# TechTalk113

# DigitalATV – Using a Spectrum Analyzer

**by Ken W6HHC**

I will venture to guess that most hams do not use a "stand-alone" Spectrum Analyzer instrument. Quite a few hams have a Spectrum Analyzer built into their HF rig (like the Icom IC-7000, the Icom IC-7600, Yaesu FT DX 3000, or even a Yaesu FTM-4000M VHF/UHF rig, etc.) to look for signals on the band. In my situation, I was introduced to a built-in Spectrum Analyzer (SA) when I purchased an Icom IC-756-Pro3 in 2007 and a stand-alone Spectrum Analyzer instrument was purchased in 2013 because my involvement in digital-ATV.

Historically, "stand-alone" Spectrum Analyzer instruments were built for industry by companies like HP and Agilent and had huge price tags of $20,000 to $40,000 new! A ham could only hope to find a used Spectrum Analyzer for sale that still worked and had an affordable price tag. At least one instrumentation company based-in-China is now producing good-quality Spectrum Analyzers at a much more reasonable price.

**Spectrum Analyzer Uses**

Rigol Technologies produces many types of instruments, including several families of Spectrum Analyzers. Charles G4GUO pointed out to me that the Rigol Model DSA815 SA instrument is an entry-level unit that can operate up to 1500 MHz and has a base-price that is only US$1295.

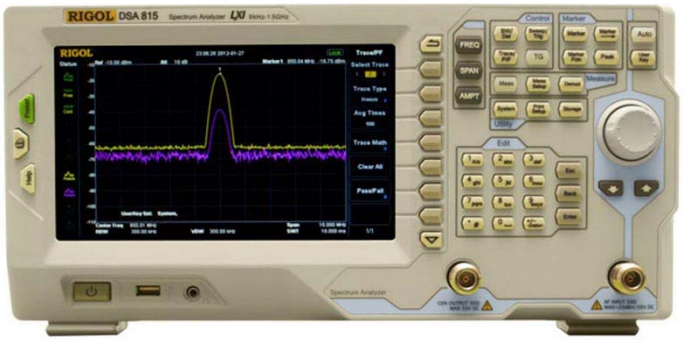


**Figure 1 - Rigol Model DSA815 Spectrum Analyzer can operate from 9 KHz to 1500 MHz**

The basic use of a Spectrum Analyzer is to analyze an RF signal over a range of frequencies. This is especially useful in DigitalATV (DATV) where you are interested in measuring bandwidth, looking for distortion, side-spurs and harmonics.

**Fig02** shows a typical DVB-S/QPSK digital modulated signal on 1.290 GHz that is well-shaped and without distortion. The display is 10 MHz wide at 1 MHz per horizontal division.

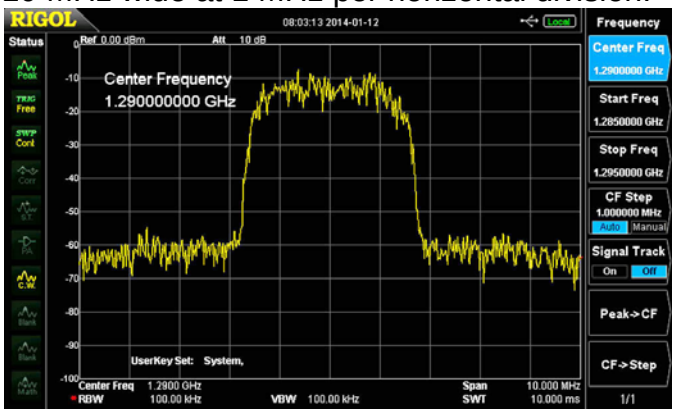


**Figure 2 – Spectrum Analyzer display of QPSK digital modulation on 1290 MHz**

The design of a good quality spectrum analyzer that is useable up to 1500 MHz requires immense attention to details like shielding to prevent introducing cross-talk. **Fig03** shows that the Rigol unit utilized a complex shielding-box milled from a solid block of aluminum to contain the RF radiations of one part of the design from unintentionally interfering with another part of the circuit design.

