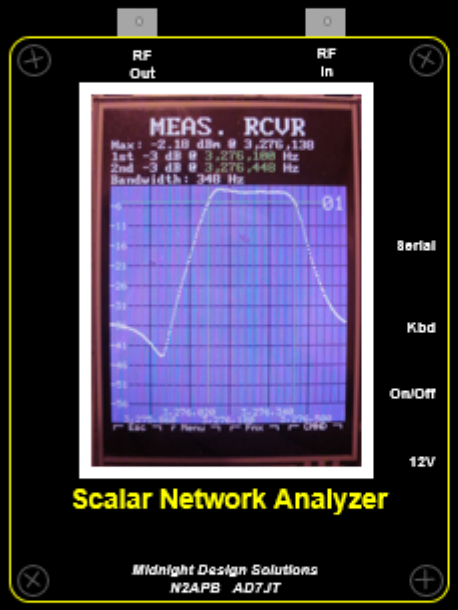
Building, Understanding and using your own …



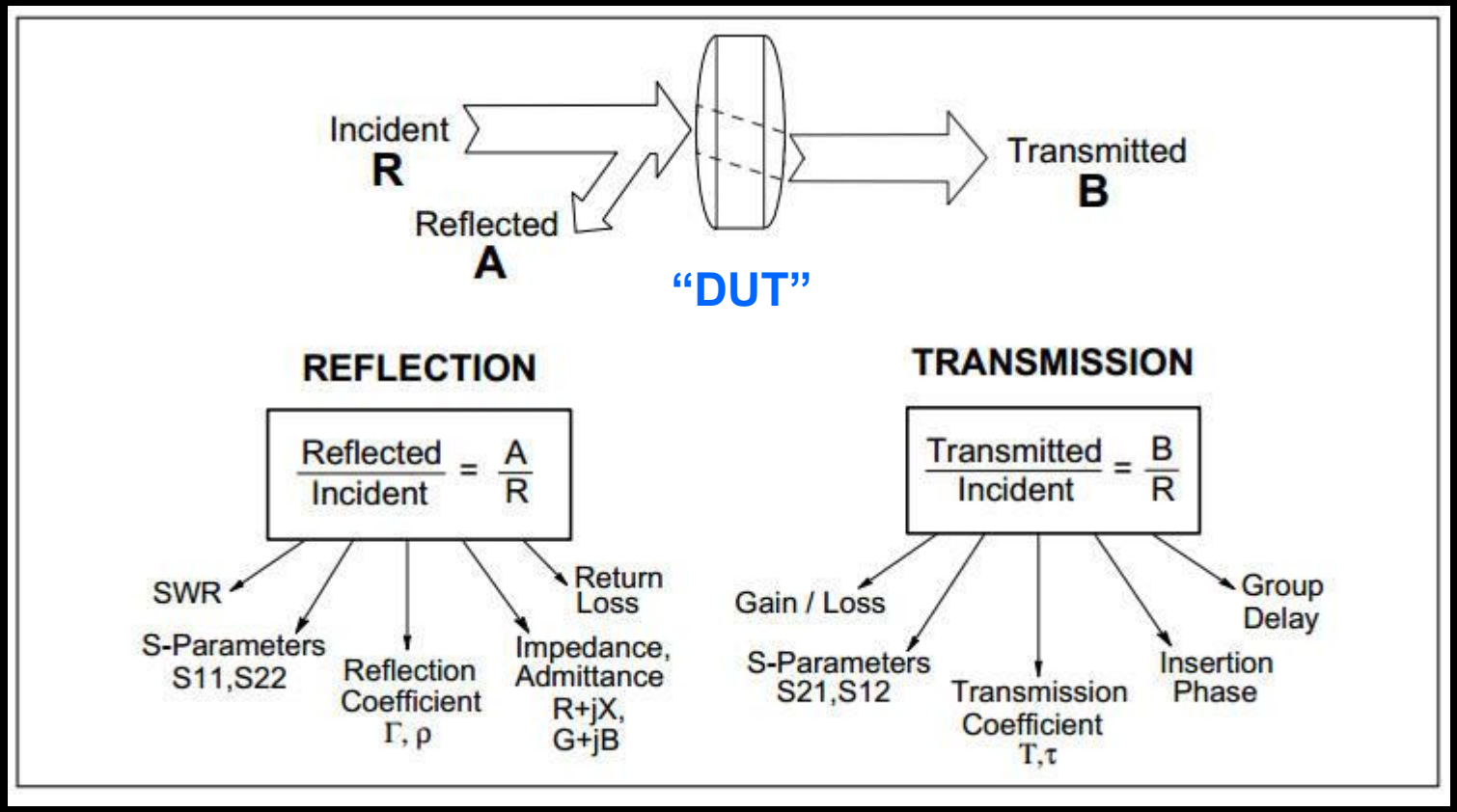
SNA

Scalar Network Analyzer

George Heron – N2APB
Dave Collins – AD7JT

Trenton Computer Festival 2015

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

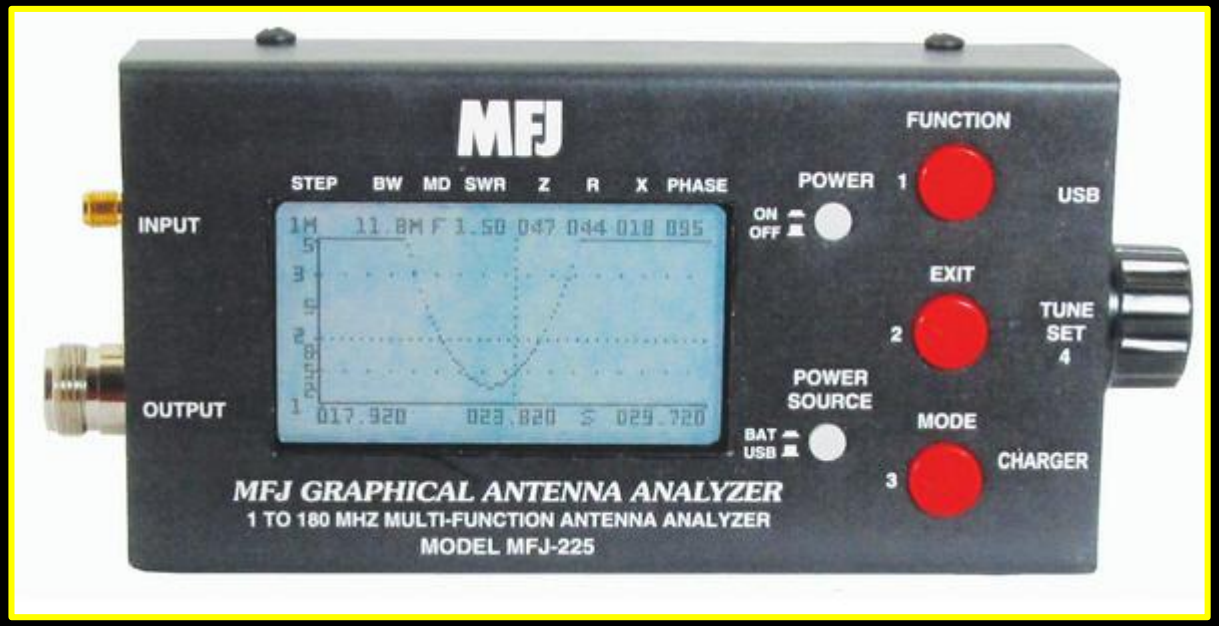
SARK 110 - http://www.sark110.com/ .... ***~$390***
Portable analyzer with graphical display
Similar in principle to AIM-4170
Now available at *StepIR*

