

# A Day in the Life of a Design Engineer



## TEKTRONIX PRODUCTS FEATURED:

- TDS 220 Digital Real-Time™ Oscilloscope
- AFG320 Dual-channel Programmable Arbitrary Function Generator
- TX3 TX-DMM™ True RMS Multimeter
- WSTRM WaveStar™ Software for Meters
- WSTRO WaveStar™ Software for Oscilloscopes

Bob Smith<sup>1</sup> is a hardware designer for a manufacturer of industrial process control systems. His job description includes design and debug of power supplies, computer interfaces, and analog, digital, and mixed-signal circuits. He selects components for his designs, evaluates his prototypes, and documents the results. His tasks are similar to those of electronic design engineers in dozens of industries. Bob works under steady pressure to solve design problems quickly, and deliver proven, manufacturable designs to the production department.

The foundation of Bob's troubleshooting work is his basic test equipment suite: a TDS 220 oscilloscope, a TX-DMM™ digital multimeter (DMM), and an AFG320 function generator. Every one

of his new designs is touched sooner or later by these tools.

"My work involves troubleshooting at the component, board, and system level," says Bob. "Here's a list of what I got done in one very busy day with my Tektronix tools:

- Debugged a D/A converter with the oscilloscope
- Used waveform publishing software to create a slide presentation containing the D/A waveforms
- Found a batch of faulty capacitors with the DMM
- Used the scope and signal generator to track down a timing problem
- Took temperature measurements overnight with the DMM and the optional stripchart software"

Let's take an hour-by-hour look at Bob Smith's tasks that day.

## 8:30 AM

Bob reports for work, switches on the PC, checks his in-basket, e-mail, and phone messages. The morning's e-mail includes an agenda for a meeting at 10:00 AM:

*"Please attend. System design team needs to see some linearity waveforms from your new D/A subsystem. There are some concerns about distortion when the circuit is operating in the system. Bring slides to share with the group."*

With only 90 minutes to prepare for the meeting, Bob turns to his TDS 220 DSO. Fortunately his prototype D/A circuit is already set up at his bench. Equally important, the TDS 220 is readily available – part of his perma-

<sup>1</sup> Bob Smith is a fictional character.

ment toolkit. Thus Bob can get right down to work at his bench without having to find an unoccupied oscilloscope. The digital-to-analog (D/A) converter subsystem has a self-test mode that provides the digital input for staircase and sine diagnostic waveforms. Both are very well suited to revealing distortion in analog circuits.

Although the system clock frequencies are relatively low, the TDS 220's 100 MHz bandwidth (1 GS/s sample rate) is useful for capturing the details of distortion. The transient's edges may contain high-frequency information; in fact, it's possible to overlook fast transients altogether if the scope lacks the bandwidth or sample rate to collect fast-changing amplitude points.

Bob sets the scope to the Peak Detect mode. Peak Detect captures glitches as narrow as 10 ns, even when viewing signals at a relatively low sweep speed. Probing the output of his circuit, Bob selects the staircase diagnostic waveform and views the signal shown in Figure 1a. The waveform appears to be clean and free of aberrations. This implies that the D/A converter is indeed linear, and the problem is elsewhere in the system.

Bob stores the waveform in the TDS 220's memory and

then carries the 1.5 kg (3.25 lb.) instrument to the full-system prototype being built in the integration center. Using the system's own internal data to drive the converter (rather than the diagnostic waveforms), he reveals a deep transient in one of the staircase steps, as in Figure 1b. Clearly, this points toward a problem – possibly a mis-connected or short-circuited bit output – in the register that drives the converter.

Although there's no time to troubleshoot the problem, Bob is well on the way to a solution. He stores the system waveform in the TDS 220's memory and returns to his desk with the TDS 220.

Bob re-connects the TDS 220 to his computer and opens the Tektronix WaveStar™ Software application. WaveStar Software is a Windows® 95/NT-compatible application that makes it easy to “drag and drop” waveform images into Microsoft® applications such as Excel and PowerPoint. Bob retrieves the waveforms from the TDS 220's memory, displays them on the PC screen, and annotates them using WaveStar Software's editing features. After opening a new presentation in PowerPoint, Bob “drags” the waveforms into the presentation and prints the pages.

## 10:00 AM

Bob presents the waveforms and answers questions at the meeting. One of the other attendees wants waveforms to use as stimulus data in testing a newly-designed subsystem, and the Documentation department needs the “clean” waveform image for the User's Manual. After leaving the meeting, Bob delivers the WaveStar Software files via e-mail to his colleagues.

