



FIVE AND NINE PLUS

THE OFFICIAL NEWSLETTER
OF THE
APPLEDORE AND DISTRICT
AMATEUR RADIO CLUB

Club Callsigns: G2FKO and GX2FKO
Web Site : www.adarc.co.uk

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| | | |
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March 2021

EDITORIAL

Welcome to another Club Newsletter.

As mentioned in last month's 5&9 Newsletter, it is our **AGM on Monday March 15th** and due to Covid 19 will be via Zoom. Invitations have been sent out by e mail and I look forward to seeing many of you on the night.

Everyone presently on the Committee is willing to stand for re-election. In addition, **Ben (2E0FTZ)** is willing to stand for election to the Committee. If anyone else wishes to either stand or propose anyone for a position on the committee, then please contact any Committee member ASAP.



Members may recall that due to Covid 19, last year's AGM was postponed until last June. Consequently, the **Jim McFee Cup and new John G0UNB Award** were not awarded for this last Club year. However, the Committee will announce at this AGM the **recipient of the John G0UNB Award** for the member who has done the most to promote constructional activity within the Club and help practically in general. Due to the present pandemic, the Committee has decided to delay awarding the **Jim McFee Cup** until normality returns to Club activities.

Of course, the AGM is the start of a new Club year and the time when **membership renewals** become due. Our Treasurer Ray (M0TLO) will announce whether there are any changes to membership fees at the AGM and remind members that again due to Covid 19, fees can be paid by Direct Debit - details of which will be in an e mail after the AGM.

Keep safe and keep healthy

Terry (G4CHD)

CLUB MEETINGS

Due to the present Covid 19 pandemic, **ALL** meetings scheduled to be held at the Appledore Football Social Club have been **CANCELLED** until further notice. Until Meetings are reinstated a programme of 'virtual Zoom Meetings' has been arranged :-

| Date | Topic |
|----------|---|
| Mar 15th | Virtual AGM via Zoom followed by general chat |

It is hoped to add further Zoom Meetings so if you want to give a talk, please contact any Committee member.

FEBRUARY ZOOM MEETINGS

- Feb 15th Zoom Talk - "Setting Up & Using the NanoVNA" by Terry (G4CHD)
- Feb 22nd Zoom Talk - "Using the NanoVNA with Software" by Terry G4CHD

These Zoom talks given by myself expanded on Mike's (G4KXQ) superb earlier talk.

The 1st talk demonstrated the Calibration and subsequent use of the NanoVNA to measure an antenna's SWR and determine the velocity factor and losses in a length of coax.

The 2nd talk introduced NanoVNA-Saver and its advantages. Recordings of both talks are in my Dropbox - please contact me for a link if interested.

LOCAL REPEATERS

2m Stibb Cross Repeater (GB3DN)

<http://www.g0rql.co.uk/gb3dn.htm>

User: Listen 145.6375 MHz - Transmit 145.0375 MHz.

Access 1750 Hz Tone or 77 Hz CTCSS

Repeater keeper is Tony (G1BHM)

Fusion/C4FM/WiresX Gateway (MB6DT)

Frequency 144.8125 MHz.

Keeper Darren (2E0LVC)

Fusion/C4FM/WiresX Gateway (MB6DN)

Frequency 144.825 MHz.

Keeper Drew (M0MFS)

LOCAL NETS

Zepp FM Net: Mon/Tues/Thurs/Fri :
145.450MHz - 4pm - 5pm
Wed via GB3DN - 4pm - 5pm

2m Elevenses FM Net: Mon/Tues/Thurs :
11 - 12.00 noon 145.475MHz
Wed/Fri :
11 - 12.00 noon via GB3DN

Friday Night 2m Net: Friday : 145.450 FM, 8 - 9pm

2m SSB Nets: Wed: 8 - 9pm 144.260MHz
USB SSB
Sun: approx 10.30am (follows
Top Band Net) 144.260MHz
USB SSB (Vertical polarised)

Top Band Net: Sunday 1.860 Mhz
9.30 - 10.15am
(LSB - 32W pep max)

CROSSWORD

Many thanks to Stuart (M1FWD) for this month's Crossword.

The answers are in next month's Newsletter. Good luck !



