NanoVNA Introduction

Lee Johnson N4WYE

NFARL January 2020

Welcome

KH6DAK in Hawaii 1957

Charter member Raleigh Amateur Radio Society

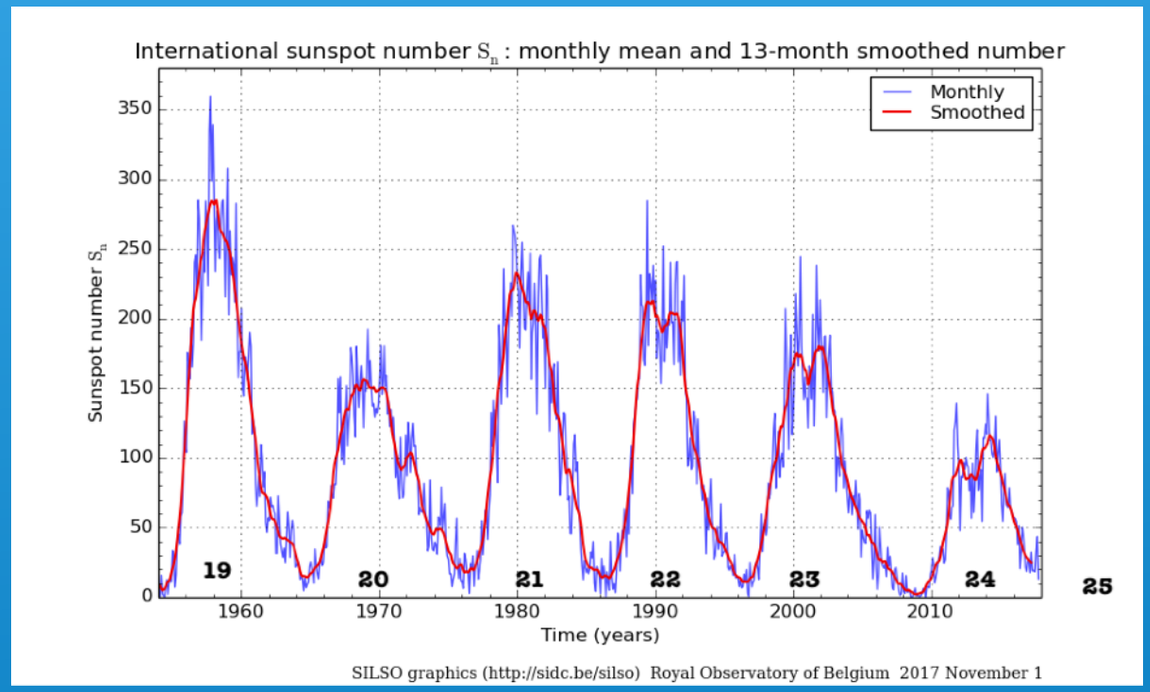
W4DW Repeater 146.64 MHz

Retired after 40 years in high tech systems

Currently in Marietta, Spouse “Mary Deane”

HF, VHF, SDR, home brew & antennas

N4WYE



NanoVNA

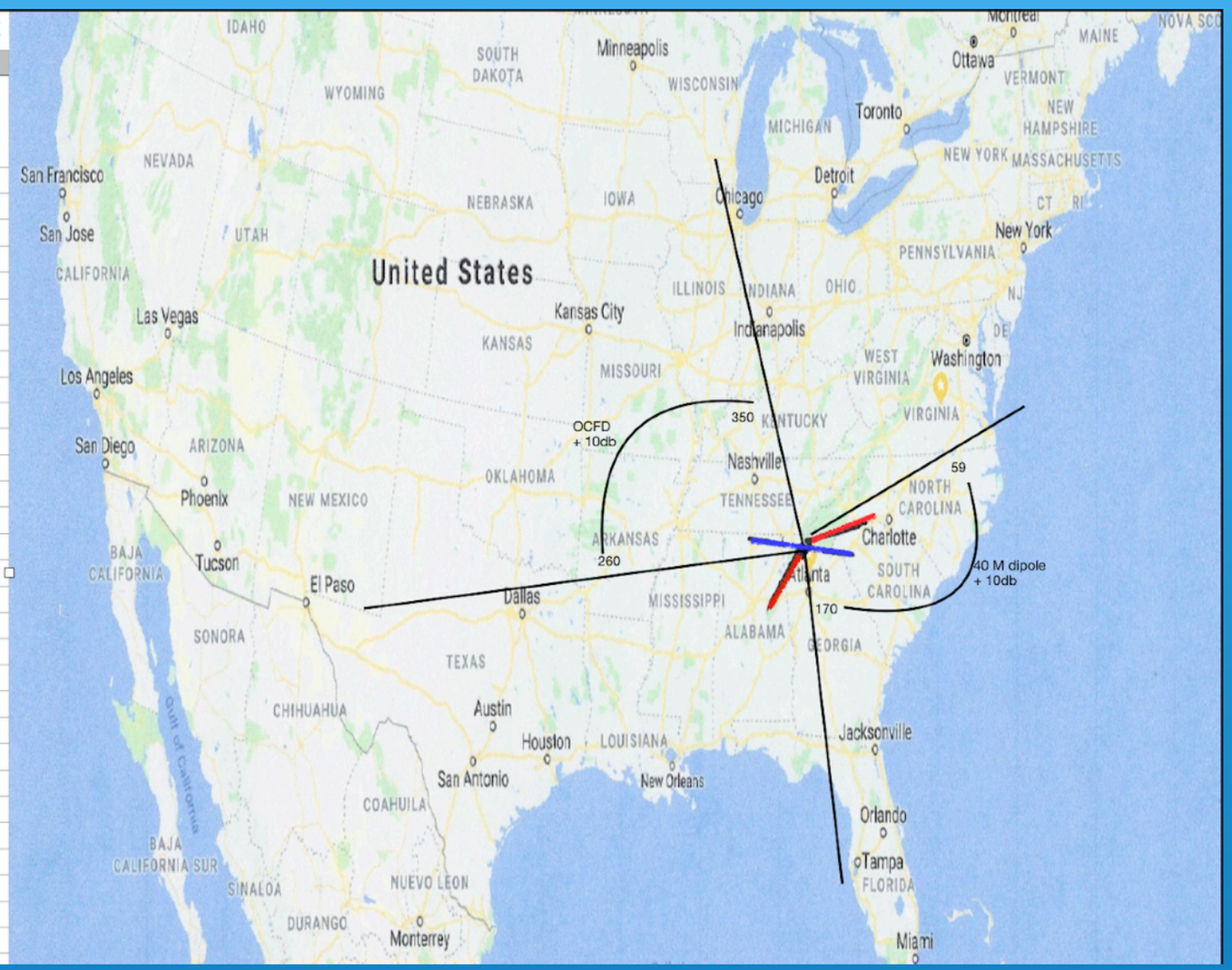
- Introduction
- NanoVNA enters the market
- How I acquired the NanoVNA
- NanoVNA technical description/specs
- Architecture
- Operation
- Application Examples
- Q & A

40 Meter coverage

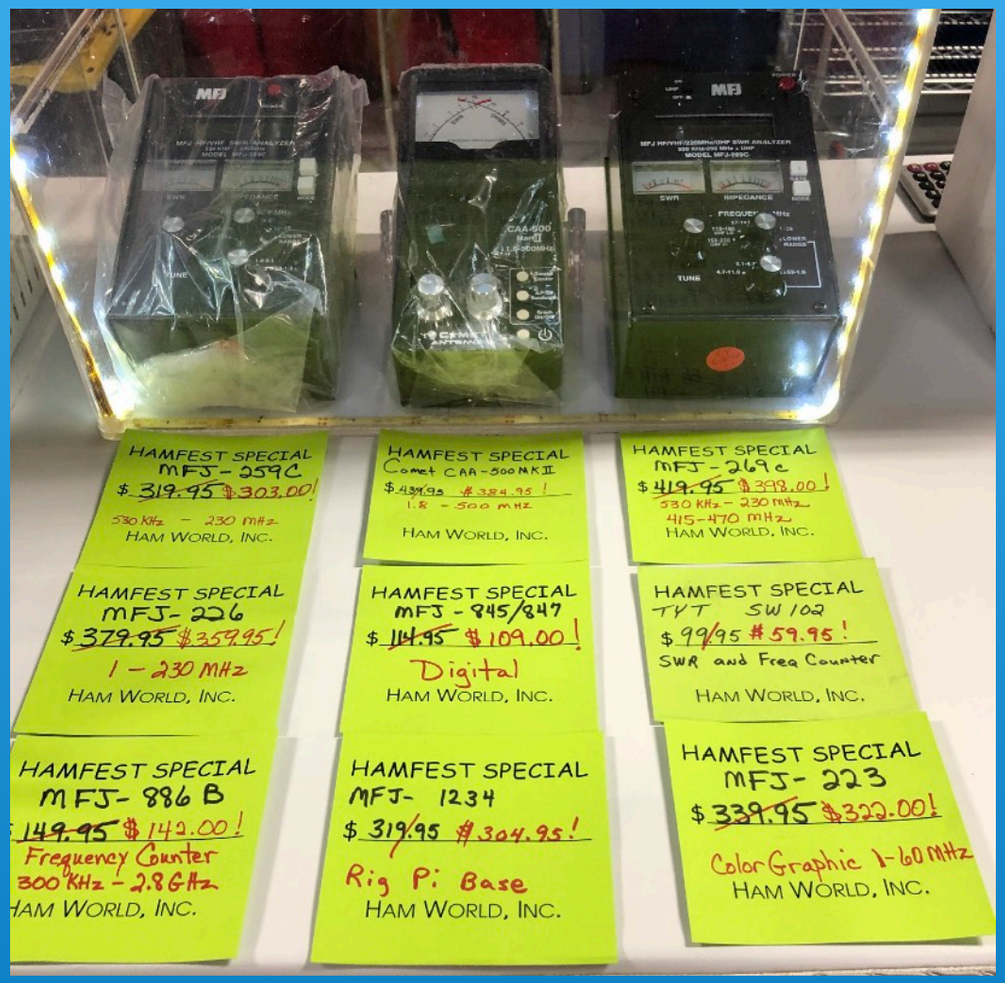
OCF dipole vs dipole

Antenna 40 meters data 2019 N4WYE

Call	Azmuth	OFC dipole advantage	40 Meter dipole advantage
K4HC	59		2 s units
Goldsboro, NC	70		2s
KR4HH	90		2s
NC4L	154		8db
KS4PC	156		2s+
KK6BS	159		2s
KM4DTY	163		10db
K0RK	165		2s
WA8ZWJ	2	2s	
K4QKY	239	1s	
K5NE	277	10db	
K1MAX	285	2s	
W5BIV	286	10 db	
KI4I	286	7db	
WA9EEH	350	10db	
W8VLN	357	1s	
KC8HMJ	7	even	
K2LAX	46	even	
K4FHI	63	even	
WB4MIO	197	1s	
K4KPT	208	even	

