Why You Need New Tools

NanoVNA & TinySA

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N4WYE

TechFest
Jan 13, 2024

Thanks for the Invitation

KH6DAK in Hawaii 1957

Founding Member: Raleigh Amateur Radio Society 1969

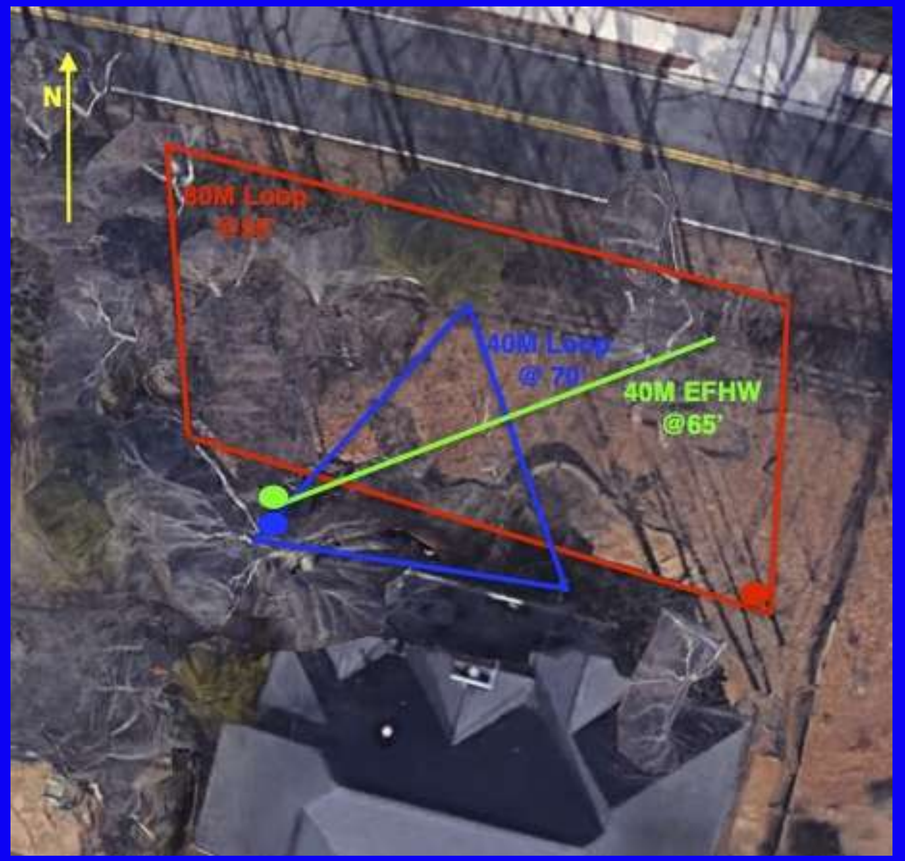
W4DW Repeater 146.64 MHz in Raleigh 1975

Retired after 40 years in high tech systems

HF, VHF, SDR, home brew & antennas

NFARL member

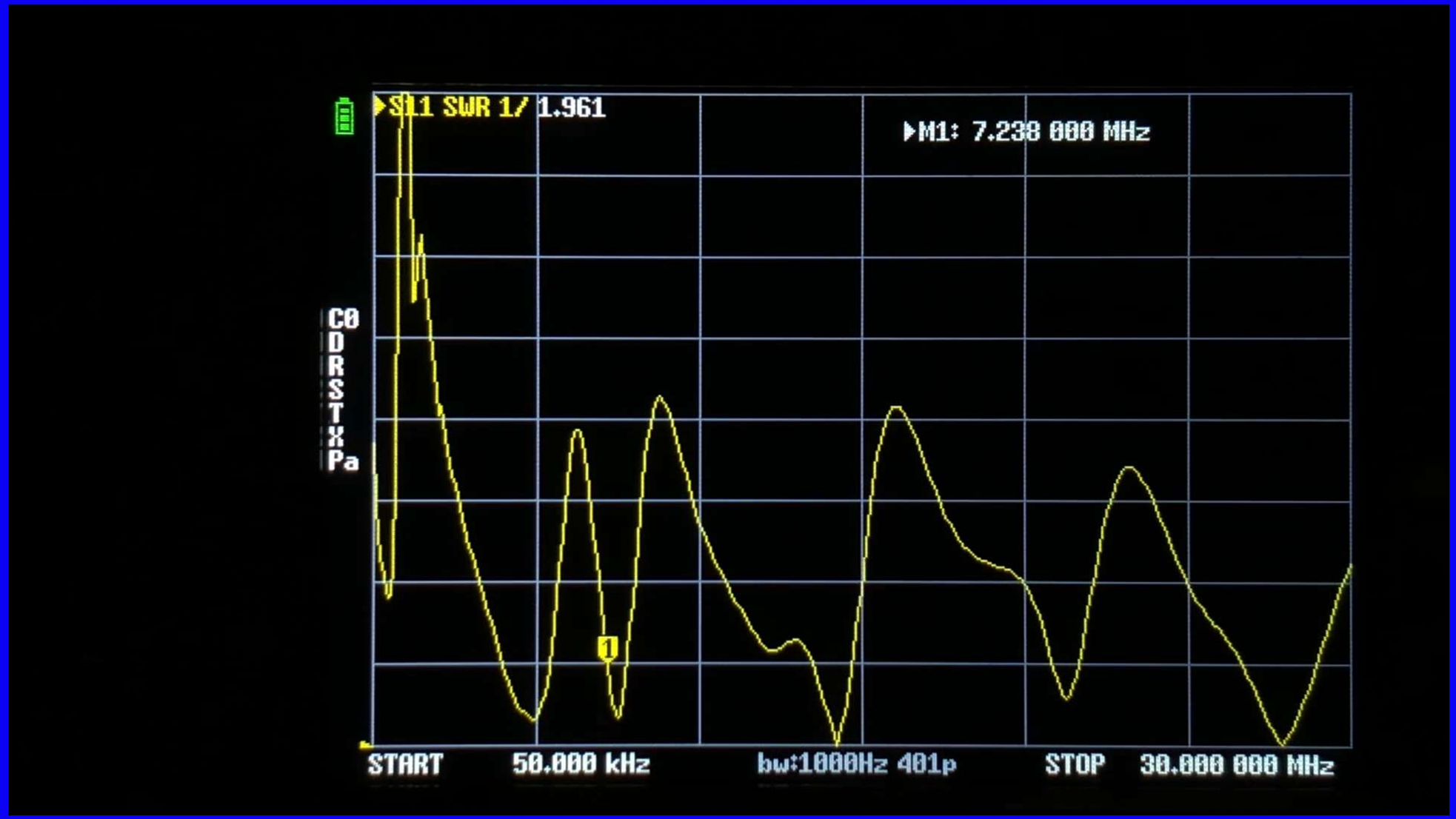
N4WYE Lee



NanoVNA & TinySA

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

My Setup for SWR



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 the ports of a device over a frequency range.

Vector Network Analyzer = Instrument used to characterize RF devices

Vector Network Analyzers

NanoVNA provides the same functionality

$50K

$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

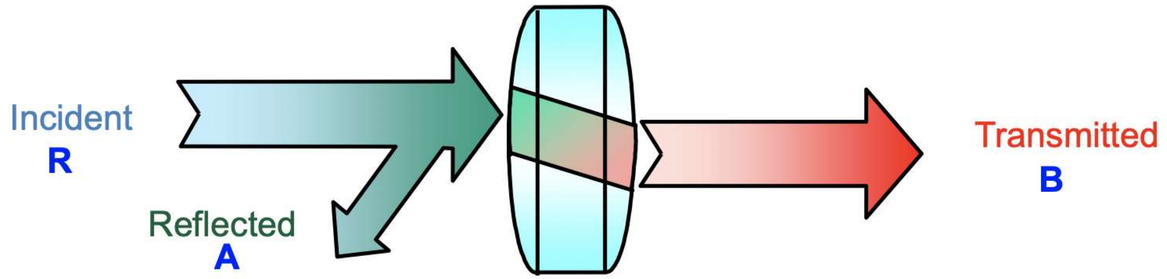
– Amplifier gain, Delay

– Cable loss, length, velocity factor

Signal Generator

Vector Network Analyzer

High-Frequency Device Characterization



REFLECTION

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

- VSWR
- S-Parameters S_{11}, S_{22}
- Reflection Coefficient G, *r*
- Impedance, Admittance R+jX, G+jB
- Return Loss

