Equipment review

Ten-Tec RF Vector network analyzer

Ron Sanders VK2WB

I often experiment with RF transformers and filters, so was delighted when TTS Systems gave me the opportunity to try the Ten-Tec Vector Network Analyzer (VNA).

The unit was designed by Tom McDermott N5EG and Karl Ireland and described in the QEX magazine (July/August 2004), published by the ARRL. The authors gave the design to the Tucson Amateur Packet Radio (TAPR) group in USA. Given the devices used and the challenges for the average amateur in soldering small SMD devices, TAPR arranged for the Analyzer to be manufactured and sold by Ten-Tec. The VNA has transmit and receive ports, and measures transfer characteristics of networks using S parameters. Connection to a computer is via USB and the software operates through the Microsoft Windows© .NET 1.1 system, which is freely available. All relevant software is provided on the CD, and updates can be downloaded via the internet.

The VNA comes complete, with CD, plug-pack, USB cable, two coax cables, two attenuators, and a 50 and a 0 (short circuit) ohm terminator used for calibration. To allow for individual test setups there is provision for calibrating and saving data for different test fixtures, so that any test fixture data can be used to correct the final measurement. The frequency range for normal accuracy is 1 – 100 MHz but can be used from 200 kHz to 120 MHz with reduced accuracy. Normal accuracy is much better than required for amateur use and, in fact, is comparable to commercial instruments costing many times more.

A separate program allows the VNA to be used as a signal generator with frequency resolution of 1 Hz. The complete manual can be downloaded from the Ten-Tec or TAPR website. The unit measures 160 mm long x 115 wide x 30 mm high (see photos).

Tests

The simplest arrangement to check an RF matching transformer is to use a passive 50 ohm Return Loss Bridge, an RF signal source and a detector (receiver with S-meter would do) to measure the bridge balance. This will give a rough indication of SWR, but nothing to show loss through the transformer. The VNA is designed for 50 ohm in/out and incorporates all the necessary equipment to make all the measurements over a range of frequencies and display the result on a computer screen.

Photo 1 – Front view of the analyzer.

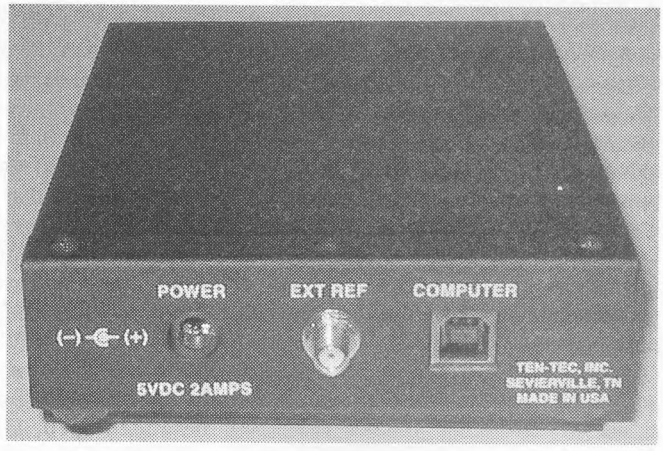

Photo 2 – Rear view of the analyzer.

Photo 4 shows a 4:1 transformer designed to match 200 to 50 ohms over 1.8 – 30 MHz, and Figure 1 shows the circuit diagram of the transformer which is made up of two transmission lines (T1 and T2) which are wound on the same core. Each transmission line is made up of two18 g PTFE insulated wires forming two turns through a BN-43-7051 large balun core. All wires must be of equal length for correct operation, and in this case each wire is approx 250 mm long.

By connecting two of these transformers back to back we can achieve 50 ohms in and out, which is required for the VNA. It is common to use this "back to back" arrangement where input and output impedances are required to be identical. The compromise is that losses are double that for a single transformer and the Return Loss is decreased (less negative) which increases the SWR of the combination when compared with a single transformer. If the combination provides satisfactory results then it can be assumed that each transformer is also acceptable.

