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.
- Etc ....etc.

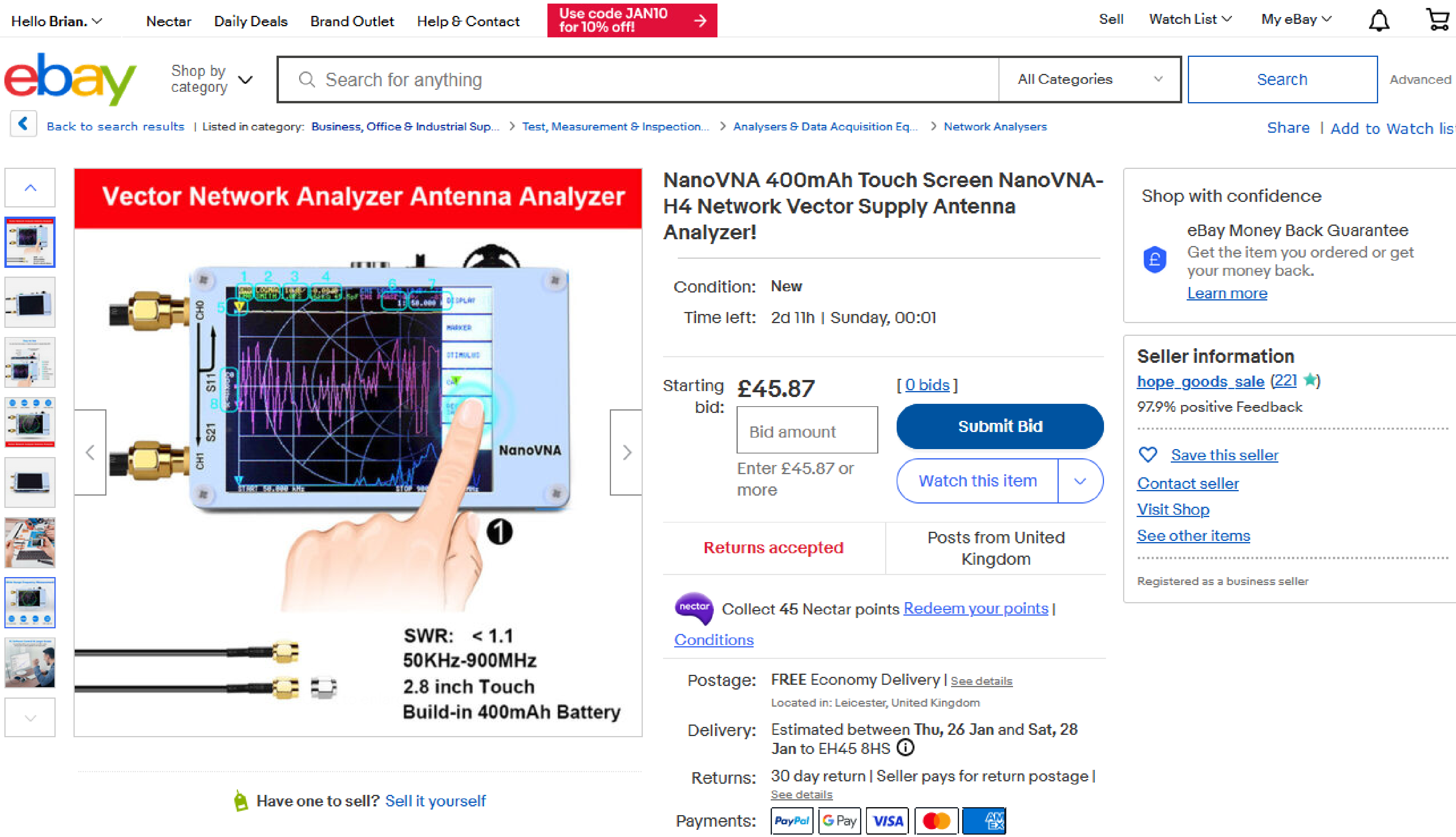
Varieties of NanoVNA

- 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!)