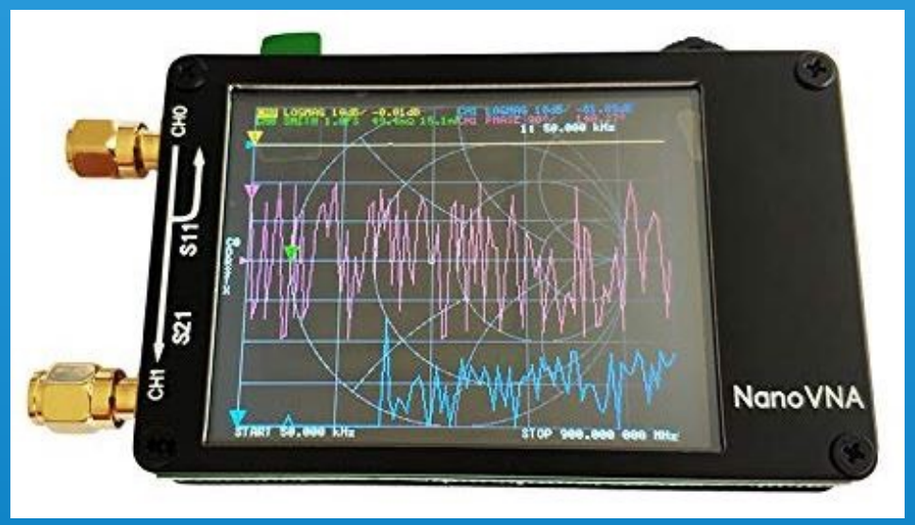


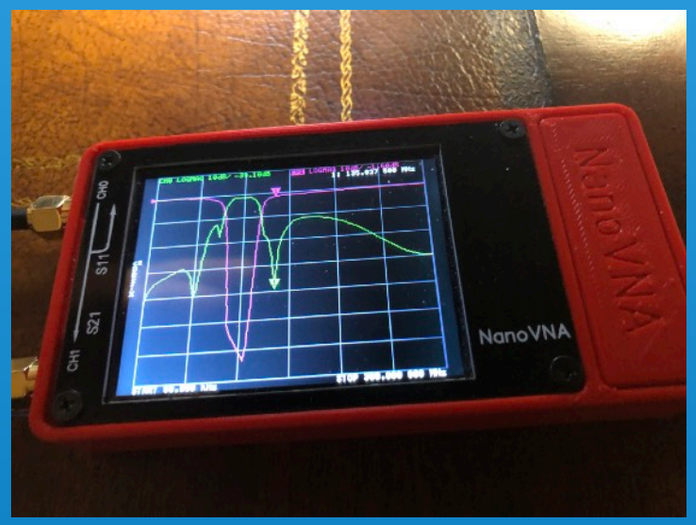
Looking for an antenna Analyzer?



Geek-Toy of the Year

**Handheld low cost Vector Network Analyzer “RF-multimeter”
capable of measuring electrical parameters of antennas,
filters & components to >900 MHz for less than $50!**





Vector Network Analyzers

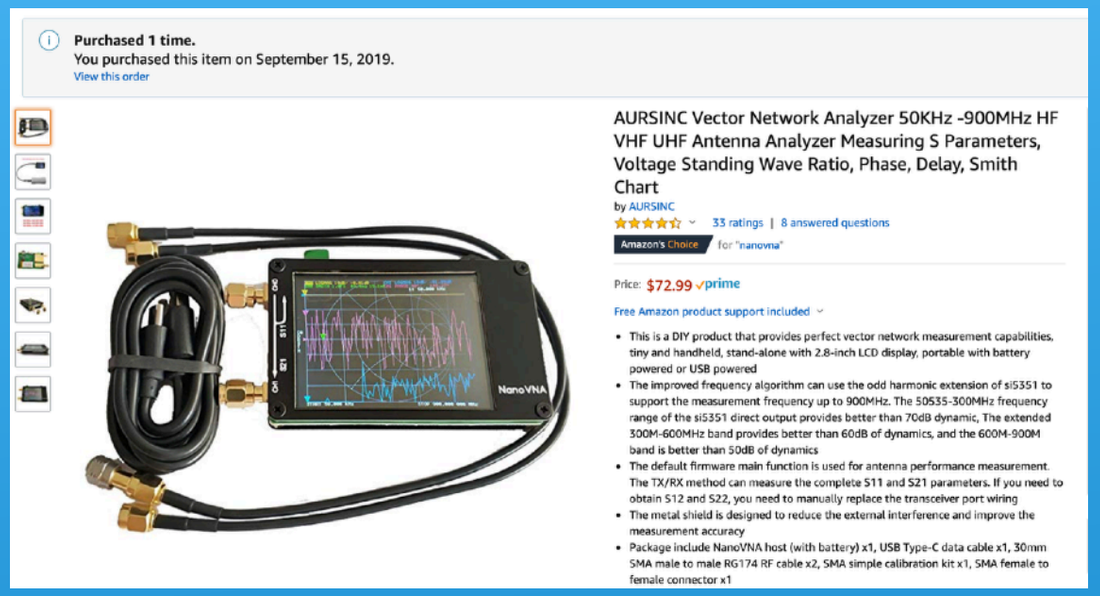
How much do you need to spend?

$50K

$5K

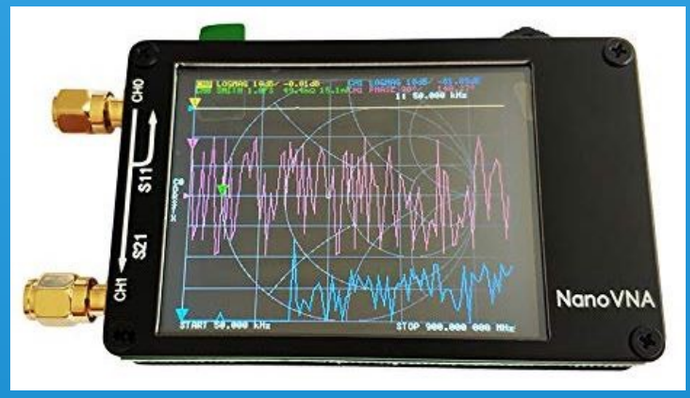
$50

My Amazon NanoVNA



NanoVNA
Background

Original NanoVNA 300MHz kit design “edy555” in 2017
Japanese ham published 2016 via open-source HW & FW at GitHub
Based on a German kit VNWA3 by Tom Baier DG8SAQ Mar/Apr 2007 QEX
“A Low Budget Vector Network Analyzer for AF to UHF”



Productized & marketed by “hugen79” a Chinese ham in 2019
Extended to 900 MHz,
open-source HW & FW at GitHub

Clone manufacturing took off in China 2019

Product extensions being developed
Larger 4 inch screens
Extension to 3GHz
Time Domain Reflectometers

Third Party Software

NanoVNA Chronology*

In 2016 “edy555” created the open source NanoVNA project on GitHub.

In early 2019 “hugen79” cloned the NanoVNA open source schematic, manufactured the device with frequency range expansion and NanoVNA Sharp software.

Hugen79's product is the black NanoVNA with shields on CH0 and CH1.

Noting the successful and positive feedback from buyer's of hugen79's product, other Chinese manufacturers soon started selling clones of the clone.

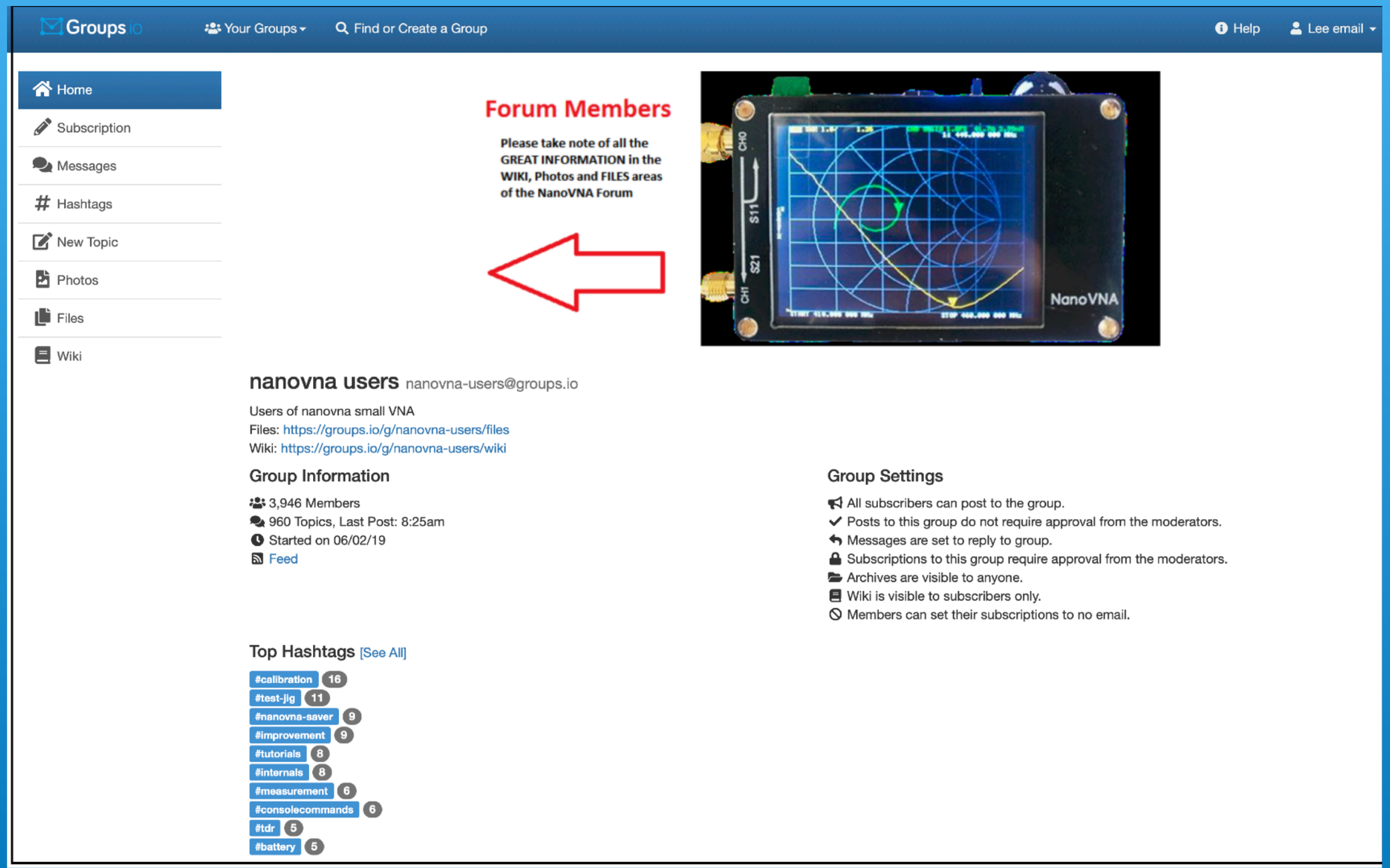
Hugen79's clone NanoVNA-H and most others use the same edy555 schematic design

Two hardware versions being sold: The NanoVNA (-H) and the NanoVNA-F.

