SO YOU BOUGHT A NANOVNA?

CORC TechNet Presentation – 9/27/2020

N8ME


NanoVNA
Very tiny handheld Vector Network Analyzer
CH0
S11
S21
CH1
NanoVNA

SO WHAT IS IT?

- Most hams will use it as a graphical antenna SWR analyzer.
- Can be used to design and tune filters, chokes and other RF hardware.

ANTENNA SWR ANALYSIS

- SWR or standing wave ratio measures how well the antenna system impedance is matched to the RF source.
- When the impedance of the source and antenna matches, the maximum energy is transferred (good thing).
- When there is an impedance mismatch, some of the energy is reflected back to the source (bad thing).
- The SWR formula is designed so a value of 1:1 indicates a perfect match (no reflected energy).
- If enough energy is reflected back, bad things can happen to transmitter finals.

SOME HAMS OBSESS ABOUT LOW SWR

- A low SWR only tells you that the antenna system impedance is matched to the transmitter impedance.
- It doesn't tell you how well the antenna radiates that energy to the ether.
- For example, a dummy load shows a very low SWR over a wide frequency range, but it's not a very good antenna (by design).
- A ¼ wave vertical without radials may show a low SWR over a wide frequency range but most of the energy goes to keeping worms warm. As you add radials, the low SWR range gets narrower, but the antenna radiates better (i.e. you hear and are heard better).

TRANSCEIVER SWR MEASUREMENT

- Transceivers monitor (so they can reduce power to protect the finals if the reflected energy gets too high) and measure SWR using a SWR bridge.
- It compares the power transmitted to the power reflected by measuring forward and reflected voltages
- A problem when tuning antennas is that significant RF is generally transmitted which can cause QRM.

MFJ 259 ANALYZER

MFJ 259

- Revolutionary when it was released (over 20 years ago, BTW)
- Consumer grade antenna analyzer at a reasonable price (~$300)
- Works by generating a low level RF signal (a few mW) and measuring the reflected RF
- RF frequency is adjustable
- Standard equipment in many ham shacks, as well as commercial radio
- Low power, less QRM (but not none, with the right antenna, enough to kerchunk the repeater), even if all the power is reflected back, not enough to damage the RF source. Of course you can fry it if you transmit into it (so be careful with antenna switches).

MFJ 259

There are many adaptations and enhancements to the basic 259

- Color screen
- Graphical display
- Still basically the same electronic guts

VNA

Vector Network Analyzer

- Measures not only the amount of reflected energy, but also the phase difference with the transmitted signal, hence “vector”
- Also, depending on the device under test (DUT), you can measure more than just reflected energy. In the case of a filter, can measure the energy coming out of the device.

DEVICE UNDER TEST (DUT) NOTATION

- The DUT can have one port in which case, only energy reflected is measured, or it can have multiple ports in which case energy coming out of other ports can be measured.
- The common notation is S with two numeric subscripts (although in a lot of cases the numbers are not written as subscripts: i.e. S11 or S21.
- The first subscript is the port being measured (the responding port). The second subscript is the port where RF is injected (the incident port).
- S11 means the incident and responding ports are the same, such as an antenna system.
- S21 means the incident and responding ports are different, such as a filter.
- You can have a higher number of responding ports (i.e. S31, S41), but these are usually laboratory instruments.

LABORATORY VNA'S

- Laboratory VNA's have been around for decades. The are expensive.
- The have precisely calibrated RF sources and receivers

THE BREAKTHROUGH

- The breakthrough enabling today's NanoVNAs was first published in the 2007 and 2009 QEX's by DG8SAQ.
- He realized that by mixing the signals (both incident and response) with a local oscillator, output frequencies in the near-audio range could be generated and these audio signals could be digitized by the two channels on a sound card and analyzed on a PC.

