Rigol Technologies DSA815-TG Spectrum Analyzer

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A spectrum analyzer is a test instrument that measures RF signal level versus frequency, referred to as measurements in the *frequency domain*. Unlike an oscilloscope that measures in the *time domain*, a spectrum analyzer can easily be used to detect and observe frequency, power level, harmonics, bandwidth and other signal parameters.

One of the key tests I perform at the ARRL Lab is the emission standards evaluation of transmitters and amplifiers in which the levels of all harmonics and spurious emissions are compared to the fundamental (carrier) signal. Typically this measurement is performed with our calibrated Agilent/HP 8563E spectrum analyzer, which covers 9 kHz to 26.5 GHz. The HP 8563E is an accurate, laboratory grade professional instrument, but it is cost prohibitive for most radio amateurs and experimenters. A *used* laboratory grade spectrum analyzer such as the HP 8563E can cost tens of thousands of dollars, and one of these instruments is overkill for most amateur experimenters.

Headquartered in China, Rigol (pronounced "regal") is an established manufacturer of test equipment that is distributed worldwide. Rigol recently introduced the DSA815, a 9 kHz to 1.5 GHz spectrum analyzer with a starting price of $1295. Rigol has been advertising the DSA815 in *QST* and demonstrating it at ham conventions. ARRL members inquired about the unit, feeling that "it was too good to be true." As a test engineer, I was curious too, so our Product Review editor ordered the DSA815-TG, the model with a factory installed tracking generator, for $1495.

Overview

The Rigol DSA815 is compact unit that sports a handle and weighs in at a mere 9.4 pounds, suitable for both laboratory and portable operation. The 8 inch diagonal colorful LCD screen dominates the front panel and has a resolution of 800 × 400 pixels. Anyone who is familiar with the operation of spectrum analyzers will have no trouble understanding the basic functions, as most of the controls are the same as on other, more expensive units.

A USB computer connection and a PRINT button allow display and setup data to be retrieved without the typical GPIB interface seen on many older spectrum analyzers and other professional test equipment. (GPIB — the General Purpose Interface Bus — is also known as IEEE 488. Rigol offers a USB to GPIB adapter as an option.) I like the flip-up front feet that enable ergonomically friendly desktop operation. The DSA815-TG is vented from the sides with a very quiet fan.

Type N connectors on the front panel are used for RF INPUT and GEN OUTPUT (tracking generator output). Both are 50 Ω. Along with the 120 V ac power connection, the rear panel jacks are for USB and LAN connections, BNC 10 MHz in/out reference connections, and a BNC connection for the trigger input. The outside looks neat and modern; but what about the inside?

