NWT4000-2 RF DIGITAL SWEEPER & ANALYZER

USER MANUAL

Manufacturer:

WUTONG ELECTRONIC

site：http://bg7tbl.taobao.com
TEL: +86134 2795 9750
Q Q: 1630 2767
Email: bg7tbl@126.com
version: V2.0
date: 2014-10-20

This document is based on the original manual from the supplier, edited and updated by Kurt Poulsen (OZ7OU)

The document and applied editing and updates devoted entirely to document the NWT4000-2 25MHz-4.4GHz unit (using 2xADF4351 PLL's)but will also be useful for the NWT4000-2 and NWT4000-1 series going from 138MHz to 4.4GHz (using 2xADF4350 PLL's). However, the latest NWT4000-2 where the SMD connector are on top of the PCB (and not at the edge) has improved screening and far better dynamic range. Watch our when building it into a case to use a plastic case. Using a metal case will most likely give elevated noise floor by several dB in the GHz region.

Watch out that you do not purchase the version in a case with two SMA connectors and a Green LED in between (believing it is a NWT4000 version), as it most likely will only have 1 PLL (ADF4350 for 138MHz version and ADF4351 for 25MHz version) and thus only is a signal generator and spectrum analyzer, not being able to sweep the frequency response of devices.

May 2015 edition

List of content:

Overview NWT4000-1 and NWT4000-2	**page 4**
Instrumental composition and technical characteristics	**page 6**
Conditions of use	**page 8**
The basic design	**page 9**
1. The hardware connection reference and software guide	**page11**
1.1 Functions not supported for NWT1400 in the WinNWT software	**page14**
2.1 and 2.2 Logarithmic Y scale sweep frequency settings	**page15**
2.3 Sweep Calibration	**page17**
2.4 Blending cursor data into the trace image and saving it	**page20**
2.5 Typical display of sweep measurements	**page23**
2.6 Saving of Graphical screen	**page24**
2.7 unsupported zoom function	**page25**
2.8 The frequency tag set of cursors	**page25**
2.9. The Y settings in the Graphical Display	**page27**
2.10 Bandwidth display settings	**page28**
2.11 Multi curve display management	**page30**
3. Linear scan settings (not supported)	**page33**
4.1 SWR measurements	**page33**
4.2 SWR Frequency settings	**page33**
4.3 SWR Calibration	**page33**
4.4 SWR Measurements examples	**page36**
4.5 Bridge performance investigation	**page37**
5.1 SWR_Ant function (not supported)	**page39**
6.1 Numerical Impedance measurements	**page39**
6.2 Selection of impedance measurement mode	**page39**
6.3 Reading from chart the numerical impedance values	**page40**
7.1 Filter test method 1	**page41**
7.2 Filter test method 2	**page41**
7.3 RF transformer measurement method 1	**page42**
7.4 RF transformer measurement method 2	**page43**
7.5 An antenna measurement method	**page43**
7.6 The small capacitance, inductance measuring method	**page44**
7.7 Amplifier amplitude frequency characteristics measuring	**page44**
7.8 Notch filter test	**page46**
9.1 Spectrum Analyzer functionality	**page46**

10.1 Wattmeter Functions **page48**
10.2 Wattmeter calibration **page48**

10.3 Saving a single or several Wattmeter measurement **page52**
11.1 VFO signal level on the output **page54**
11.2 VFO frequency setting **page53**
12. Frequency calibration **page55**
Appendix 1: FAQ **page59**
Appendix 2: return loss, reflection coefficient, voltage standing wave conversion tables. **page66**
Appendix 3：Sweep equipment history **page67**
Appendix 4 NWT4000 Sweep flatness and frequency calibration **page77**
Appendix 4.1 Flatness calibration **page77**
Appendix 4.2 Frequency calibration **page81**

Overview NWT4000-2

Sweep Features

★ 35MHz-4400MHz

35MHz - 4400MHz range of fast and accurate measurement

★ Dynamic range: >70dB

★ Software calibration function to reduce the system error

★ Directly display 3dB, 6dB, 60dB bandwidth

★ Curves of maximum minimum value display，with cursor

★ VFO output

★ Power meter function

★ SWR measurement

★ SWR measurement of Antenna with coax feed line simulation

NB not supported by NWT4000

★ Impedance measurement

★ Spectrum Analyzer 35MHz- 4.4GHz

★ Print of measurement data and curve

Overview

NWT series digital virtual frequency sweeper is a high intelligent RF frequency analyzer. The equipment is composed of MCU, RF detection, RF generator(s), and the circuit board contains the linear detection, log detection, completely analyzing systems for amplitude versus frequency characteristics. The amplitude frequency characteristics can be fast and accurate measurement of RF devices in the 35MHz - 4400MHz range.

NWT series of digital virtual measurement scanner will by way of man-machine dialogue, display of the numbers on the screen, and can also print out the measurement data and the curves. The instrument has the function of self checking, through the host computer and related devi ces, perform self calibration, so that more accurate measurement can be done, computing power, and perform signal generator function.

NWT series digital virtual frequency sweeper can be widely used within radio, television, communication and other fields. The measured object includes RF Devices like coaxial cables, amplifiers, combiners, amplifier modules, filters, attenuators, splitters, loads, antennas, power-dividers, and tuners.

NWT series of digital virtual frequency units are sweepers equipped with microwave integrated circuits and digital integration technology, controlled by the high performance CPU being a software instrument, and has the advantages of simple operation, reliable and easy to use by amateurs, RF developers, television equipment manufacturers, and being the best choice for RF measurement research institute.

Instrumental composition and technical characteristics

Instrument:

NWT Series sweep instrument	1PCS
USB cable	1PCS
AC (100-240V) to DC 12V power supply	1PCS
DISC	1PCS
SWR BRIDGE (OPTION not included)	1PCS
40db ATT (OPTION not included)	1PCS
6db ATT (OPTION not included)	1PCS

The version with improved screening as shown above was purchase from cart100

http://www.cart100.com/Product/40865867643/

Technical characteristics (comparison chart to other products by WUTONG ELECTRONIC)

The basic parameters

type	frequency	step	log	line	power	att	ALC
NWT25-EX	2k-25M	1Hz	>70dB	no	12V/0.4A	0-50dB	no
NWT25-USB	2k-25M	1Hz	>70dB	no	USB(5V/0.4A)	0-50dB	no
NWT70-EX	50k-85M	1Hz	>70dB	0-0.7VRMS	12V/0.4A	0-50dB	yes
NWT70-USB	50k-85M	1Hz	>70dB	0-0.7VRMS	USB(5V/0.4A)	0-50dB	NO
NWT150-EX	50k-300M	1Hz	>70dB	0-0.7VRMS	12V/0.4A	0-50dB	yes
NWT150-USB	50k-300M	1Hz	>70dB	0-0.7VRMS	USB(5V/0.4A)	0-50dB	NO
NWT500-DDS	50k-500M	1Hz	>60dB	0-0.7VRMS	12V/0.5A	0-50dB	no
NWT500-PLL+DDS	50k-500M	10Hz	>60dB	0-0.7VRMS	12V/0.5A	0-50dB	yes
NWT3000	138-3000M	1kHz	>50dB	NO	USB(5V/0.4A)	NO	no
NWT4000-1	138-4400M	1kHz	>65dB	NO	12V/0.5A	NO	NO
NWT4000-2	35-4400M	1kHz	>65dB	NO	12V/0.5A	NO	NO

Note: All the sweepers input port has **maximum power: 10dBm** (not to exceed this power level, otherwise it may cause damage to the detection device requiring return to factory for repair). If a need exist to apply power level of more than 10dBm, use external attenuator.

The system accuracy

Frequency accuracy: can be calibrated to the smallest step accuracy：3ppm

Frequency stability: 3ppm/year

Power measurement error: + -2dB

The physical characteristics (a typical example amongst all types)

Dimensions: L*W*H=113.5*92.5*30 (a typical example)

Weight: 75g (a typical example)

Working temperature: 0 ℃ to +40 ℃

Installation and storage

Conditions of use

NWT series digital virtual frequency sweepers are using USB or external DC 12V power supply, and need to be kept away from strong radiations (high power switching power supply, high power RF emission).

Operation temperature: 0-40 degrees centigrade.

Preheating:

NWT series digital virtual frequency sweepers are most accurate after 30 minutes preheating prior to measurement.

Storage

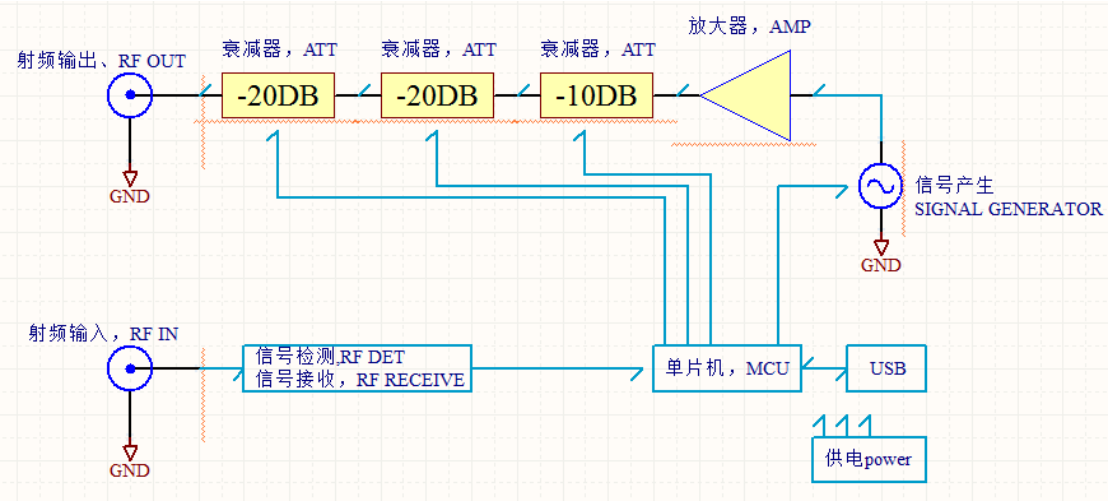
Clean up the NWT series digital virtual frequency sweeper container, filled with desiccant, can be stored at ambient temperature -10 to +50 ℃.

The basic design

Hardware configuration

1.1：

Theory:



The block diagram only for reference, some sweepers does not have att. and amplifier.

The NWT4000-2 contains addition circuitry such as two PLL signal generators but does not contain any attenuators or Amplifier.

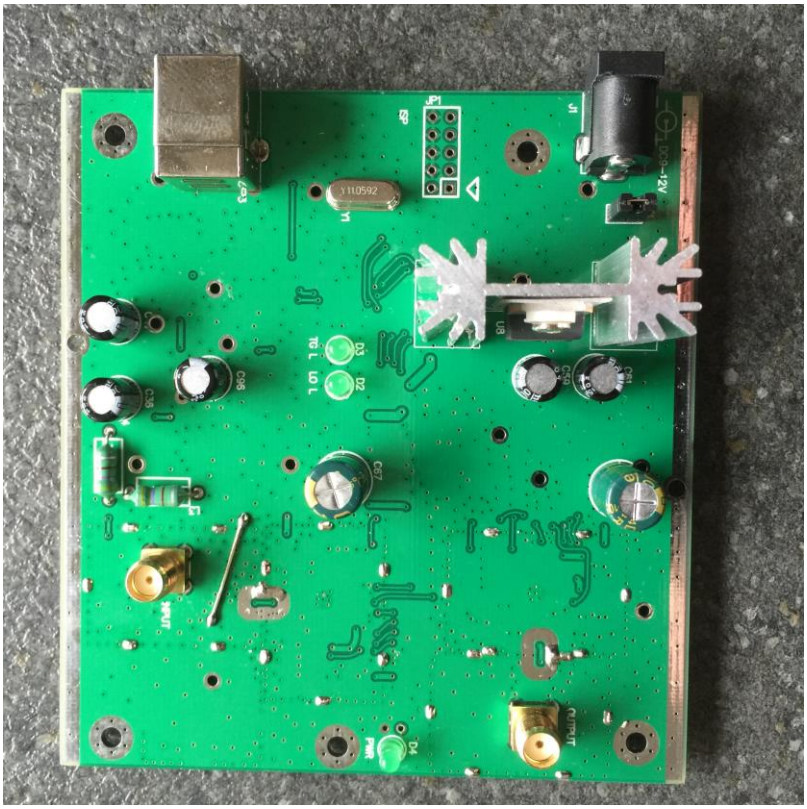
1.2

Hardware connect

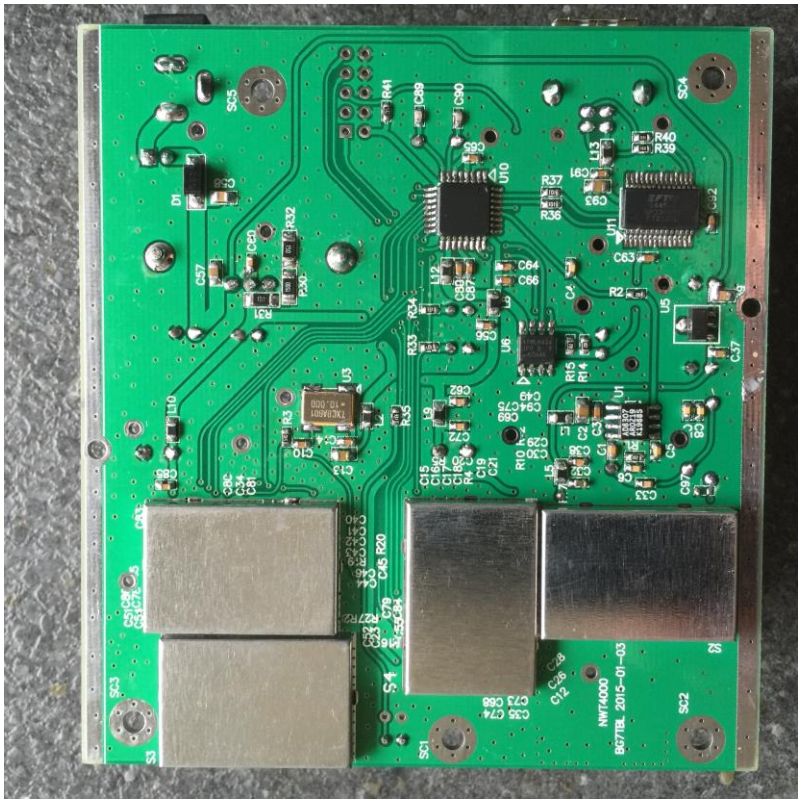
With the DC-12V and RS232/USB connected, external devices are connected to the SMA connectors. (If the power supply method is via USB, as for other type of products, you only need to connect the USB plug but the NWT4000-2 uses external DC-12V supply)

NOTE: The supply must we a clean source and voltage can be reduced to 8V to reduce temperature of the 5V regulators cooling fin, which else being quite hot.

The power connector shall be with positive center.



Top view (note new position of SMA Input and Out)



Bottom view (with latest improved screening)

The hardware connection reference map

The software guide

Software installation and configuration.

Dependent your operating system, the USB driver might be installed automatic. Let the computer search on the Internet and it might take several minutes.

Otherwise find on the supplied disk relevant drivers:

If not installed automatic then:

Install USB driver by running ftdi_ft232_drive.exe for WIN7, WIN8 or use inf file install driver.

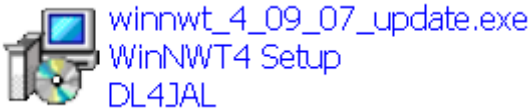
Double click install USB driver

1.1 WINNWT

Install WINNWT software

first

,

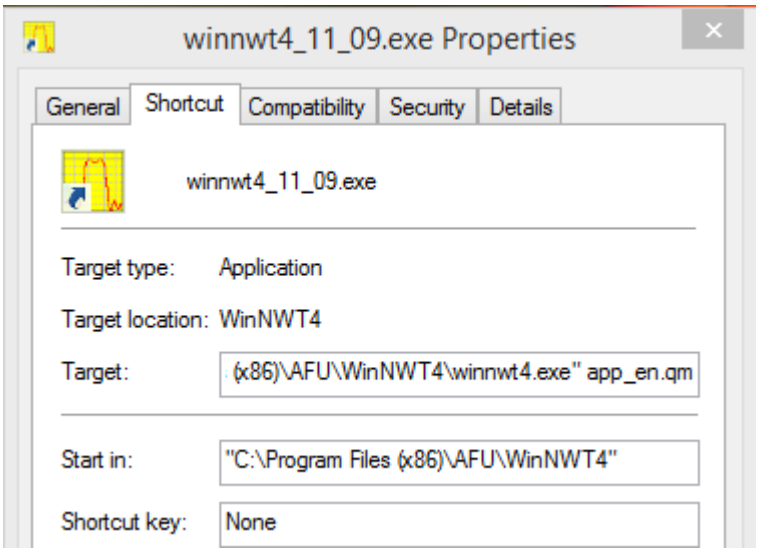
second 

After installing the WINNWT, the attribute shortcuts on the desktop can be modified to support a number of languages as described below.

Right click on the shortcut and select properties and perform the modification as described.

However, you may experience problem installing the software supplied on the Disk due error messages. Copy the two zip files to your hard disk and unzip those, and remove the Chinese character in the folders/filenames. That worked for me to install the 4.09 version and the 4.09.07 update. In any case it is recommended to use the latest published version 4.11.09 of WINNWT from below link, as several more and improved features available: http://www.dl4jal.eu/hfm9.htm. That version used for this documents screendump.

Original Chinese startup settings (remark the app cn.qm extension to winnwt4.exe)



The line “G:\Program Files\AFU\WinNWT\winnwt4.exe" app_cn.qm

Changed to:

“G:\ProgramFiles\AFU\WinNWT\winnwt4.exe” app_en.qm available

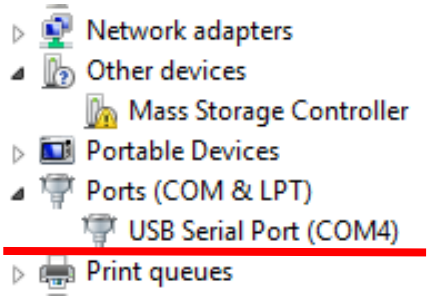
close and restart the program and the English menu is available.

