Tektronix

Application Note

"Routine" Measurements Call for High-Performance Tools

Measurements that were on the "cutting edge" just a few years ago are routine today. Just about every engineer can tell stories about tracking down problems caused by a few nanoseconds of delay or by a near-invisible transient in the signal. Measurements on today's circuits must deal with faster edges, higher clock rates, and analog characteristics (especially in digital systems!). The same oscilloscope used for timing characterization in the morning may be used for analog troubleshooting by mid-day and for power supply measurements in the afternoon. All are routine measurements but the requirements vary widely.

Let's take a look at some of these "routine" measurements and what they require of an oscilloscope:

- **Basic measurements:** "Signal present" and waveshape, amplitude and frequency (or period), noise

  Although frequency ranges are higher today than in the past, most scopes can perform these measurements adequately. It is desirable to have a bandwidth in the 60 to 100 MHz range to bring out edge details and transients.

  The most valuable scope asset for basic measurements is ease of use. Automated measurements and cursors provide readings more quickly and accurately than graticule interpretation.

- **Digital measurements:** Edge relationships, transients, "single-shot" events

  For digital measurements, scope bandwidth and sample rate are important. Fast edge transitions and glitches can be degraded or even lost if the scope is "too slow." To reliably capture non-repetitive events, the scope's sample rate (frequency) must be several times higher than the frequency of the measured signal.

- **Semiconductor measurements:** Setup and hold, clock-to-data, bus events

  Semiconductor measurement needs are similar to those of digital measurements, but cursors and automation can make repetitive tests much easier, and waveform storage is often needed to document device performance.

- **Power measurements:** AC voltage, current, harmonics

  Power measurements are not all that different from other dynamic measurements with a scope – except that voltage and current levels may be dangerously high, and signals may lack a true ground. Special probing solutions are required.

  For measuring power harmonics (a requirement for compliance with regulatory power quality standards), FFT (Fast Fourier Transform) tools are needed to provide a frequency-domain view of the signal.

Clearly it's important to choose a versatile oscilloscope for today's measurement tasks. Fortunately the modern digital storage oscilloscope (DSO) is well-equipped for most of the measurements described here. But features, performance, and value vary widely among available DSO models. The Tektronix TDS 220 DSO is one of the most versatile instruments in its price class, offering 100 MHz bandwidth (with 1 GS/s sample rate), measurement automation, exceptional portability (with an instrument weight of only 1.5 kg), waveform storage, and a wide range of probing and communication options. A 60 MHz model, the TDS 210, is also available.

Digital Circuit Measurements

Prototype debug is part of every digital design project. Sometimes, if the circuit is functioning erratically (or not at all), it's necessary to confirm that the master clock signal is routed correctly throughout the system, and is arriving at its destinations intact. Often there are many test points and device pins to be checked. One way to do this is to measure the signal's frequency and/or amplitude while visually checking its integrity.

The procedure would be prohibitively time-consuming if not for the help that measurement automation can provide. An automated DSO such as the TDS 220 is the right tool for this job.

The TDS 220's AUTOSET function (accessed via a front-panel button) immediately brings up a usable display of the waveform. AUTOSET automatically sets up the triggering, acquisition mode, vertical scale factor, and other parameters needed to capture the waveform and present it clearly. With the waveform on-screen, it's a simple matter to check it for aberrations or distortion.

The next step is to measure the frequency and amplitude, using another built-in time-saving feature. The MEASURE button lets you set up four different automated measurements to perform and display simultaneously. The TDS 200 retains the setup as you move from test point to test point, recalculating new measurements as you proceed. Figure 1 shows the result. The clock signal is displayed, along with quantitative readings for frequency, period, and peak-to-peak amplitude.

When your design combines sensitive analog circuitry with fast digital components, digital switching transients can find their way into the analog circuits. In a VCR, for example, these can cross over to the video signals, causing objectionable picture distortion. Frequently the transients are hidden by the analog circuit's own inherent noise. Where do the transients come from?

The TDS 220's AVERAGE mode helps you see through the noise and pinpoint the troublesome transients. AVERAGE is a choice available via the acquisition menu. The scope lets you select up to 128 acquisitions to make up an averaged waveform; simply choose the number that produces the best result. Figure 2 shows the result of an averaged view of an analog signal line. The digital transients, formerly masked by uncorrelated noise, now stand out clearly from the baseline. The frequency and timing of the transients provide clues to their origin. In this particular case, a pair of circuit board traces were placed too close together, and digital edges were coupled into the analog trace.