TRANSMISSION

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

- Gain / Loss
- S-Parameters S_{21}, S_{12}
- Transmission Coefficient T,*t*
- Insertion Phase
- Group Delay

NanoVNA
Backgrounder

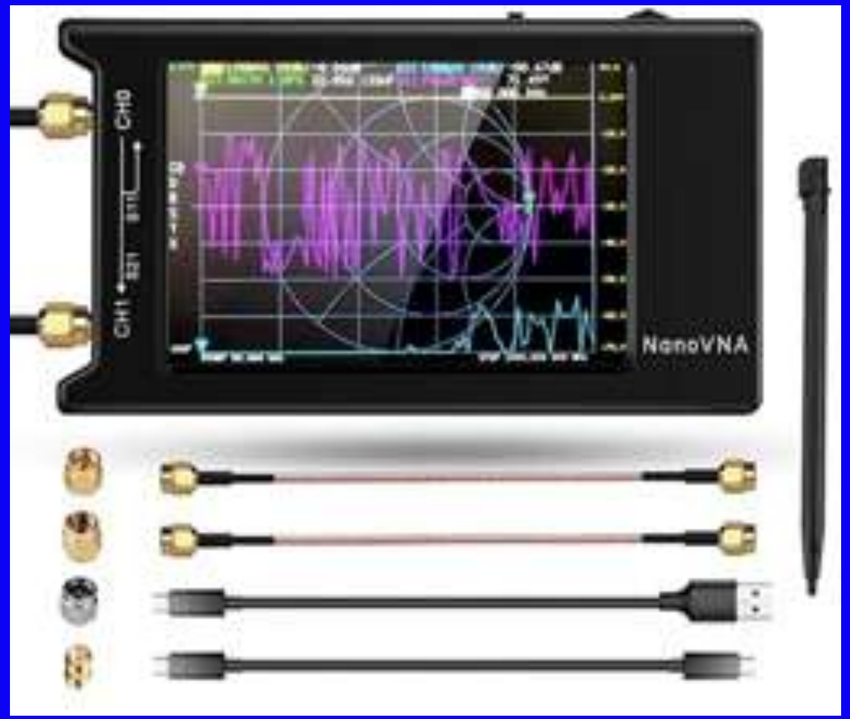
Original NanoVNA 300MHz kit design “edy555” in 2016
- Japanese ham published 2016 via open-source HW & FW at GitHub
- Based on kit by Tom Baier DG8SAQ Mar/Apr 2007 QEX

Clone manufacturing took off in China 2019

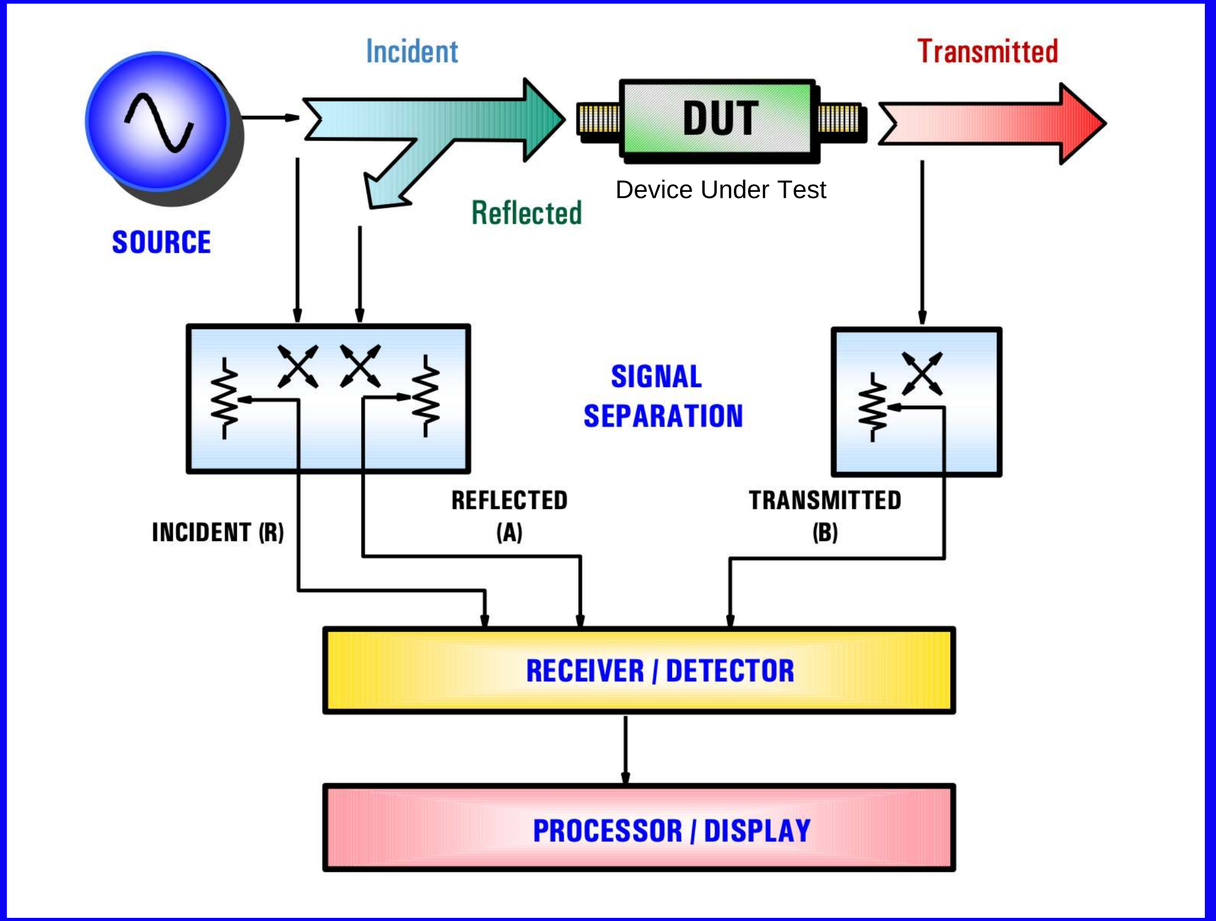
Productized & marketed by “hugen79” a Chinese ham in 2019
- NanoVNA version gen111.taobao.com
- Extended to 1.5 GHz

Product evolution
- Larger screens 4 inch
- Extension to >3GHz
- SD card - screen capture images
- Time Domain Reflectometers
- Tiny Spectrum Analyzers

