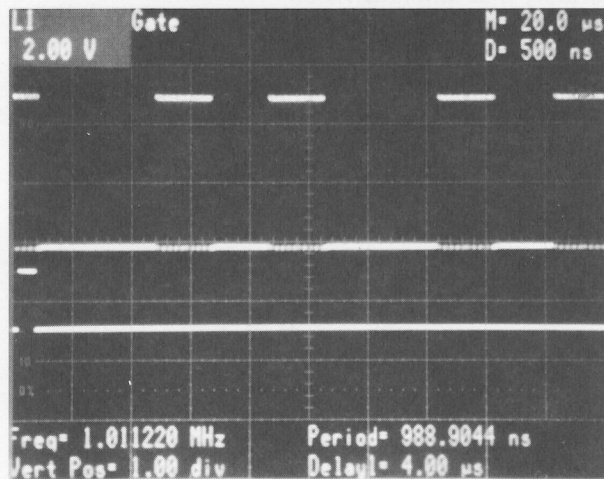


Figure 3. The frequency displayed on the screen is that of the signal within the burst (top trace) that occurs when the counter is gated on (as shown by center trace).

The frequency display is not the frequency of the signal within the pulse burst. You should now have a display similar to the one shown in figure 3, although obviously the frequency you are reading will probably differ from the one shown in our example. You can verify that you are gating on the proper frequency by pressing Horizontal Delay and rotating the right-hand knob to position the gate between clock bursts. This will verify that no frequency measurement is taking place.

Comparing Frequencies

It would make a lot of sense, if you suspect that a clock frequency is not stable enough, to compare that frequency at several places at various times. To do that, place probe L1 on the clock signal proper, where it is continuous, and in Figure 4, sampling the frequency at various points.

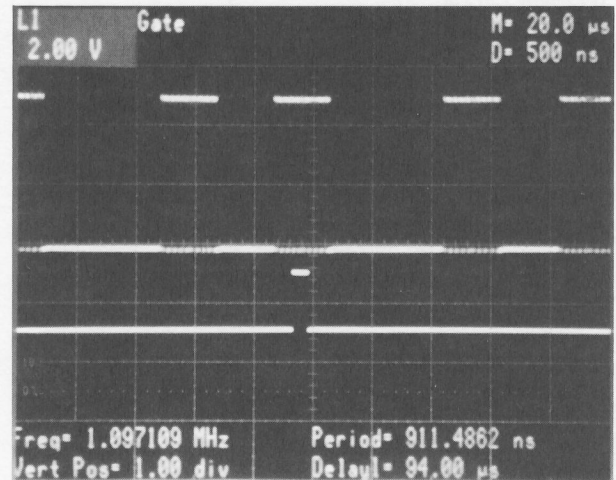


Figure 4. Moving the counter gate through a large portion of the clock pulse train allows sampling of frequency stability of the circuit.

Once you have satisfied yourself that the clock is stable, you can attach another probe at other areas that should be synchronized to the clock frequency, and verify that, as seen in figure 5 by setting the 11300A Series oscilloscope's counter to display Δ frequency between L1 and L2. That is done as follows:

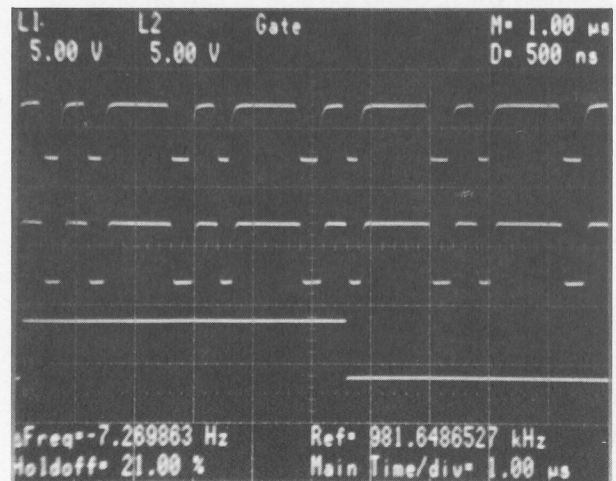


Figure 5. By triggering the top trace from the master clock, and measuring its frequency, the second trace can be gate-frequency checked for only difference in frequency.

Simply select the Numeric Entry display and touch Null. This will set the reference frequency to whatever is being measured at this time. When you exit numeric entry, the screen display at the lower left will say " Δ Frequency" and the value displayed will be the difference between the measured frequency and the reference.