The use of English version recommended but Chinese cn), Spanish (es), Hungary (hu), Netherland (nl), Polish (pl) and Russian (ru) language may be chosen. The native German language requires no extension after winnwt4.exe” (the “ required before and after the path as shown)

1.3. Setting COM port

Insert the USB into the computer.

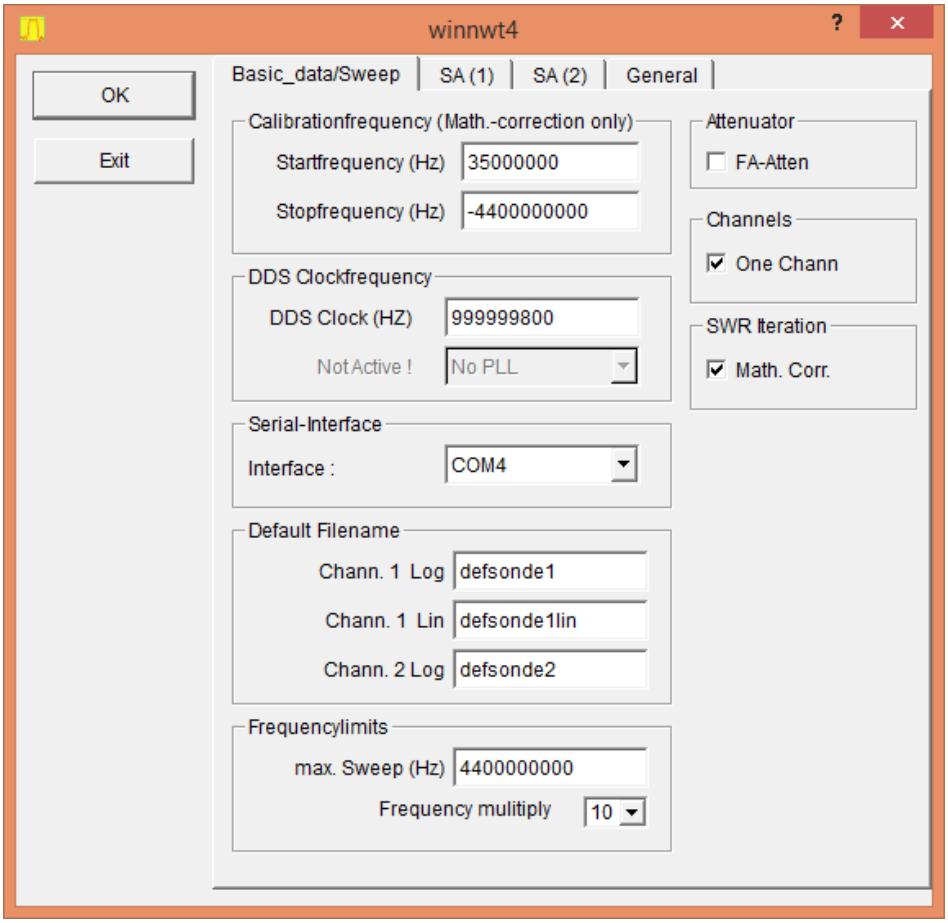
Because USB driver is already installed, in the device manager you will find the corresponding COM port and the allocated port number.



The port number to remember in this case is COM4.

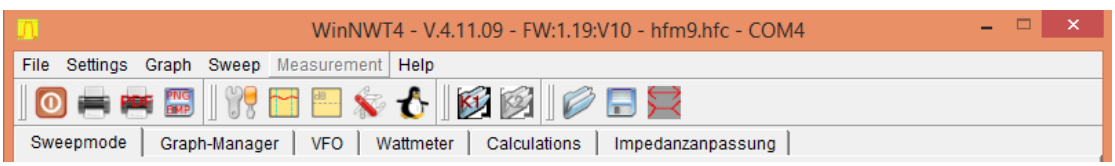
When installing the driver, on different computers the COM port number will be different

In WINNWT software "Settings", "Options", select the corresponding COM port, and click "OK".



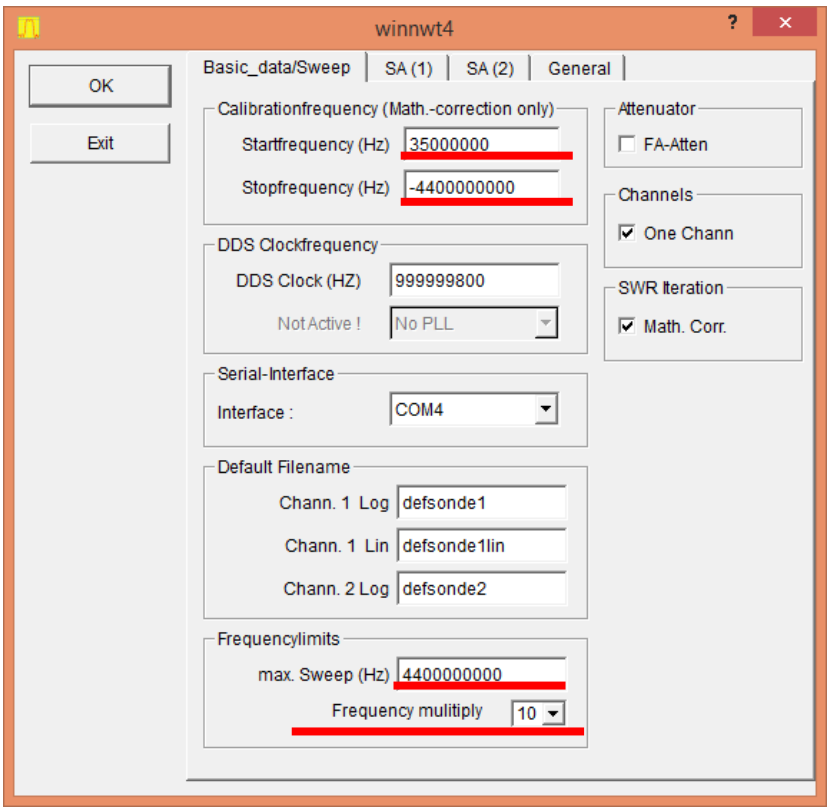
Select COM port

Choose the correct com port and if successful, you will see the hardware firmware version. Otherwise, check the connection and incorrect settings.



Correct prompt after selection of the correct COM port

When using NWT3000, NWT4000-1 or NWT4000-2, you must set frequency multiply to 10 rate in Settings/Options.



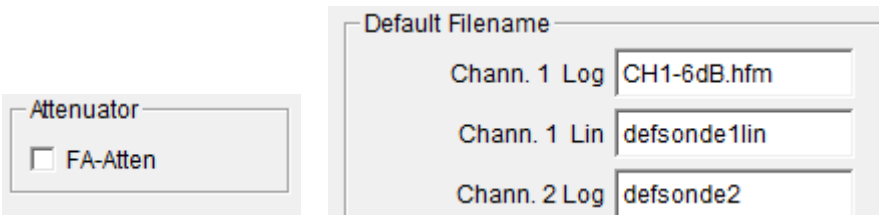
Note the settings for start and stop frequency **where stop is negative**. Note also the max sweep setting. If One Chann. tickmark in Channels is removed then you have two channel operation, e.g. quite handy to have two different calibrations in actions. Also select Math. Corr. to allow SWR itteration.

1.1 Functions not supported for NWT1400 in the WinNWT software by DL4JAL

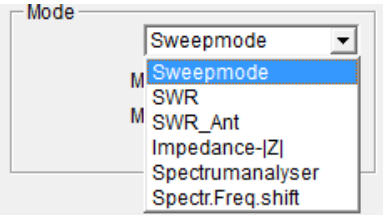
The WinNWT software developed by DL4JAL was for another project and has a number of function not supported by the NWT4000 family of products. These are:

- In the Settings Options a number of fields are not supported:
  Only Basic_data/Sweep is supported. SA(1), SA(2), General has no functions

  Attenuator has no function. Channel. 1 Lin not supported (only Log).
  Remark file name for Channel 1 and Channel calibration files can be entered in the text field so in use when program started. (here CH1-6dB.hfm)

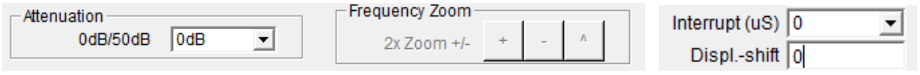


- In the mode selection box under sweepmode only **sweepmode**, **SWR** and **Impedance-|Z|** is supported. The remaining selection cannot be used as they are.



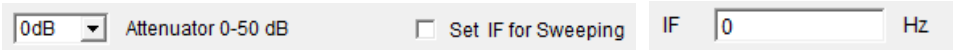
Attenuation and **Frequency Zoom** cannot be used.

Display shift OK for the dB Y Axe. Interrupt (uS) = rest time for each sample



-

- For the Graph-Manager all functions supported
- For VFO: Attenuator 0-50dB , Set IF for Sweeping and IF setting has no function.



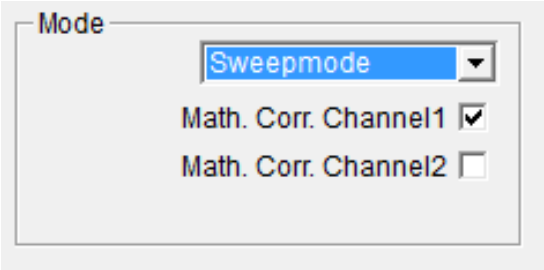
- For Wattmeter the VFO on/off does not stop the output but allows to type remarks and save these. Do not save in the application path but under a folder of your choice as else hidden for later retrieval.
- The calculations and Impedanzanpassung (impedance matching) are with no comment.

2

Logarithmic Y scale sweep frequency settings

2.1

Select the sweep frequency mode



Select the sweep frequency mode

2.2 Set the frequency parameter

Enter the start frequency, the end frequency, scanning numbers / number of samples for a scan. There are two kinds of scanning modes, a continuous scanning where the number of samples (max 9999) are being scanned, until final sample to stop scanning is measured.

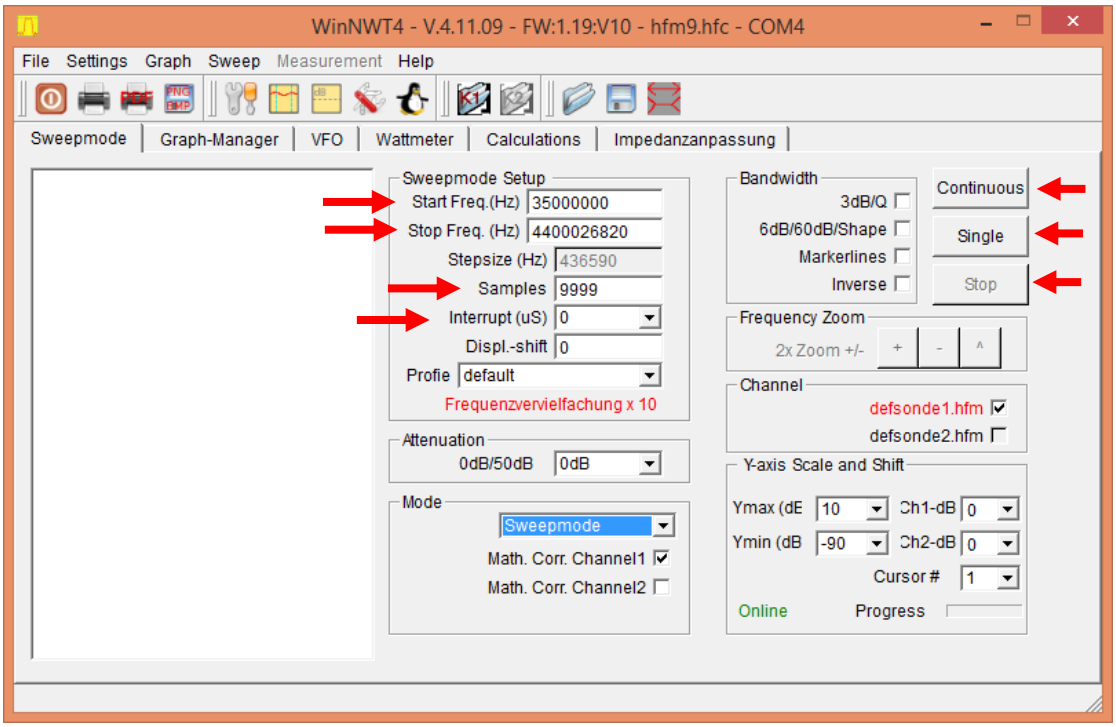
Another is the single scanning where only one scanning performed for the number of samples. For changing frequency settings, scanning numbers/number of samples and other parameters, you must click on Stop before change settings.

The scan delay for each point/sample of the output frequency, are long latency for power measurement.

Enable the Math. Corr. Channel1 (and Channel2 if enabled)

Y scale and Shift can only be set, provided the scan is stopped.

Attenuation is not applicable for the NWT4000 models



Other possible settings to be explained in later sections of this document

2.3 Before starting measurement the Instrument should be calibrated.

It is recommend to initially using the software on the supplied disc called COM assiter.exe. It performers an excellent flat calibration of you particular hardware and the result is saved into the hardware. However the levels from -10dB to 0dB is nonlinear due to about 4dB compression in the internal reception mixer and/or logarithmic detector. The -40dB level is calibrated and consequently the -10, -20 and 30dB level are not fully accurate. It applies also for all levels below -40dB. This problem can be eliminated by inserting a 6dB attenuator in the Output path (mounted on the SMA TX output at all times) but this however reduces the dynamic range by 6dB. As the WinNWT software also have calibration routines, which is allowing the top level calibration, to be performed at a user selected lower level this 6dB attenuator is only used during calibration within the WinNWT software and removed after calibration. Then the full dynamic range is available with the only limitation that 0dB level is compressed to about -3dB but from -10dB and downwards everything is perfect. If the device tested has an insertion loss above 3-4dB then the compression has no effect. If not so then use a 6dB att. permanently and accept the 6dB loss of dynamic range and create a different calibration.

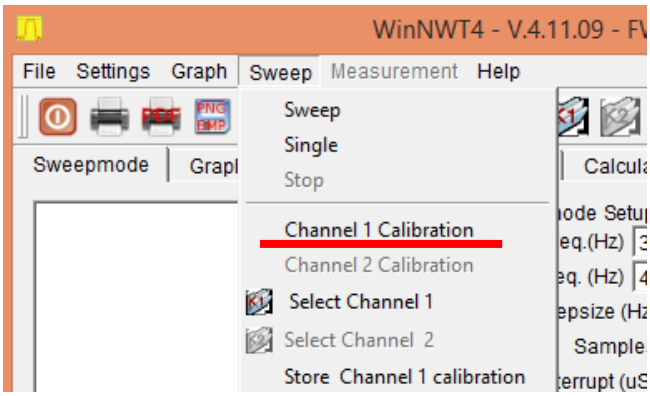
The WinNWT software can save as many calibration files as you wish so just find you own way.

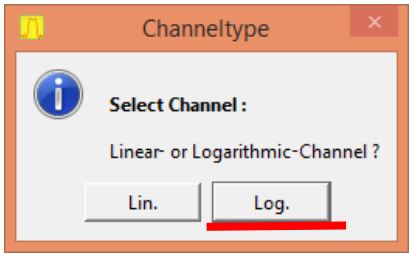
The initial calibration being the platform the WinNWT calibrations is described in the document “Calibration step_UK.pdf” published same public places as this document. The documentation also added as Appendix to this document. It also contains a frequency calibration method, which works nicely and allows 1KHz setting at 4.4GHz (but that stability not maintained over time or temperature changes).

The frequency calibration is performed at 1GHz and the measured output frequency just entered in the WinNWT DDS (PLL) clock field, as seen previously above on page 12 as 999999800Hz. Tricks a possible to use a 100MHz counter as described in said document and the Appendix.

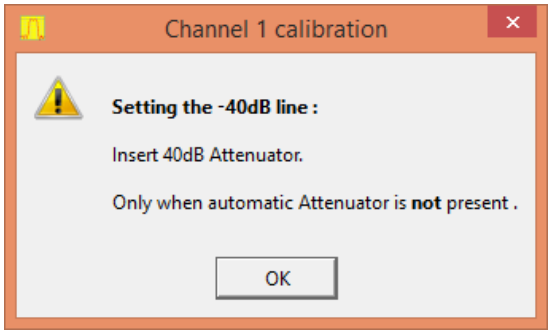
A WinNWT calibration performed as follows

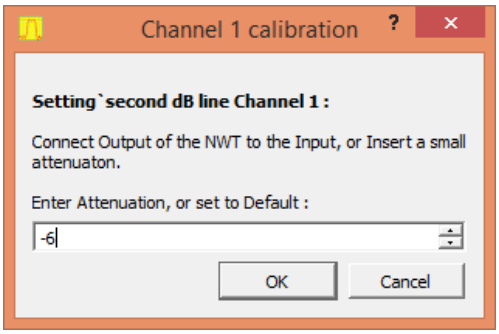
Select Channel 1 Calibration and subsequently Logarithmic Channel (Lin does not apply for NWT4000 hardware):



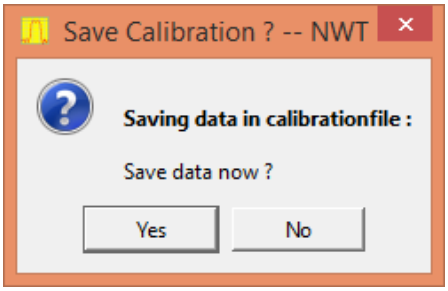


Insert a 40dB attenuator in the Transmit path (at the SMA Output) and click OK
Subsequent you are promptedd to insert a 0dB attenuator or select differently a user defined att. here stepped down to -6dB. The sweep is performed automatic with 9999 samples.