OBTAINING THE PRODUCT

- Initially, the NanoVNA's were only available via direct import from China.
- I bought my NanoVNA-F from AliExpress and had to tell my Credit Card company that yes I was sending money to AliExpress
- Buyer's needed to be aware of the possibility of bad clones
- I lucked out and everything went okay with my transaction and even though I bought from a different retailer (because BH5NHU's web store was offline), I did end up buying from a legitimate reseller and have a genuine model (Leon verified my serial number for me).
- It took about 4 weeks to get mine in November 2019.

US HAM STORES

- Fortunately US ham stores are now importing the units, although they may be tough to keep in stock.
- US hams can buy from someone stateside and be sure of who they are dealing with and what they are getting.
- I predicted that (had there been Hamvention® 2020) that any vendor who could bring a truckload of them would sell out.

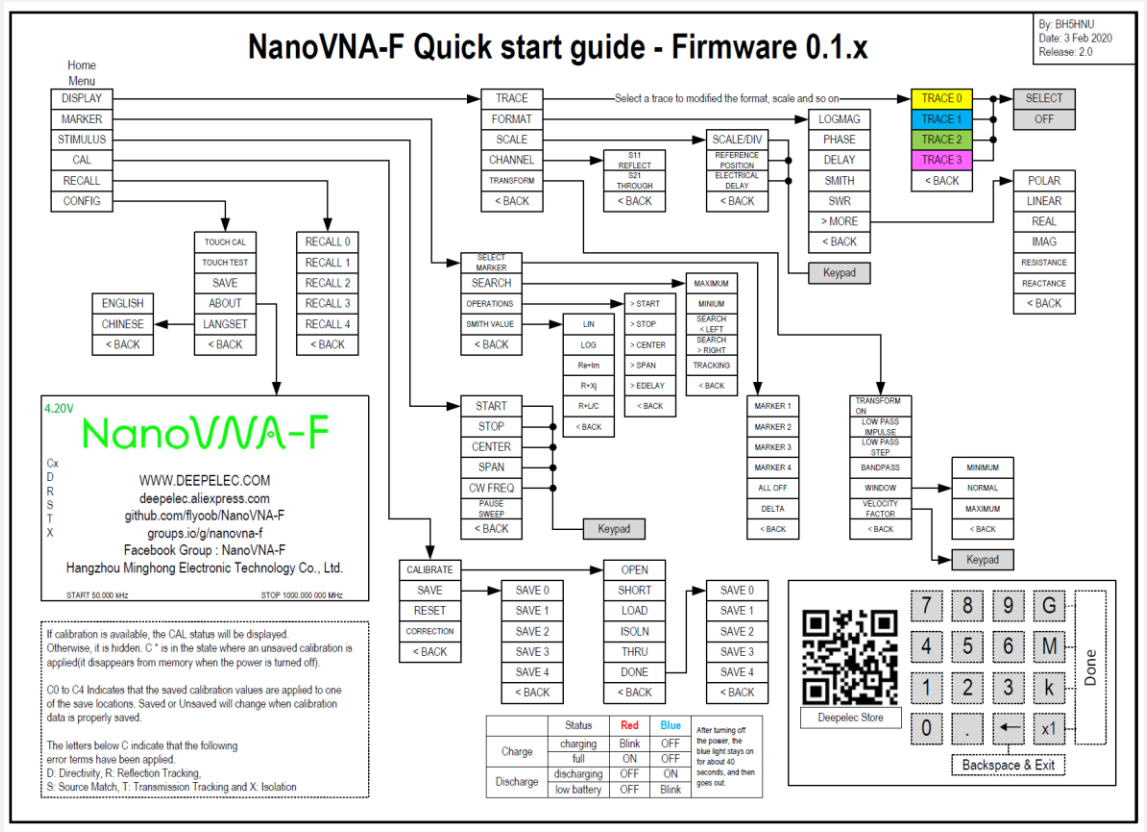
PRODUCT DESCRIPTION

- Color LCD touch screen
- On off switch
- Rocker / toggle switch (or three buttons on the latest F design)
- USB-C port for charging the battery and communicating with a PC
- Two SMA connectors
  - S11 (S-one-one, not S-eleven)
  - S21 (S-two-one, not S-twenty-one)
- USB A port on the F model to use the internal battery as a battery bank to power your cell phone