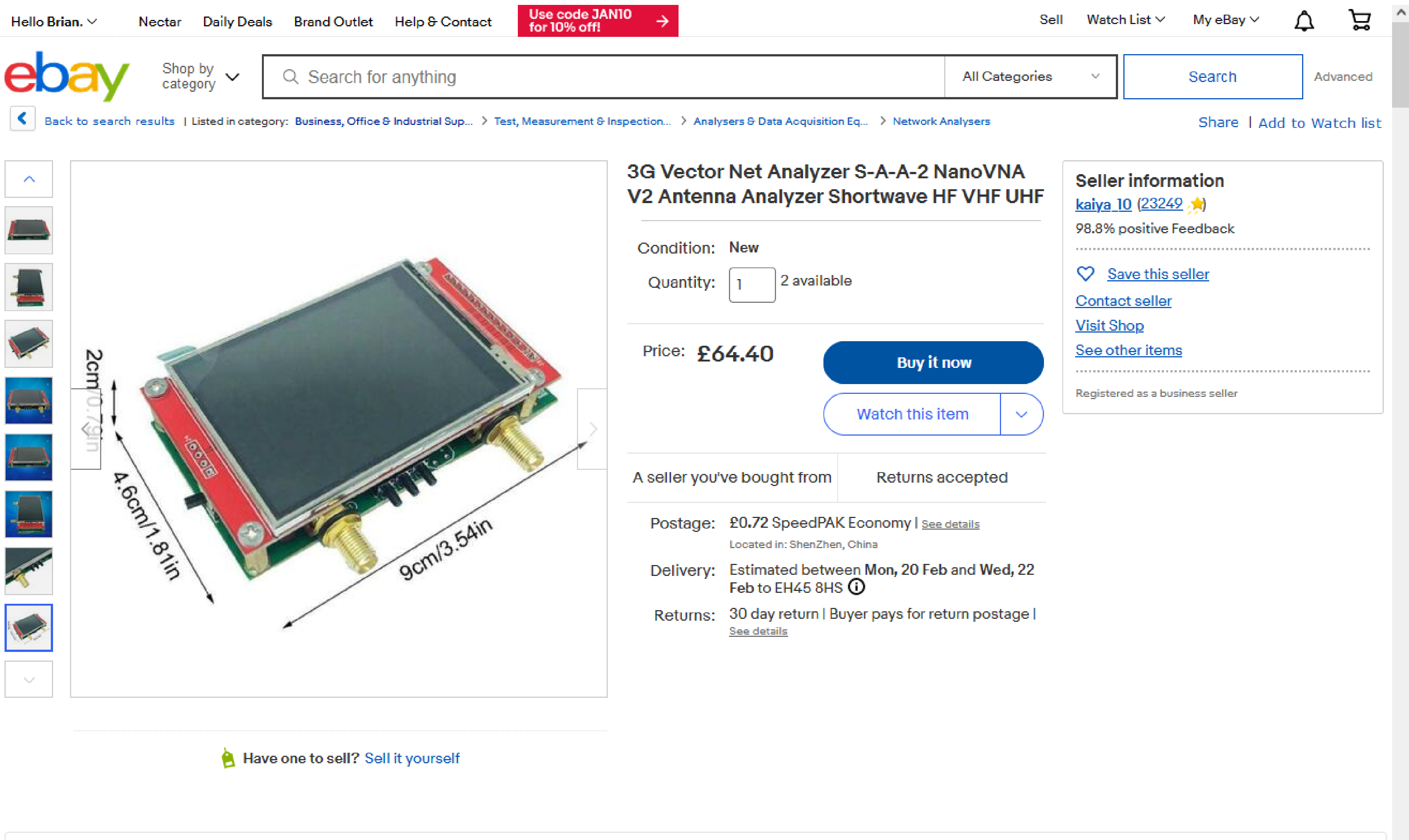
Cost and Sourcing

- 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



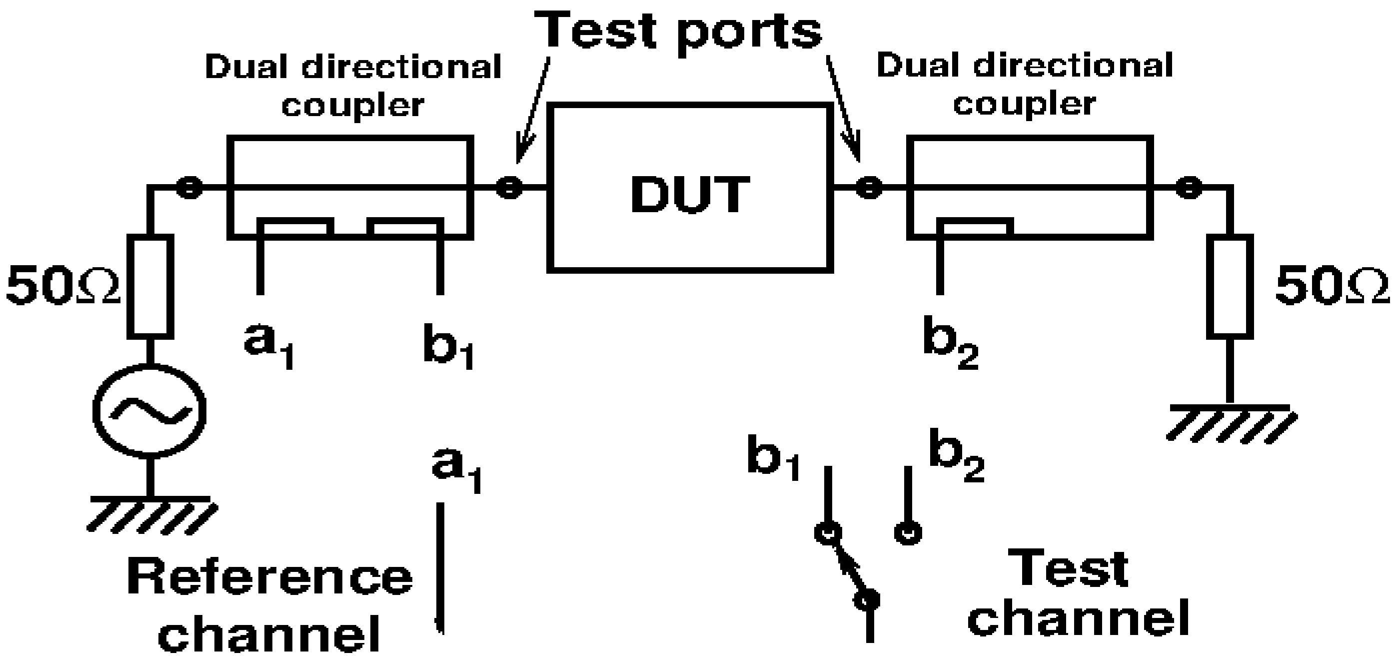
NanoVNA SAA2 4GHz Version



