

# Why You Need New Tools

## NanoVNA & TinySA

Lee Johnson  
N4WYE

RARS  
Aug13, 2024

# Thanks for the Invitation

KH6DAK in Hawaii 1957

Charter Member: Raleigh Amateur Radio Society 1969

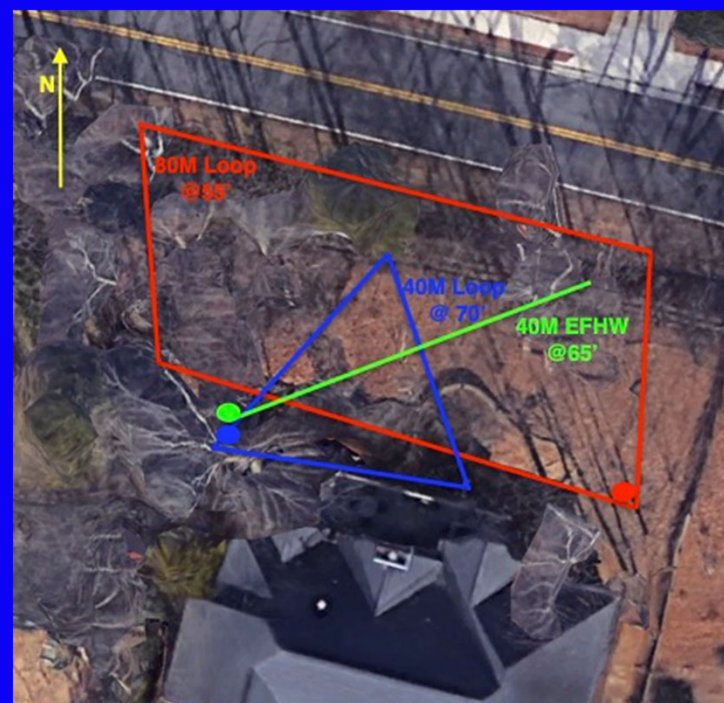
W4DW Repeater 146.64 MHz in Raleigh 1975