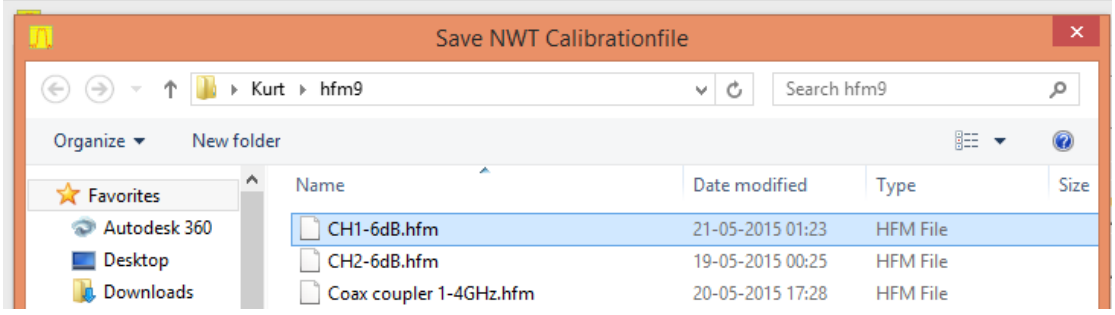




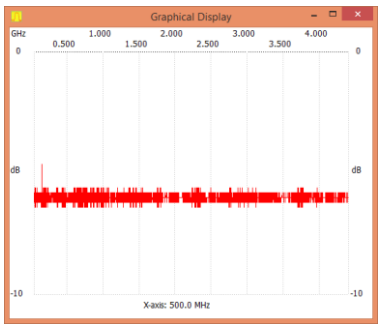
Then you are asked to save the calibration or not.
(if not then only in force as long the NWT4000 switched on)



A file name selected here CH1-6dB.hfm

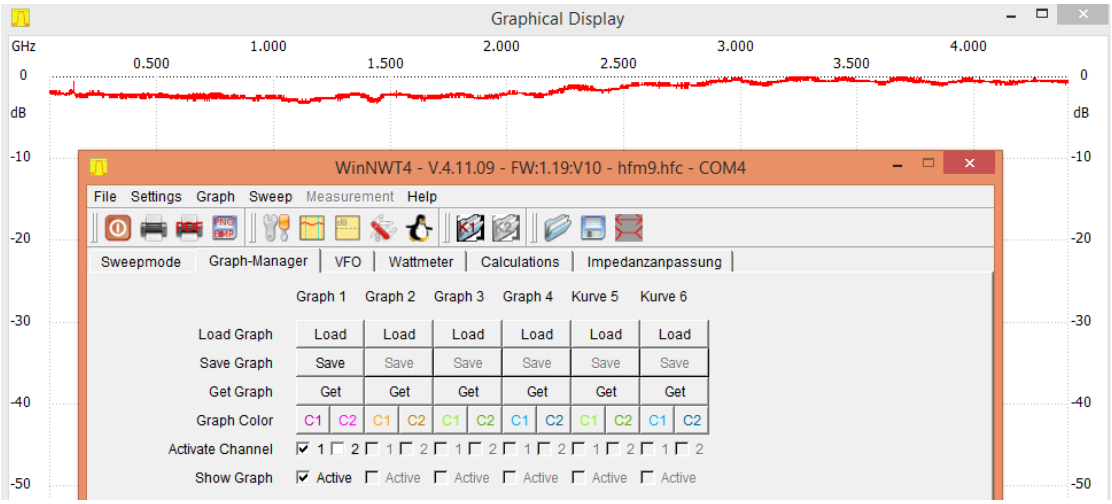


When accepted by a click on OK the trace is jumping to it correct position -6dB. If Y scaling change to 0 and -10dB we see it bang on -6dB (small image below)

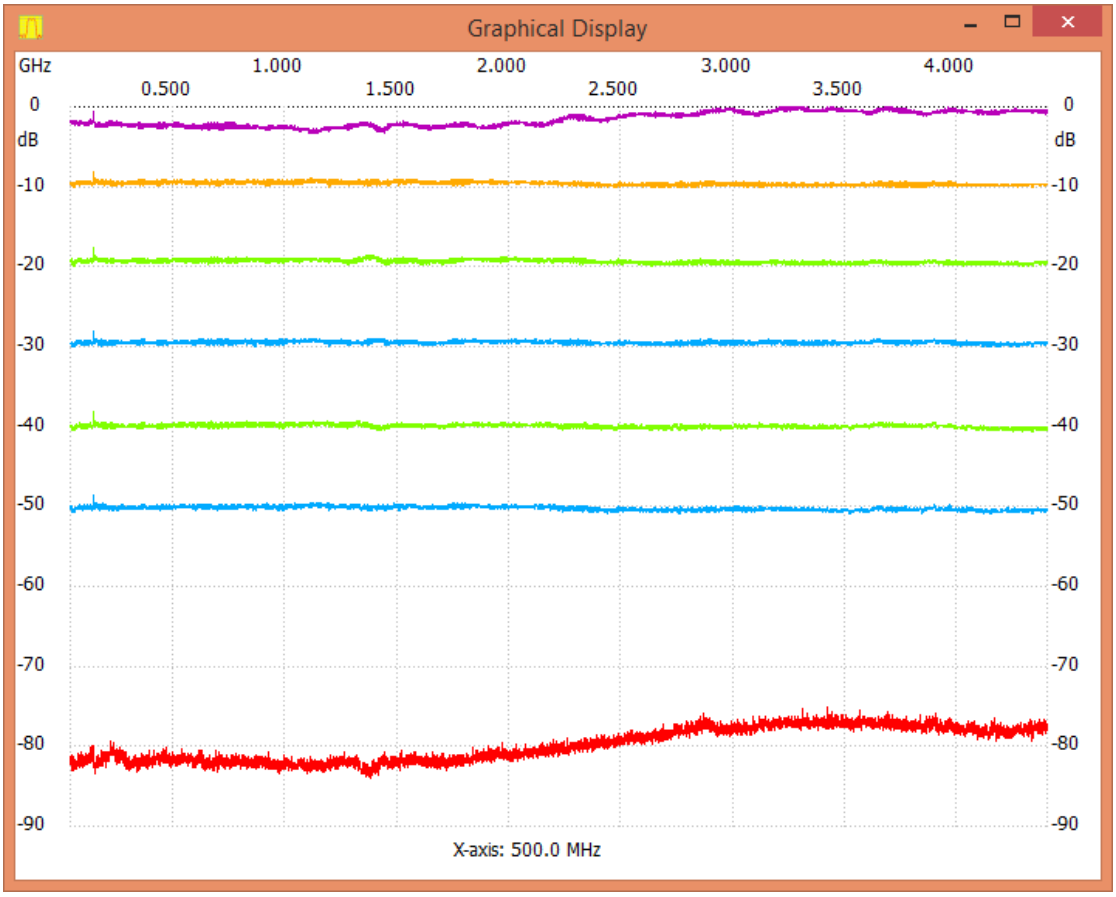


If we enter the 40dB att. and run a single scan, we will see it is flat on -40dB from 35MHz to 4.4GHz

If we connect the Output and Input directly and run a sweep we see the degree af compression in the mixer. Below 2GHz it is about max. 2.5dB and above 2GHz it is reduced to less than 1 dB. By clicking on Graph Manager we can maintain the sweep by clikcing on Get and enable tickmark Active Channel 1 and Active as shown. Thus we can have up to 6 traces for ch1 on the screen in addtion to the current run sweep.

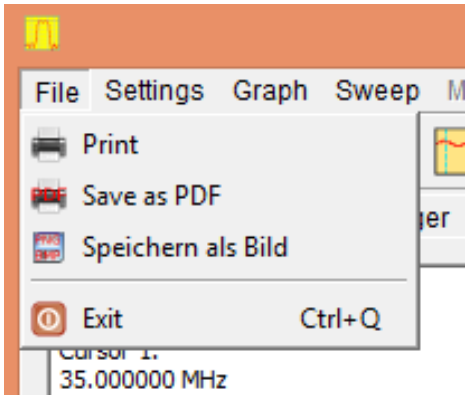


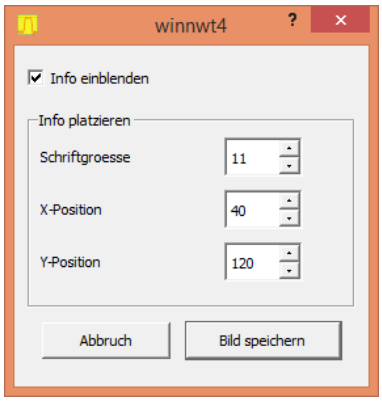
As can be seen below the linearity is quite excellent and the noise floor pretty low

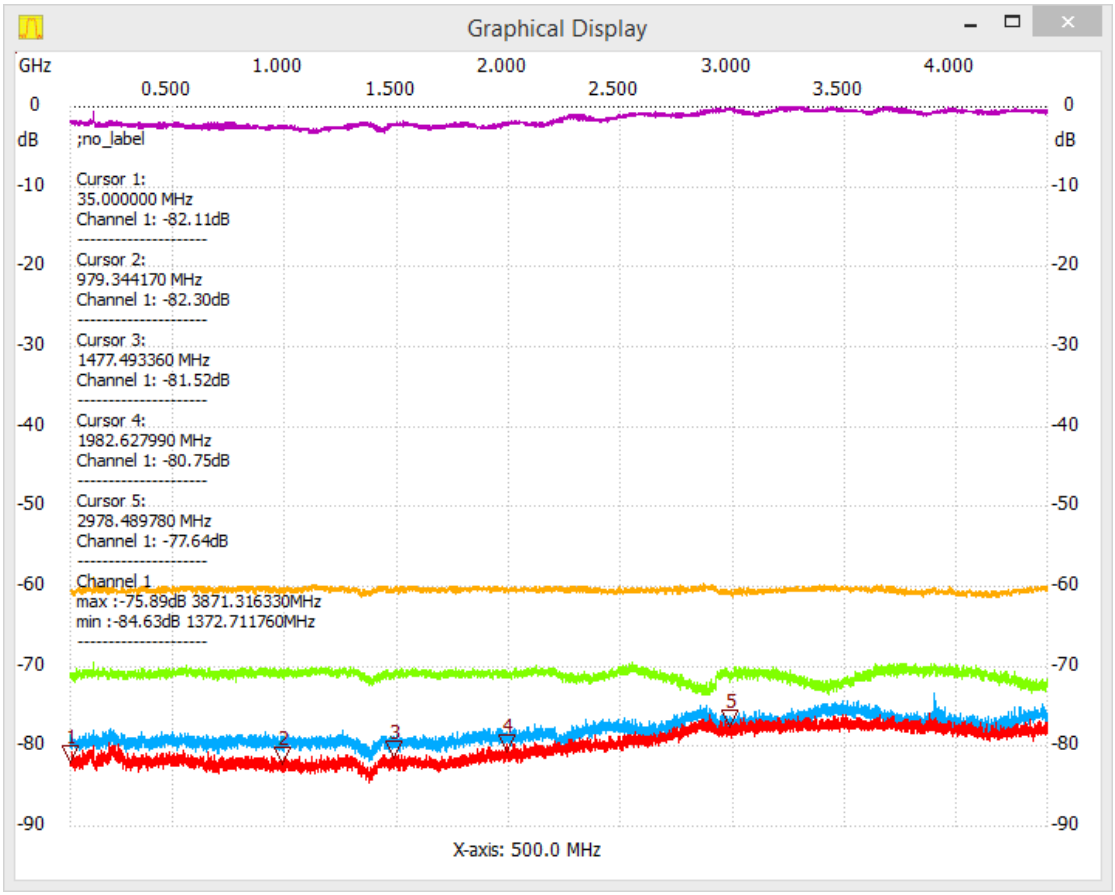


2.4 Blending cursor data into the trace image and saving it

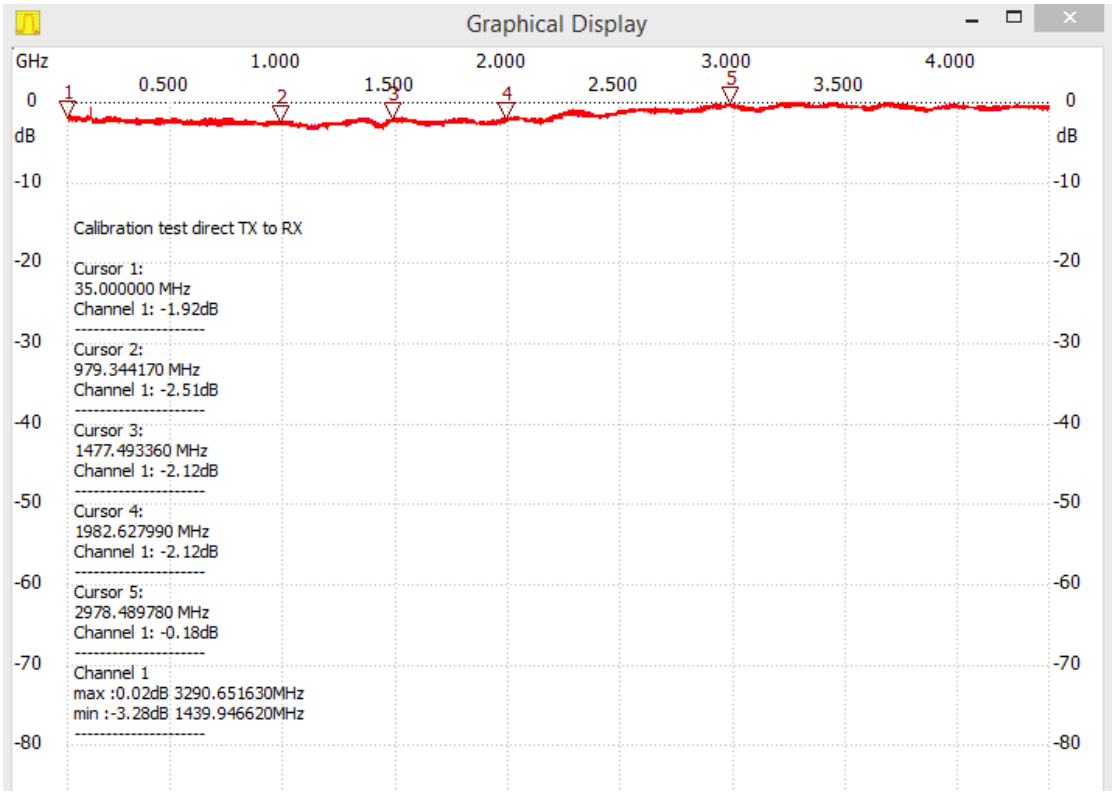
It is possible to blend cursor data into the trace image. First of all press the numeric key from 1 to 5 on the keybord and click on the frequency position where you want the particulator cursor number to be placed. When so done select in the main menu File / Speichern als Bild (store as image). When next screen promt apears enable tickmark “Info einblenden” and with X and Y position, place the information where you want it. You may also change letter size with Schriftgroesse. When you click on the “Bild speichern” you can save the image to harddisk incl. the data information as shown below.







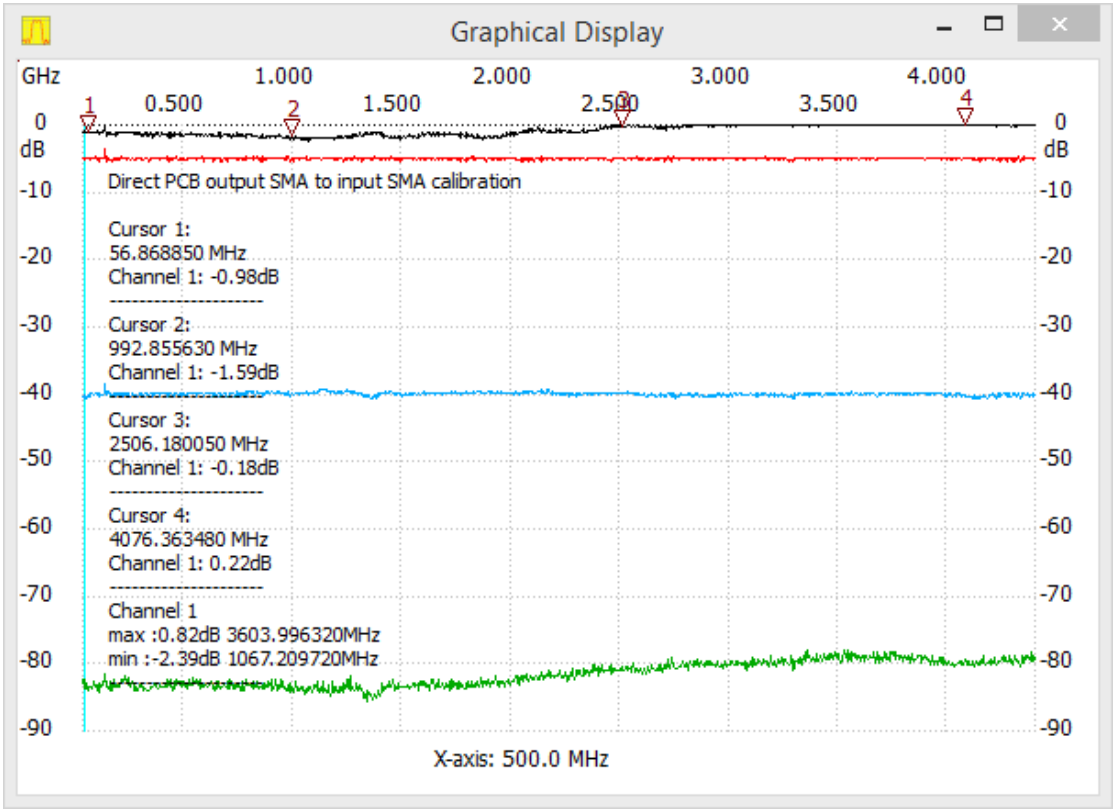
You may edit first line ;no_label prior to “einblenden” as seen on the next image below.