Version 2 device - Both edy555 and hugen79 in development.

* https://groups.io/g/nanovna-users

nanovna-users@groups.io

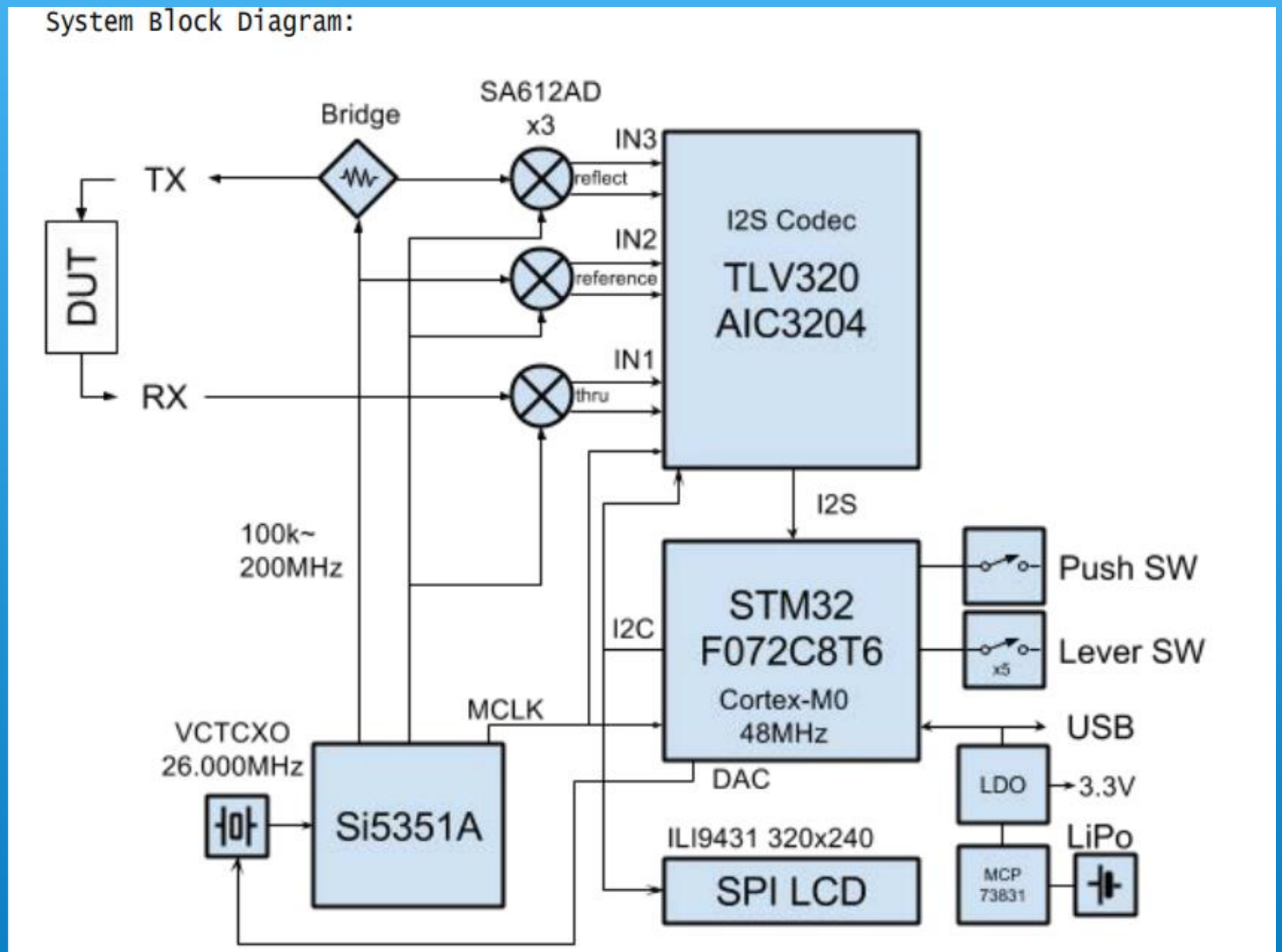


NanoVNA specifications

Frequency Range:	50kHz to 900MHz
RF output:	-13dbm (-9dbm maximum), or ~0.1 mW
Dynamic Range:	70dB (50kHz - 300MHz), 60dB (300MHz - 600MHz), 50dB (600MHz - 900MHz)
Display:	2.8 inch TFT (320x240)
USB Interface:	USB Type C (power + data)
Power:	USB 5V 120mA, internal LiPo battery 400 mAh
Scanning Points:	101 (fixed)
Display:	4 traces, 4 markers + 5 memories for calibration
Frequency deviation:	<0.5 ppm (e.g., 50 Hz error at 100 MHz.)