Retired after 40 years in high tech systems

HF, VHF, SDR, home brew & antennas

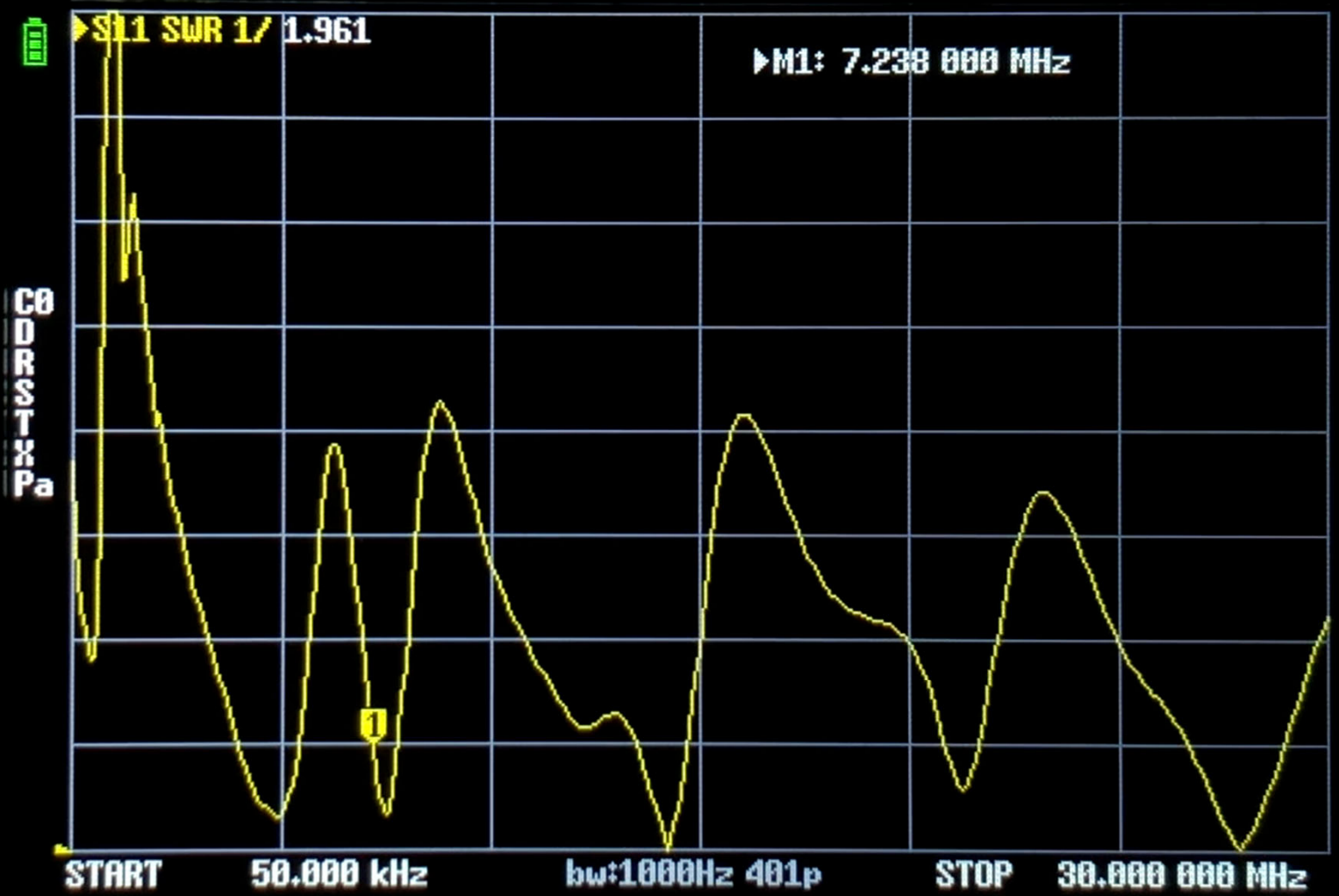
NFARL & RARS member

N4WYE Lee



# NanoVNA & TinySA

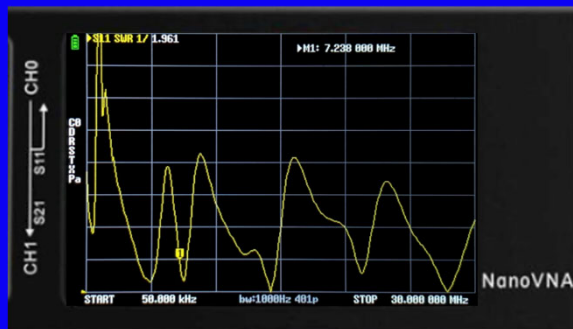
- Introduction
- How I use them
- NanoVNA & TinySA enter the market
- Technical description/specs
- Operation/Demo
- Application Examples
- Reference Sources
- Q & A



# NanoVNA and TinySA are similar but not!

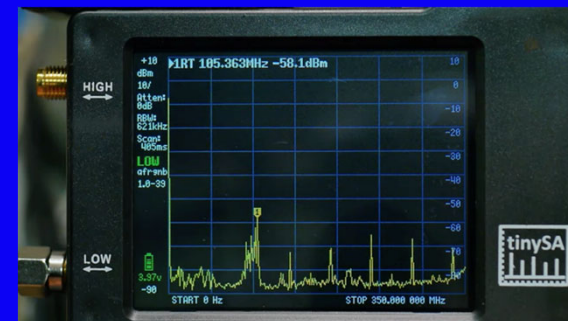
## NanoVNA is a Vector Network Analyzer

- Measures reflected and transmitted power
- Antenna SWR and complex impedance
- Characterize amplifiers, filters & cables



## TinySA is a Spectrum Analyzer

- Measures magnitude of a signal versus frequency
- Analyze signals in the rf spectrum
- Measure harmonics & intermodulation products
- RFI location tool



## So What is a NanoVNA?

### Vector Network Analyzer

Measures the magnitude and phase of the reflection and transmission properties of an antenna or device over a frequency range.

Vector Network Analyzer = Instrument used to characterize RF devices

# Vector Network Analyzers

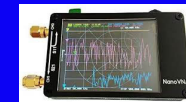
NanoVNA provides the same functionality



\$50K-250K



\$5K



\$60

# NanoVNA Measurements

Handheld, low cost Vector Network Analyzer “RF-multimeter” capable of measuring electrical parameters of antennas, filters & components to 1.5 GHz

## S11 Reflection

- Antenna measurements-VSWR
- Complex load impedance
- Power splitters, Diplexers
- Filter return loss
- Amplifier return loss
- Cable impedance
- Feed line length
- Distance to fault

## S21 Transmission

- Baluns, Chokes
- Frequency response
- Attenuators (flatness, delay)
- Power splitters
- Phasing networks
- Crystals, Resonances, Impedances
- Amplifier gain, Delay
- Cable loss, length, velocity factor

## Signal Generator



# NanoVNA Backgrounder

## Original NanoVNA 300MHz kit design “edy555” in 2016

Japanese ham published 2016 via [open-source HW & FW at GitHub](#)  
Based on kit by Tom Baier DG8SAQ Mar/Apr 2007 QEX

## Clone manufacturing took off in China 2019

## Productized & marketed by “hugen79” a Chinese ham in 2019

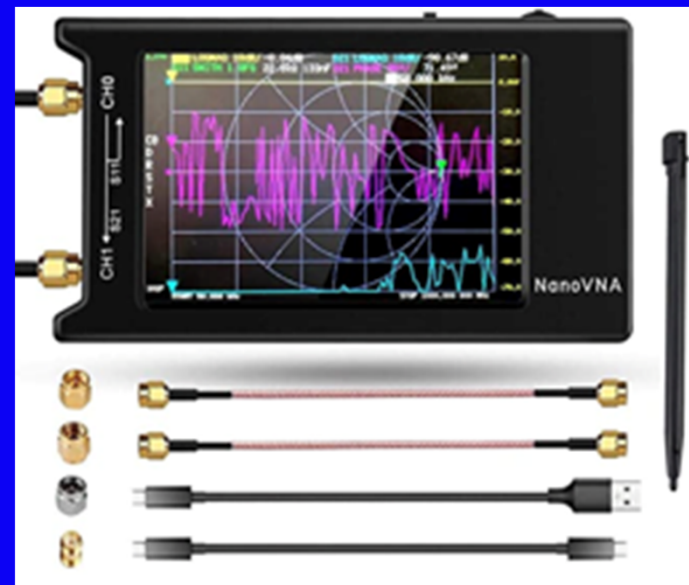
NanoVNA version [gen111.taobao.com](#)  
Extended to 1.5 GHz