## 10:30 AM

Back at his bench, Bob gets a phone call:

*“Can you help us troubleshoot a problem in the shaft speed monitoring circuit? The readout is accurate at lower speeds but gets worse as the shaft speed increases.”*

The speed monitoring circuit accepts a stream of pulses coming from a Hall-effect sensor on the system's rotating shaft. It produces a readout on a digital panel meter, and prompts an audible alert if the shaft speed is not within range. The circuit's accuracy is important because the shaft speed affects the quality of the product this system is being used to manufacture, as well as safety of the equipment itself. To ensure this accuracy, the circuit uses components with 5% tolerance.

To get a better understanding of the problem, Bob uses the

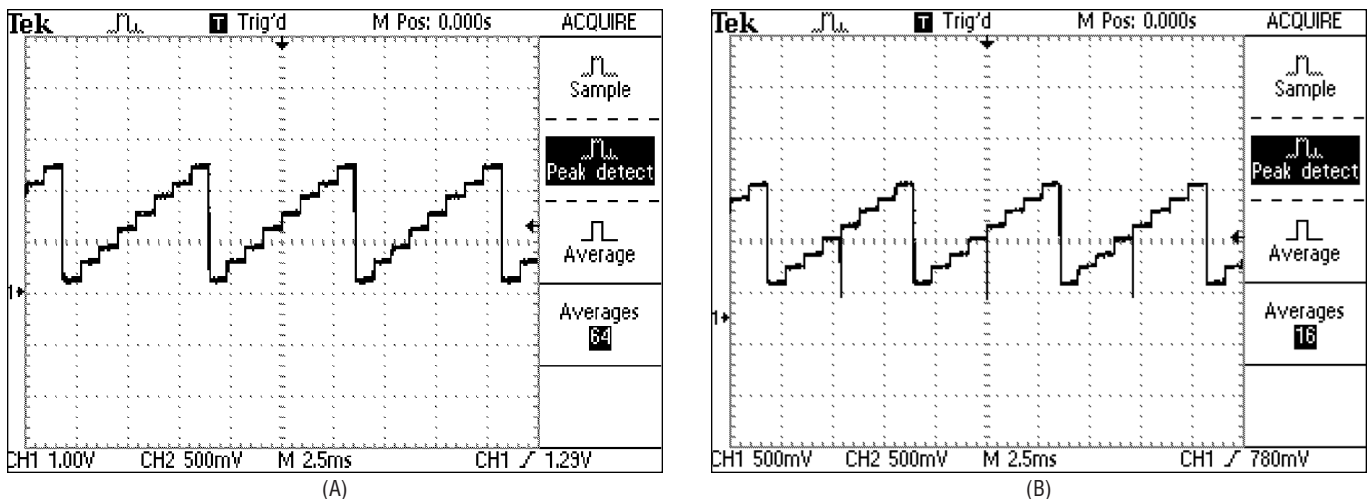


Figure 1. a) Bench prototype diagnostic signal; b) Full system D-to-A signal.

