Review: The Rigol DS1052E and Tektronix TBS1042 Oscilloscopes
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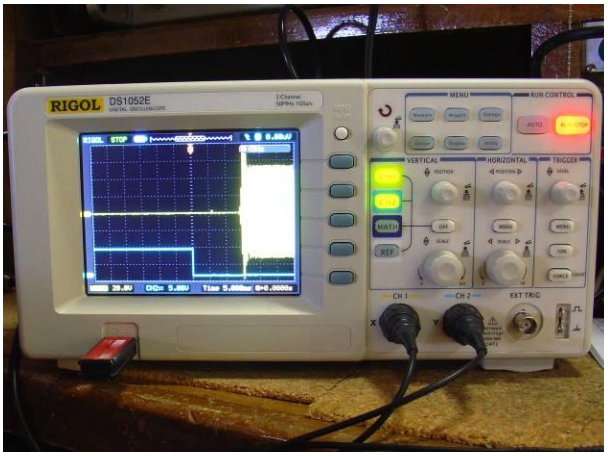

Figure 1: Rigol DS1052E Oscilloscope

Figure 2: Tektronix TBS1042 Oscilloscope

Introduction

Most hams have basic test equipment consisting of at least a DVM, SWR Meter, and (hopefully) a dummy load. These three instruments provide the ability to do basic troubleshooting. For the ham experimenter, additional equipment often includes an accurate power meter, a frequency counter, and an oscilloscope. Of these instruments, the oscilloscope has historically been the most expensive – leading hams to look at the used equipment market. Used analog oscilloscopes can be quite good. But they are also large, are not convenient for recording data, and may be difficult and expensive to repair. Digital sampling oscilloscopes (DSO's) have recently become available at prices justifiable for many ham experimenters. The two oscilloscopes reviewed here provide features and capabilities that will satisfy most home users.

The Oscilloscope Decision Process

In the past, there were a number of factors to be considered when choosing an oscilloscope. These 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 if spectrum analysis capability is desired. However with today's new DSOs the only decision you really need to make is the bandwidth required. But as you increase the bandwidth requirement, the cost of the oscilloscope can increase significantly. With this in mind, this review focuses on Rigol and Tektronix DSOs with a 40-50MHz 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. Multi-page detailed specifications can be found in the on-line complete manuals.

Table 1 – Rigol DS1052E and Tektronix TDS1042 basic specifications

	Rigol DS1052E	Tektronix TBS1042
Bandwidth:	50MHz	40MHz
Analog Channels:	2	2
Vertical Sensitivity:	2mv/div – 10V/div	2mv/div – 5V/div
Real-time sample rate:	1GSa/s (1 ch, 500MSa/s (2 ch)	500MSa/s

Vertical Resolution	8 bits	8 bits
Max Input Voltage(rms):	300V@30KHz, 60V@50MHz	300V@100KHz, 13Vpk@3MHz and above
Probe Impedance:	1:1 1MΩ//100pf, 10:110MΩ//17pf	10:1 only - 10MΩ//20pf
Math:	+, -, x, FFT	+, -, x, FFT
Std Interface:	USB (front & rear), RS232	USB (front & rear)
Size/Weight:	12”W x 6”H x 5-1/2”D/5.1 lbs	13”W x 6”H x 5”D/4.9lbs

Let’s make a few tests

Both of these oscilloscopes are very easy to use, and have similar specifications. So I selected some tests that I thought many 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 the calibrated set-up of Figure 1, and checked the amplitude of the frequency on 7-, 28-, and 50-MHz. As the Rigol has a 50MHz bandwidth, and the Tektronix has a 40MHz bandwidth, I would expect to see some roll-off 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.

