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TEN-TEC Model 418 100 W HF and 6 Meter Linear Amplifier

Give your QRP transceiver a boost.

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TEN-TEC's new linear amplifier is designed to boost the power output of the popular 5 W class low power (QRP) radios to 100 W over the 160 to 6 meter amateur bands, including the 60 meter channels. Switchable input attenuators are provided to allow radios with power outputs of up to 20 W to operate with the amplifier without overdriving the input. While the 418 is clearly designed as a companion to the TEN-TEC model 539 Argonaut VI QRP transceiver (announced, but not available as we write this), it can work equally well with most other QRP rigs.

Back to the Future

This amplifier follows in a long tradition of TEN-TEC QRP radios starting with the original TEN-TEC 5 W Argonaut transceiver introduced in 1971. The following year, TEN-TEC introduced the model 405, a 5 W in, 50 W out amplifier, designed to follow the Argonaut. It was offered at $149, equivalent to $821 in 2012.[1]

The proliferation of "amateur" 10 meter linear amplifiers marketed to CB operators at truck stops and other retailers resulted in the FCC ruling that amplifiers requiring less than 50 W drive for rated output were illegal, effectively outlawing external amplifiers for QRP transceivers. Recent FCC rule changes have made them available again, but only if they include a means to ensure that they cannot amplify any signals on frequencies between 26-28 MHz.[2] The use of internal frequency counters and processors makes this more feasible than in the past.

As anyone who has operated with QRP knows, radios at 5 W or even much less can be surprisingly effective. Many hams enjoy taking compact QRP transceivers on hiking or camping trips, along with temporary wire antennas. Operating QRP from home stations with permanent antennas is even more effective. Still, there are times when conditions require higher power than 5 W to overcome noise or interference at the far end. This amplifier will provide a 13 dB boost to a 5 W transceiver, an increase of more than two S units, making the signal sound as strong as the typical home station transceiver.

So What's it Do?

The earlier model 405 amplifier had a BAND switch, TR DELAY control and POWER ON/OFF button along with analog meters showing output power and SWR on its front panel. It was essentially just an amplifier and a few relays inside a box. The Model 418, in common with most current amplifiers at any power level, is a marvel of modern microprocessor based control and indicator functionality.

Display

The display includes bar graphs for forward power output to 100+ W and SWR up to 3:1. In addition to rapidly following the output power on a voice syllable or CW element basis, the forward power bar graph includes a "hanging" dot that indicates peak power — very handy. There are also OVERDRIVE and FAULT indicators that show up only when appropriate, with the nature of the fault indicated. The display can be backlit by red, blue or green LEDs that can be independently adjusted.

Also on the front panel are numerical displays of final amplifier collector current (I_C) and heat sink temperature — handy for keeping track of what's happening inside.

Front Panel Controls

Pushbutton controls are provided for setting the input attenuator (ATTN), changing band (see below), selecting HF antenna outputs ANT 1 or ANT 2, setting TR delay (DLY), changing display background color and intensity, and turning power ON or OFF.

Either of the two HF antenna ports can be used on 160 through 10 meters, while a third port is dedicated to, and automatically selected for, 6 meters. This is a perfect arrangement if your 6 meter antenna is the usual monoband Yagi. It's not as handy if you are using a wire antenna and tuner on all bands, or if you have an antenna that operates on 6 meters along with other bands, such as my coupled resonator 6 meter add-on to a triband Yagi.[3] The folks at

Bottom Line

The TEN-TEC model 418 linear amplifier can provide a handy 13 dB (about two S unit) boost to low power radios if used where enough dc power is available. While the model 418 is designed as a companion to the soon to be released Argonaut IV 5 W transceiver, it can also operate seamlessly with other transceivers of the same power class.

[1]www.bls.gov/data/inflation_calculator.htm
[2]Code of Federal Regulations, Title 47, §97.317, Standards for certification of external RF power amplifiers.

TEN-TEC announced a production change that allows 6 meter output to go to the ANT 1 or ANT 2 ports if desired, while leaving the dedicated 6 meter port for those who can make use of it. This change went into effect with software version 418V1b203 and is included with amplifiers shipping November 5, 2012 and later. If you have an earlier version of the 418 and need a combined HF/6 meter antenna port, contact TEN-TEC to arrange for a firmware upgrade.