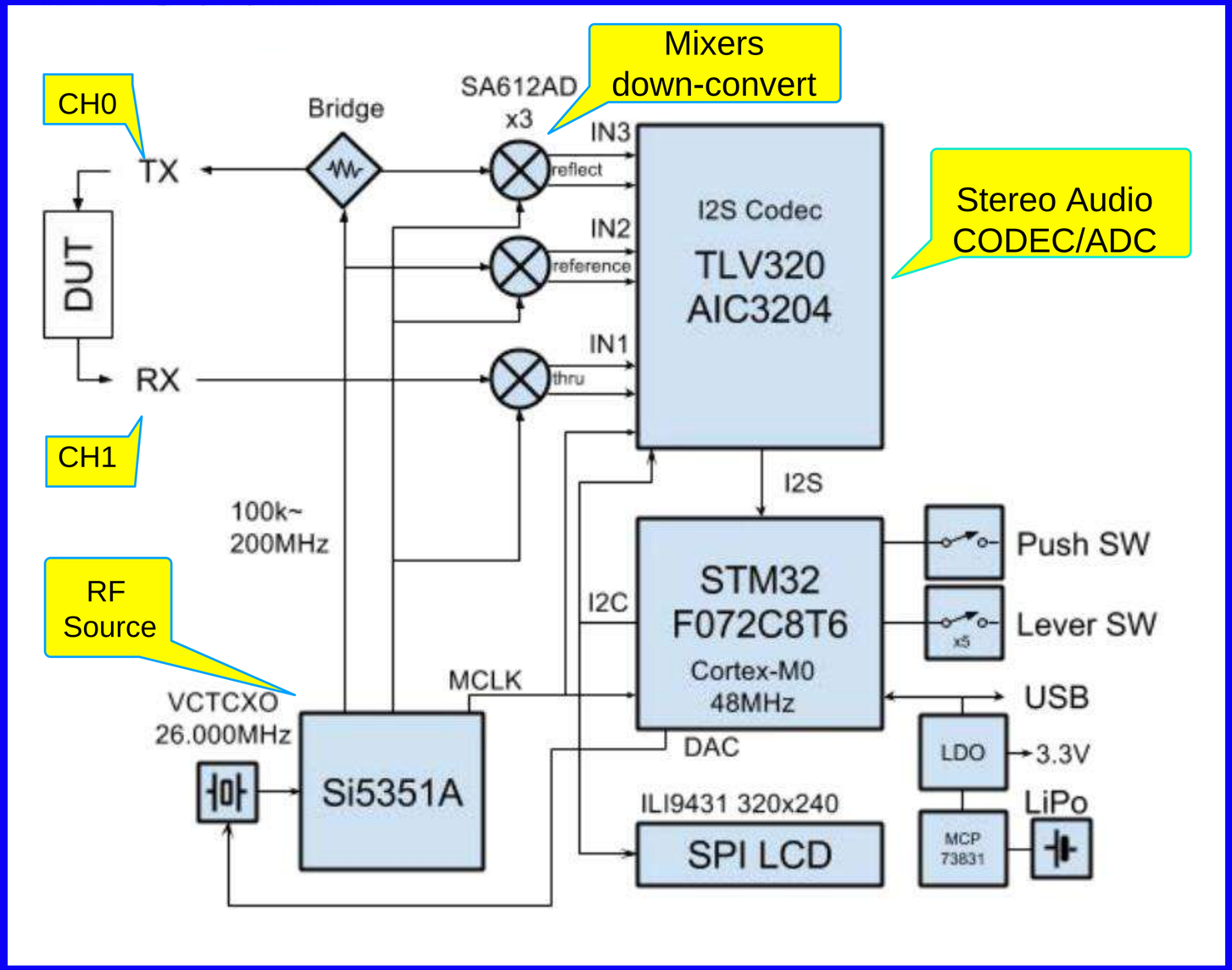
As of today
- Best option is the NanoVNA-H4 model
- NanoVNA-V2plus4 and others with higher performance



Vector Network Analyzer Block Diagram



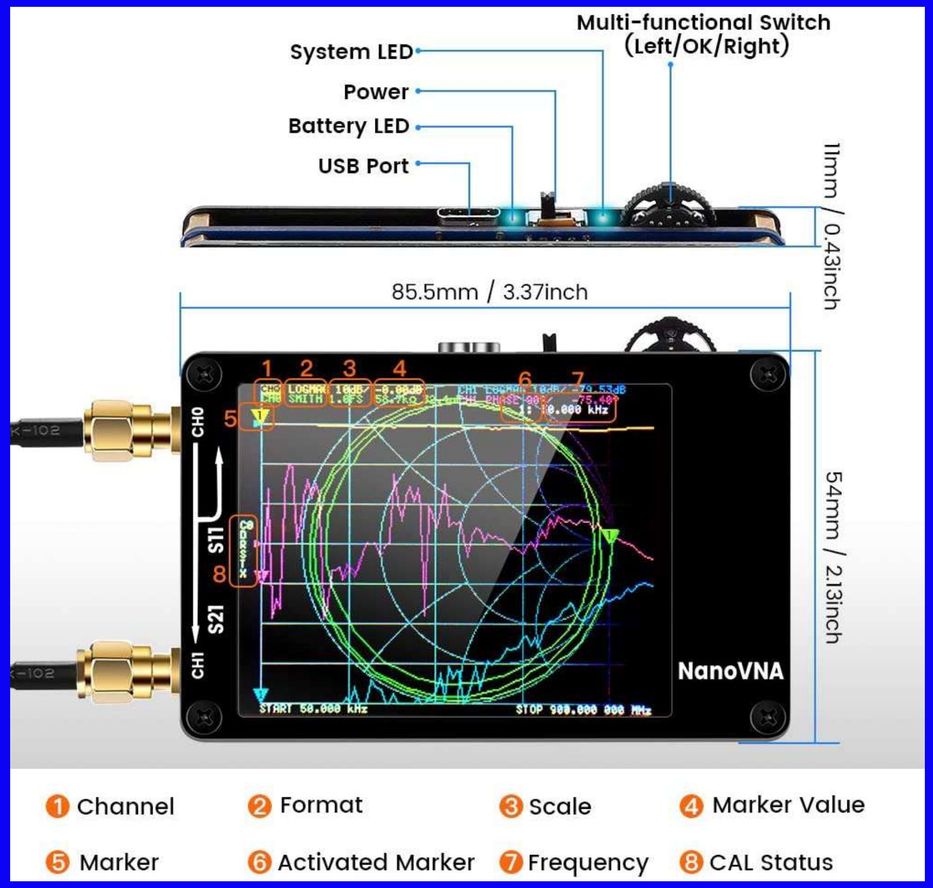
NanoVNA Block Diagram

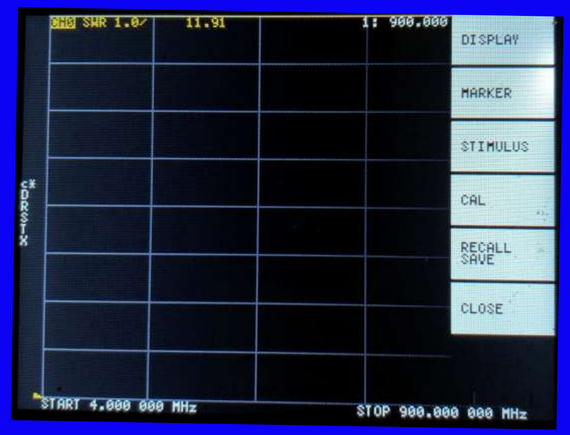


NanoVNA-H4 and TinySA specifications

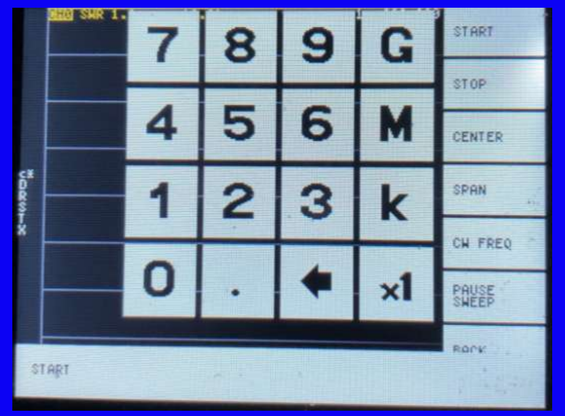
	NanoVNA-H4	TinySA
Frequency Range	10kHz to 1.5GHz	100kHz to 960MHz/6GHz
RF output	0 dbm	Input level +10dBm max
Dynamic Range	70dB (50kHz - 300MHz) 60dB (300MHz - 900MHz) 40dB (0.9GHz - 1.5GHz)	112dB
Display	4 inch TFT	4 inch TFT
USB Interface	USB Type C (power + data)	USB Type C (power + data)
Power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