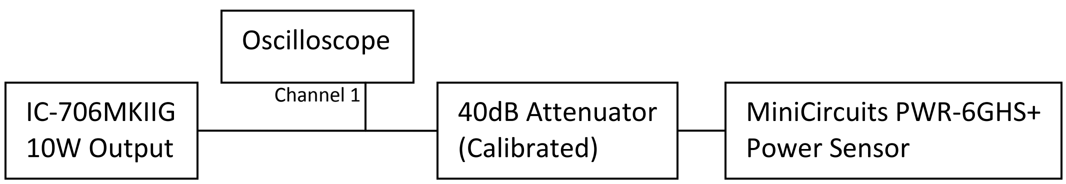

Figure 1: Frequency Response Test Set-Up

My next test involved measuring transmitter overshoot as shown in Figure 2. When a transceiver’s output power is reduced, often the transceiver output will overshoot the set power on the first “dit” or speech syllable as a finite time is required for the transceiver’s ALC to control the signal. If this overshoot is high enough, it can trip-off an external amplifier or even damage it. For this test I set my IC-706MKIIG to 25 watts output, as this is the approximate drive power needed for full output from my KPA500 amplifier.

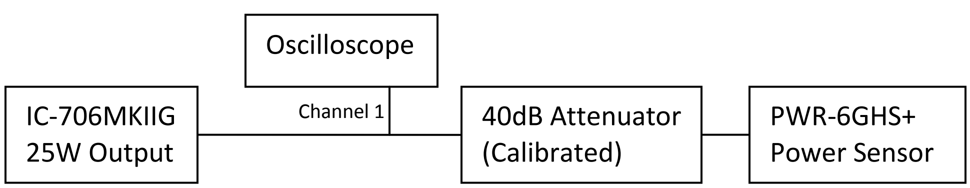

Figure 2: Transmitter Overshoot Test Set-Up

Next I wanted to look at the amplifier enable/disable timing versus the RF signal output. This timing is important when driving an amplifier so as to ensure that no hot-switching of the amplifier or transceiver takes place. And both the amp key-to-RF signal and RF signal-to-amp unkey timings are important, as you want to make sure that there is no chance of hot-switching on either amplifier keying or amplifier unkeying. As shown in Figure 3 I fed the IC-706MKIIG 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.

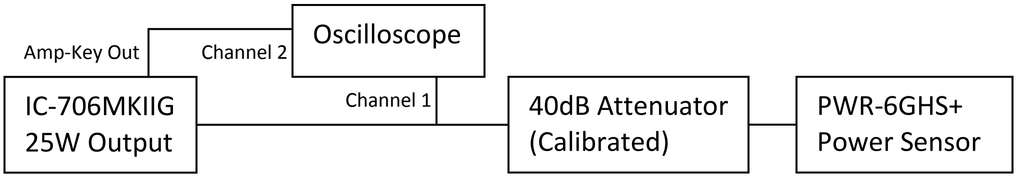

Figure 3: Amp Enable/Disable Test Set-Up

My final test involved 2-tone testing of my transceiver. A 2-tone test is a standard test of your transceiver's linearity that normally requires a spectrum analyzer. However, both oscilloscopes have a fast fourier transform (FFT) math feature which should permit you to display the signal in the frequency domain. For this test, a 2-tone audio signal is fed into the transceiver's microphone input, and the composite level adjusted for 25-watts peak output power. After displaying the normal modulated RF signal on the oscilloscope, select FFT and make sure you are displaying in the dB scale. Now use the vertical know to select dB/division, the horizontal timing knob to select the Hz/division, and center-up the signal on your display with the horizontal position control. Figure 4 shows my set-up.