INCLUDED ACCESSORIES

- USB-A to USB-C cable
- Calibration tools:
  - short
  - load
  - open
  - SMA-SMA cable
- Quick-start guide (showing menu tree)
- NO MANUAL

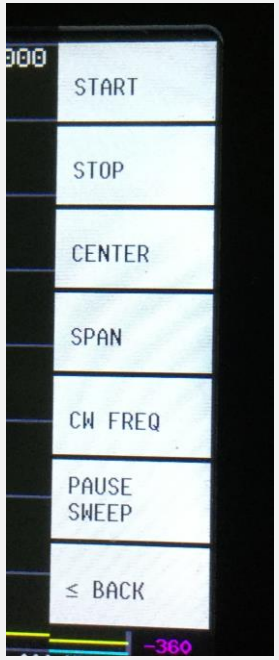
QUICKSTART GUIDE

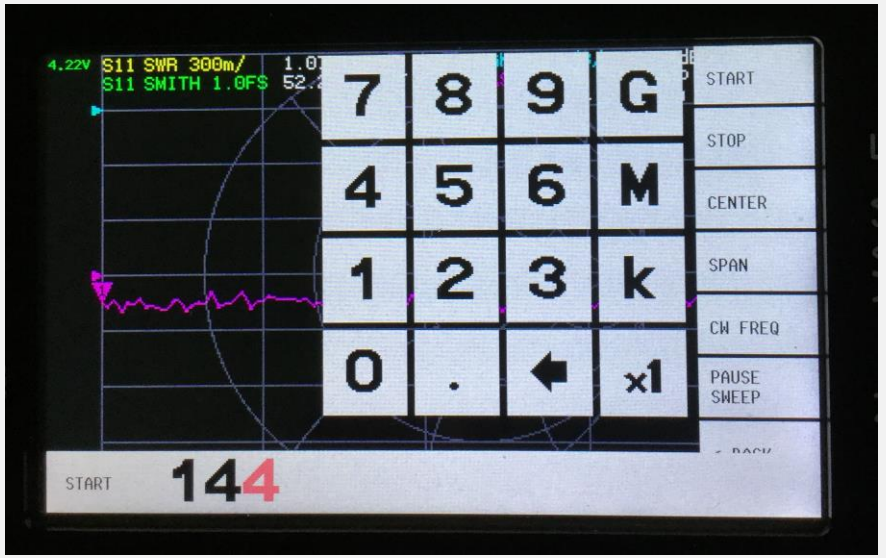


TOUCH SCREEN

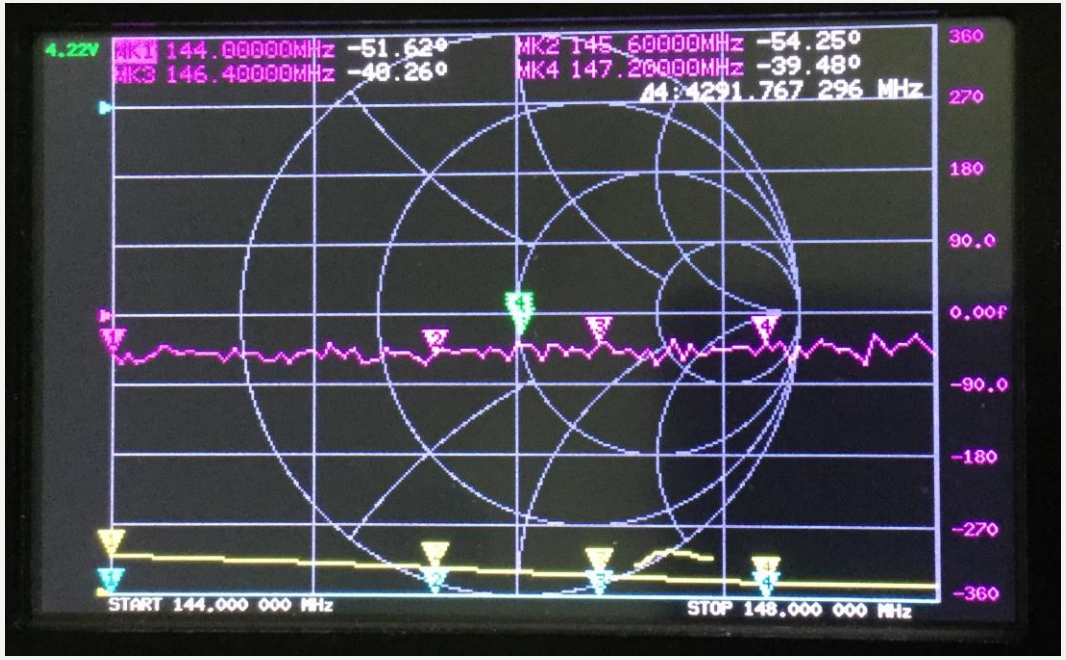
- I found that it's easier to use a rubber tipped stylus than my fat fingers. I have a freebie ball-point pen with a rubber stylus on the other end that works just fine.
- Once the unit is on, touch anywhere on the right side of the screen to bring up the menu system. It's a tree structured menu. The menu usually remembers where on the tree you were the last time you used the menu.