NanoVNA User Interface





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



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*

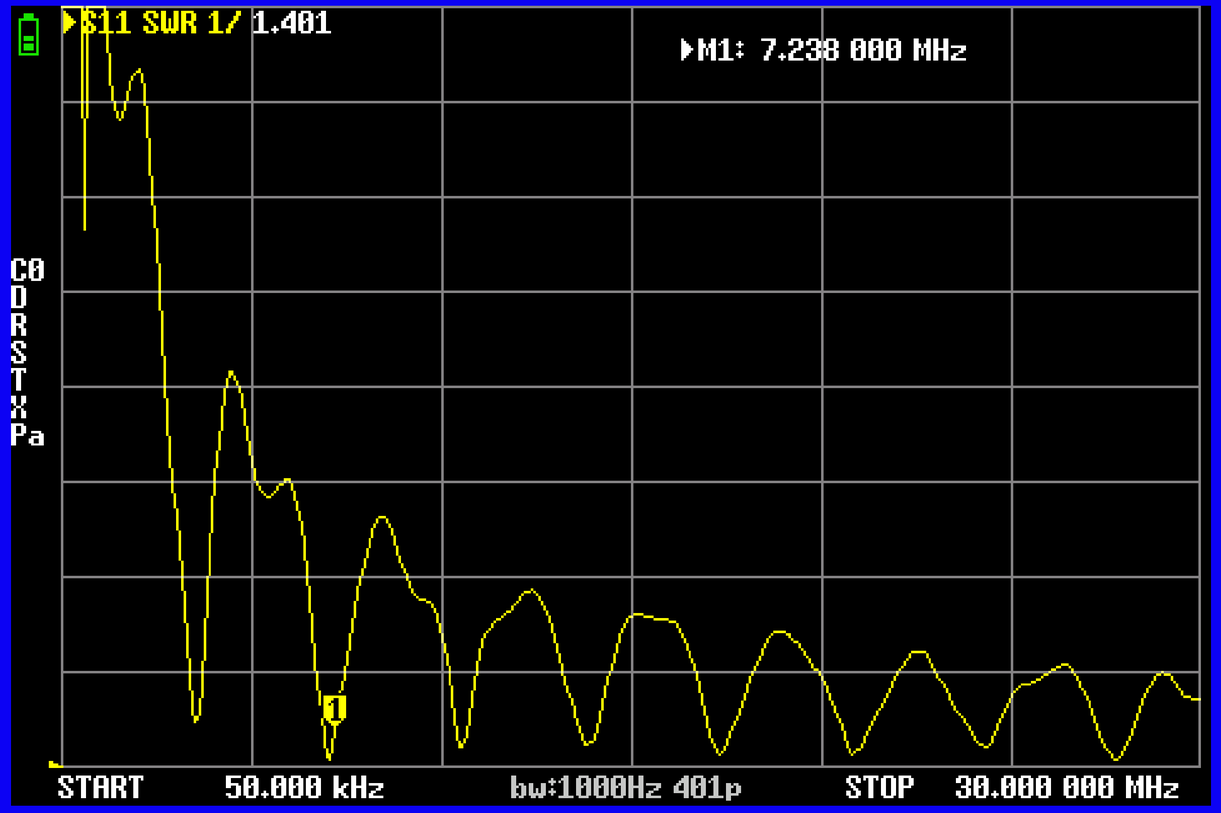
Configure NanoVNA for the type of measurement:

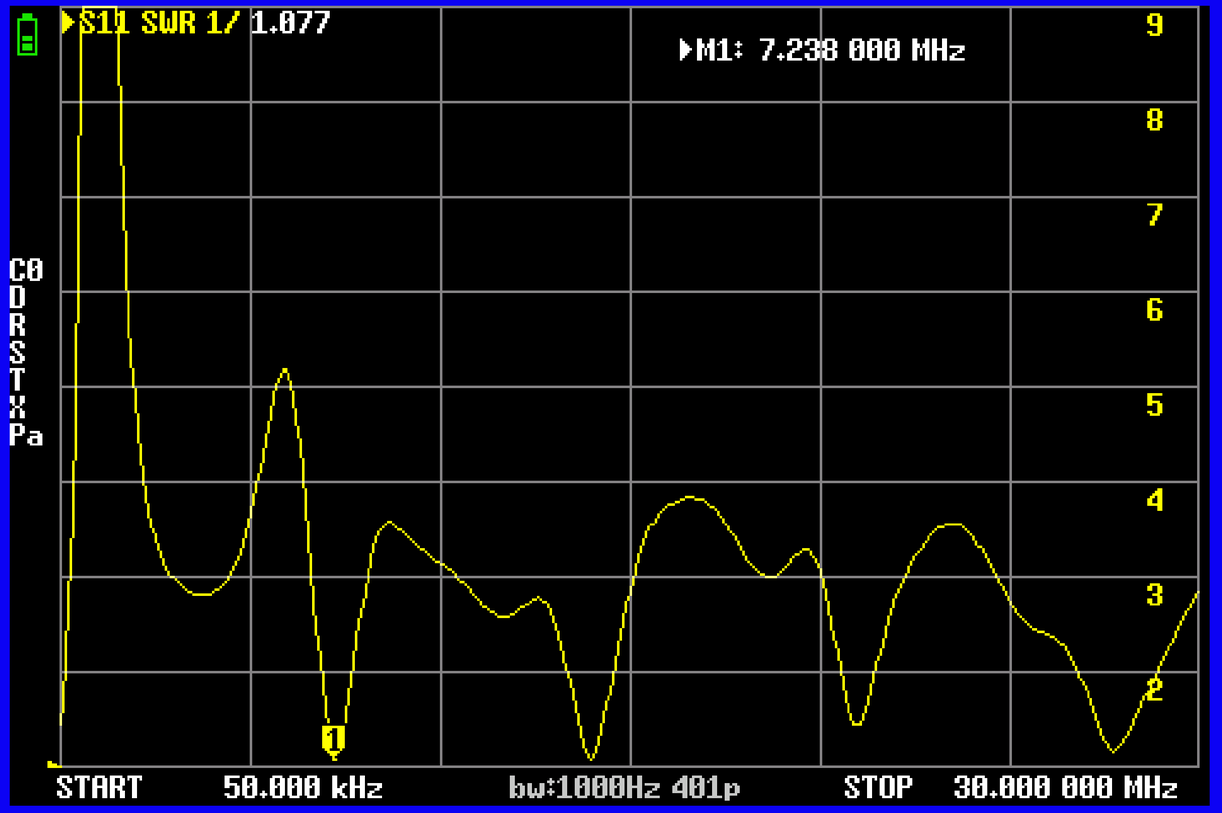
- **Traces to display (up to four)**
- **Format**
- **Channel (CH0 REFLECT or CH1 THROUGH)**
- **Scale for each trace separately**
- **Reference position**
- **Stimulus frequency range (sweep frequency)**
- **Calibrate the NanoVNA**

