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Rigol DS1052E and Tektronix TBS1042 Oscilloscopes

Smaller, lighter and less expensive test equipment for the amateur experimenter.

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Most hams have basic test equipment consisting of at least a digital multimeter, SWR meter and dummy load. These three instruments provide the ability to do basic troubleshooting. Additional equipment often includes an accurate RF power meter, a frequency counter and an oscilloscope. Of these, historically the oscilloscope has been the most expensive, leading hams to explore the surplus equipment market. Used analog oscilloscopes can be quite good, but they are also large and inconvenient for recording data. If something goes wrong, they may be difficult and expensive to repair.

Digital sampling oscilloscopes (DSOs) have become available at prices justifiable for many ham experimenters. The two reviewed here provide features and capabilities that will satisfy most home users.

The Oscilloscope Decision Process

In the past, factors to be considered when choosing an oscilloscope included the number of simultaneous signals that you might need to measure, the bandwidth necessary, on-screen digital data readouts along with the waveform display, and spectrum analysis capability. With today's DSOs, the only decision you really need to make is the bandwidth required. As you increase the bandwidth requirement, though, the cost of the oscilloscope can increase significantly.

With these factors in mind, this review focuses on Rigol and Tektronix DSOs with a 40 to 50 MHz bandwidth, as this is sufficient to permit most measurements desired at the lowest cost. As you can see in Table 1, these two instruments have very similar basic specifications. Detailed specifications can be found on the manufacturers' websites.

Let's Make a Few Tests

To see how the oscilloscopes perform, I selected several tests that I thought hams would find useful and interesting. For the first test, I looked at the measured frequency response of the oscilloscopes. I measured RF power with a calibrated setup and then checked the amplitude of the frequency on 7, 28 and 50 MHz. The Rigol has a 50 MHz bandwidth and the Tektronix has a 40 MHz bandwidth, so I would expect to see some rolloff on 10 and 6 meters. This doesn't mean you can't look at signals, just that the amplitude of higher frequency signals may not be completely accurate.

My next test involved measuring transmitter overshoot. When a transceiver's output power is reduced, often the transceiver output will overshoot (be higher than) the set power on the first CW character or speech syllable. This happens because a finite time is required for the transceiver's ALC to control the signal. If overshoot is high enough, it can trip protection circuitry in an external RF power amplifier or even damage it. For this test I set my Icom IC-706MKIIG transceiver to 25 W output, as this is the approximate drive power needed for full output from my Elecraft KPA500 amplifier.

Next I wanted to look at the amplifier enable/disable timing versus the RF signal output. This timing is important when driving an amplifier to ensure that no hot switching of the amplifier or transceiver takes place. (Hot switching means transmitting a signal before relay contacts have closed.) The amp key-to-RF signal and RF signal-to-amp unkey timings are both important because you want to make sure that there is no chance of hot switching on either amplifier keying or amplifier unkeying. I fed the IC-706MKIIG transceiver's HSEND output to channel 2 on the oscilloscope and set the oscilloscope to trigger on channel 2. A falling edge trigger shows the amp-enable timing, and a rising edge trigger shows the amp-disable timing. I could have fed HSEND into the EXTERNAL TRIGGER input on the oscilloscope, but I wanted to display HSEND along with the RF signal to better clarify the timing.

My final test involved two-tone testing of my transceiver. A two-tone test is a standard test of a transceiver's linearity that normally requires a spectrum analyzer. However, both oscilloscopes have a fast fourier transform (FFT) math feature that should permit display of signals in the frequency domain. For

Table 1
Rigol DS1052E and Tektronix TDS1042 Basic Specifications

	Rigol DS1052E	Tektronix TBS1042
Bandwidth	50 MHz	40 MHz
Analog channels	2	2
Vertical sensitivity	2 mV/div – 10 V/div	2 mV/div – 5 V/div
Real-time sample rate	1 GSa/s (1 ch), 500 MSa/s (2 ch)	500 MSa/s
Vertical resolution	8 bits	8 bits
Max input voltage(RMS)	300 V @ 30 kHz, 60 V @ 50 MHz	300 V @ 100 kHz, 13 V pk @ 3 MHz and above
Probe impedance	1:1 — 1 MΩ//100 pF 10:1 — 10 MΩ//17 pF	10:1 only — 10 MΩ//20 pF
Math	+, –, ×, FFT	+, –, ×, FFT
Standard interface	USB (front and rear), RS232	USB (front and rear)
Price	$329	$680

