VECTOR NETWORK ANALYZERS

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VECTOR NETWORK ANALYZERS

- Supplies an RF signal to a “Device Under Test” (DUT).
- Measures resulting voltages and currents.
- “VECTOR” means a VNA measures both amplitude *and* phase.
- VNA has separate output (TX) and input (RX) Ports.
- Can be used to measure 2-port devices such as filters and amplifiers (Also can measure 3-port devices).
- Also can be used with 1-port devices such as antennas and inductors or capacitors.

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- Use of VNAs based on S-Parameters.

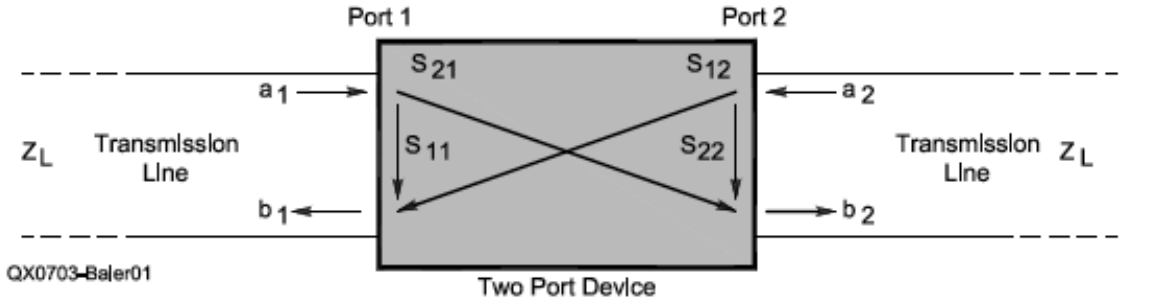

Figure 1 — Connection between S-parameters and incident and evanescent waves at an electrical two port device.

- Think of a_1, a_2, b_1, and b_2 as "traveling waves" that are incident and reflected from the DUT.
- S_{11} and S_{22} are measurements of "return loss" e.g. $b_1=a_1 \cdot S_{11}$
- S_{21} and S_{12} are measurements of "insertion loss" e.g. $b_2=a_1 \cdot S_{21}$

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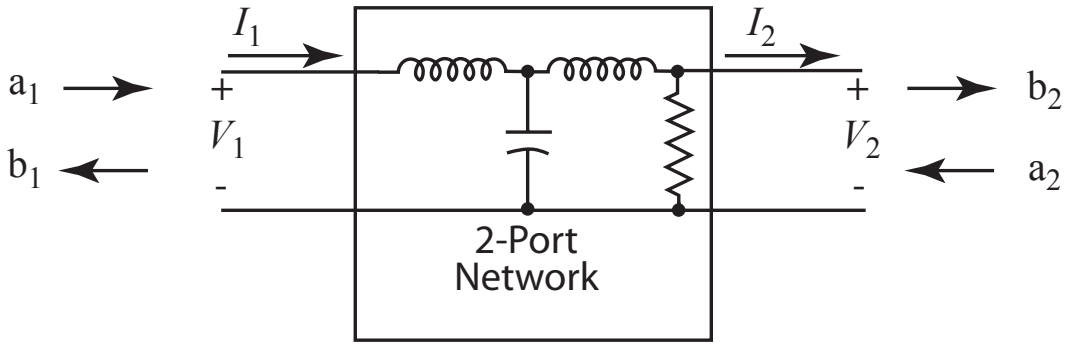
- Traveling waves can be converted to V and I



$$V_1 = \sqrt{Z_0}(a_1 + b_1) \qquad V_2 = \sqrt{Z_0}(a_2 + b_2)$$

$$I_1 = \frac{1}{\sqrt{Z_0}}(a_1 - b_1) \qquad I_2 = \frac{1}{\sqrt{Z_0}}(b_2 - a_2)$$

Z_0=Reference Impedance, usually 50 ohms

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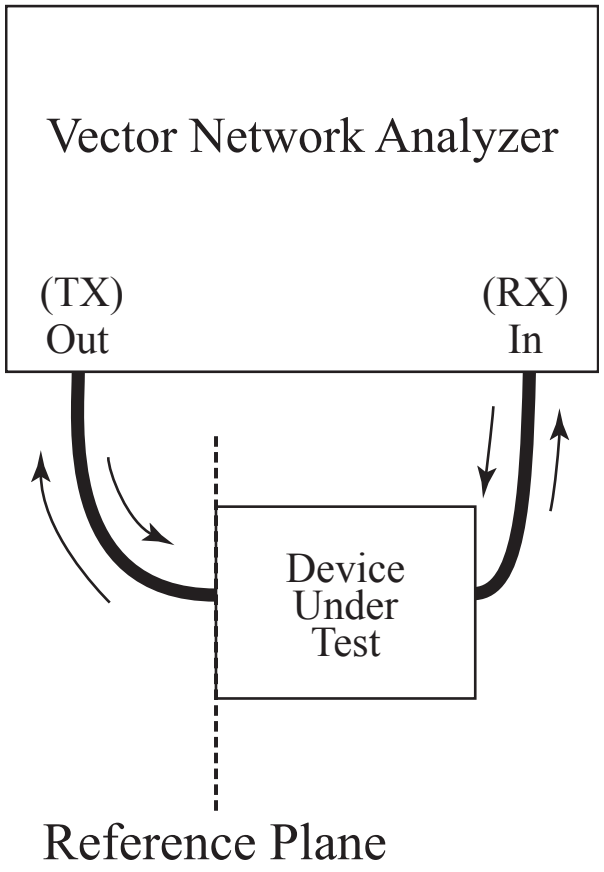
- Measurements made with respect to a “Reference Plane”