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

Scalar Network Analyzer

EXAMPLES



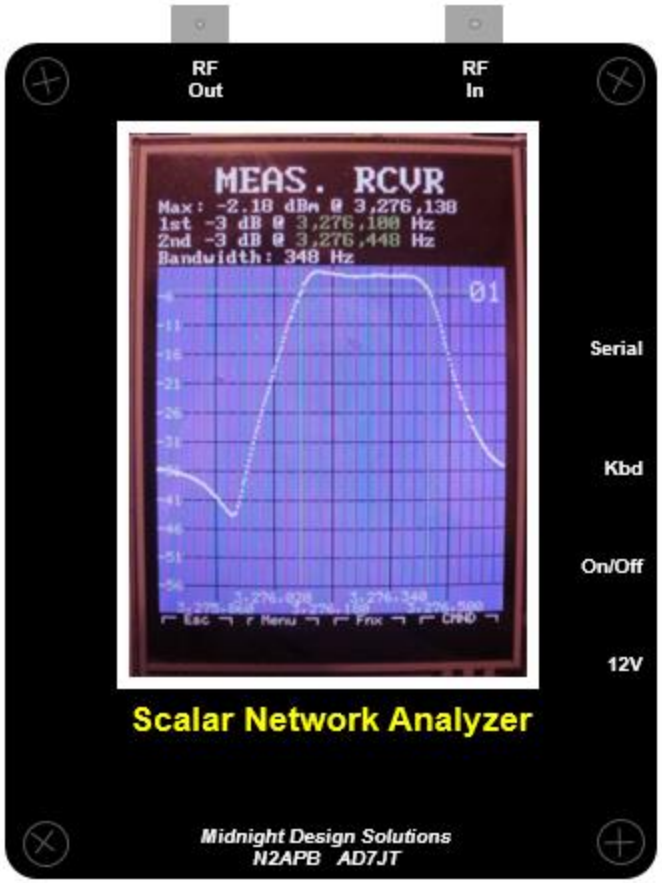
What the MFJ-225 Measures:

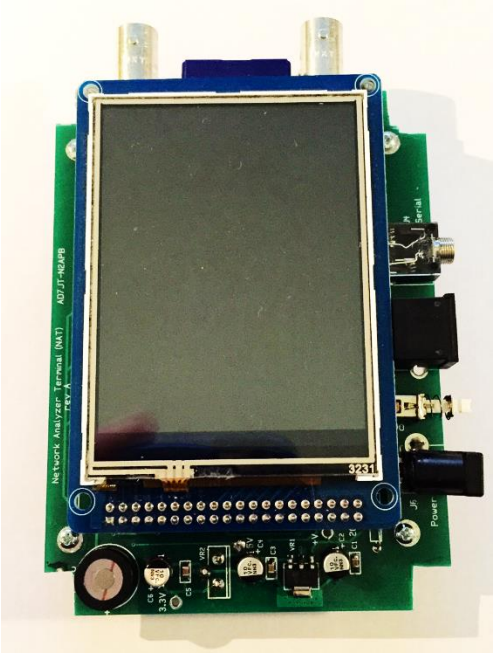
- SWR (1:1 to 9.9:1)
- Complex Impedance (R+jX)
- Impedance Magnitude (Z)
- Return Loss (RL, 0-30dB)
- Phase (0-180°)
- Capacitance (0-9999pF)
- Inductance (.1uH-80uH)
- Cable Length (0.5-45m)
- Cable Loss (0-30dB)

MFJ 225 antenna analyzer/VNA .... *~$300*
http://www.mfjenterprises.com/Product.php?productid=MFJ-225
Portable or bench VNA

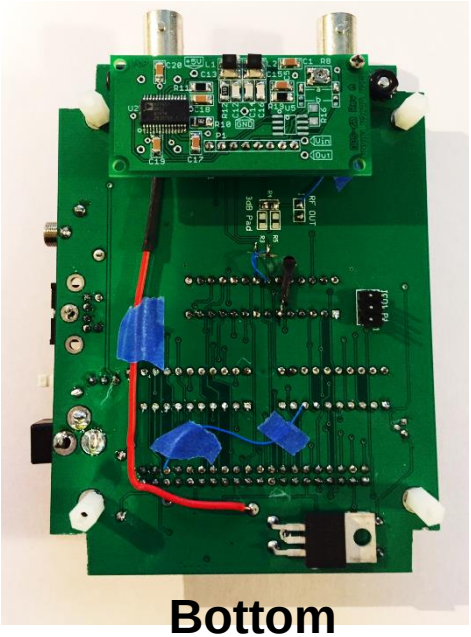
OR …

You can make your own Scalar Network Analyzer!





