Signal Hound

Compact 4.4GHz spectrum analyser and matching tracking generator


PHOTO 1: The SA44B spectrum analyser (front) and TG44 tracking generator.

INTRODUCTION. A spectrum analyser is a very desirable item of test equipment. It enables you to check the spectral cleanliness of your signal, find instability problems and can act as a selective measurement receiver and a great deal more. A new professional spectrum analyser can cost many tens of thousands of pounds. Even pre-owned spectrum analysers can be very costly. Then if something goes wrong they can be expensive to repair. But all that is changing. Several companies now offer high performance spectrum analysers, based on software defined radio (SDR) technologies, within the budget of many amateurs.

The Signal Hound SA44B costs less than many HF transceivers. It is made by the American company Test Equipment Plus (TEP) [1] and is a high performance spectrum analyser covering from near DC to 4.4GHz with a performance that should be more than adequate for most radio amateurs.

The SA44B can also be used as a measurement receiver with CW, SSB, AM and FM demodulation capability across the entire 4.4GHz frequency range. The claimed amplitude accuracy is better than ±1.5dB from 0dBm down to the displayed noise level (which depends on frequency and resolution bandwidth) and ±2dB from 0 to +10dBm. Using the internal reference the frequency accuracy is better than 1ppm (part per million).

PREREQUISITES. The Signal Hound is not a standalone item. A laptop or desk top computer with two or more USB 2.0 interfaces is required to use the Signal Hound SA44B and TG44. The Signal Hound is powered from the computer over the USB interface. The same interface is used to pass data to and from the instrument. All data processing is done in the computer; you'll need a Windows system with at least a 2GHz processor and 1GB of RAM.

The SA44B spectrum analyser and TG44 tracking generator are housed in identical extruded aluminium cases. At just 20cm long and weighing 290g they should be easily accommodated on most work benches.

BRIEF OVERVIEW OF THE ANALYSER SYSTEM. I was requested not to open up the case of the review analyser so, of necessity, this section relies heavily on the manufacturer's description of the Signal Hound hardware.

From the basic block diagram in the manual, it appears to use a conventional superhet RF front end with a digital sampling back end that converts the filtered intermediate frequency signal to an I/Q (in-phase and quadrature) bit stream. The bit stream passes over the USB connection to the host computer for signal processing and display on the computer screen. Few details of the signal processing are given in the manual.

The spectrum to be displayed enters the SA44B through an SMA socket on the front panel and then to an attenuator with three selectable steps, from 0 to 15dB. The attenuator is directly connected to the input in order to retain response down to DC. This could make the attenuator vulnerable to damage if any DC appears at the input. For this reason an external DC block, with good frequency response to at least 4.4GHz, should be used whenever the low frequency response is not needed. The DC block is not supplied with the SA44B, but is available as an accessory.

The attenuator is followed by a wideband preamplifier that can be switched into the signal path when extra sensitivity is required. The preamplifier cannot be used below 500kHz.

After the preamplifier the input spectrum passes to one of two mixers. In its simplest operating mode, the local oscillator that feeds the two mixers is stepped, under software control, over the required frequency range in 200kHz steps (or less) in order to produce a series of bands at 200kHz intervals. These are filtered to 250kHz wide individual bands by the 10.7MHz IF filter. This arrangement produces a whole series of responses from the input spectrum. At least one of the responses will be the band of image frequencies from the input spectrum. The software is left to process this complex spectrum to identify and remove not only the image frequencies but also any other internally generated spurious signals. It does this extremely effectively.

A disadvantage of this technique is that covering a span of 4.4GHz in 200kHz steps can take over 30 seconds. Narrower spans take considerably less time. A 5MHz bandwidth filter is used during wide frequency sweeps. Narrow bandwidth filtering down to as low as 0.1Hz takes place in the host computer using FFT (fast Fourier transforms).