- A calibration is required at the Reference Plane.
- At the TX Port: Short, Open, Load (SOL).
- The “Load” is usually 50 ohms.
- From TX to: Open, Connected.

- The DUT must be reversed to measure both forward and reverse parameters.
- An “S-Parameter Test Set” can be added to do this reversal automatically using relays.

VECTOR NETWORK ANALYZERS

- Article by Thomas Baier, DG8SAQ, in the Jan/Feb 2009 issue of QEX magazine.

Prof. Dr. Thomas C. Baier, DG8SAQ

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A Small, Simple, USB-Powered Vector Network Analyzer Covering 1 kHz to 1.3 GHz

You will want to build this new variation on a popular project!

Summary

Since I had published my ideas for a simple and low cost vector network analyzer (VNWA) in *QEX* in 2007, I have received lots of feedback, showing, that there is a great interest in this field.[1] The original design (VNWA1.0) had a few shortcomings. It only covered a fundamental frequency range up to 160 MHz. On the other hand, it could measure at some limited higher frequency bands up to 500 MHz, with reduced accuracy, by using higher DDS alias frequencies.[2] Another drawback was that it was a veroboard design. This made it very tough to duplicate. So, I have thought about how to make the VNWA design even simpler, better, and last but not least easier to build. In this article, I describe the very satisfactory result of this development process, which is a small single printed circuit board VNWA covering 1 kHz to 1.3 GHz in one continuous frequency band, which can be powered directly from a computer USB interface.

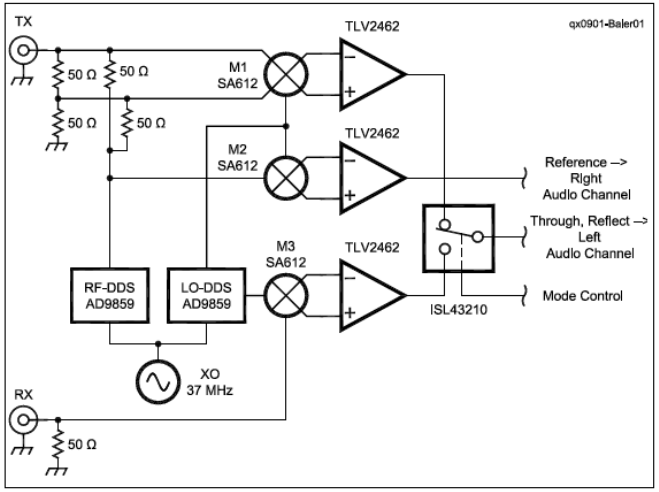
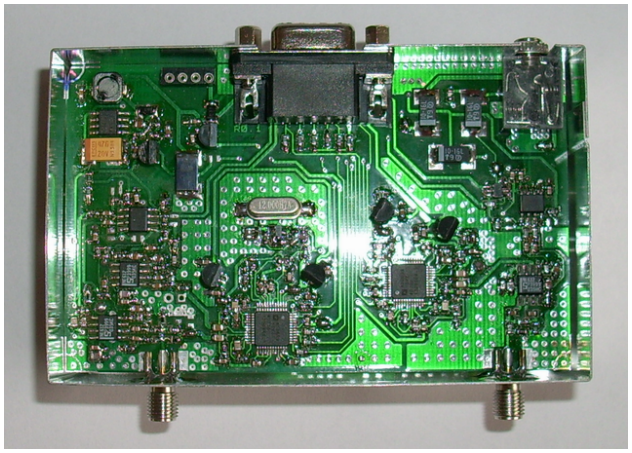
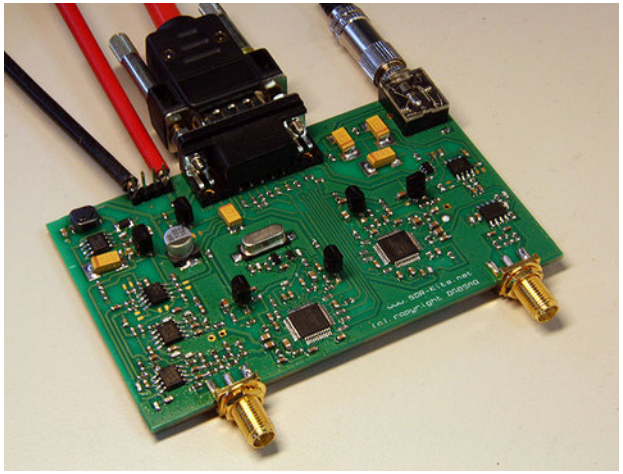


Figure 1 — A block diagram showing the fundamental design of the VNWA2.1.