Top



Bottom

SNA

Midnight SNA Features

- 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*

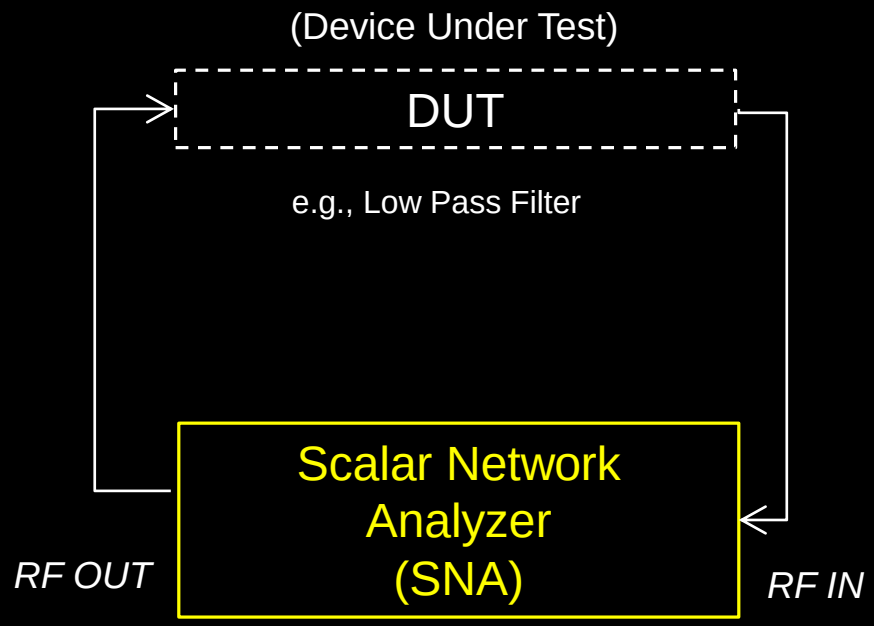
Specifications

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)*

SNA

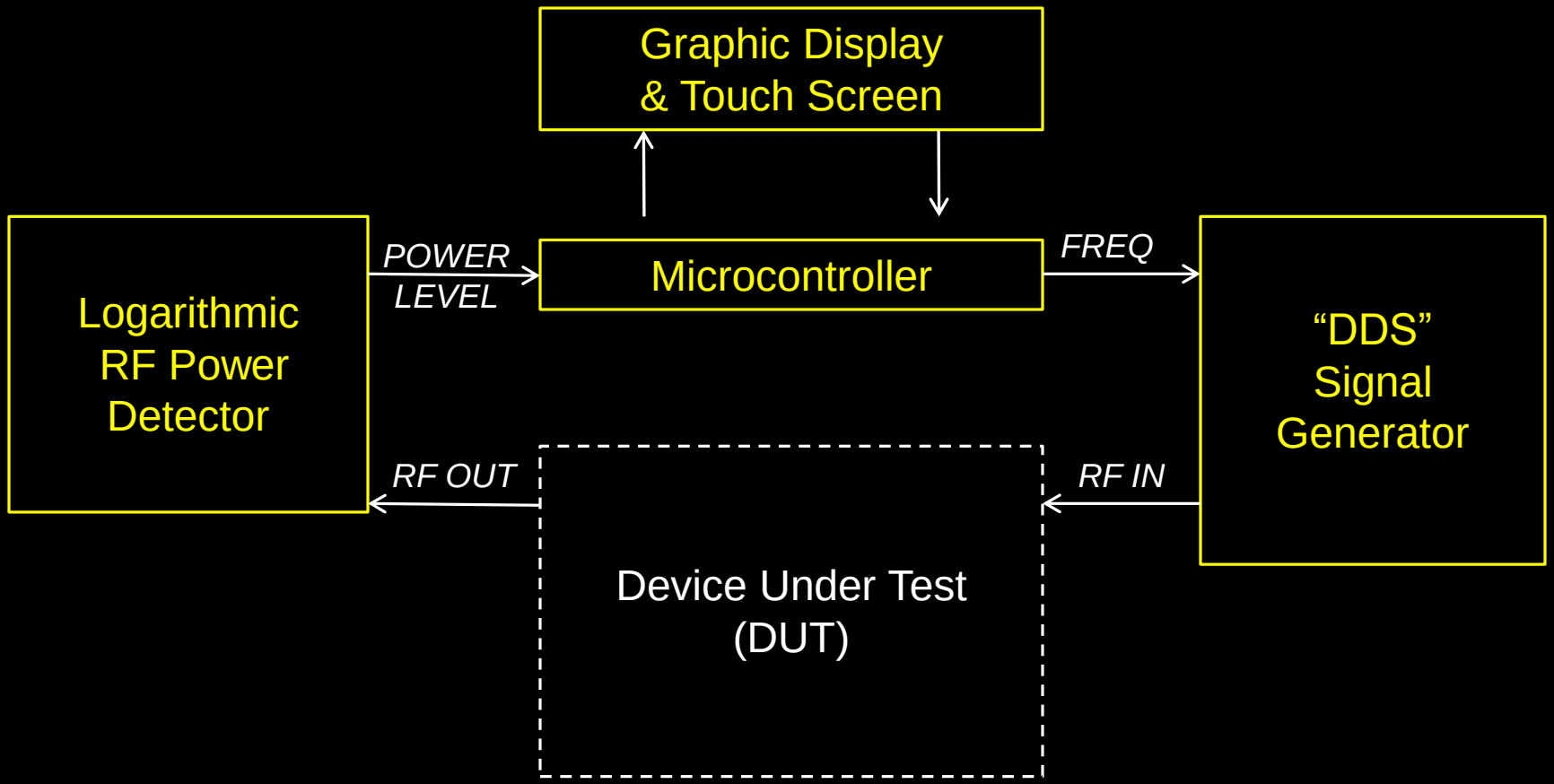
Block Diagram

(Simple)



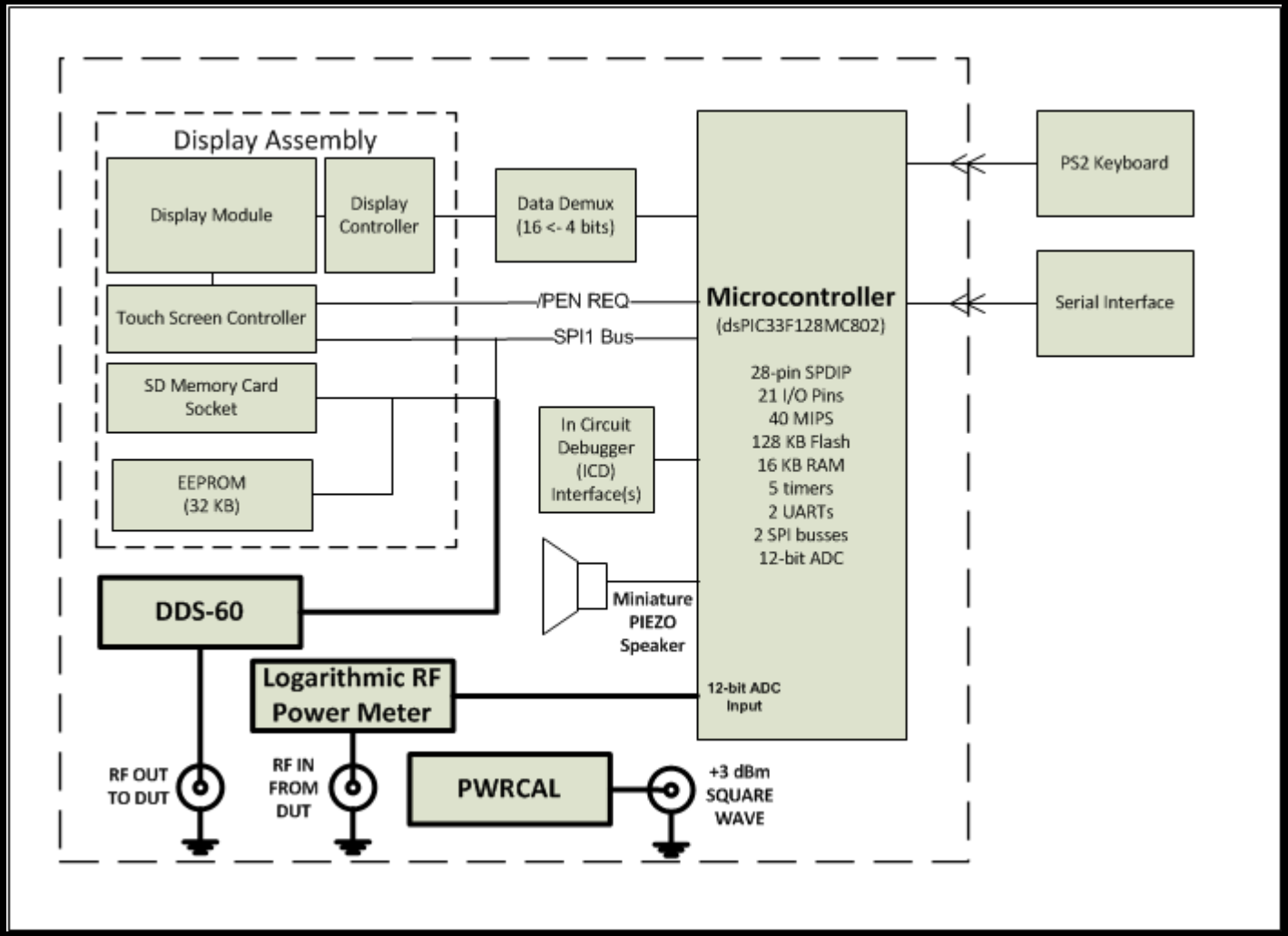
SNA

Block Diagram
(Detailed)



