Building, Understanding and using your own ...

SNA
Scalar Network Analyzer

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So **WHAT IS** a “Network Analyzer”?  

**SCALAR Network Analyzer (SNA)** … *Deals only with signal Magnitudes*  
**Vector Network Analyzer (VNA)** … *Deals with both Magnitudes and Phase*
What can you **DO** with a Network Analyzer?

- Measure Filters … Low Pass, Band Pass, Receiver IF stages
- Measure Crystals … Frequency, “Motional Parameters”
- Measure Antennas … SWR, Return Loss
- Measure Impedance … “Complex $Z = R +/- jX$”
- Generate RF Signals … Stable reference frequencies
- Measure Coax Cables … Integrity, length, shorts

And more!
Scalar Network Analyzer

EXAMPLES

Features

- Pocket size and lightweight
- Solid aluminum case
- Intuitive and easy to use
- Operating modes: Scalar Chart, Smith Chart, Single Frequency, Cable Test (TDR), Field Mode, Multi-band, Signal Generator, and Computer Control
- Excellent accuracy over a broad range of impedances
- Resolves the sign of the impedance
- Manual and automatic positioning tracking markers
- Transmission line add and subtract
- Circuit models function: transmission line, inductor, capacitor and crystal
- Internal 2MB USB disk for the storage of measurements, screenshots, configuration and firmware upgrade
- Exports data in ZPLOTS-compatible format for further analysis on a PC
- SARK Plots client software for Windows
- Lifetime free firmware upgrades
- Open to community requested features
- Open source Software Development Kit (SDK) including a device simulator for development of user applications

SARK 110 - http://www.sark110.com/ .... ~$390
Portable analyzer with graphical display
Similar in principle to AIM-4170
Now available at SteppIR
Scalar Network Analyzer

EXAMPLES

What the MFJ-225 Measures:
- SWR (1:1 to 9.9:1)
- Complex Impedance (R+jX)
- Impedance Magnitude (Z)
- Return Loss (RL, 0-30dB)
- Phase (0-180°)
- Capacitance (0-9999pF)
- Inductance (.1uH-80uH)
- Cable Length (0.5-45m)
- Cable Loss (0-30dB)

MFJ 225 antenna analyzer/VNA .... ~$300
Portable or bench VNA
OR ...

You can make your own Scalar Network Analyzer!
• Handheld instrument for “scalar measurements” …
  - Testing and evaluating filters
  - Measuring crystal parameters
  - Return Loss Measurement
  - VSWR and antenna tuning
  - Continuous/repeated operation options
• 3.2”, 240 x 320, 16-bit color graphic LCD display
• Touch panel & Keyboard as input devices
• Field upgradable firmware
• Serial port connection to other devices
• EEPROM for storing settings & options
• SD Card mass storage up to 1 GB provides:
  - Data spooling and playback
  - Calibration data storage and reloading
  - Direct data exchange with Windows and Linux apps
  - DOS–like commands to manage and playback data files

Specifications
PCB: 4.47" x 3.31"
Enclosure: 4.82" x 3.77" x 1.39"
Data rates: 1.2 to 19.2 kbaud
Power: 12V DC @ 120ma (typ) (330ma with DDS-60)
Weight: 7 oz (approx)
Scalar Network Analyzer (SNA)

Block Diagram (Simple)

- **DUT** (Device Under Test)
  - e.g., Low Pass Filter

**RF IN** → **DUT** → **RF OUT**
Block Diagram (Detailed)

Graphic Display & Touch Screen

Microcontroller

“DDS” Signal Generator

Device Under Test (DUT)

Logarithmic RF Power Detector

RF IN

RF OUT

POWER LEVEL

FREQ

POWER LEVEL

FREQ
QVGA Display

Display module - under $20 on eBay:

- 240 x 320 Pixel (QVGA), 16-bit color, 3.2” LCD
- SSD1289 display controller
- Resistive touch screen with ADS7843 controller
- SD Card socket
- Pads and interconnect for serial (SPI) EEPROM
- Single, 40-pin interface connector
SNA Menu-Driven Operation

1. **Main Menu**
   - 1 - SNA Functions
   - 2 - Generator Functions
   - 3 - Return Loss Bridge & SMR
   - 4 - Measure Xtal Parameters
   - 5 - Memories
   - 6 - Scan
   - * - Options & Calibrations

2. **SNA Functions**
   - FREQ LO is: 1,000,000 kHz
   - FREQ HI is: 31,000,000 kHz
   - FREQ ST is: 5,000 kHz
   - Press:
     - 0 - CTRL-R to run
     - 0 - ALT-R to overwrite
   - Escape to quit

3. **Graph**
   - Min: -57.95 dBm @ 14,200,000 kHz
   - Max: 3.45 dBm @ 37,000,000 kHz
   - 1st -3 dB @ 8,650,000 Hz

4. **Input**: 500000

5. **CTRL-R**
RF Power Meter Mode
- Primarily intended for QRP applications
- Power reading taken about 200 times/second (every 5 ms)
- 100 dBm range, use attenuators to shift the range
- DDS used only for calibration

Three Power Meters Displayed
- Current power reading (10-point running average)
- Average Power (200-point running average)
- Peak Power (updated every 200 samples)
Measuring Antenna “SWR”

RETURN LOSS BRIDGE

RF INPUT (FROM DDS)

RETURN LOSS
(TO RF POWER METER)

RESONATING DUT
(e.g., antenna)

RETURN LOSS

RIF INPUT

(FROM DDS)

10T-Bifilar
(FT37-43)

50 Ω

50 Ω

50 Ω
Antenna Analysis with the RLB
SNA

Crystal Characterization

CRYSTAL TEST FIXTURE

RF OUT

-3dB Attenuator

9.1

150

10T-Bifilar (FT37-43)

CRYSTAL SOCKET

10T-Bifilar (FT37-43)

-3dB Attenuator

RF IN
Crystal Matching
SNA

More Crystal Characterization & Matching
Gain ratio  = \( P_{out}/P_{in} \)

Gain (dB) = \( 10 \log(P_{out}/P_{in}) \)

Gain (dBm) = \( 10 \log(P_{out}/.001) = 10 \log(P_{out} \times 1000) = 10 (\log(P_{out}) + \log(1000)) = 10 \log(P_{out}) + 30 \)

Short circuit gain = \( 10 \log(P_{in}/P_{in}) = 10 \log(1) = 0 \) for any \( P_{in} \)

Gain (dBm) = \( 10 \log(P_{in}) - d \) where:
\( P_{in} = \) power meter reading
\( d = \) short circuit gain reading

DDS output level varies with frequency (due to \( \sin(x)/x \) sampling effect) therefore \( d \) is a function of frequency: \( d(f) \)

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**Figure 7.** \( V_{OUT} \) vs. Input Level (dBm) at Various Frequencies
RF Network Analyzer Basics Tutorial ...
http://www.radio-electronics.com/info/t_and_m/RF-network-analyzer/analyser-basics-tutorial.php

SNA Home Page & Kit Availability ...
http://www.midnightdesignsolutions.com/nat

SNA Yahoo Group ...
https://groups.yahoo.com/neo/groups/NAT-SNA/info

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