VNWA Design

Figure 1 shows the fundamental design





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- A later article by Thomas Baier, DG8SAQ, in the May/June 2009 issue of QEX magazine describes an S-Parameter Test Set

Prof. Dr. Thomas C. Baier, DG8SAQ

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A Simple S-Parameter Test Set for the VNWA2 Vector Network Analyzer

This test set eliminates the need to swap input and output connections to the vector network analyzer when measuring S-parameters.

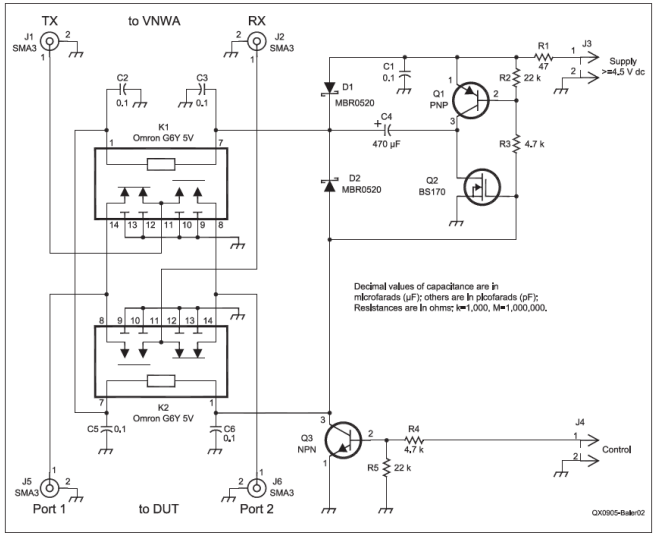

Figure 2 — Schematic of the VNWA S-Parameter Test Set.

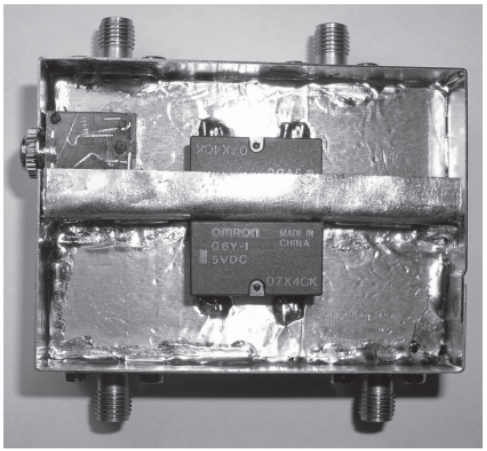

Figure 3 — Test set as seen from top. The shielding wall between the relays is most crucial for good isolation. The sheet metal box size is 65 × 45 mm².

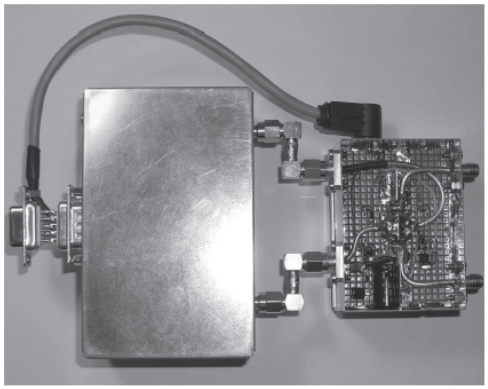

Figure 4 — The test set as seen from the bottom, hooked up to the VNWA2. Note that the connection cable taps the 5 V dc power supply and the control line at the VNWA digital Sub D9 interface.