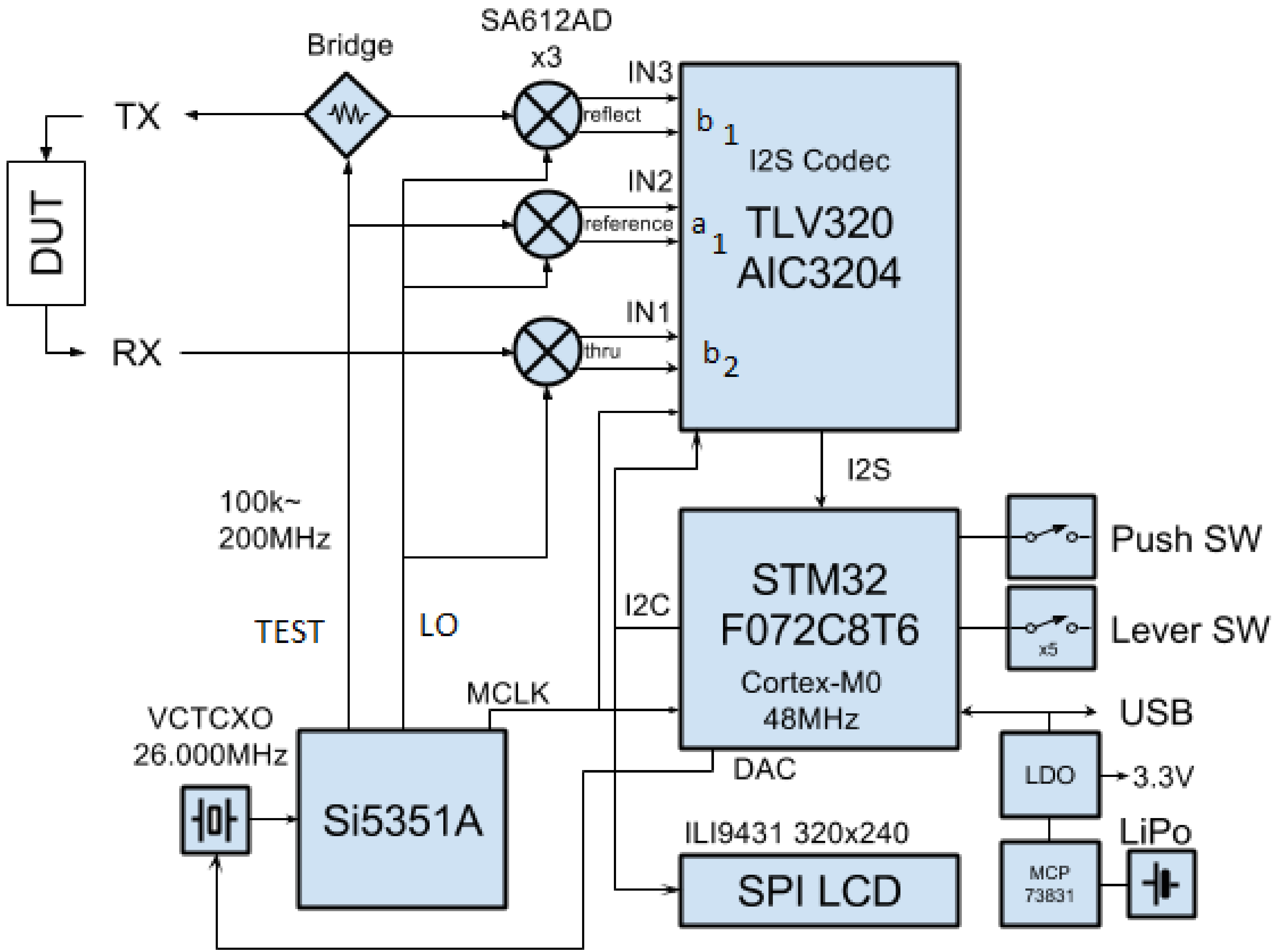
900 MHz NanoVNAs

- 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 S11 and S21.
- Need to reverse the DUT to measure S22 and S12.