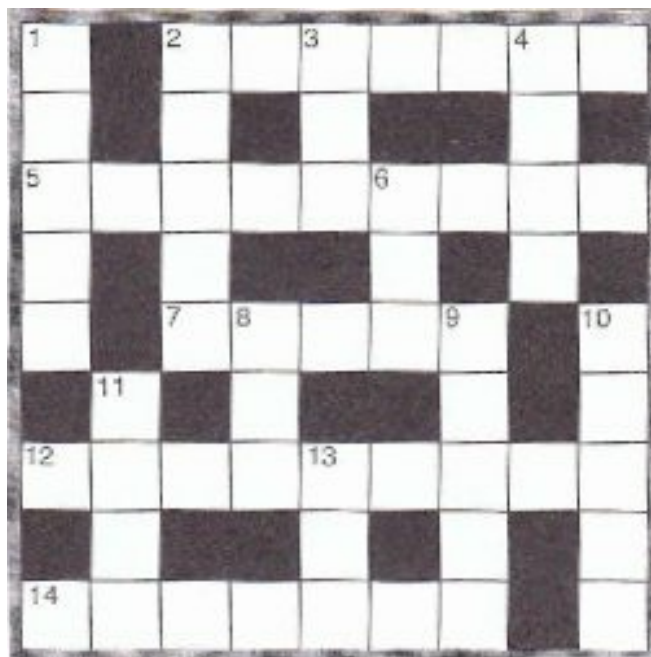
CLUES ACROSS

- 2) A system of connected electrical conductors (7)
- 5) RF spectrum ? are test instruments used to look at signals in the frequency domain (a plot of signal strength against frequency) (9)
- 7) Sweeps frequencies looking for signals (5)
- 12) This word describes anything which causes tiredness or boredom, e.g. in readers, listeners, viewers, etc. (9)
- 14) The male fertilising organs of a flowering plant (7)

CLUES DOWN

- 1) Prefix meaning 'on or to the other side of' (5)
- 2) Gets closer (5)
- 3) Endeavour (3)
- 4) Uncommon (4)
- 6) ? Marino, Tango Seven (T7) location (3)
- 8) Road vehicle (3)
- 9) Sun ?, temporary phenomena of darker areas on the

- Sun's photosphere, caused by concentrations of magnetic field flux (5).
- 10) Splint placed inside a blood vessel to remove an obstruction (5)
- 11) ? frequency oscillator creates an audio frequency signal from CW (4)
- 13) Nickname of the 34th US president (3)



Last month's answers :-

ANSWERS ACROSS: 1) Ho 2) booby 7) Roots 8) Sri 9) flux 10) lath 12) rib 13) gecko 14) mains 15) id

ANSWERS DOWN: 1) Hartford 3) Ouse 4) Bismarck 5) Columbia 6) Richmond 11) agin

SUDOKU PUZZLE

The aim is to enter a number into each cell so that any column, or any row, or any block of cells contains all numbers from 1 to 9

Terry (G4CHD)

| | | | | | | | | |
|--|---|---|---|---|---|---|---|---|
| | 2 | | | | 5 | 3 | 1 | |
| | | 1 | 9 | 6 | | | | 2 |
| | | 3 | | 1 | 8 | | | |
| | | | | | | 9 | 5 | |
| | | | | 3 | | | | |
| | 4 | 5 | | | | | | |
| | | | | 6 | 8 | | 5 | |
| | 8 | | | | 9 | 2 | 7 | |
| | 1 | 9 | 4 | | | | | 8 |

**USING THE NANOVNA TO MEASURE SWR AND
CABLE VELOCITY FACTOR**

I have written an accompanying article to the Zoom talks I recently gave on using the NanoVNA. Part 1 is on the following pages which I hope some members may find interesting.

Terry (G4CHD)

So that's it for this month

Hopefully not too many errors this month!!

Terry (G4CHD)

AN INTRODUCTION TO USING THE NANOVNA

by Terry (G4CHD)

1 WHAT IS A VNA

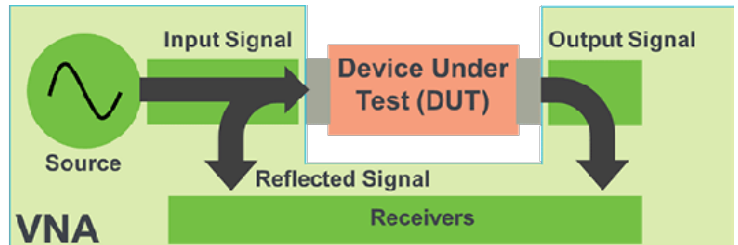
A **V**ector **N**etwork **A**nalysier (VNA) sends a signal of known frequency and magnitude to a **D**evice **U**nder **T**est (DUT) - eg an Antenna or Filter - and measures the **magnitude** and **phase** of the transmitted, reflected and output signals from the DUT. The VNA calculates various properties of the DUT from these measurements.

The VNA has 2 Ports labelled CH0 (S11) and CH1 (S21).

Port CH0 transmits a signal and measures any reflected signal enabling this single Port to measure eg the SWR of an Antenna.

Port CH1 (on the NanoVNA) is used solely to measure received signals and is used in conjunction with CH0 to measure eg the frequency response of a Filter - CH0 transmits a signal to the Filter and CH1 measures the signal output from the Filter.

It can therefore be seen that a VNA is an invaluable piece of test equipment for the radio amateur.



2. INTRODUCING THE NANOVNA

Years ago a VNA was an expensive investment and even today, a professional quality VNA can cost thousands - eg an Agilent 9GHz VNA costs over £8000!!

However, in 2016 in Japan, Tomohiro Takahashi (aka edy555) created an open source NanoVNA project to which in 2019 Hugen in China added further development and mass produced it as the NanoVNA-H. It was as a result of this mass production and the appearance of various clones that the price plummeted to less than £100 and suddenly owning a VNA became very affordable and desirable to the radio amateur.



Today there are several versions of the NanoVNA with different screen sizes and frequency ranges which can be quite confusing. However, **this article is based upon the NanoVNA H4** which has a 4" screen and covers 50kHz to 1.5GHz but hopefully much of this article's content will be applicable to your version.