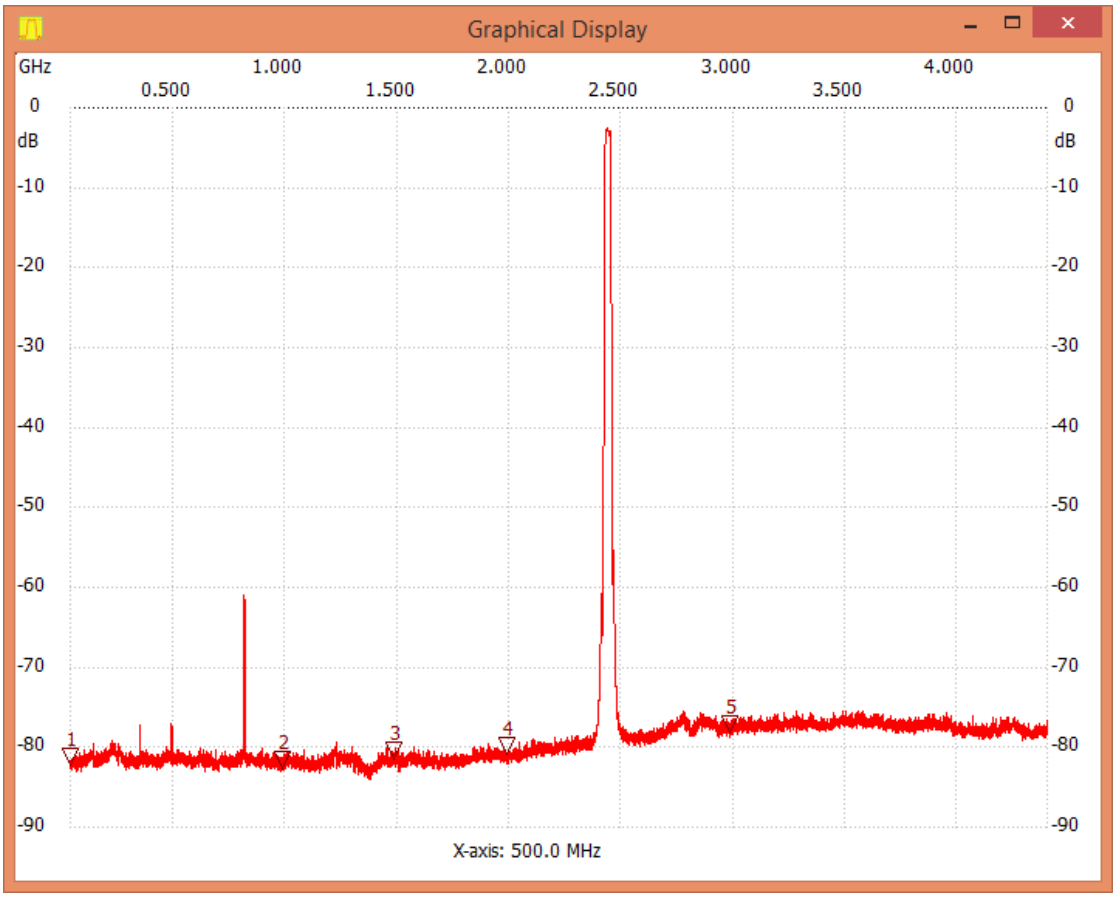
Above measurement done with two 5cm long male SMA SMA cables connected from the PCB SMA connector to a front panel with female female SMA adaptors used as the TX and RX connections. As previous described the NWT4000-2 has best dynamic range if mounted in a plastic case. Below plot shows a calibration performed without these two 5cm MSA SMA cables and the female female adaptors, thus directly at the PCB SMA adaptors and the dynamic range even better manintaning 80dB to 4.4 GHz.

To utilized the NMT4000-2 to the extreme two male female SMA adaptor might be a possiblity to get the Input and Output to penetrate the case on the top and let the cooling fin be exposed to the ambient.

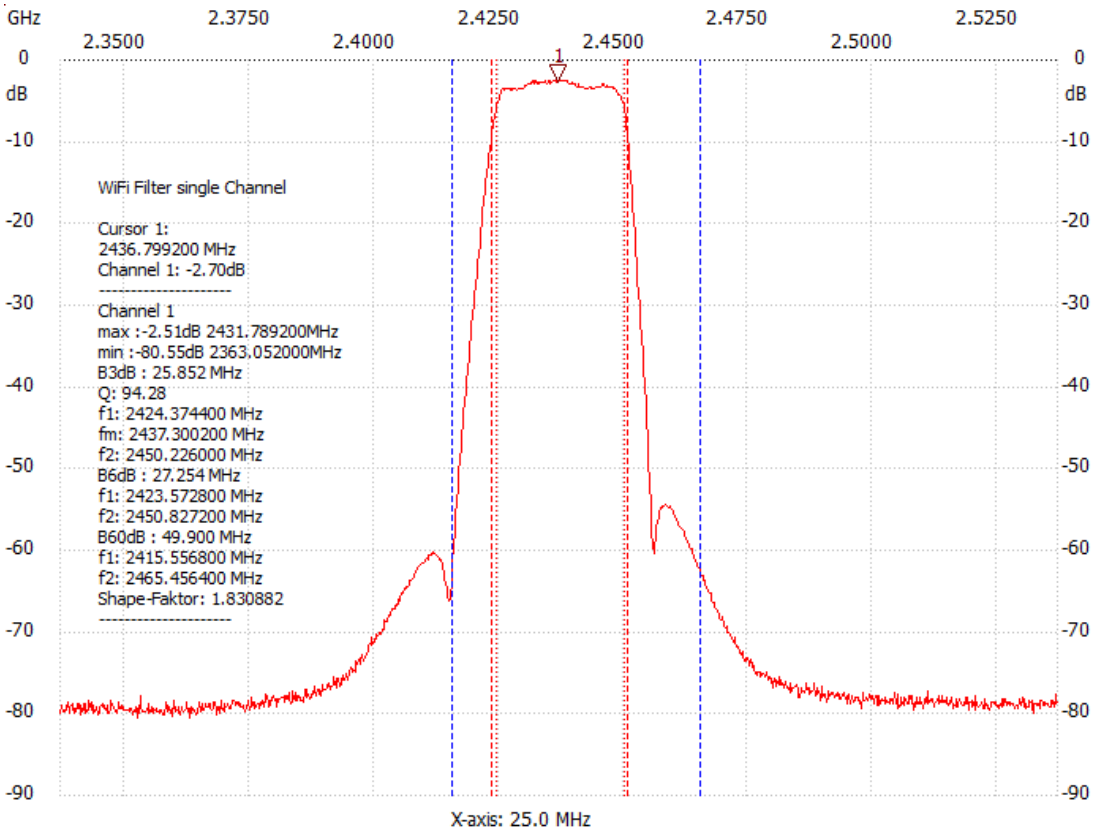
The black trace for Input and Output directly connected shows below 3GHz up to 2dB loss off signal amplitude due to mentined compression in the internal mixer and/or logarithmic detector. If the DUT has insertion loss more than 2 dB it has no effect.

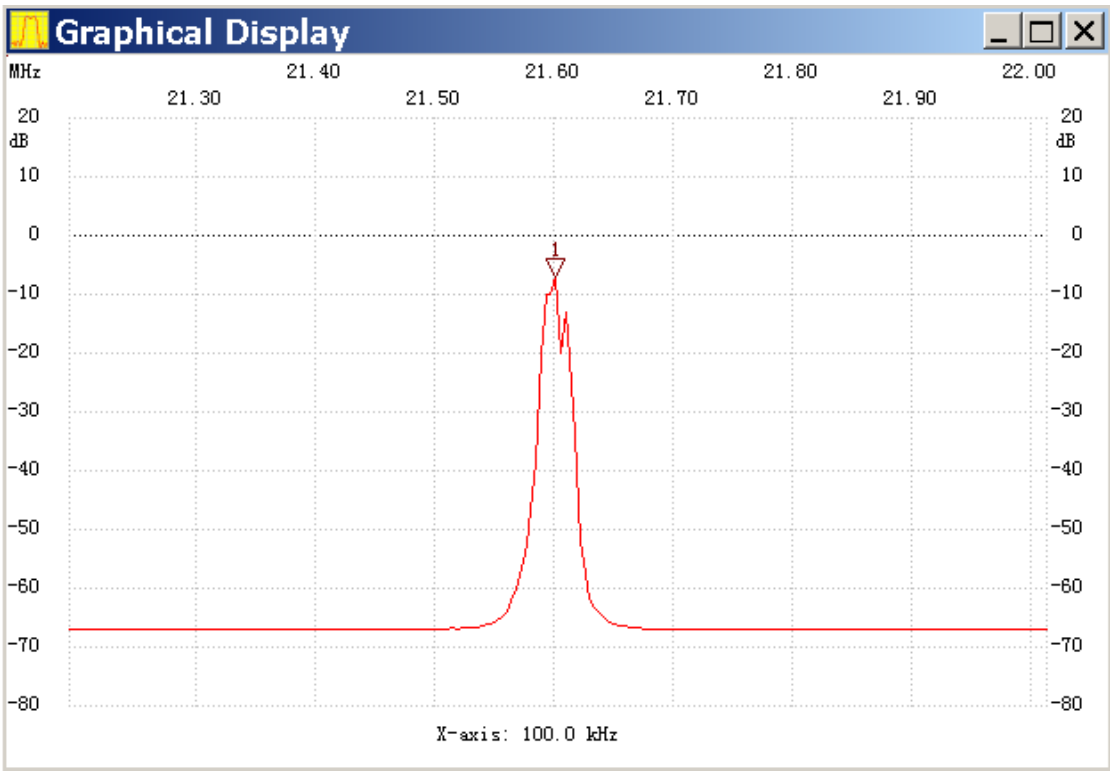


2.5 Typical display of sweep measurements



WiFi Filter single Channel



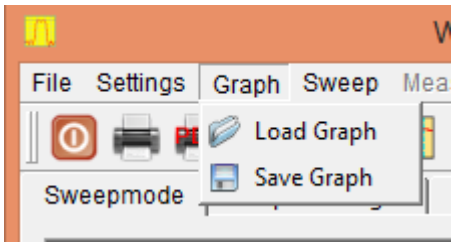


A single scan curve, the curve is a curve of a 21.6M filter

2.6 Saving of Graphical screen

The Grapical Screen can be saved and re-loaded by clicking on Graph.

The format is *.hfd and saving can happen to a folder at your choice.

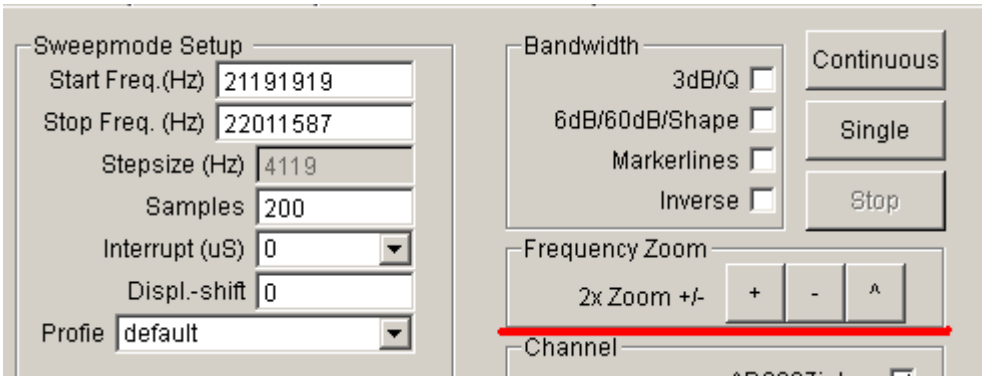


2.7

The below mentioned function about frequency zoom is not supported by the NWT4000 series and only mentioned for reference.

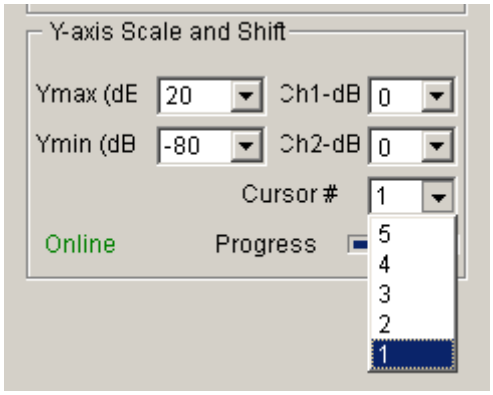
2 times zoom settings

For a measurement, the available frequency scaling functions are magnified 2 times, reduced 2 times, fast frequency response measurement device. The + button 2 times magnification operation, bond was reduced 2 times operation.

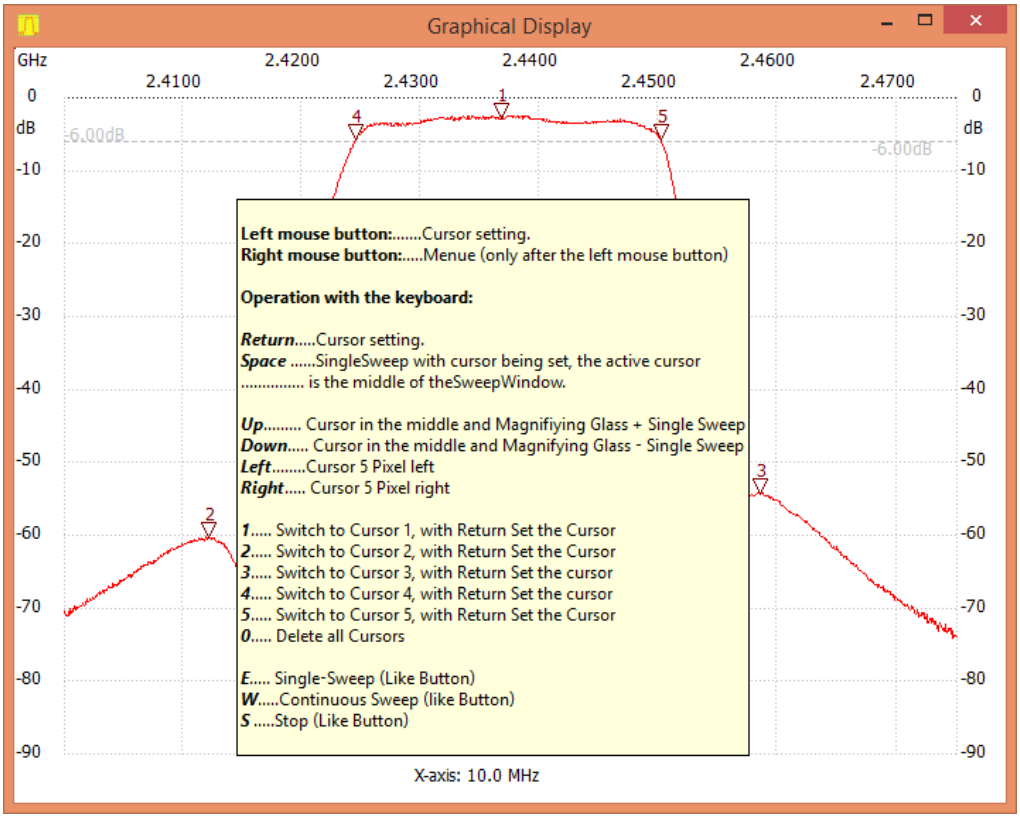


2.8 The frequency tag set of cursors

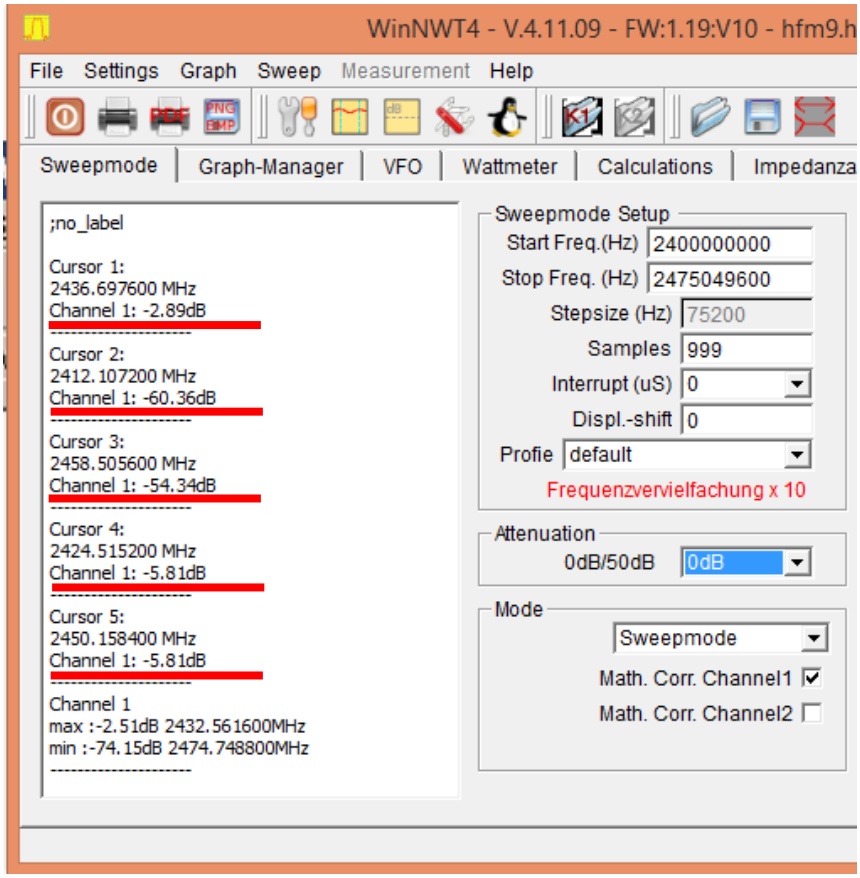
Select with Curcor #, in the drop down list, either 1,2,3,4 or 5, and on the Graphical Display, with a click of the left mouse button, where the marker is desired to be positioned. On the Graphics Display area will be displayed an inverted triangle, and in the text area, the marker frequency and corresponding amplitude will be shown. By a right click on the Graphical display you may delete a single or all markers. The Cursor # can also be selected by tapping the corresponding number on the PC keyboard, as a shortcut to the frequency tag setting.