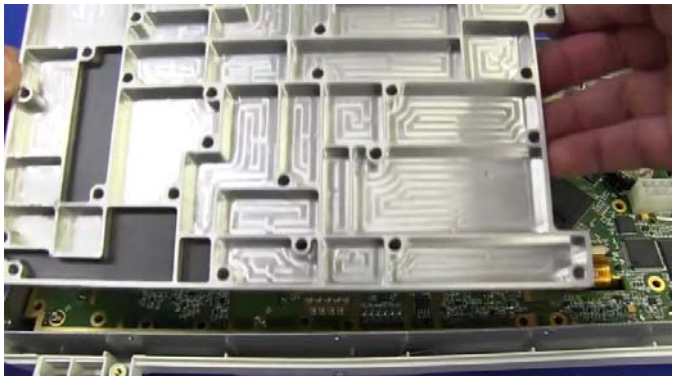

**Figure 3 – Construction of the RF shielding-box milled from solid aluminum block**
**(Courtesy of YouTube EEV #391)**

There are quite few other functions that can be performed by a Spectrum Analyzer, such as:

- Signal generation
- SWR measurements
- Power measurements

## Tracking Generator option

Rigol produces a variation of the base DSA815 SA unit that includes a "tracking generator" option. This model is called DSA815-TG. A tracking generator is a sweeping signal generator that tracks with the display span of the Spectrum Analyzer. Not only does the tracking generator help measure the performance of filters, but it makes a fine stand-alone RF signal generator that operates from 9 KHz up to 1500 MHz.

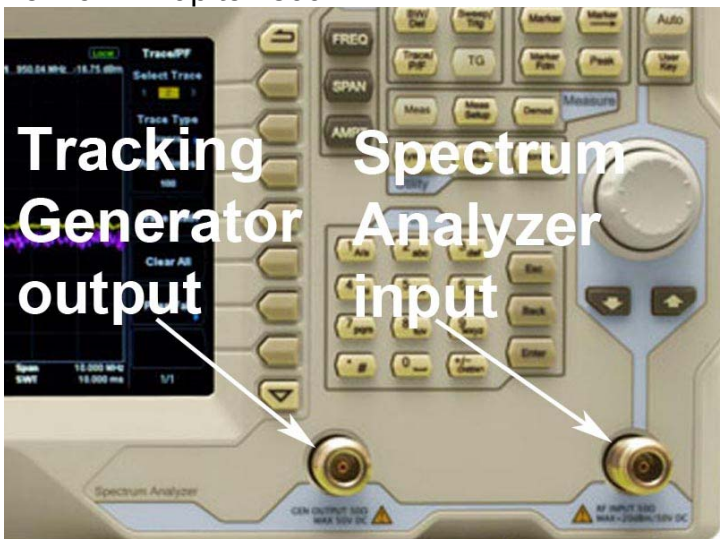


**Figure 4 – Location of Tracking Generator output relative to the input connector of the SA**

Want to calibrate a receiver…just place the tracking-generator output on the frequency of interest with a steady carrier and no sweeping.

As I mentioned earlier, one use of a tracking-generator option is to simplify the measurements of and displaying the performance of a filter. **Fig05** shows the measured performance a surplus tunable band-pass filter loaned to me for testing by Robbie KB6CJZ.

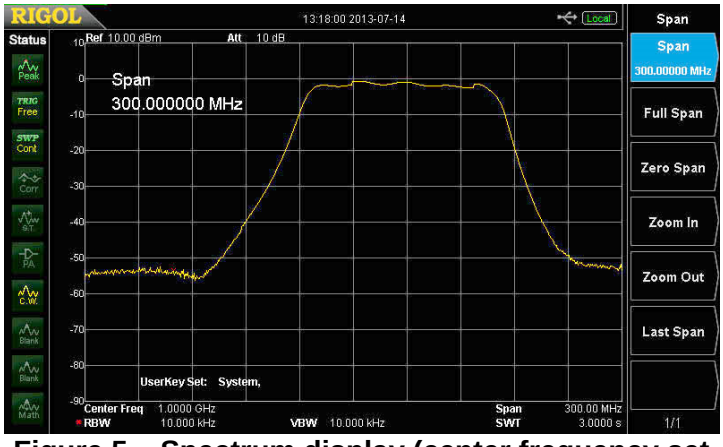


**Figure 5 – Spectrum display (center frequency set to 1.0 GHz) of a surplus tunable band-pass filter**

This tunable filter had the value of 1030 MHz hand-written on the unit. I think it is easy to envision using the Spectrum Analyzer to confirm re-tuning of this band-pass filter.

The Rigol Tracking-Generator option is priced at US$200, but must be ordered as a model DSA 815-TG Spectrum Analyzer, since it is not a plug-in option. The price of a DSA815-TG unit is US$1495, total.

## SWR option

Another neat aspect of a tracking-generator is that it simplifies measurement and reports for documenting SWR of an antenna. The heart of making an SWR measurement with a Spectrum Analyzer is using a microwave directional – coupler to take a sample of the reflected RF and puts that sampled signal back into the input connector of the SA. **Fig06** shows a typical surplus microwave directional coupler.