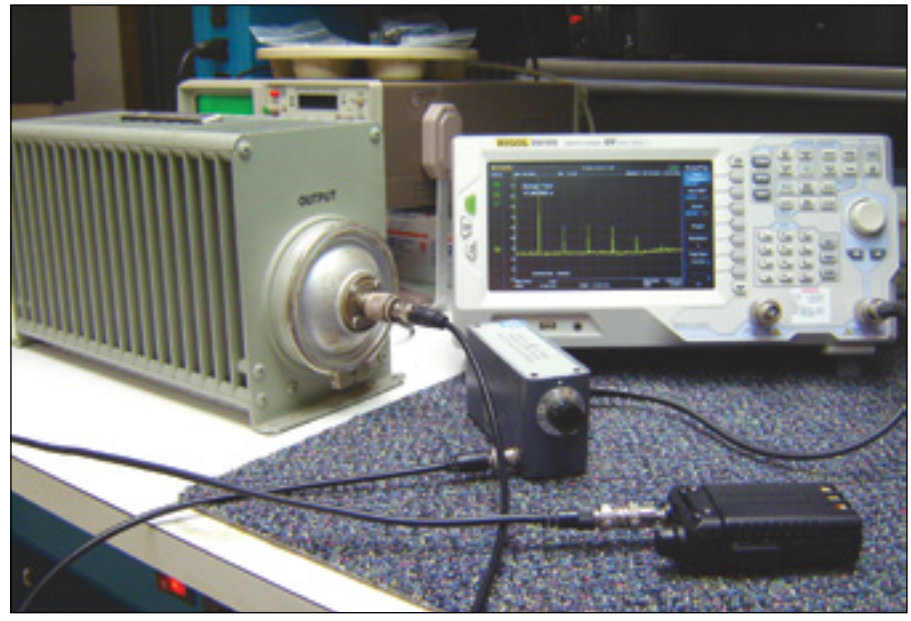

Figure 2 — In the Lab we use one or more high power attenuators and a step attenuator to bring the power of a transmitter under test down to a safe level for the input of test equipment (usually we shoot for around 1 mW). Here the DSA815-TG is used to observe the fundamental signal and harmonics of a 2 meter handheld.

Bottom Line

The Rigol DSA815-TG is a lightweight, portable spectrum analyzer that is affordable for serious experimenters and self employed service technicians. It has many uses in the amateur workshop.

Table 2
Rigol Technologies Spectrum Analyzer, Model DSA815-TG, s/n DSA8A142400036

The following manufacturer's specifications have been determined to be "as specified" by Essco Calibration Laboratories, of Chelmsford, Massachusetts.

