

NanoVNAs – Part 2: Operation and Practice

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Overview of Presentation

- Last talk covered some of the background theory of the VNA.
- Today I will cover some of the measurements it can be used to make.
- Will also look at the different varieties of NanoVNA.
- The operation of the NanoVNA.
- The circuit design of the NanoVNA.
- The importance of calibration.
- Firmware and software aspects of the NanoVNA.

Uses of NanoVNA

- Checking antenna matching
- Measuring feeder losses
- Measuring components, R, L and C.
 - Useful for small value Ls and Cs
- Checking performance of parts at specific frequencies.
Ls and Cs depart from ideal above a few MHz
- Tuning and evaluating filters
- Checking gain and phase characteristics of amps.
- Finding Cable faults in TDR mode.
- Etcetc.

Varieties of NanoVNA

- There are a number of variants of the NanoVNA theme available.
- Mostly of Chinese origin from a range of makers and it is often difficult to determine the actual maker as there is wide copying.
- Broadly there are two major classes
 - Those that work to around 900MHz
 - Those that work to around 3 – 4 GHz (some to 6GHz!)

Cost and Sourcing

- Classic NanoVNA ~£45
- 3 – 4 GHz versions SAA2 ~£50-60
- Both available with boxes and cases and larger screens at added cost.
- Available from the usual on-line sources.

Classic NanoVNA

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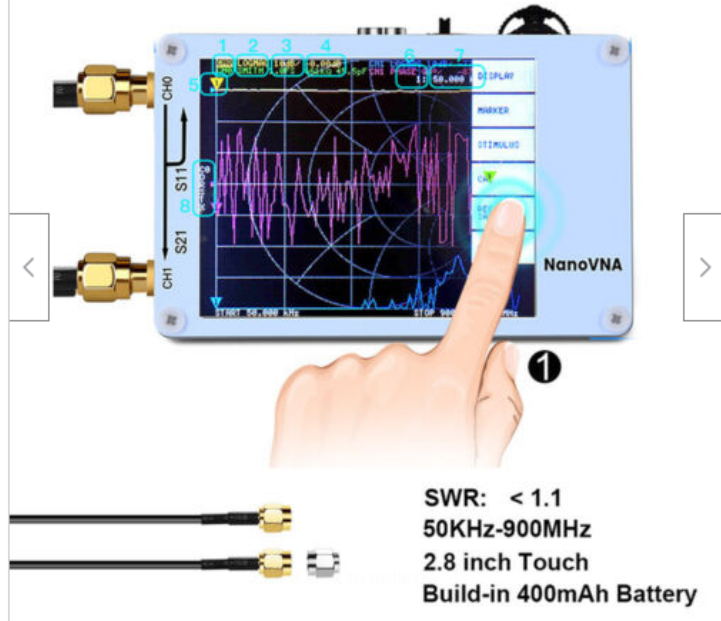
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NanoVNA SAA2 4GHz Version