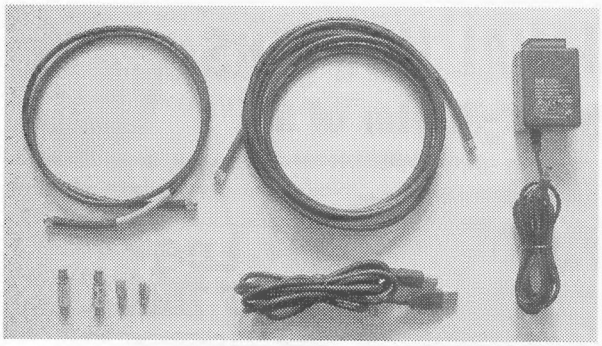

Photo 3 – Accessories that come with the Analyzer.

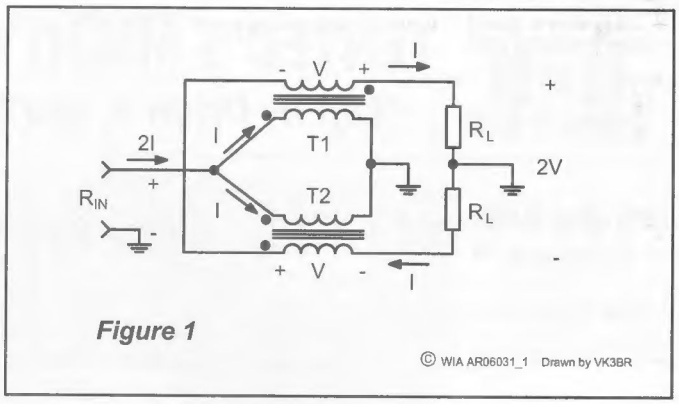

Fig 1 – Circuit diagram of the 4:1 transformer shown in Photo 4.

The following table shows the relationship between SWR and Return Loss (-db)

SWR	Return Loss	SWR	Return Loss
1.0:1	infinite	1.3:1	17.7
1.1:1	26.4	1.4:1	15.8
1.2:1	20.8	1.5:1	14.0

VNA features

Fig 2 shows the S11 and S21 screen presentation for the two back to back transformers as mentioned above.

The test Start and Stop frequencies can be set to 1 Hz resolution. The plot shows the sweep is from 0.5 – 35 MHz, which easily covers the HF amateur bands. Plots can be Single Sweep (SgSwp) or Free Run and the number of points across the sweep can be set between 100 and 1020 with the FreqGrid menu.

There is provision to load a test fixture file by selecting the relevant file from the Calibration menu and selecting Apply Fixture Calibration – bottom right hand corner.

The File menu allows you to give the plot a title.

The Tx Level is usually set to a maximum of 0dB, but can be increased up to about +3dB.

Note that there is an absolute maximum of +10 dBm which can be applied to either the Receive or Transmit port.

The Ref Level in conjunction with the VertScale menu can be set to a value that gives a clear display of the traces.

Up to five markers can be set anywhere on the plots at points of interest and will display relevant data in the top left corner. The trace in Fig 2 shows markers at the HF amateur band limits.

The green (upper) trace is the S21 measurement and indicates the gain/ loss through the two transformers. The maximum loss is about 1dB and occurs around 21 MHz – note that the grid line just above the green trace is 0 dB (Ref Level offset +5 dB) which is the Tx Level shown at the bottom of the screen. This indicates that each transformer has about 0.5 dB max loss.

The red (lower) trace is the S11 measurement of Return Loss and indicates the SWR of the combination.

A reading of –14 dB or more corresponds to an SWR of 1.5 or better. The combined transformers are at least –16 dB which indicates each transformer has an SWR of 1.4 or less.

As mentioned previously, the sweep can be set to Free Run which is very useful if you want to adjust the tuning

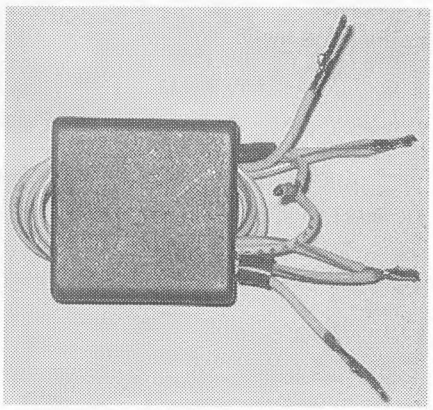

Photo 4 - A 4:1 transformer designed to match 200 to 50 ohms over 1.8 – 30 MHz.