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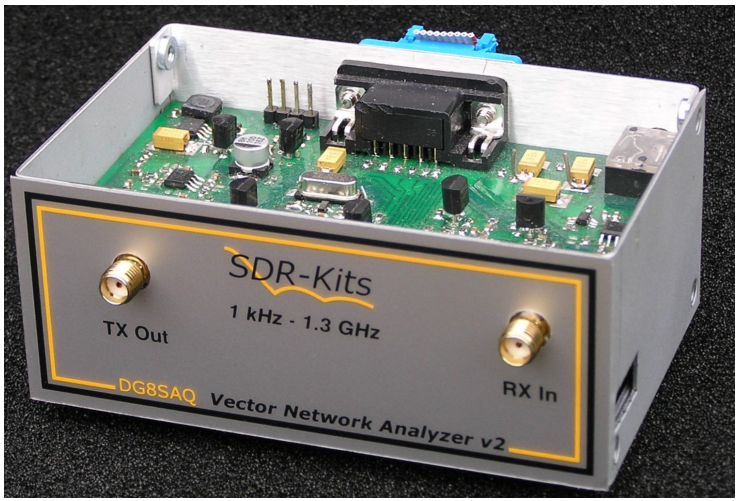
- An assembled and tested DG8SAQ VNA can be purchased from SDR-Kits in the UK. (www.sdr-kits.net)



- Powered through a USB connector.
- Free software runs under Windows.
- Frequency range to 1.3 GHz by overclocking chips.
- There is an active Yahoo Group of interested users.

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- Let's try some measurements

  - First, a typical calibration
  - Low-pass filters
  - An inductor
    - Inductor Q
  - An Antenna
  - A resonant circuit
  - A crystal
  - Time domain analysis of a coaxial cable