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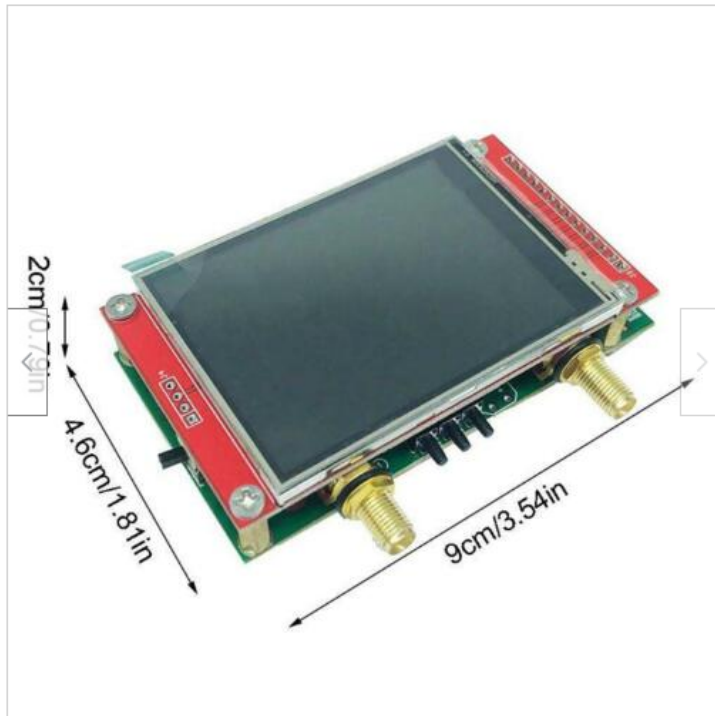
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