Select the 1-5 Icon in the drop down list



Inverted triangle marker displayed



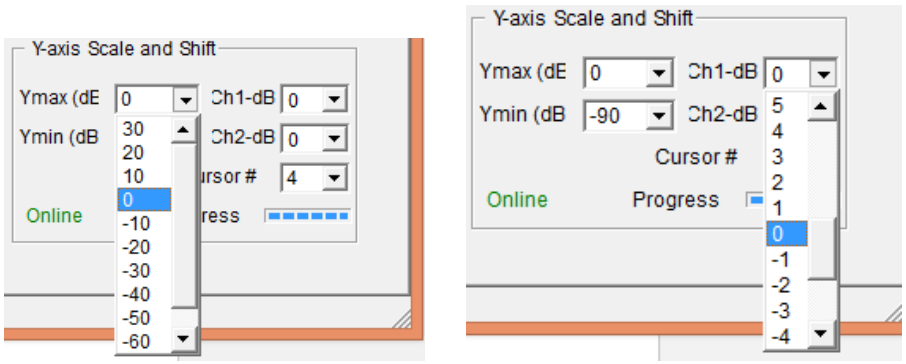
Frequency of the 5 screen markers displayed, and the signal level in dBm

2.9. The Y settings in the Graphical Display

The Y axis scaling function:

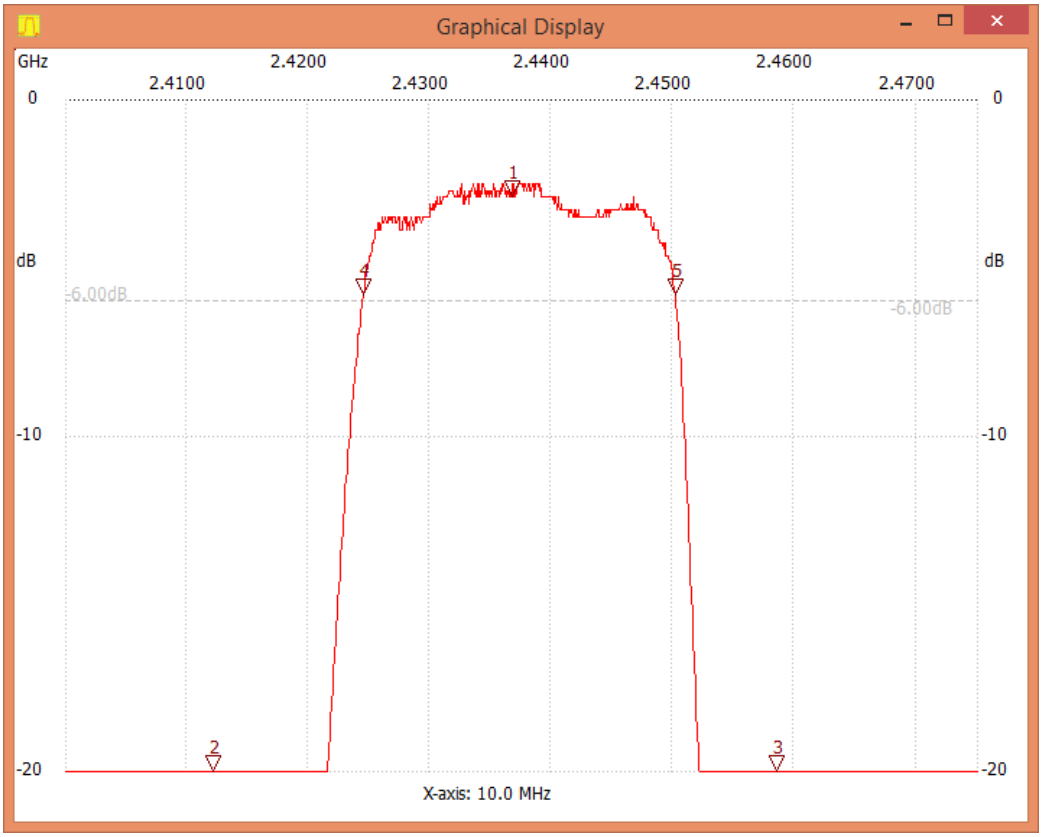
The Ymax signal level on the Graphical display is selected in the drop down list. Standard level is 20dB but 0dB more relevant for the NWT4000 family

Ymin signal level on the Graphical display is also selected in a drop down list, generally choose -90dB. Fine adjustment in 1dB step is also selectable.

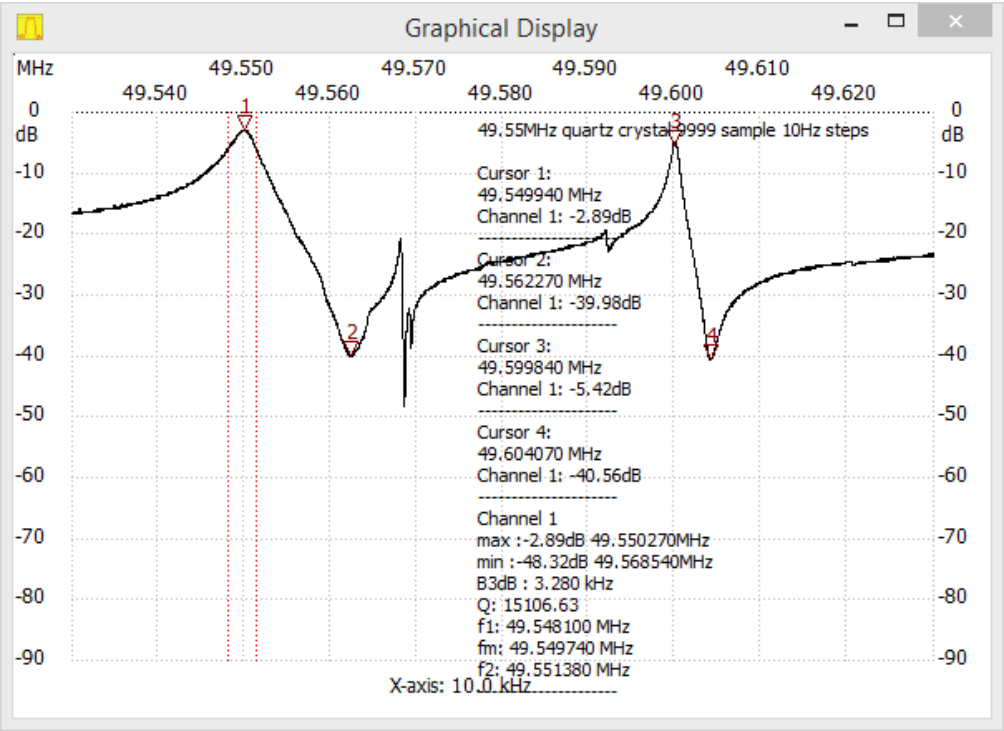


Y axis scaling function

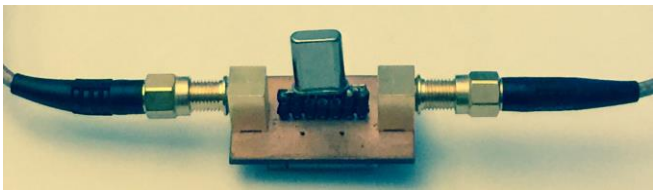
To magnify the top area of a trace you may change the settings to Ymax=0dB and Ymin= -20dB. Note that, because of the limited resolution of the MCU AD conversion the curve may appear “stepped” / jagged as seen below.



Select back to Ymax=0dB and Ymin=-90dB

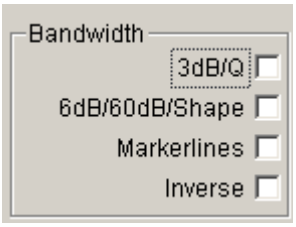


Measurement of a 49.55MHz Quartz Crystal



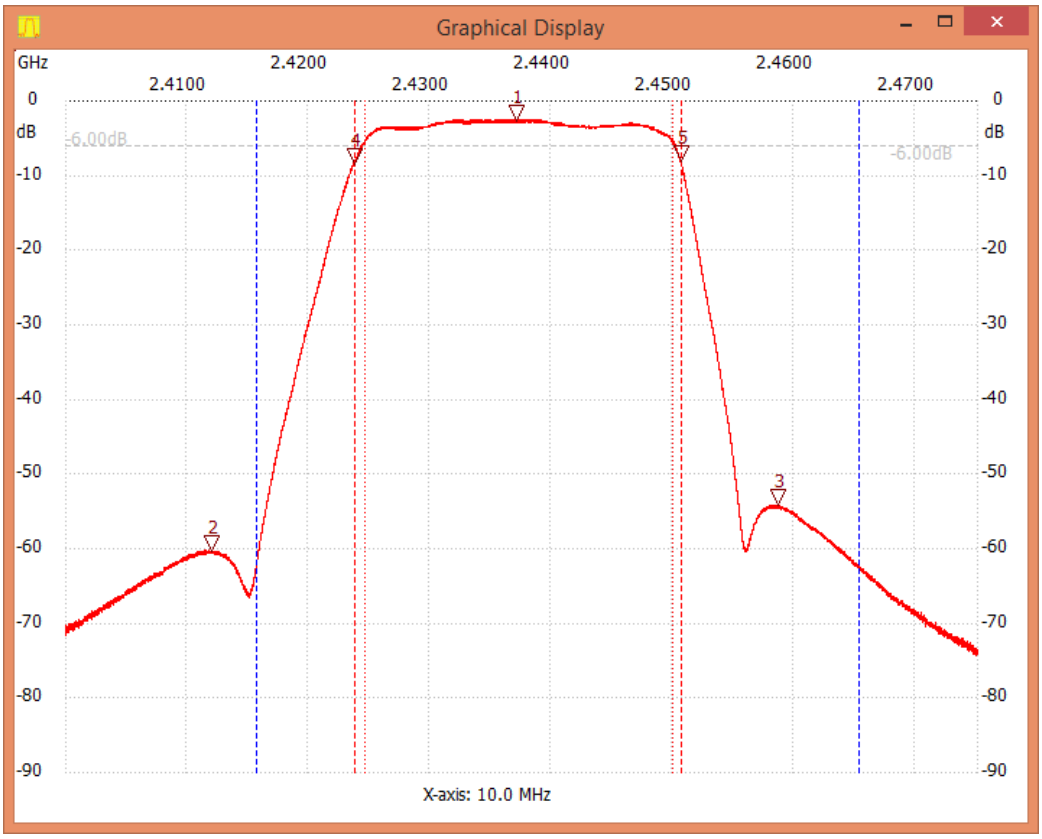
2.10 Bandwidth display settings

The measured curve, can directly have in the Graphical Display the 3dB, 6 and 60dB bandwidth shown as lines and the data shown in the text field with additional Q value and rectangular coefficient. Tick mark the required function in the Bandwidth selection box. A tick in “Markerlines” toggles all the marker line presentations in the Graphical display on and off.

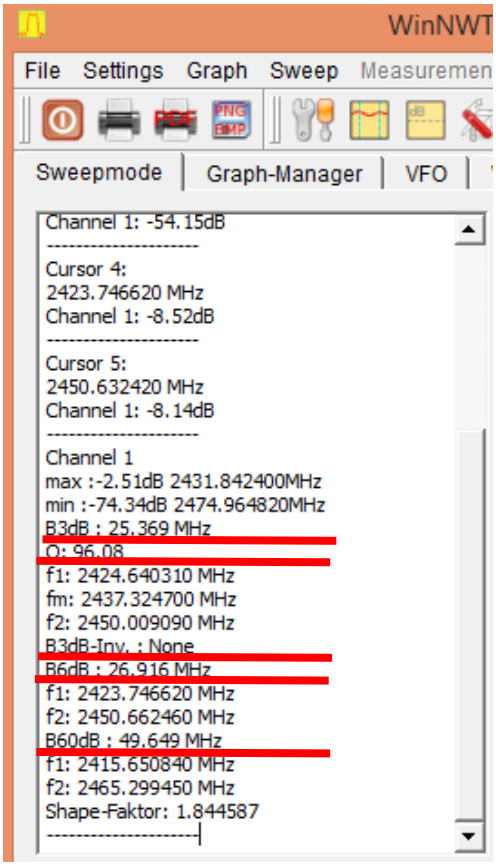


Bandwidth selection

6dB/60dB and 3dB/Q tick, the software will display the measured curves 3dB bandwidth and Q value. On above image the Q value calculated for a 49.55MHz quartz crystal and below for the WiFi filter remark the 60dB on the high side of the curve is way off because the notch is not 60dB deep enough some 56dB relative top level at marker 1.



The measured curve



Display of 3dB bandwidth, Q value and related parameters

6dB bandwidth and 60dB bandwidth, is similarly rectangular coefficient.

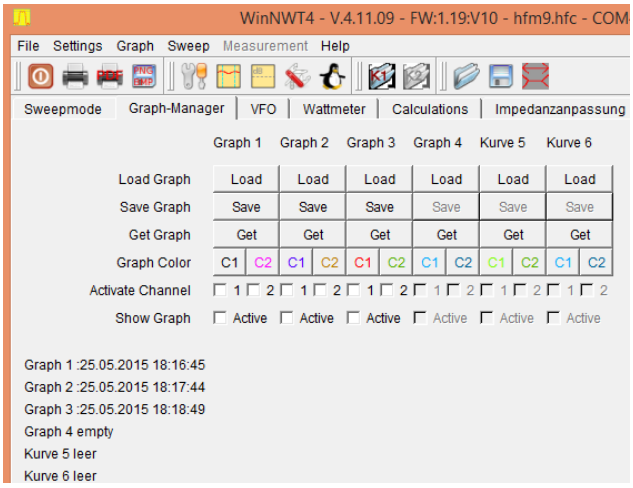
Markerlines are used to display the dotted line bandwidth in the Graphical Display area, for better recognition of bandwidth parameters.

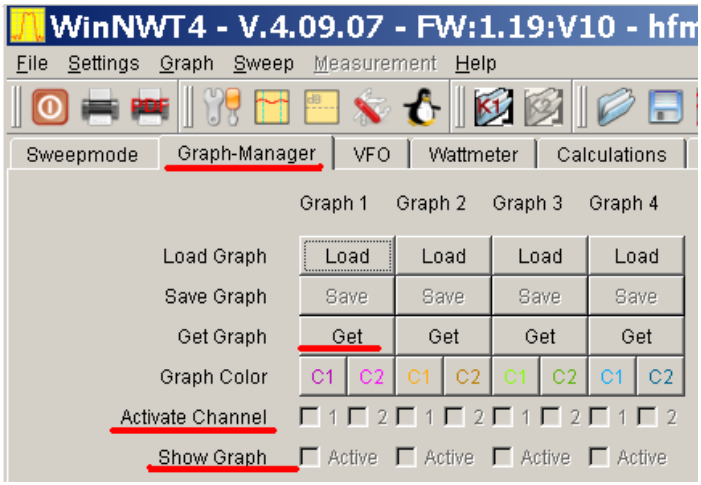
B3dB Inverse is used for trap measurement.

2.11 Multi curve display management

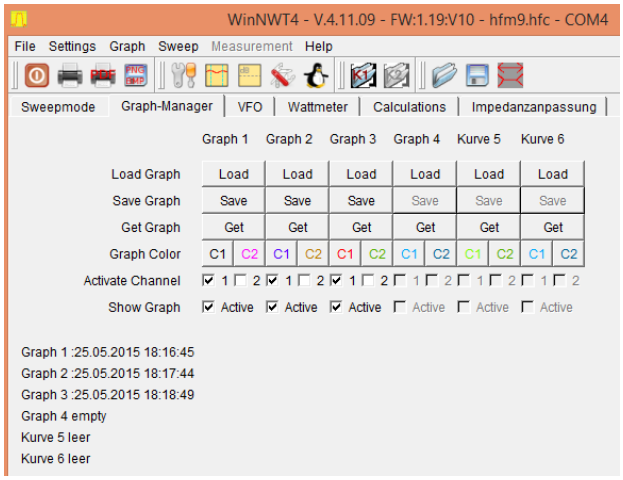
Graphic-Manager Get；Active channel；Show Graph

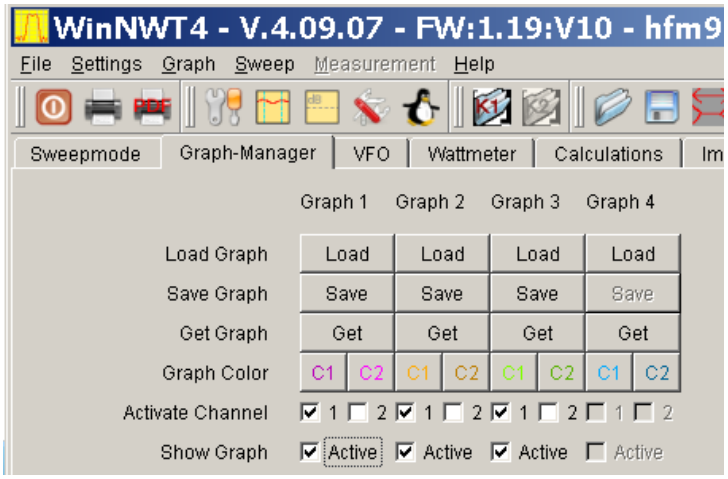
After a measurement, the curve can be stored and controlled by the Graphical Manager. The current trace is acquired by a click on the Get button. Then tick the active channel number and tick Active for Showing Graph.