Frequency range: 9 kHz to 1.5 GHz.
Frequency resolution: 1 Hz.
Internal frequency reference: 10 MHz.
Temperature drift, 20° to 30° C: <2 ppm.
Marker resolution: Span / (sweep points – 1).
Marker frequency counter resolution: 1 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz.
Frequency span: 0 Hz, 100 Hz to 1.5 GHz.
SSB phase noise, carrier offset, 10 kHz: <–80 dBc/Hz.
Resolution bandwidth (RBW), (–3 dB): 100 Hz to 1 MHz, in 1-3-10 sequence.
RBW, (–6 dB) (Option): 200 Hz, 9 kHz, 120 kHz.
RBW uncertainty: <5%, nominal.
Resolution filter, shape factor (60 dB:3 dB): <5, nominal.
Video bandwidth (–3 dB): 1 Hz to 3 MHz, in 1-3-10 sequence.
Amplitude measurement range: 10 MHz to 1.5 GHz, displayed average noise level (DANL) to +20 dBm; 100 kHz to 10 MHz, DANL to 0 dBm.
Maximum rated input level, dc voltage: 50 V.
CW RF input power (with RF attenuation = 30 dB): +20 dBm (100 mW).
Maximum RF input level before damage: +30 dBm (1 W).
Displayed average noise level (DANL), with 0 dB RF attenuation, RBW=VBW=100 Hz, sample detector, trace average = 50:
Preamplifier off: 100 kHz to 1 MHz: <–90 dBm, typical –110 dBm; 1 MHz to 1.5 GHz, <–110 dBm + 6 × (f/1GHz) dB, typical –115 dBm.
Preamplifier on: 100 kHz to 1 MHz, <–110 dBm, typical –130 dBm; 1 MHz to 1.5 GHz, <–130 dBm + 6 × (f/1 GHz) dB, typical –135 dBm.
Level display range: log scale, 1 dB to 200 dB; linear scale, 0 to reference level.
Number of points: 601; number of traces: 3+ math trace.
Trace detector: Normal, Positive-Peak, Negative-Peak, Sample, RMS, Voltage Average, Quasi-Peak (optional).
Trace functions: Clear Write, Max Hold, Min Hold, Average, Freeze, Blank.
Scale unit: dBm, dBmV, dBµV, nV, µV, mV, V, nW, µW, mW, W.
Frequency response, 10 dB RF attenuation, relative to 50 MHz, 20° to 30° C:
(Preamplifier off), 100 kHz to 1.5 GHz, <0.7 dB;
(Preamplifier on),1 MHz to 1.5 GHz, <1.0 dB.
Input attenuation setting range: 0 to 30 dB, in 1 dB steps.
Reference level range: –100 dBm to +20 dBm in 1 dB steps.
Resolution: log scale, 0.01 dB; linear scale, 4 digits.
RF input VSWR, 10 dB RF attenuation, 1 MHz to 1.5 GHz: <1.5.
Intermodulation, second harmonic intercept: +40 dBm; third-order intercept, fc >30 MHz, +10 dBm.
1 dB gain compression, total input power of mixer, fc = 50 MHz, preamplifier off: >0 dBm.
Note: Mixer power level (dBm) = input power (dBm) – input attenuation (dB).
Spurious responses: image frequency, <–60 dBc; intermediate frequency, <–60 dBc; spurious response, inherent, <–88 dBm, typical.
Sweep time range: 100 Hz =Span= 1.5 GHz, 10 ms to 1500 s; zero span, 20 µs to 1500 s.
Sweep mode: continuous, single.
Trigger source: free run, video, external. External trigger level: 5 V TTL level.
Tracking generator (TG) (DSA815-TG) frequency range: 9 kHz to 1.5 GHz.
TG output level: –20 dBm to 0 dBm, in 1 dB step.
TG output flatness: 1 MHz to 1.5 GHz, referenced to 50 MHz: ±3 dB.
Input/output RF impedance: 50 Ω. Connector: N-type, female.
TG output impedance: 50 Ω. Connector: N-type, female.
10 MHz REF IN/10 MHz REF OUT/external trigger in connector: BNC female.
10 MHz REF IN amplitude: 0 dBm to +10 dBm.
10 MHz REF OUT amplitude: +3 dBm to +10 dBm.
Display type: TFT LCD. Resolution: 800 × 480. Size: 8 inch. Colors: 64 k.
Printer protocol: PictBridge.
Remote control: USB, USB TMC, LAN 10/100 Base-T, RJ-45, LXI-C Class, IEC/IEEE BUS (GPIB) with USB-GPIB interface converter option IEEE 488.2.
Power supply input voltage range, ac: 100 V to 240 V, nominal, 45 Hz to 440 Hz.
Power consumption: typical 35 W, max 50 W with all options.
Operating temperature range: 5° to 40°C; storage temperature range: –20° to 70°C.
Dimensions (HWD): 7.0 × 14.2 × 5.0 inches; weight, with tracking generator: 9.4 lbs.
Price: DSA815-TG, $1495; DSA815 (without tracking generator), $1295.

While I dared not open it up to take a peek (this voids the calibration), Rigol explains, "The DSA815 uses digital IF technology (DSP), that enables smaller bandwidth settings which reduces the average noise level." The narrowest filter bandwidth setting of this model is 100 Hz. The use of this technology reduces the complexity of the hardware and also explains its compact size. The frequency range of this unit is 9 kHz to 1.5 GHz, reasonable for measurements of most amateur equipment. Other Rigol models offer frequency coverage to 3 GHz, greater sensitivity and narrower resolution bandwidth.

In the ARRL Lab, our RF shielded screen room and instruments are set up for the testing of typical Amateur Radio equipment, not for testing other laboratory instruments. To verify whether or not the DSA815 performs as specified in Rigol's literature, I sent the unit to the lab that annually calibrates our test equipment — Essco Calibration Laboratory of Chelmsford, Massachusetts. Essco checked all specifications, and soon afterward it arrived back at the ARRL Lab sporting a calibration sticker. Table 2 lists Rigol's key specifications for the DSA815-TG, and Essco confirms that the test results are "as specified."