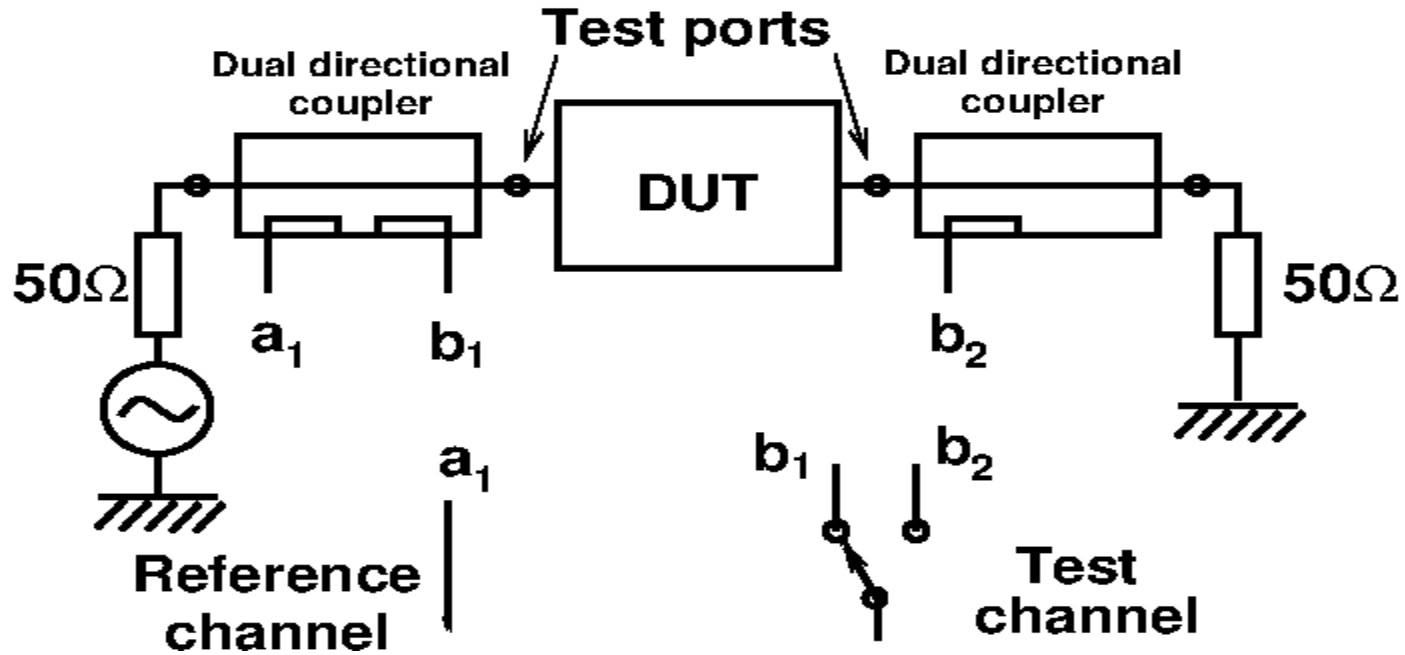
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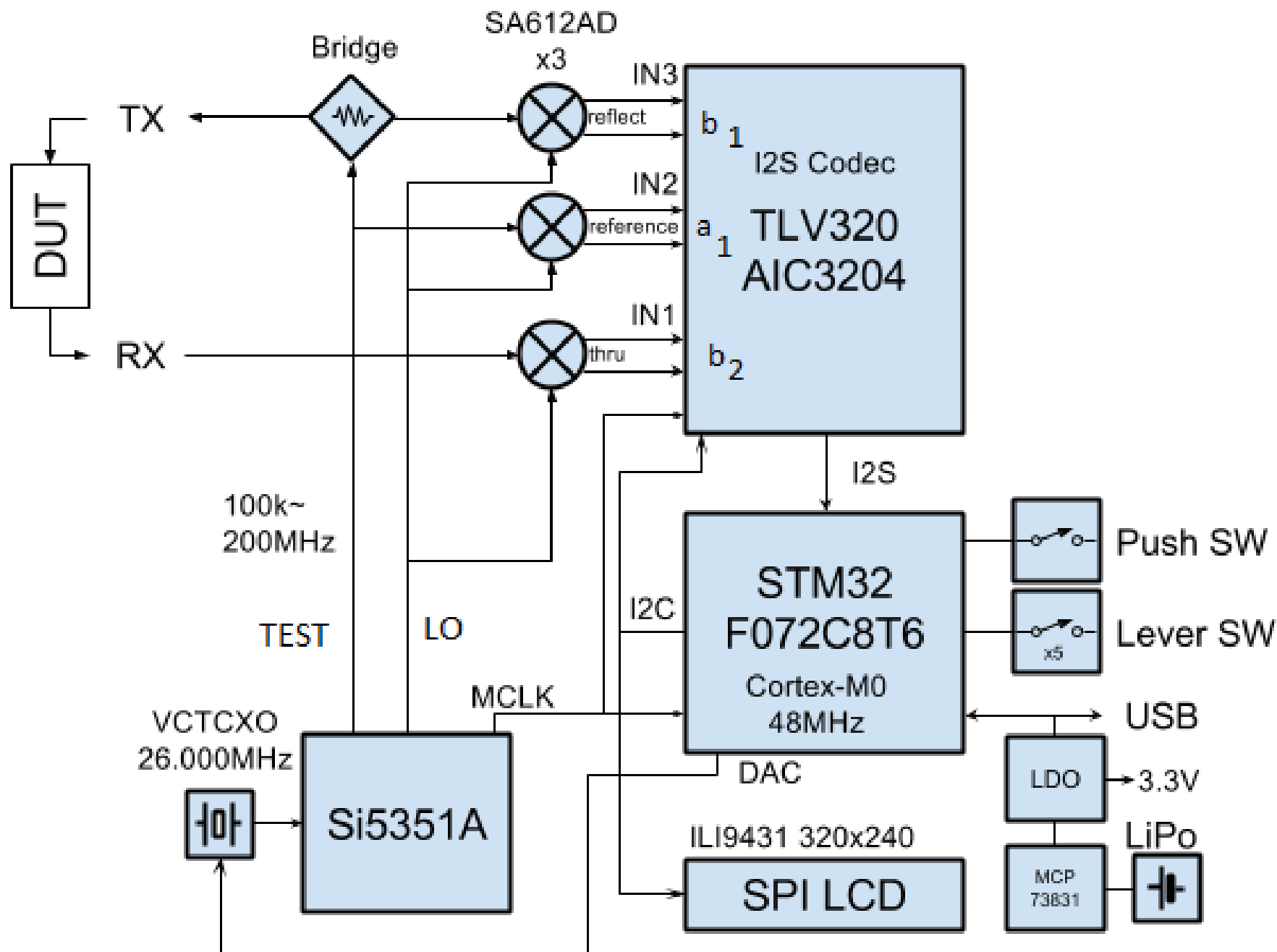
900 MHz NanoVNAs

