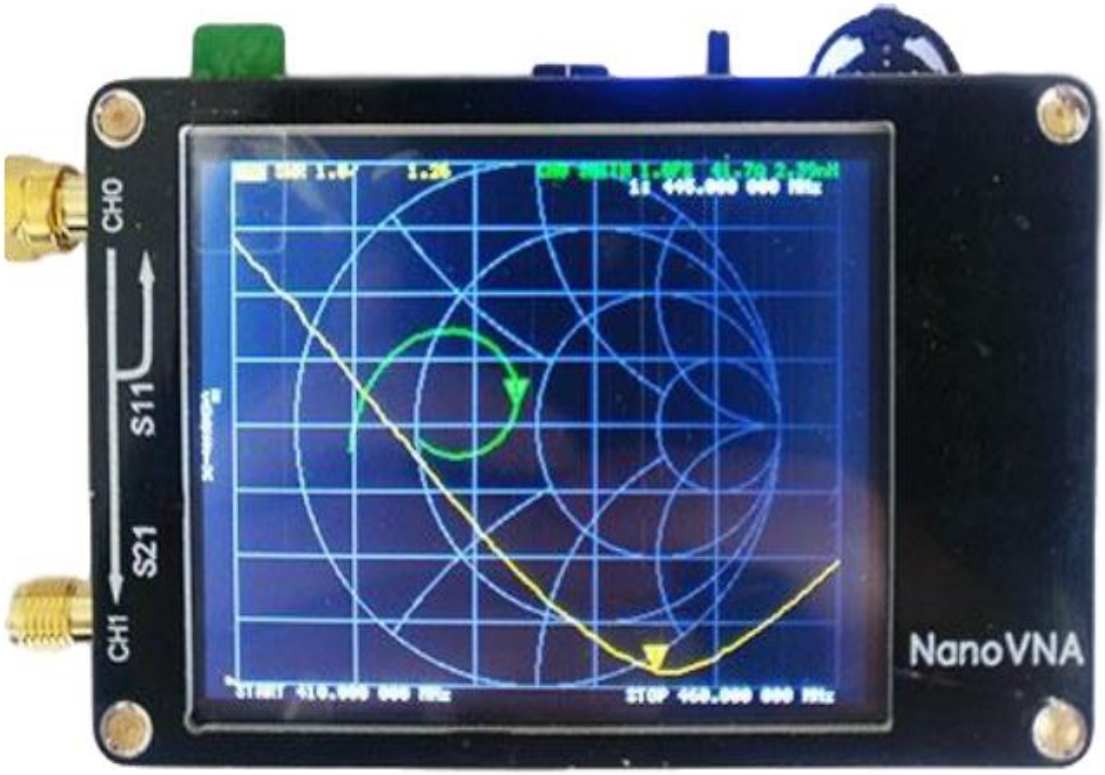
Nano VNA

Introduction to the Nano Vector Network Analyzer



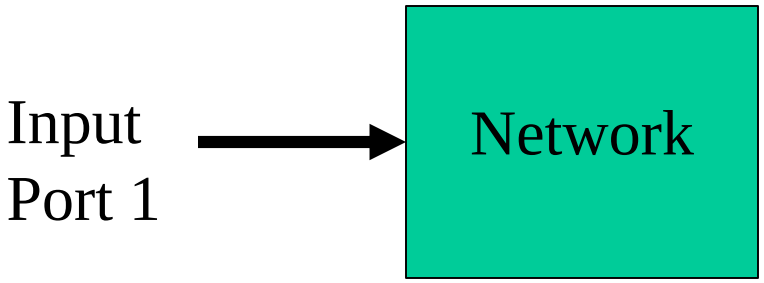
Greg Algieri WA1JXR

Presentation Outline

- What is a Network? One Port, Two Port?
- How can we measure in RF networks? S-Parameters
- What is a Vector Network Analyzer?
- How does the Vector Network Analyzer work?
- Why do you need to Calibrate the Network Analyzer
- Short, Open, Load, Through Calibration Kit
- How to use the Nano VNA Menu and Displays
- Free PC software you can download and use
- Typical measurement applicable to Ham Radio
- Nano VNA Demo board and measurement Clinic

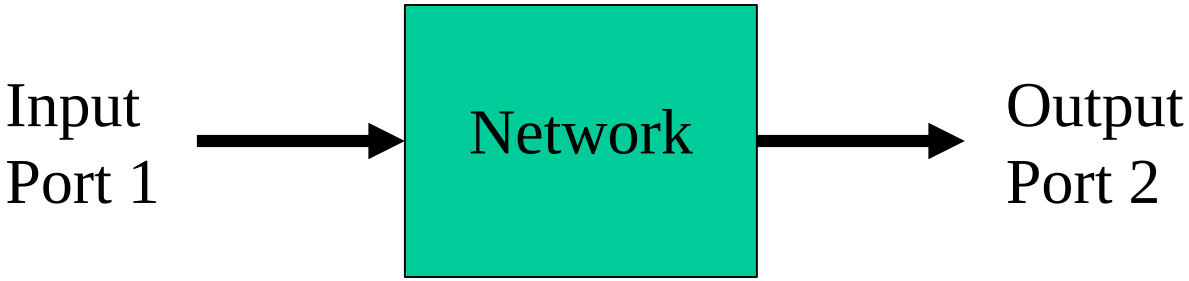
What is a Network?

- One Port Network
  - Typical One Port Network Devices
    - Amateur Antenna
    - RF Load
    - RF Transmission Line Open or Shorted Stub



What is a Network?

- **Two Port Network**
  - **Typical Two Port Network Devices**
    - **RF Amplifier**
    - **RF Transmission Line (Coax)**
    - **RF Filter**
    - **RF Phasing Stub Lines**



Measuring RF Networks

- With low frequency Audio and IF circuits we can measure the input and output voltage and current. Z, Y, and h parameters.
- With RF circuits we can measure incident, reflected and transmitted power. S (scattering) parameters.