The NanoVNA H4 came in a smart box containing :-

NanoVNA, USB A-C charging/computer cable, short USB C-C cable, 2 off 15cm RG316 male to male SMA leads, in line female to female SMA connector, Open/Short/50 ohm calibration loads, menu diagram and plastic plectrum.

It has been suggested that the NanoVNA threaded SMA connectors are prone to damage and being used regularly should be protected by purchasing 2 **male to female SMA adaptors** which are permanently connected to the NanoVNA. Furthermore, to protect these connectors from lateral strain, the supplied RG316 flexible leads should then be connected. Since these leads are terminated with male SMA connectors, the supplied female to female adaptor should be connected to the CH0 lead.



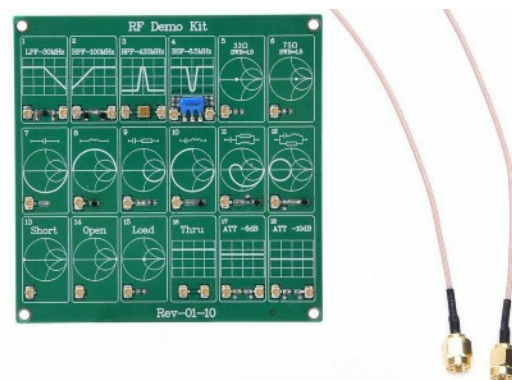
For measurements not involving CH1 (see later) there is some debate as to whether CH1 should be left open circuited or terminated by a 50 ohm load. From a purists point of view, using a 50 ohm load would lessen the chance of stray signal pickup but this would require purchasing another female to female SMA adaptor and extra 50 ohm load.

Finally, SMA adaptors are required to enable connection to eg the antenna coax and thus two female PL259, N or BNC to male SMA adaptors (as appropriate) should be purchased.

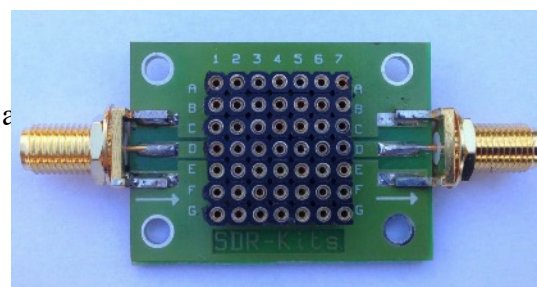
- Hence my suggested ‘shopping list’ would be :-
- 2 off male to female SMA adaptors
 - 2 off female to female SMA adaptors
 - 2 off male SMA to female 259/N/BNC adaptors
- optional :- soft case to house NanoVNA and leads/adaptors

A useful luxury addon is an **RF Demo Kit Board** which contains 18 test components/filters etc and a pair of connecting leads. The board contains Calibration loads, LPF, HPF, BPF, and tuned circuits etc and is very useful for experimenting with your NanoVNA.

My only criticism is that the small plugs on the end of the flying leads are an extremely tight fit onto the test board connectors which judging from reviews is a common problem.



An alternative **Testboard kit** is available from SDR-Kits and benefits from using good quality SMA connectors. An option is available to include the components to create on the plug in board a 5MHz 3 pole Butterworth Filter or a 13MHz Crystal Filter.



3. SETTING UP THE NANOVNA

a) Initial Battery Charge

On the ‘bottom’ of the NanoVNA there is a USB-C socket enabling the NanoVNA to connect to a computer using the supplied USB lead. This enables the NanoVNA to be both charged and communicate with the computer - something that will be explored later but for now, the NanoVNA will be used purely as a stand alone device.

Once connected, a red LED adjacent to the socket flashes to indicate charging which becomes a steady red once charged. Note that the NanoVNA can be charged whilst switched off.

b) Calibration of the Touch Screen

The NanoVNA has a touch screen which operates using resistive technology which requires the correct amount of pressure to operate correctly.

To calibrate the touch screen, bring up the Main Menu by pressing the multifunction switch and rocking the switch to highlight **CONFIG**. Press the switch again to bring up a sub menu and again rocking the switch, highlight **TOUCH CAL** and press the switch to bring up a blank screen with the command to **TOUCH UPPER LEFT**. Using either the supplied plectrum or a soft tip pen, touch the screen in the top left corner and a new command **TOUCH LOWER RIGHT** will appear. Again using the plectrum or soft tip pen touch the screen in the bottom right corner causing the sub menu to reappear. By rocking the switch highlight **SAVE** and press the switch to save the calibration. The plectrum or soft tip pen can now be used.

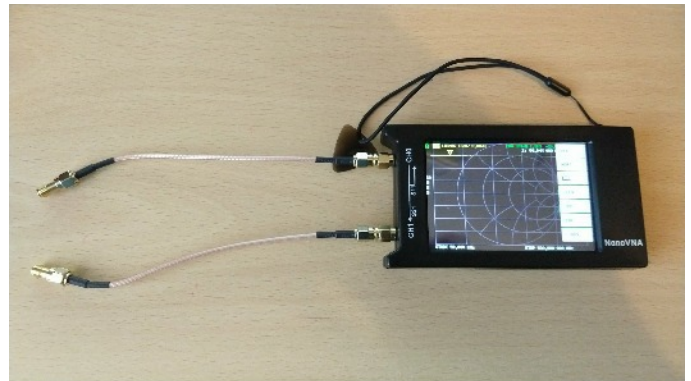
Finally to test the screen calibration, touch anywhere on the screen to bring up the Main Menu and select **CONFIG** and then **CONFIG-TOUCH TEST** to produce a blank screen. Draw all over the screen with your plectrum etc which should leave a line on the screen. Once you stop the screen will return to normal and the test is complete.