SNA

Block Diagram
(More Detailed)

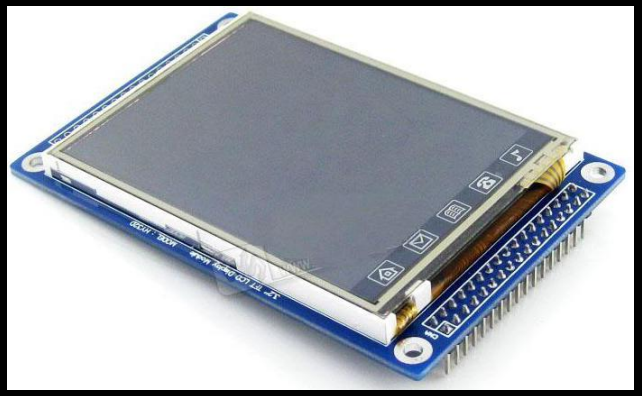


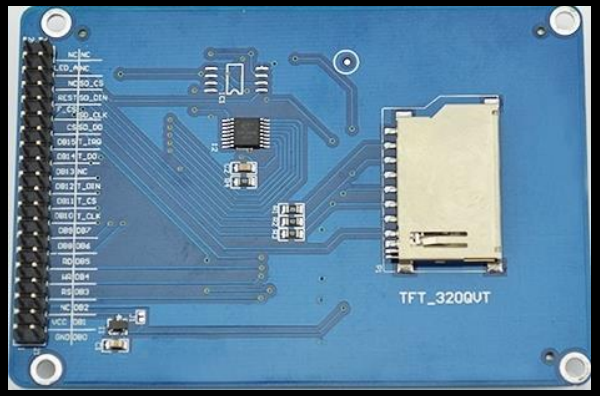
SNA

QVGA Display

Display module - under $20 on eBay:

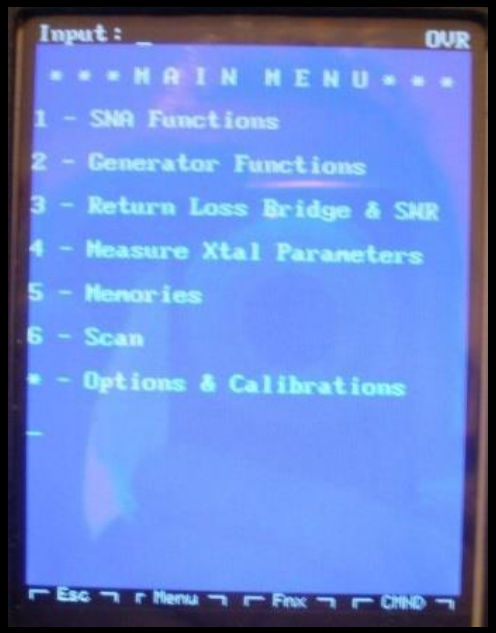
- 240 x 320 Pixel (QVGA), 16-bit color, 3.2” LCD
- SSD1289 display controller
- Resistive touch screen with ADS7843 controller
- SD Card socket
- Pads and interconnect for serial (SPI) EEPROM
- Single, 40-pin interface connector