Bottom Line

The two oscilloscopes reviewed here are ideal for hams interested in more serious experimenting. They both deliver excellent performance at a price comparable to popular station accessories.

this test, a two-tone audio signal is fed into the transceiver's microphone input, and the composite level adjusted for 25 W peak output. After displaying the normal modulated RF signal on the oscilloscope, select the FFT mode and make sure you are displaying in the dB scale. Use the vertical knob to select dB/division, the horizontal timing knob to select the Hz/division, and center the signal on your display with the horizontal position control.

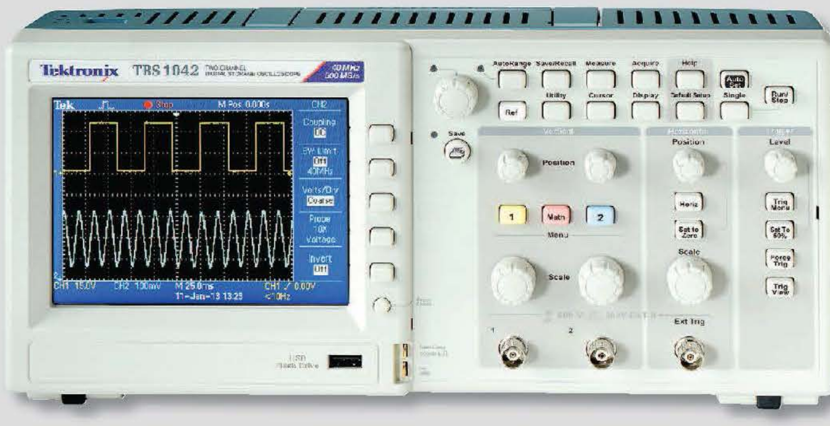
Table 2
Tektronix Storage Oscilloscope, Model TBS1042, s/n C010148

General Specifications:

Display type: 5.6 inch diagonal color TFT LCD.
Display resolution: 320 horizontal × 240 vertical pixels.
Power consumption: 100-240 V ac, 50/60 Hz, 115 V RMS, 400 Hz.
Operating environment: 32 to 104 °F, 5 to 85% relative humidity; 32 to 122 °F, 5 to 45% relative humidity, at <10,000 feet above sea level.
Input coupling: DC, AC, GND.
Input impedance 1 MΩ ±2%.
Size (HWD), weight: 6.2 × 12.9 × 4.9 inches, 4.4 pounds.

The following specifications have been determined to be "as specified" by Essco Laboratories, of Chelmsford, Massachusetts

Sample rate range: 5 samples/second – 500 M samples/second.
Scanning speed: 5 ns/div – 50 s/div.
Analog bandwidth: ≥30 MHz, (checked at 40 MHz).
Maximum input voltage: 300 V RMS.
DC gain accuracy: 5 mV/div – 10 mV/div.
Internal trigger sensitivity: 0.01 div – 5.0 div.
Trigger level range: ±8 divisions from center of screen (internal), ±1.6 V (external).



Tektronix TBS1042

As with many computers and test instruments today, only a condensed version of the manual was enclosed with the TBS1042. The full manual (159 pages) is downloadable online. The only accessories provided with the oscilloscope are the 120 V ac power cord and a pair of 10:1 probes (not switchable to 1:1). For most measurements, you'll want to use a 10:1 probe because the capacitive loading of a 1:1 probe will be a problem for higher frequency RF signals. Also, a 10:1 probe provides better overload protection should you accidentally connect to a high voltage source. A 1:1 probe is most usable for audio measurements at very low signal levels.

An important feature of any instrument is its ease of use. Therefore I attempted to use the TBS1042 without reading the manual, other than reading about how to compensate the probes. As it turned out, I was able to quickly set up and measure everything in all the tests without cracking the book! What makes this easy is the AUTOSET button that sets up the unit for you. Just apply a signal and press AUTOSET. Within a few seconds you'll have a display that will be very close to what you want. From this point, you can simply change the vertical sensitivity and horizontal timing to refine the display to your liking.