c) NanoVNA Calibration

The first Calibration should be suitable for general use of the NanoVNA and therefore cover a frequency range from the lowest frequency available to the highest frequency you are likely to ever use. In my case this would be from 50kHz to 500MHz to include all bands from topband to 70cm. The purpose of the Calibration is to compensate for any attenuation/signal delay within the NanoVNA including any adaptors or leads up to the Calibration Plane which is where measurements are made.

eg the Calibration Plane would be at the ends of the leads for the NanoVNA shown opposite.

In order to get accurate measurements, the NanoVNA must be calibrated using supplied Open, Short and 50 ohm loads. If you intend making only single Port (CH0) Reflective measurements on an antenna eg SWR then a three step calibration using the 3 loads is all that is required.



However if you intend using both Ports (CH0 and CH1) eg to measure a Filter response, then two further steps are required which ideally needs a 50 ohm load on both CH0 and CH1. It is also important to perform the calibration **at the point** where you intend making your measurements ie at the Calibration Plane.

Consider an antenna fed by coax and you want to measure the antenna's impedance. If we calibrate the NanoVNA using the calibration loads **at the antenna end** of the coax, then measurements will automatically compensate for the length of coax and it will be as if one had made the measurements actually **AT** the antenna terminals.

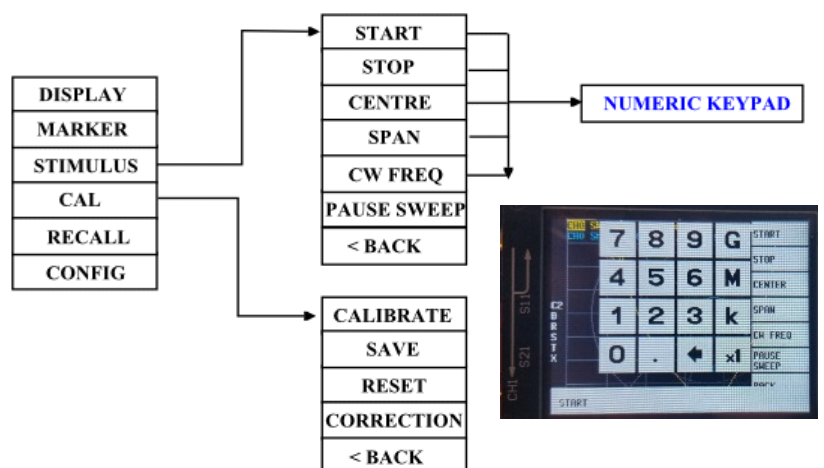
d) General Full 2 Port Through Calibration (Both CH0 and CH1 used) - stored in location 0

As this is to be a **general purpose Calibration**, then the frequency range is **50kHz to 500MHz** (as explained earlier) and a **Full Calibration** involving all 5 steps will be used (covers both Reflective and Through type measurements). This Calibration should be stored in **location 0 (C0)** as this is loaded by default when the NanoVNA is switched on (and needed when driven by external software as explained later). Will assume only have one 50 ohm Load so CH1 left open circuit.

STIMULUS and **CAL** sub Menus are used as shown :-

Set Frequency Range :-

Touch screen to reveal Top Menu
 Touch **STIMULUS** and then **START - Numeric Keypad** window opens - touch 5, 0, k. Touch screen to reopen sub Menu and touch **STOP** - and using **Numeric Keypad** touch **5, 0, 0, M**. Frequency Range is now entered



Perform Calibration :-

Touch screen to reveal previous sub Menu and touch <BACK> to return to the Top Menu.

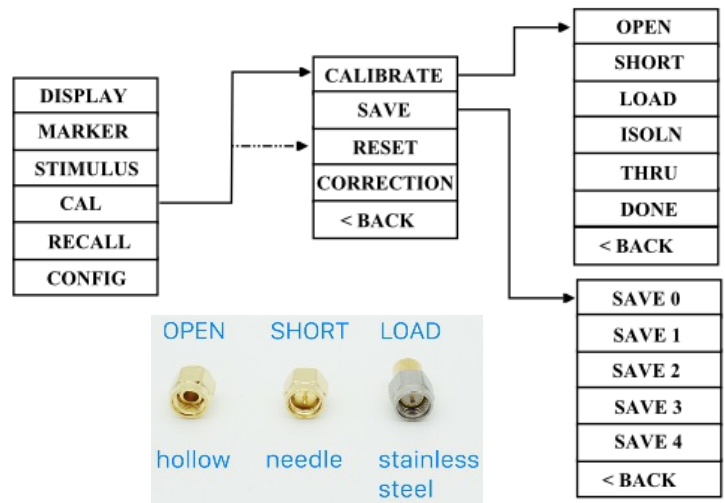
Touch **CAL** to bring up sub Menu and touch **RESET** to clear.

Now touch **CALIBRATE** to bring up sub Menu.