MENU EXAMPLES

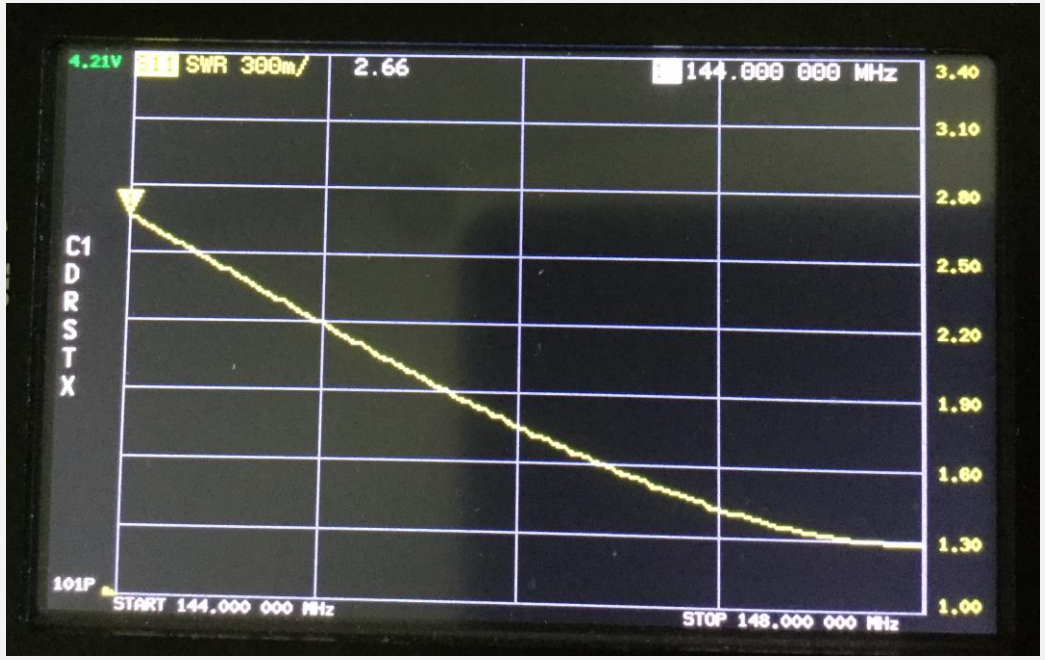




DECLUTTER MAIN SCREEN

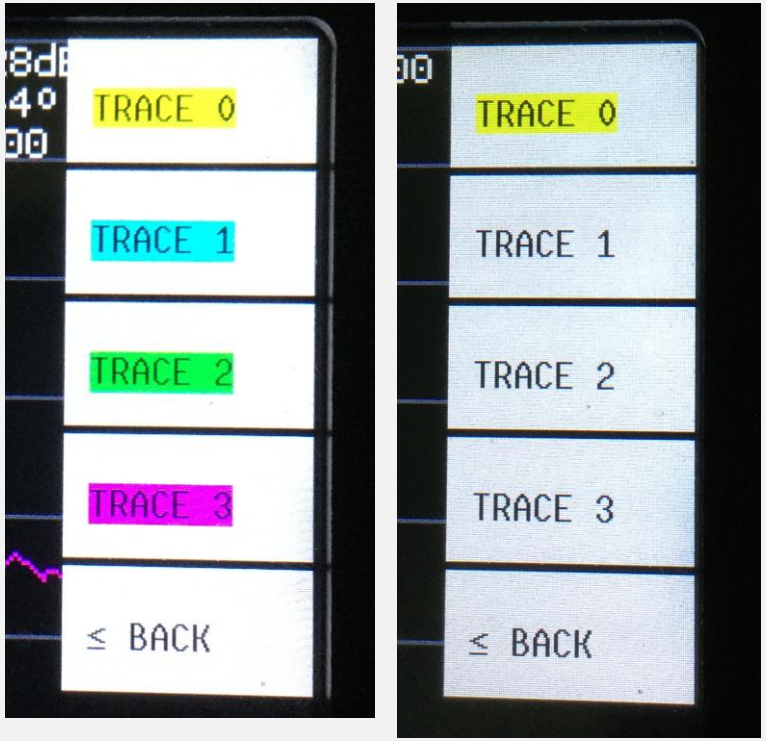


DECLUTTER MAIN SCREEN



TURN OFF TRACES 2,3 AND 4

- Use DISPLAY | TRACE
- One touch selects, the second touch turns off the color (and the trace)



TURN OFF MARKERS 2,3 AND 4

- Use MARKER | SELECT MARKER
- Touch markers 2, 3 and 4 to turn off

CHANGE THE DISPLAY FORMAT TO SWR

- Use DISPLAY | FORMAT | SWR

SAVE YOUR SETUP

- If you cycle the power now, the NanoVNA will likely redisplay the extra clutter.
- The only way I have found to save the setup is to save a calibration. If you are using a saved calibration when you turn of the NanoVNA, it will restore that display when you power on again.

CALIBRATION TOOLS

CALIBRATION

- Since this isn't a laboratory grade instrument, component variations can affect the accuracy.
- With proper calibration, results compare favorably to laboratory grade instruments, at least close enough for most ham usage.