For anyone familiar with conventional spectrum analysers the Signal Hound SA44B may require a period of adjustment. It took me about an hour of playing with the SA44B to familiarise myself with it enough to start to get the best out of it. It can be time-consuming to use the SA44B to adjust circuits as the screen display is not in real time. There can be a noticeable delay between making adjustments and seeing the result on the screen. In these circumstances it is best to make circuit adjustments using narrow spans and then to open out the span to see the results at higher or lower frequencies.

An external 10MHz reference input, via a BNC socket on the rear of the SA44B, can improve the frequency accuracy of the instrument as well as its phase noise performance. A second BNC connector on the rear of the SA44B provides a trigger input/output connection. This is useful for synchronising sweeps to some external event. It will accept both 3.3V and 5V (TTL) levels. The TG44 tracking generator sweep is triggered from this same connection.

Located centrally on the rear panel is a type B USB 2.0 connector to allow the

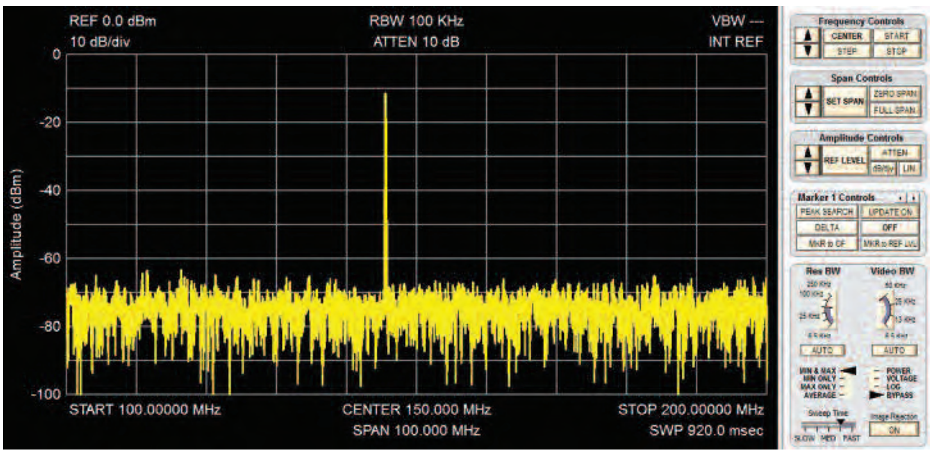

FIGURE 1: 144MHz output from Kenwood TH-6F.

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supplied USB lead to connect the Signal Hound to the host computer. A bi-colour LED on the front panel shows green when the Signal Hound is powered and flashes amber when it is receiving data from the host computer.

GRAPHICAL USER INTERFACE (GUI) DISPLAY. A software defined radio relies heavily on the quality of the controlling application software. I'm pleased to say that the Signal Hound GUI seems to have been well thought out, is easy to use and works well. The version current at the time of this review was 2.07. This version provides support for the tracking generator as well as a number of useful utilities such as harmonic measurement, channel power and phase noise. These are in addition to the usual spectrum analyser facilities of carrier level and spectral response.

Figure 1 shows the captured output spectrum from my Kenwood TH7 handheld (suitably attenuated) when transmitting an unmodulated carrier on the 144MHz band. The GUI provides a large screen area for the spectrum display in a 10 by 10 matrix. The usual spectrum analyser control 'buttons' are located down the right side of the screen. The 145.500MHz signal is the vertical line near the middle of the frequency scale.

Frequency, Span and Amplitude buttons control the main functions of the analyser. In this case the top of the screen has been set to a 0dBm (1mW/50Ω) reference level. The vertical screen display is set at 10dB/division and the horizontal screen is set to show from 100MHz on the left to 200MHz on the right. Sweep time is 920msec. The displayed average noise level (DANL) is approximately -75dBm with the 144MHz carrier at -12dBm. No markers have been selected; the resolution bandwidth (set automatically by the computer) is 50kHz.

Image reject is switched on. When switched off there are several spurious responses in addition to the main image 21.4MHz below the wanted display signal. This indicates over 70dB of spurious display rejection at this frequency. The same or better performance is seen with a carrier at 433MHz.