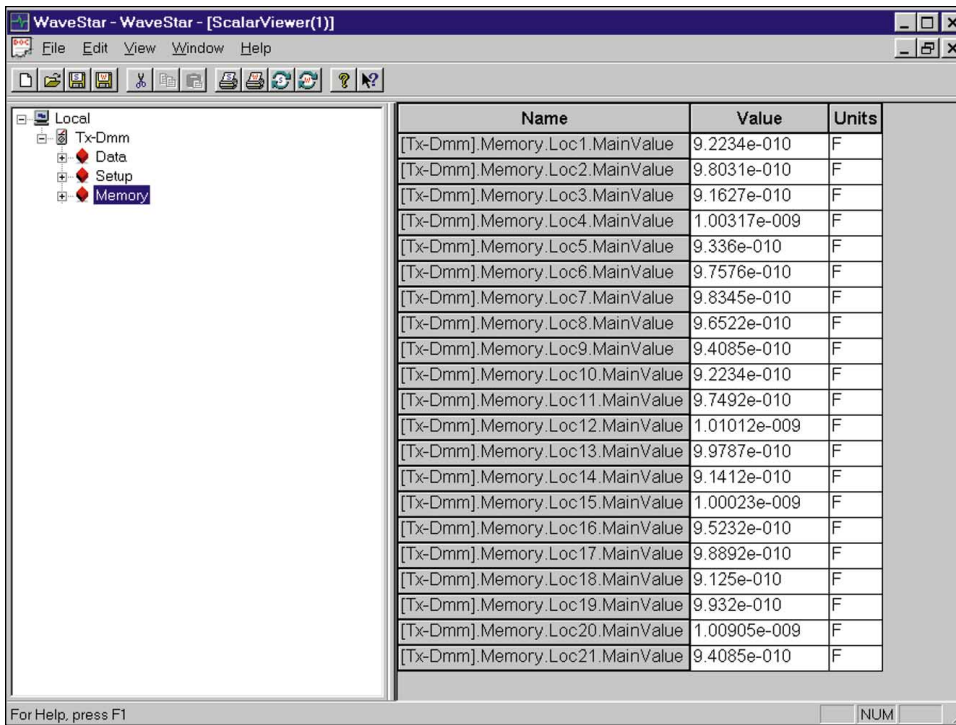


Figure 2. TX-DMM / WaveStar Software printout.

TDS 220 to check the signal coming from the sensor and measure its frequency. At a glance, Bob can see that the wave shape and amplitude are within acceptable limits. Yet the accuracy of the counter declines as frequency increases. The symptom implies some kind of problem in the counter's input circuit, a resistive/capacitive (RC) attenuator.

Bob knows that when frequency-dependent errors occur, reactive components are usually at fault. His first step is the right one: he

removes the capacitors in the circuit and measures their values using his TX-DMM digital multimeter. This instrument provides capacitance measurement ranges down to 5.000 nF (0.005 μF) full-scale as a standard feature.

Before long, Bob comes across a 1000 pF polystyrene capacitor that, like the others in the counter, is marked with 5% tolerance... but its measured value is 922 pF -7.8% tolerance.

Going back to the new parts bin, Bob runs a random

check on 20 more capacitors, storing the results in the DMM's memory. Several more components are out of tolerance. He uses WaveStar Software again (this time the WSTRM tool, a WaveStar Software version that's designed

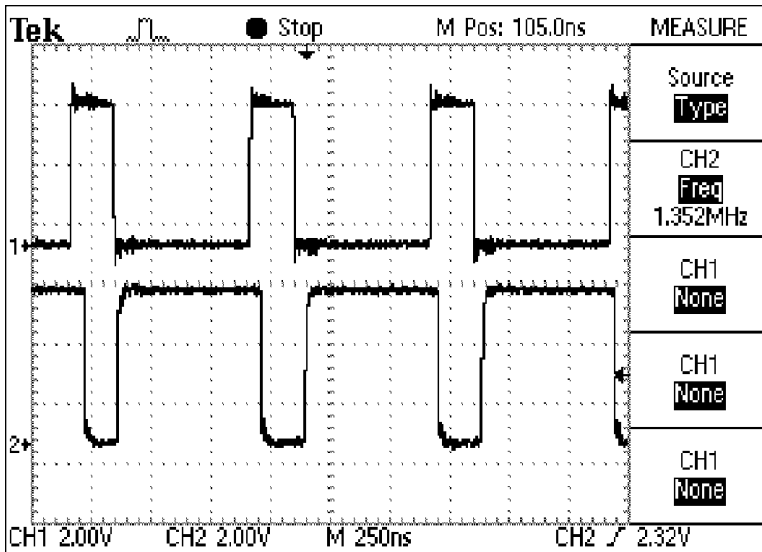


Figure 3. Data line signals.

specifically to work with his TX-DMM digital multimeter) to take the information from the DMM and print it (see Figure 2).

Bob attaches the WaveStar Software printout to a memo addressed to the Purchasing Department:

*"We are paying a premium for the 5% capacitors used in our counter circuit. The attached DMM readings prove that many of the components are out of tolerance. This could affect our product quality and our manufacturing throughput. We need to talk to the vendor about this!"*

**12:30 PM**

Lunch break

**1:10 PM**

After returning from lunch, Bob is at last able to resume work on the troubleshooting procedure he began yesterday. The new product's control system uses data in and out lines that are suspected of causing problems.

Once again, Bob's first step is to look at the circuit installed in the prototype system. He takes another trip to the prototype lab with his TDS 220 and uses the two channels to acquire a full record of concurrent signal activity on the data lines. Figure 3 shows the result.

Back at his desk, Bob imports the signals into his AFG320 function generator via GPIB. Another essential personal tool, the AFG320 offers this unique capability as a standard feature. Although Bob's setup includes a PC, the computer is not necessary for the import procedure.