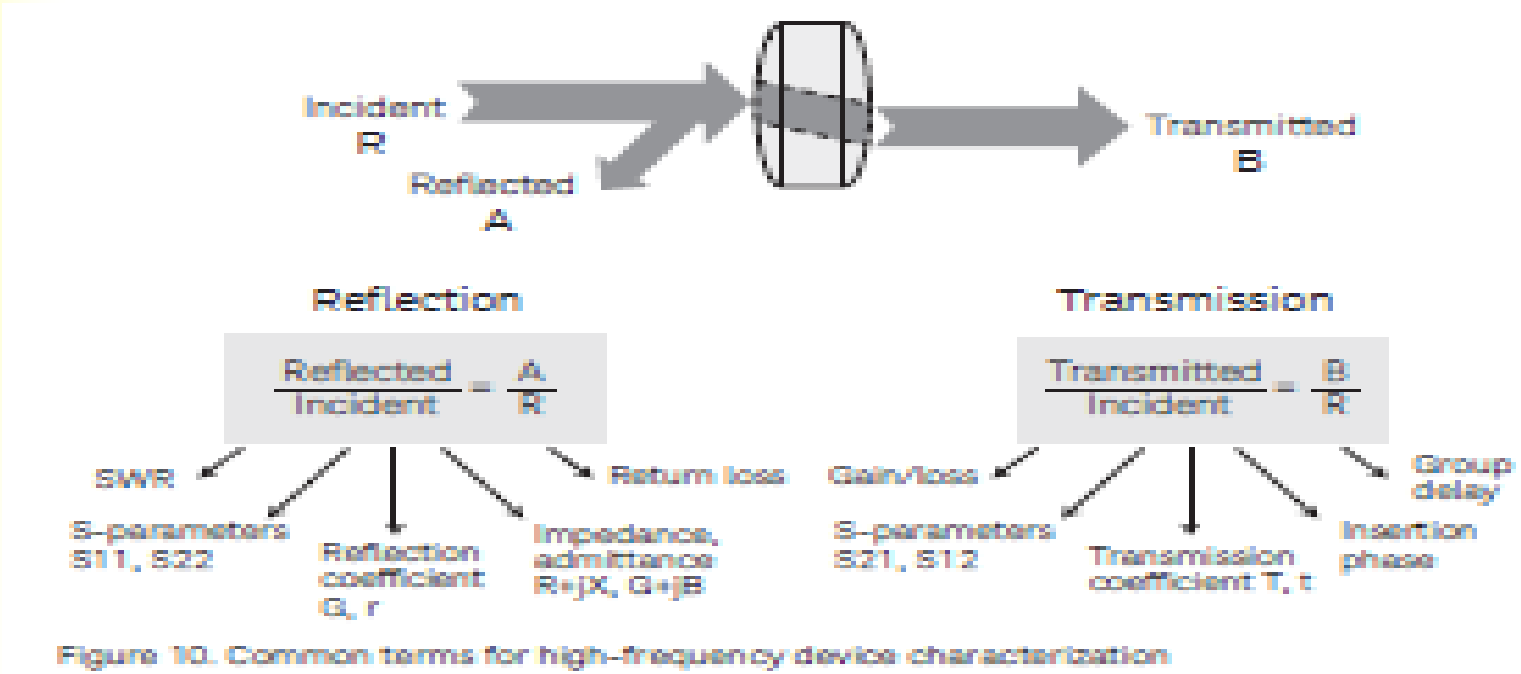
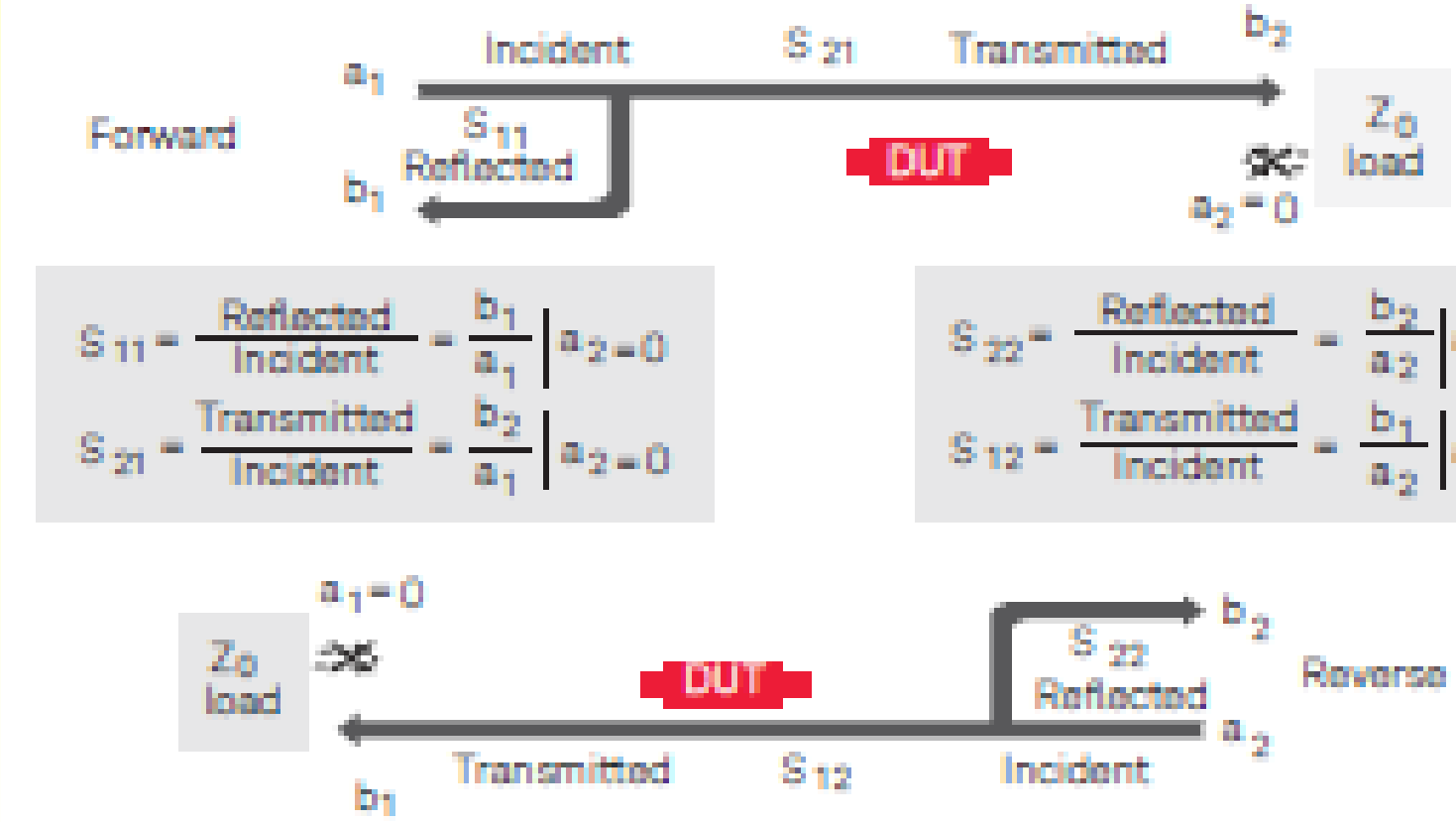