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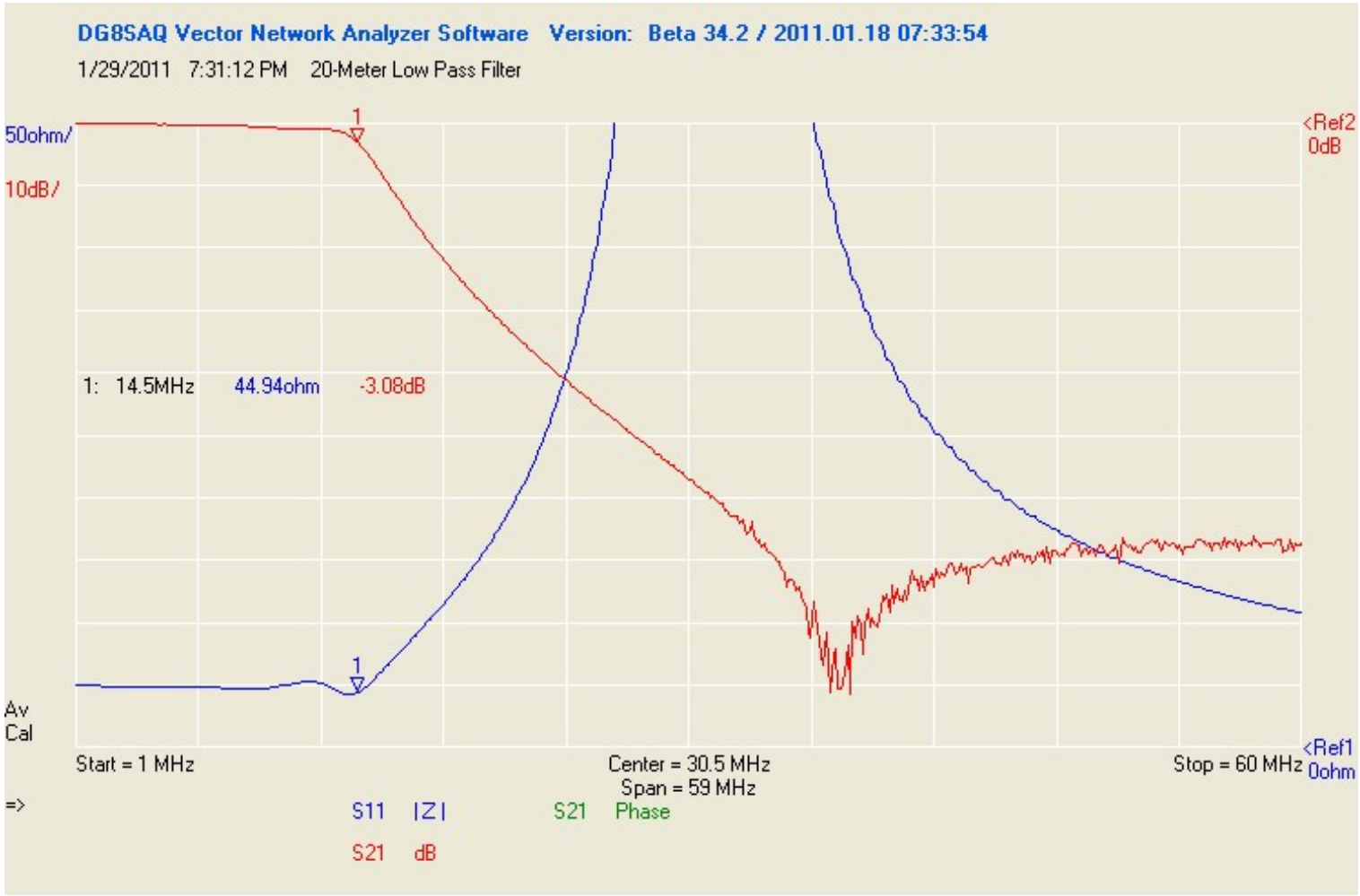
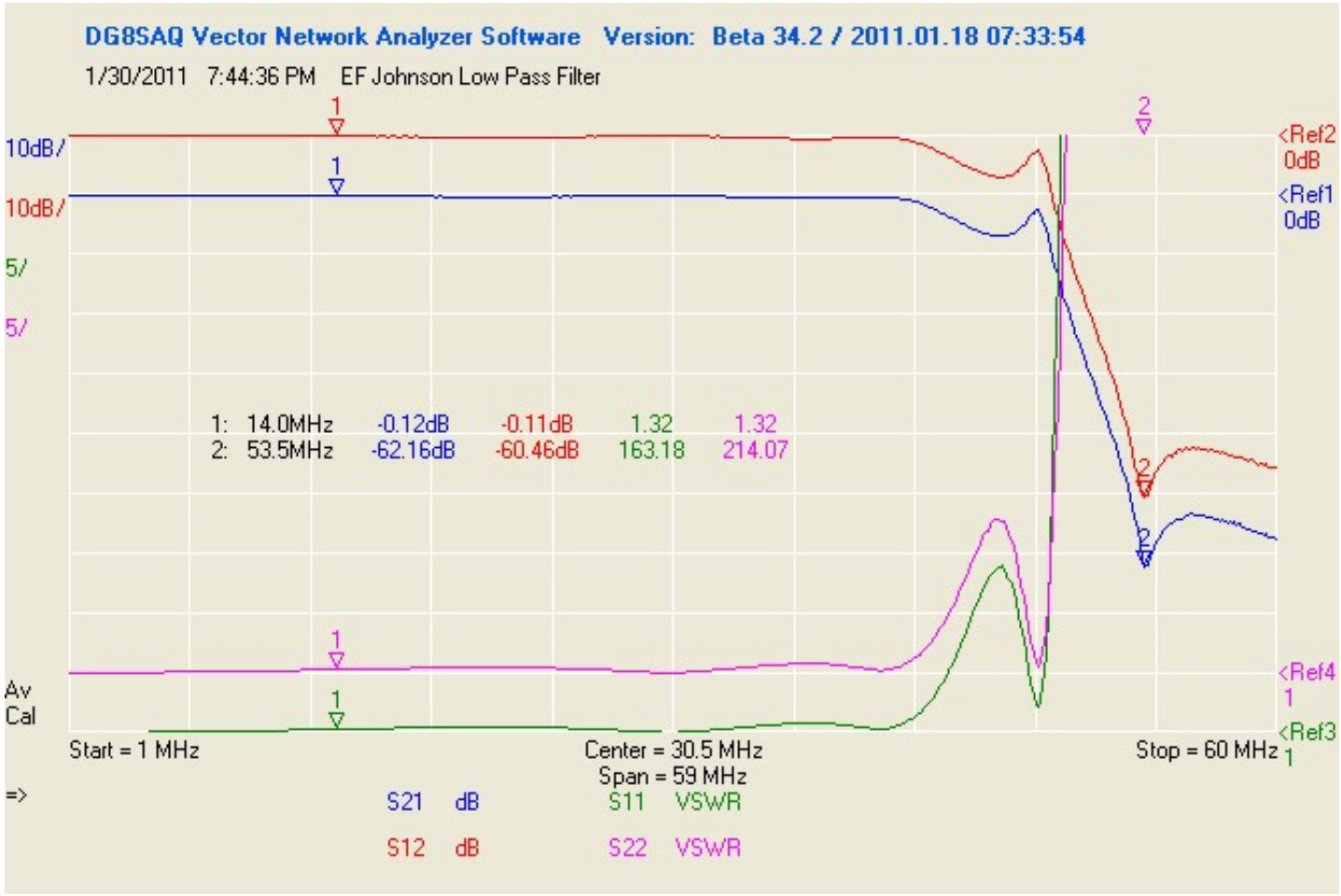
- Low Pass Filter