## Product evolution

- Larger screens 4 inch
- Extension to >3GHz
- SD card - screen capture images
- Time Domain Reflectometer
- Tiny Spectrum Analyzer

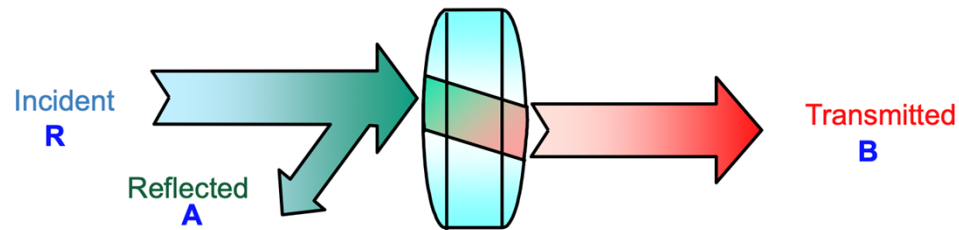
## As of today

Best option is the [NanoVNA-H4 model](#)  
NanoVNA-V2plus4 and others with higher performance



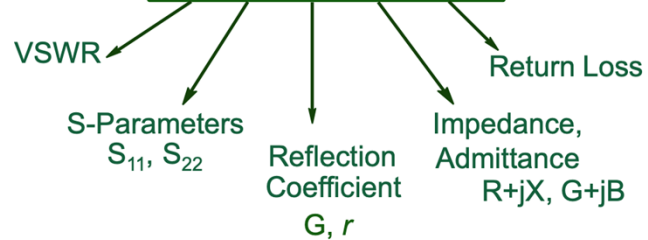
# Vector Network Analyzer

## High-Frequency Device Characterization



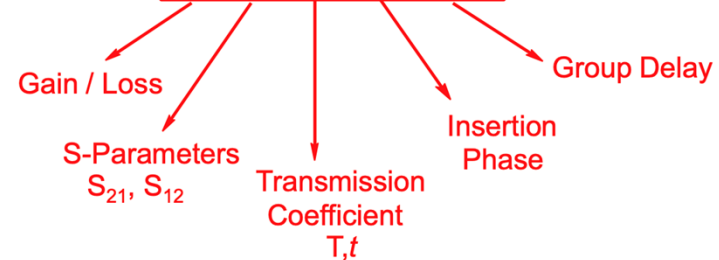
### REFLECTION

$$\frac{\text{Reflected}}{\text{Incident}} = \frac{A}{R}$$

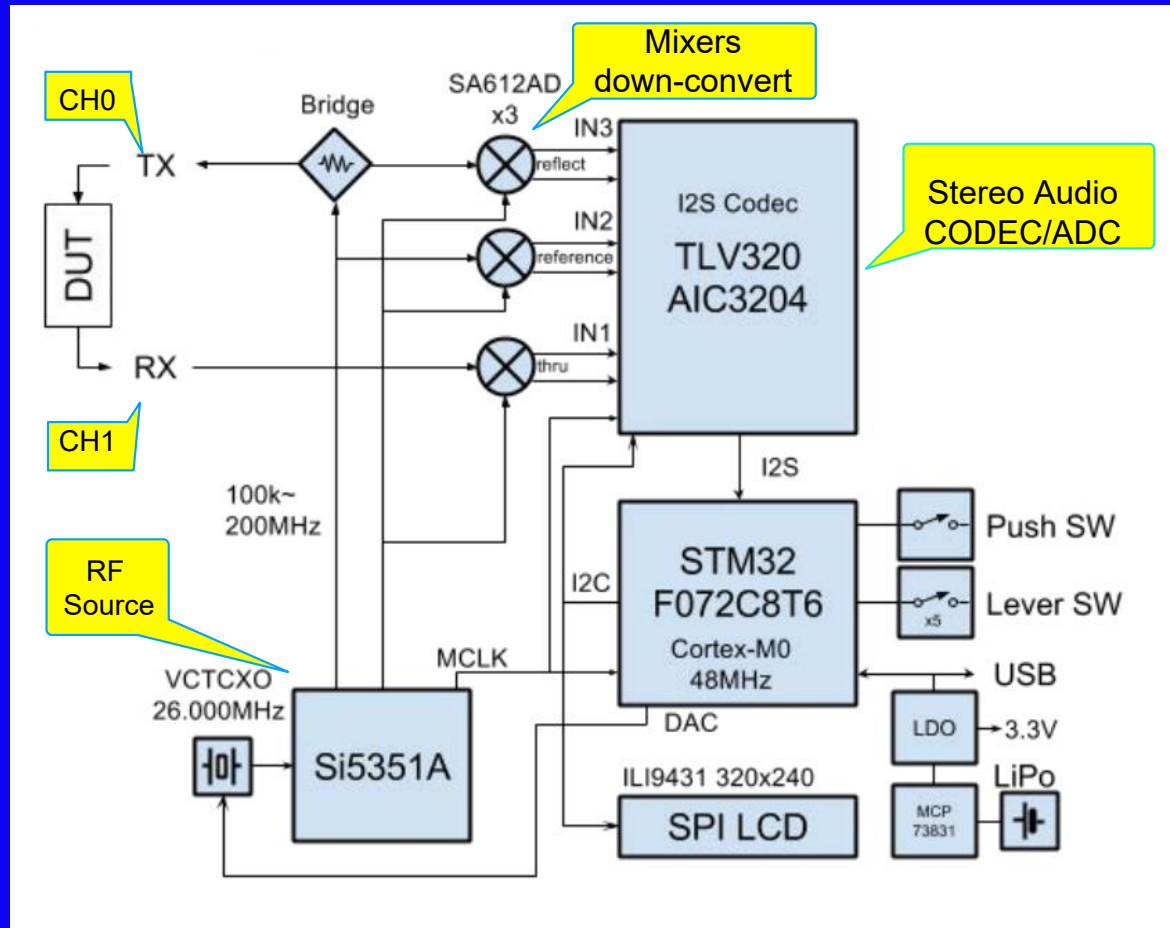


### TRANSMISSION

$$\frac{\text{Transmitted}}{\text{Incident}} = \frac{B}{R}$$



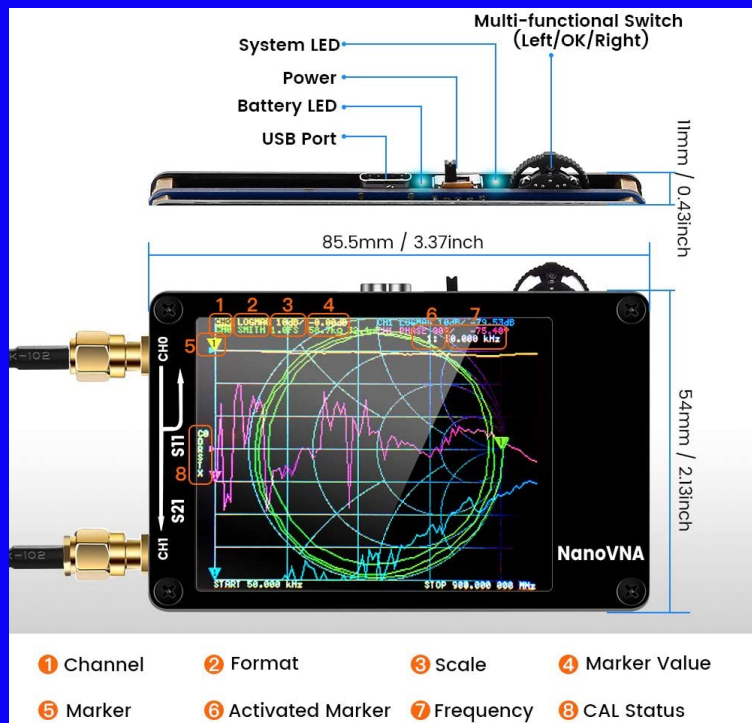
# NanoVNA Block Diagram



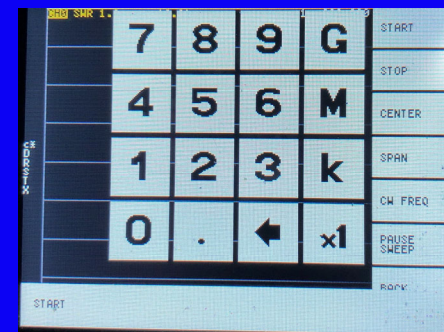
# NanoVNA-H4 and TinySA specifications

	<u>NanoVNA-H4</u>	<u>TinySA</u>
<u>Frequency Range</u>	10kHz to 1.5GHz	100kHz to 960MHz/6GHz
<u>RF output</u>	0 dbm	Input level +10dBm max
<u>Dynamic Range</u>	70dB (50kHz - 300MHz) 60dB (300MHz - 900MHz) 40dB (0.9GHz - 1.5GHz)	112dB
<u>Display</u>	4 inch TFT	4 inch TFT
<u>USB Interface</u>	USB Type C (power + data)	USB Type C (power + data)
<u>Power hrs)</u>	USB 5V 200mA, Lipo battery 1950 mAh (8 hrs)	Power 2 hrs operation
<u>Scanning Points</u>	up to 401	145 to 290
<u>Display</u>	4 traces, 4 markers + 6 memories	
<u>Frequency stability</u>	<0.5 ppm	

# NanoVNA User Interface



Traces, Formats, Scale, Channels  
Add, Function, Search  
Start, Stop, Center, Span  
Calibration