Applications

The user of the DSA815 and all other spectrum analyzers must pay close attention to the power levels at the input. With the Rigol, any power level greater than +20 dBm (100 mW) will lead to an expensive repair and recalibration, so a power attenuator and step attenuators are always used between the device under test and the spectrum analyzer. In the Lab for safety's sake and to avoid overload leading to measurement errors, we use an input signal no greater than 1 mW and use attenuation as needed to get to that level. Figure 2 shows a typical Lab setup for testing a transmitter. For more information on how we use spectrum analyzers during various tests we perform on Amateur Radio equipment, please check out the ARRL Lab's *Procedure Manual* online.[6] *The ARRL Handbook* also explains the use of spectrum analyzers in its Test Equipment and Measurement chapter.[7]

[6] *The ARRL Lab Test Procedures Manual* is available for download from **www.arrl.org/product-review**.

[7] *The ARRL Handbook*, 2013 edition. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 4050. Telephone 860-594-0355, or toll free in the US 888-277-5289; **www.arrl.org/shop**; **pubsales@arrl.org**. Chapter 25, Test Equipment and Measurements, explains the use of spectrum analyzers.

In the Field

Our DSA815-TG was quickly pressed into service at the ARRL National Convention at Pacificon in Santa Clara, California, last October. There, yours truly set up a booth with the Rigol spectrum analyzer, power and step attenuators, and a Bird 43 power meter (Figure 3). I tested hundreds of VHF and UHF handheld transceivers, each owned by a ham eager to see if his or her unit met the FCC spectral purity requirements (Part 97.307e). The Rigol never skipped a beat during the entire event, unlike some of the handhelds I tested that didn't make the grade. The LCD screen was easily seen by all who visited my booth, despite the bright overhead fluorescent lighting.

In the ARRL Lab

Back at the ARRL Lab, I put the DSA815-TG through its paces, performing some of the same tests I normally do for transceiver testing. I also found the DSA815-TG's tracking generator very useful while sweeping some of the band-pass filters I use during amplifier tests. Figure 4 shows the response of a band-pass filter with the tracking generator level set to –20 dBm, with a start frequency of 0 MHz and a stop frequency of 30 MHz. I was then able to use the storage function to transfer a CSV file (comma separated values with the X and Y axes) of the band pass filter plot to a flash drive. From that file, I used *DPlot* plotting software to create the chart shown in Figure 5. Look closely: our filter has an attenuation of 5 dB at 4 MHz and will attenuate a signal at the high end of the 75 meter band (that's good to know!).Though our own HP 8563E spectrum analyzer does not have the tracking generator option, I used our analyzer and our IFR 2040 signal generator to measure the same band-pass filter at several frequencies; the measurements were virtually the same as those made with the Rigol DSA815-TG. For basic measurements, it appears the Rigol unit does just about everything a more expensive spectrum analyzer can do within its frequency range. The more expensive instrument will have a greater frequency range and will have better resolution while looking at chunks of spectrum spanning 1 MHz or less. That translates to more data points along the spectrum. Table 3 compares the capability of the DSA815 and HP 8563E, showing the smallest resolution bandwidth setting available versus the amount of swept frequency.

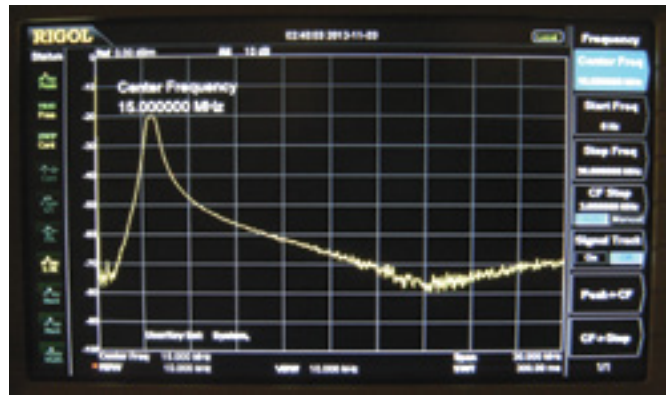

Figure 4 — The DSA815-TG's built-in sweep generator is handy for testing filters. Here is the frequency response of an 80 meter band-pass filter.