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



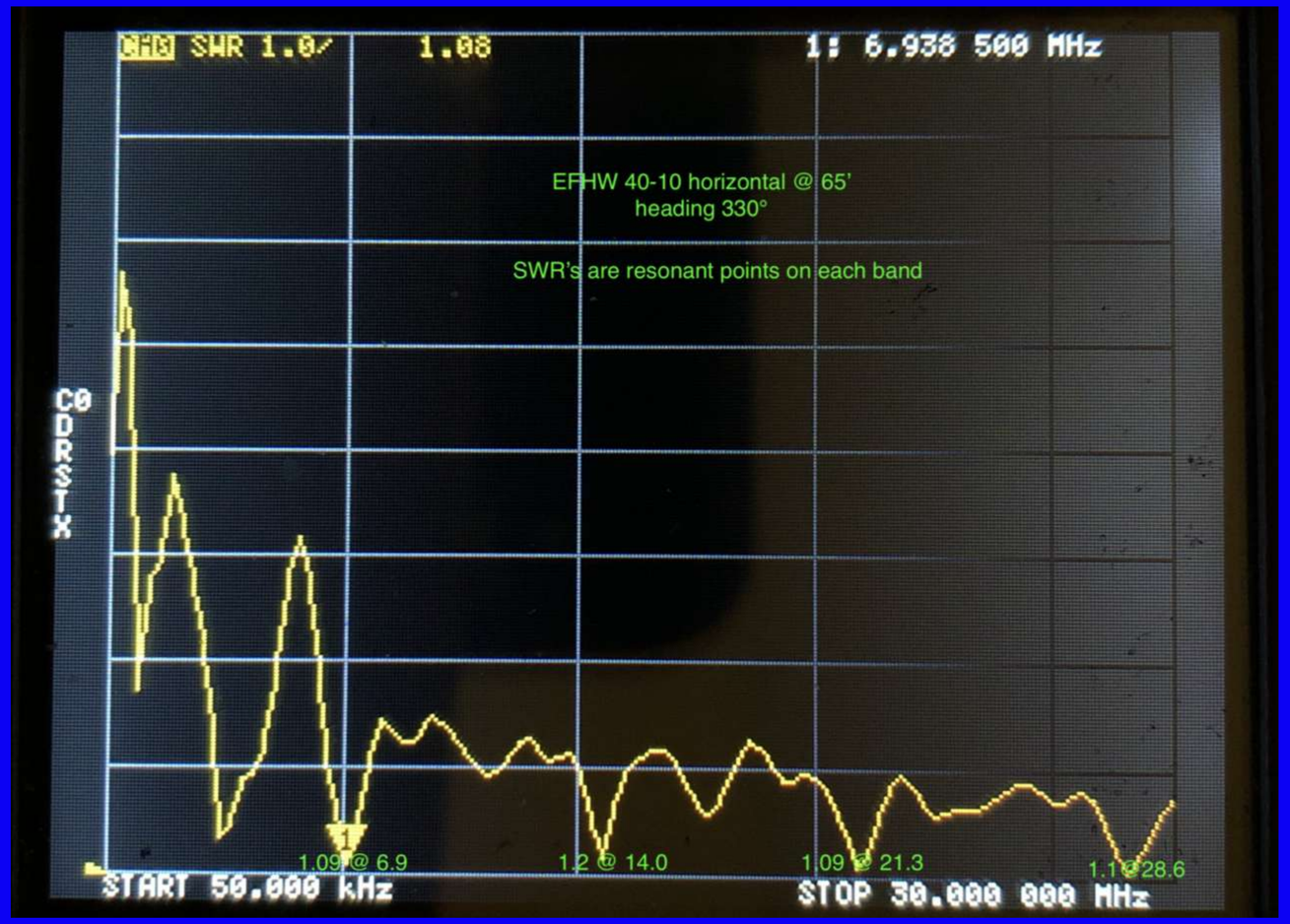


SWR Measurements
80 M Loop

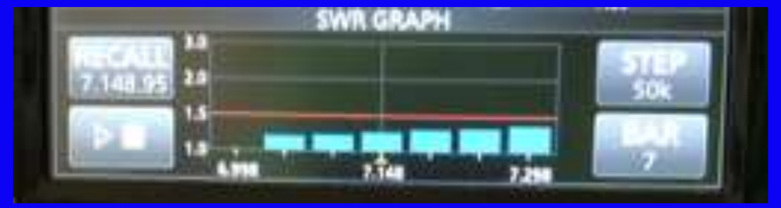
SWR & Smith Chart Measurements
80M Loop on 40M