Version 4.11.09 Graph-Manager Version 4.09.07

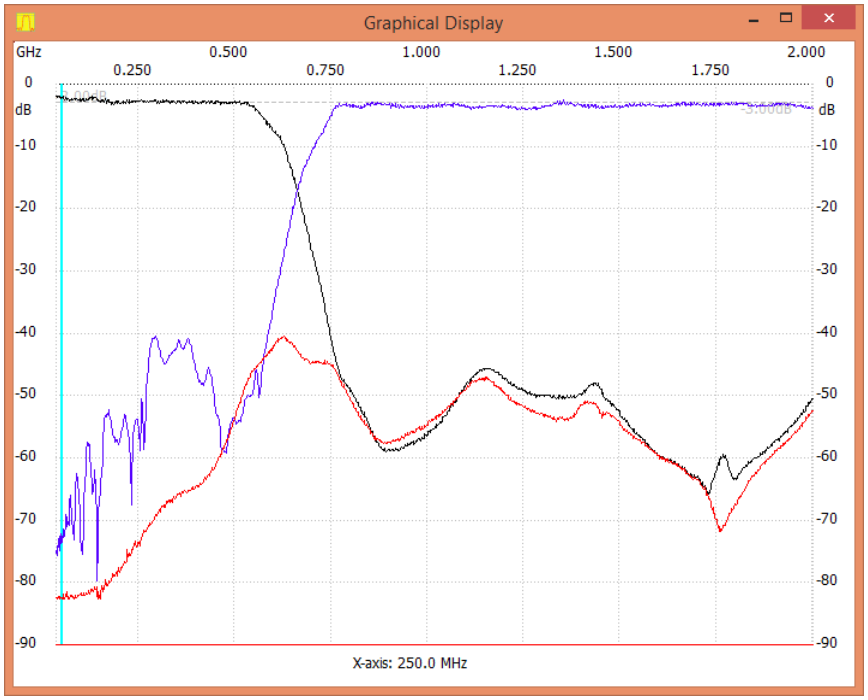


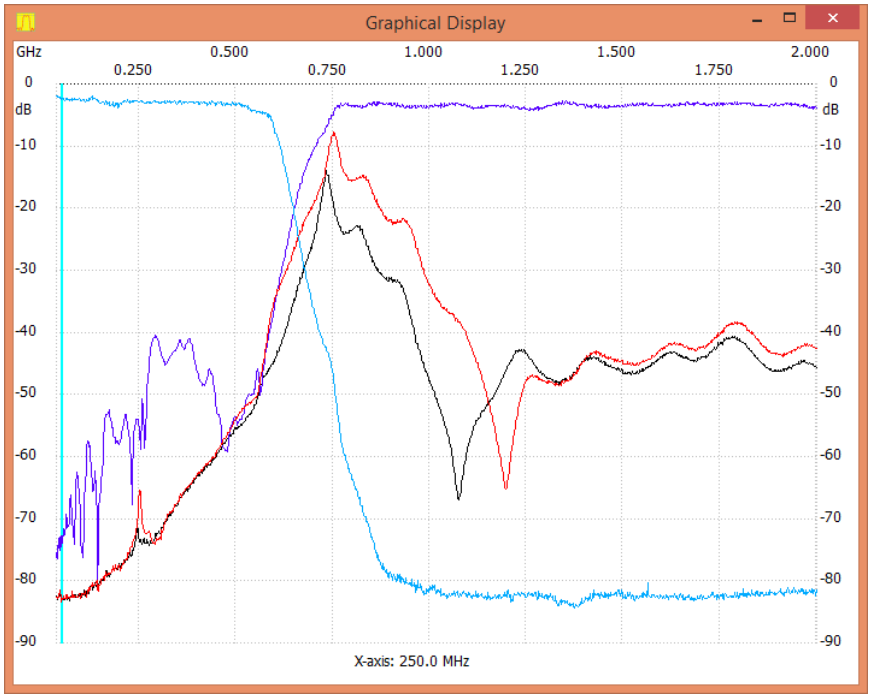


Version 4.11.09 Graph-Manager Version 4.09.07

3 traces selected for presentation for a 500MHz diplexer.

Low/High pass and Isolation (red)





The Graphical Manager is quite handy for measuring e.g. diplexers. As the first graph for this diplexer (specifiied as 0-500MHz/800-1300MHz) showed many spurious responces in the 35 to 500MHz region. As the NWT4000 deliver squarewave signals as the output signal, the 3. and 5. harmonics (or even higher orders) passes unattended throught the higpass filter. By inserting a 500MHz (black trace) or 600MHz (red trace) low pass filter, only the 3. harmonics of 250MHz is visible and the true resonce of the the diplexer below 600MHz found.

3. Linear scan settings (unsupported)

Note: Some type of equipment do not have this function and are not supported by NWT4000 family of products.

4. SWR

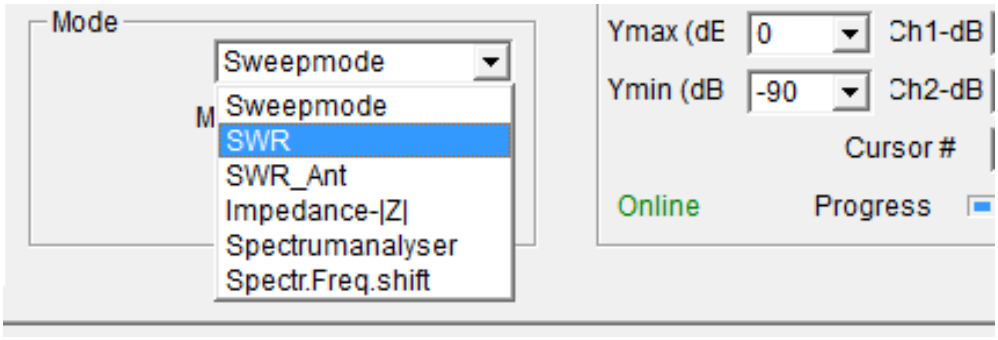
4.1 SWR Measurements

Enter SWR mode

For SWR measurement an external brídge is required.

Connect the bridge. The bridge input is connected to the NWT scanner RF output, The bridge output is connected with the NWT scanner RF input. See later for the calibration method used.

Select the SWR measurement Mode



Test mode select

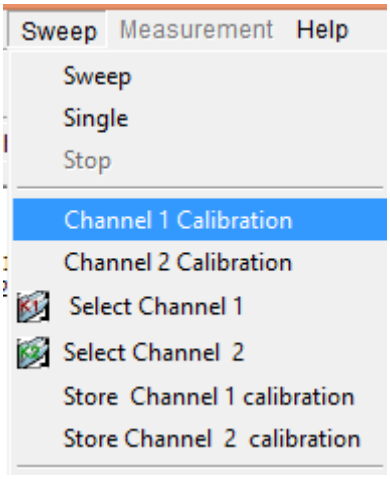
4.2 SWR Frequency settings

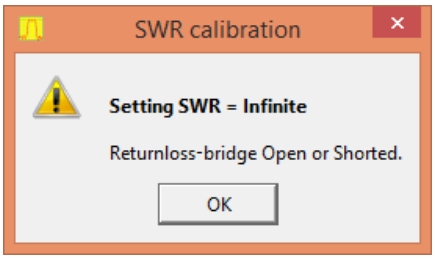
Set the frequency and log the same scanning pattern. Enter the start endpoints, frequency, frequency, continuous or single measurement can be read directly of the SWR. The need for accurate calibration for measuring needed.

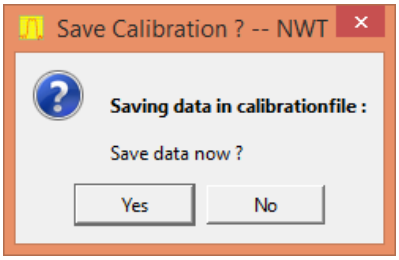
4.3 SWR Calibration

With bridge properly connected and the output of the bridge either shorted or open select Sweep/Channel1 Calibration. With bridge none terminated the calibration is started by clicking on OK. The number of samples automatic changed to 9999 and after a while, you are asked to save the calibration under a descriptive name.

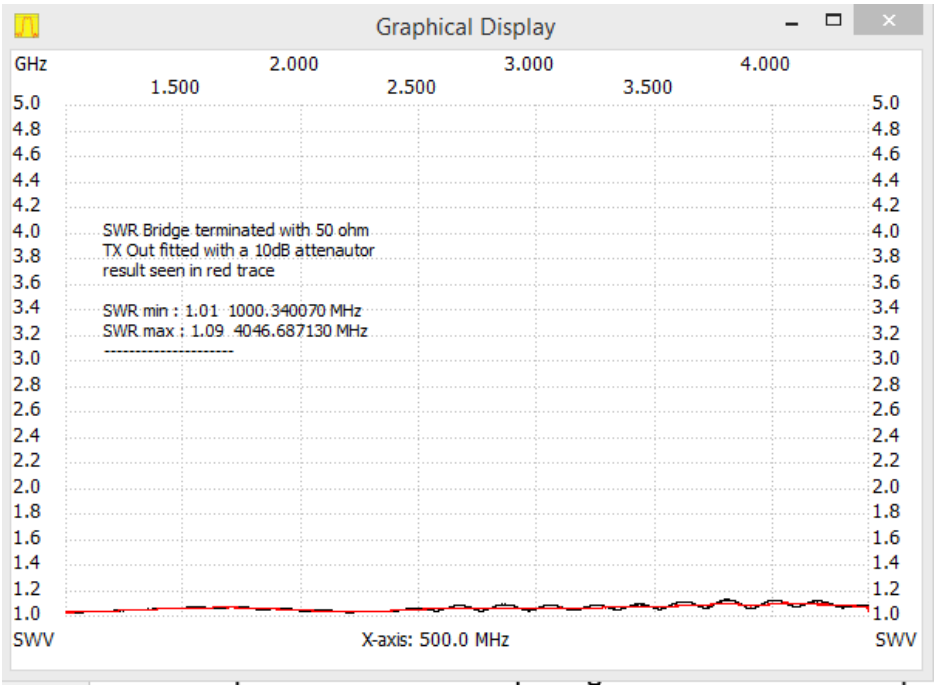
Then at any time you can recall the calibration by “select Channel 1” in the menu shown, and choose the calibration file previously saved.

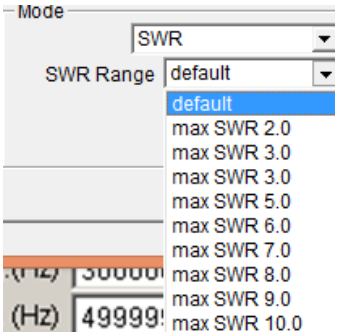




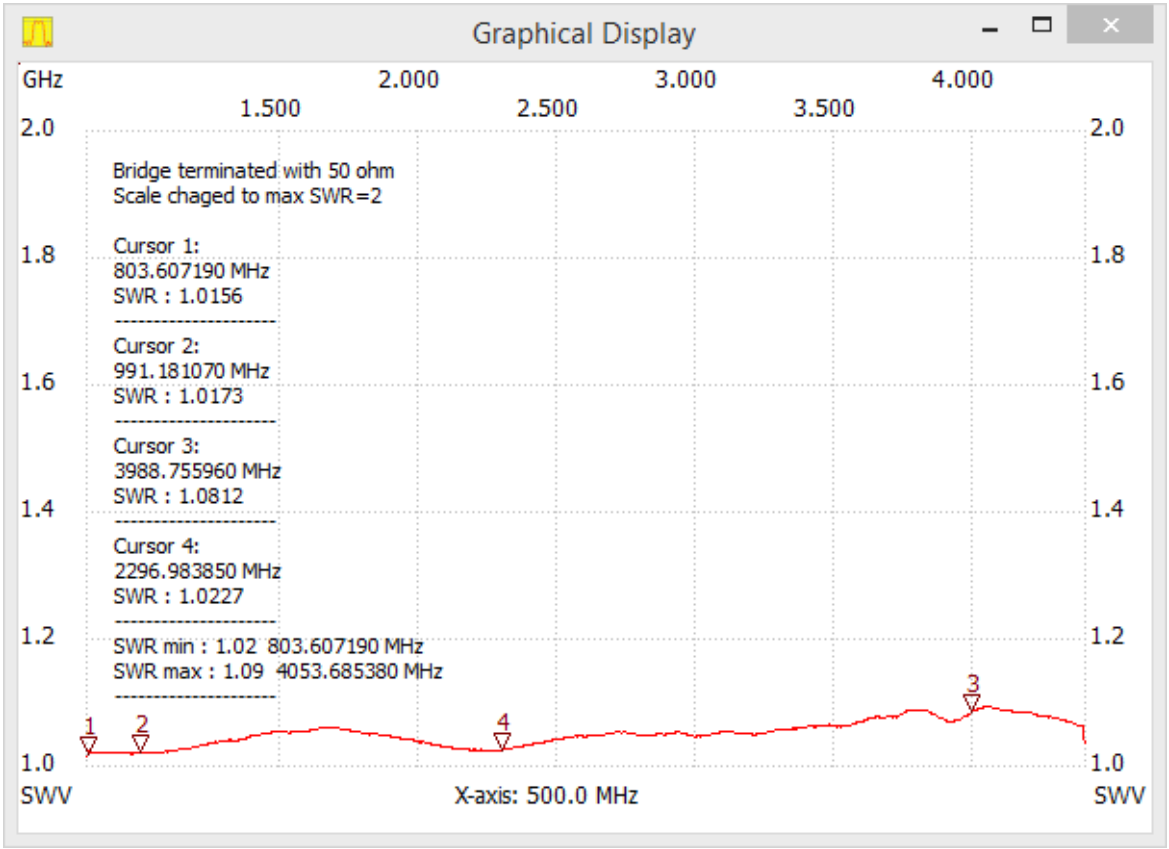


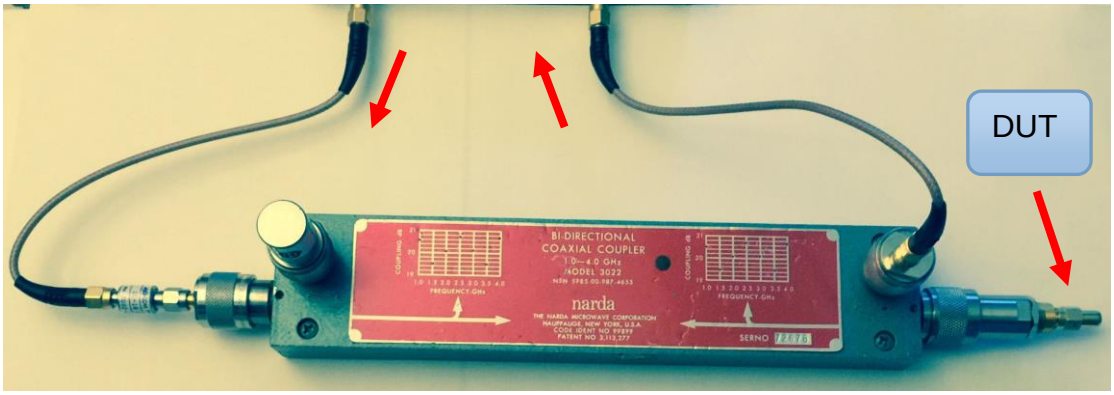
In the shown example below the Bridge used is a Narda bidirectional coupler model 3022 specified for 1 to 4GHz and selected frequency setting 1 to 4.4GHz. When running a SWR sweep the number of samples is e.g. changed to 999 for a faster sweep, as the Calibration always uses 9999 samples. It will be seen that above 2.5GHz a slight ripple exist due to reflection between NWT4000 TX output and Bridge input. By inserting a 10dB attenuator in the TX output this ripple is removed (red trace) and the TX out now closer to 50 ohm for all frequencies.



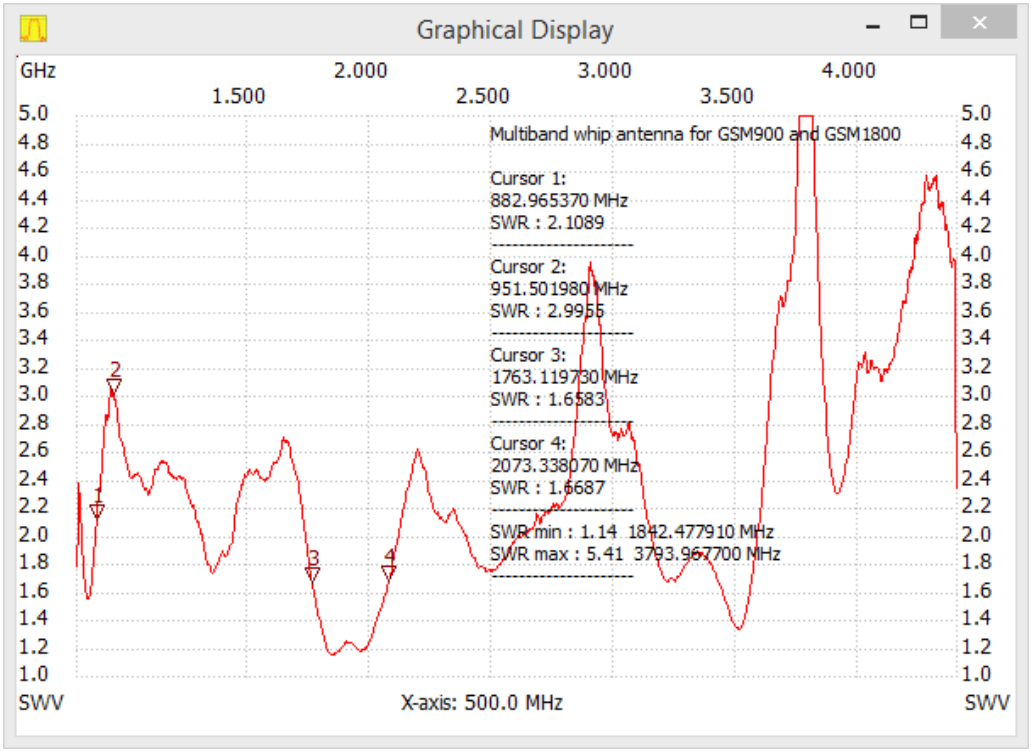


Black trace without any attenuator in the TX path and red trace with 10dB attenuator inserted. The bridge output is -20dB below input signal and as there is ample sensitivity in the RX so this 10dB attenuator does not harm. Please observe the SWR range can be changed with the drop down list.