Of course an analyser needs to be able to 'zoom' right into a signal in order to be able to analyse modulation. In order to obtain a clear and unambiguous display this means using a resolution bandwidth filter that is much less than that of the occupied bandwidth of the modulated signal. Figure 2 shows a 433.5MHz narrow band FM signal. This is a screen capture showing the output from my Kenwood TH7 handheld, modulated by a single tone. The resolution bandwidth of 200Hz clearly shows the individual sidebands of the FM signal.

Along the top of the display in Figure 2 you can see a row of buttons including one marked 'Utilities'. When you click on this a drop-down menu allows access to a number

Parameter	Manufacturer's claim	Measured	Comments
Frequency range	1Hz to 4.4GHz	<10kHz to 4.4GHz	
Marker frequency accuracy	±1ppm	0.25ppm*	Internal TCXO at 21°C. * Measured with 100kHz span at 2.4GHz.
Marker amplitude accuracy			
100MHz			
0dBm		-0.6dB	
-30dBm		-0.4dB	
-60dBm		-0.5dB	
1GHz			
0dBm		-0.35dB	
-30dBm		-0.3dB	
-60dBm		-1.0dB	
2.4GHz			
0dBm		-0.1dB	
-30dBm		-0.5dB	
-60dBm		-1.5dB	
1dB gain compression			
100MHz	+16dBm typical	+18dBm	15dB attenuation, preamp off.
1GHz	+19dBm typical	+20dBm	
Displayed average noise level (DANL)			*Marker offset to avoid low level spurious output at 100MHz and 1GHz.*
100MHz, preamp off	-148dBm	-158dBm	Normalised to 1Hz
100MHz, preamp on	-161dBm	-170dBm	from measurement at
1GHz, preamp off	-144dBm	-152dBm	100Hz resolution bandwidth.
1GHz, preamp on	-158dBm	-165dBm	
Residual spurious at the input connector		*Att. 15dB, preamp on*	*Att. 0dB, preamp off*
1Hz to 500kHz	-70dBm	Not measured	Not measured
500kHz to 1GHz	-57dBm	-57dBm	-20dBm
1GHz to 2.3GHz	-47dBm	-55dBm	-20dBm
2.3GHz to 2.6GHz	-40dBm	-55dBm	-28dBm
2.6GHz to 3.0GHz	-27dBm	-60dBm	-27dBm
3.0GHz to 4.4GHz	-35dBm	-48dBm	-27dBm

of useful functions. The first of these is 'Audio listen'. This opens a small window from which you can select frequency, IF bandwidth, mode and de-emphasis. It is first necessary to display the signal you want to listen to by placing the marker on that signal. Now you can apply the selected demodulation parameters. The computer speaker allows you to listen to the selected signal. A little lower down the utilities menu you will see 'Measuring Receiver'. This opens a window showing the frequency and modulation characteristics of the selected signal. Many other utilities are included but space precludes reporting on them all.

MEASURING SPECTRUM ANALYSER PARAMETERS. Since a spectrum analyser is likely to be relied upon for a number of amateur radio related measurements, some idea of its accuracy was required. I felt it was worth checking a number of the manufacturer's claims against professional test equipment that originally had cost many times the price of the Signal Hound. In Table 1 the first column identifies parameters, column 2 shows the manufacturer's specification and column three contains my measurements. The fourth column has my comments. Although my equipment is not formally calibrated, it is regularly compared with calibrated equipment. Even so, some discrepancies may be noticed, which may be due to differences in measurement technique or interpretation of specifications.

TG44 TRACKING GENERATOR. The TG44 is housed in the same robust case as the SA44

PHOTO 2: Front of SA44B analyser. The front of the TG44 tracking generator is similar.

PHOTO 3: SA44B rear panel. The TG44 is similar.

and has a similar single SMA connector on the front panel for RF output, two BNC connectors on the rear panel for interconnection to the spectrum analyser and a type B USB2.0 USB connector for connection to the host computer. A BNC to BNC lead, USB cable and SMA male to male adapter are supplied with the TG44.