Vector Network Analyzer, 2-Port S-Parameters

NanoVNA



Si5351A Clock Generator

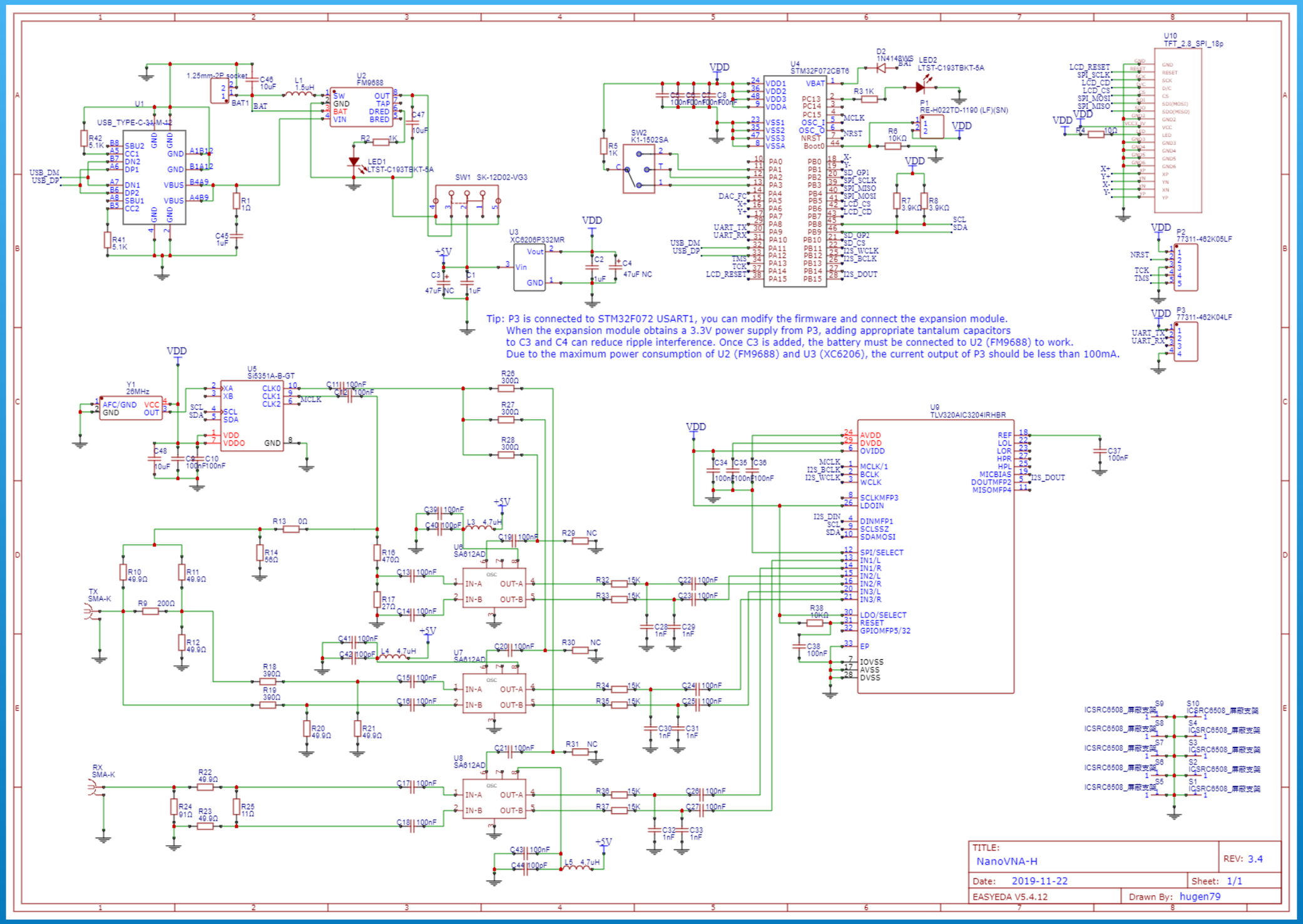
SA612AD Mixer-Oscillator

TLV320 AIC3204 I2S/PCM interface audio codec

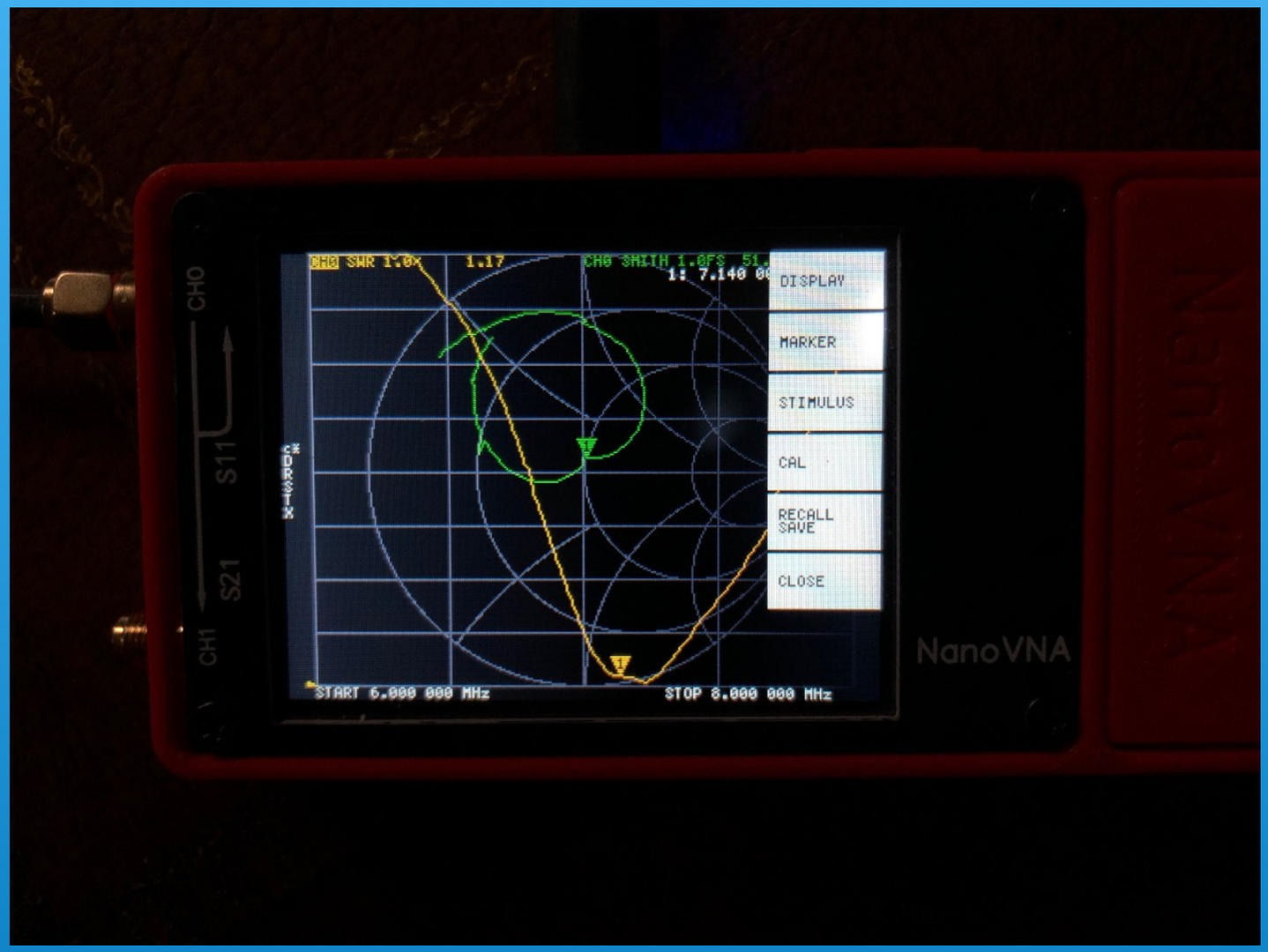
STM32 Microcontroller

LCD

NanoVNA Schematic

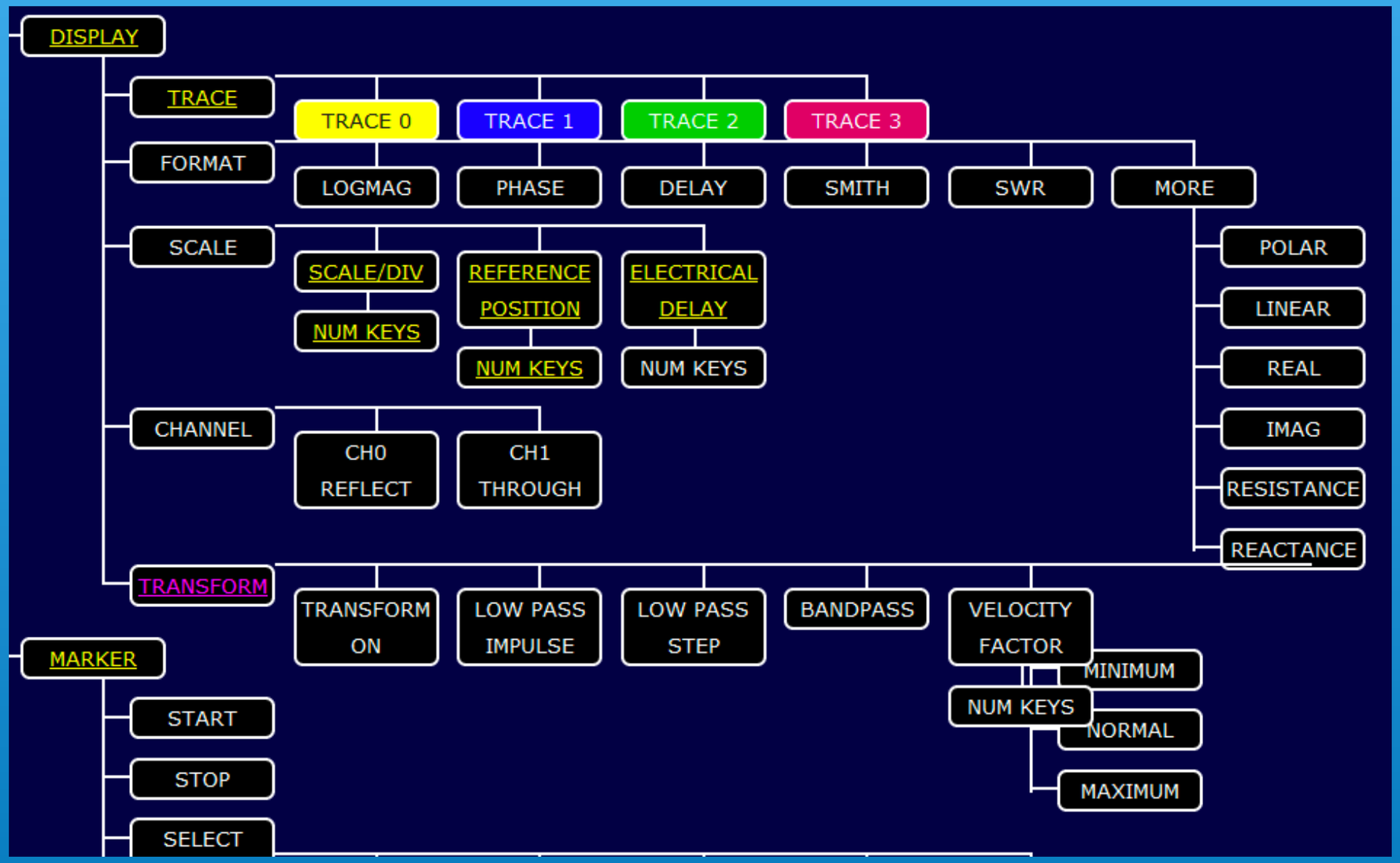


How to use it



NanoVNA Top-Level Menu (Touchscreen)

Partial Menu Tree Options



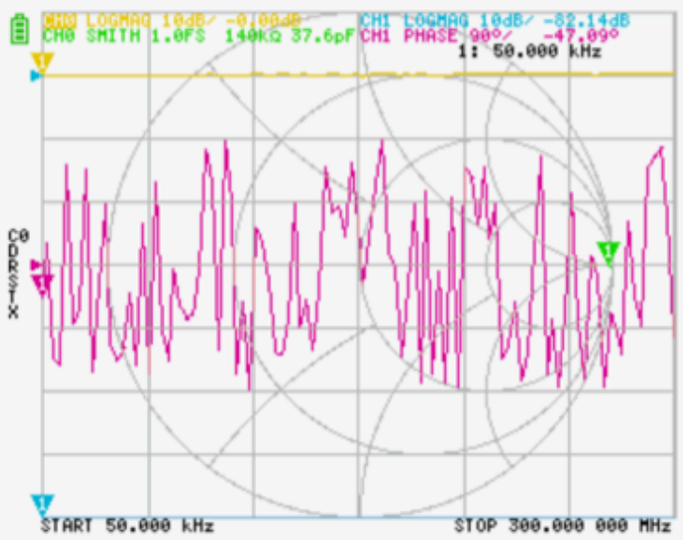
NanoVNA Menu Structure Map

HOME MENU

- DISPLAY → TRACE → TRACE 0 / TRACE 1 / TRACE 2 / TRACE 3 / <BACK
- MARKER → SELECT MARKER → MARKER 1 / MARKER 2 / MARKER 3 / MARKER 4 / ALL OFF / <BACK
- STIMULUS → START / STOP / CENTER / SPAN / CW FREQ / PAUSE SWEEP / <BACK
  - START, STOP, CENTER, SPAN, CW FREQ → NUMERIC KEYPAD
- CAL → CALIBRATE / SAVE / RESET / CORRECTION / <BACK
  - CALIBRATE → OPEN / SHORT / LOAD / ISOLN / THRU / DONE / <BACK
  - SAVE → SAVE 0 / SAVE 1 / SAVE 2 / SAVE 3 / SAVE 4 / <BACK
- RECALL → RECALL 0 / RECALL 1 / RECALL 2 / RECALL 3 / RECALL 4 / <BACK
- CONFIG → TOUCH CAL / TOUCH TEST / SAVE / VERSION / >DFU / <BACK
  - >DFU → RESET AND ENTER DFU / CANCEL

Close menu if next item is sentinel

nanovna.com



TRACE

- FORMAT → LOGMAG / PHASE / DELAY / SMITH / SWR / >MORE / <BACK
  - >MORE → POLAR / LINEAR / REAL / IMAG / RESISTANCE / REACTANCE / <BACK
- SCALE → SCALE/DIV / REFERENCE POSITION / ELECTRICAL DELAY / <BACK
  - SCALE/DIV, REFERENCE POSITION → NUMERIC KEYPAD
  - ELECTRICAL DELAY → NUMERIC KEYPAD
- CHANNEL → CH0 REFLECT / CH1 THROUGH / <BACK
- TRANSFORM → TRANSFORM ON / LOW PASS IMPULSE / LOW PASS STEP / BANDPASS / WINDOW / VELOCITY FACTOR / <BACK
  - WINDOW → MINIMUM / NORMAL / MAXIMUM / <BACK
  - VELOCITY FACTOR → NUMERIC KEYPAD

If calibration is available, the CAL status will be displayed. Otherwise, it is hidden. C* is in the state where an unsaved calibration is applied (it disappears from memory when the power is turned off). C0 to C4 Indicates that the saved calibration values are applied to one of the save locations. Saved or Unsaved will change when calibration data is properly saved. The letters below C indicate that the following error terms have been applied. D: Directivity, R: Reflection Tracking, S: Source Match, T: Transmission Tracking and X: Isolation.