Figure 10. Common terms for high-frequency device characterization

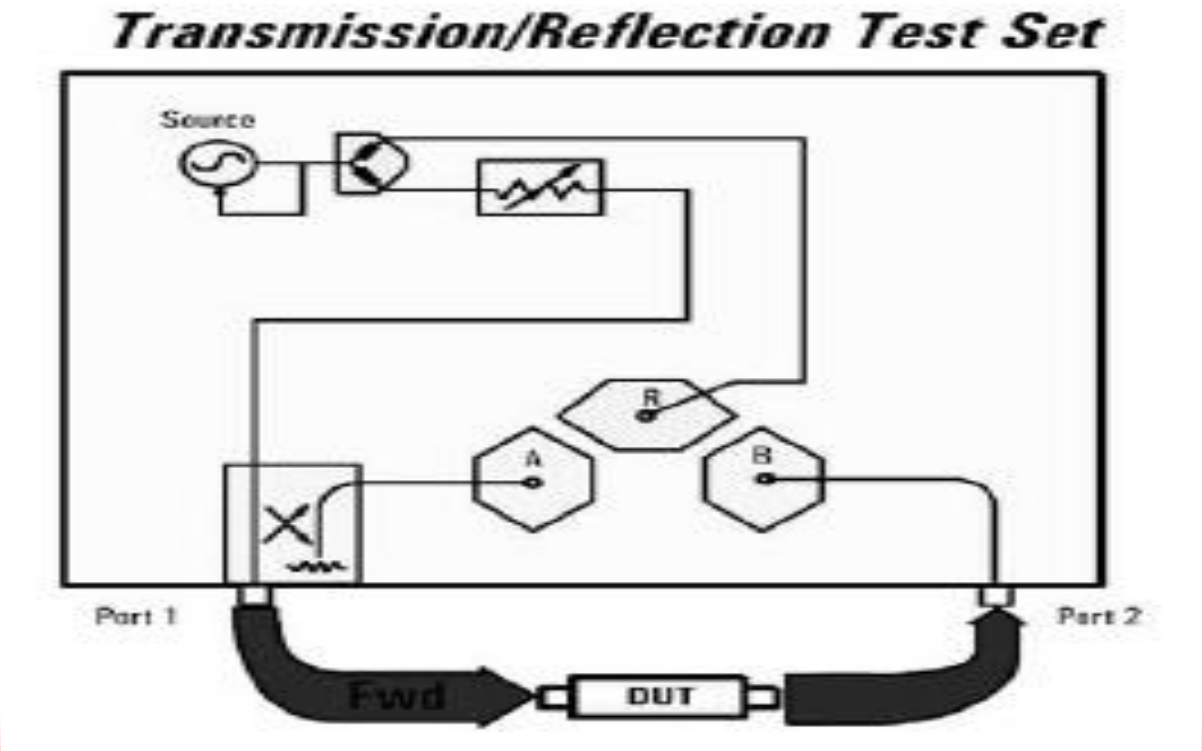
Network S – Parameter Measurement

- **Forward (S11,S21) and Reverse (S22, S12) Measurements**



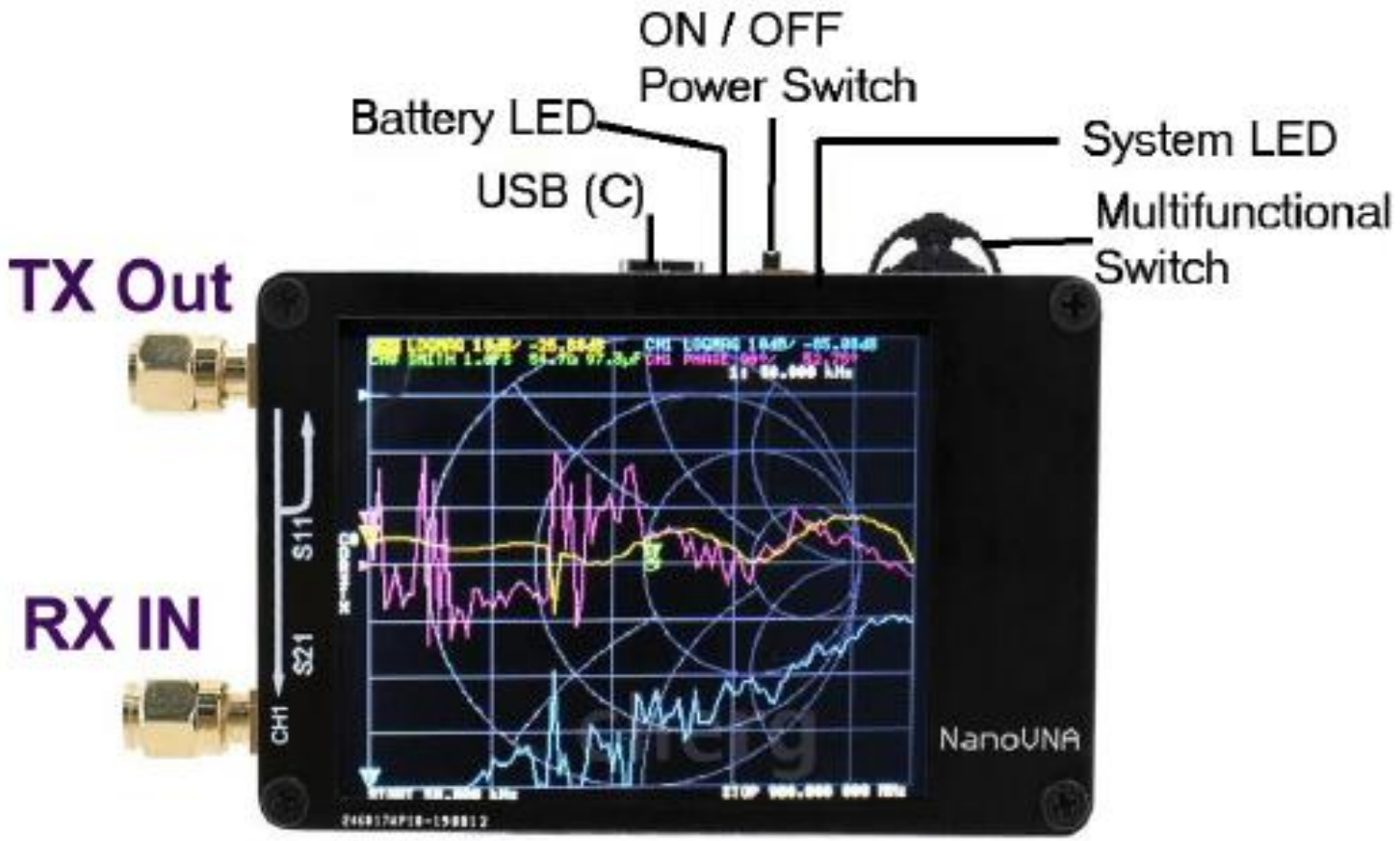
How a Vector Network Analyzer works

- **A, B, & R are RF Measurement Receivers that measure signal magnitude (strength) and phase (phase of the measured signal compared to reference signal)**



The Nano VNA

- **Controls and Connectors on the Nano VNA**



The Nano VNA

- **Use of “Connector Savers” on the SMA Connectors**

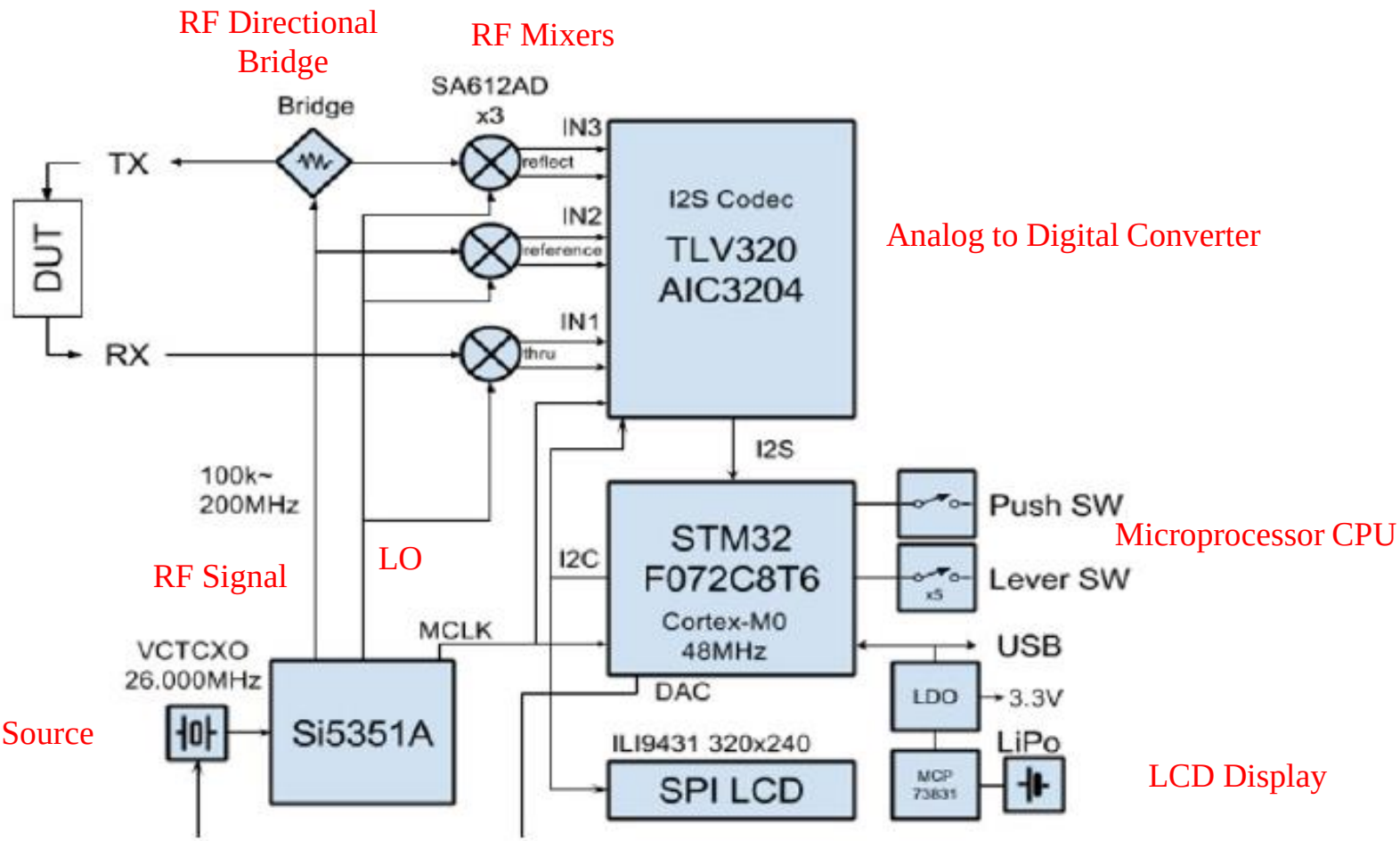
SMA Male to Female adapters on the two Ports of the Nano VNA is highly recommended to save wear and damage to the instrument ports from multiple connects and disconnects.

The Nano VNA Specifications

- Frequency range : 50kHz to 900MHz (300 - 900MHz with harmonics)
- RF output: -13dbm (maximum -9dbm) , so approx. 0.1 mW
- Dynamic range : 70dB (50kHz - 300MHz), 60dB (300MHz - 600MHz), 50dB (600MHz - 900MHz)
- Display: 2.8 inch TFT, resolution 320x240 … like the “new” Nokia 3310 !
- USB interface: USB type C (power/charging + data connection to PC)
- Power: USB 5V 120mA , LiPo battery +/- 500 mAh
- Number of points : **101 (fixed)** **biggest disadvantage** !
- Display : 4 traces, 4 markers + **5 memories for calibration & settings** (C0-C4)
- Frequency error : < 0.5 ppm (e.g. 50 Hz error at 100 MHz)