The TG44 can be used with the SA44B spectrum analyser to create a simple but effective scalar network analyser system that can be used to measure RF gain, frequency response, gain compression and insertion loss. Used with a suitable directional coupler or bridge, it can also be used to measure return loss. The reviewed software does not allow for normalisation in this mode, but this may be added in a future release.

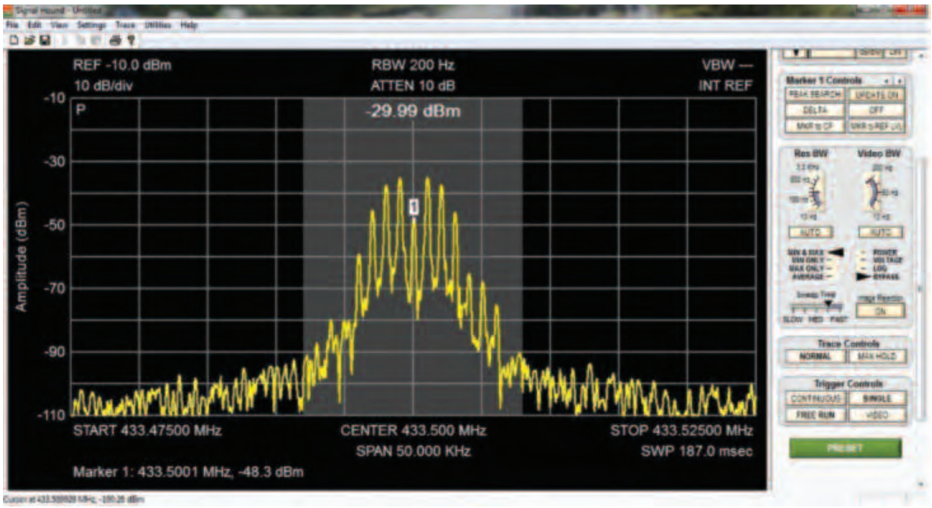

FIGURE 2: 433MHz FM modulated output from the Kenwood TH-6F.

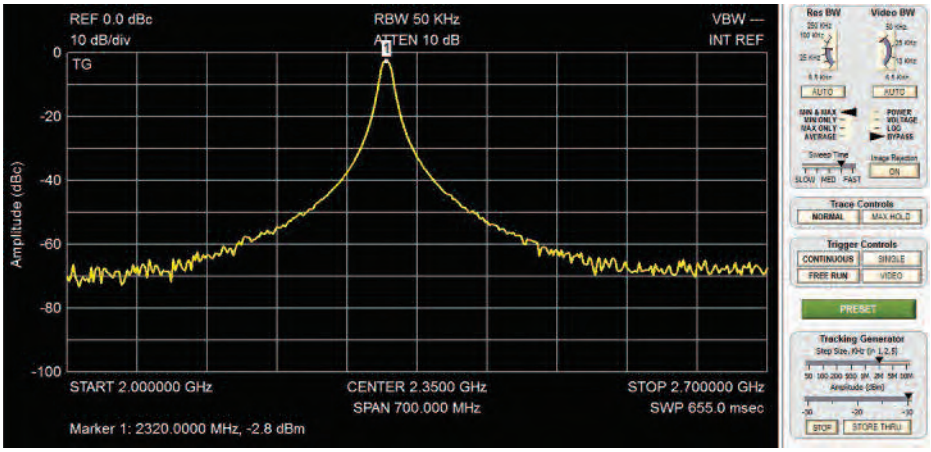

FIGURE 3: 2.3GHz filter response plotted with the help of the TG44 tracking generator.

In addition to use as a tracking generator, the TG44 can also be used as a CW (unmodulated) signal generator with output from 10Hz to 4.4GHz. This is an enormous frequency range and makes the TG44 worth having in the shack for this purpose alone. Note that the harmonic output of the generator is quite high, which may make it unsuitable for some measurements. An external low pass filter or two could easily solve the harmonic problem for many applications.

