Vector Network Analyzers

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What is a vector network analyzer?

- What is a vector?
- A vector is a quantity having magnitude and direction
- A vector can be described in rectangular (X,Y) or polar (|Z|∠θ) notation



What is vector impedance?

 Vector impedance is a way of describing an impedance in terms of its resistive and reactive components (Z = R + jX), at a given frequency



What can be done with vector impedance?

- Use it directly to characterise antennas, transmission lines, components, design matching networks etc.
- Use it to calculate reflection coefficient (ρ), VSWR, return loss (RL)
 - $\rho = \left| \frac{Zu Zr}{Zu + Zr} \right|$ where Zu = unknown impedance (R + jX), Zr = reference impedance
 - $VSWR = \left(\frac{1+\rho}{1-\rho}\right)$
 - $RL = -20 \log 10 \left(\frac{VSWR + 1}{VSWR 1} \right) = -20 \log 10 \rho$
 - Note that scattering parameter S11 = ρ
- So Vector Network Analyzer is just a fancy name for an RF impedance bridge

One-port vs two-port analyzers

- A one-port analyzer can only measure at the input (or output) port of a network
- A two-port analyzer can measure the transfer function between input and output ports
- but possible to calculate transmission line loss by making one-port measurement



SARK-110 Vector Network Analyzer

- Pocket size
- 3" Color TFT display
- Frequency range 100 kHz to 230 MHz
- Excellent accuracy over a broad range of impedances
- Resolves the sign of the impedance
- Internal disk for storage of measurements, screenshots, configuration and firmware upgrades
- USB Connection to a PC
- Menu-driven, with a number of measurement modes



SARK-110 Specifications

- General
 - Frequency range: 100 kHz to 230 MHz
 - Frequency resolution: 1 Hz
 - Frequency stability: ± 30 ppm
 - Sine wave output
 - RF Connector: MCX socket
 - Output power: approx. -10 dBm (0.1mW, 70.7mV rms) into a 50ohm load
 - Sweep time (Scalar Chart/Smith Chart/Field Mode): 3 seconds (Normal/fast sampling), 5 seconds (Double/slow sampling), 1.5 seconds (Normal/low resolution)
 - Sweep time (FDR): 6 seconds
 - Frequency Resolution: 258 points per sweep (258 to 10000 in deep sweep mode)
 - Return loss dynamic range: 0 to -60 dB

Vector Network Analyzers

SARK-110 Specifications

- General
 - VSWR dynamic range: 100:1 maximum
 - Impedance reading in open circuit: 60000 (@1 MHz)
 - Measurement limits: |Z| < 100K, |R| < 100K, |X| < 100K, |Rho| < 0.98, C < 100 nF, L < 100 mH, -180 < Θ < 180
- Measured Parameters
 - Complex impedance (series and parallel) and reflection coefficient in rectangular and polar form, VSWR, return loss, reflection power percentage, quality factor, equivalent capacitance, equivalent inductance
- Operating modes
 - Scalar Chart, Smith Chart, Single Frequency, Cable Test (TDR), Field, Multi-band, Signal Generator, Computer Control and Band Scan

Scalar Chart Mode

- Displays two user-selectable traces
 - Complex impedance (series and parallel) and reflection coefficient in rectangular and polar form, VSWR, return loss, cable losses, reflection power percentage, quality factor, equivalent capacitance, equivalent inductance
- Two markers available: manual or tracking modes



Smith Chart Mode

- Displays the reflection coefficient on a Smith chart
- Two markers available



Vector Network Analyzers

Single Frequency Mode

- Displays VSWR and impedance at a single frequency
- Two element equivalent circuit model
- Advanced circuit models analysis (CModel)



Cable Test Mode

• Impulse and Step responses graph for finding discontinuities in transmission lines



Field Test Mode

• Simplified chart aimed for operation in the field



Vector Network Analyzers

Multiband Mode

 Displays four independent charts at different frequency bands



Signal Generator Mode

- Eight user selectable levels from -73 dBm to -10 dBm
- Frequency sweeps can be programmed with linear, bilinear, logarithmic, or bi-logarithmic functions
- Can also include modulation



Vector Network Analyzers

Transmission line Add/Subtract

 Capability of subtracting a length of transmission line (transpose to load) or adding a length of transmission line (transpose to input)



Vector Network Analyzers

Circuit Models

Loop Antenna / Coil





Capacitor





Vector Network Analyzers

Calibration

- Open-Short-Load (OSL) calibration to improve measurement accuracy
- Up to eight calibration profiles can be stored, for different frequency ranges and type of probe



SARK Plots – Client Software for Windows

- Scalar, Smith and Impulse/Step response charts
- Operates online or offline with captured files





SARK-110 Remote Screen

- Windows client application for the PC that reproduces the user interface of the device
- Experimental functional application intended mainly for doing presentations on the device
- Device buttons are simulated using the following map to the computer keys:



Measurement examples

- Components; inductors, capacitors, crystals
- Resonance
- Transmission lines
- Antenna
- Signal generator

How it works

 Basic idea is to measure the magnitude and phase of the voltage across (VU), and the current through (IU) the unknown impedance (ZU) as a function of frequency



 Usually more convenient to derive IU from the voltage (VR) across a known resistance



Block diagram

- The SARK-110 comprises four main sections
 - a signal generator used as an active source
 - a bridge to provide signal separation
 - two tuned receivers that down-convert and detect the signals
 - a microcontroller and display for calculating and reviewing the results



- Array Solutions AIM-4300 Single Port (5 kHz-300 MHz)
- US\$495
- Requires external PC for control and display)



Vector Network Analyzers

- Array Solutions AIM UHF Single Port (5 kHz-1000 MHz)
- US\$695
- Requires power supply and external PC for control and display)



- Array Solutions VNA 2180 Dual Port (5 kHz-180 MHz)
- US\$995
- Requires external PC for control and display)



- Array Solutions VNA UHF Dual Port (5 kHz-1200 MHz)
- US\$1295
- (Requires external PC for control and display)



- SDR Kits DG8SAQ VNWA3 Dual Port (1 kHz-1300 MHz)
- US\$440
- Requires external PC for control and display)



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- Pocket VNA2 port handheld unit covering 500 kHz to 4 GHz
- US\$430



Vector Network Analyzers

- MFJ-226 1 to 230 MHz, 1Hz resolution.
- US\$339.95



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