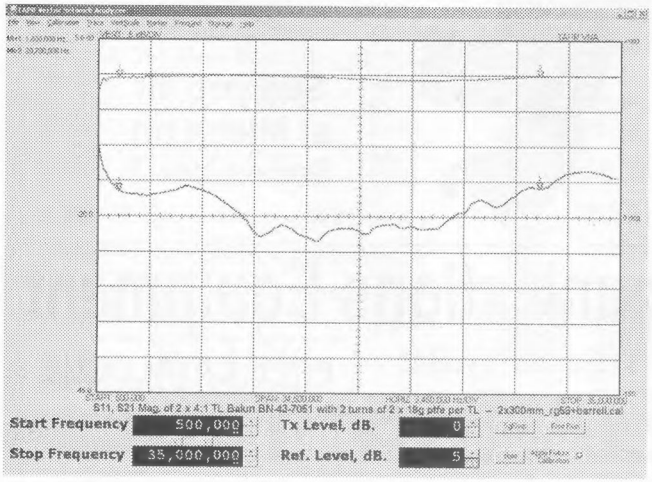

Fig 2 - The S11 and S21 screen presentation for the two back to back transformers (see text)

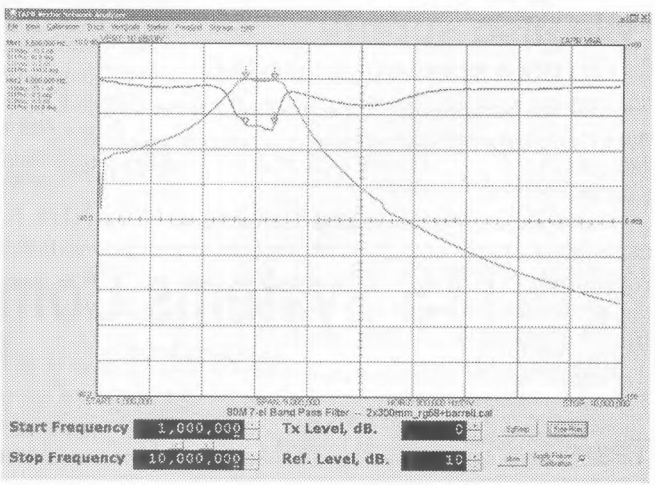

Fig 3 - Plots of an 80 metre bandpass filter which has markers at 3.5 and 4 MHz.

of a device to get the required frequency response.

Fig 3 shows plots of an 80 metre bandpass filter which has markers at 3.5 and 4 MHz.

Some other measurements available from the menus are listed below:

(a) Time Domain Reflectometry (TDR) measurements, useful for coax cable fault finding.

(b) Smith Chart (Polar) plots which show markers in frequency, complex number form and SWR.

(c) Phase measurements of S parameters.

Conclusions

The VNA is easy to use and can replace several different instruments which are often found around the ham shack. The only extra pieces of equipment you may require are SMA adaptors to suit your normal coax connectors.

See the following internet references for more information:

http://www.ttssystems.com.au
http://www.tapr.org
http://www.tentec.com

Editorial comment *continued*

struggling with health issues, while assisting with easing me into the Editor's role. Bill Roper VK3BR has been a tower of strength behind this journal for a long time, as recognised by the Board of the WIA with the presentation of Life Membership earlier this year. Not only has Bill been the "gatekeeper" for the Publications Committee; he has subedited material as it passed along the production chain, prepared the graphics (both photographs and circuit diagrams) for publication, maintained the Articles Register (essential to keep track of the progress of articles), and has been an excellent point of reference for many issues relating to publication preparation. Bill's contributions over many years are very much appreciated by many amateurs. Were it not for Bill's contributions, I probably would have continued to say "NO!" to the approaches I received late last year to take up this role!

I welcome Ernie Walls VK3FM aboard the team as the new Secretary. In reality, this new role is simply a "change of hats", as Ernie has been a member of Publications Committee for some time. There may be some hiccups during the transition, but I am sure that Ernie will do the role proud. Bill will continue to assist as his health allows, especially in the preparation of diagrams – the consistent quality that you (normally) see is the result of Bill's hard work!

New Contest Columnist

I can announce that we will have a new Contest column author, as of the November issue. Firstly, I must thank Ian Godsil VK3JS for his continued contributions. I welcome Ian's replacement, Phil Smeaton VK2BAA. Phil can be contacted via vk2baa@wia.org.au, so why not drop Phil a line and make some suggestions for column content – it is your column after all!

Cheers,

Peter VK3KAI

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