Data Entry

## Words To Know

- Display (root menu)
- Trace (one of four possible line/chart drawings)
  - Traces can be toggled on and off
- Format (goes with a trace-how you want the data displayed)
- Stimulus (goes with a trace-sets the limits on the data display)

# NanoVNA Calibration

Cx (Calibrated for Memory Mx)  
D (Directivity)  
R (Reflection Tracking)  
S (Source Match)  
T (Transmission Tracking)  
X (Isolation)

Mx = 0,1,2,3,4,\* Calibration values storage location



# NanoVNA Measurement Configuration\*

Configure NanoVNA for the type of measurement:

- Traces to display (up to four)
- Format
- Channel (CH0 REFLECT or CH1 THROUGH)
- Scale for each trace separately
- Reference position
- Stimulus frequency range (sweep frequency)
- Calibrate the NanoVNA

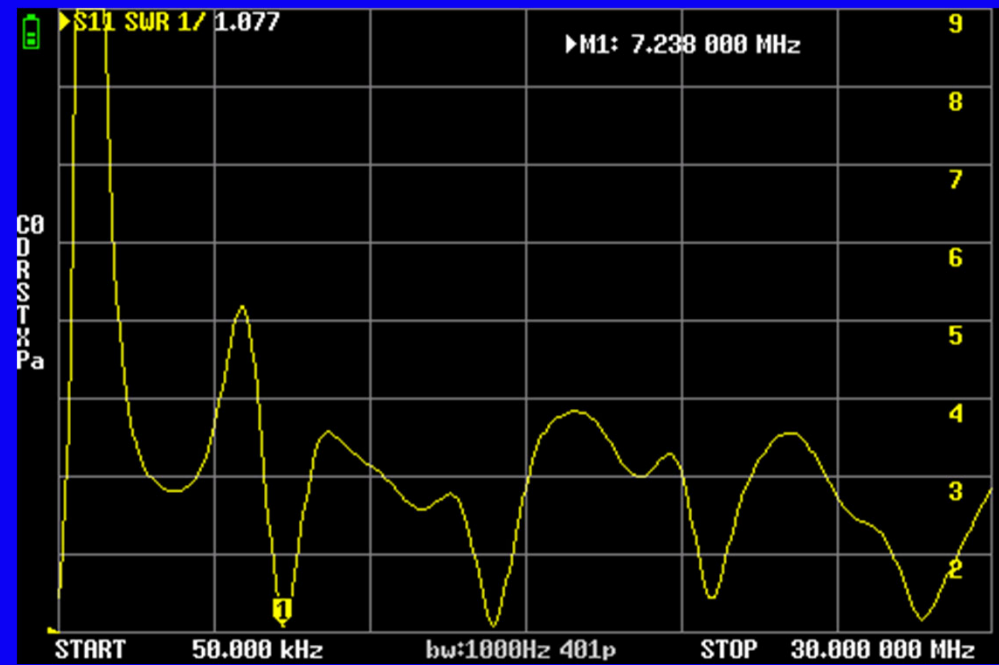
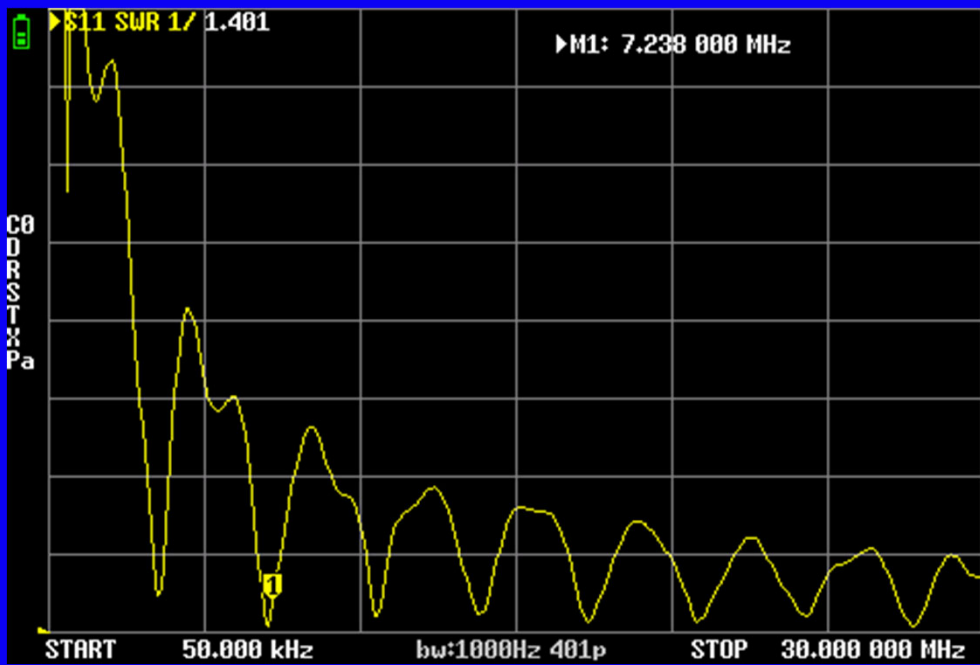
Calibration (done last) also saves the settings, so you can “recall” a whole setup e.g. SWR