NanoVNA Architecture



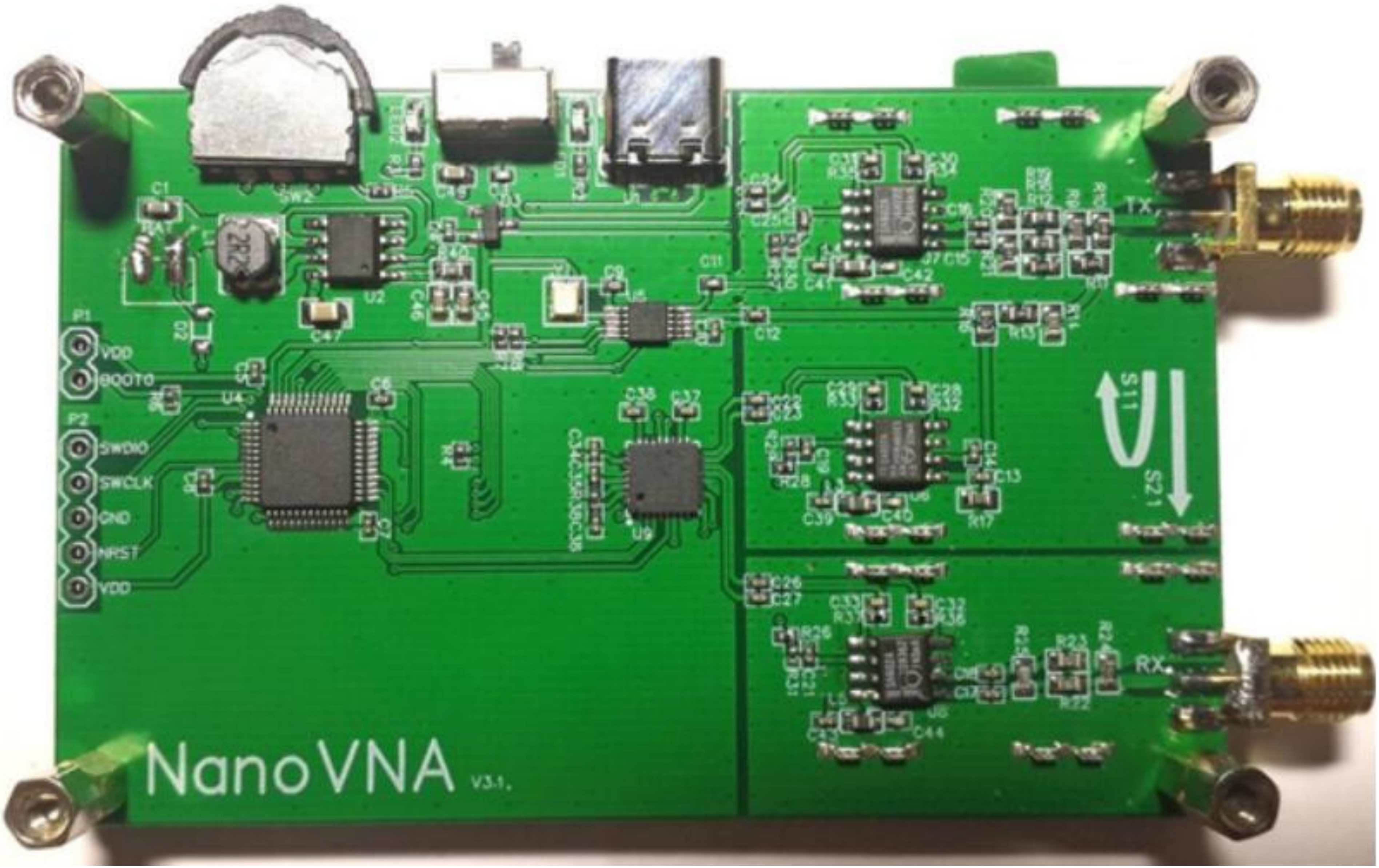
$$S_{11} = \frac{b_1}{a_1} / \theta_{11}^{\,o} \ldots\ldots\ldots S_{21} = \frac{b_2}{a_1} / \theta_{21}^{\,o}$$