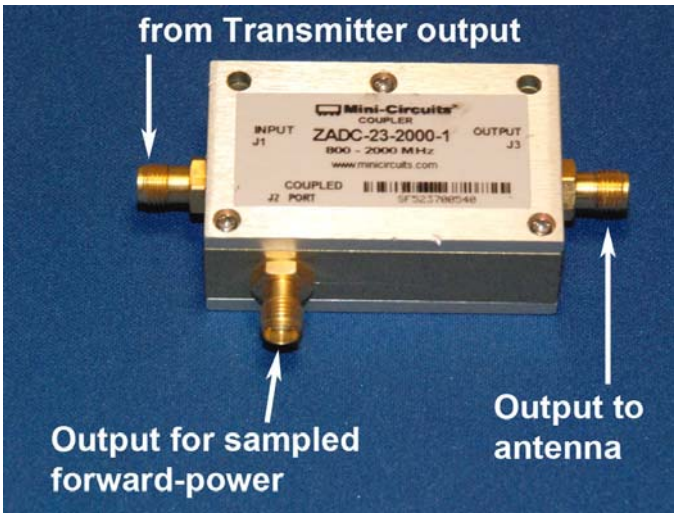


**Figure 6 – Typical surplus directional-coupler with forward-power sampled output connector**

Surplus directional-couplers are usually specified for a specific range of microwave frequencies. However for basic measurements of antenna SWR, you can use directional-couplers that are designed for a different frequency range. All that really changes is the gain of the sampled signal. Note - directional-couplers can be purchased with either SMA or N-connectors. Also, these units are reversible; connect the transmitter to the J3 connector…and now the sampling connector delivers reflective-power.

**Fig07** illustrates how a directional-coupler can be used with the Tracking-Generator output to

find resonance on an antenna and help you tune it to the correct frequency. As a NOTE: No special NO special Rigol optional-cost SWR software was used in **Fig07** to perform the test.


**Figure 7 – Using a direction-coupler to tune an antenna (but, no special SWR software)**

Next, because modern Spectrum Analyzers contain microprocessors, a little software can be offered as an option to measure all the displayed SWR signal values…calculate a few values…and can provide you with a finished SWR report.

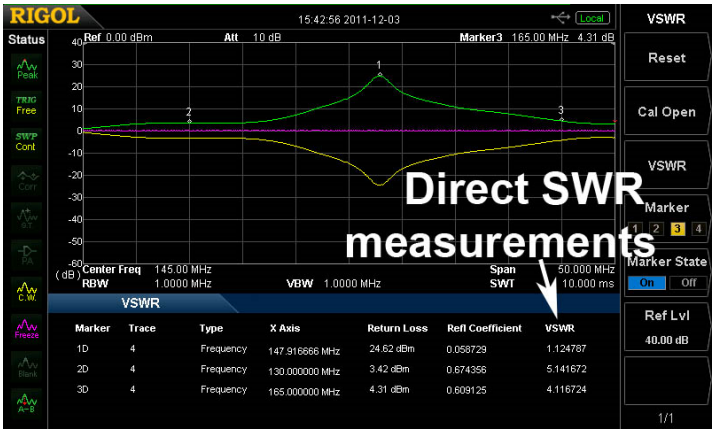


**Figure 8 – The Rigol software DSA800-VSWR option measures values and displays SWR report**

Rigol optionally sells two SWR accessories. The software-only measurements-calculations accessory Model DSA800-VSWR software kit sells for US$459 and provides professional reports that do all of the tedious calculations. Rigol also sells accessory Model VB1020 kit that includes (a) a specially designed directional-coupler hardware unit that has a frequency range from 1 MHz –to– 1500 MHz, (b) the hardware unit screws directly onto the TG-output and the SA-input connectors, and (c) the software measurements and SWR report code. The cost of the optional Rigol Model VB1020 kit is US$599.

**Power Measurement option**

All Spectrum Analyzers can perform power measurements on simple carriers and even complex digital modulation without special software. Just put the SA into the dBm scale. However, for the complex digital-modulation signals, you need to compensate for the video-bandwidth setting of the SA, compared to the channel-bandwidth of the digital-modulation signal.

For a simple un-modulated carrier signals, because the bandwidth of the signal is so narrow (less than 1 KHz), the peak reading of the carrier is directly equal to the output power-level.

Mike WA6SVT (a commercial television station engineer) explained to me that for a more complicated RF signal such as a DVB-S/QPSK “hay-stack” (see **Fig02** of an example), the Video BandWidth (VBW) and Resolution BandWidth (RBW) setting on the Spectrum Analyzer has to be set to a value that is a little wider than the DATV signal you want to measure. If the RBW can be set correctly, then the DATV average power level is the value at the top of the “hay stack”.