SWR Comparison

NanoVNA

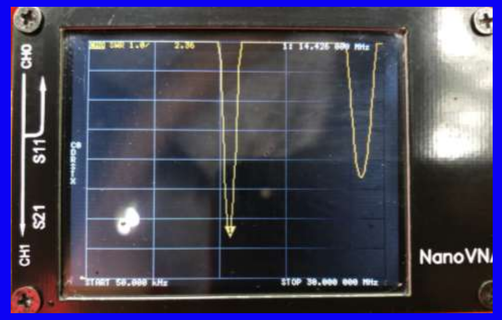


IC-7300

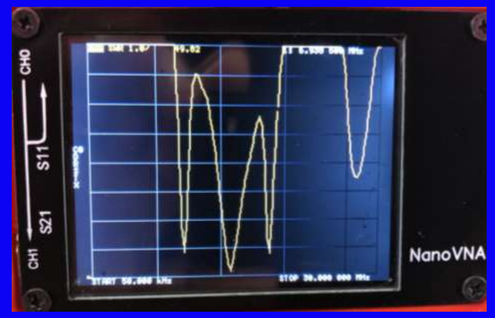


20M Delta Loop

Antenna

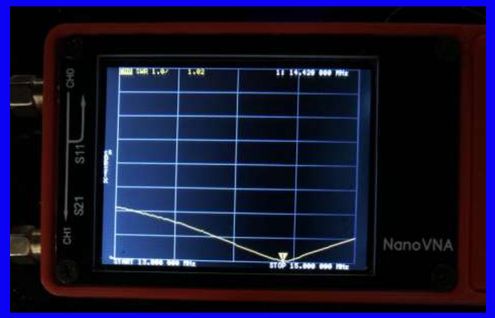


Matching Section



matching section

Shack



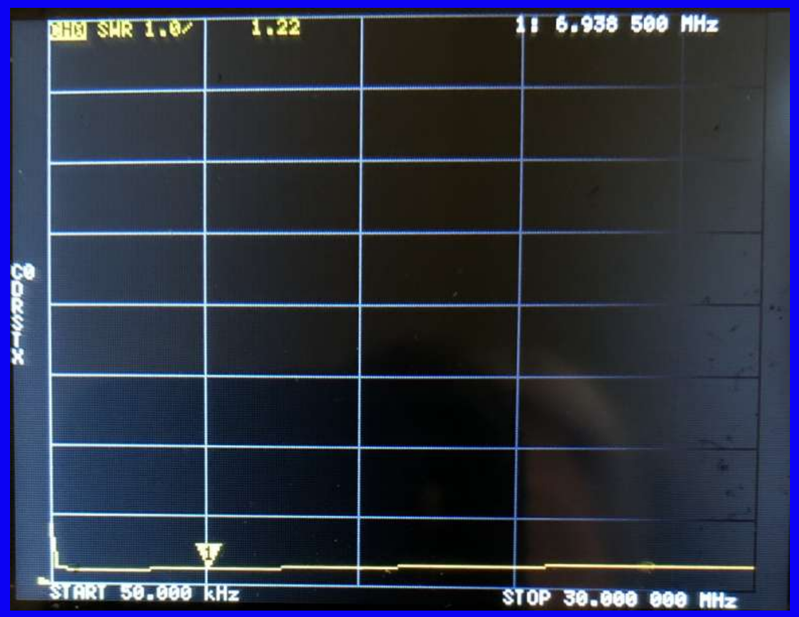
SWR 0.05-30 MHz

SWR 13-15 MHz

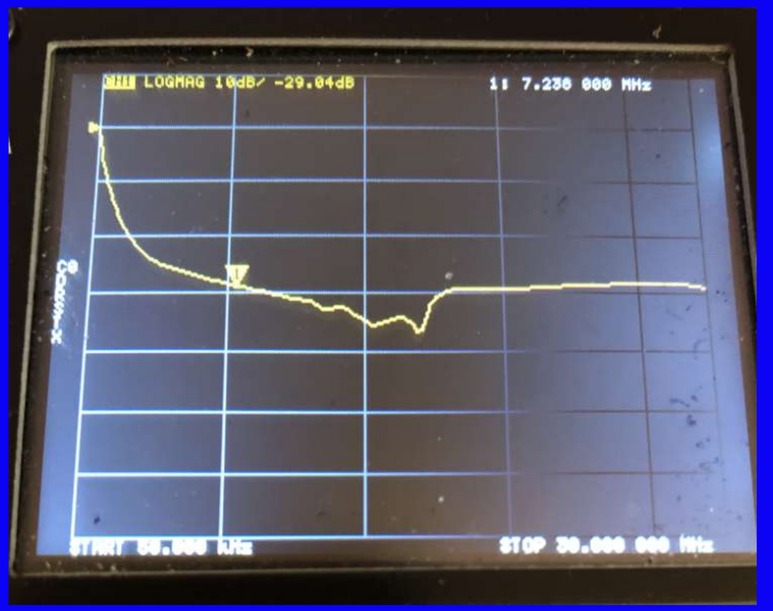
Smith Chart

Balun for 80M Loop Antenna

4:1 Current Balun
dual core



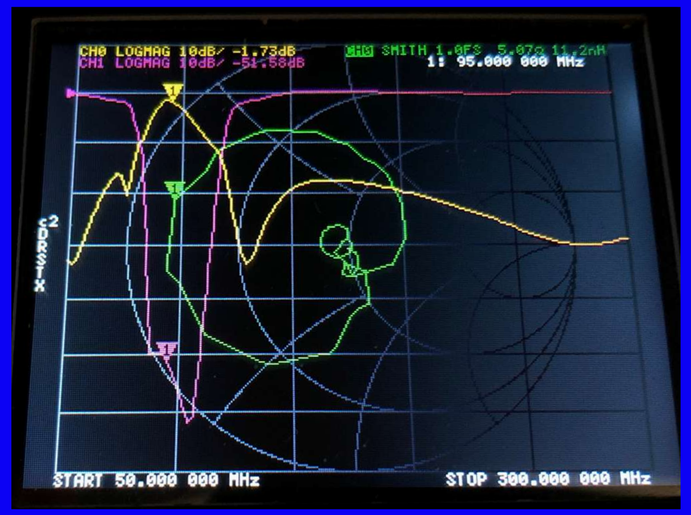
SWR <1.2:1
across HF band



Common Mode Rejection
~30 dB

Filter & Amplifier Characteristics

88-108 MHz Bandstop filter



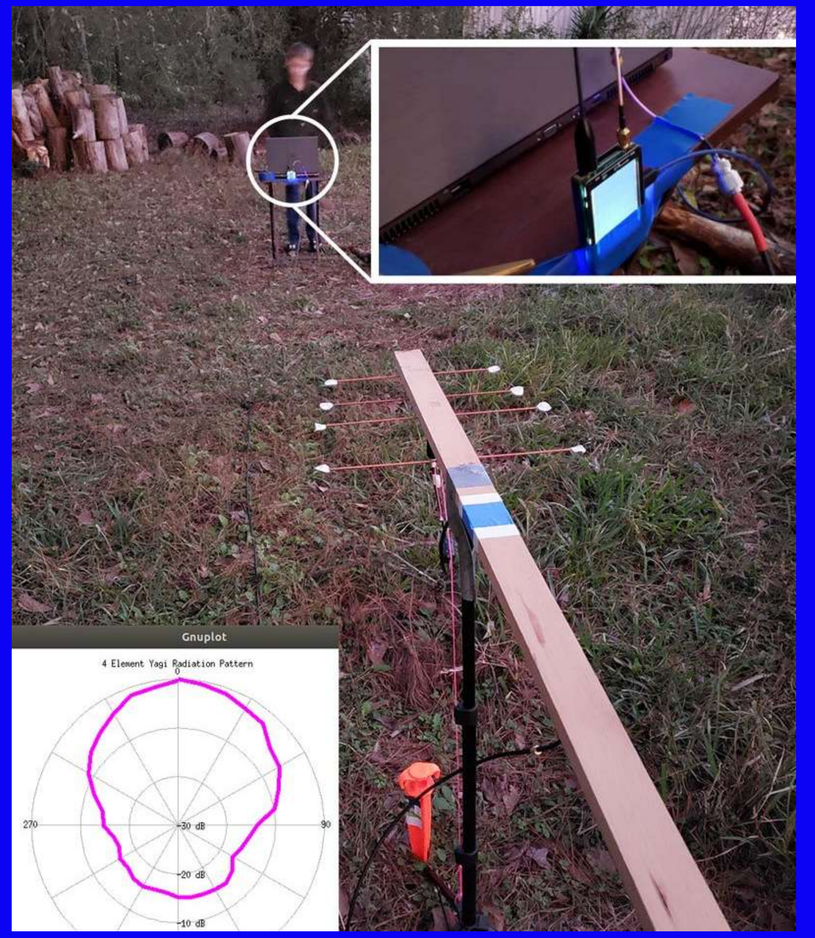
Antenna Radiation Pattern

Set up antenna with NanoVNA outside the near field

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

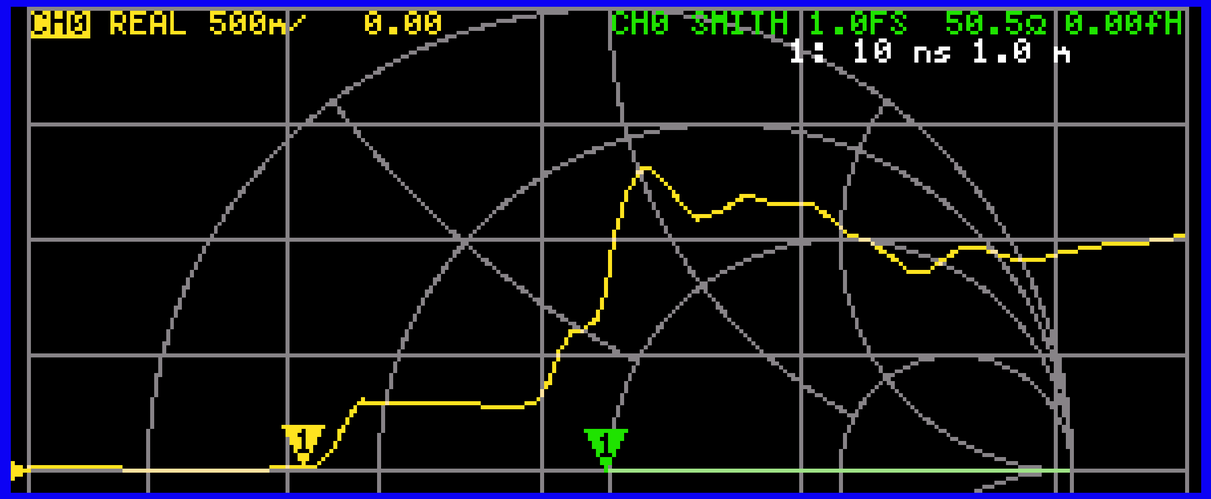
Measure & collect S21 reading over multiple rotations of Yagi

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

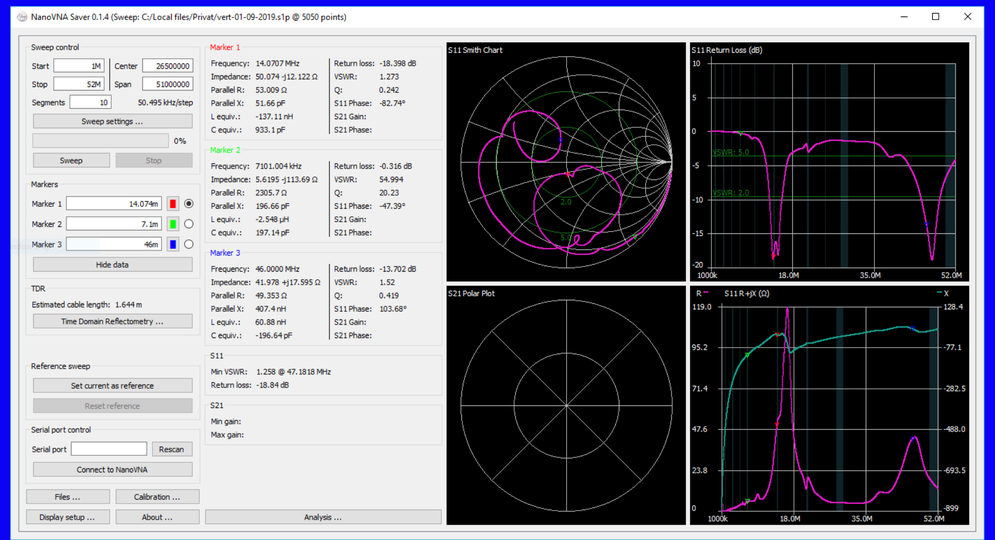
A multi-platform computer tool to save Touchstone files from the NanoVNA, sweep frequency spans in segments to gain more than 101 data points, and generally display and analyze the resulting data.