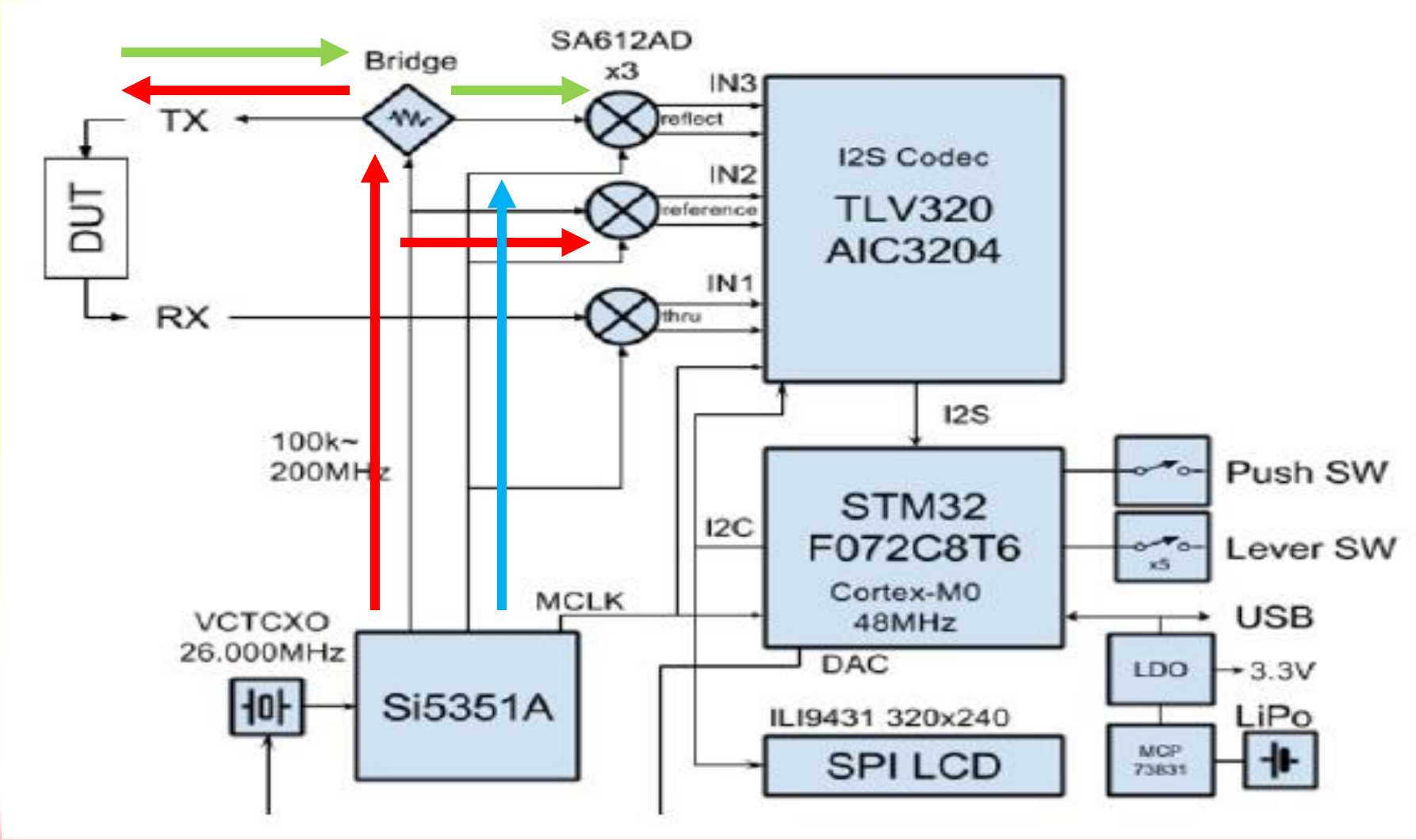
Block Diagram of the Nano VNA

- **What's Inside**



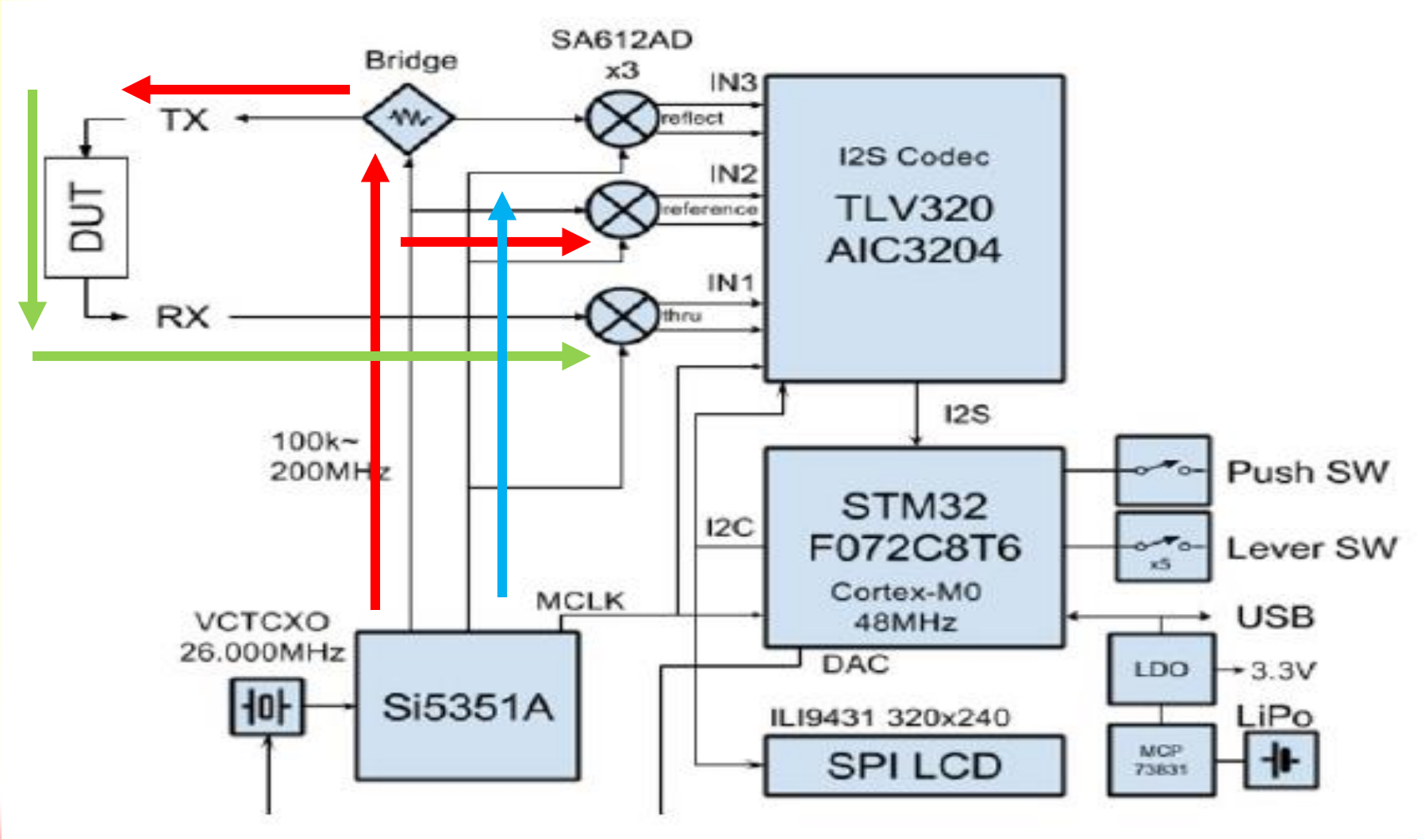
Block Diagram of the Nano VNA

- **How it works – reflection measurement S11**



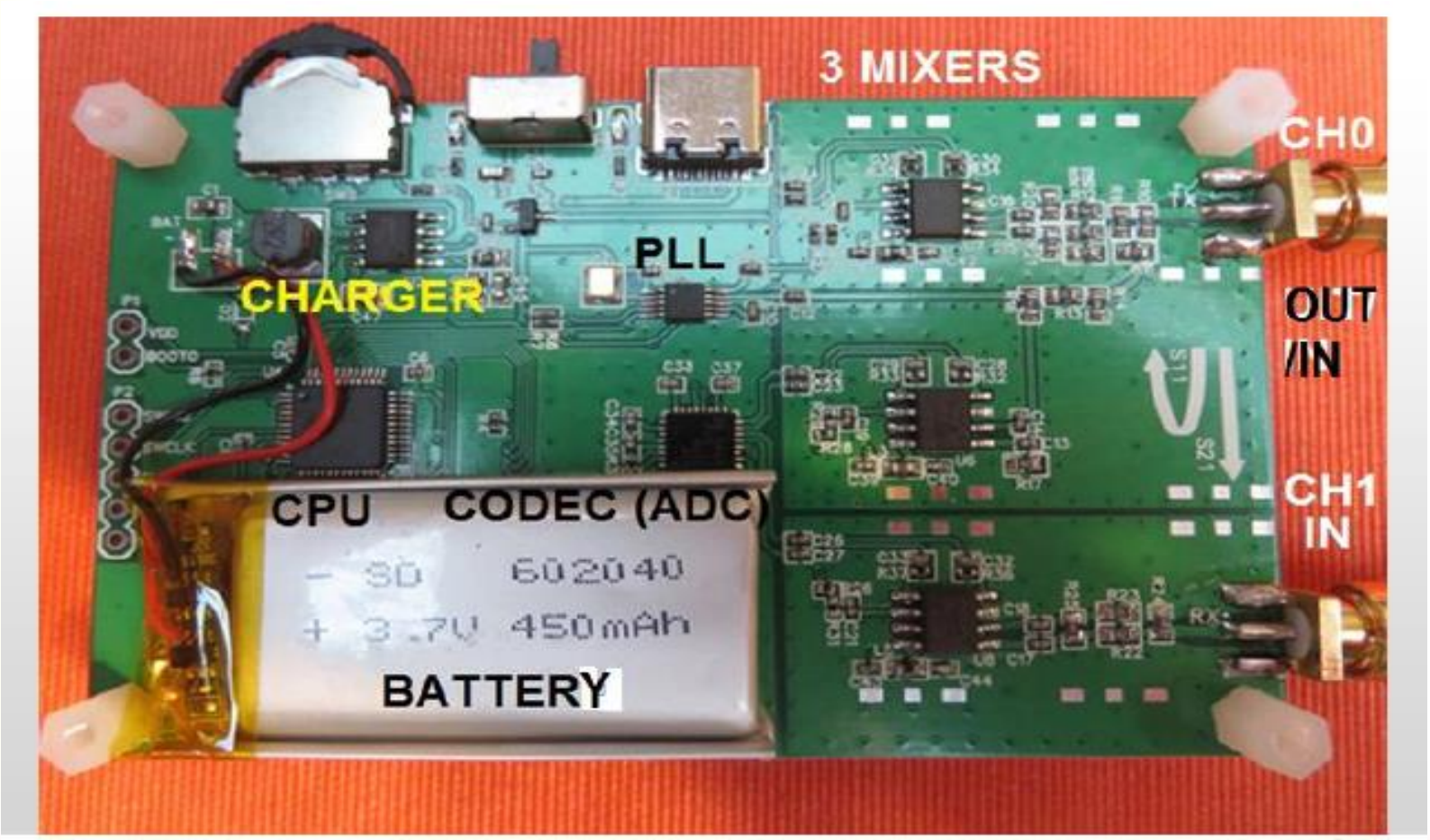
Block Diagram of the Nano VNA

- **How it works – transmission measurement S21**



The Nano VNA

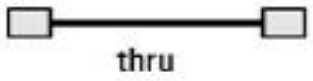
- **A look at the inside of the Nano VNA**



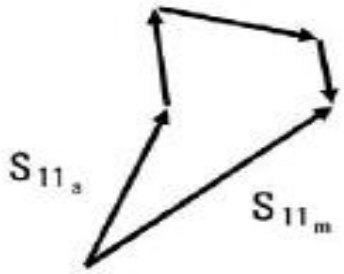