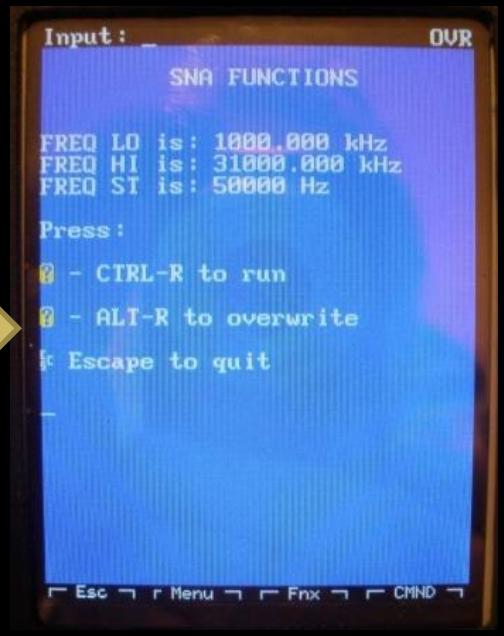
SNA

Menu-Driven Operation

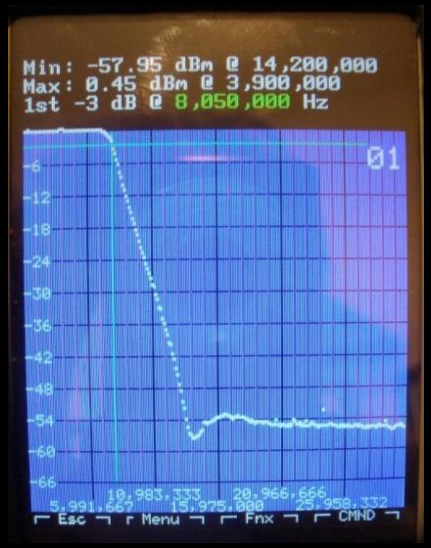


1

ENTER



CTRL-R

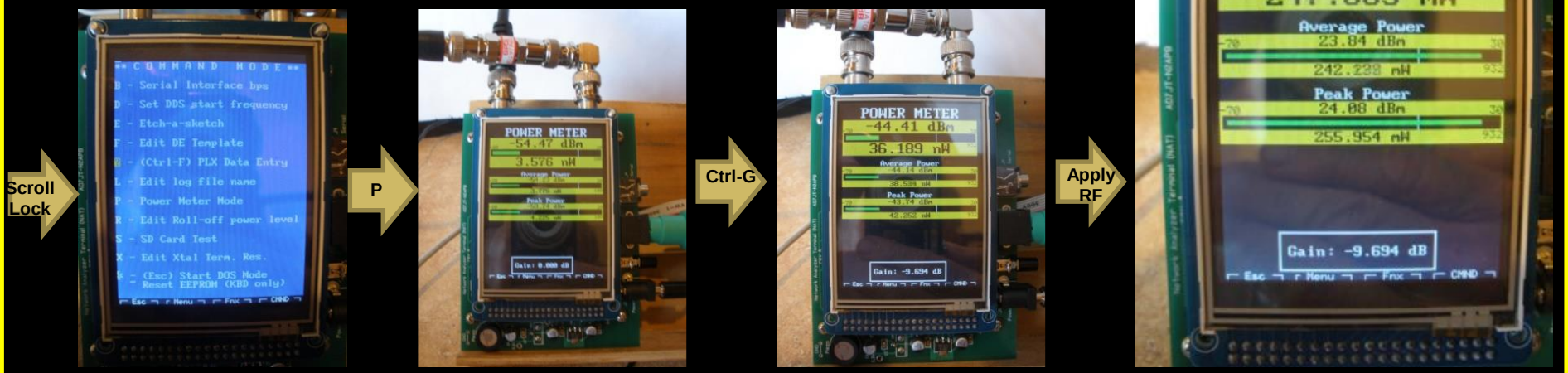


SNA

Measuring Power

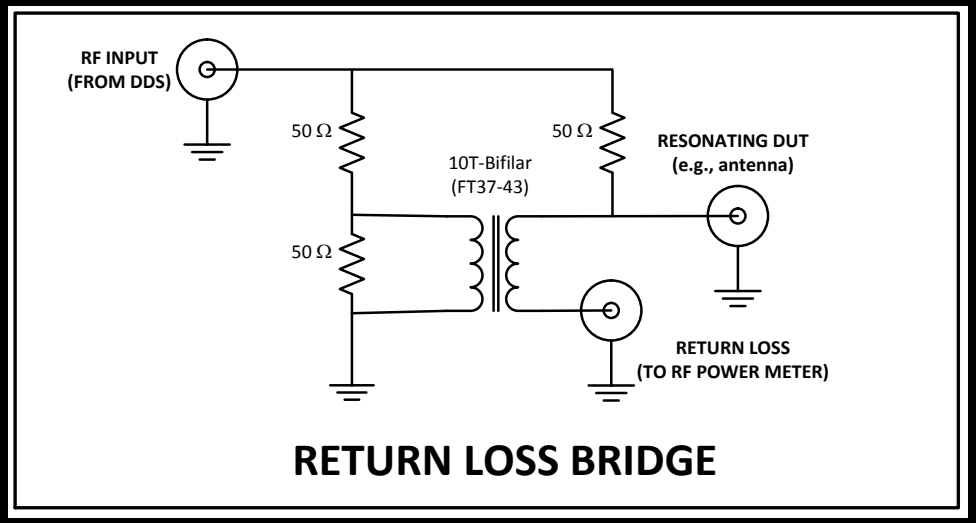
- RF Power Meter Mode
  - Primarily intended for QRP applications
  - Power reading taken about 200 times/second (every 5 ms)
  - 100 dBm range, use attenuators to shift the range
  - DDS used only for calibration

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

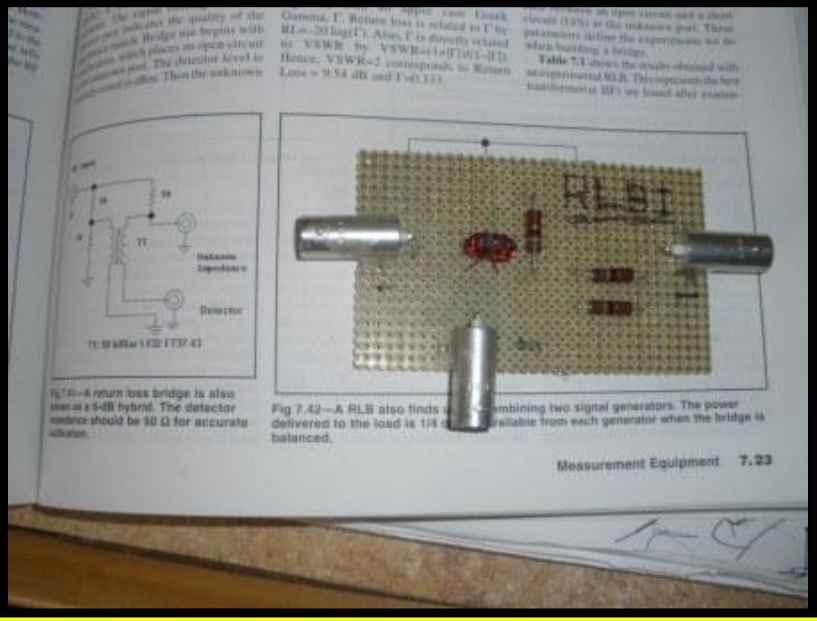


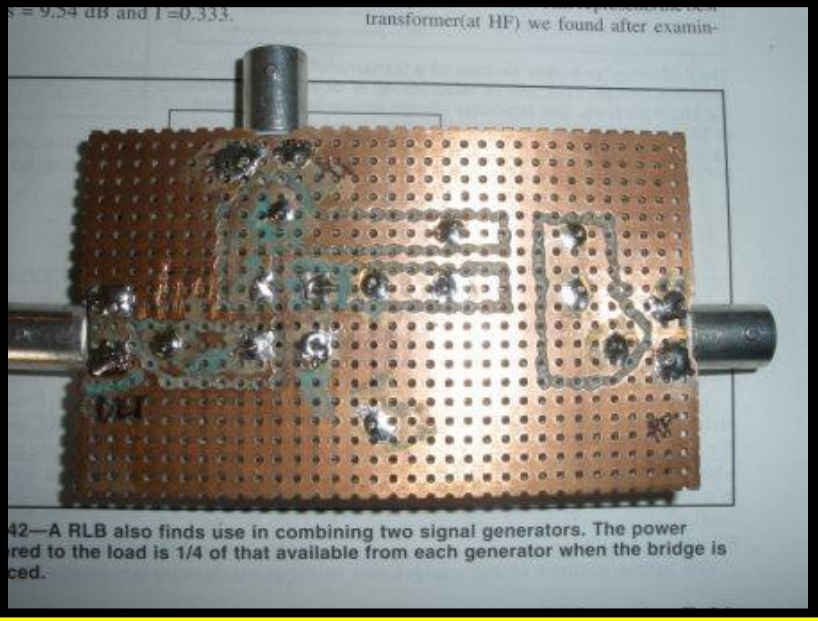
SNA

Measuring Antenna “SWR”