- These were the first available and I will consider these to start with.
- The design files are on GitHub (ie Open source)
- Use a superhet type architecture in that the signals are converted down to an IF frequency (in the audio region) to do the processing in a microcontroller.
- Use a mono-directional structure ie only measure S_{11} and S_{21} .
- Need to reverse the DUT to measure S_{22} and S_{12} .

NanoVNA Architecture

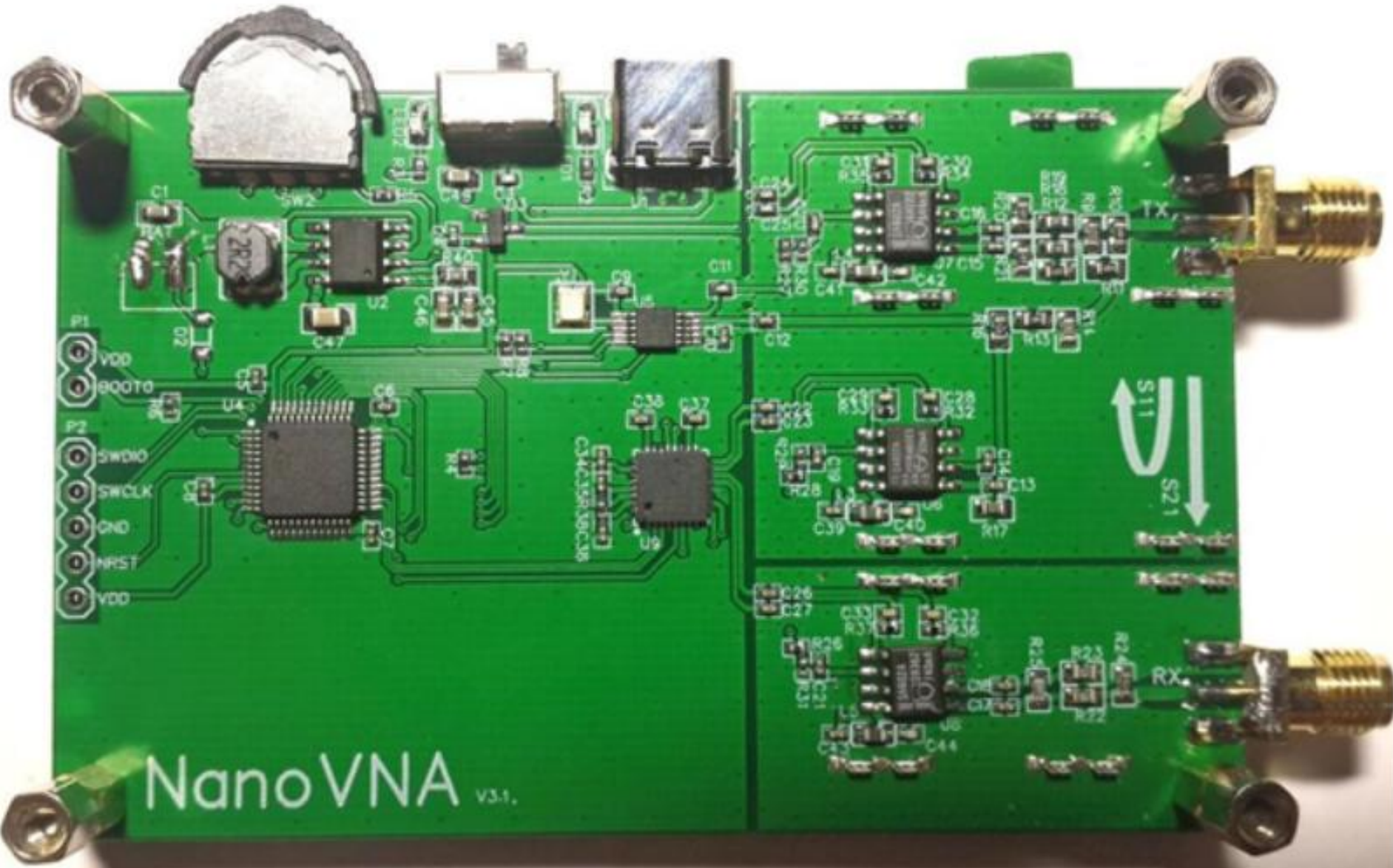


$$S_{11} = \frac{b_1}{a_1} / \theta_{11}^{\circ} \dots \dots \dots S_{21} = \frac{b_2}{a_1} / \theta_{21}^{\circ}$$