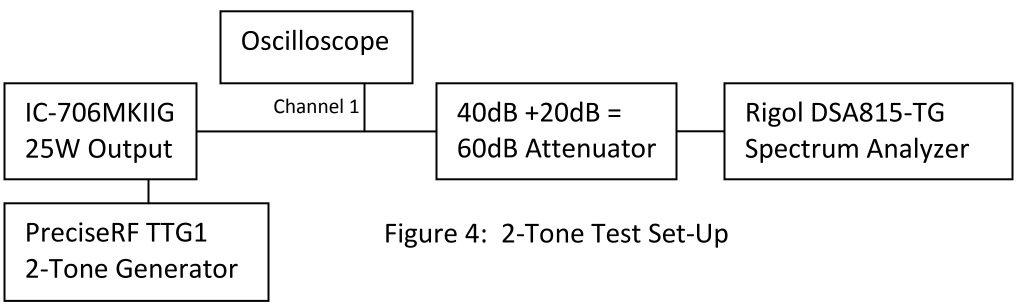

Figure 4: 2-Tone Test Set-Up

<u>The Tektronix TBS1042</u>

Like 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 on-line. The only accessories provided with the oscilloscope are the 120VAC power cord and a pair of 10:1 oscilloscope 10:1 probes, not switchable to 1:1. However, for most measurements you'll want to use a 10:1 probe as the capacitive loading of a 1:1 probe will be a problem for higher frequency RF signals, plus a 10:1 probe provides better overload protection should you accidentally connect to a high voltage source. A 1:1 probe is most usable only 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 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 roll-off of 0.57dB on 10 meters, and 1.67dB on 6 meters, much better than the 40MHz 3dB specification.

For the overshoot test I set my transceiver output to a nominal 25-watt level and triggered the TBS1042 on the channel 1 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 5. Note that with a set output power of 25 watts, the output peaks at 72Vpk (100 watts) on the first dit

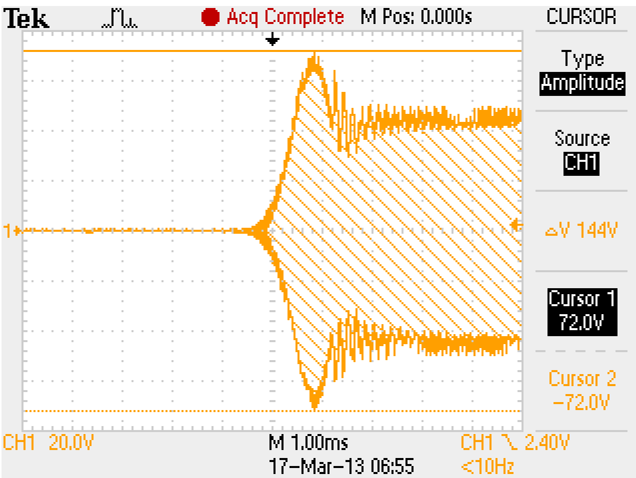

Figure 5: IC-706MKIIG Overshoot Measurement

Next I looked at the amp-key enable (Figure 6) timing with the IC-706MKIIG set for full break-in. The blue trace is the amp-enable HSEND line out of the IC-706MKIIG. The results are interesting. The amp-enable-to-RF output time of 15 milliseconds is fine for vacuum relays and PIN diodes. It is probably OK for open frame relays used on many non-QSK amps, but it is marginal. I.e., a typical enable time for open-frame relays is typically 12-20 ms.

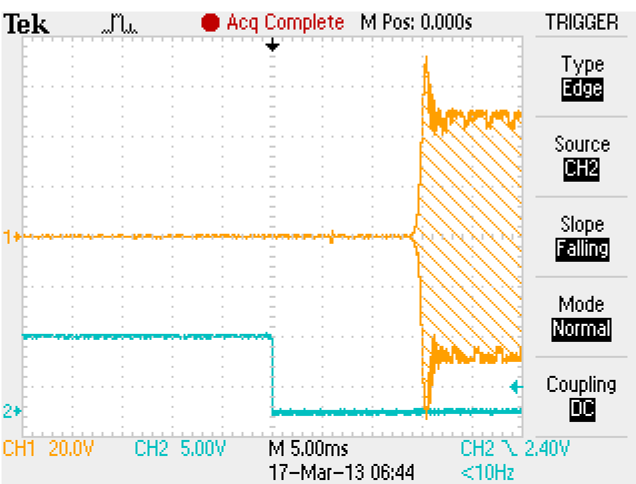

Figure 6: IC-706MKIIG Amp key-to-RF output timing

The amp-disable timing (Figure 7) shows a problem with QSK-switched amplifiers. I.e., the amp-disable line goes high about 4-milliseconds BEFORE RF drops to zero (the vertical cursors were enabled to better show this). So you may hot-switch a QSK amplifier if operating full-break-in. To be on the safe side, IC-706MKIIG users should only operate semi break-in.