IN USE. The TG44 was used in conjunction with the SA44B to measure the response of a two pole interdigital filter tuned to 2.320MHz. This filter forms part of my 2.3GHz band system.

Control of the TG44 is from the spectrum analyser GUI. The controls for sweep and level are located at the lower right hand side of the GUI screen. In order to perform a sweep of a filter, such as shown in **Figure 3**, the sweep frequency limits should be set as appropriate. For a filter the RF level should not be important, so use the maximum available from the TG44 in order to achieve the largest on-screen dynamic range.

First, connect the tracking generator directly to the spectrum analyser using the RF cable and connector adapters you will be using to connect to the filter.

There should be a flat, straight line on the display. However, it will probably be some way below the top-of-screen reference line. Click the 'STORE THRU' button on the GUI screen. The through loss will now be subtracted and the display will move to the top of the screen. Connect the filter or other device under test (DUT) between the test leads. The frequency response of the DUT will appear on screen. Click the marker peak search and the on-screen marker will appear at the peak of the DUT response. If it is a filter then the filter insertion loss will be shown at the bottom of the screen. Using marker delta or two markers, the filter bandwidth or filter out-of-band response can be measured. Wide sweep widths require the TG44 10MHz output to be connected to the SA44B 10MHz reference input.

CONCLUSIONS. My measurements on the spectrum analyser revealed surprisingly good results. Amplitude accuracy was particularly good and certainly more than adequate for the majority of amateur radio purposes.

Frequency accuracy, even using the internal TCXO, was much better than expected, but could be improved upon further by using a suitable external 10MHz reference, preferably one with low phase noise. This makes the SA44B very useful as a selective frequency measuring device, particularly when several signals are present or waveforms are very distorted. A frequency counter alone can easily be fooled into measuring and indicating the wrong frequency under these conditions.

The discrepancies in the DANL measurements in the measurements table may be due to differences in where the visually averaged noise waveform was taken to lie.

I wonder if TEP might not have updated their manual from a previous version of the SA44 since the spurious outputs at the input connector seemed unduly pessimistic. I added a fourth data column to the table entry to show that without the attenuator set to 15dB and the preamp switched out, the spurious levels were closer to those in the SA44B manual. The measured figures are very good for this type of receiver where there is no RF band-pass filter to help with LO rejection.

I mentioned near the beginning of this review that it might take a little getting used to compared to a conventional spectrum analyser. The reason for this is that wide band sweeps can take many seconds to complete. In some situations this can make this type of analyser difficult to use for adjustment purposes, since you might have to wait a long time to see the results of each adjustment made. For narrow sweeps this should not be a problem.

The TG44 tracking generator proved extremely useful but the GUI display froze a few times when making adjustments to the swept frequency range. This necessitated re-booting the software. However, an updated TG44 was due for imminent release and this should eliminate these (firmware related?) problems.

I would have liked to have seen a facility for saving screen shots. Printing is already taken care of, but if you want to save a screen shot, such as the display of the TH-6F FM modulation, it is necessary to use CNTL Prt SC and then import the bit map into a suitable editing program. If there is a facility to do this already, I didn't find it!

For the tests I used a Sony Vaio laptop with Intel CORE i3 processor with 2.3GHz clock and 6GB RAM running on Windows 7 Professional.

Overall, I was very pleased with the performance of the SA44B. If I didn't already possess a good spectrum analyser I could be very tempted to buy one of these. The TG44 is perfectly useable and has excellent frequency coverage.

My thanks to Test Equipment Plus for the loan of the review samples. The Signal Hound SA44B spectrum analyser costs €799 + 19% VAT and the TG44A tracking generator is €520 + 19% VAT. The European distributor is Dutch company Foltronics, see www.SignalHound.eu.

WEBSEARCH

[1] Test Equipment Plus – www.signalhound.com