Another TDS 220 acquisition mode known as PEAK DETECT helps capture fast, narrow glitches. These events often elude analog scopes and equivalent-time acquisition on other DSOs. PEAK DETECT provides yet another tool to ensure that no event goes undetected.

The example in Figure 3 shows a staircase waveform from a digital-to-analog converter. The negative spike in each cycle may be the result of a stuck bit in the conversion. Note that the TDS 220's PEAK DETECT feature combined with its high bandwidth and 10X oversampling, exposed the transient in the first place. Now it's useful to examine the spike more closely.

To do so, position the trigger indicator (the arrow on the top of the display) to the center of the screen using the horizontal position control.

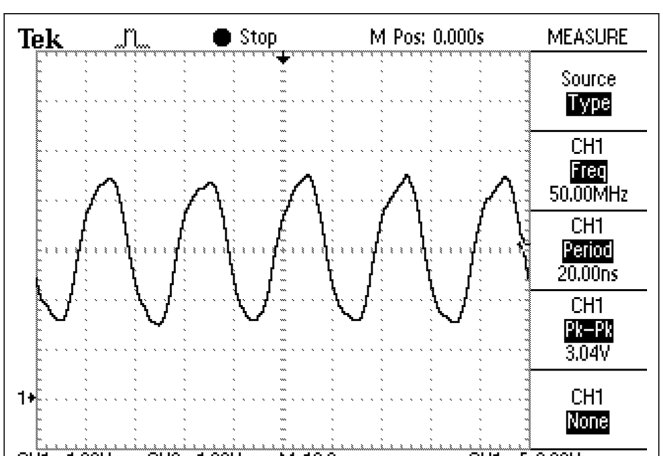

Figure 1. Automated measurement of clock frequency.

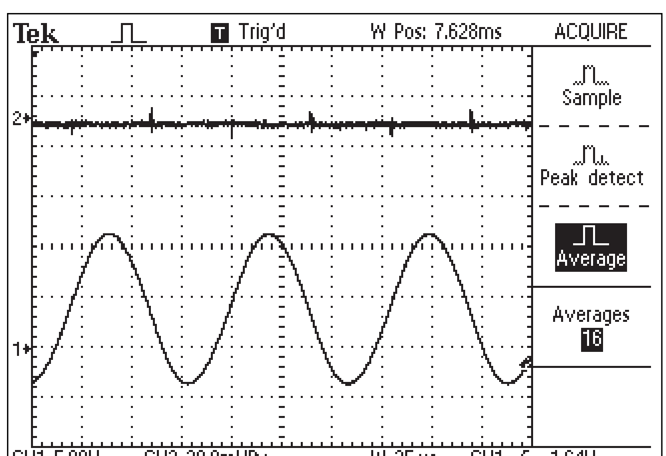

Figure 2. AVERAGE-mode view of a noisy analog signal line.

At this point, the main timebase position (M Pos) should be zero. Then, adjust the trigger level until the glitch portion of the waveform is centered on-screen. The last step is to simply expand the glitch using the horizontal SEC/DIV control. Figure 4 shows the resulting display.

Semiconductor Measurements

Setup and hold time specifications for logic devices have become more critical as clock rates have increased over the years. Even though the manufacturer's data sheets provide setup and hold parameters, it's common practice to confirm these measurements prior to designing new devices into your circuit. The TDS 220's time cursors make setup and hold measurements simple.

Setup time is defined as the time between the arrival of valid data and the clock edge that clocks the data into the device; in other words, how long the data must be in place before it is clocked in. Figure 5 depicts the data and clock signals; in this example the falling edge of the clock signal does the work. To measure the setup time, simply press the TDS 220's CURSOR button and select the time cursors; then, position them with the Vertical Position knobs. In this example, Cursor 1 is set at the 50% amplitude point of the data signal (lower trace), while Cursor 2 sits atop the falling edge of the clock. The "Delta" reading to the right of the waveform display is the measured setup time – in this example, 10 ns.

To find the hold time, follow the same procedure. Hold time is defined as the time data must stay valid after the latching edge clocks it in. Figure 6 shows the measurement. The result (Delta) is 10.8 ns.