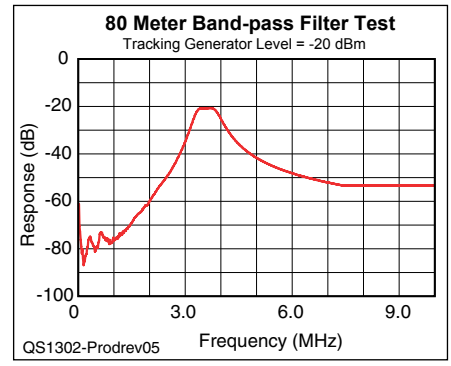

Figure 5 — This chart was made by saving the data from the filter sweep shown in Figure 4 to a CSV file, which was then imported into *DPlot* graphing software to take a close look at the filter's response from 1 to 10 MHz.

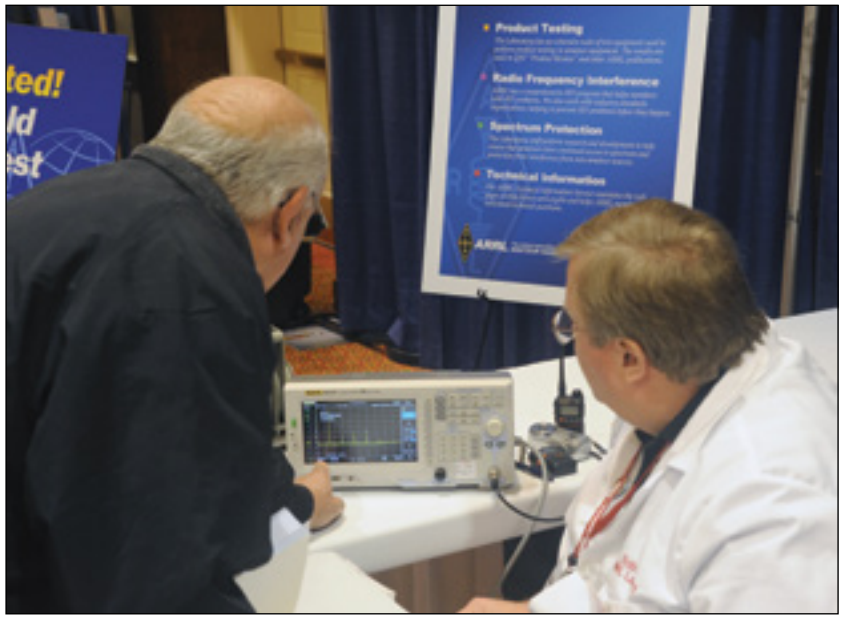

Figure 3 — Bob Allison, WB1GCM (in the white coat), checked the spectral purity of handheld radios for visitors at the ARRL National Convention at Pacificon last November. Most radios met FCC requirements, but there were a few surprises.

More Features

The DSA815-TG has the ability to search and display the input signal of an unknown frequency by pressing the AUTO button. I did this repeatedly with a handheld transceiver connected through an attenuator and sure enough, the carrier would appear in the center of the screen and with the signal level auto scaled. I also connected a VHF/UHF ground plane at the input and pressed the AUTO button. Not surprisingly, the DSA815 showed local FM broadcast stations to be the strongest received signals at our location.

Most spectrum analyzers have a headphone jack, and the Rigol has one too. This allows the user to hear AM or FM analog stations via a headphone jack while using a demodulator. After some adjustments, I got the Rigol to play music from an FM broadcast station, but the audio was disappointingly low.