\* Absolute Beginner's Guide to NanoVNA , Martin Svaco, 9A2JK



# SWR

## 80 & 40 M Loops



SWR Measurements  
80 M Loop

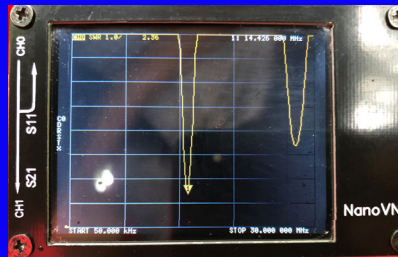


SWR & Smith Chart Measurements  
80M Loop on 40M

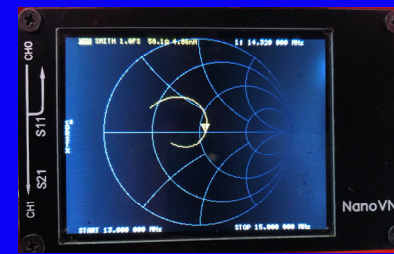
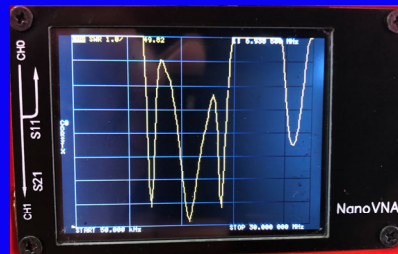