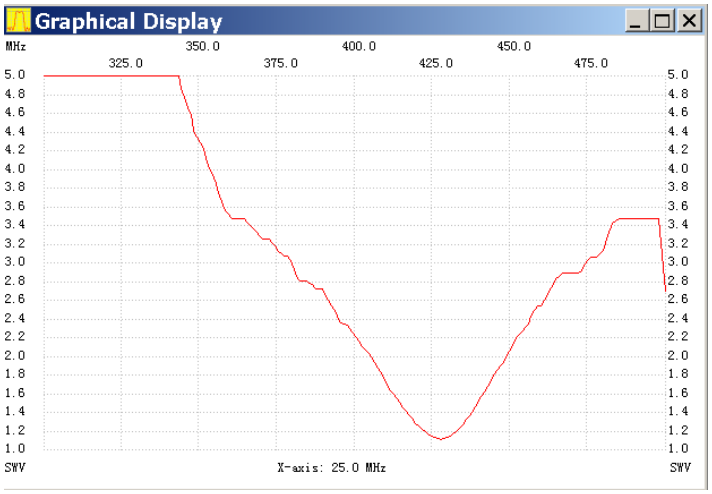


4.4 SWR Measurements examples

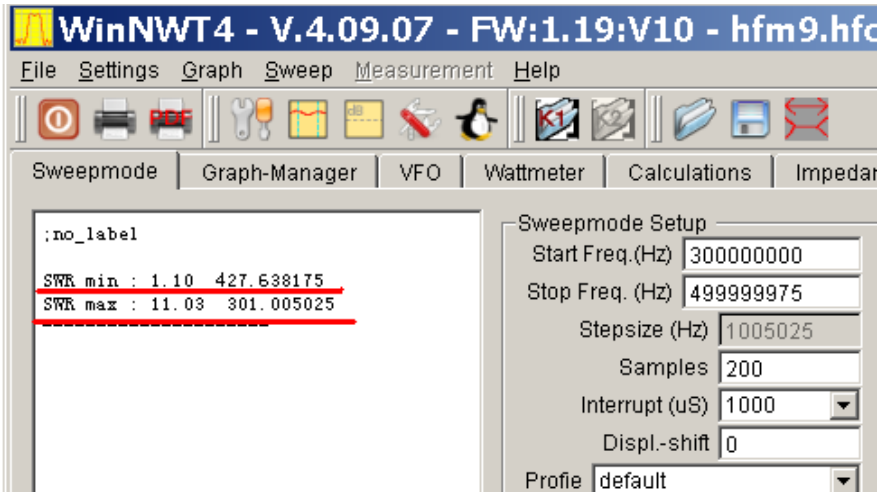


The GSM900 band between marker 1 and 2 has too low a resonance and then too high SWR but GSM1800 inside marker 3 and 4 quite OK

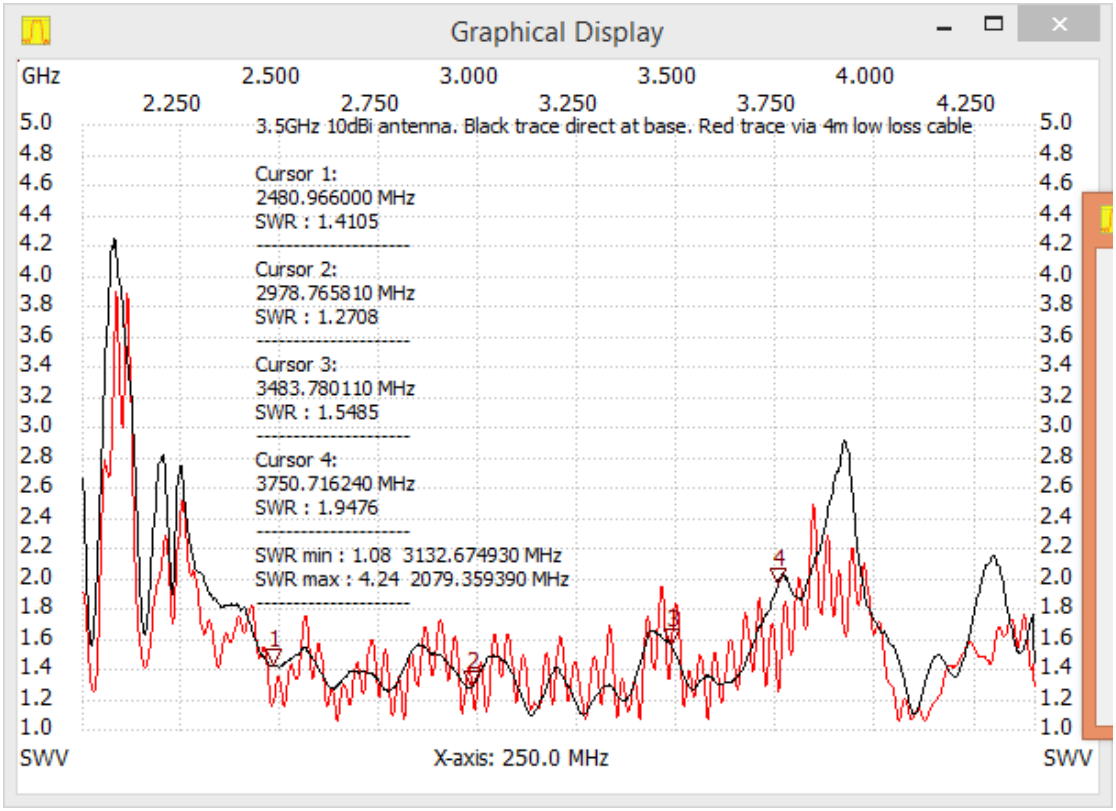
The picture below is a measurement of a UHF low band antenna. The resonant point at about 430M, SWR about 1.1. The related limit values are to read in the text area.



The measured antenna curve



The text area shows the standing wave maximum, minimum

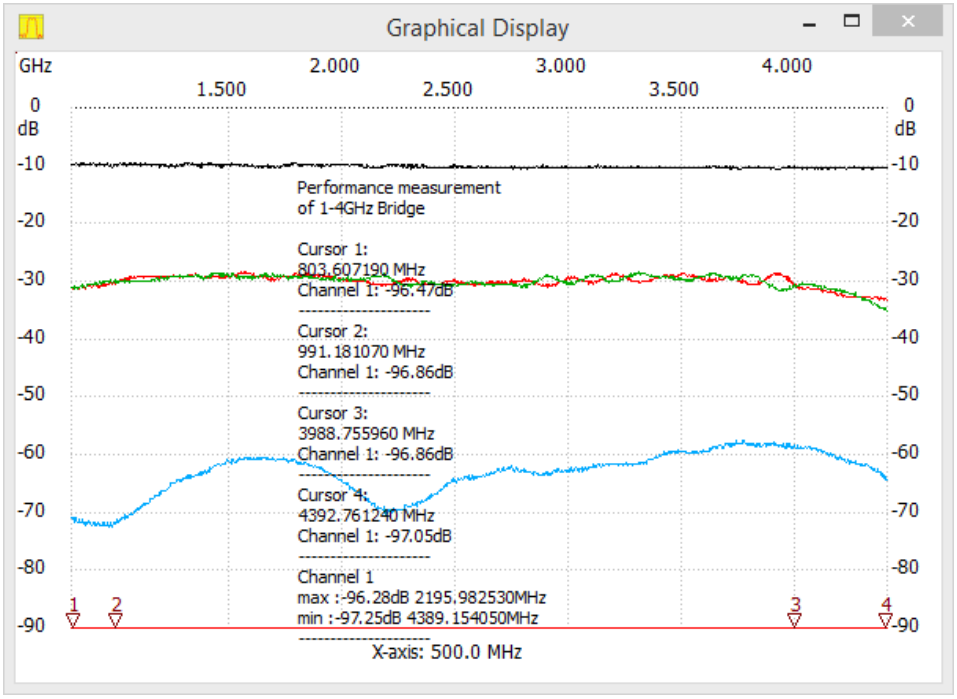


Another case of a 3.5GHz 10dBi vertical antenna with and without 4m feed line cable

4.5 Bridge performance investigation

Is is also posssible to examine the Bridge for proper operation to be used for SWR measurements.

Run a sweep for the bridge from input to output and also for the bridge coupler output with the Bridge output terminated with open, short and 50 ohm.



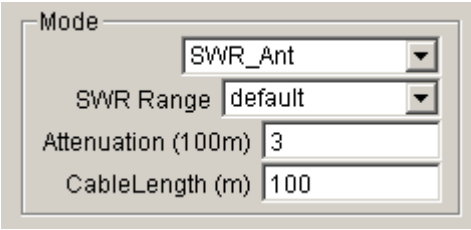
The NWT4000 output fitted with a 10dB attennuator to stabilize the output impedance closer to 50 ohm.

Black trace input to output. Red trace output terminated with short and green with open and thus with full reflection). Blue trace when output terminated with 50 ohm (and thus no reflection). The span from terminated with 50 ohm and short/open is better than 30dB yelding adequate span for SWR measurements.

5 SWR_Ant mode

5.1 SWR antenna measurement with coax feed line

This function is not compatible with the NWT4000 family.



Setting the cable parameters

Wrong results obtained if used

6. Impedance - |Z|

6.1 Numerical Impedance measurements

You need to use the bridge to measure the numerical impedance. During the measurements you need to insert a 50 ohm resistor in series with the DUT. This means if the bridge is terminated with 50 ohm the reading is 0 ohm.

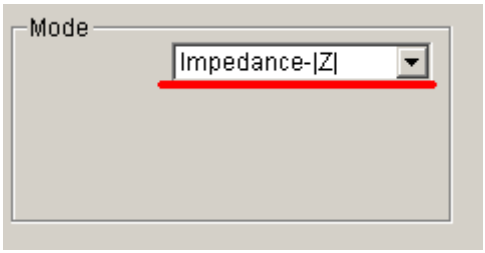
Do not measure impedances directly as impedances below 50 ohm also will give positive readings.

SWR calibration required if not already performed prior to measurement of the DUT.

For the SWR calibration procedure see section 4.3

6.2 Selection of impedance measurement mode

After calibration, select the impedance measurement mode

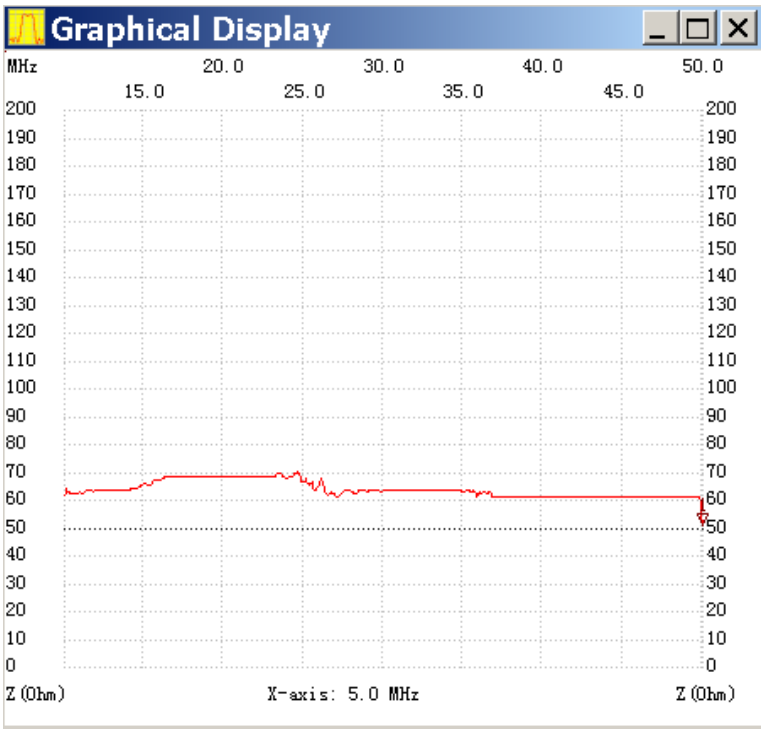


Selection of impedance measurement model

After selection read the prompt and then ignore.

6.3 After measurement read directly from the chart the numerical impedance values

During measurement a 50 ohm resistor in series with bridge and DUT required.

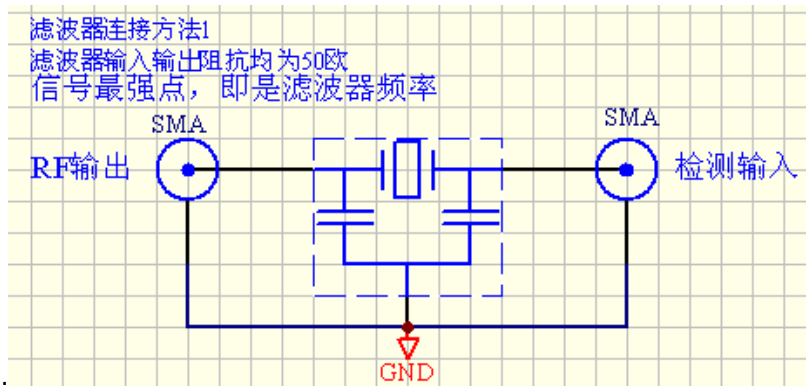


Measurement of a 65 ohm resistance.

7 Measuring a device connection methods

7.1 Filter test method 1

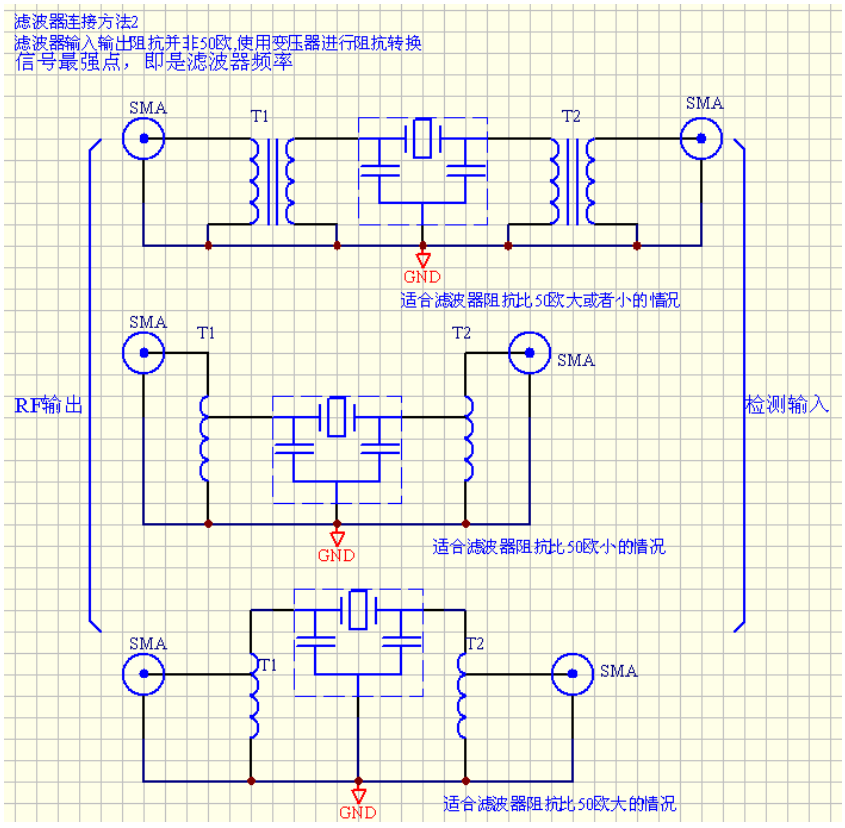
The following diagram is suitable if the filter input and output impedance is 50 ohm, if the filter impedance has mismatch, the measurements are prone to error in passband bandwidth and big fluctuation of measurement inaccuracy might exist.



Methods 1, suitable for filters with input and output impedance of 50 ohm.

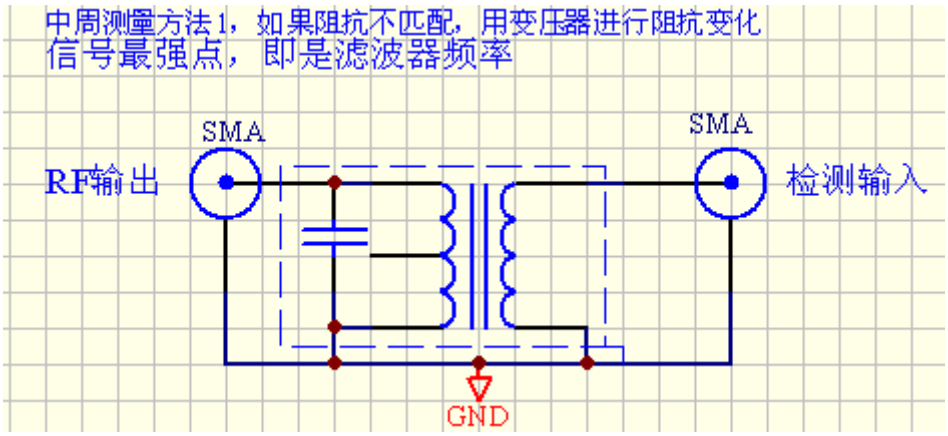
7.2 Filter test method 2

If the filter does not need the 50 ohm impedance matching then matching transformers introduced. After matching the curve and filter measurements was accurate. Resistance matching can also be used, but the matching method introduces very large insertion loss.