The USB port on the front of the unit provides either print or save functions. The TBS1042 determines if the connected device is a printer or memory stick, and will either print or save the screen data when the PRINT button is pushed.

The frequency response test resulted in a measured rolloff of 0.57 dB on 10 meters, and 1.67 dB on 6 meters, much better than the manufacturer's 3 dB specification for the 40 MHz bandwidth.

For the overshoot test, I set my transceiver output to a nominal 25 W output level and triggered the TBS1042 on the channel 1

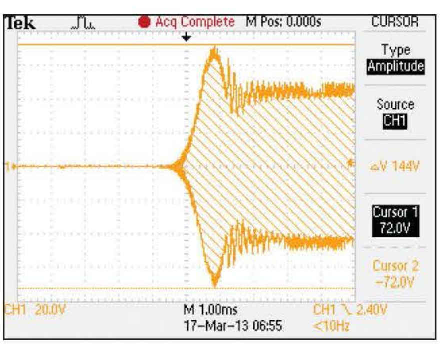


Figure 1 — Transceiver overshoot measurement with the Tektronix TBS1042.

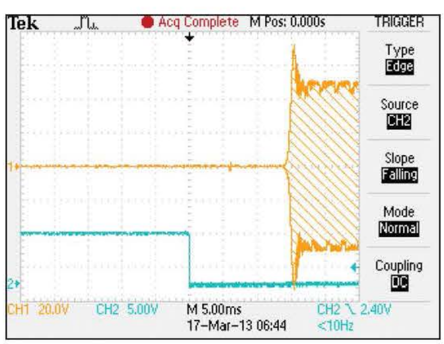


Figure 2 — Transceiver amp-key-to-RF-output timing measurement with the Tektronix TBS1042.

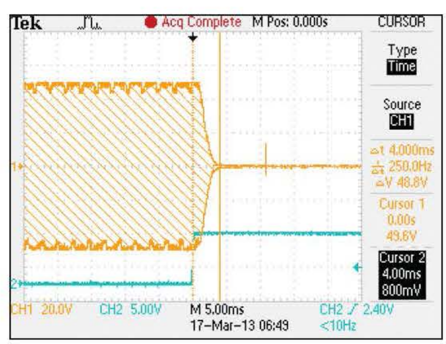


Figure 3 — Transceiver un-key/RF output timing measurement with the Tektronix TBS1042.

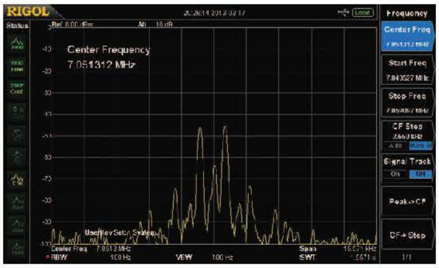


Figure 4 — Spectrum analyzer display of an SSB transceiver two-tone test.

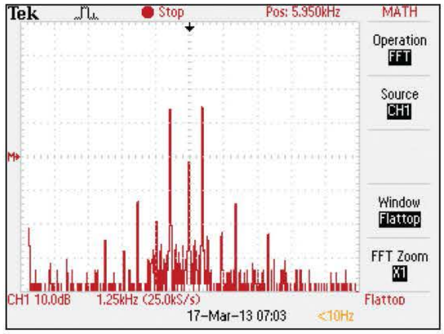


Figure 5 — Tektronix TBS1042 two-tone test FFT display using the same test setup as for Figure 4.

input. You have a choice of enabling either two horizontal cursors to measure amplitude, or two vertical cursors to measure time. I enabled the horizontal cursors to display the overshoot amplitude. The results are shown in Figure 1. Note that with a set output power of 25 W, the output peaks at 72 V peak (100 W) on the first dit.

Next I looked at the amp-key enable (Figure 2) timing with the transceiver set for full break-in. The blue trace is the amp-enable HSEND line from the radio. The results are interesting. The amp-enable-to-RF output time of 15 ms is fine for vacuum relays and PIN diodes. It is probably okay for open frame relays used on many amps not designed for full break-in (QSK) operation, but it is marginal. A typical enable time for open-frame relays is 12-20 ms.

The amp disable timing (Figure 3) shows a problem with QSK-switched amplifiers. The amp disable line goes high about 4 ms *before* RF drops to zero (the vertical cursors were enabled to better show this). So you may hot switch an amplifier that is operating in QSK. To be on the safe side, IC-706MKIIG users should only operate semi break-in.

