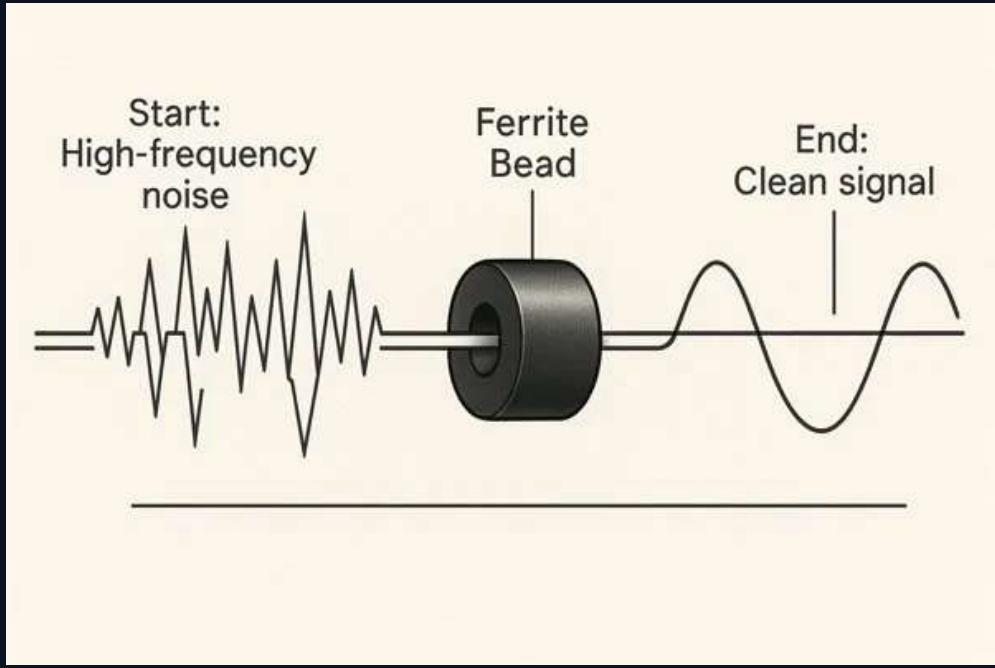
Measuring the Impedance of Ferrite Beads and Toroids



Rick Fletcher, W7YP
Flathead Valley Amateur Radio Club
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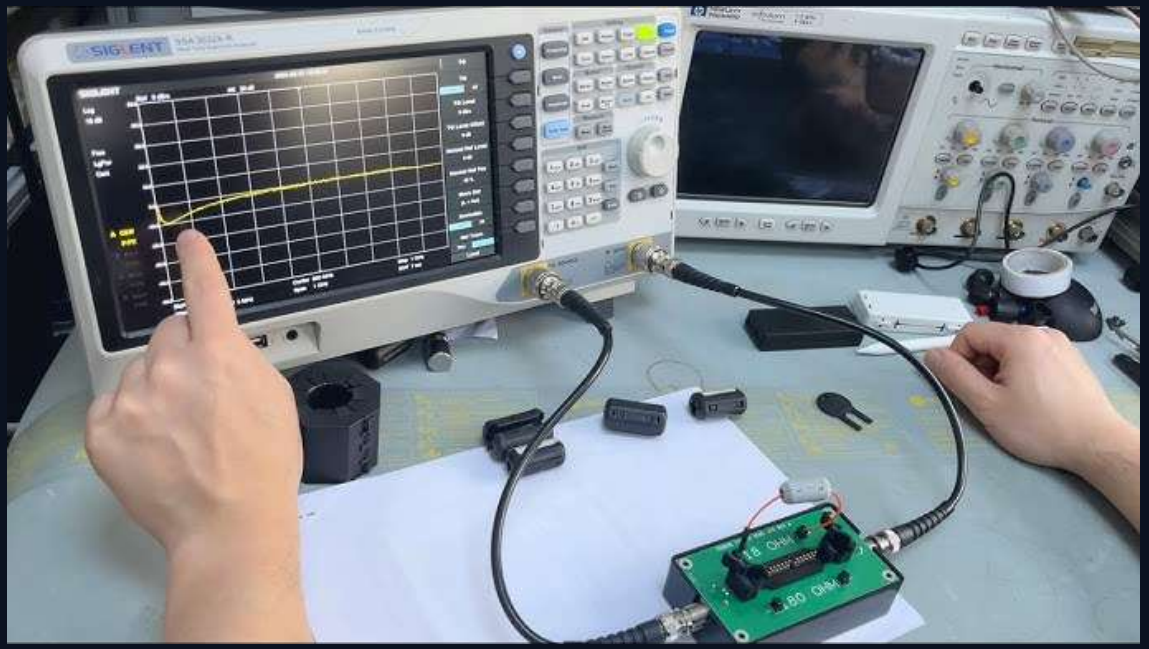
Topics