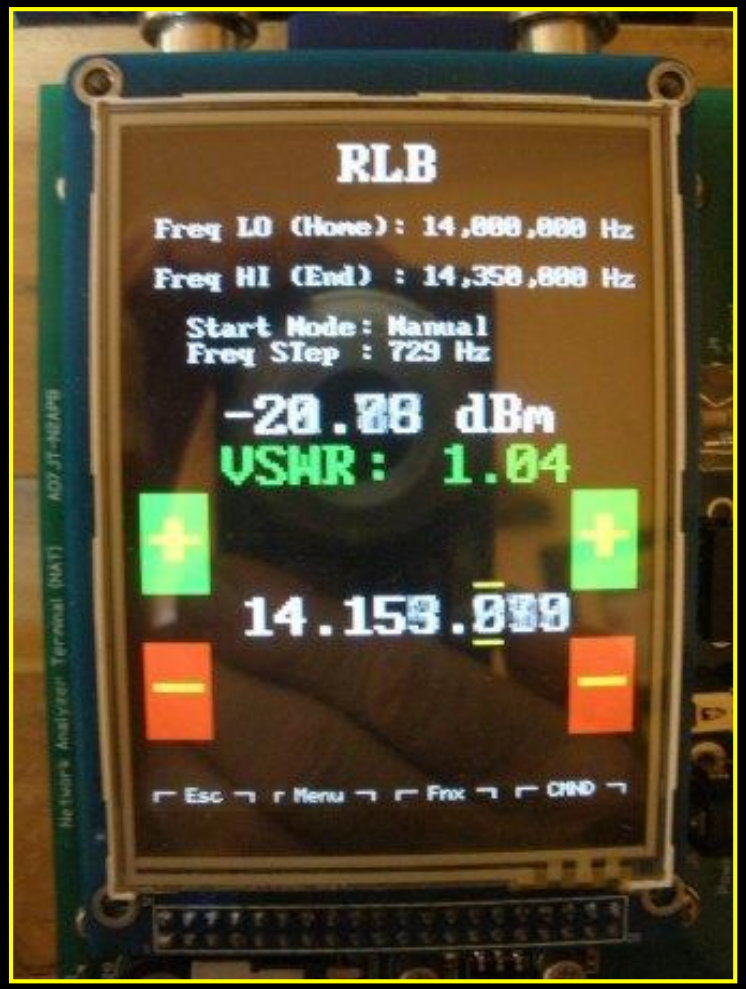
RETURN LOSS BRIDGE

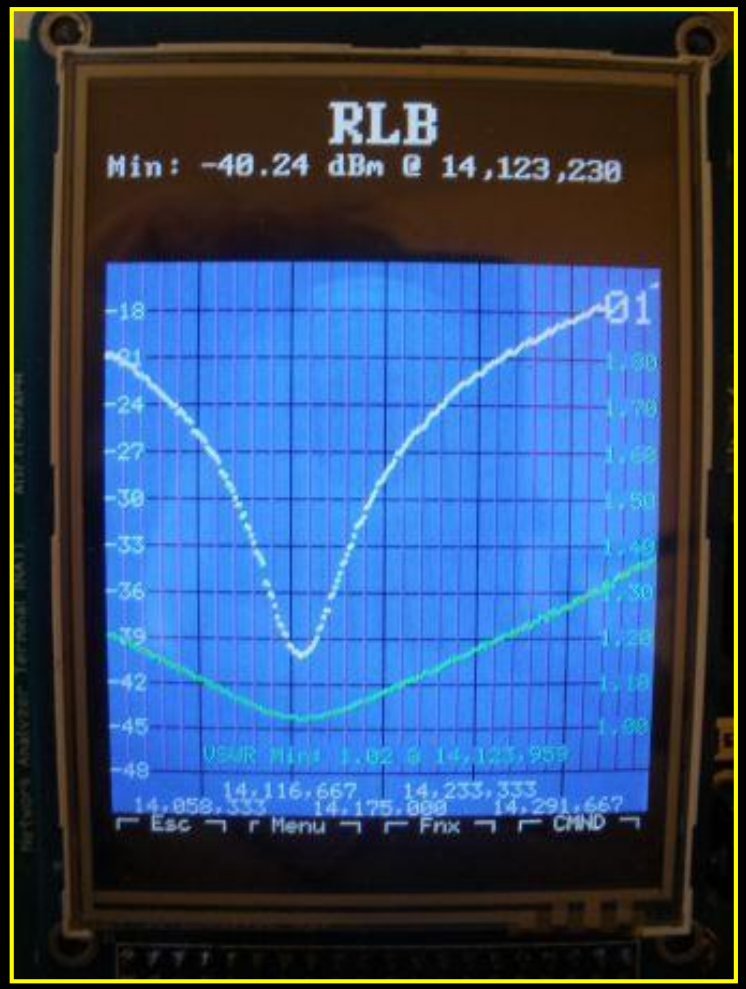




42—A RLB also finds use in combining two signal generators. The power
red to the load is 1/4 of that available from each generator when the bridge is
ced.