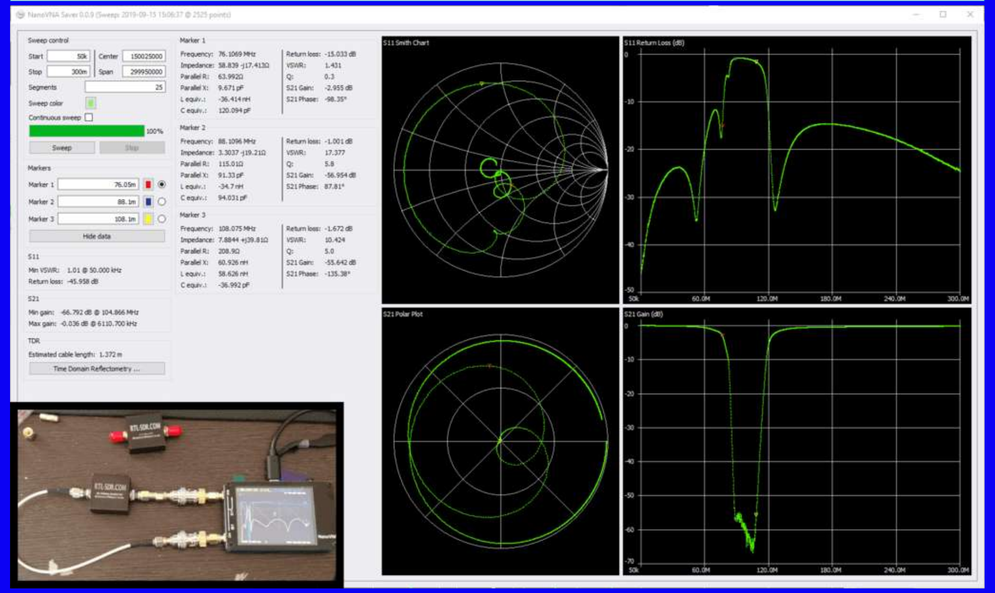
Introduction

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/mihtjel/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

NanoVNA groups.io Forum
https://groups.io/g/nanovnausers

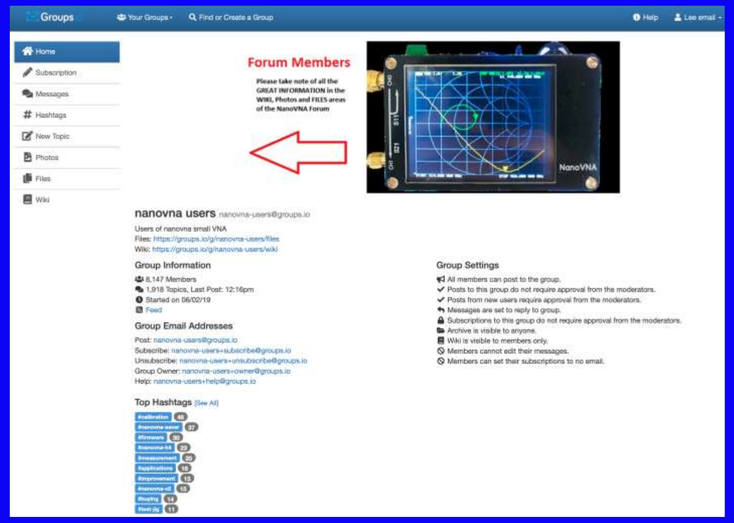
NanoVNA Saver by Rune B. Broberg / 5Q5R
https://zs1sek.com/blog/nanovnasaver/

TinySA Home page
https://tinysa.org/wiki/pmwiki.php?n=Main.HomePage

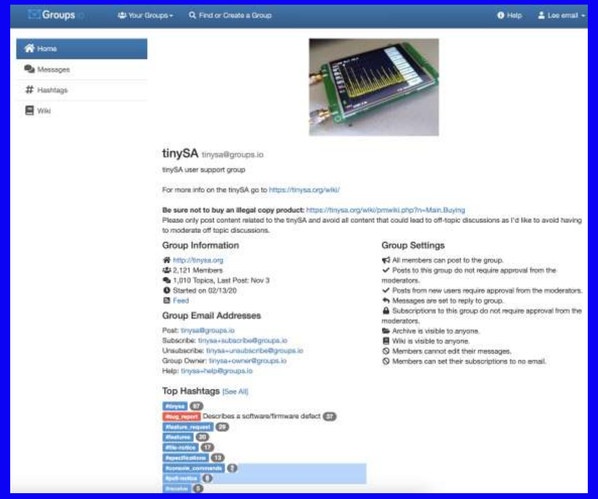
Groups.io Forum
https://groups.io/g/tinysa

TinySA YouTube videos
https://www.youtube.com/watch?v=n6WEM3--Npc&t=642s

groups.io


Groups
Your Groups
Find or Create a Group
Help
Lee email
Home
Subscription
Messages
Hashtags
New Topic
Photos
Files
Wiki
Forum Members
Please take note of all the GREAT INFORMATION in the WIKI, Photos and FILES areas of the NanoVNA Forum
NanoVNA
nanovna users nanovna-users@groups.io
Users of nanovna small VNA
Files: https://groups.io/g/nanovna-users/files
Wiki: https://groups.io/g/nanovna-users/wiki
Group Information
8,147 Members
1,918 Topics, Last Post: 12:16pm
Started on 06/02/19
Feed
Group Email Addresses
Post: nanovna-users@groups.io
Subscribe: nanovna-users+subscribe@groups.io
Unsubscribe: nanovna-users+unsubscribe@groups.io
Group Owner: nanovna-users+owner@groups.io
Help: nanovna-users+help@groups.io
Top Hashtags [See All]
Group Settings
All members can post to the group.
Posts to this group do not require approval from the moderators.
Posts from new users require approval from the moderators.
Messages are set to reply to group.
Subscriptions to this group do not require approval from the moderators.
Archive is visible to anyone.
Wiki is visible to members only.
Members cannot edit their messages.
Members can set their subscriptions to no email.


Groups
Your Groups
Find or Create a Group
Help
Lee email
Home
NanoVNAV2@groups.io NanoVNAV2@groups.io
NanoVNAV2@groups.io
NanoVNA V2 (S-A-A-2) user group official
This is the official support forum/user group for the NanoVNA V2, which is a low cost 3GHz T/R VNA (vector network analyzer). It is not based on tifftech's NanoVNA design but a new from scratch design using 2 ADF4350 to cover up to 3GHz and SI5351 to cover down to 50kHz. Compared to the original tifftech design, V2 uses only the fundamental signal for measurements and achieves higher dynamic range.
There is only one official NanoVNA V2 groups.io forum, which is NanoVNAV2@groups.io. All other groups are unofficial and you will only get support on this forum. Check the official website for user groups and social media pages:
https://nanorfe.com/nanovna-v2.htm
Hardware revisions
You can check your hardware revision by selecting CONFIG > VERSION in the menu.
Please see https://nanorfe.com/nanovna-versions.html
There are many clones of the NanoVNA V2. While they are all based on the earliest V2.2 design, some differ in parts used and may not be compatible with the official firmware. To ensure you get a supported hardware version, see official stores below.
Name
Release Date
Remarks
V2 Plus4 (V2.4)
2020/10
4 inch display. 4x faster sweep (400 points/s). Up to 80dB dynamic range to 3GHz.
V2 Plus (V2.3)
2020/10
2x faster sweep (200 points/s). Noise improvements. PCB text still indicates "V2_2".
V2.2
2019
The earliest version of the V2 hardware. No longer sold.


Groups
Your Groups
Find or Create a Group
Help
Lee email
Home
Messages
Hashtags
Wiki
tinySA tinysa@groups.io
tinySA user support group
For more info on the tinySA go to https://tinysa.org/wiki/
Be sure not to buy an illegal copy product: https://tinysa.org/wiki/pmwiki.php?n=Main.Buying
Please only post content related to the tinySA and avoid all content that could lead to off-topic discussions as I'd like to avoid having to moderate off topic discussions.
Group Information
http://tinysa.org
2,121 Members
1,010 Topics, Last Post: Nov 3
Started on 02/13/20
Feed
Group Email Addresses
Post: tinysa@groups.io
Subscribe: tinysa+subscribe@groups.io
Unsubscribe: tinysa+unsubscribe@groups.io
Group Owner: tinysa+owner@groups.io
Help: tinysa+help@groups.io
Top Hashtags [See All]
#tinysa 37
#bug_report Describes a software/firmware defect 27
#feature_request 26
#features 20
#file-rydles 17
#specifications 15
#console_commands 8
#pull-request 6
#scripts 6
Group Settings
All members can post to the group.
Posts to this group do not require approval from the moderators.
Posts from new users require approval from the moderators.
Messages are set to reply to group.
Subscriptions to this group do not require approval from the moderators.
Archive is visible to anyone.
Wiki is visible to anyone.
Members cannot edit their messages.
Members can set their subscriptions to no email.