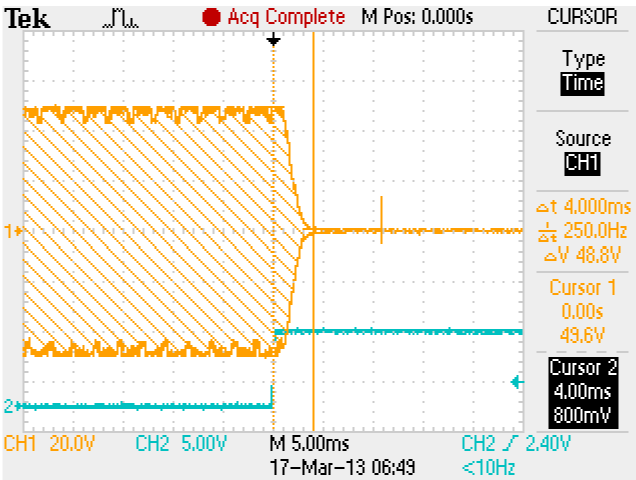

Figure 7: IC-706MKIIG RF/amp disable timing

My last test was a 2-tone test of the IC-706MKIIG. Figures 8 and 9 compare the displays of a real 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.

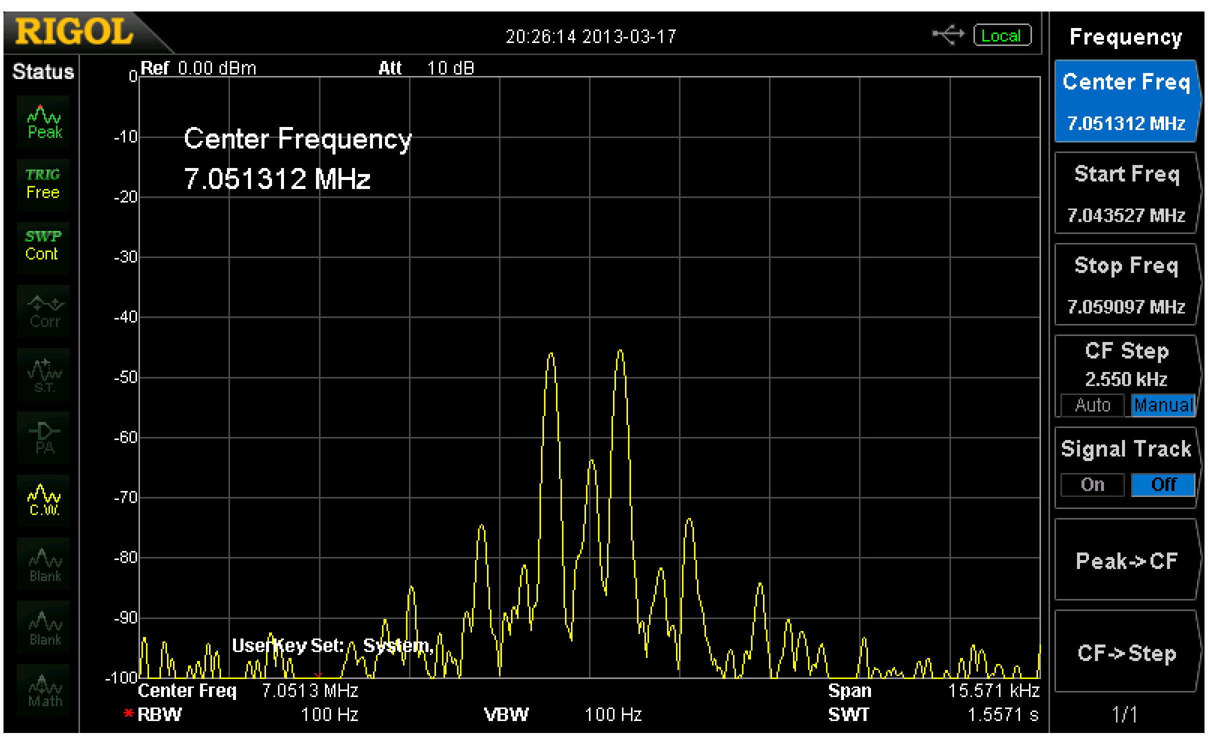

Figure 8: Spectrum analyzer display of IC-706MKIIG 2-tone test

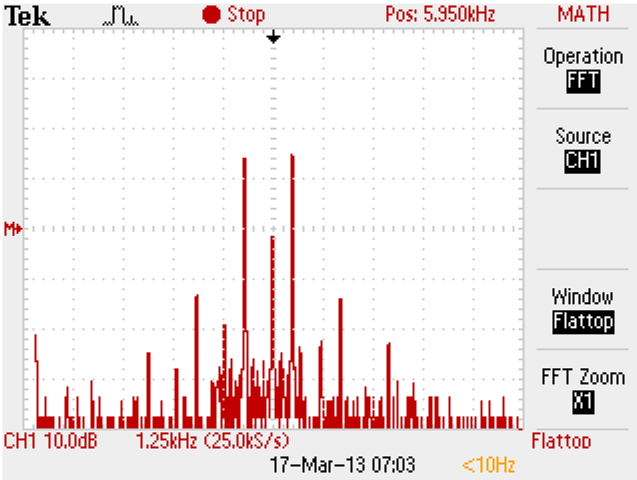

Figure 9: TBS1042 2-tone test FFT display

The Rigol DS1052E

There was not an abbreviated manual supplied with the DS1052E. However, the full manual (166 pages) is downloadable on-line. The DS1052E includes a 120VAC line cord, a pair of switchable 10:1/1:1 oscilloscope probes, and a USB A/B cable for interfacing to your computer.