Nano VNA Vector Calibration

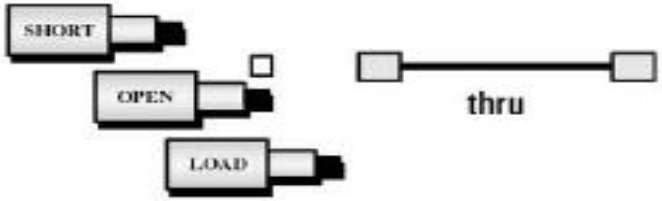
- **Short, Open, Load, Thru (SOLT) Calibration of Vector Network Analyzer**

- **response (normalization)**
  - simple to perform
  - only corrects for tracking errors
  - stores reference trace in memory, then does data divided by memory



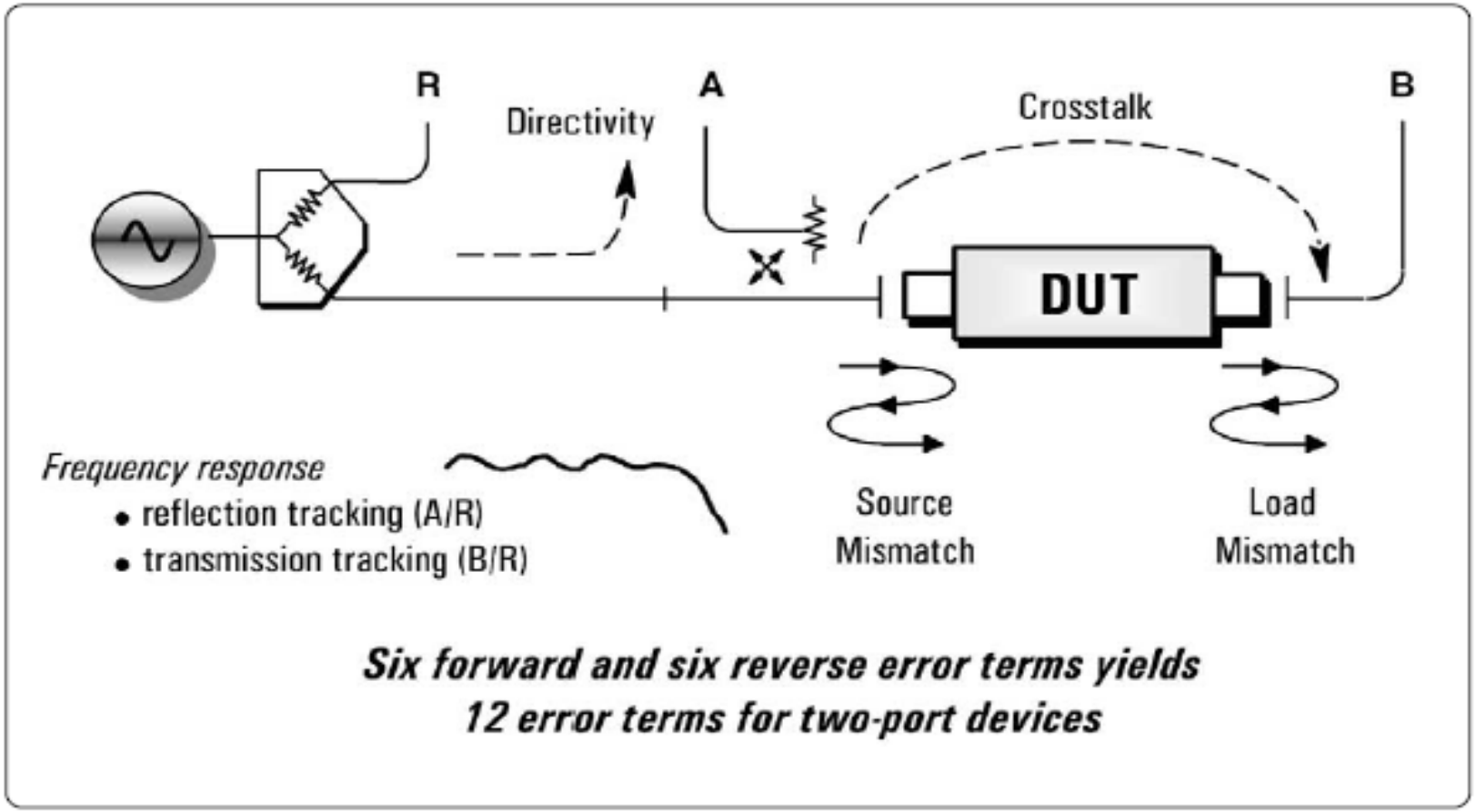
- **vector**
  - requires more standards
  - requires an analyzer that can measure phase
  - accounts for all major sources of systematic error