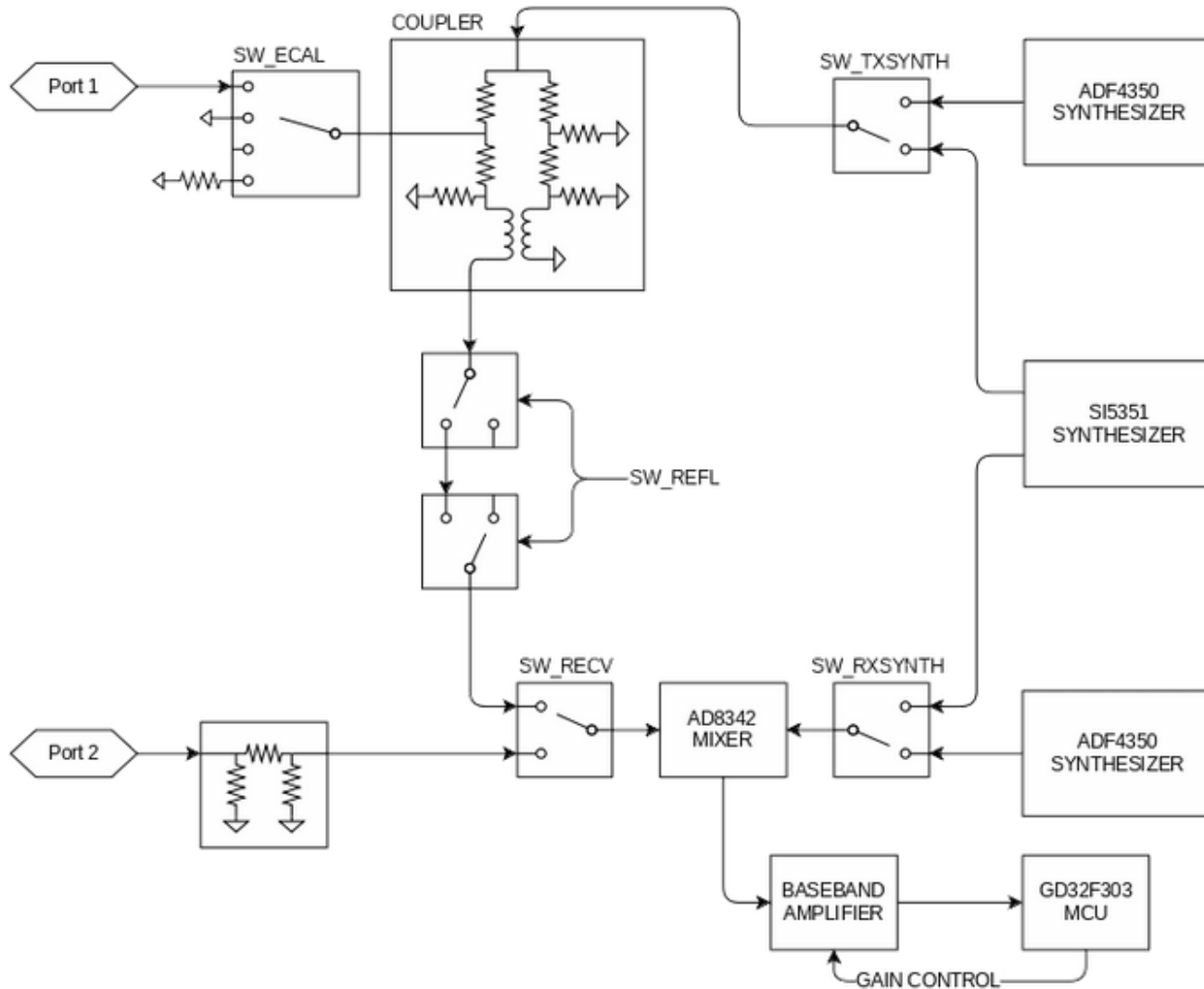
Block Diagram

- Si5351A produces three outputs under control of uProcessor – a test signal – an LO Spaced by 6 kHz from the test signal and uProcessor clock.
- Three SA612s downconvert the three a and b waves down to a 6 kHz IF. Amplitude and phase relationships are retained in the mixing process.
- Three 6 kHz IF signals are digitised in the TLV320 audio codec chip and fed to the STM32 for processing and display on the LCD touchscreen.