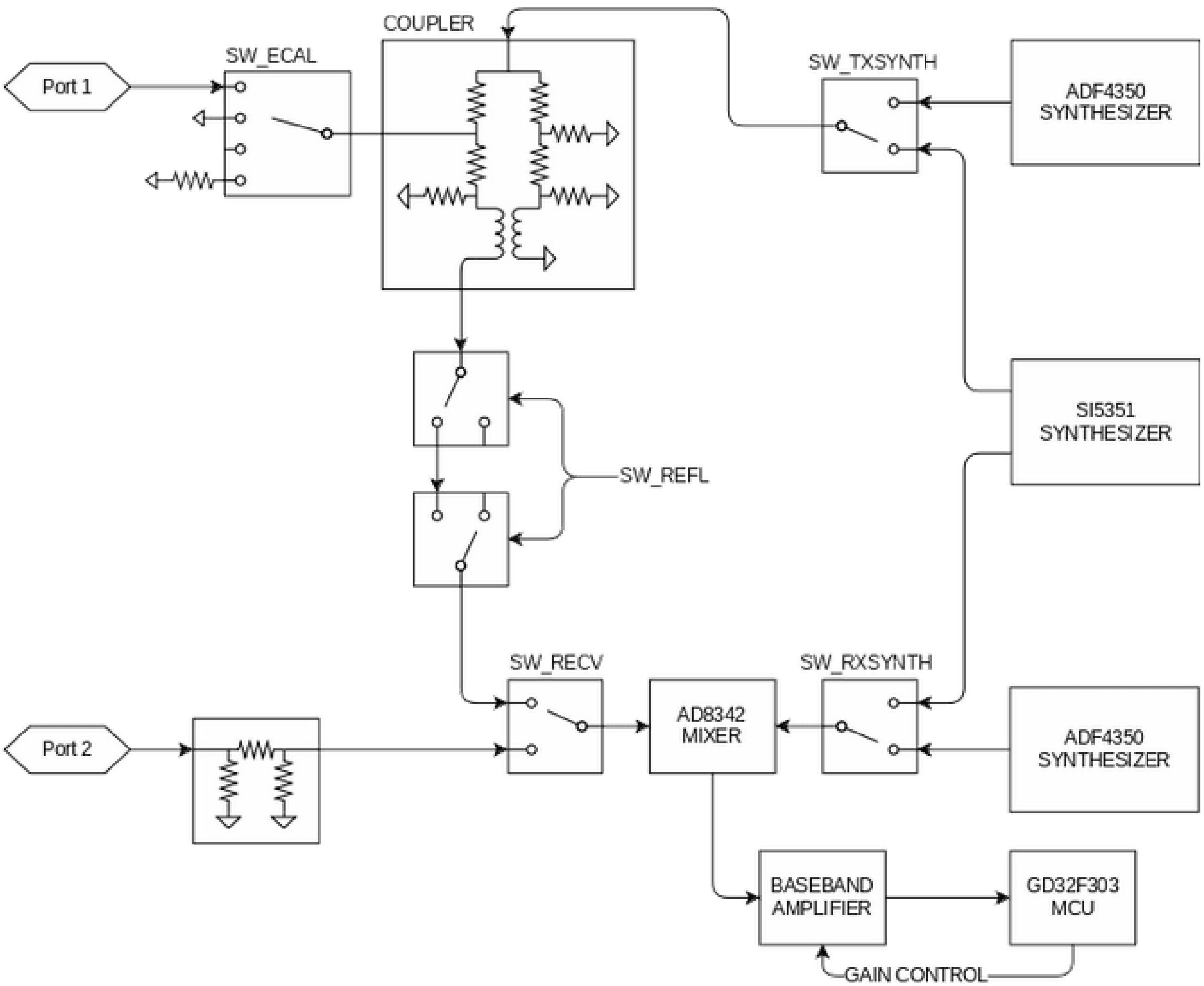
SA612AD
x3
Bridge
TX
DUT
RX
IN3
reflect
b 1
I2S Codec
IN2
reference
a 1
TLV320
AIC3204
IN1
thru
b 2
I2S
100k~
200MHz
TEST
LO
I2C
STM32
F072C8T6
Cortex-M0
48MHz
Push SW
Lever SW
x5
USB
MCLK
VCTCXO
26.000MHz
Si5351A
DAC
LDO
3.3V
ILI9431 320x240
SPI LCD
LiPo
MCP
73831