Again, I attempted to use the oscilloscope without reading the manual, other than the 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 to your liking.

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. Whereas the specification is for a 3dB roll-off at 50 MHz, I found no roll-off 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 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 10. The blue trace is the amp-enable/disable (HSEND) line out of the IC-706MKIIG.

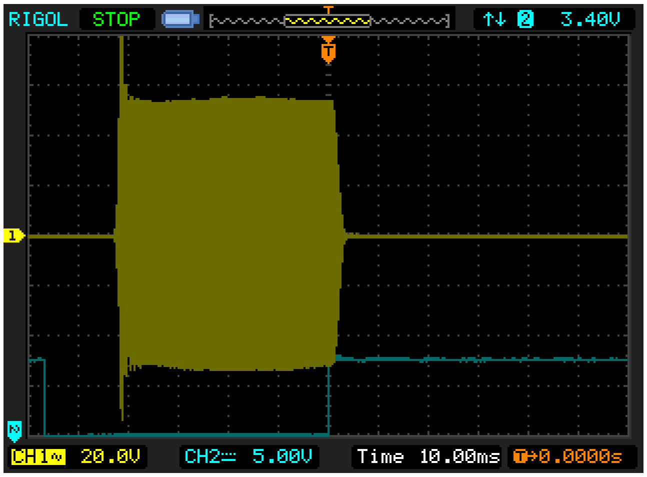

Figure 10: Amp enable-to-RF-to-amp disable timing. Again, note the first dit overshoot.

However, 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. Figure 11 shows the first-dit overshoot, which lasts less than 2ms. And Figure 12 shows the amplifier un-key timing showing that RF is still being output about 4ms after the amp-key line has gone high.