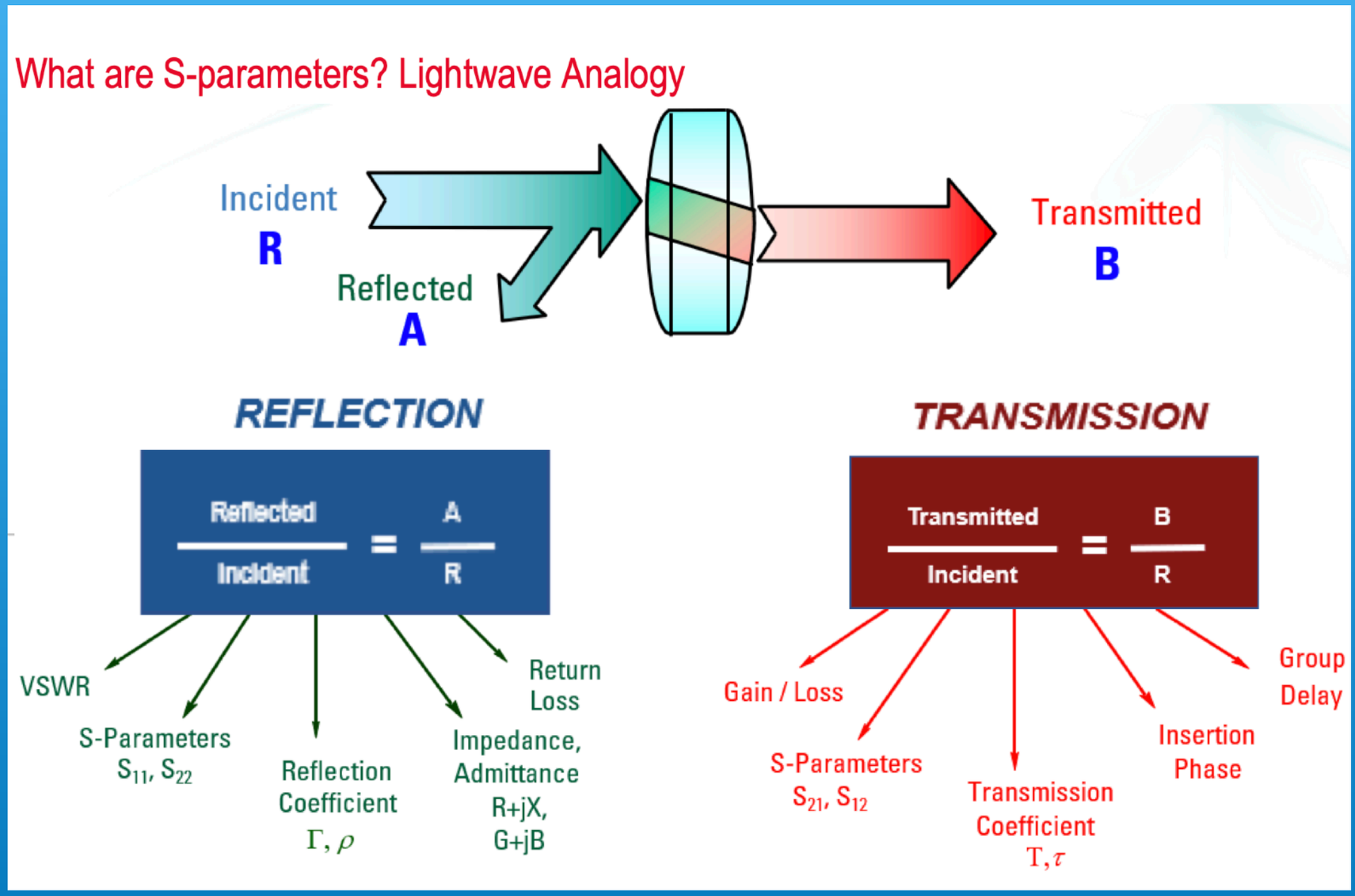
NanoVNA
“Getting Started Manual”

- **NanoVNA Device**
- **Stand-Alone Operation**
- **Operation with PC and “NanoVNA Saver V.2.0”**

- **Author: Gunthard Krause, DG8GB**
  January 13, 2020
  http://www.gunthard-kraus.de/fertig_NanoVNA/English_NanoVNA_V1.5._final.pdf

S-parameters

Complex matrix that show Reflection/Transmission characteristics (Amplitude/Phase) in frequency domain.



NanoVNA

Handheld, low cost Vector Network Analyzer “RF-multimeter” capable of measuring electrical parameters of antennas, filters & components to 1 GHz

S11

– Antenna measurements-VSWR

– Complex load impedance

– Power splitters, diplexers

– Filter return loss

– Amplifier return loss

– Cable impedance

S21

– Filter response

– Attenuators (flatness, delay)

– Power splitters

– Baluns

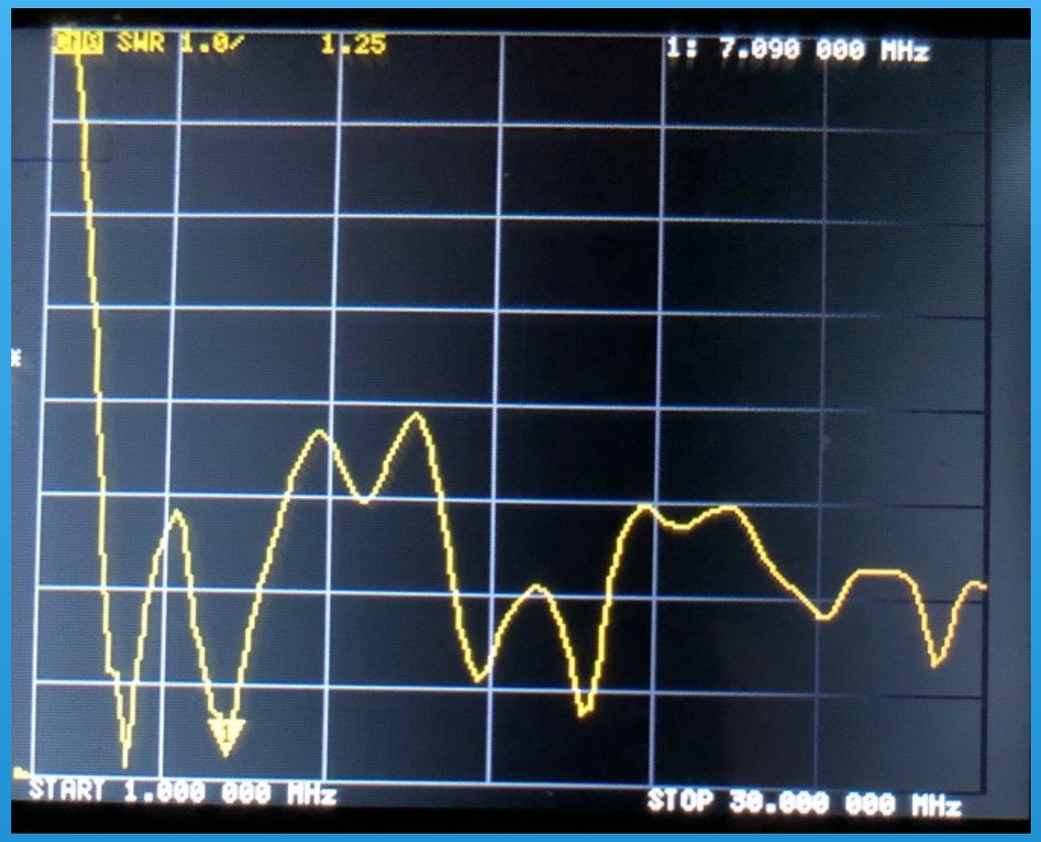
– Phasing networks

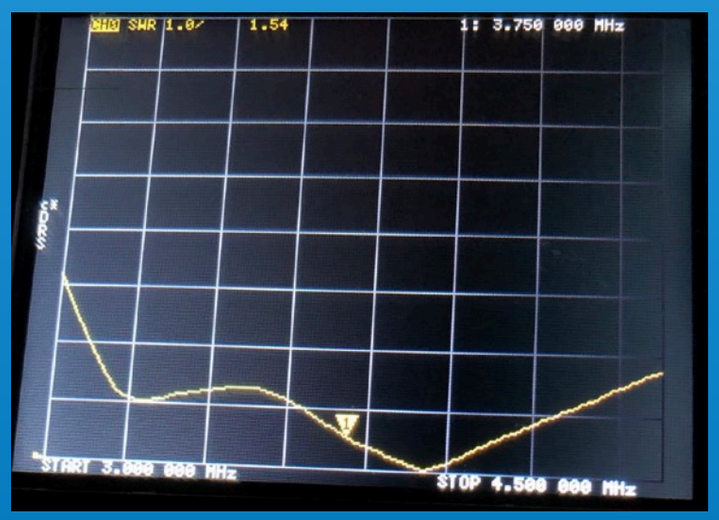
– Crystals, resonances, impedances

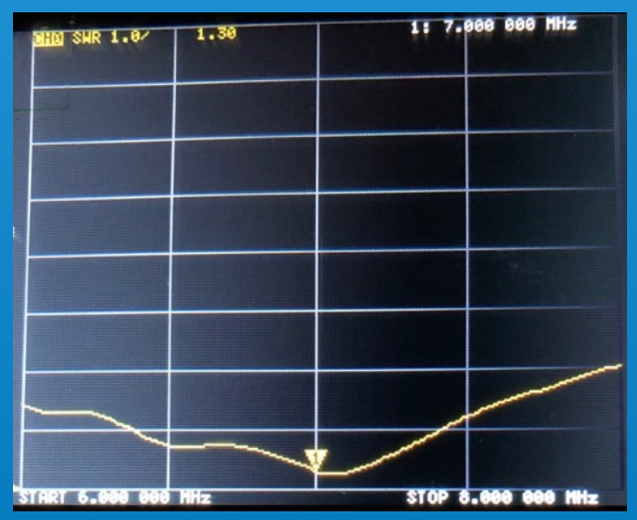
– Amplifier gain, delay

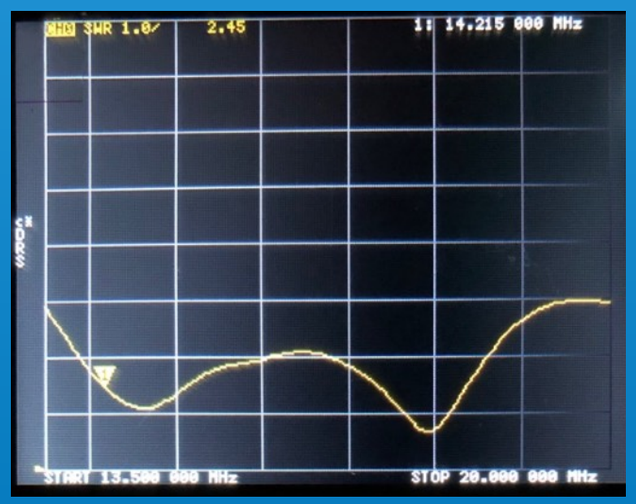
– Cable electrical length, velocity factor