- You are actually calibrating everything up to where the calibration plugs are used. For HF the cabling to the calibration probably has insignificant effects on the results. Be careful with UHF.
- You don't need to run a calibration every time you use the NanoVNA.
- You can save up to 5 (0 – 4) calibration setups. For example one calibration for each of 5 different bands.

FREQUENCY RANGE

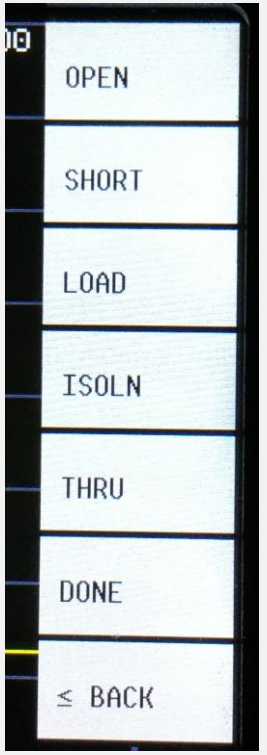
- The NanoVNA can scan bandwidths up to about 1.5 GHz.
- However, it only samples 101 points in the selected bandwidth, thus if you have a range of 100 MHz, each step is 1 MHz
- Usually it's best to select a smaller range. For example with a 500 kHz range for 80m, each step is only 5 kHz

CALIBRATION

- Specify the desired frequency range.
- Use STIMULUS | START and enter the frequency with the keypad.
- Repeat with STIMULUS | END.