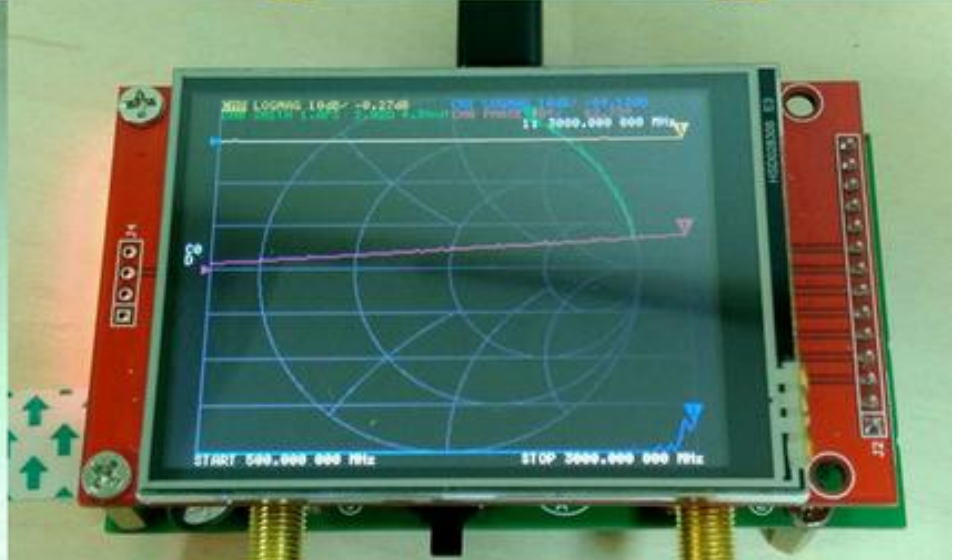
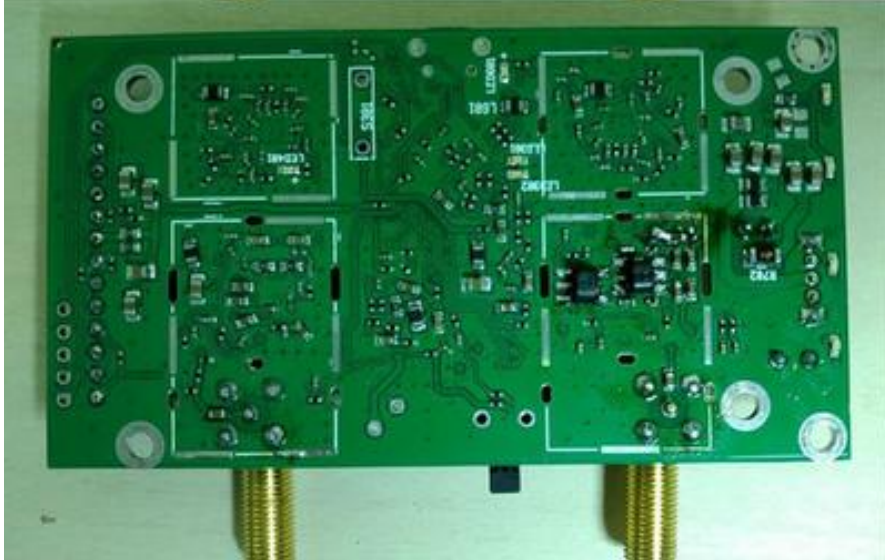
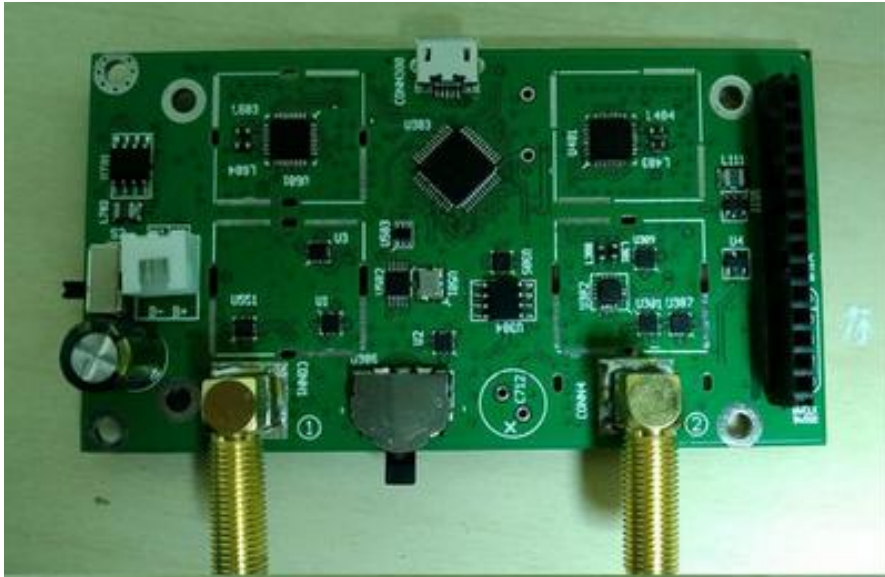