SWR
OCF Dipole Antenna

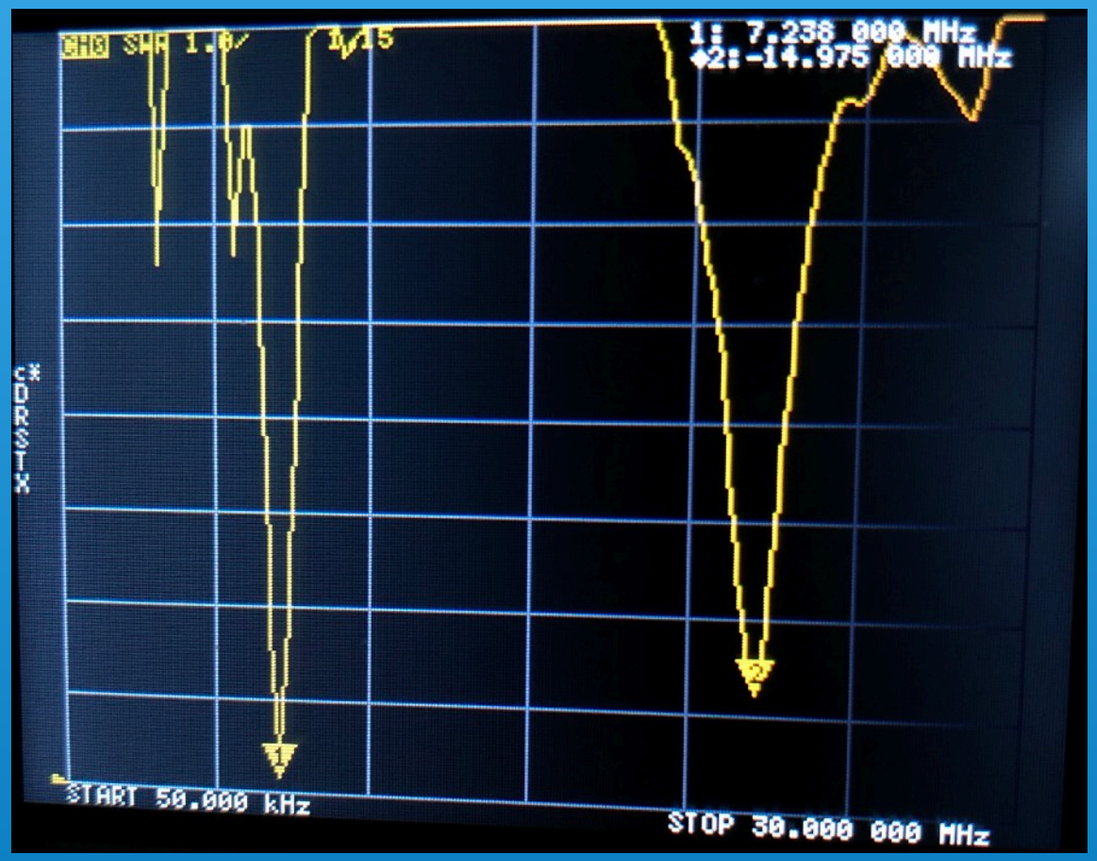


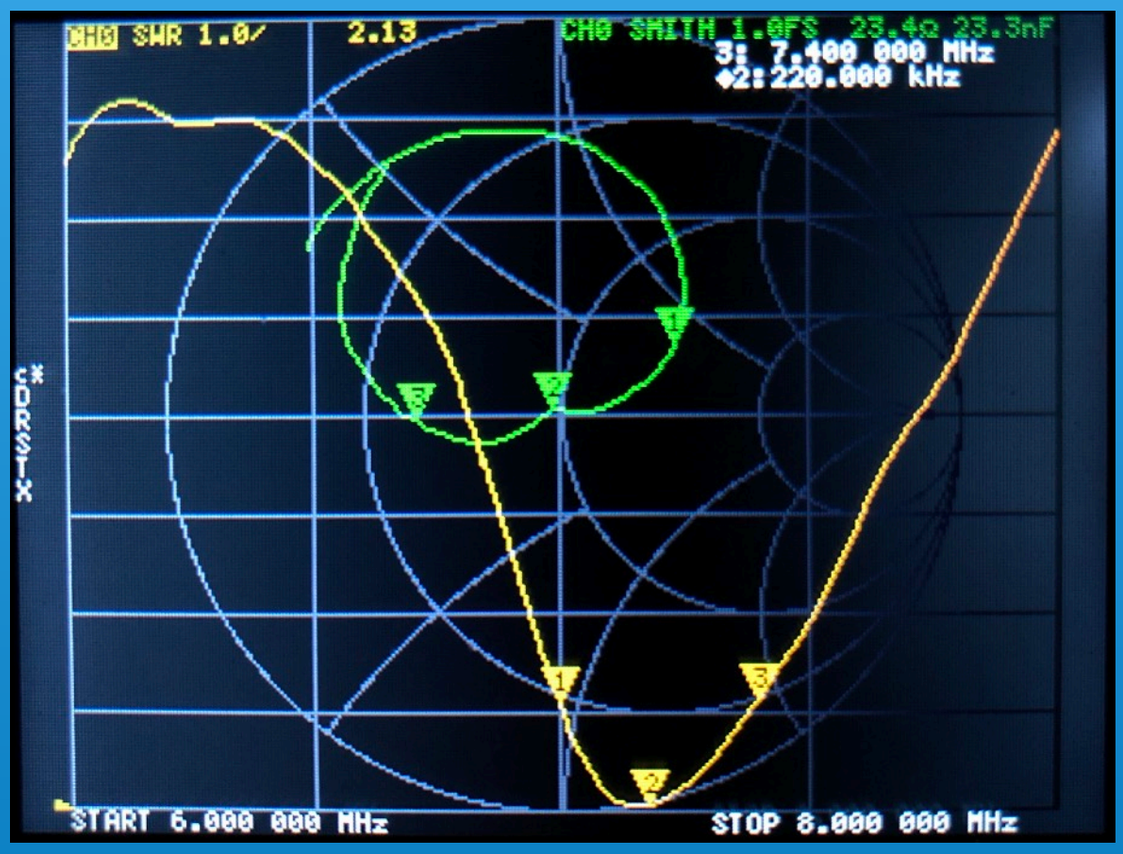






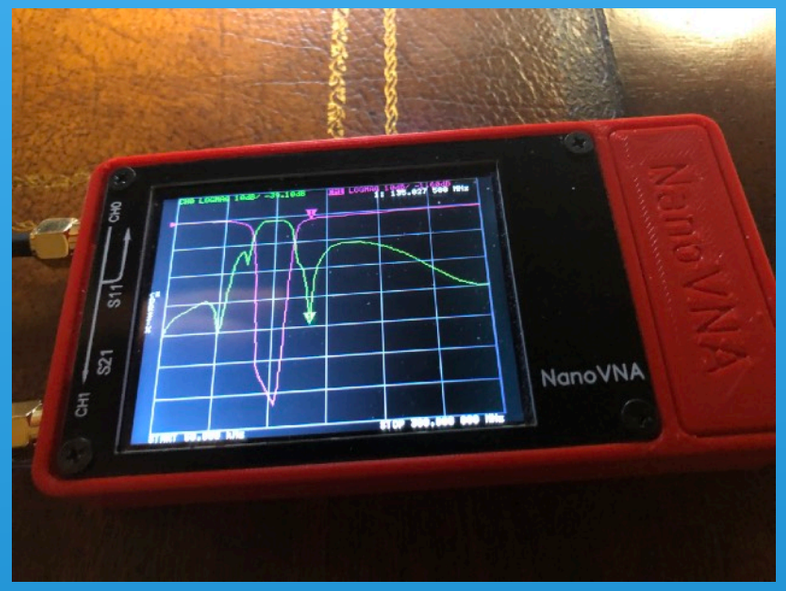
SWR
40 Meter Dipole Antenna

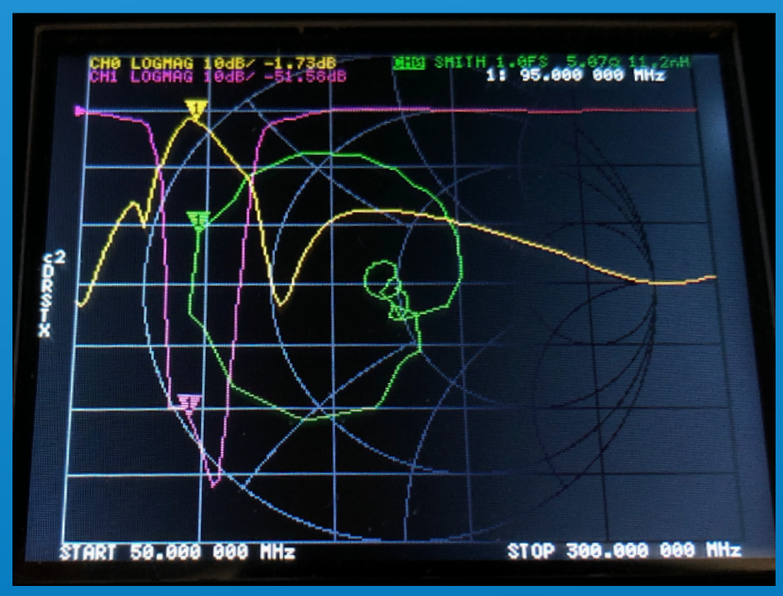




Filter & Amplifier Characteristics

88-108 MHz Bandstop filter





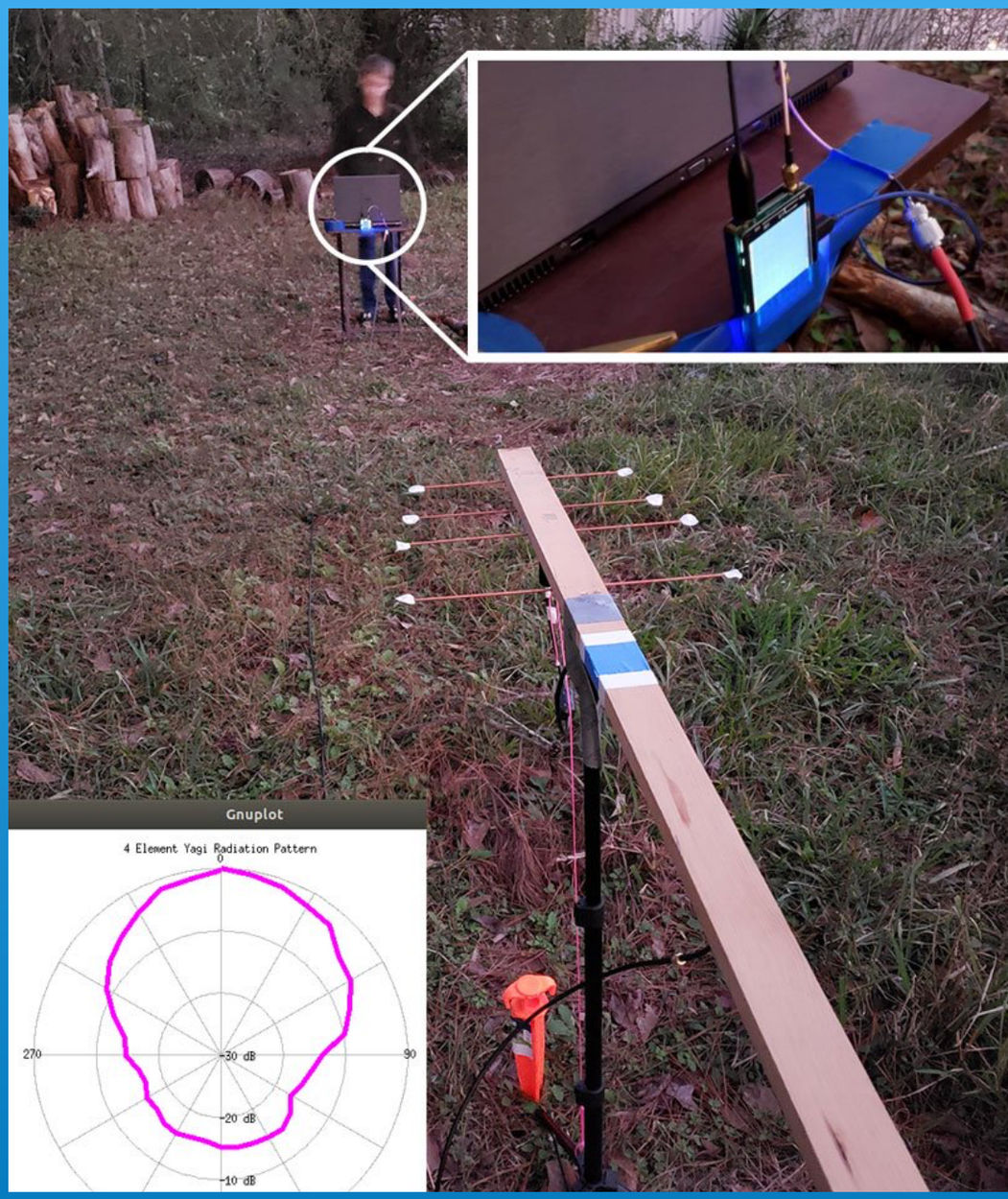
Antenna Pattern

Set up antenna with NanoVNA outside the near field

Connect the Yagi to the TX ChO port of the NanoVNA via a long coax cable, and connect an omnidirectional whip antenna to the RX Ch1 port of the NanoVNA