Frequently it's necessary to check signal risetimes as part of IC device characterization. The TDS 220's optional TDS2MM Measurement Module provides automated rise and fall time measurements without the use of cursors. The automated measurements appear under the MEASURE menu when the module is installed.

Documenting your findings is often part of the characterization procedure. When equipped with the TDS2HM Hardcopy Module, the TDS 220 can print waveform images on a compatible printer connected to its Centronics port; with the optional TDS2CM Communications Extension Module or the TDS2MM Measurement Extension Module, the scope can also send information to an external PC computer. In

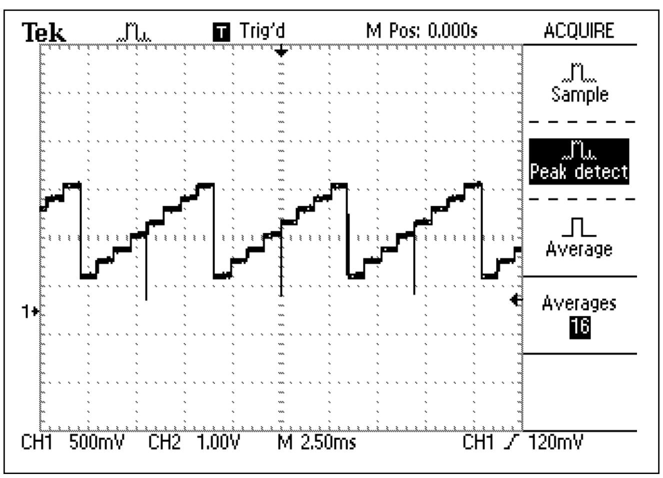

Figure 3. PEAK DETECT has identified a glitch in the waveform.

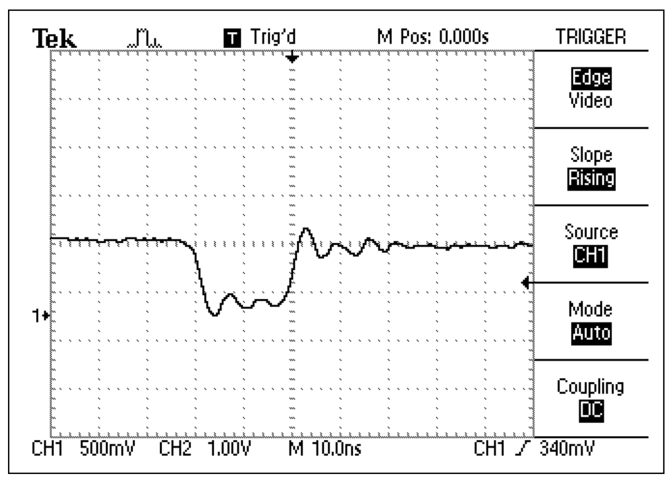

Figure 4. Expanded glitch waveform.

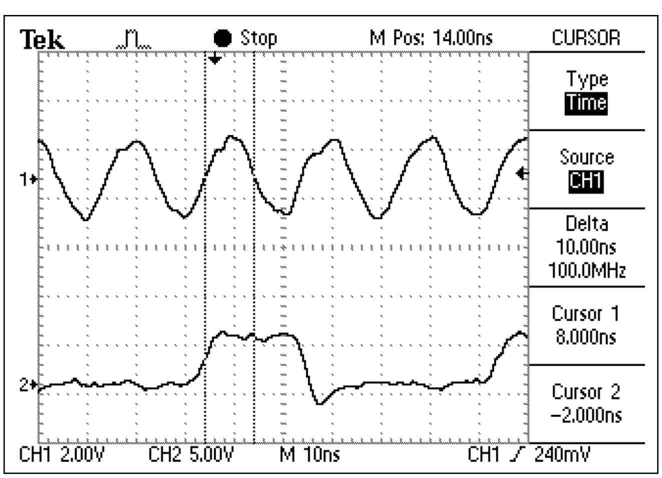

Figure 5. Measuring setup time with TDS 220 cursors.