NanoVNA V3.1

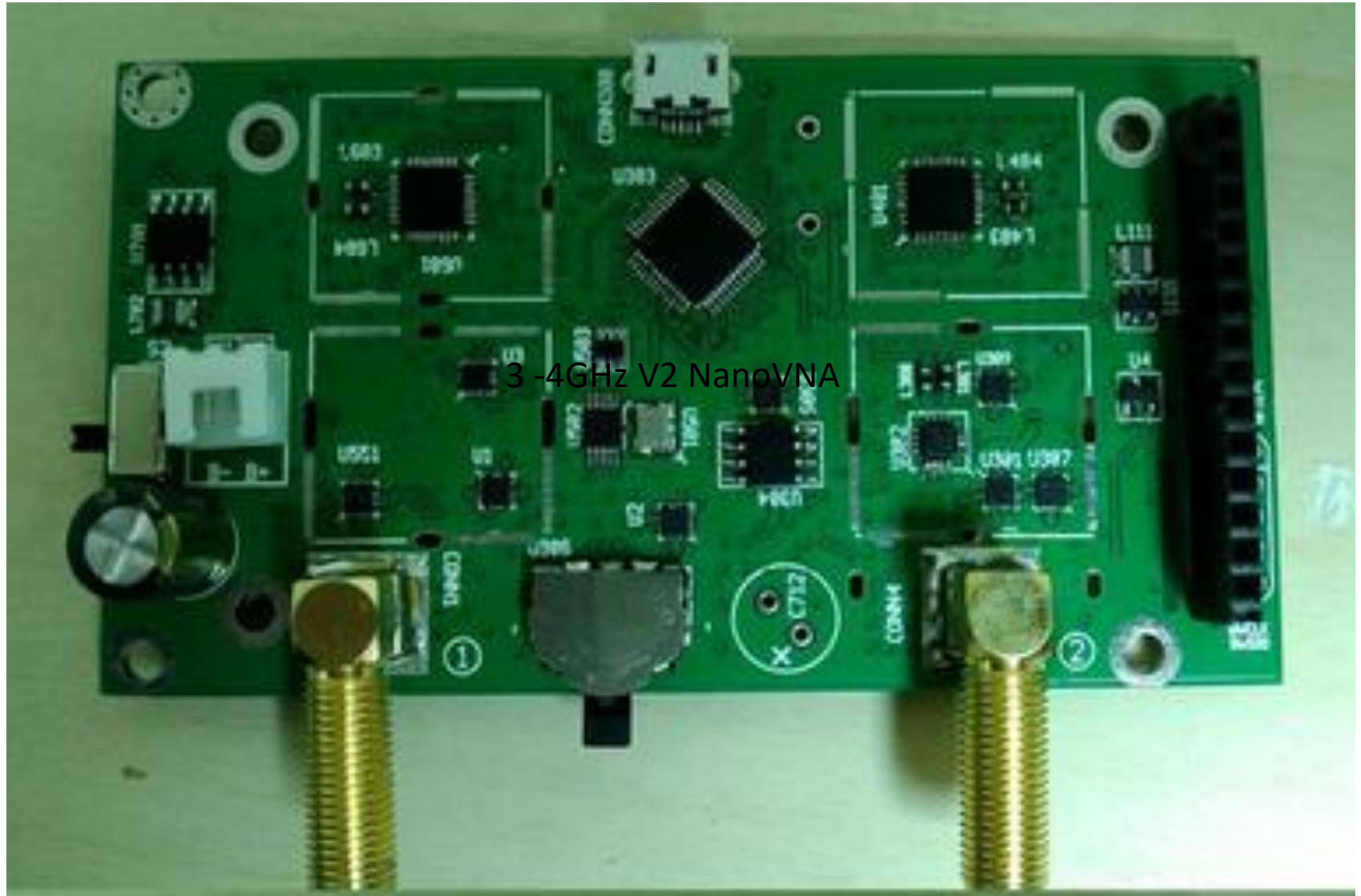
3 – 4 GHz Version SAA-2



3 -4GHz V2 NanoVNA



3 -4GHz V2 NanoVNA



NanoVNA Calibration

- Any VNA requires to be calibrated for the required frequency range.
- Calibrate is done with known reflection and transmission standards.
- Open circuit
- Short circuit
- Matched load (50 Ohms)
- Through line

Function of calibration

- Shorts, open and through lines have inherently known reflection and transmission coefficients and are stable in value.
- Connectors should be small in relation to the wavelength of the measuring frequency.
- Ideally would use APC7 type “sexless” connectors for phase measurements, particularly at high frequencies.
- In practice, at the lower frequency ranges covered by the NanoVNAs, small connectors such as SMAs are adequate.
- Professional VNA cal kits can be very expensive!!

Typical NanoVNA Cal Kit

Calibrate the NanoVNA with the calibration standards that came with the device: OPEN, SHORT, 50Ω, SMA to SMA