VECTOR NETWORK ANALYZERS

- Low Pass Filter



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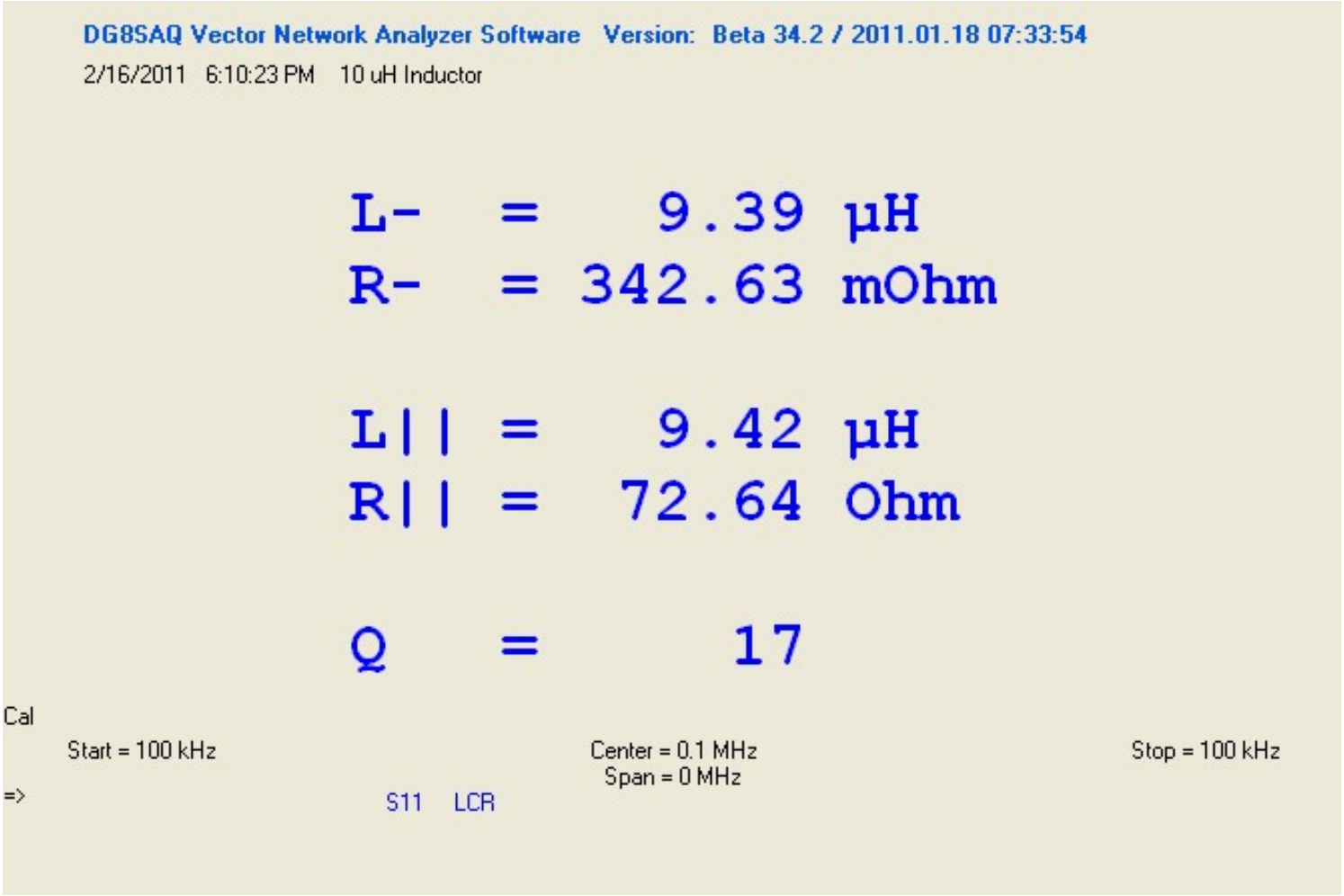
- Inductor