Block Diagram

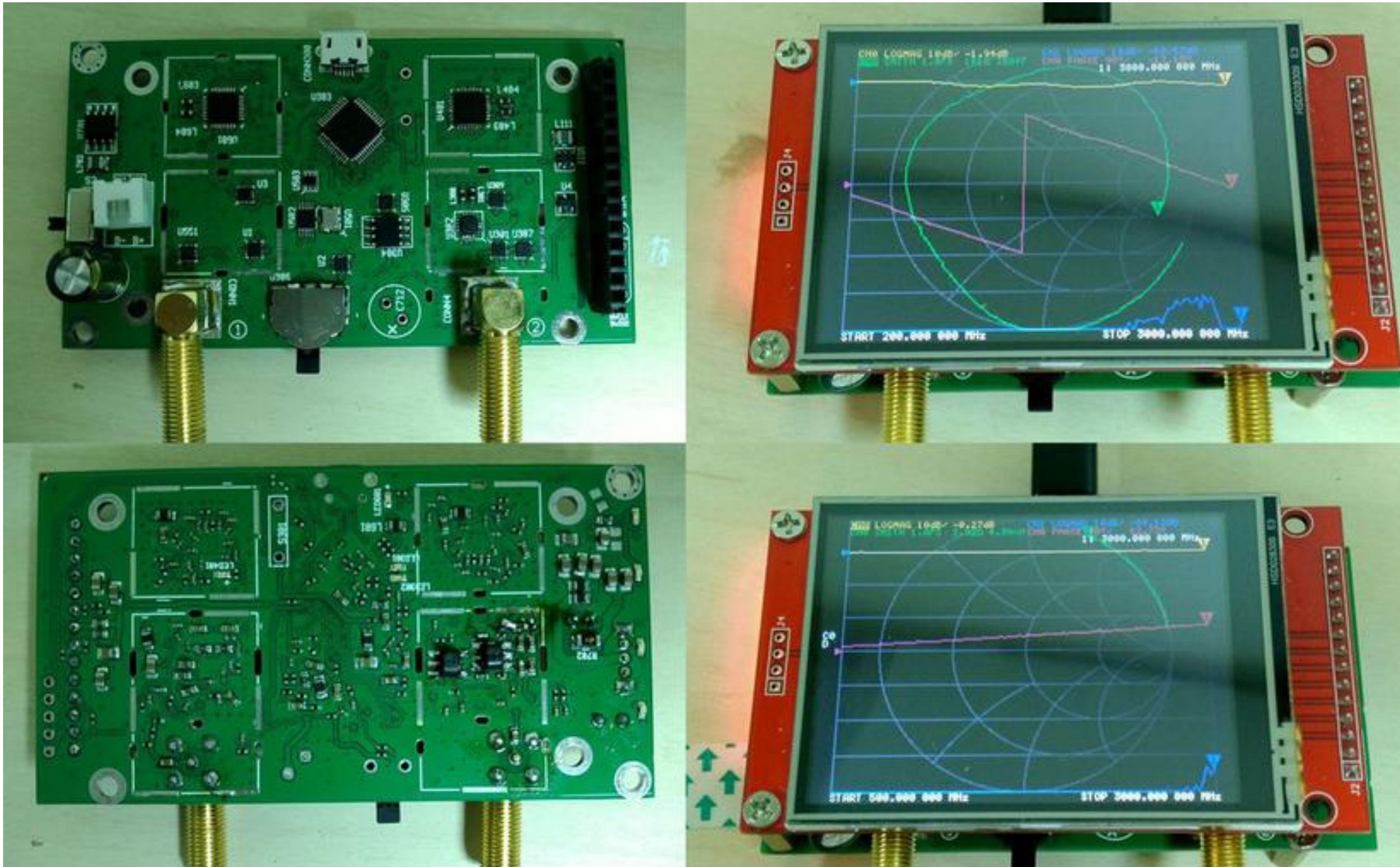
- Si5351A produces three outputs under control of uProcessor – a test signal – an LO Spaced by 6 kHz from the test signal and uProcessor clock.
- Three SA612s downconvert the three a and b waves down to a 6 kHz IF. Amplitude and phase relationships are retained in the mixing process.
- Three 6 kHz IF 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
TX
RX
S11
S21
P1
VDD
BOOT0
P2
SWDIO
SWCLK
GND
NRST
VDD