I did encounter a problem when adjusting resolution bandwidth, frequency span and demodulation time in rapid succession

Table 3
Display Frequency Width versus Resolution Bandwidth (RBW)

Sweep Width (MHz)	Minimum RBW (Hz) Rigol DSA815	HP 8563E
1000	1000	10,000
100	300	3000
10	100	1000
1	100	10
0.1	100	10
0.01	100	10
0.001	100	10

— the Rigol display froze up. The instrument usually recovered from my demanding requests within a few seconds, but once I had to power down and power up again to let it reboot.

Accessories

The DSA815-TG comes with a printed *Quick Guide* and a CD-ROM with a more detailed *User's Guide* and *Programming Guide*. You'll need to supply cables and attenuators suitable for the measurements you want to make.

Rigol offers a number of optional accessories for the DSA815, including a USB to GPIB converter, rack mount, carrying bag and attenuator. Other options include a VSWR measurement kit, an EMI/quasi peak detector kit, and an advanced measurement kit for evaluating parameters such as adjacent channel power, occupied bandwidth, emission bandwidth, harmonic distortion and third order IMD. A utility kit with a variety of cables, adapters and antennas is available as well.

One feature I would like to see is the option to power the DSA815 from an internal rechargeable battery, a feature I've seen on some other portable spectrum analyzers and storage scopes. That would make this compact unit even more attractive for measurements in the field.

In Summary

A spectrum analyzer is a valuable tool for anyone who enjoys building, modifying or evaluating oscillators, amplifiers, filters, transmitters and other RF equipment. In the not too distant past, most spectrum analyzers that amateurs could afford for home use were old, surplus professional units that had seen better days. Often they were long out of calibration and difficult, if not impossible, to repair if anything went wrong. More recently, hams paired fairly simple hardware with PC-based sound cards and software to make RF spectrum analysis available at a reasonable price.[8] The Rigol DSA815 takes the next step, using DSP technology to make an affordable, standalone, accurate test instrument.

Overall, I was pleased with the DSA815-TG's performance and ease of operation. It looks sharp, and its small size makes a great addition to any test bench.

US Distributor: Rigol Technologies Inc., 7401 First Place, Suite N, Oakwood Village, OH 44146; **www.rigolna.com**; tel 877-474-4651; fax 440-232-4488.

[8]G. Steber, WB9LVI, "Experimenter's RF Spectrum Analyzer," *QST*, Oct 2008, pp 36-40.

See the Digital Edition of *QST* for a video overview of the Rigol DSA815-TG spectrum analyzer.

New Products

DxSpot App for iPad, iPhone and iPod Touch from Green Creek Technology

DxSpot from Green Creek Technology is available from the iTunes store for iPhone, iPad and iPod touch (IOS 3.2 or later). This app provides mobile access to the Amateur Radio DX cluster network, and its database contains the connection parameters for more than 300 Internet DX clusters. Connection parameters can be customized to access new or private clusters. Other features include automatic cluster logon with optional password entry, telnet access to the cluster console and the ability to enter cluster commands. *DxSpot* monitors DX spots in real time, creating formatted table displays. Other displays include colorized WWV propagation data, users currently connected to the cluster, and cluster announcements. The app also provides automatic QRZ.com web page search by DX, spotter or user call signs. Another screen displays detailed information about ARRL DXCC entities, including name, prefix, flag, continent, CQ/ITU zones, latitude/longitude and UTC time offset. This application is for licensed Amateur Radio operators and a valid call sign is required for use. Price: $3.99 from the iTunes app store. For more information, visit **www.greencreektechnology.com**.

High Power VHF/UHF Amplifiers from Lunar-Link International

The Lunar-Link amplifier business has been acquired from the estate of the late Steve Powlishen, K1FO, by Louis Parascondola, W1QJ, and Steve Simons, W1SMS. Lunar-Link International will offer legal limit output VHF/UHF linear amplifiers, accessories, technical support, repairs and replacement parts. These amplifiers and accessories are intended for use in demanding applications including EME, contesting and digital modes. Deliveries were expected to begin in the first quarter of 2013. For more information, or to order, visit **www.lunarlink.com**.