The transceiver I used with this amplifier was intended to operate at 10 W output, so this provided a good test of the input attenuator function. Using the 4 dB setting worked fine, as expected. The attenuator can also be used to reduce power for antenna tuner adjustment, for example, if the transceiver doesn't offer easy power adjustment.

Figure 1 — The TEN-TEC 418 rear panel connections.

Band switching is accomplished by pushing a dedicated front panel pushbutton for each band. If you forget to change bands at the amplifier, the frequency counter included to restrict CB operation will note the discrepancy and change bands automatically, as long as the drive level is 200 mW or higher.

Rear Panel Connectors

The rear panel (Figure 1) includes four UHF (SO-239 type) sockets, one for RF input (INPUT) and three for RF output (HF ANT 1, HF ANT 2 and ANT 6M ONLY). The dc power connector is a pair of Anderson Powerpoles, oriented in the now standard configuration. A 25 A automotive type fuse is available directly on the rear panel and is replaceable without opening covers. The amplifier keying loop (see below) is supported by a single ⅛ inch stereo jack — tip for KEY IN, ring for KEY OUT.

TEN-TEC thoughtfully provides a mating cable that splits out the functions to two RCA type plugs. In addition, there is an accessory socket (ACC 1) that is an eight-pin DIN type socket (mating connector and cable supplied). This connector includes amplifier keying capability and other functions identified for use with TEN-TEC's future Argonaut VI transceiver— CLOCK INPUT, ENABLE INPUT and DATA INPUT.

Full Break-In CW Operation

Successful full break-in CW (QSK) operation, in which transmit-receive (TR) switching occurs between dots and dashes to allow listening in between code elements, requires careful control of TR switch sequencing. As a part of the TR process with QSK, there must be a delay in the generation of RF until the amplifier is ready to transmit. Likewise, the switchover back to receive must be delayed to make sure that no RF will still be coming from the transmitter or amplifier while the amplifier relays are in the process of switching. This could quickly burn up the TR relay contacts. Lab measurements indicated that our sample amplifier switches to transmit about 5.5 ms after the KEY IN is closed, and is back off about 9 ms after KEY IN is opened.

Semi break-in, in which the switchover back to receive is delayed so it doesn't occur between code elements, is automatically protected from this kind of problem because the longer switchover delay sidesteps the issue. Many CW operators prefer semi break-in for casual operation to avoid distractions, while QSK is quite popular with DXers, contesters and traffic handlers.

The 418 can support full QSK operation in a number of different ways. The amplifier is equipped to support the unique TEN-TEC keying loop, in which the KEY line in the transceiver doesn't actually key the transceiver directly. The KEY line first comes to the amplifier to key it, and then is fed to the transceiver. This feature need not be used, and in fact won't be supported by most transceiver brands other than TEN-TEC. Reportedly, the TEN-TEC Argonaut IV

Table 1
TEN-TEC, 418, serial number 3053051430

Manufacturer's Specifications	Measured in ARRL Lab
Frequency range: All amateur frequencies in the range of 1.8 to 29.7 MHz and 50 to 54 MHz.	As specified.
Power output: 100 W ±1 dB; SSB/CW continuous service; AM/FSK/PSK, 50% duty cycle.	As specified.
Driving power required: 1 to 20 W.	As specified. Up to 20 W with built-in attenuator.
Spurious and harmonic suppression: HF, –50 dBc; 6 Meters, >–60 dBc.	HF, –52 dBc worst case*; typically –60 to –64 dBc. 50 MHz, –64 dBc. Meets FCC requirements.
Third order intermodulation distortion (IMD): 30 dB below PEP.	3rd/5th/7th/9th: 37/38/47/57 dB below PEP (14 MHz, 100 W PEP output).
Power requirements: 13.8 V dc at 17 A.	At 13.8 V dc, 17 A transmit (100 W PEP output), 0.2 A standby.
Size (height, width, depth): 3.6 × 6.5 × 7.6 inches; weight, 5.4 lbs.	
Price: $785.	
*30 meters, at maximum output.	

[3]J. Hallas, W1ZR, "Add 6 Meters to Your Triband Yagi," *QST*, Sep 2011, pp 40-43.

will support the TEN-TEC keying loop.

For transceivers that don't support the keying loop, a single amplifier keying line will be used, as with most other amplifiers. Without the keying loop to keep timing under control, sequencing can be accomplished by inserting sufficient delay in the switchover from the transceiver for the leading edge and delaying the response in the amplifier for the trailing edge.