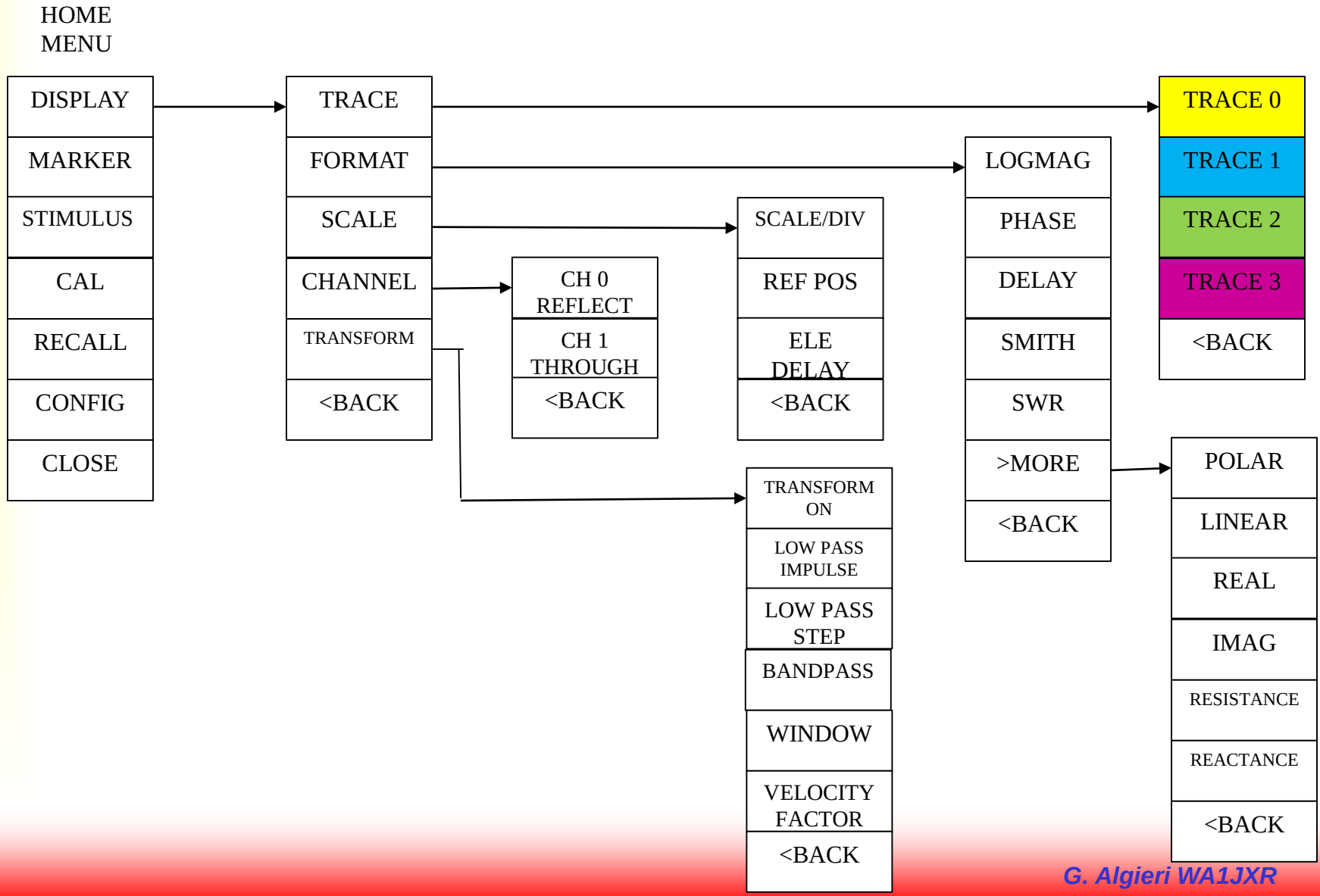


Calibration Error Terms

- **Vector Network Analyzer Calibration Error Terms**



DISPLAY MENU MAP



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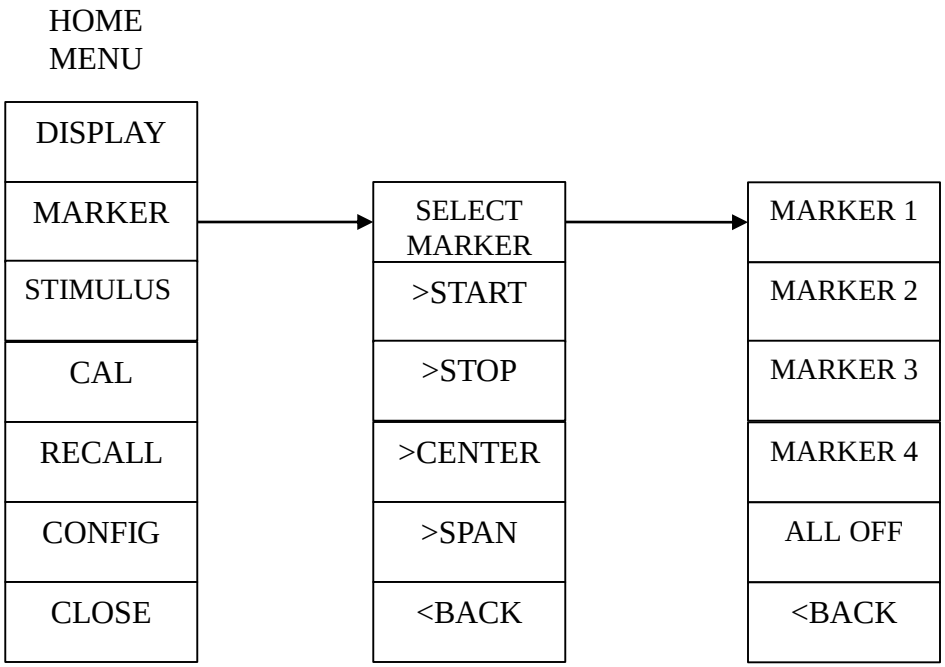
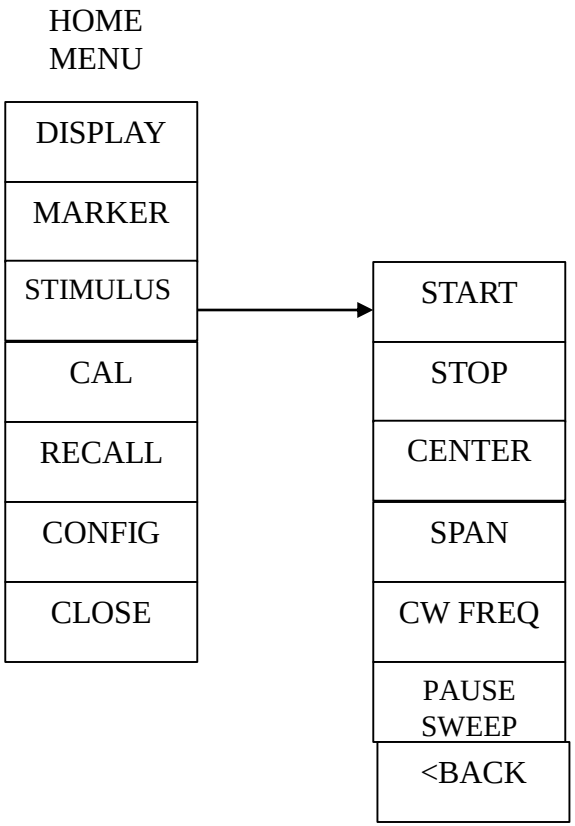
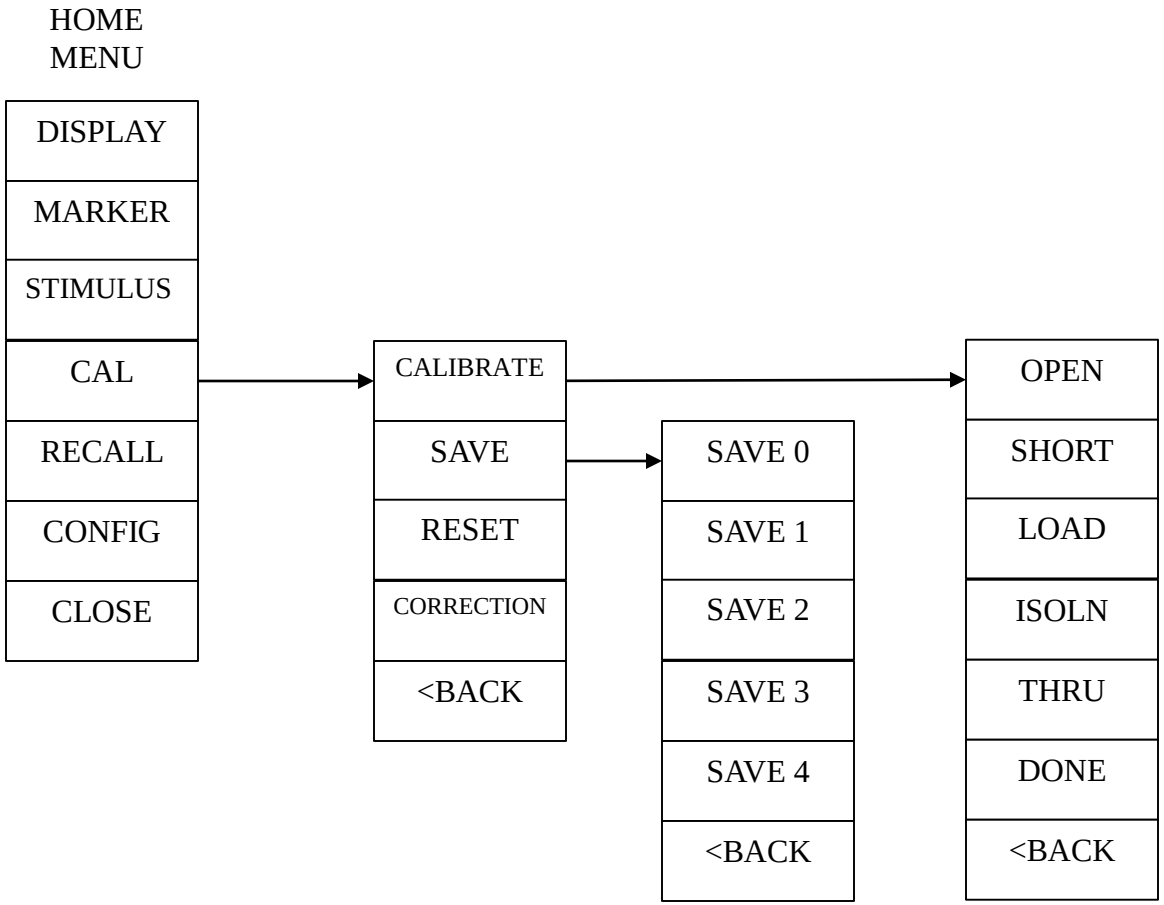
MARKER MENU MAP