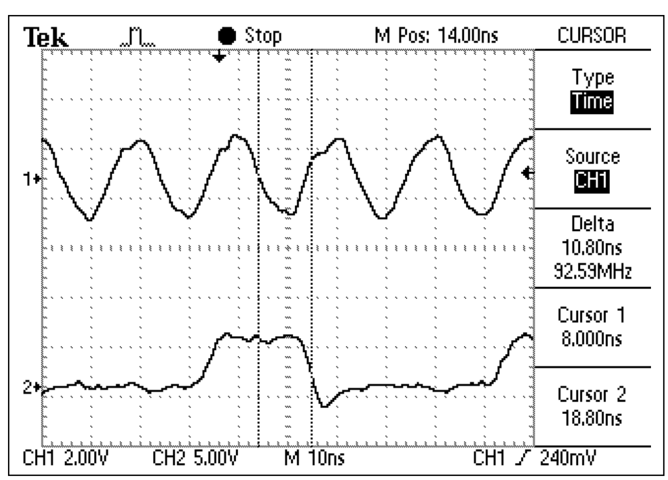

Figure 6. Hold time measurement with the TDS 220 cursors.

addition, the instrument can store two complete (2500-point) waveforms for recall and display at any time.

Power Measurements

Power measurements have special requirements. Voltages and currents are usually higher, of course. But most importantly, power test points may be “floating;” that is, not referenced to ground. Because most oscilloscopes require a ground-referenced signal, it’s necessary to use a probe that isolates the scope ground from that of the circuit. The Tektronix P5200 Differential Probe is such a tool. It’s self-powered, fully compatible with the TDS 200, and handles up to 1300 V. The probe is well suited for motor drive, power supply, and other floating measurement applications.

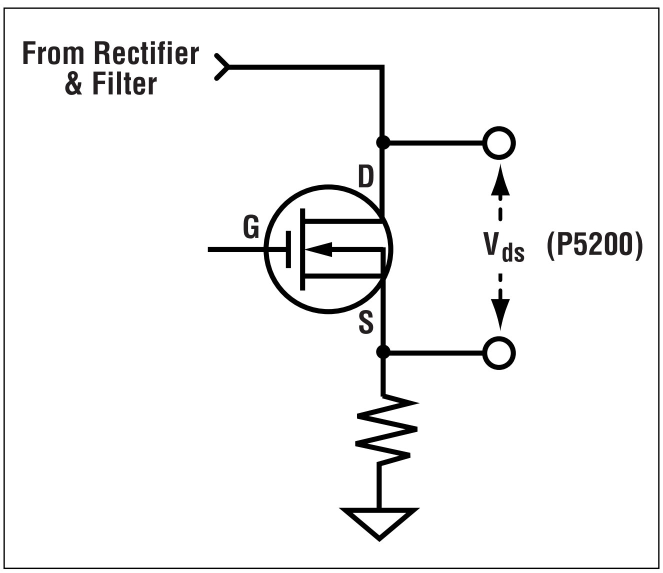

Figure 7. Switching power supply regulator circuit (simplified).

Switching power supplies typically use power MOSFETs in their regulator circuits. To measure V_{ds} (voltage from drain to source) across a MOSFET (see Figure 7), connect a P5200 to the scope input and set the probe’s attenuation switch to 50X or 500X (as appropriate for the voltage levels in the circuit under test). Using the VERTICAL MENU button of the channel in use, select the vertical scale that matches the voltage level being measured. This ensures that the screen readout appears in proper terms. Being a differential probe, the P5200 has two leads that span the test points. The P5200’s output is a low-level, single-ended signal that, like other TDS 220 waveforms, can be acquired with AUTOSET, measured automatically or with cursors, and so on.

Current measurements are equally straightforward. The Tektronix A621 self-powered current probe connects directly to the TDS 220 and measurements are set up in the same manner. The current probe is non-intrusive; a sensor “surrounds” the conductor and acquires the signal via inductive coupling. In Figure 7, the current measurement involves placing the A621’s sensor tip around the wire coming in from the rectifier and filter.

Switching power supplies tend to generate odd-order harmonics, which can find their way back into the power grid. Increasingly, it’s necessary to measure harmonic content to comply with regulatory standards for power quality, such as IEC 555. The optional TDS2MM Measurement Module equips the TDS 220 for harmonic measurements. The TDS2MM automatically converts a conventional time-domain waveform (such as the voltage or current waveform described above) into its frequency components (harmonics).

Conclusion

Many oscilloscope measurements are “routine” but that doesn’t mean they are innately simple. They call for an instrument that simplifies tasks such as time and amplitude measurements, glitch detection, and floating voltage measurements – while providing accurate results. The Tektronix TDS 200 Series provides all of these attributes in an oscilloscope that is compact and affordable enough to deserve a place on every engineer’s bench.

For further information, contact Tektronix:

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