- Test station
- VNAs
- Test fixtures
- Calibrating and configuring VNA
- Taking measurements
- Review
- Q & A

Test Station

- Vector Network Analyzer (VNA)
- Test fixture
- Wire/coax test cabling
- Ferrite beads/toroids



Vector Network Analyzer

- A 2-port VNA has Port 1 and Port 2 (“0” and “1” on some VNAs)
  - Simultaneously measures magnitude and phase (“vector”)
- Four fundamental measurements:
  - Forward reflection (S11): How much RF signal transmitted from Port 1 is reflected back to Port 1
  - Forward transmission (S21): How much signal entering Port 1 emerged from Port 2
  - Reverse Transmission (S12): How much signal entering port 2 emerged from Port 1
  - Output reflection (S22): How much RF signal transmitted from Port 2 is reflected back to Port 2

Hobbyist Examples (< $300)

- Basically 3 “safe” affordable hobbyist grade VNAs:
  - NanoVNA-H4/H ($90-130)
  - NanoVNA V2/SAA-2N/-F V3 class ($120-299)
  - LiteVNA 64 ($180-246)
- Recommended vendors:
  - R&L Electronics
  - Nooelec
  - Radioddity
  - AURSINC or SEESII on Amazon

What To Avoid

- Very cheap anonymous Amazon/eBay NanoVNAs
  - Counterfeit or poorly-built clones are very common
- Anything claiming unrealistic GHz performance for a very low price
- “No-name” versions with altered firmware
- Original NanoVNA V1, if you care about UHF/microwave accuracy
- Listings that don’t identify the actual hardware version

Vector Network Analyzer (cont.)

- 90% of amateur VNA work is:
  - S11 for:
    - Antenna SWR and return loss
    - Feedline matching
    - Tuning matching networks
    - Measuring resonant frequency and impedance
  - S12/S21 for:
    - Filter testing/tuning
    - Amplifier gain
    - Feedline loss
    - Duplexers and Cavities
    - Crystal filters

SEESII NanoVNA-H4 V4.4

- 9kHz – 1.5GHz
- 4” LCD touchscreen
- MicroSD card slot
- 70+ dB dynamic range
- Calibration kit
- Accessories with case
- $92 at SeeSii Store on Amazon:
  - https://tinyurl.com/ye5945rt
- $93 at Radioddity

NanoVNA V2/SAA-2N/”F V3”

- AURSINC NanoVNA SAA-2N V2.2
  - 50kHz – 3GHz
  - 4” touchscreen
  - Calibration kit
  - Cables, adapters and bag
  - $110 at AURSINC store on Amazon:
    - https://tinyurl.com/bdvrpt52

LiteVNA 64

- 50kHz – 6.3GHz
- 4” touchscreen
- MicroSD slot
- Calibration Kit
- Adapter cables/adapters
- Pick (for touchscreen)
- $179 on Amazon:
  - https://tinyurl.com/3vxrb9uf

SEESII NanoVNA-F V3

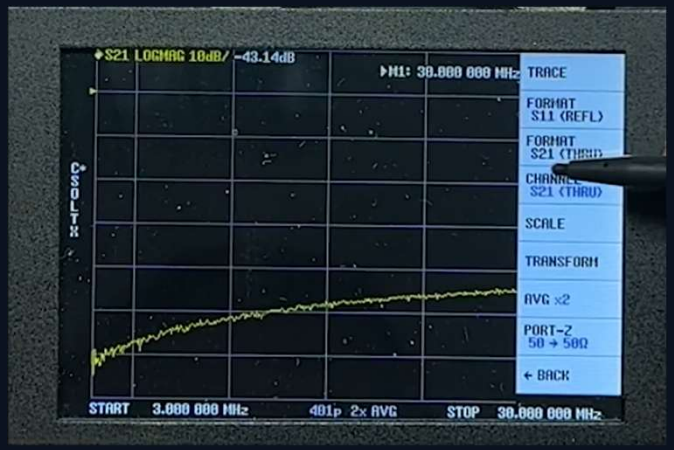
- 1MHz – 6GHz
- 4.3” touchscreen
- Calibration kit
- Cables and adapters
- Stylus
- $299 at SeeSii Store on Amazon:
  - https://tinyurl.com/5ycxa373

!!! WARNING !!!

Always ensure that you and whatever you're connecting to the ports on the VNA are not carrying a static electric charge!