Some transceivers have the capability to delay RF transmission until the amplifier is switched, but minimalist portable QRP rigs may not support this. I thought the amplifier's DLY control might serve this purpose, but its delay in the first step above 0 is longer than that desired for full QSK, perhaps oriented more for semi break-in or SSB operation. By setting the DLY to 0, the amplifier will operate in full QSK mode, under the assumption that the transceiver can manage the required delay.

Another option is to use your external keyer or hand key to key the amplifier using the KEY IN line and use the KEY OUT line to key the transceiver. This puts the timing back under control of the amplifier, but has an additional advantage. By keying in this manner, the amplifier can be used with transceivers that don't include provision for keying an amplifier, a feature that is not always provided in compact portable radios.

On the Air

For on the air testing, I used the 418 with the Elecraft KX3 that I reviewed in *QST* for the December 2012 Product Review.[4] It's an interestingly serendipitous arrangement — we are in a short segment of the space-time continuum in which TEN-TEC has their amplifier available but not their companion transceiver, while Elecraft offers their transceiver but not their amplifier. Perhaps by the time you read this, all four units will be available. In a way, this makes for an interesting test, since many buyers will choose this amplifier to use with other brands of QRP transceivers.

The amplifier worked with the KX3 without any difficulty. While the KX3 is a nominal 10 W unit, I could choose to reduce power either from the KX3 or by using the amplifier attenuator. I chose the latter so that if I wanted to operate with just the KX3 I wouldn't need to remember to change its settings.

I used the single KEY OUT line from the KX3 to control TR switching by connecting it to the amplifier's KEY IN line. It worked well on voice, using VOX or PTT. Using CW in semi break-in mode, it worked fine with barely noticeable relay noise.

I also tried QSK, but with the output power turned down to avoid damaging relays, since the KX3 does not offer adjustable delay. As noted in its *QST* review the KX3's output is delayed by about 15 ms. While that would be fine on the leading edge, the radio could still be putting out RF as the amplifier switched back. Following completion of the review, TEN-TEC made me aware of a previously unpublished feature. The 418 includes built in hot switching protection for the trailing edge of each pulse. If the key down line is opened after it has been transmitting RF, the 418 will not switch back to receive until the RF has disappeared. This prevents the TR relays from trying to switch high levels of RF, avoiding this concern. This description is now included in the manual. It was interesting to note that in the review of the LNR Precision FX-2, the switching time was shown as about 2 ms, so these little radios may switch faster than many we're used to — watch out![5]

I found the relay noise to be just noticeable with the amplifier quite close and while listening using a loudspeaker. The sound of the sidetone was significantly louder, so with that on, it was not an issue.

Documentation

The TEN-TEC 418 comes with a 16 page instruction manual that does a good job describing setup and operation. There are good illustrations of the controls, indicators and connection points. A block diagram is provided, but there is no schematic diagram included in the manual. The TEN-TEC website provides a nice seven page schematic diagram package for those who would like that information; it's useful for troubleshooting, or just to better understand the functionality. The manual is also available on their website, so you can look that over to help you decide if it's the amplifier for you.

Manufacturer: TEN-TEC, Inc, 1185 Dolly Parton Parkway Sevierville, TN 37862, tel 800-433-7373; **www.tentec.com**.

[4]J. Hallas, W1ZR, "Elecraft KX3 HF and 6 Meter QRP Transceiver," Product Review, *QST*, Dec 2012, pp 39-44.

[5]C. Skolaut, KØBOG, "LNR Precision FX-2 40/30 Meter QRP CW Transceiver," Product Review, *QST*, Jan 2013, pp 54-56.

See the Digital Edition of *QST* for a video overview of the TEN-TEC 418 solid state linear amplifier

Rigol Technologies DSA815-TG Spectrum Analyzer

Reviewed by Bob Allison, WB1GCM
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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?

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.