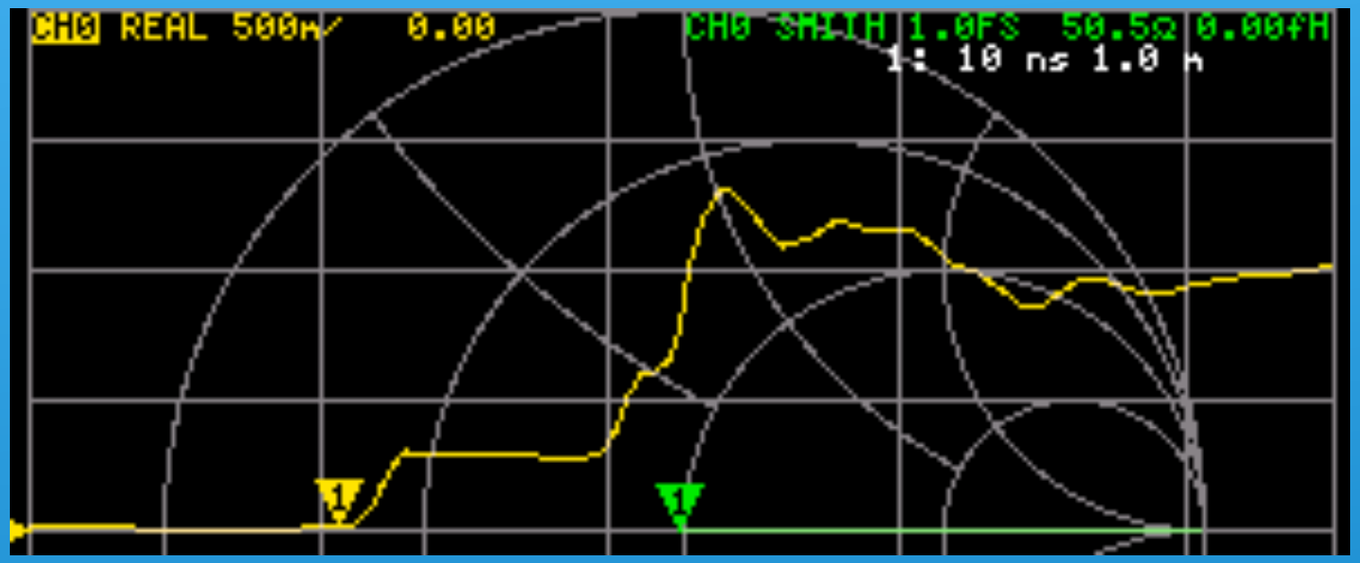
Measure collect S21 reading over multiple rotations of Yagi

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 PC Software

There are several great companion PC tools from third-parties

NanoVNASaver by mihtjel (recommended)
https://groups.io/g/nanovna-users/wiki/home#NanoVNASaver

NanoVNASharp Windows software by hugen79

NanoVNA WebSerial/WebUSB by cho45

Android NanoVNA app by cho45

TAPR VNAR4 supports NanoVNA by erikkaashoek

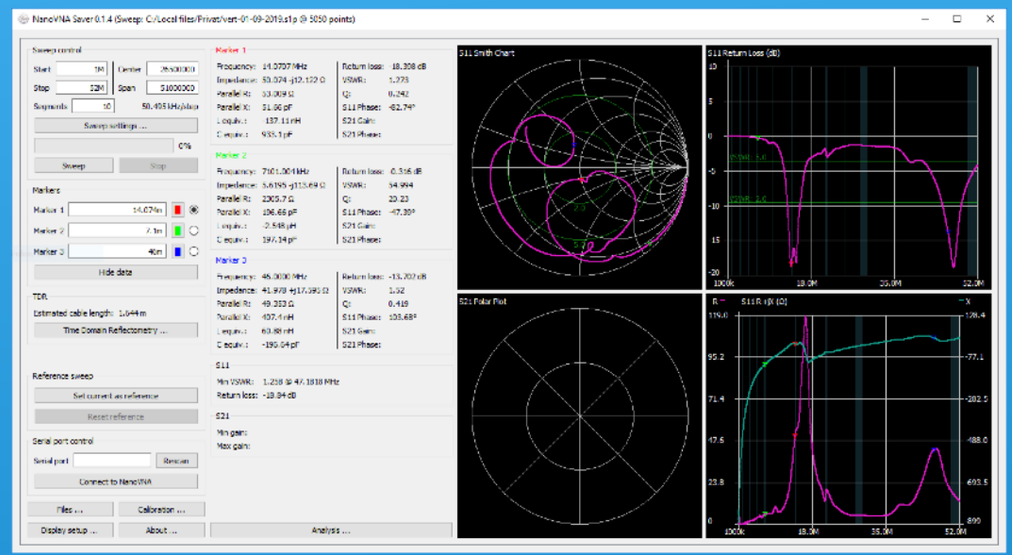
NanoVNASaver

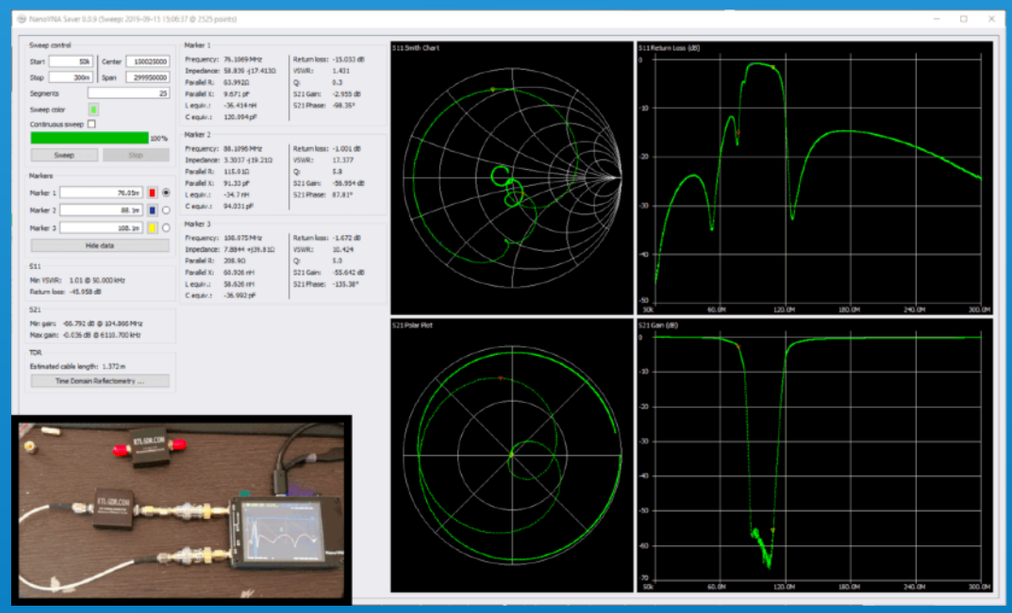
NanoVNASaver
A multi-platform tool to save Touchstone files from the NanoVNA, sweep frequency spans in segments to gain more than 101 data points, and generally display and analyze the resulting data.

Introduction
This 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 and VSWR-charts, for both S11 and S21
Displaying markers, and the impedance, VSWR, Q, equivalent capacitance/inductance etc. at these locations
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





Sources & Links

NanoVNA Introduction video
https://www.youtube.com/watch?v=8kx9SWbEcXI

NanoVNA groups.io Forum:
Documentation & Update Files: https://groups.io/g/nanovna-users/files
Knowledge-based Wiki: https://groups.io/g/nanovna-users/wiki
Group Home: https://groups.io/g/nanovna-users

NanoVNA “Manual”
http://www.gunthard-kraus.de/fertig_NanoVNA/English_NanoVNA%20V1.5._final.pdf

Smith Chart intro video
http://www.antenna-theory.com/tutorial/smith/chart.php#introduction

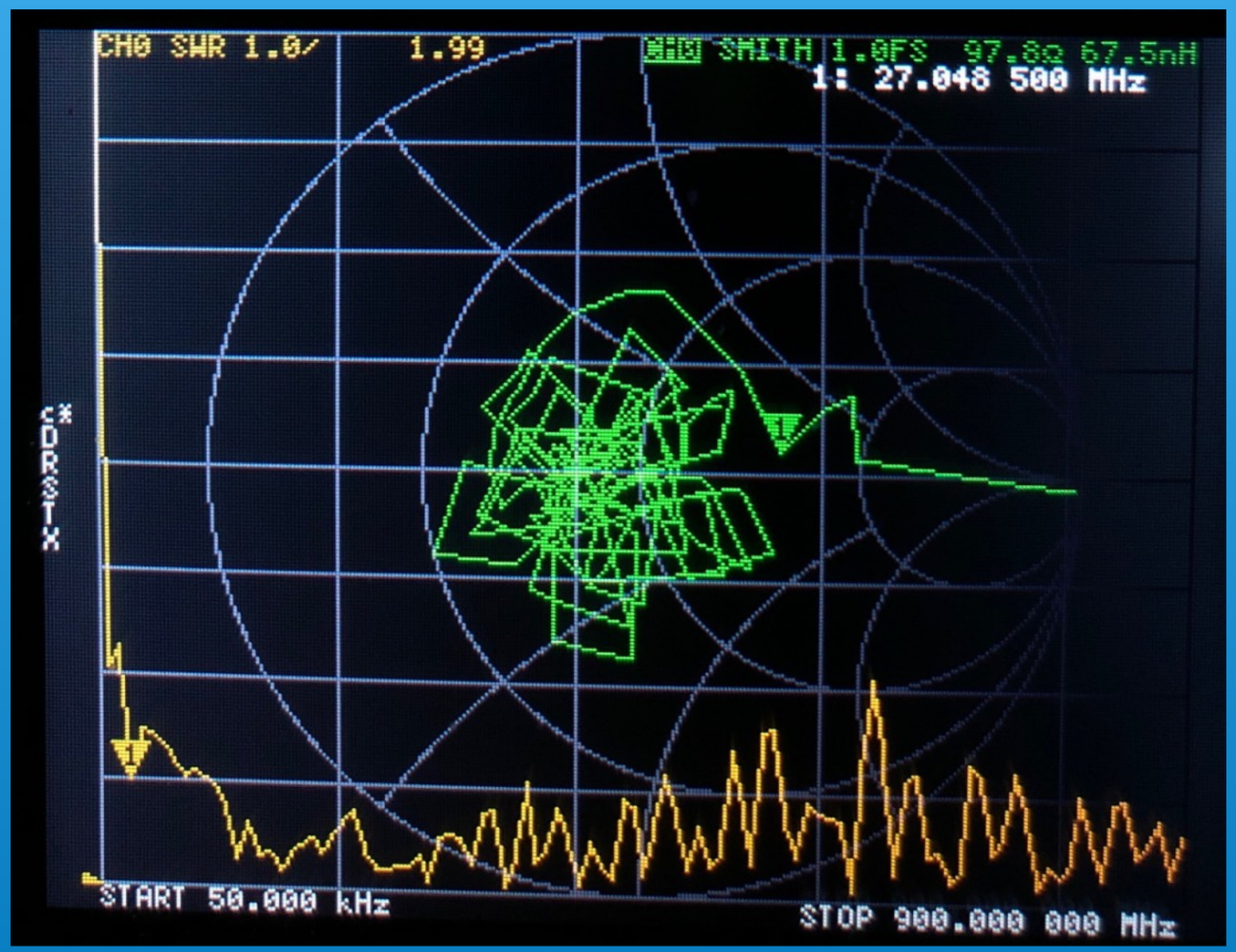
NanoVNA Saver by Rune B. Broberg / 5Q5R
https://zs1sci.com/blog/nanovnasaver/