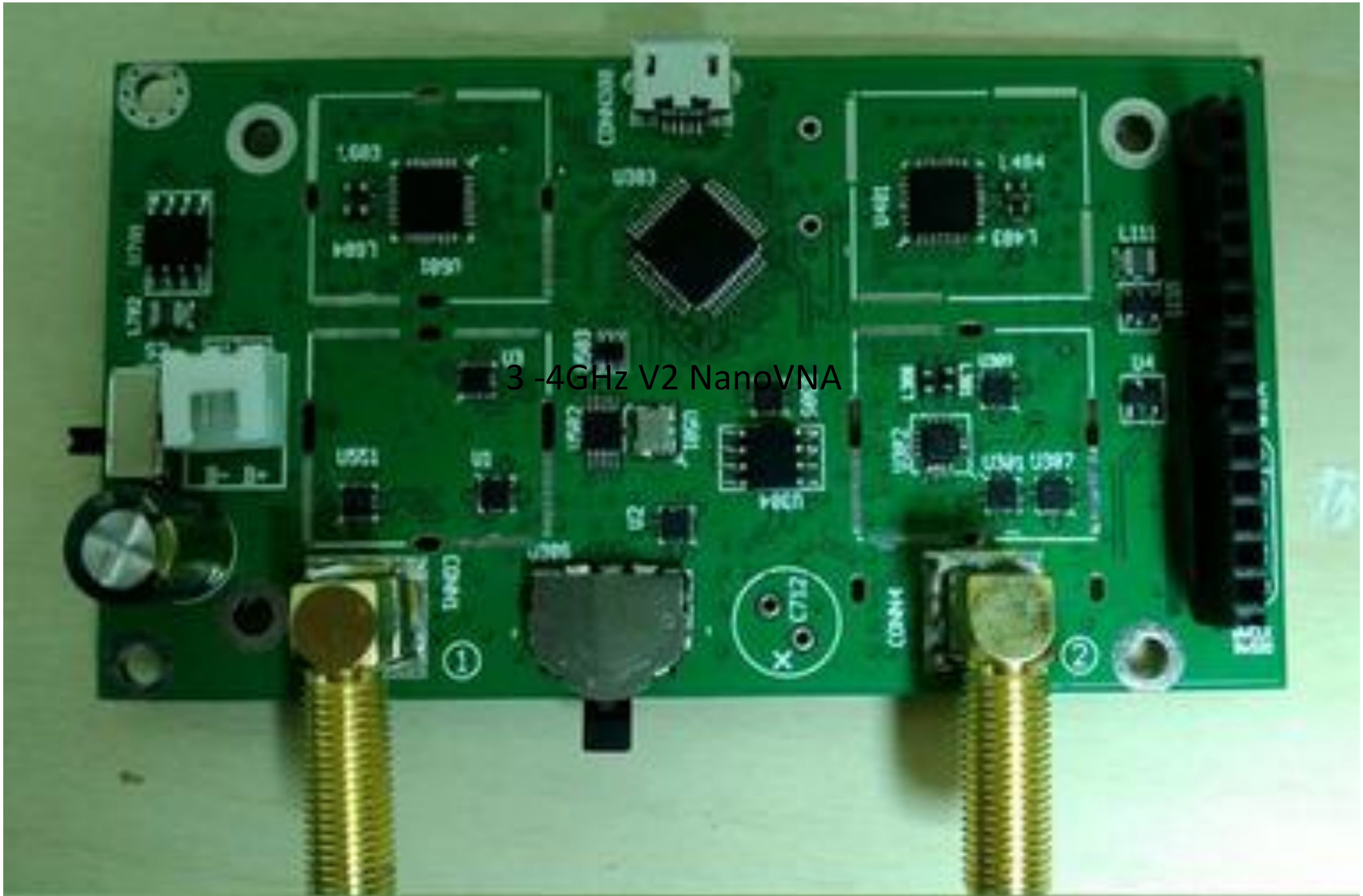
3 – 4 GHz Version SAA-2



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

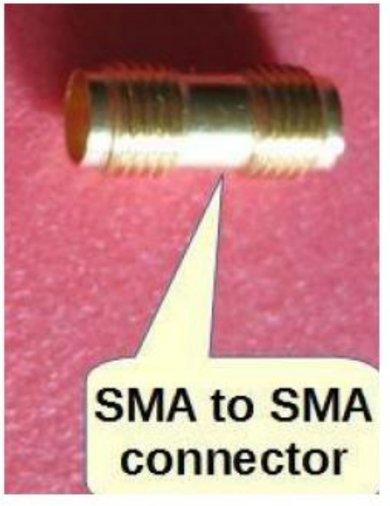


Figure 31

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)