Connect **Open Cct Load** to calibration point and touch **OPEN**. Now prompted to connect **Short Cct Load** and when done, Touch **SHORT**. Now when prompted connect **50 ohm Load** and when done touch **LOAD**. Have now completed a 1 Port Calibration and if this is all that is required, touch **DONE** and **SAVE** to any location other than 0 as we need location 0 for the 2 Port Calibration.

Continuing with a 2 Port Calibration, you will be prompted to do **ISOLN**. There is some debate as to how this should be done but assuming you only have one 50 ohm Load, transfer it to the CH1 lead and touch **ISOLN**. Now when prompted to do **THRU** which involves connecting CH0 and CH1 leads. Remove the 50 ohm load and using the female to female adaptor on CH1, loop the leads together and touch **THRU**.

Finally touch **DONE** and touch **SAVE 0** to store the Calibration as **C0**.



e) Testing the Calibration using a Smith Chart

The Calibration is now completed and saved in the NanoVNA. To check that the calibration was successful, we will use the Smith Chart display.

On a Smith Chart, the central horizontal straight line is a line of pure resistance values - the extreme right hand end is a pure open circuit and the extreme left hand end is a pure short circuit. The dead centre is a value of 50 ohms pure resistance. To display the Smith Chart, as per setting traces in the Example in section f), use **DISPLAY/FORMAT/SMITH** for the selected trace.

Hence, after calibration, attaching the standard Open, Short and 50 ohm loads in turn should produce the Smith Chart images as shown below :-



Open Circuit

Short Circuit

50 Ohm load

f) Measurement Configurations

Having now done a General Calibration, it is useful to consider what other types of measurement you wish to make and to decide for each - which Traces (4 max) you want displayed, the Format for each Trace (eg Smith or Logmag etc), Stimulus Frequency Scan Range, and finally a Calibration which will be Stored together with all settings for future use when making this measurement.

3 EXAMPLE 1 - MEASUREMENT OF VHF/UHF ANTENNA SWR

A different calibration is required which covering **100MHz to 500MHz** rather than the general calibration in location 0 (which covers 50kHz - 500MHz). In addition, this calibration only needs to use the first 3 steps for a **1 Port Reflective** and can be stored in eg **location 1**.

As described at the bottom of page 3 set **STIMULUS** to **START** at **100MHz** and **STOP** at **500MHz**.

Then as described on page 4, repeat the **Open, Short and 50 ohm Load** steps and then touch **DONE** and **SAVE 1 (C1)**.

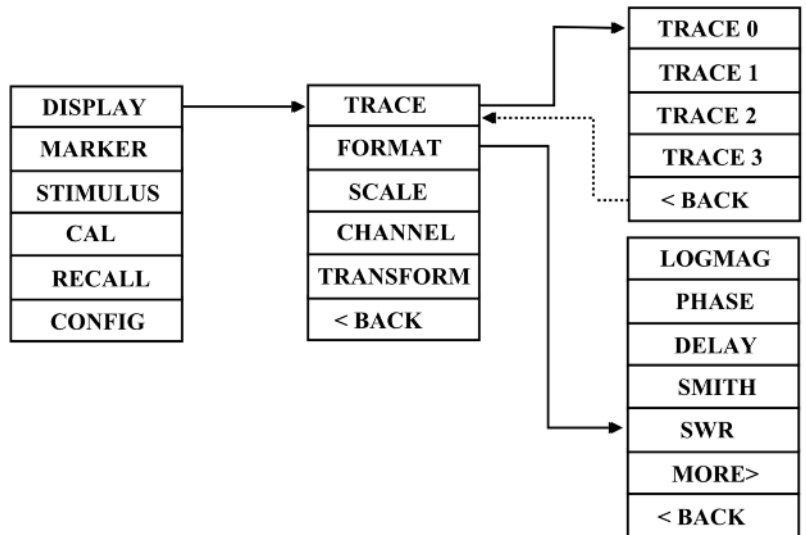
Finally, just one trace is required ;- **SWR**