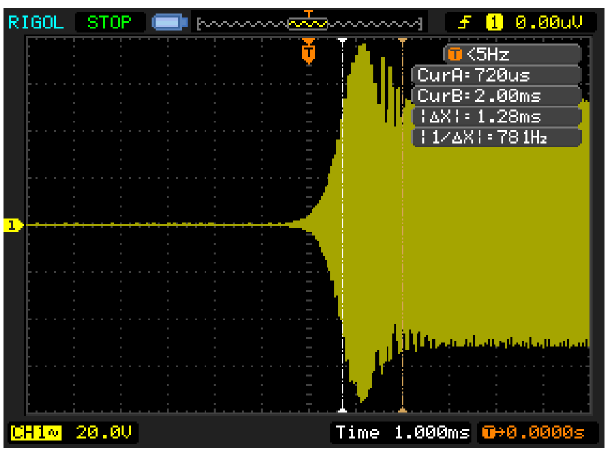

Figure 11: IC-706 Overshoot duration

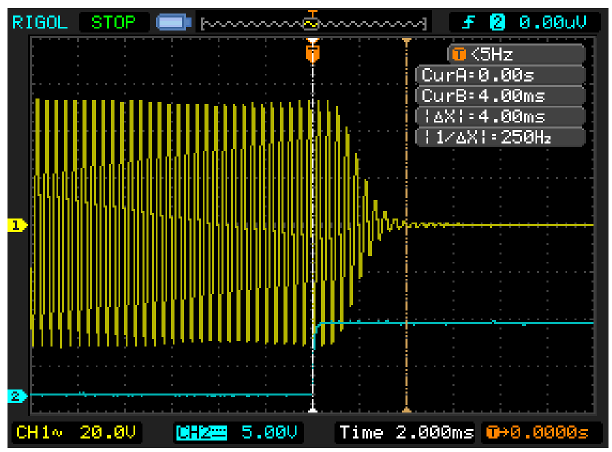

Figure 12: IC-706 amp disable/RF out timing

For the final test I attempted a 2-tone test as I'd done with the Tektronix unit. Figure 13 shows the time-domain 2-tone RF-modulated signal. Apparently the Rigol DS1052E doesn't have enough buffer memory depth for the necessary resolution for 2-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.

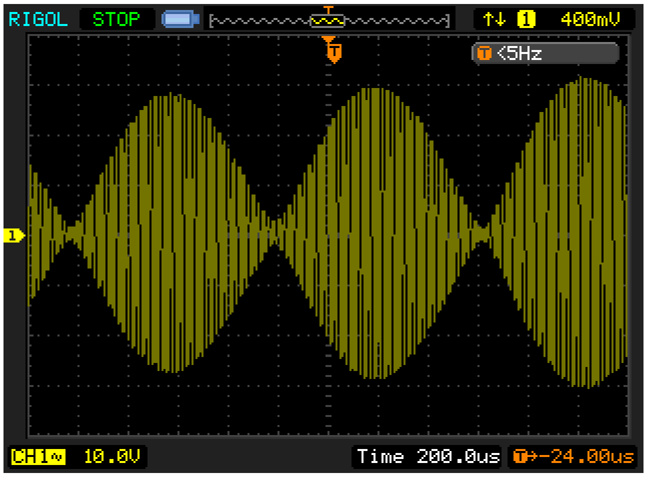

Figure 13: 2-tone RF-modulated transceiver output

One somewhat off-topic observation

I would like to see the ARRL lab measure transceiver overshoot and amplifier enable/disable timing in their equipment reviews. These parameters are becoming increasingly important when interfacing a transceiver to an amplifier – especially when the amplifier is solid-state.

Some final observations

I noticed a few other differences between these two oscilloscopes that are worthy of mentioning. Both oscilloscopes have a 5.7" 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 2-tone test spectrum is important to me.

Conclusion

For hams that 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.

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 some high-end watt-meters on the market!

Manufacturer, TBS1042: Tektronix Inc., 14150 SW Karl Braun Drive, P.O. Box 500, Beaverton, OR 97077. www.tek.com

Maufacturer, DS1052E: RIGOL Technologies Inc., 7401 First Place, Suite N, Oakwood Village, OH 44146. www.rigolna.com