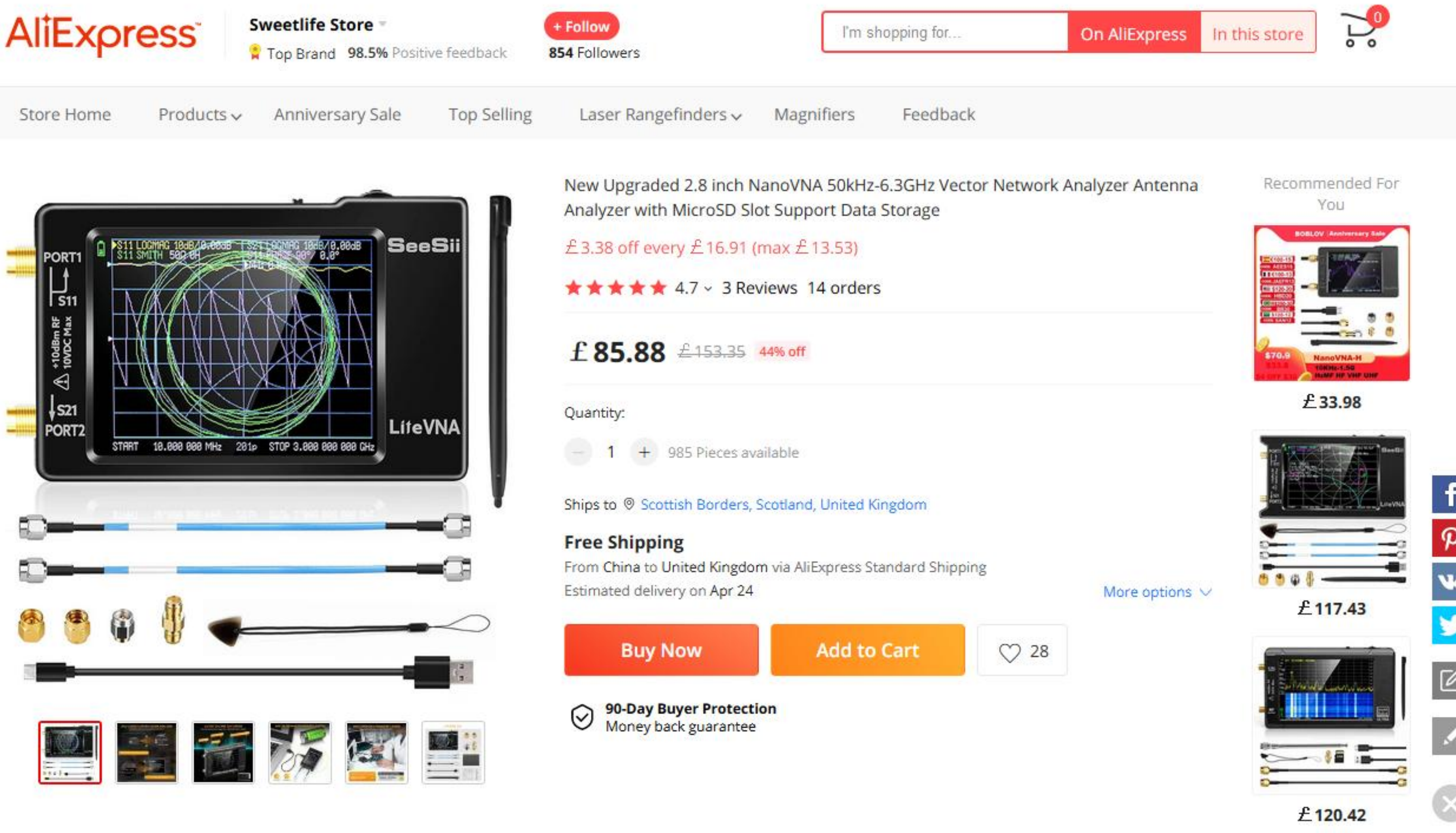
NanoVNA Firmware

- 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!



Any Questions