Method is as follows:-

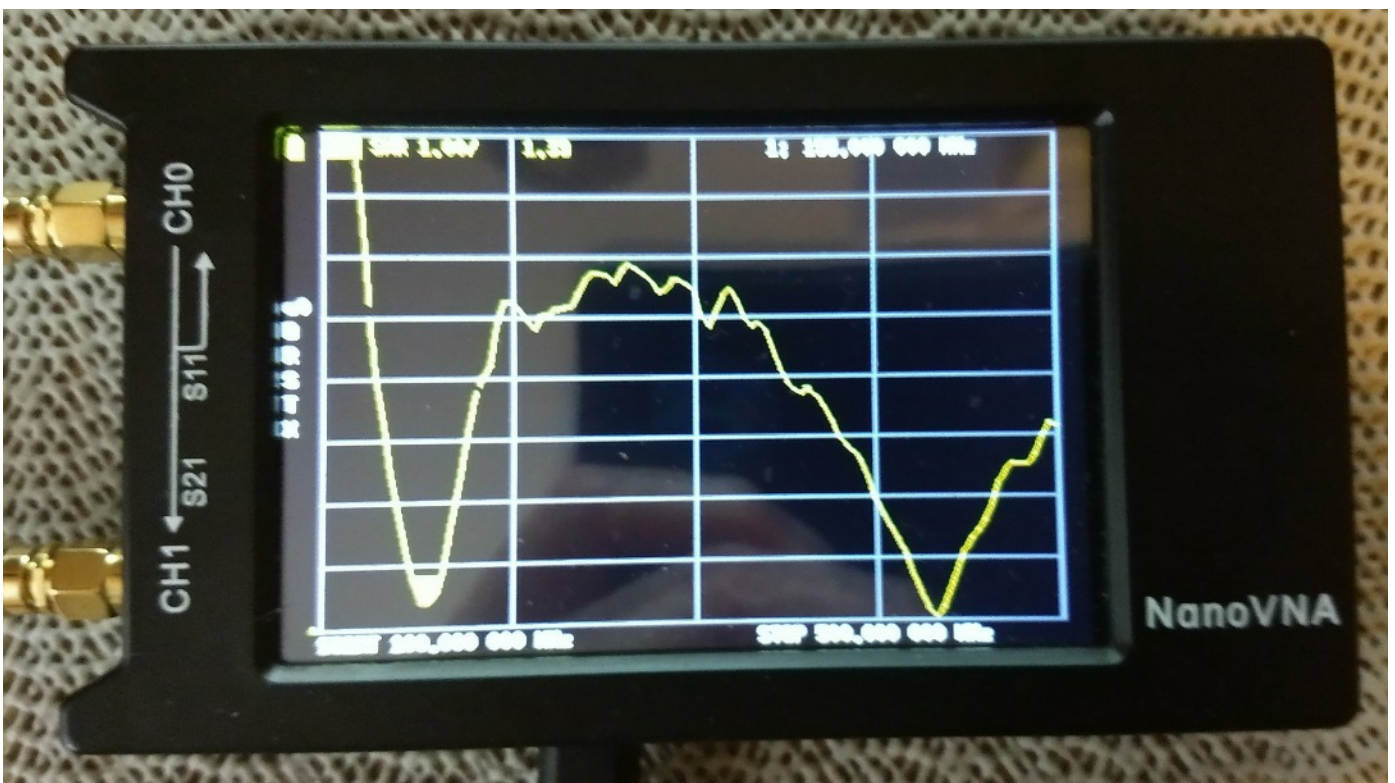
Touch **DISPLAY** then **TRACE** to bring up Traces sub Menu

Touch **TRACE 0** if not already highlighted and touch any other highlighted traces to disable them.

Touch **FORMAT** and then touch **SWR**.



Connect the antenna feed coax to **CH0** via an adaptor (if required) and the SWR trace should be displayed as shown below:-



Move the Marker by rocking the top Rocker switch on the NanoVNA to the required frequency (in white at top of display) and read off SWR (Yellow).

4. EXAMPLE 2 - MEASUREMENT OF COAX VELOCITY FACTOR & ELECTRICAL LENGTH

This will be performed using an unknown length of RG8 X purchased from Nevada

a) Coax Cable Measured Physical Length and Specification Attenuation

The coax cable used was a 35m length (according to the order) of mini RG8 Super X coax purchased from Nevada.

The **Specification** of the cable according to the Nevada web site is :-

Characteristic Impedance 50 ± 3 ohms Attenuation dB/100m :-

Velocity Factor (VF) 80% (0.8)

Capacitance 80pF /m

The **measured physical length** of the cable was 40m 70cm **ie 40.7m**

However it is the electrical length (in wavelengths) at a selected frequency which needs to be measured.

| f (MHz) | dB/100m |
|----------|----------|
| 5 | 2.1 |
| 10 | 2.9 |
| 50 | 7.2 |
| 100 | 10.5 200 |
| 15.2 400 | 22.2 |
| | |

The wavelength λ in **free space** of a radio wave and frequency f are related by the formula:- **$f \times \lambda = c$** where c is the speed of light equal to 300 million m/s

However, a radio wave travels slower in a coax cable (due to the dielectric) by a factor termed the Velocity Factor VF (between 0 and 1)

Hence :- Electrical length (in wavelengths) = [Physical Length (m) x f (MHz)]/[300 x VF]

eg for a 40.7m physical length of coax with a VF of 0.8, then at 7.15MHz

Cable Electrical Length is $[40.7 \times 7.15]/[300 \times 0.8] = \mathbf{1.21 \text{ wavelengths}}$

assuming the specified Velocity Factor of 0.8,

b) Measurement of cable's Velocity Factor

There are two ways it can be measured using the NanoVNA :-

Method 1 - Using Pulsed signal from CH0 with cable Open/Short circuited and 1 Port Calibration

Set up the NanoVNA to send a pulsed signal down the cable which has an **open or short circuited load**. All of the pulsed signal will be reflected back to the NanoVNA which measures the time for the pulse to travel there and back. If the anticipated value of Velocity Factor VF is used, then the NanoVNA can calculate from the measured time, the physical length of the cable. Hence, by refining the value of VF until the NanoVNA produces the measured value for the physical length, the actual VF can be determined thus :-

Another 1 Port Reflective calibration is required from **50kHz to 60MHz** to be stored in **location 2 (C2)**

Perform a **1 Port (Open, Short, Load only) Calibration** over the frequency range **50kHz to 60 MHz** and store in **location 2** (see pages 3 & 4) then -

Ensure the far end of the coax is either open or short circuited and set up the Channel, Display etc as described below :-