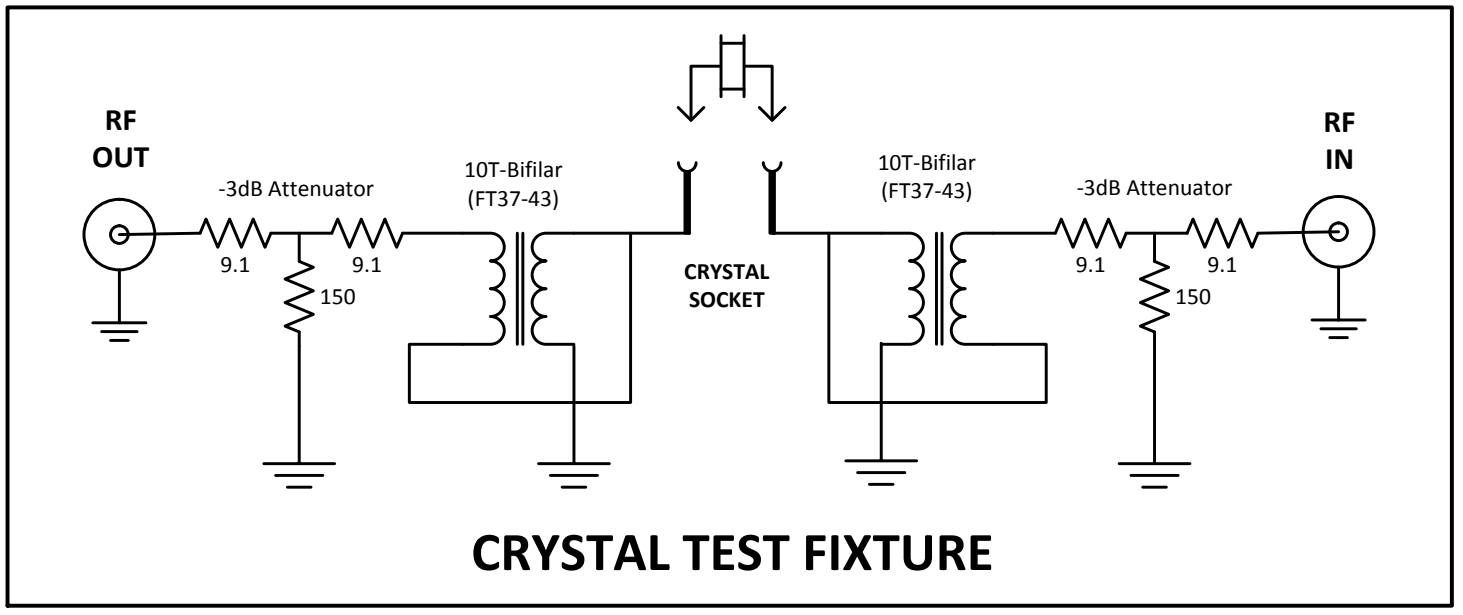
SNA Antenna Analysis with the RLB

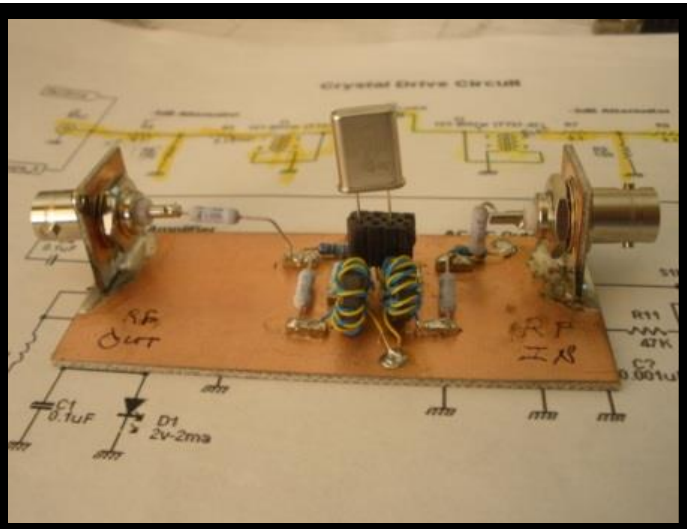




SNA

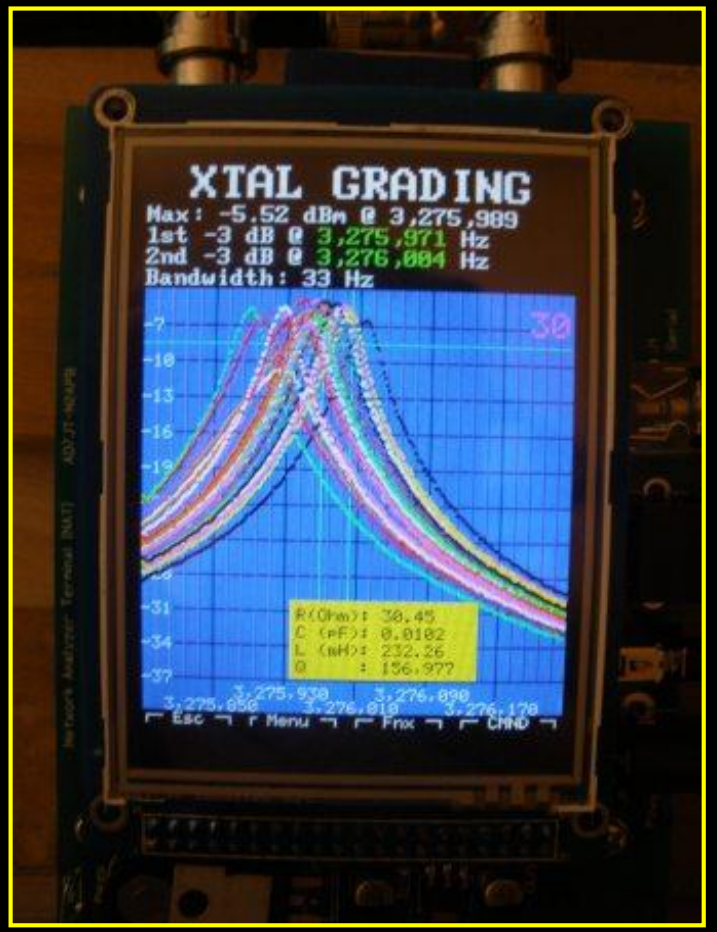
Crystal Charaterization





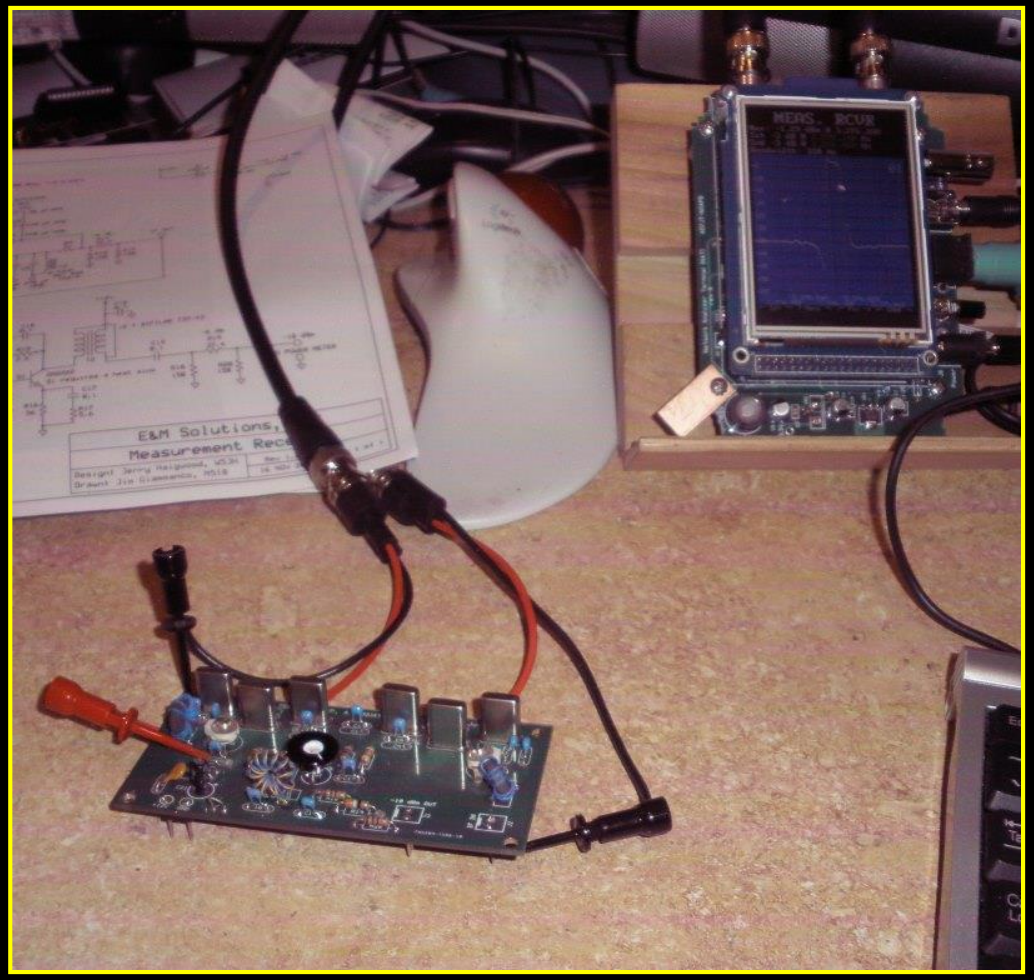
SNA

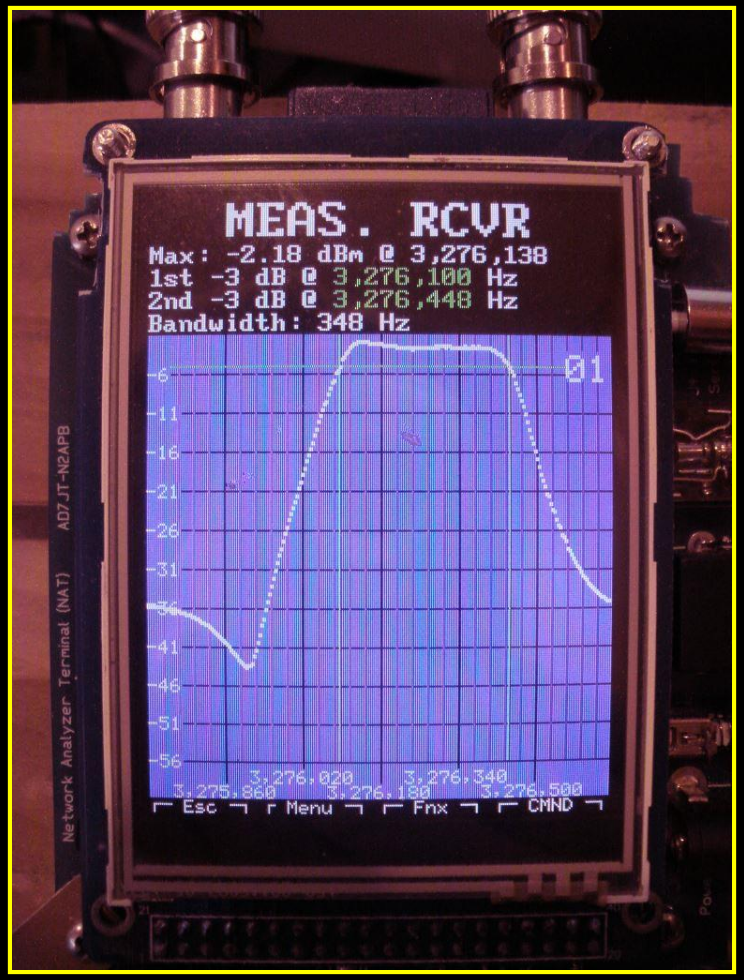
Crystal Matching



SNA

More Crystal Charaterization & Matching





Midnight SNA

DEMO

SNA

Time for a Little Math?