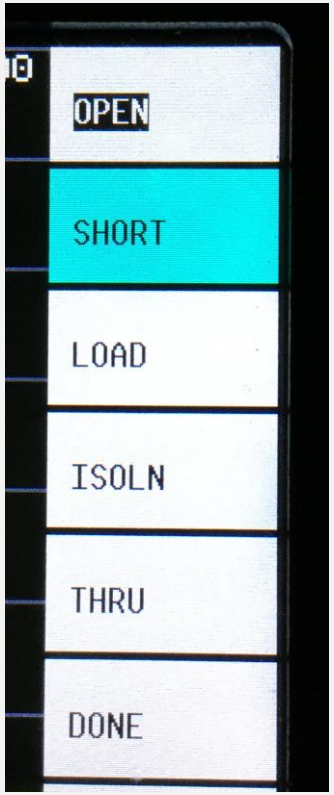
CALIBRATION

- Use CAL | RESET to erase the current calibration
- Use CAL | CALIBRATE to display the menu. You calibrate up to 5 different items.
- Connect the open slug to S11 and press OPEN



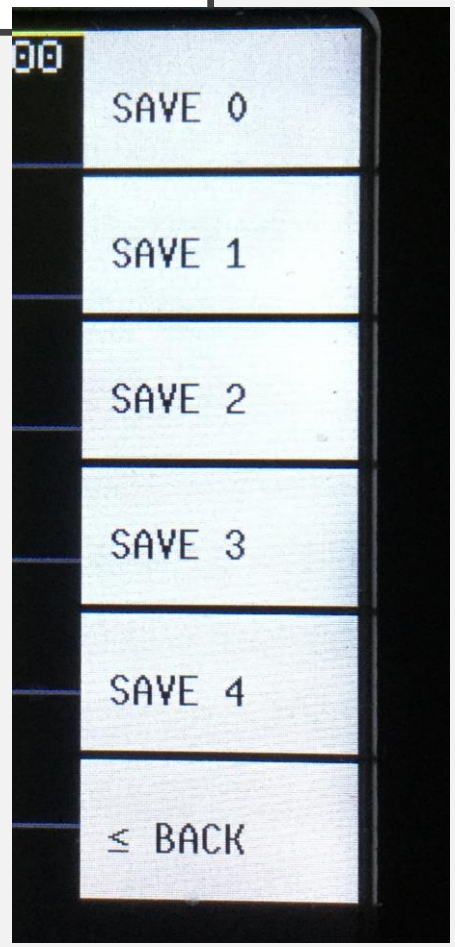
CALIBRATION

- Once you tap OPEN, the OPEN calibration is run and the menu moves to the next step, SHORT
- Replace the open slug with the short slug and press SHORT
- Replace the short slug with the load slug and press LOAD
- At this point, if you only intend to use the NanoVNA as S11, you can press DONE
- Otherwise, remove the slug and press ISOLN (isolation). This measures how much energy leaks from S11 to S21 with no connection.
- Connect the SMA-SMA cable between the S11 and S21 ports and press THRU
- Press DONE



CALIBRATION

- Click the slot to save the calibration
- Saved calibrations can be recalled using RECALL from the top menu