The Menu Diagram on the following page will help you navigate the Menu structure

Touch screen to show **TOP MENU**

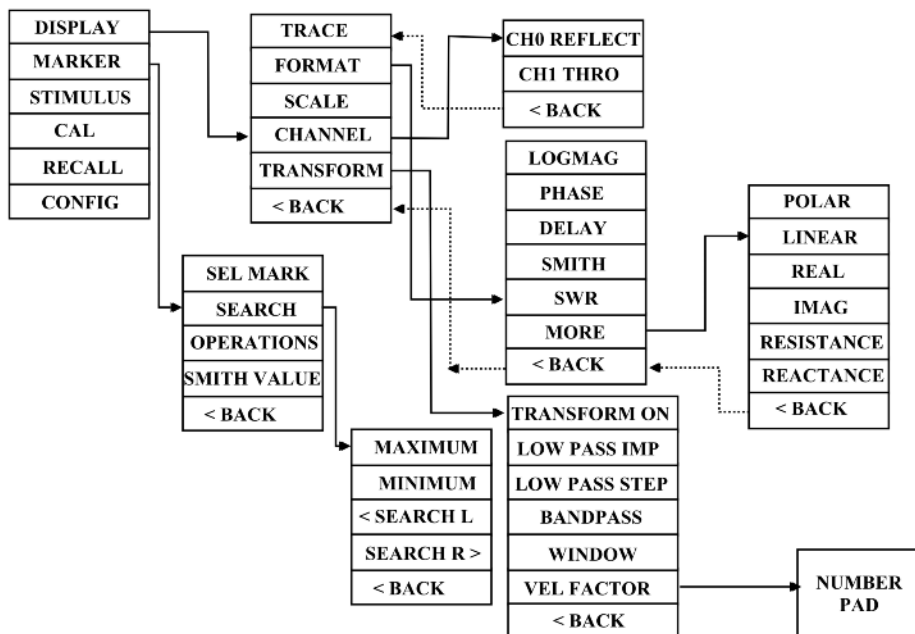
Touch **DISPLAY** and then **CHANNEL** and then **CH0 REFLECT**.

Touch screen to redisplay **DISPLAY** Menu

Touch **TRACE** and disable all but **BLUE** trace (touch any highlighted Trace to disable)

Touch **BACK** to return to the **DISPLAY** Menu

Touch **FORMAT** then **MORE** and then **LINEAR** Touch screen to redisplay **FORMAT** Menu
 Touch **BACK** and **BACK** again to return to the **DISPLAY** Menu.



Touch **TRANSFORM** then **LOW PASS IMPULSE**

Touch the screen to redisplay the **TRANSFORM** Menu and touch **TRANSFORM ON**.

Touch the screen to redisplay the **TRANSFORM** Menu and touch **VELOCITY FACTOR** and using the Number Pad enter eg **80 x1** for a value of 0.8)

Touch the screen and touch **BACK BACK** to return to the **TOP MENU**

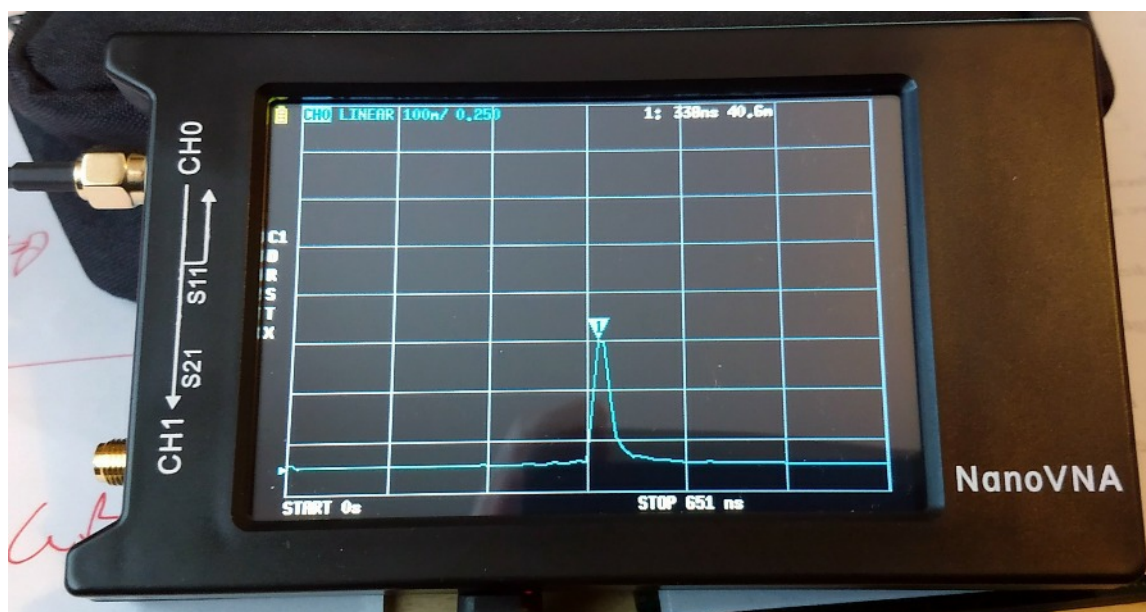
Check that the Stimulus Stop frequency previously set to 60MHz is adequate using the formula :- Stop (MHz) = (5850 x VF)/max coax length eg: if VF = 0.8, then 60MHz Stop freq gives 78m max measurable coax length.