Looking For Jitter

Another example of the usefulness of the gated-frequency measurement is a high-speed, asynchronous serial data transmission, as shown in figure 6. If the error rate is out of acceptable limits, you might want to first examine the transmitted data against the system clock, and also against the frequency requirement of the receiver circuit.

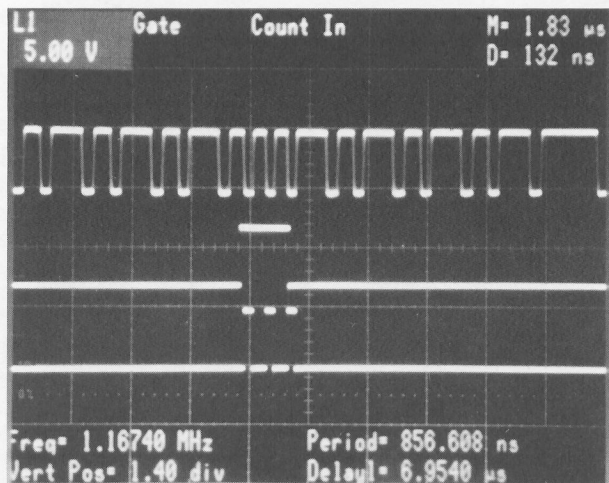


Figure 6. Asynchronous serial data transmission rate can also be verified with the gated frequency measurement feature of the 11300A Series oscilloscope.

During this check, the very high brightness of the 11300A Series oscilloscope's micro-channel-plate CRT also offers you the opportunity to observe the trace closely for occasional pulse anomalies. Pulses that only occasionally glitch, being too slow to turn on or off, or pulses that exhibit excessive rounding, will be clearly visible, although they will be seen at a reduced intensity.

Measuring Other Shifts

The final gated frequency example is the signal reflected by a moving target to a pulsed Doppler radar or a sonar system. As shown in figure 7, this signal would appear as a series of frequency bursts. Once the counter gate is positioned under the echo to be

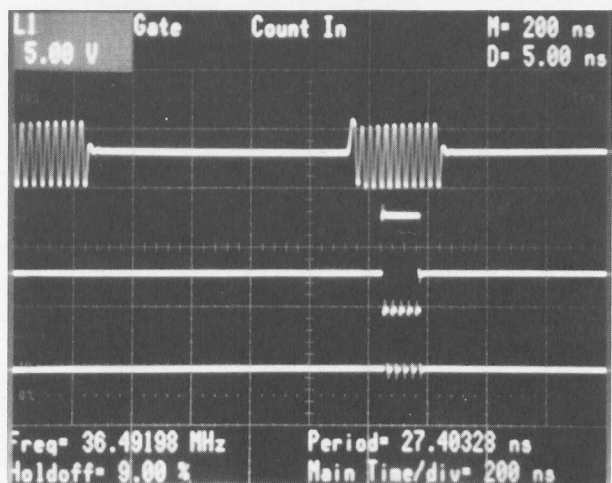


Figure 7. Frequencies of reflected signals from a pulsed Doppler radar or sonar can be measured directly on the screen of the 11300A Series oscilloscopes with the Gated Frequency feature. In this simulation, the frequency of the burst returned from the moving object can be compared to the frequency of a burst returned from a stationary object.

measured, a direct readout will appear in the counter window on screen. Comparison of this frequency to that of the transmitted pulse or a return from a known stationary target will allow verification of target speed data.

These are only a few examples of the ways in which gated-frequency capabilities make testing and design easier. The ability to make gated frequency measurements directly on screen, as we have shown in this application note, makes the 11300A Series oscilloscopes especially well suited to design and testing many frequency-critical systems, including frequency-hopping communications and radar systems, communications and telecommunications systems, and those systems mentioned earlier.

Gated and non-gated frequency measurement accuracy depends on many elements. One important one is the counter's time base accuracy. The 11300A is available with two different time bases. The standard time base provides a 10 digit accuracy of 1 part per 10 million. The High stability time base (Opt 1T) provides a 10 digit accuracy of 1 part per 50 million.


If you have more specific questions about the capabilities of the 11300A Series, either regarding avionics systems or any other applications, please call you local Tektronix Field Engineer or Applications Engineer. They are anxious to assist you.

Special thanks to Paul Thompson LID Marketing for helping with this application note.

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