My last test was a two-tone test of the transceiver output. Figures 4 and 5 compare the display of a spectrum analyzer (a Rigol DSA815-TG) with the FFT display on the TBS1042. As you can see, the TBS1042 frequency display is virtually identical to the spectrum analyzer, very useful for this type of measurement.

Manufacturer: Tektronix Inc, 14150 SW Karl Braun Dr, PO Box 500, Beaverton, OR 97077; **www.tek.com**.

Rigol DS1052E

The DS1052 did not include abbreviated instructions, but the full manual (166 pages) is downloadable online. The DS1052E includes a 120 V ac line cord, a pair of switchable 10:1/1:1 oscilloscope probes, and a USB cable for interfacing to your computer.

Again, I attempted to use the oscilloscope without reading the manual, other than the section on probe compensation. And again I had no problems. The AUTO button on the Rigol oscilloscope is equivalent to the AUTOSET button on the Tektronix oscilloscope. After applying a signal, press AUTO and then adjust the vertical sensitivity and horizontal timing to refine the display.

The only thing I had problems with was saving the display to a USB memory stick. The SAVE procedure is very flexible, permitting you to save different formats and even permitting you to name the files. The SAVE process wasn't intuitive, requiring me to refer to the manual.

The frequency response test was interesting. The specification is for a 3 dB rolloff at 50 MHz, but I found no rolloff at all on 6 meters.

For the overshoot and amp-key/unkey timing tests, I found I could display everything at the same time. When I went to the TRIGGER menu I found that one of the options was triggering on both negative and positive going slopes of the triggering signal. This let

Table 3
Rigol Storage Oscilloscope, Model DS1052E, s/n DS1ED142306733

General Specifications:

Display type: 5.6 inch diagonal color TFT LCD.
Display resolution: 320 horizontal × 240 vertical pixels.
Power consumption: 100-240 V ac, 45-440 Hz.
Operating environment: 50 to 104 °F, ≤60% relative humidity; 50 to 95 °F, ≤90% relative humidity, at <10,000 feet above sea level.
Input coupling: DC, AC, GND.
Input impedance 1 MΩ ±2%.
Size (HWD), weight: 6.1 × 11.9 × 5.2 inches, 5.1 pounds.

The following specifications have been determined to be "as specified" by Essco Laboratories, of Chelmsford, Massachusetts
Sample rate range: 13.65 samples/second – 1 G samples/second.
Scanning speed: 5 ns/div – 50 s/div.
Analog bandwidth: 50 MHz.
Maximum input voltage: 300 V RMS.
DC gain accuracy: 2 mV/div – 5 mV/div.
Internal trigger sensitivity: 0.1 div – 1.0 div (adjustable).
Trigger level range: ±6 divisions from center of screen (internal), ±1.2 V (external).

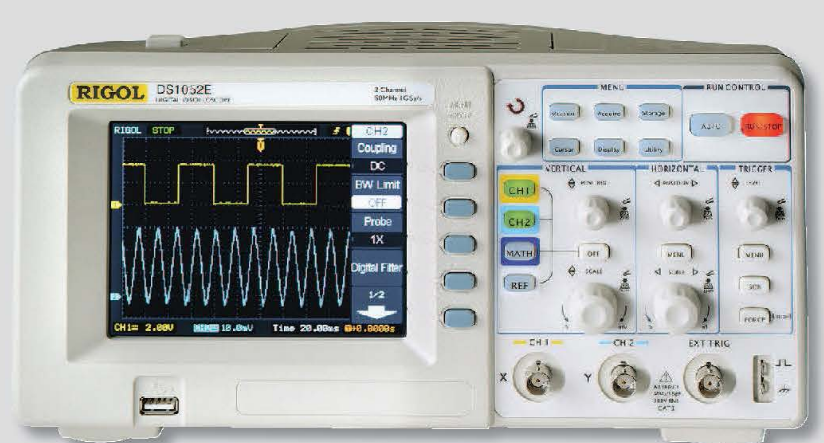


Figure 6 — Amp-key-to-RF-to-amp-disable timing using the Rigol DS1052E. Again, note the first dit overshoot.