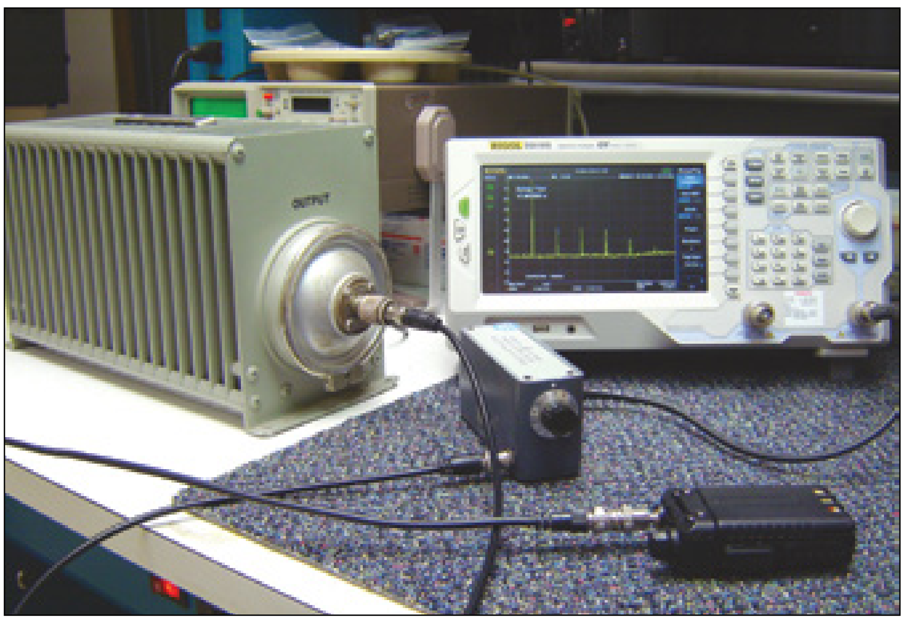

Figure 2 — In the Lab we use one or more high power attenuators and a step attenuator to bring the power of a transmitter under test down to a safe level for the input of test equipment (usually we shoot for around 1 mW). Here the DSA815-TG is used to observe the fundamental signal and harmonics of a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

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.

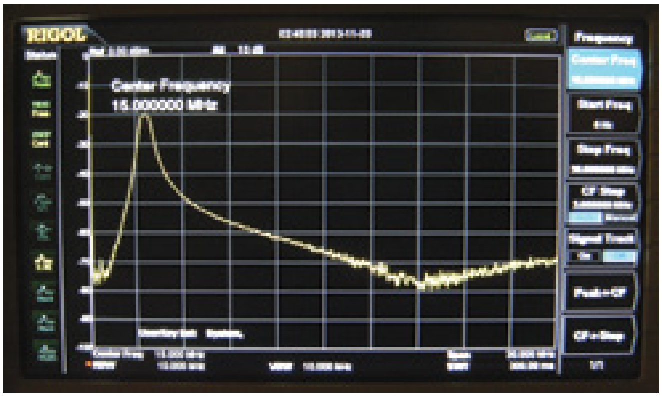

Figure 4 — The DSA815-TG's built-in sweep generator is handy for testing filters. Here is the frequency response of an 80 meter band-pass filter.

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.

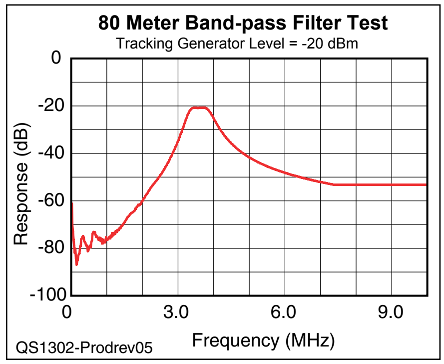

Figure 5 — This chart was made by saving the data from the filter sweep shown in Figure 4 to a CSV file, which was then imported into *DPlot* graphing software to take a close look at the filter's response from 1 to 10 MHz.