Bob has a duplicate of the interface circuit, including components, cables, and interconnection hardware, assembled in a nearby lab area. In the lab, it's a simple matter for Bob to drive the interface circuit with the AFG320, re-creating the two signals he acquired from the system. The AFG320's dual outputs allow him to accu-

rately simulate both data signals simultaneously, just as they occurred in the system. Capturing the interface device's output as he feeds in the imported signal, Bob finds a small but damaging timing problem – capacitance on the data outputs is delaying one of the data signals, which causes the clock and the data to arrive at its destination “out of step.” The indicated solution is to redesign the output circuit to provide better buffering from the cable's innate capacitance.

In this case, the mobility of the TDS 200 and the AFG320 made it possible for Bob to bring a sample of his actual system's behavior to the R&D lab and examine it to arrive at a solution.

### 5:00 PM

The last task of the day: set up for an overnight temperature test on the new system controller module.

The new system controller, actually a dedicated computer

built around an industry-standard microprocessor, is experiencing intermittent failures and lockups during diagnostic testing. But everything passes the bench tests. Bob suspects a thermal problem. He knows that most ICs get slower as they get hotter. Maybe signals are drifting out of synchronization because module components are overheating, causing signal delays. Bob is fully prepared for thermal tests because he has a TX-DMM digital multimeter. This model, unlike most DMMs, includes temperature measurement functions and probes as standard equipment. When used with the WSTRM version of WaveStar Software, the TX-DMM digital multimeter is capable of long-term unattended data logging, including temperature measurements.

Bob sets up the controller in an enclosure that approximates the thermal conditions inside the system housing. He

places the temperature probe into the enclosure and connects the DMM to the serial port of his laptop computer. With WaveStar Software, Bob has the choice of stripchart-style or tabular-style datalogging. He chooses strip chart style. He sets the acquisition interval to 5 minutes. WaveStar Software and the TX-DMM digital multimeter will begin capturing data automatically as soon as Bob activates the START button on the WaveStar Software screen.

As Bob prepares to leave for the day, he makes a final check that everything is set up and ready to run overnight. Tomorrow morning, Bob will analyze the logged data to see how the controller's internal temperature varied during the night and compared with his internal diagnostic routine. Each logged point is stored with a time, value, and units (degrees centigrade) entry, as shown in Figure 4. WaveStar Software highlights the out-of-tolerance temperature values by displaying them in a contrasting color.

If there are concerns about thermal problems with specific components (ICs) in the controller, Bob can probe them individually after the night's thermal run. As he begins to home in on problems, he might even heat certain components with a heat gun and view the effects on signal behavior with the TDS 220 DSO.

We have seen how these Tektronix products have helped Bob overcome unknown issues. Are you equipped for tomorrow's unknown? Call your local Tektronix Distributor today.

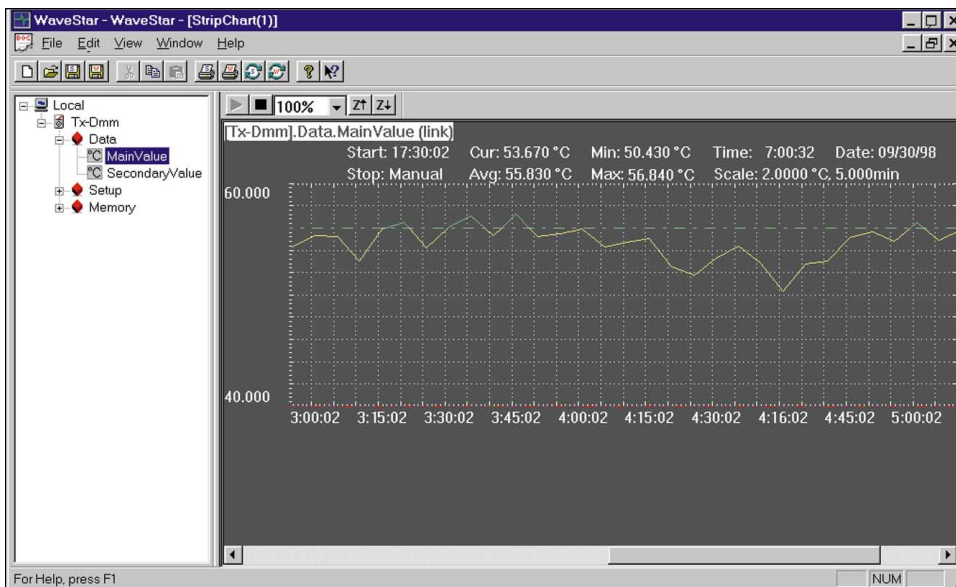
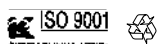


Figure 4. TX-DMM stripchart display captured with Wavestar Software.

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