# 20M Delta Loop

Antenna

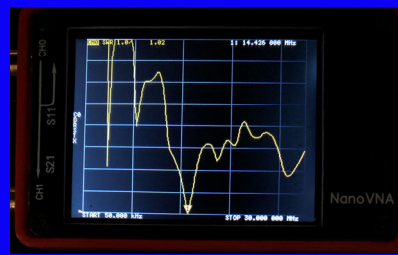


Matching Section



matching section

Shack

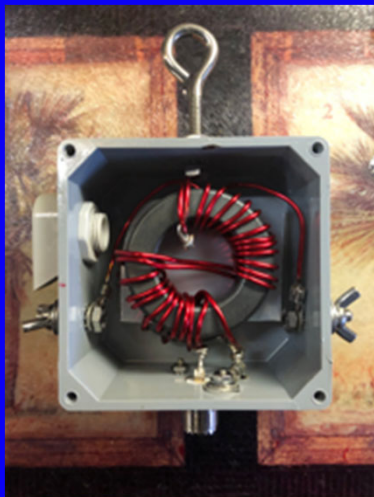


SWR 0.05-30 MHz

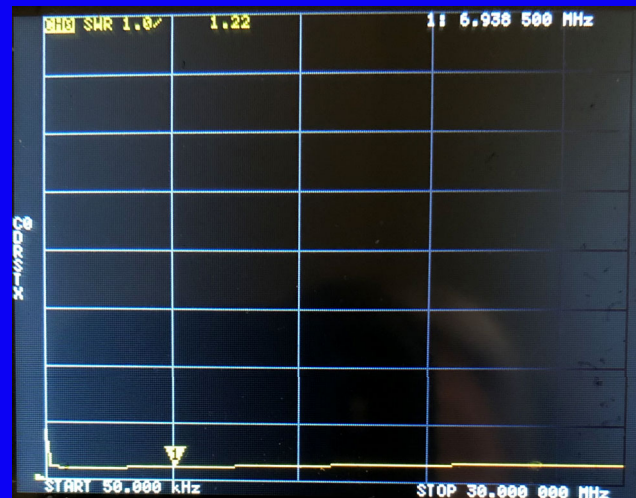
SWR 13-15 MHz

Smith Chart

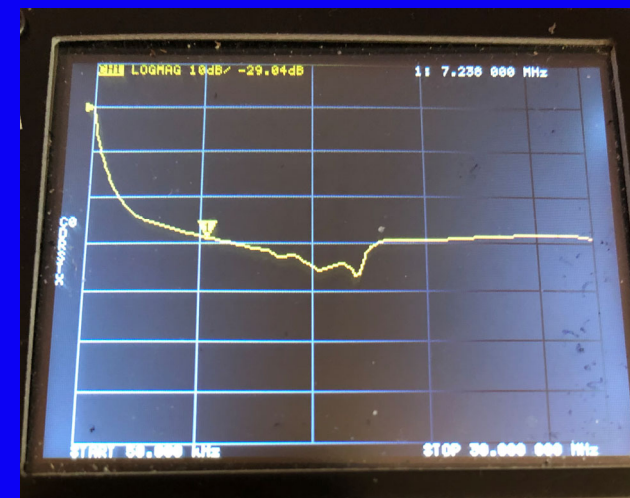
## Balun for 80M Loop Antenna



4:1 Current Balun  
dual core



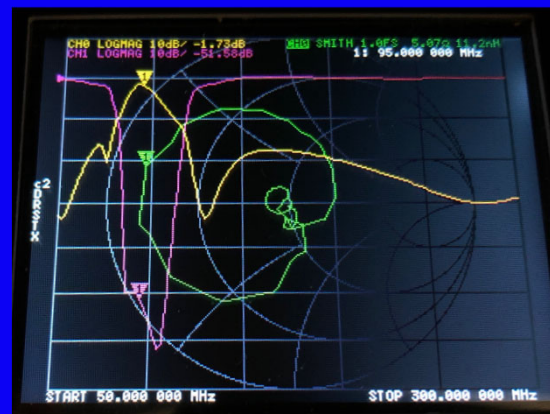
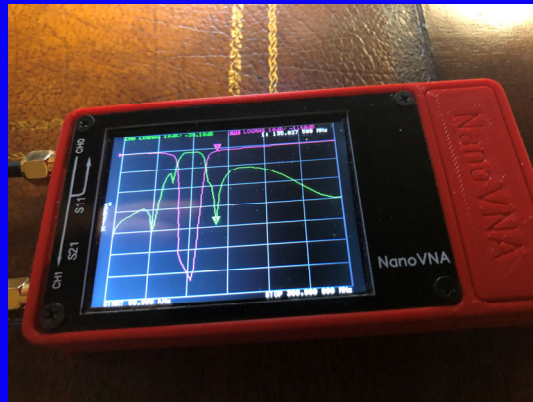
SWR < 1.2:1  
across HF band



Common Mode Rejection  
~30 dB

# Filter & Amplifier Characteristics

88-108 MHz Bandstop filter





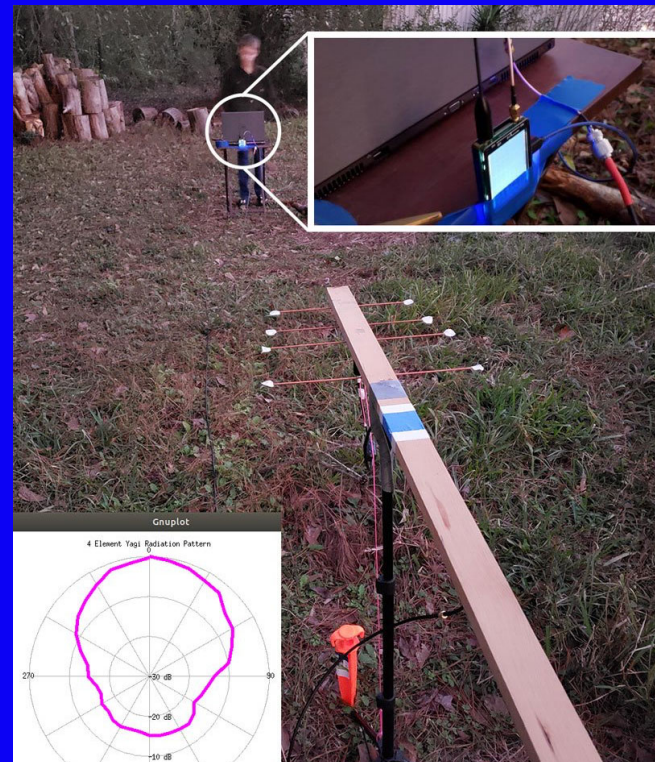
# Antenna Radiation Pattern

Set up antenna with NanoVNA outside the near field

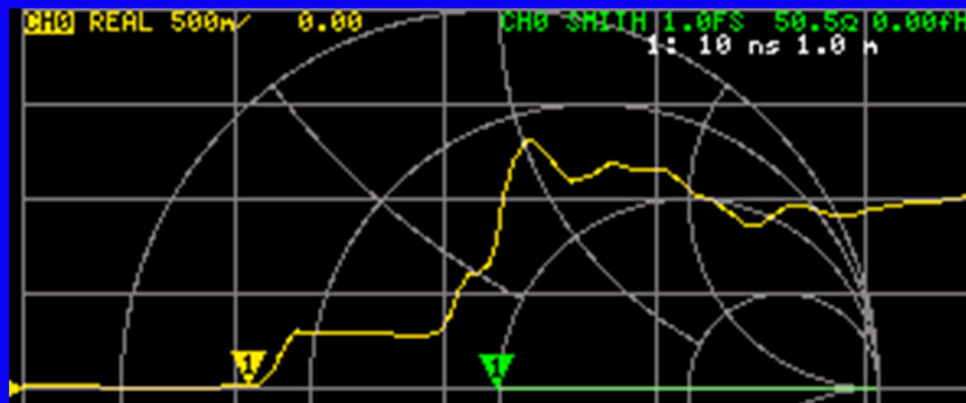
Yagi on TX Ch0 port via a long coax cable  
Omnidirectional whip antenna on RX Ch1 port

Measure & collect S21 reading over multiple rotations of Yagi

Data then plotted revealing two dimensional radiation pattern  
for the Yagi



## Time Domain Reflectometer Distance & Impedance



Measures on the Vertical Axis the 'Amount of Reflection' & Calculates the Impedance of What is Connected to NanoVNA vs. Distance from NanoVNA on the Horizontal Axis

Example: A Four Foot Section of 50 ohm Type Coax Followed by a Four Foot Section of 93 ohm Type Coax

Far End of Coax is Left Open



# NanoVNA Saver

## NanoVNA Saver

A multi-platform computer tool to save Touchstone files from the NanoVNA, sweep frequency spans in segments to gain more than 101 data points, and generally display and analyze the resulting data.