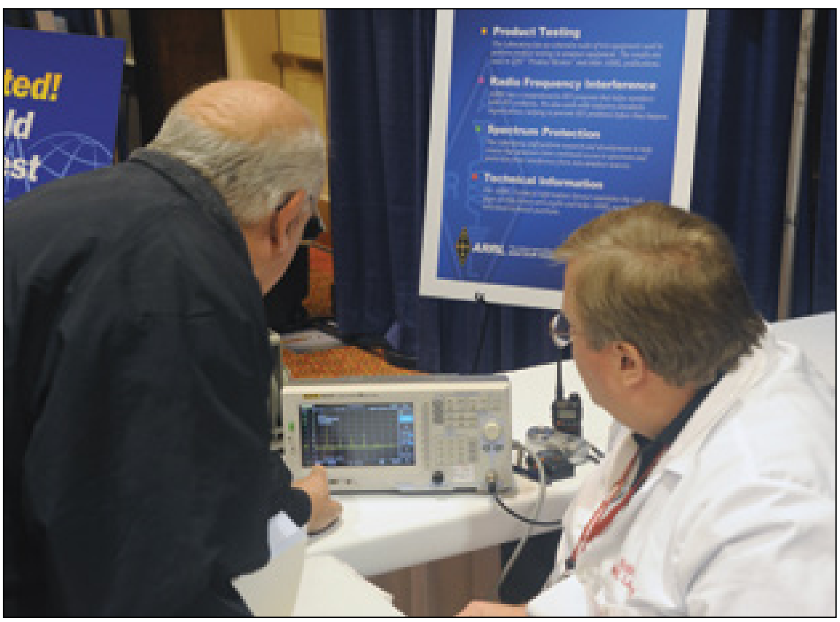

Figure 3 — Bob Allison, WB1GCM (in the white coat), checked the spectral purity of handheld radios for visitors at the ARRL National Convention at Pacificon last November. Most radios met FCC requirements, but there were a few surprises.

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**.

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Arrow Antenna GP146/440 Ground Plane

With so many dual-band 2-meter/70-centimeter transceivers on the market, there is strong demand for simple dual-band antennas. By "simple" I mean antennas that work on both bands without the hassle of running two separate coaxial lines all the way back to the radio. "Simple" also means antennas that are easy to set up with little, if any, tuning required.

For casual applications, as well as public service use, it is often best to rely on an omnidirectional antenna that radiates a reasonably uniform pattern to all points on the compass. For VHF/UHF work, one of the most popular designs is the venerable *ground plane* — an antenna with a vertical radiating element and several horizontal elements below it that form the RF ground plane, hence the name.

Most ground plane designs are limited to a single band, but the Arrow Antenna GP146/440 manages to support operation on 2 meters and 70 centimeters simultaneously. All that's needed is a single coaxial cable to connect to your transceiver.

The Arrow GP146/440

The GP146/440 works its magic with two vertical elements. The longest element is "hot" and the other is at ground potential. The success of the design depends on the interaction between the vertical elements, which results in the antenna providing a 50 Ω impedance match to a single feed line over a substantial portion of each band.

The GP146/440 is made of solid aluminum elements with stainless steel nuts and bolts. I managed to assemble the ground plane in less than 15 minutes with nothing more than a crescent wrench.

The antenna uses a unique method of securing the radials; they are sandwiched between two pieces of aluminum plate. You insert the radials and gradually tighten the three bolts that hold the plates together. As the nuts and bolts tighten, the plates grab and clamp the radials in place.

The package includes saddles and mounting bolts that will allow you to clamp the antenna onto masts up to 1.25 inches in diameter. The coaxial cable connection is made to an SO-239 socket.

For this review I mounted the GP146/440 onto a 15-foot PVC pipe and fed it with low-loss coax. The setup was smooth and quick, especially considering the fact that I didn't have to tune the antenna.

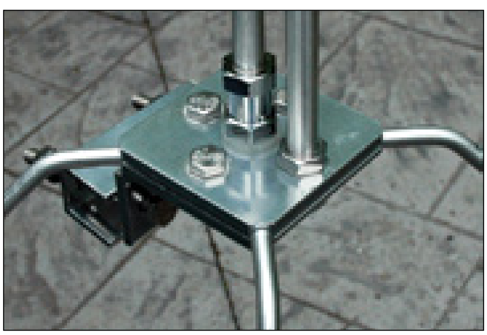
With the GP146/440 at the ready, it was time to sweep it with an analyzer. On 2 meters the antenna presented a reasonably flat 1.7:1 SWR across the band. On 70 centimeters there were some peaks and valleys with peaks as high as 2.5:1 at the band edges and as low as 1.5:1 elsewhere.

On the Air

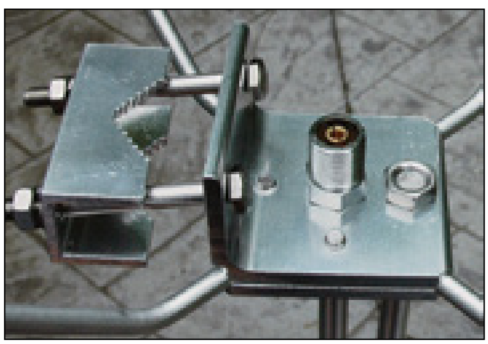
The GP146/440 turned in reliable performance, even after being on the receiving end of a particularly nasty blast of rain and high winds. I enjoyed consistently good reports while making contacts through distant repeaters (on both bands). The antenna also acquitted itself well on simplex, including a remarkable tropo band opening when I was heard on 146.52 MHz at a distance of 400 miles. The GP146/440 isn't intended for satellite operating, but I couldn't resist the temptation to give it a shot. I made a number of contacts on the OSCAR 27 and OSCAR 50 satellites and also used the GP146/440 to monitor 70 centimeter CubeSat downlinks (despite not having a preamp at the antenna).