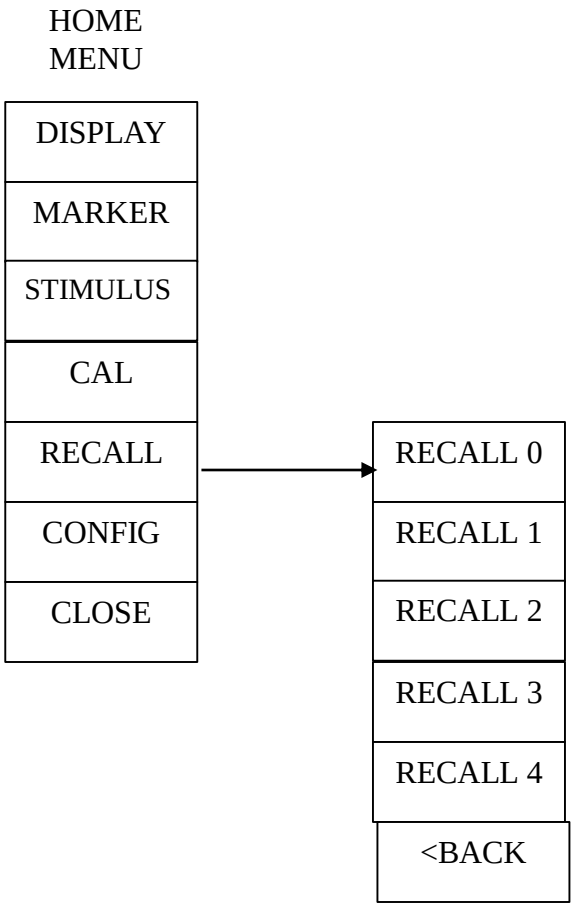
STIMULUS MENU MAP



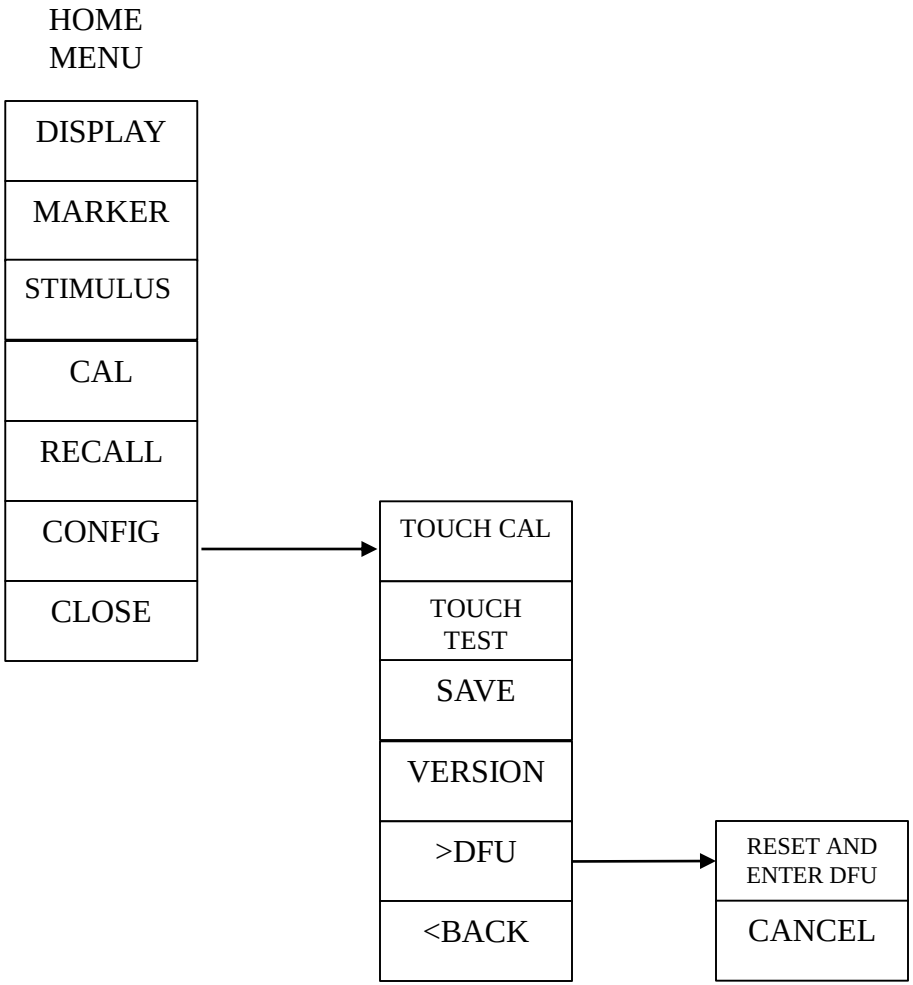
CALIBRATION MENU MAP



RECALL MENU MAP



CONFIG MENU MAP



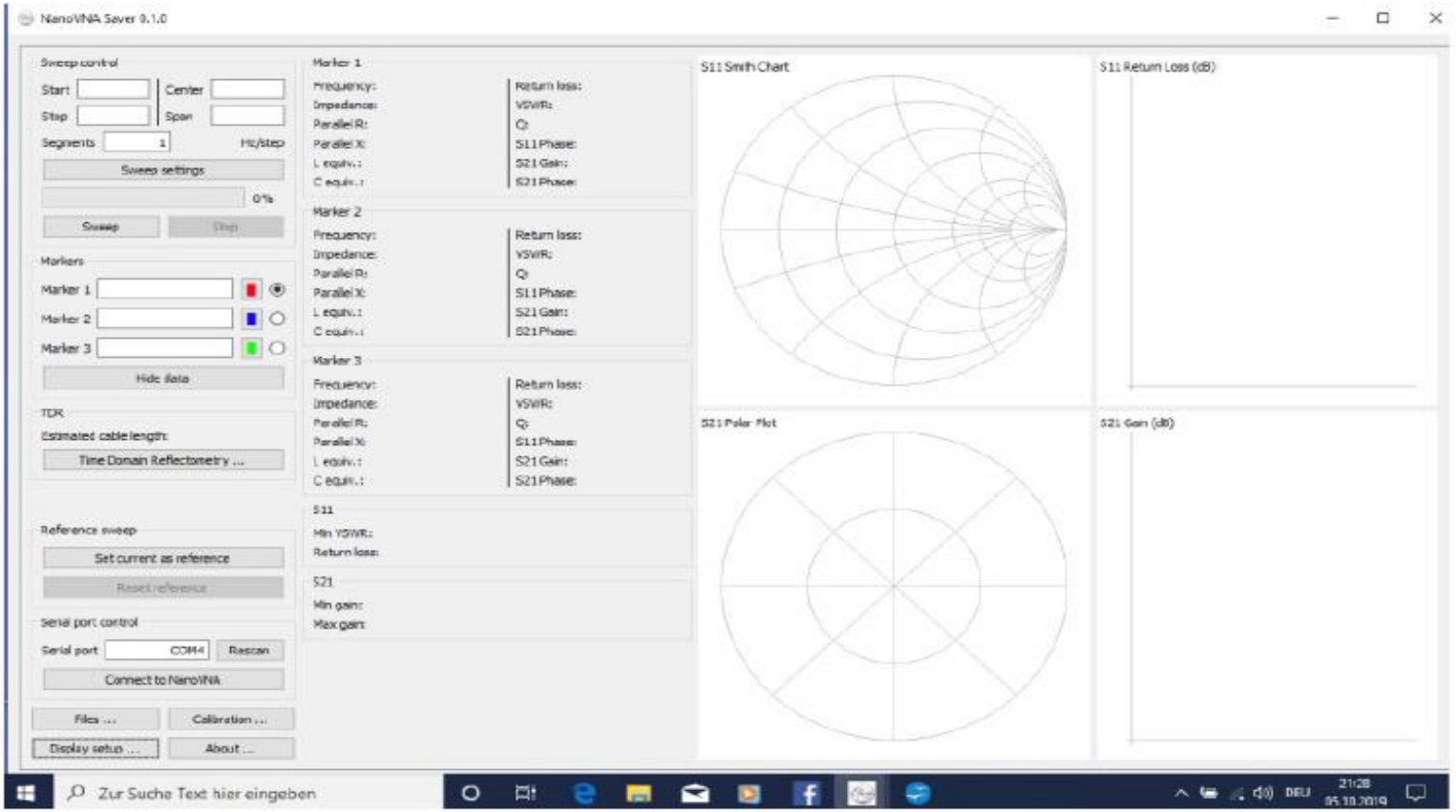
Nano VNA Users Group

- **Documentation that comes with the Nano VNA is almost nothing so you need to join the User Group**
- **nanovna-users@groups.io**

Nano VNA – Saver Software

NanoVNA - saver v0.2.0.exe

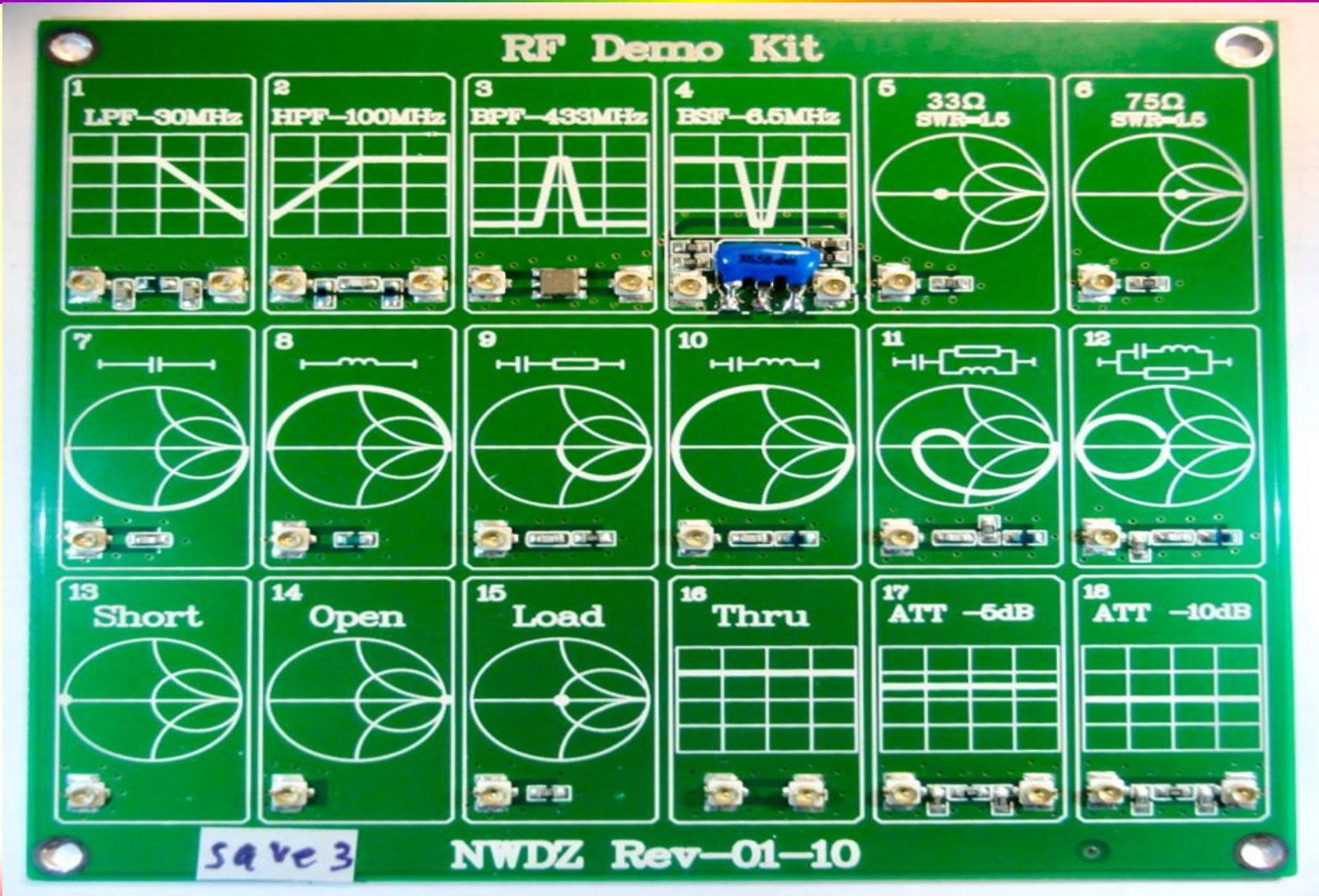
It can easily be copied to a USB stick and operated from there. After starting the program, wait 10 seconds because a dark DOS Screen appears followed by this picture:



Typical Ham Radio Measurement with the Nano VNA

- Let's measure an antenna with the Nano VNA
- Remember an antenna is a 1-Port device
- Set the Start and Stop frequency to cover the frequency range of the antenna
- Calibrate the VNA with the Short, Open Load
- So connect the antenna to the TX Port on the VNA
- Set Display Trace to Trace 0
- Set the Trace format to SWR
- Read the SWR of the antenna over the freq. band

Nano VNA RF Demo Kit Board



Nano VNA RF Demo Kit Board

- Test fields, Diagram, Frequency span, Resonance
- 1. LPF-30 MHz S21 LogMag 10 MHz - 150 MHz
- 2. HPF-100 MHz S21 LogMag 50 MHz - 200 MHz
- 3. BPF-433 MHz S21 LogMag 400 MHz - 470 MHz