NanoVNA Saver GitHub link - download
https://github.com/mihtjel/nanovna-saver/releases

NanoVNA Sharp and more!
https://www.youtube.com/watch?v=zw7Dp1nwvD8 & https://drive.google.com/drive/folders/1-JViWLBOIzaHTdwdONX2RP8S4EgWxoND

NanoVNA WebApp (Android)
https://play.google.com/store/apps/details?id=net.lowreal.nanovnawebapp&hl=nl

Test Question
Name of this antenna type?



Q & A

- What kind of pig tails can be used to connect NanoVNA?
- How can you transfer data from NanoVNA?
  “Pause Sweep", and the data is saved in the nanovna nice trick, but it will works until power off…or Use PC SW to store data

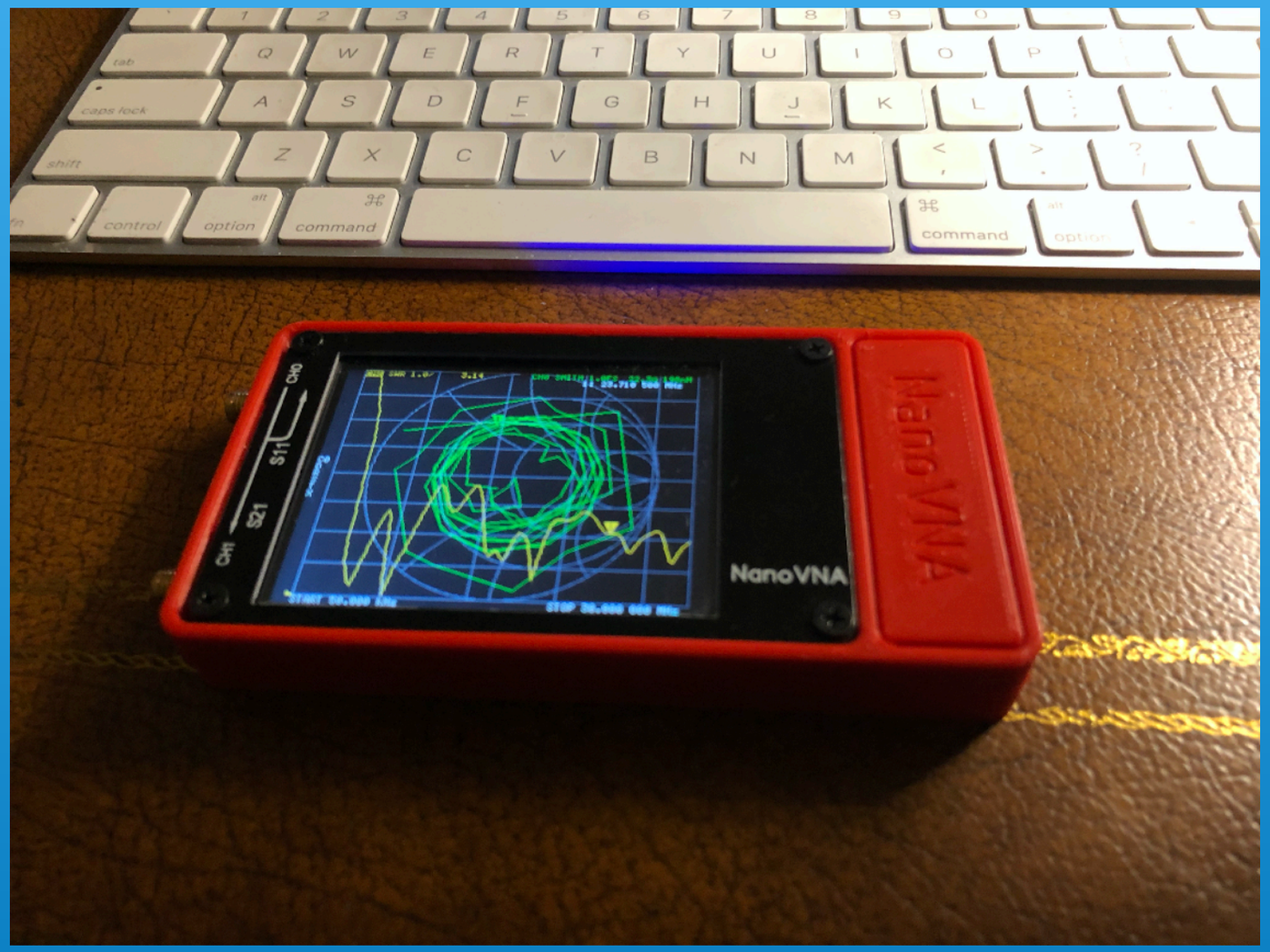
Notes for sourcing

3.4 version 650mAh battery Original Hugen NanoVNA-H 2.8" Touchscreen Vector Network Analyzer HF VHF UHF Antenna Analyzer
https://www.alibaba.com/product-detail/3-4-version-650mAh-battery-Original_62342877955.html?spm=a2700.7724838.2017115.1.506b1b80T9cUaF&fullFirstScreen=true

4.2 version 1950mAh battery Original Hugen NanoVNA-H4 4.0" Touchscreen Vector Network Analyzer HF VHF UHF Antenna Analyzer
https://www.alibaba.com/product-detail/4-2-version-1950mAh-battery-Original_62455845943.html?spm=a2700.galleryofferlist.0.0.51cb5a4bLLLaU8

Very good review, by hwalker, of the newest Hugen version 4 NanoVNA
https://groups.io/g/nanovna-users/message/10012

My NanoVNA

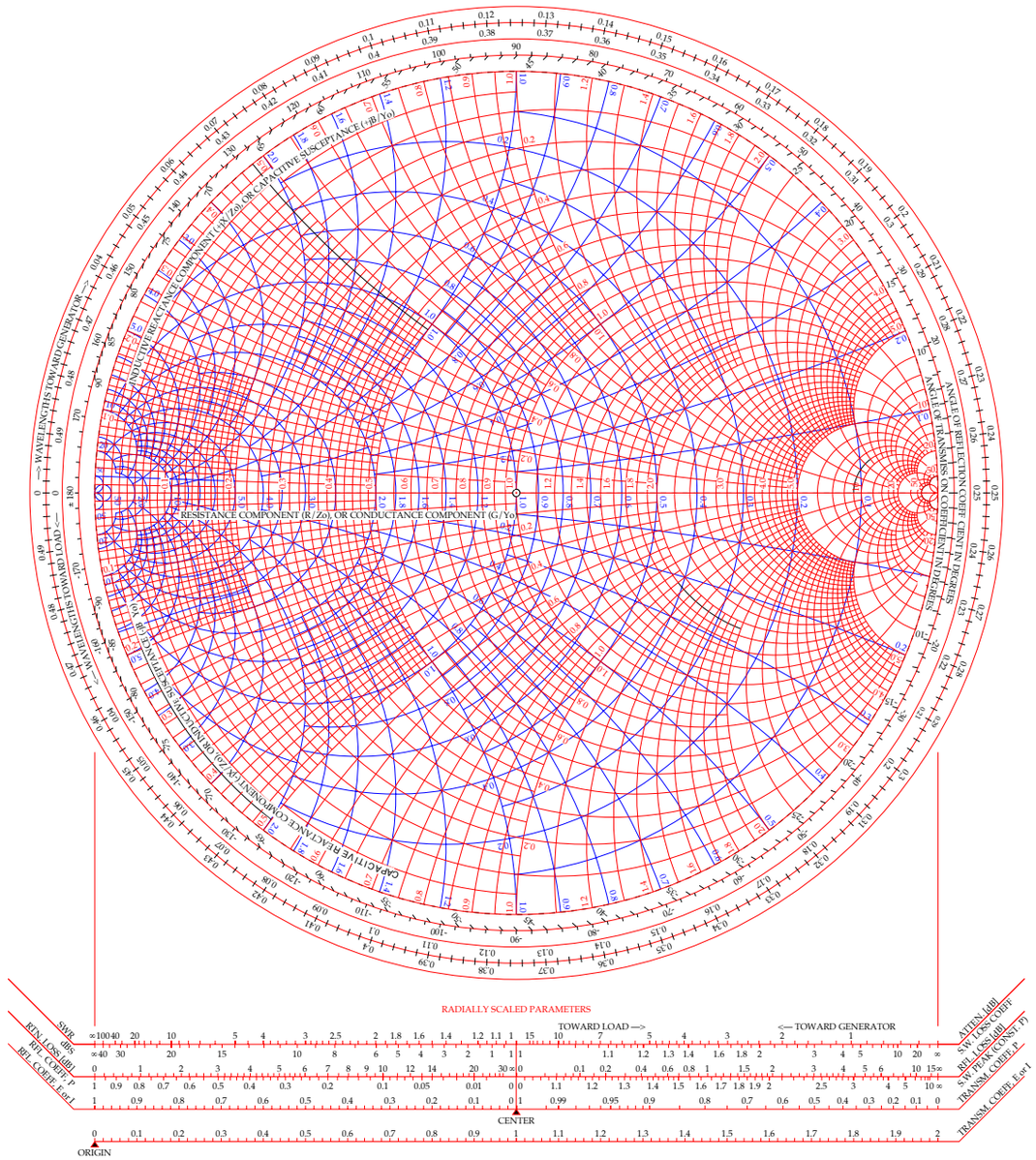


OCF dipole 80-10 meters

Smith Chart

NAME	TITLE	DWG. NO.
		DATE
SMITH CHART	Courtesy of Microwaves101.com	

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



RADIALLY SCALED PARAMETERS