Copyright 2019 Rune B. Broberg

## Introduction

This computer software connects to a NanoVNA and extracts the data for display on a computer, and for saving to Touchstone files.

## Current features:

Reading data from a NanoVNA

Splitting frequency range into multiple segments to increase resolution (up to >10k points)

Averaging data for better results particularly at higher frequencies

Displaying data on multiple chart types, such as Smith, LogMag, Phase & VSWR-charts, S11 & S21

Displaying markers, and the impedance, VSWR, Q, equivalent capacitance/inductance etc.

Displaying customizable frequency bands as reference, for example amateur radio bands

Exporting and importing 1-port and 2-port Touchstone files

TDR function (measurement of cable length) - including impedance display

Filter analysis functions for low-pass, high-pass, band-pass and band-stop filters

Display of both an active and a reference trace

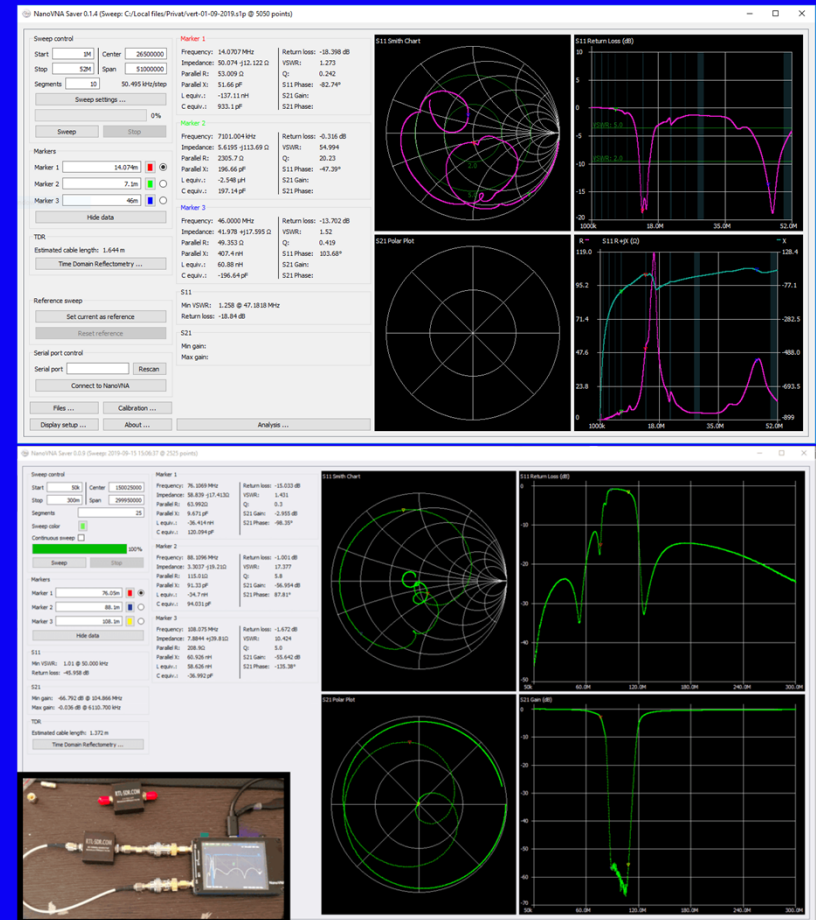
Live updates of data from the NanoVNA, including for multi-segment sweeps

In-application calibration, including compensation for non-ideal calibration standards

Customizable display options, including "dark mode"

Exporting images of plotted values

<https://github.com/mihjtjel/nanovna-saver/blob/master/README.md>



# Reference Sources & Links

## NanoVNA-H4 Made Easy

<https://www.youtube.com/watch?v=ay58sp8VaNM>

## How to use the NanoVNA to sweep / measure antenna SWR

<https://www.youtube.com/watch?v=xa6dqx9udcg>

## NanoVNA YouTube videos

[https://www.youtube.com/results?search\\_query=w2aew+nanovna](https://www.youtube.com/results?search_query=w2aew+nanovna)

## NanoVNA groups.io Forum

[NanoVNA Saver](#) by Rune B. Broberg / 5Q5R

## TinySA Home page

<https://tinysa.org/wiki/pmwiki.php?n=Main.HomePage>

## Groups.io Forum

## TinySA YouTube videos

<https://www.youtube.com/watch?v=n6WEM3--Npc&t=642s>

# Summary

**NanoVNA & TinySA - Software defined RF tools extraordinaire**

**Functionality expanding - open architecture**

**YouTube videos & Groups:io**

**US source - R&L Electronics**

**NanoVNA-H4" \$90**

**TinySA 4" \$80**

Q & A

# NanoVNA-H4 Menu

## NanoVNA Menu Structure Map