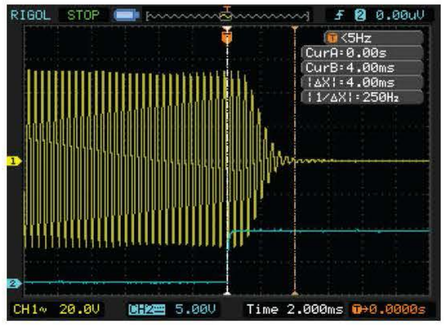


Figure 8 —Transceiver un-key/RF output timing detail viewed on the Rigol DS1052E.

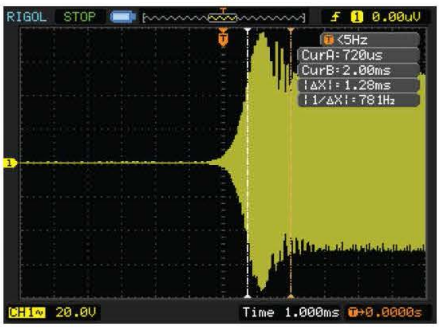


Figure 7 — A close-in view of the transceiver overshoot duration using the Rigol DS1052E.

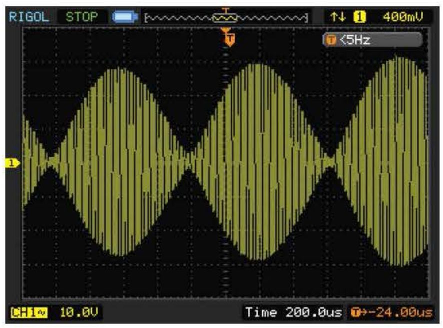


Figure 9 — Two-tone RF-modulated transceiver output measurement with the Rigol DS1052E using the same test setup as for Figures 4 and 5.

me look at the amp-key HSEND going low on transmit and high on un-key, and the resultant RF signal — including overshoot. The resulting timing waveform is shown in Figure 6. The blue trace is the amp-enable/disable (HSEND) line out of the IC-706MKIIG.

I also tested the overshoot and amp-disable timing separately so as to provide detail similar with the Tektronix TBS1042 tests. I enabled the vertical cursors in both cases so as to more easily display the time. From the detailed view, I found that the first dit over-shoot lasts less than 2 ms (Figure 7) and on un-key, RF is still being output about 4 ms after the amp key line has gone high (Figure 8).

For the final test I attempted a two-tone test as I'd done with the Tektronix unit. Figure 9 shows the time-domain two-tone RF-modulated signal. Apparently the Rigol DS1052E doesn't have enough buffer memory depth for the necessary resolution for two-tone testing (the buffer memory is where the captured samples are stored). There is plenty of resolution to show the main signal and its harmonics, but close-in signal resolution is not practical.

Manufacturer: Rigol Technologies Inc, 7401 First Place, Suite N, Oakwood Village, OH 44146; **www.rigolna.com**.

Some Final Observations

I did notice a few other differences between these two oscilloscopes that are worthwhile to point out.

Both oscilloscopes have a 5.7 inch diagonal color display. However, you can turn off the right-side menu on the Rigol, which provides a little more display area than on the Tektronix. The Tektronix oscilloscope takes about 30 seconds to boot up, whereas the Rigol is up and running in less than 10 seconds. Also, the Tektronix takes about 30 seconds to save a file to a USB memory stick, whereas the Rigol takes about 1 second. And I did like the Rigol's ability to trigger on both a positive and negative trigger on the same display. However, the Tektronix oscilloscope's ability to display a frequency domain two-tone test spectrum is important to me.

Somewhat off-topic, I would like to encourage the ARRL Lab to include transceiver overshoot and transceiver amplifier enable/disable output timing measurements with reviews of HF transceivers. These parameters are becoming increasingly important when interfacing a transceiver to an amplifier — especially when the amplifier is solid-state.

Conclusion

For hams who want to step up to the next level of testing, troubleshooting and understanding equipment performance, an oscilloscope becomes more of a necessity. Fortunately, digital sampling oscilloscopes have become surprisingly affordable. The two oscilloscopes discussed here will provide most of the capabilities desired by the more sophisticated ham at a price that is easily justifiable.

See the Digital Edition of *QST* for a video overview of the Rigol DS1052E and Tektronix TBS1042 oscilloscopes.