At just under $40, the Arrow Antenna GP146/440 is a good value, especially if you're looking for a dual-band antenna that you can essentially install and forget. And with its quick assembly in mind, the GP146/440 is also an excellent candidate for public service applications.

Manufacturer: Arrow Antenna, 911 East Fox Farm Rd, #2, Cheyenne, WY 82007; tel 307-222-4712; **www.arrowantennas.com**. *$39*



The top side of the GP146/440 base with the dual radiating elements and three bolts that secure the radial "sandwich" plates.



The underside of the GP146/440 showing the SO-239 coaxial connector.

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PAR Electronics OA-50 6-Meter Antenna

If you're searching for a horizontally polarized omnidirectional antenna for VHF and above, you are bound to encounter a lot of loops. You'll see them cropping up in the form of circular "halos" or square "squalos." Both are essentially half wavelength dipoles that have been shortened and formed into loops. They work well, although the resulting radiation pattern can sometimes deviate from being truly omnidirectional and the 2:1 SWR bandwidth tends to be restricted as well.

The PAR Electronics OA-50 takes a different approach. The Omniangle antenna, as it is called, is actually longer than a half wavelength and rather than being a shaped into a circle or square the elements take the form of a triangle. The result is a more uniformly omnidirectional radiation pattern and a wider SWR bandwidth. This gives the OA-50 the ability to perform well across much of the "bottom end" of the 6 meter band.

Assembly

The PAR OA-50 is almost ridiculously easy to assemble. All you need is a Phillips head screwdriver. An impedance transformer mounts at the center of the triangle "base" with the help of two stainless-steel bolts. Next, you simply insert the two remaining 5/16-inch diameter aluminum tubes and gently bend them so that they mate with the plastic-shrouded tip assembly. Total time: less than 10 minutes.

What you have in the end is a triangle antenna that's 44 inches long at its longest point and about 41 inches wide. It is lightweight at only 1.5 pounds.

The reason for the impedance transformer, by the way, is because the Omniangle design is not resonant. That is, it doesn't present a 50-Ω impedance at the feed point. That being the case, the transformer's job is to convert the existing impedance to 50 Ω to match your coaxial cable (the transformer includes an SO-239 jack). The transformer is rated for 160 W continuous power.

Set Up and Test

To initially tune the OA-50 I attached it to a 10 foot fiberglass pole. After making my first sweep with the antenna analyzer, I discovered that the desired 2:1 SWR bandwidth was below the bottom edge of 6 meters. Not a problem. You tune the antenna by gently sliding the 5/16 inch tubes in or out of the main radiating element in equal measures. A quick adjustment of the tubes resulted in a 2:1 SWR bandwidth between 50.000 and 50.700 MHz with the SWR dipping to 1.2:1 at 50.250 MHz.

Although the OA-50 is less affected by ice and rain detuning compared to traditional VHF loops, PAR advises you to tweak the antenna to achieve a low SWR point about 50 to 100 kHz above your "favorite" frequency. The SWR will be only slightly higher and will "move" downward when the antenna becomes wet or icebound.

The transformer at the Omniangle feed point.

Mechanical tension keeps the angled aluminum tubes firmly in place. Even so, you can reduce the tension and slide them in and out for easy tuning.

On the Air

The OA-50 turned in an outstanding performance, despite the fact that I had it mounted only 15 feet above ground. I consistently enjoyed SSB contacts with stations 150 miles away and was able to work several grid squares more than 1000 miles distant during Sporadic E band openings.

I was particularly fascinated at how well the OA-50 worked for weak-signal JT65 and FSK441 meteor scatter. An omnidirectional pattern is hardly ideal when every bit of signal energy counts, but the OA-50 measured up to the challenge, giving me successful contacts out to 1200 miles in one instance. I'm eager to see what will happen with the OA-50 if we get some more F2 openings on the "Magic Band" during what remains of the current solar cycle peak.

Manufacturer: PAR Electronics, PO Box 645, Glenville, NC 28736; tel 828-743-1338; **www.parelectronics.com**. *$99.*