- 4. BSF-6.5 MHz Ceramic S21 LogMag 5.5 MHz - 7.5 MHz
- 5. 33R SWR = 1.5 S11 SWR-Smith 50 KHz - 900 MHz
- 6. 75R SWR = 1.5 S11 SWR-Smith 50 KHz - 900 MHz
- 7. Capacitor 115 pF S11 Smith 50 KHz - 300 MHz
- 8. Inductor 470 nH S11 Smith 50 KHz - 300 MHz
- 9. C--R 115 pF 50R S11 Smith 50 KHz - 30 MHz

Nano VNA RF Demo Kit Board

- Test fields, Diagram, Frequency span, Resonance
- 10. C--L 18 pF 24 nH S11 Smith 50 KHz - 300 MHz , 240 MHz
- 11. C-- R || L,100 pF, 0.4 nH S11 Smith 50 KHz - 900 MHz, 800 MHz
- 12. R || C--L 50R S11 Smith 50 KHz - 900 MHz, 500 MHz
- 13. Short S11 Smith 50 KHz - 900 MHz
- 14. Open S11 Smith 50 KHz - 900 MHz
- 15. Load 50R S11 Smith 50 KHz - 900 MHz
- 16. Thru S11 LogMag 50 KHz - 900 MHz
- 17. Att -5 dB S21 LogMag 50 KHz - 900 MHz
- 18. Att -10 dB S11 LogMag 50 KHz - 900 MHz

- The micro coax plug is named U.FL/IPX, 50 Ohm, about 2mm diameter. For more details see on Wikipedia.

Summary

- **Hope this presentation provided you with what the Nano VNA is and how it works.**
- **How the Nano VNA can be used for Amateur Radio measurements.**
- **Where to get support for the Nano VNA.**
- **If you have questions after you can reach me via e-mail at wa1jxr@comcast.net or wa1jxr@arrl.net**
- **Questions??**
- **73's Greg WA1JXR**