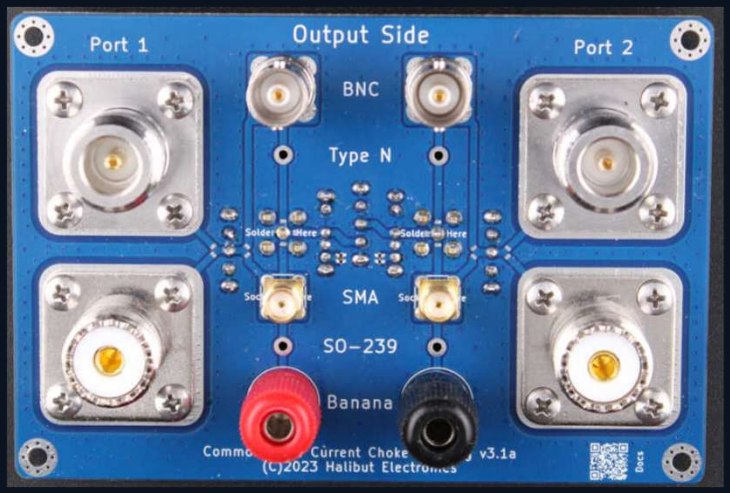
Calibrating and Configuring VNA

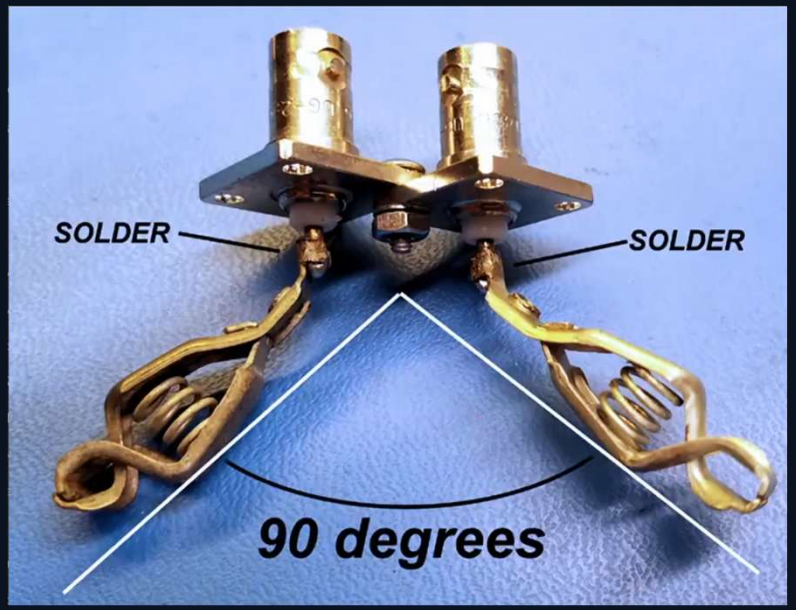
- Calibrate VNA: Open, Short, and 50Ω Load
  - Simply select “Thru” measurement, if your VNA offers that
- Set start and end frequencies of interest
- Select S12/S21 logarithmic magnitude (LOGMAG) trace display
- Set scale, if desired



Test Fixtures

- Halibut Electronics (Kit: $59)
- SMA Male to Dual Alligator clips
- Pair of BNC/SMA Bulkhead Connectors Soldered Together





Taking Measurements

Thanks to the YouTube channel “Electronics for the Inquisitive Experimenter”

https://www.youtube.com/watch?v=DC8WcPjBVk0&t=5s

Review

- An inexpensive VNA and a DIY test fixture is all that's required to test ferrite beads, toroids and chokes
- The mix type can usually be determined by the frequency range of the maximum common mode current suppression
- Actual suppression levels at specific frequencies can be accurately measured
  - At least 20 dB of suppression will fix most RFI problems
- A VNA can also be used to test filters, tune duplexers, test diplexers and measure return loss on transmission lines and antennas
- Using TDR, some can measure the length of coax and the distance to faults in a transmission line

“Trick” Question

Q: Should shielded ethernet cables always be used around amateur radio transmitters?

A: Not necessarily. If improperly grounded, shielded cable can conduct RF between devices, create ground loops, and worsen common mode currents. CAT6/6A is usually good enough.

Q&A

References

- Evaluating Clip-on Ferrite Beads With Your VNA
  - https://www.youtube.com/watch?v=DC8WcPjBVk0&t=5s
- How To Properly Measure Common Mode Chokes With A NanoVNA
  - https://www.youtube.com/watch?v=AyURuo0UEdE
  - Demonstrates using the Halibut test fixture
- How To Measure Ferrites using a NanoVNA
  - https://www.youtube.com/watch?v=LGwgn_0ADUI