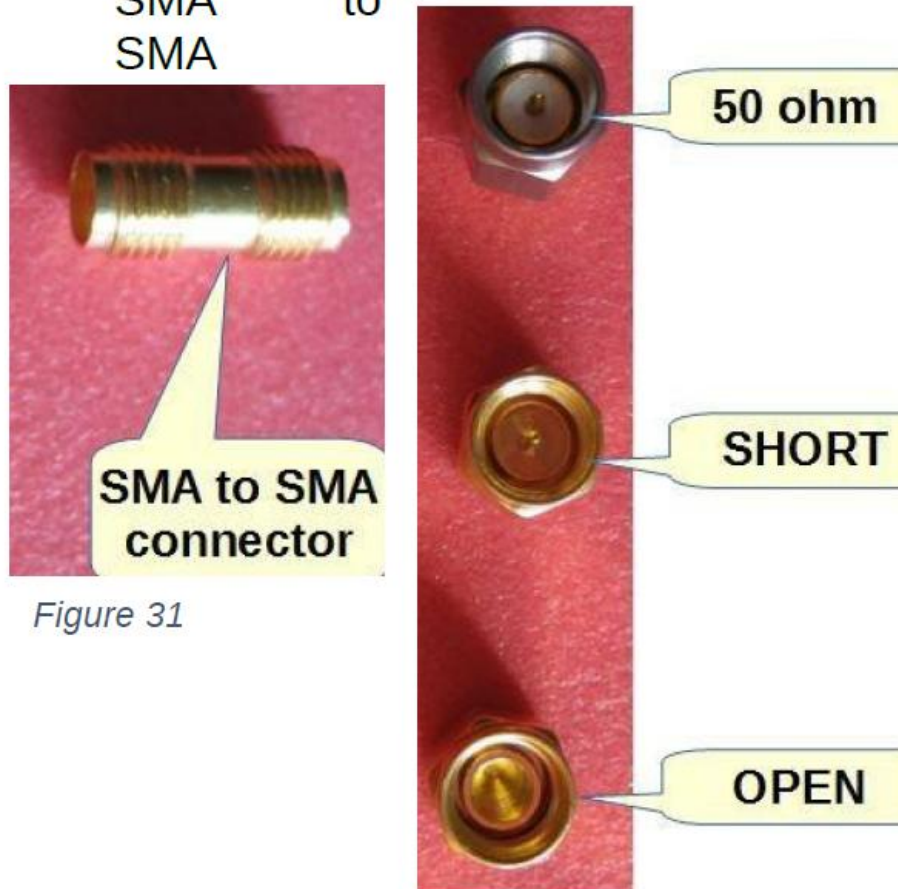


Figure 31

Calibration and Reference Planes

- Phase shift is important in transmission and reflection.
- Need to decide where we want to measure phase shift between.
- Normally chose the terminals of DUT, but that is not strictly necessary.
- Can calibrate with any length of test leads but both should be the same electrical length.

Calibration Procedure

- Set desired stimulus (Start/stop frequencies)
- Menu driven process
- VNA prompts you which cal piece to attach
- Go through SOLT (Short, Open, Load, Through).
- Save calibration to memory in the NanoVNA.
- Calibration can also be stored on an external PC.

Limitations of Simple Calibration Kits

- Reasonably easy to make a good “short” cal piece.
- Open cal pieces are more difficult because of radiation from the open end of the unterminated line.
- One way round this is to have a set of correction data associated with the set of cal pieces that can be fed into the software.
- Professional cal kits usually come with a set of such data but this is not too important at the frequency ranges of the NanoVNAs

DIY Cal Kits and Test Leads

- Possible to make up your own cal kits.
- Connector manufacturers produce open and shorts and loads.
- Selecting good quality ones can allow you produce your own kit which may be better than the ones supplied.
- A set of well constructed test leads made of good quality flexible coax and good connectors are also a plus.
- Useful here to have access to a professional VNA to check them out.

Applications of a NanoVNA

- Measuring and setting up antenna matching
- Alignment of filters
- Measurements of cables
- Cable fault diagnosis
- Testing of attenuators
- Testing amplifiers for gain and frequency response
- Evaluation of components
- Are components such as capacitors good at high frequencies?
- Measurements of unknown inductors both for value and loss
- Measuring small value components, eg 1pF capacitors
- Testing ferrites

Computer control

- There is a wide range of software for using a VNA with a PC to get a bigger screen and a means of recording the results.
- Hook up via USB
- Possible to take screen shots.

NanoVNA Software

- NanoVNA Saver
- NanoVNA Sharp
- SimSmith
- NanoVNA QT
- TAPR NanoVNA
- NanoVNA Solver
- SimNEC (Cross platform – Linux)

NanoVNA Firmware

- There is also an extensive range of firmware that can be flashed into the NanoVNA.
- Allows increased frequency range
- More calibration memories

Extensions and Upgrades

- Possible to extend the frequency range of the basic NanoVNA to about 1.5GHz.
- Firmware can easily be reflashed.
- Firmware is available to support larger screens.
- Extra LF decoupling on the Synthesiser power rails to reduce phase noise can improve the dynamic range.

And Finally the LiteVNA!

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