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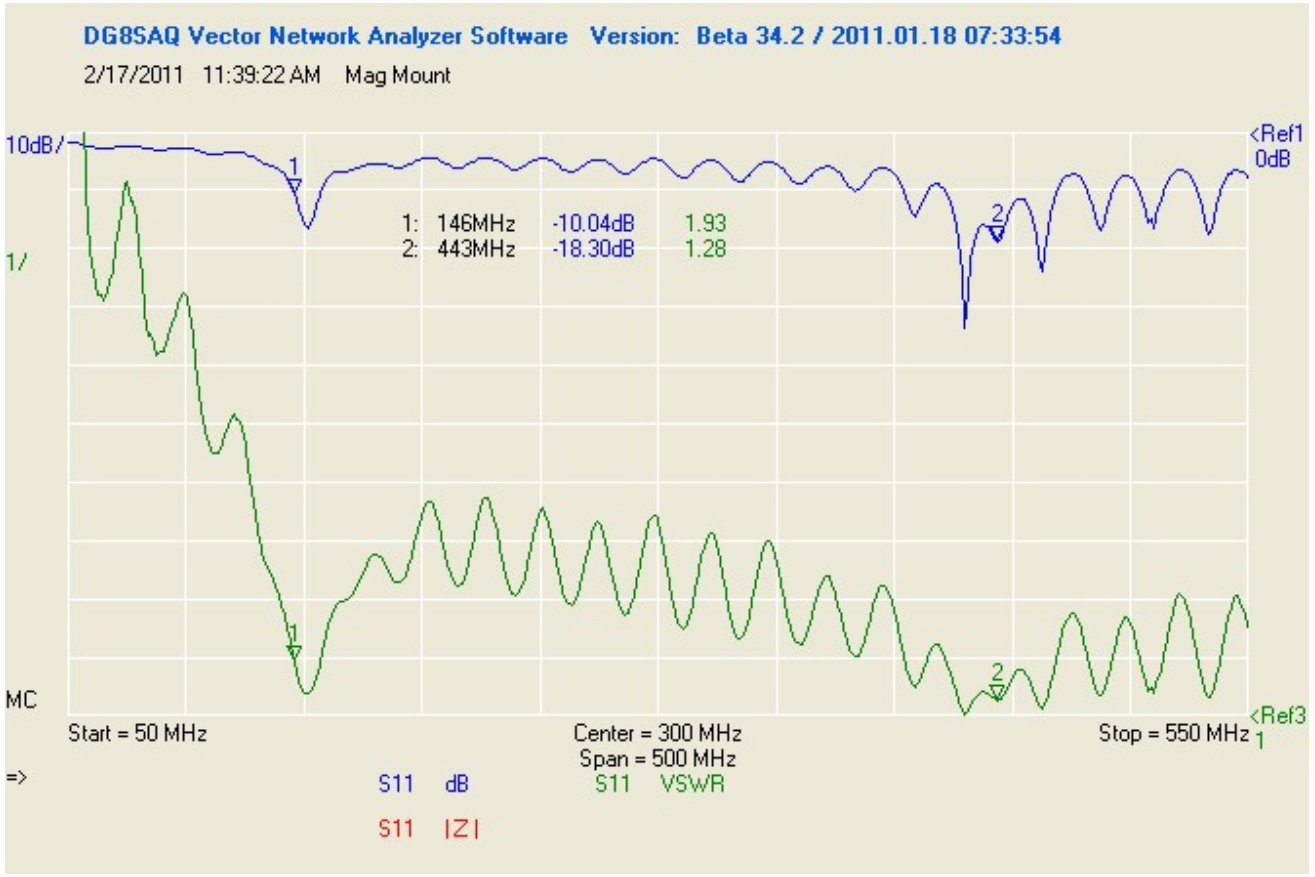
- Mag Mount Antenna



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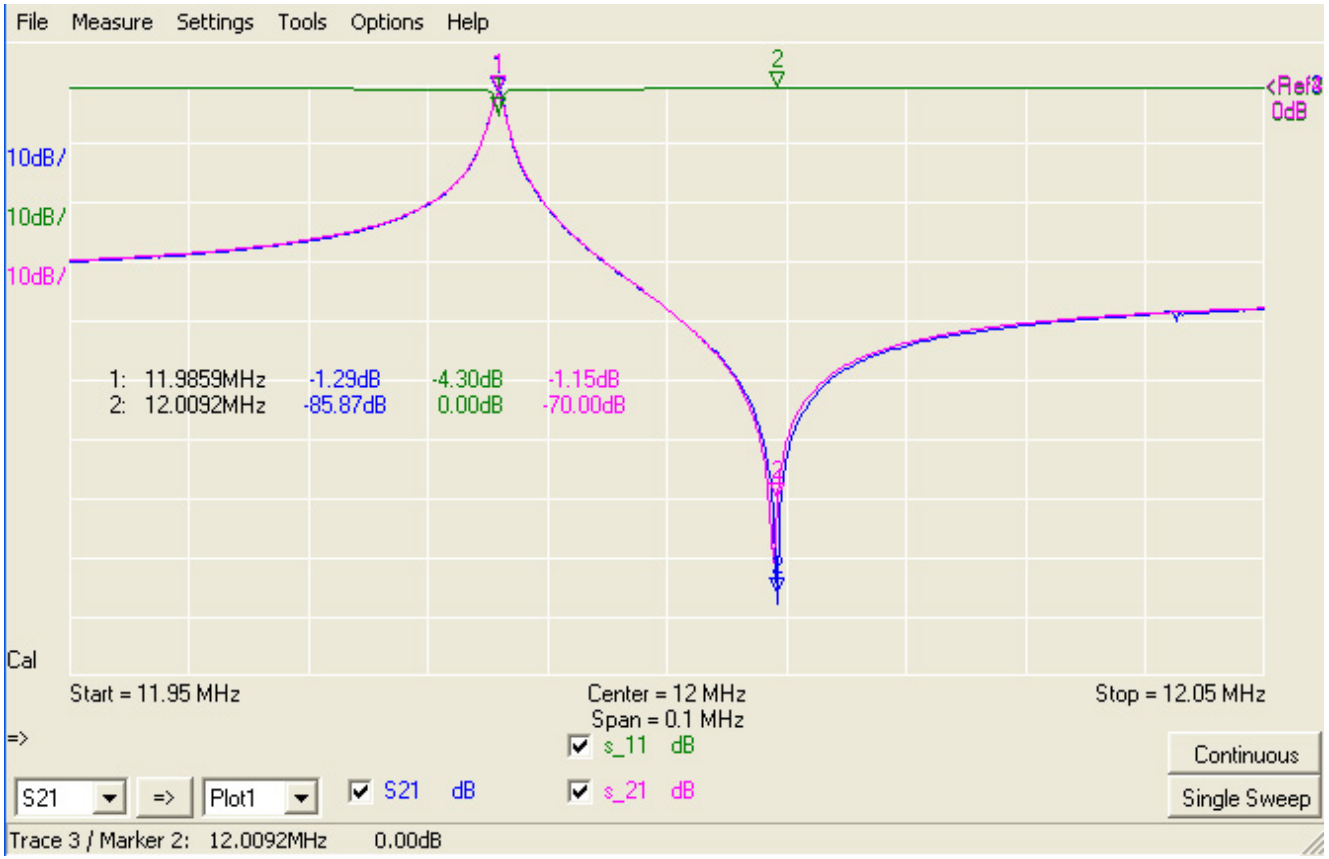
- 12 MHz Crystal