On my entry-level Rigol DSA815, the largest VBW and RBW setting available is 300 KHz. This bandwidth is too small to directly measure power on a DATV signal that has 3 MHz or greater Occupied BandWidth. Fortunately there is a mathematical conversion that can compensate for a narrow VBW/RBW setting. Ron W6RZ and Rob MØDTS both suggested to me on the Yahoo DigitalATV Forum that the correction factor in dB for spectrum analyzers is

**10*log10 (channel bandwidth/resolution bandwidth)**

Rigol optionally sells a software-add-on accessory to measure power directly called DSA800-AMK (Advanced Measurements Kit). The Channel Power mode of this kit uses the built SA microprocessor to integrate the power level measurements over an “integration BW” that you can select. **Fig09** is a display of the optional Channel Power mode measuring the RF output of a barefoot DATV-Express board signal running SR=2.2 MSymb/sec at 1292 MHz. The integration BW was set to 4 MHz for this measurement of 13.81 dBm power output. This Channel Power mode

option sure makes it simple to measure DATV power levels. No more worrying if the Bird power meter you are using is a bolometer/thermal type or not…..and without digging out your scientific log calculator The optional cost of the Rigol Model DSA800-AMK kit is US$499

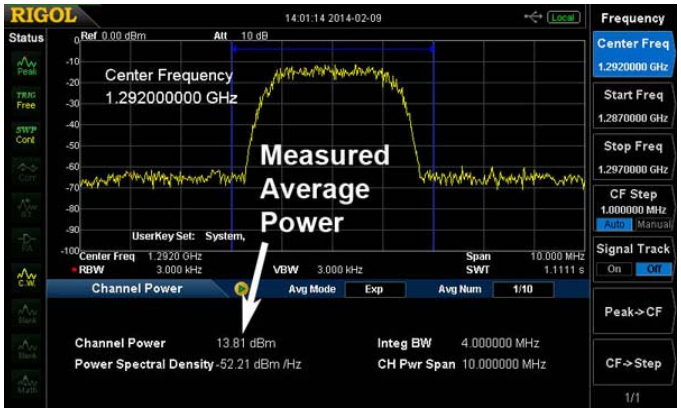


**Figure 9 – Display of Channel Power option measuring 13.81 dBm average power (DVB-S at 2.2 MSymbols/sec)**

### "Secret" Demo-Mode for Options

One complaint that I have is that NONE of the Rigol (or Rigol distributor) literature or web site materials explains that most of the extra-cost software options are available as a free demo mode to try out. The time-out period on the demo-modes is 200 hours of Rigol Spectrum Analyzer power-on. A phone conversation with technical support of Rigol (quite good at helping me use the instrument) hinted about the unpublicized demo-mode…but he did not have any real details of trial-period, etc. I finally discovered the demo-mode when I only had about 11 hours of use left to try them out.

### Easy Screen-Capture Feature

A small feature on the Rigol SA that I really enjoy using is the one-button screen capture directly to an inserted USB-memory-stick. Just plug the USB-memory into the front-panel USB port…make sure the screen displays what you want to record….and press the PRINT button on the SA. Capturing the screen (just as displayed) could not be easier. I wish Windows would think about providing a setting for printing the screen directly to a USB-memory-stick.

### Conclusion

While not essential, a Spectrum Analyzer is a very useful instrument to have available for looking at DATV signals. For normal DATV usage, viewing the SA is perfect for adjusting the drive into RF power amplifiers. An over-driven PA starts to exhibit spectral-regrowth distortion where the distortion creates a signal that grows wider and wider as the drive level is increased. The problem with spectral-regrowth is that the received video still looks good, but more and more RF interference is occurring on the sides of your intended signal. DATV uses include:

- Adjusting RF power amplifier drive
- Inspecting quality of transmitted signal
- Confirming any spurs are low-level
- Checking for undesired harmonics
- Tuning band-pass filters
- Measuring power of digital-modulation
- Pointing antenna to weak DX signal (Spectrum Analyzer will see weak signal faster than STB can lock onto to signal)

### Useful URLs

- Rigol Technologies (North America) – see **www.Rigolna.com/**
- Rigol (United Kingdom) – see **www.Rigol-UK.co.uk/**
- TEquipment USA Distributor for Rigol – see **www.TEquipment.net/**
- YouTube "Tear-down" of Rigol DSA815-TG unit (EEVblog #391) – see **www.youtube.com/watch?v=EY0acWrCYjw**
- British ATV Club - Digital Forum – see **www.BATC.org.UK/forum/**
- CQ-DATV online (free monthly) e-magazine – see **www.CQ-DATV.mobi**
- DATV-Express Project for DATV – see **www.DATV-Express.com**
- DigiLite Project for DATV (derivative of the "Poor Man's DATV" design) – see **www.G8AJN.tv/dlindex.html**
- Orange County ARC entire series of newsletter DATV articles – see **www.W6ZE.org/DATV/**
- Yahoo Group for Digital ATV - see **groups.yahoo.com/group/DigitalATV/**
- dBm to Watt power convertor – see **www.rapidtables.com/convert/power/dBm_to_mW.htm**