Summary

NanoVNA & TinySA - Software defined RF tools extraordinaire

Functionality expanding - open architecture

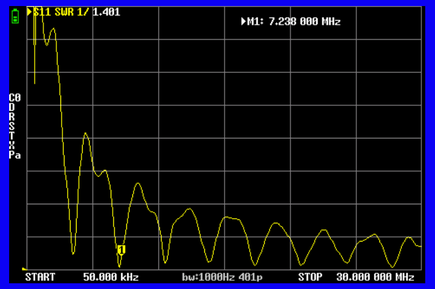
YouTube videos & Groups:io

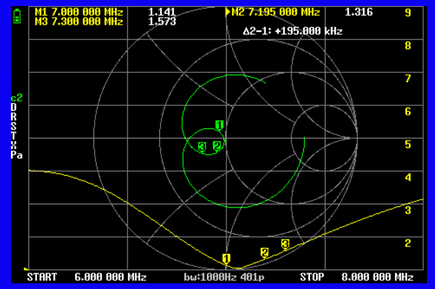
US source - R&L Electronics

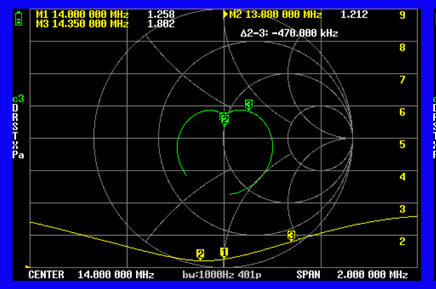
NanoVNA-H4”	$90
TinySA 4”	$80

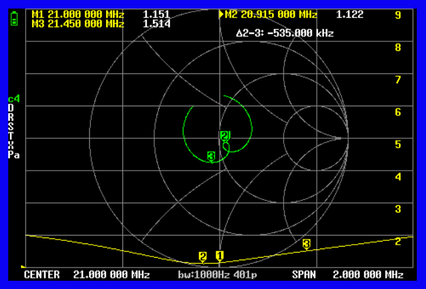
NanoVNA screen shots

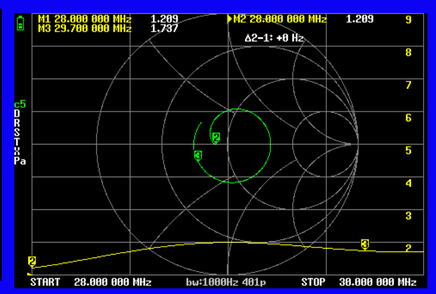
80M Loop

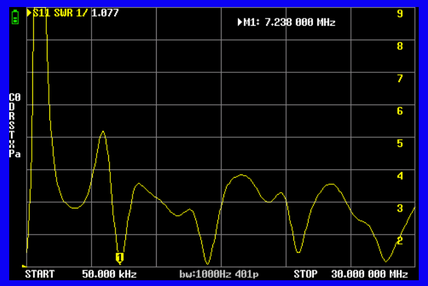




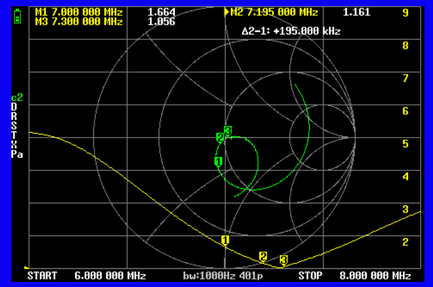


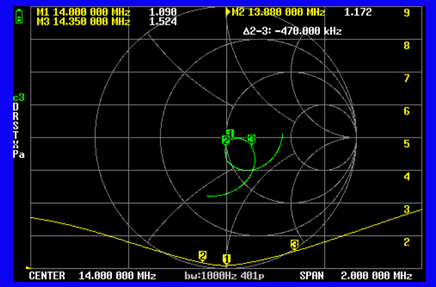


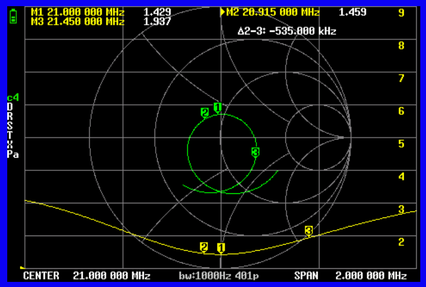


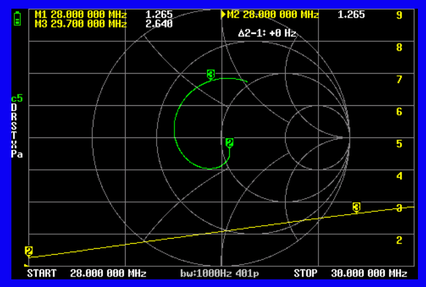


40M Loop



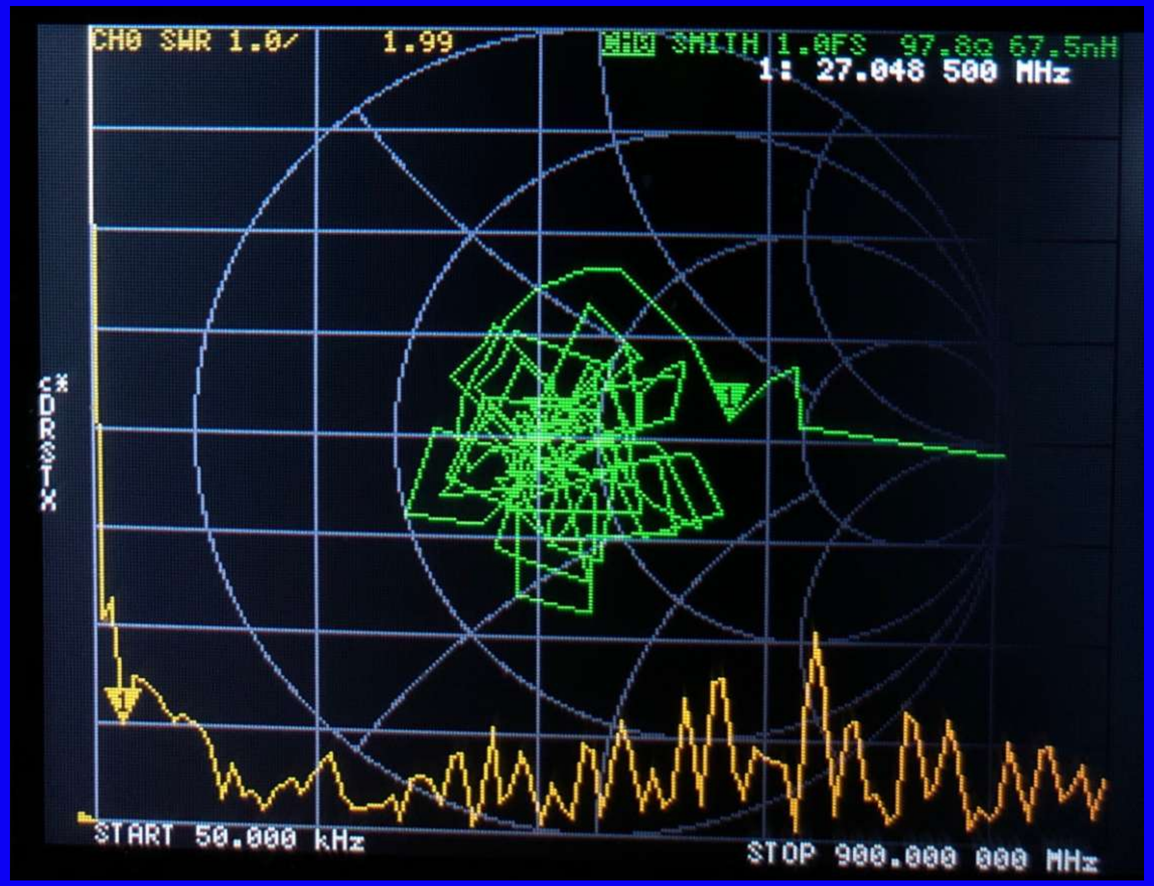






On power up you see 50kHz to 30MHz SWR
Select “Recall” and step through each band

Test Question
Name of this antenna type?



Q & A

NanoVNA-H4 Menu