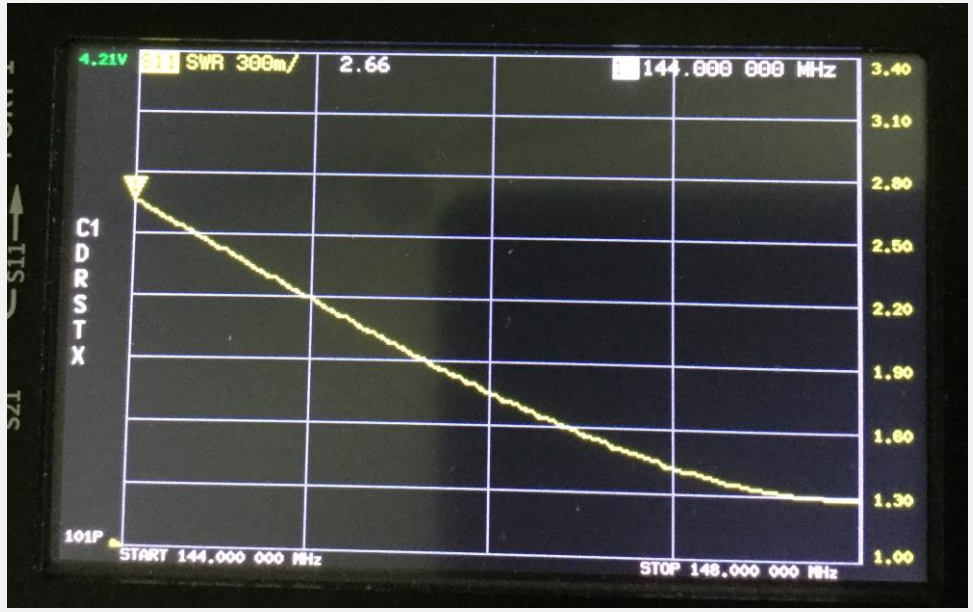


ANALYZE

- If your antenna doesn't have an SMA connector, you will need an adapter
- I recommend a short cable rather than just an adapter plug to avoid stress on the SMA connector
- Connect your antenna to the S11 port

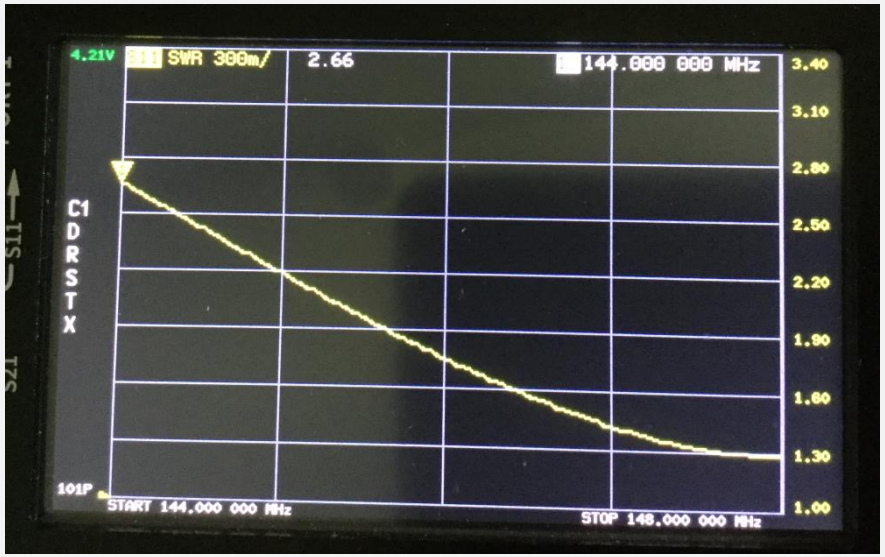
ANALZYE

- Unless you stop it, the NanoVNA is constantly scanning the selected frequency range. As you attach the antenna, you will see the display jump as the impedance change during the connection process.



ANALYZE

- The triangle is the marker.
- You can move the marker by rocking the rocker knob, but try not to press it as that activates the menu. You can always exit the menu and try moving the marker again.
- To me, the rocker switch press is a weaknes. I see that the newer NanoVNA-F replaced the rocker with 3 pushbuttons. That should be better.



ANALYZE

- You can pause the scanning, STIMULUS | PAUSE SWEEP to analyze the sweep data without it updating.

DISPLAY DISCUSSION

- Text at top – info about marker frequency
- Text at bottom – frequency scan range
- Text at right – scale
- Text at left – info about the current calibration
  - using calibration C1
  - DRSTX, which tools were used for calibration