Hence for shorter coax lengths - a higher Stop frequency would be needed. eg: for a 20m length of coax with VF = 0.8, Stop (MHz) frequency would need to be raised to $5850 \times 0.8/20 = 234\text{MHz}$ (suggest a Stop frequency of 250MHz). Adjust Stop Frequency if required.

Now to locate the top of the displayed Pulse :-

Touch **MARKER** then **SEARCH** and then **MAXIMUM** and touch screen to hide the Menu

Note length at top of screen (in white). If different from measured length - alter VF until length agrees with measured value. Final value where displayed and measured lengths agree gives the Velocity Factor.



Using this method with 40.7m of RG8 X coax, gave a **Velocity Factor a fraction over 0.8** which compared closely with the Specification value of 0.8.

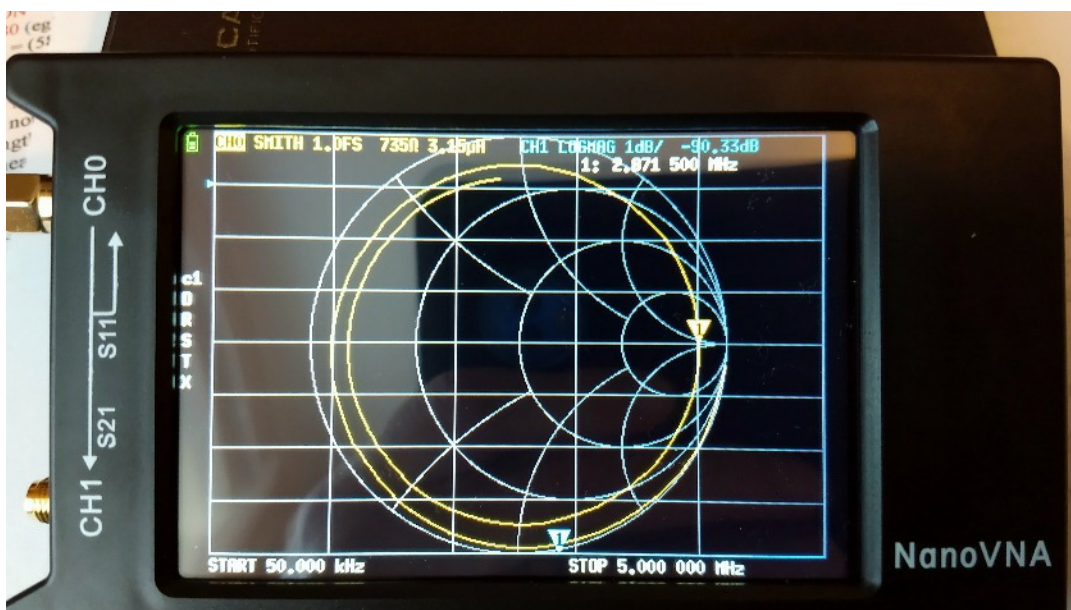
Method 2 - Using Smith Chart to determine frequency where cable is $\lambda/2$ using 1 Port Calibration

This alternative method uses an open or short circuited load on the end of the coax, and uses a **Smith Chart** to find the lowest frequency where the impedance is the same as the load which occurs when the coax is an electrical half wavelength. Method is as follows :-

Connect test coax to **CH0** connector of NanoVNA using eg a SMA male to SO239 and ensure far end of coax is either **open or short circuited**.

Start with **the 50kHz to 60MHz 1 Port Calibration C2** stored in location 2 as the **START** frequency needs to be the lowest possible. However, the **STOP** frequency of 60MHz may be too high and a value of 5MHz give a less cluttered display (this ideally should mean a fresh calibration to only use calibrated frequencies in the sweep but you may find that simply changing the STOP frequency without recalibrating gives adequate accuracy)

Enable a single trace eg **Trace 1 (Blue)** and set the Format to **SMITH**



On Smith Chart, trace starts near to right hand end of horizontal resistance line indicating near to infinite resistance (not quite since measuring here at 50kHz). Using the top rocker control move the marker from this starting point clockwise through 360degs until the trace cuts the resistance line again near the right hand end. The frequency for this point is shown at the top of the screen and should be noted. It is the frequency at which the length of coax under test behaves as an electrical half wavelength.

Thus at measured freq f , length L of coax behaves electrically as $\lambda/2$.

Let Velocity Factor of coax be V , and speed of light in free space be c .
Hence **in coax** $f \times \lambda = V \times c$ ie $\lambda/2 = (V \times c)/(2 \times f)$ which equals the measured physical length of the coax, L

Rearranging we finally get $V = (L \times 2 \times f)/c$

Using this method with **40.7m** of RG8 coax, gave a frequency on the Smith Chart of **2.871MHz**
Hence using the above formula, the **Velocity Factor $V = (L \times 2 \times f)/c = (40.7 \times 2 \times 2.871)/300 = 0.78$** which agrees closely with **Method 1** which gave 0.8.

Equally, knowing that the length of coax behaves as an electrical half wavelength at a particular measured frequency, its electrical length at any other frequency can be derived.