- 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} x 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)

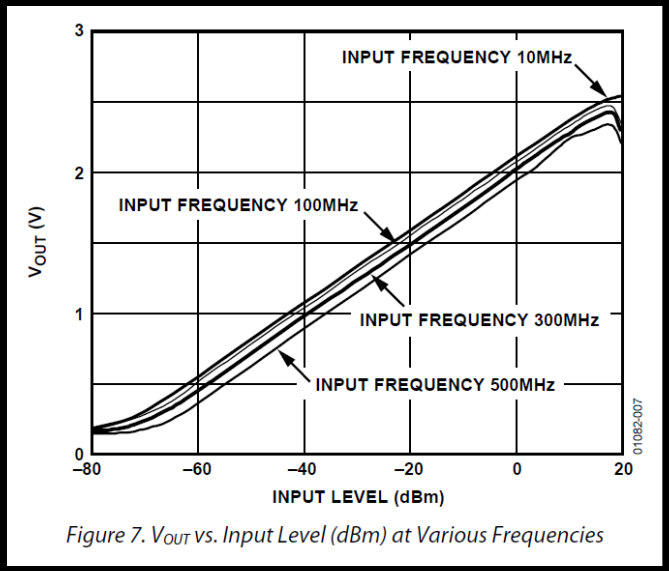
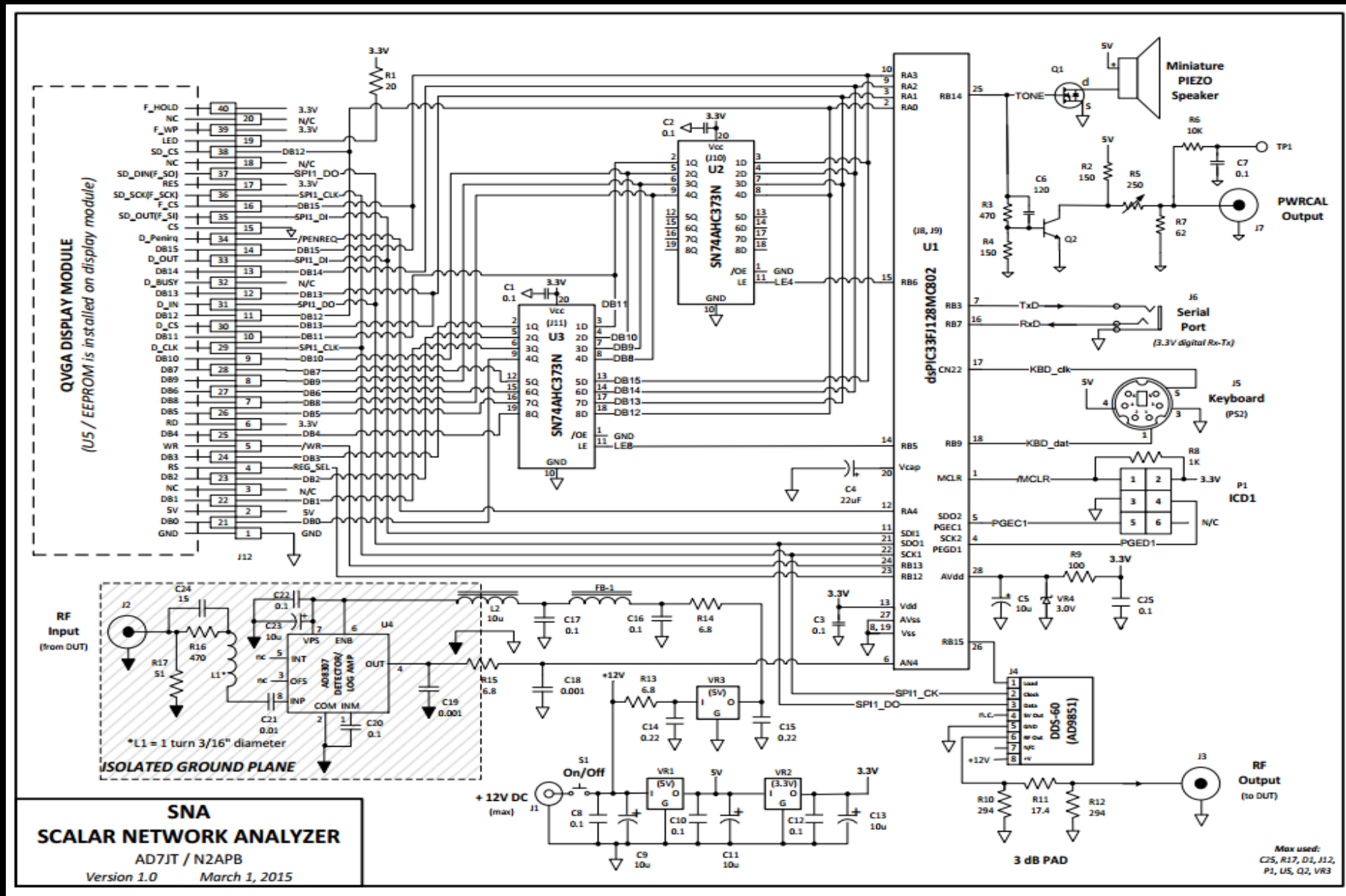


Figure 7. V_{OUT} vs. Input Level (dBm) at Various Frequencies

SNA *Midnight* SNA Schematic



SNA

References

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

Contact the SNA Designers:

George Heron, N2APB … n2apb@midnightdesignsolutions.com
Dave Collins, AD7JT … ad7jt@dnbrealty.com