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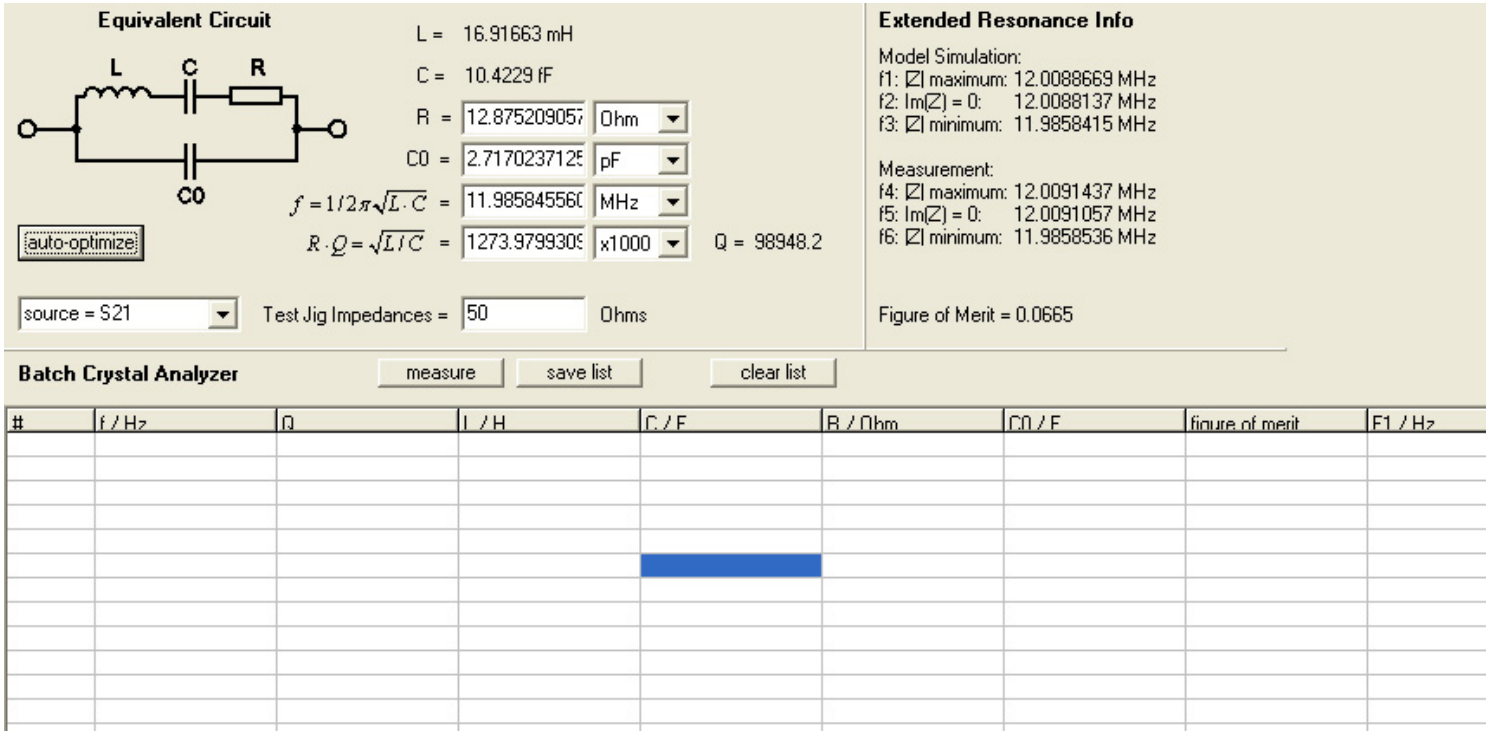
- 12 MHz Crystal



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- Time Domain Measurement of a Coax Cable