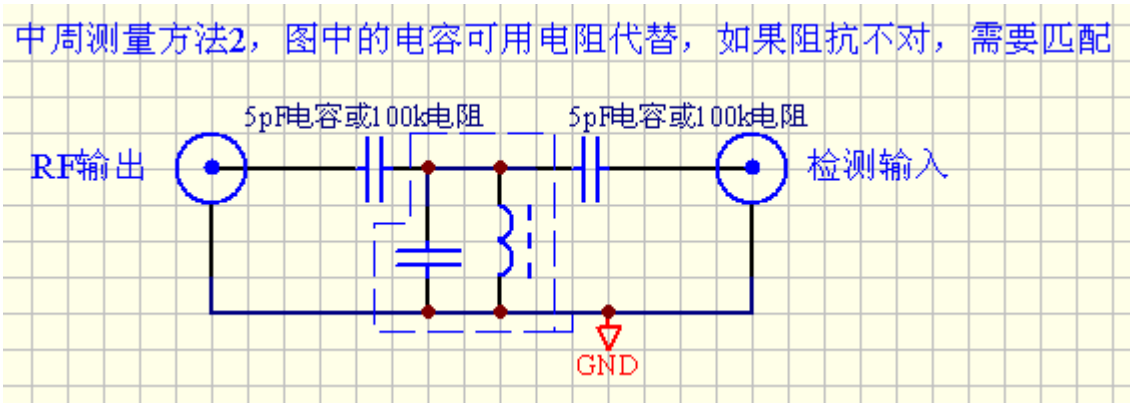
Method of impedance matching, this method can measure the insertion loss

7.3 RF transformer measurement method 1



RF transformer measurement method 1

7.4 RF transformer measurement method 2



RF transformer measurement method 2

7.5 An antenna measurement method

For NWT series of frequency sweep meter you need an additional external bridge for antenna SWR measurements. A reference circuit are as follows:

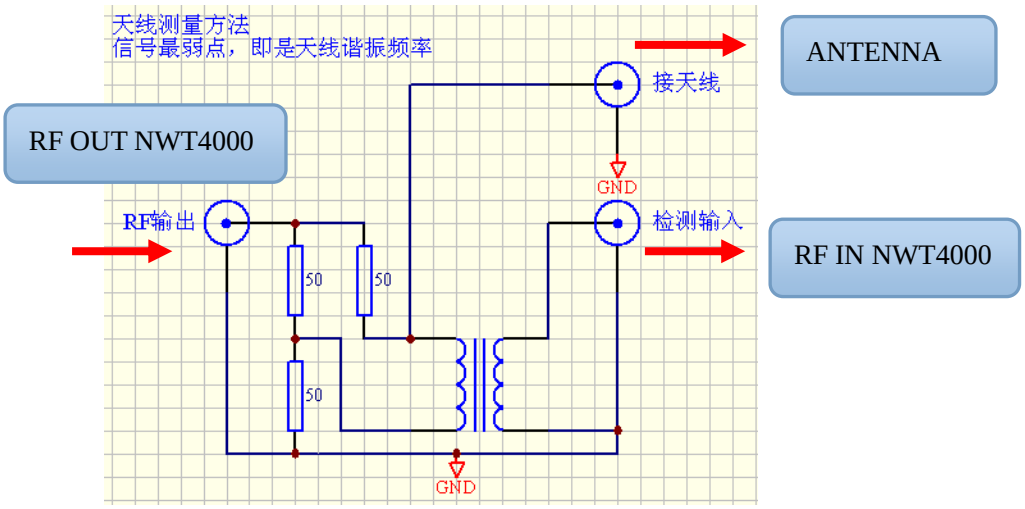


diagram of SWR bridge

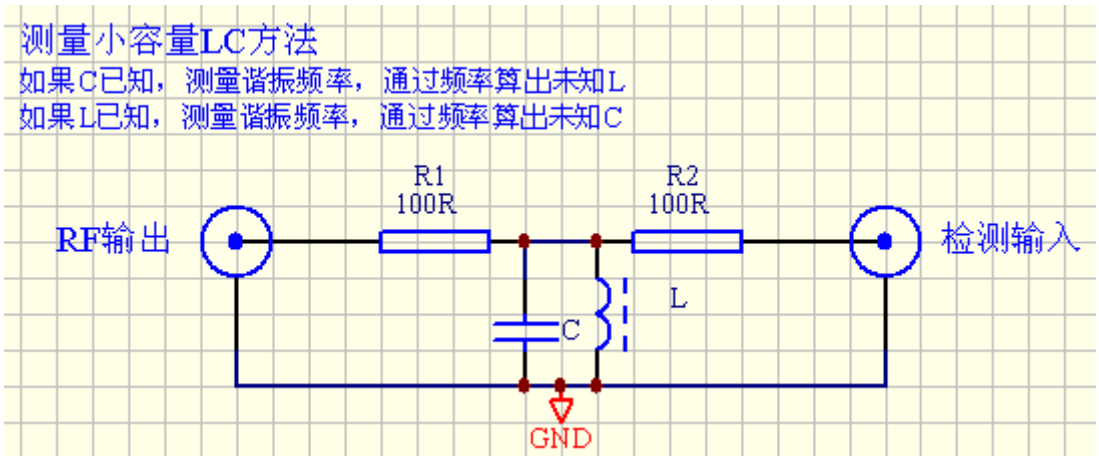
Because the bridge needs to be a precision device, not easy to make yourself, you are recommended to buy a finished bridge. The finished bridge pictures are as follows:

Swr bridge

In below diagram is shown a frequency sweep with logarithmic Y scale (in sweep mode) measuring an antenna, connected to the bridge output, and a dip seen where the antenna has resonance just like when measuring in the SWR mode.

VHF antenna measurement curve with a bridge

7.6 The small capacitance, inductance measuring method

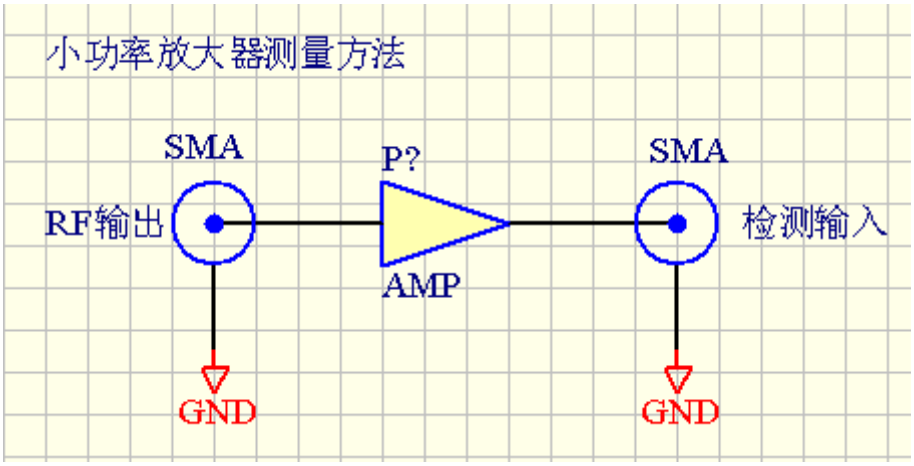


Testing of unknown L or C

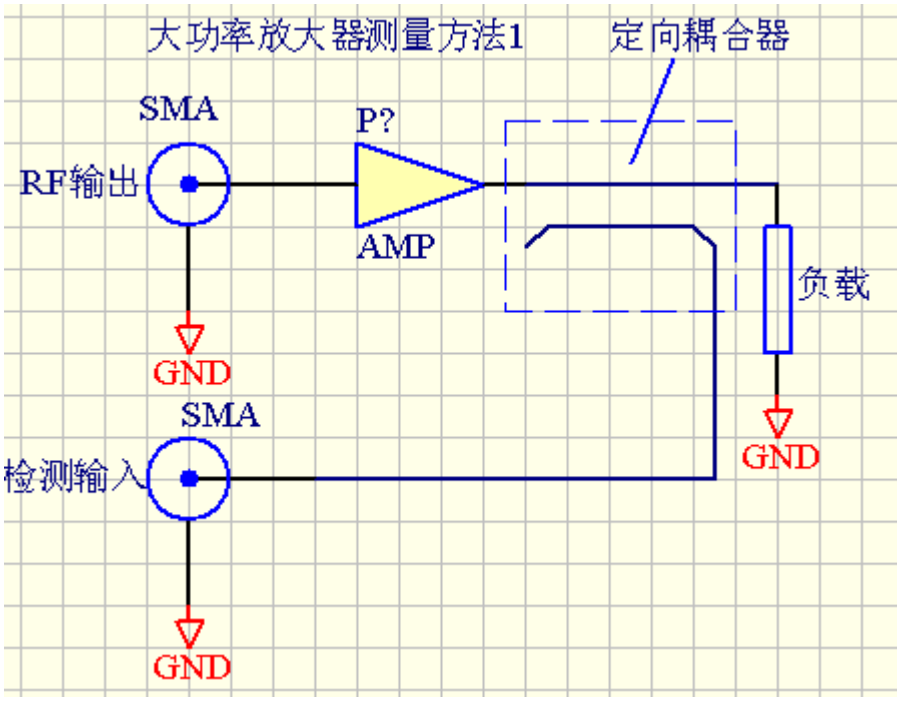
7.7 Amplifier amplitude frequency characteristics measuring method

If it is a small power amplifier, and the output power is less than 10dBm, you can directly connect to the sweeper's RF OUT and IN without to destroy NMW4000 series. However as seen before the INPUT saturates for a lesser amplitude so attenuator needed. If the power amplifier, needs to be used with the directional coupler or attenuator for signal attenuation, then enter the attenuators in the detection circuit (RF IN).

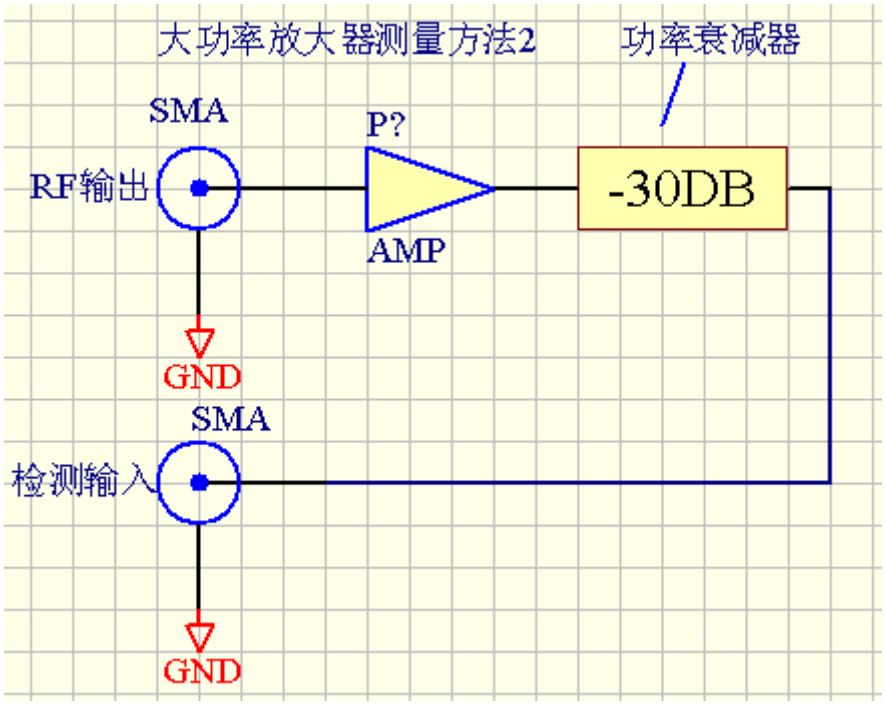
During measurements you need to pay attention to the amplifier and load impedance matching. For the power amplifiers, you need to pay attention to frequency scan range which should not be too broad, otherwise the amplifier impedance changes, standing wave increase, and easy to cause damage.



Amplifier test method



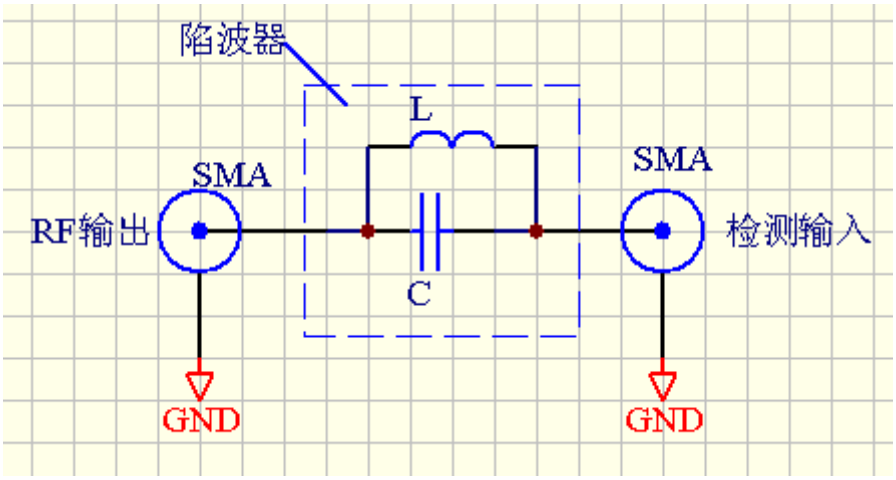
Power amplifier test 1



Power amplifier test 2

7.8 Notch filter test

For a trap LC parallel circuit, available method for testing shown where a dip seen in the sweep mode when connected between RF OUT and RF IN.

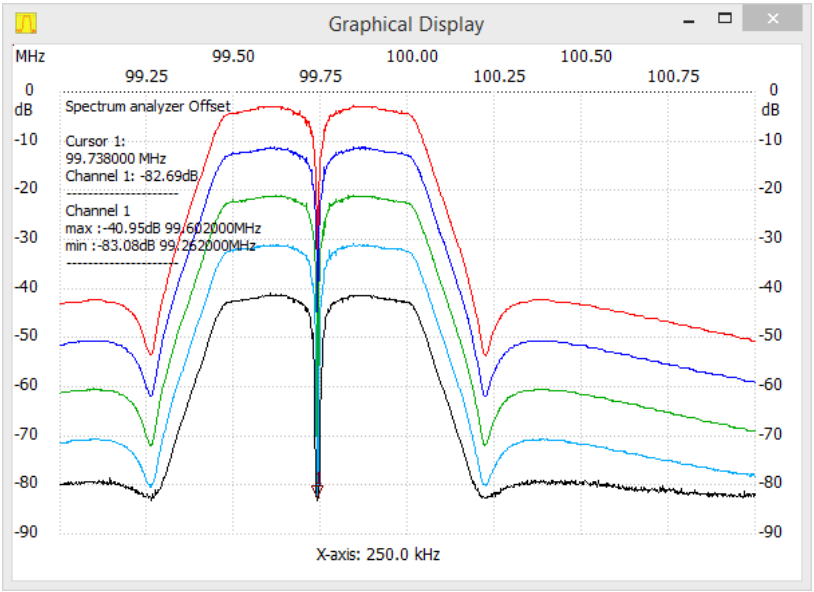


LC parallel notch filter measurement connection method

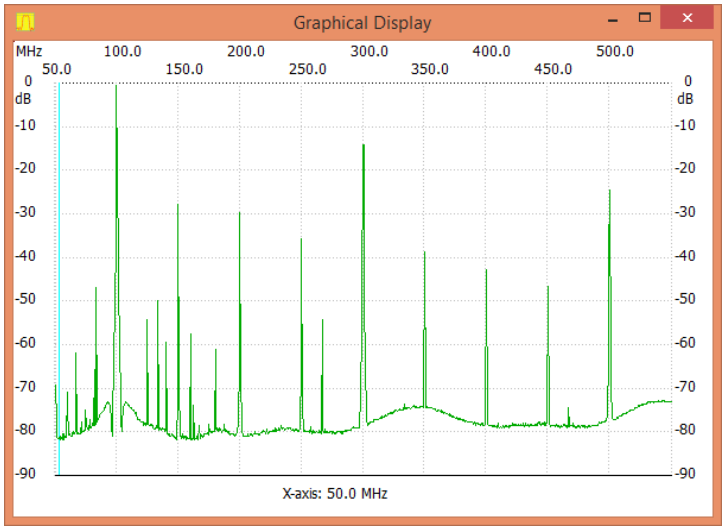
9 Spectrum Analyzer

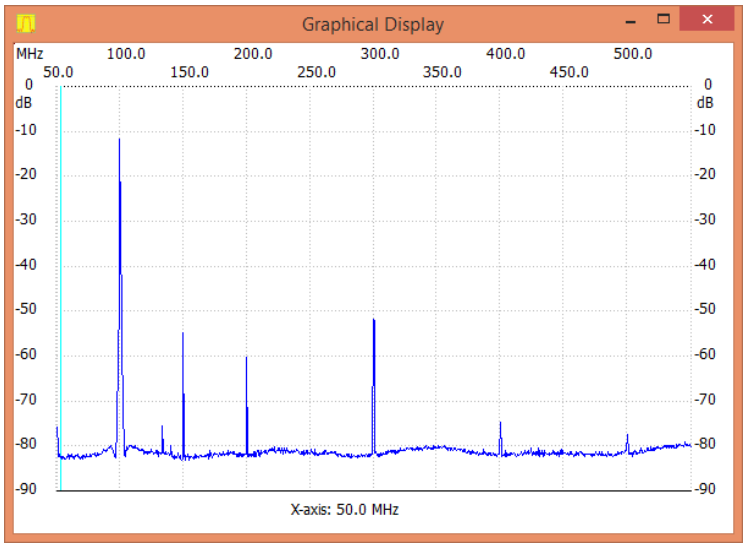
9.1 Spectrum Analyzer functionality

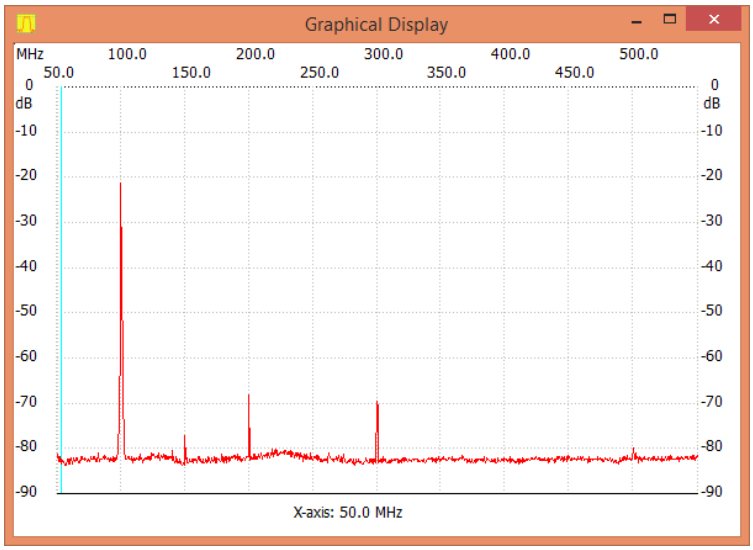
The Spectrum Analyzer is a simple spectrum analyzer which is utilizing one of the PLL's in the NWT4000-2. Quite simply the spectrum analyzer is no less than the sweeper where the signals to be analyzed is applied to the Input Port. The PLL delivering signal for the receiver mixer (receiver PLL), is running with a fixed offset from the wanted frequency of 260KHz, to facilitate the sweeper is measuring on the right frequency. The PLL being input to the RX mixer, beats with the RX input signal and generates an IF signal on either side of the input frequency, but not being on the required frequency. The IF signal is passing through a low pass filter from 15KHz to 300KHz and being detected in the Logarithmic detector for presentation. The other PLL on the TX side is doing nothing when we are analyzing the spectrum. Below is shown an input signal of 100MHz from the Marconi 2022A Wavegenerator stepped down in 10dB steps which discloses the Offset between the two PLL's.



Spectrum of the 100MHz signal when -6dBm, -16dBm and -26dBm applied to the input It is clarly seen that all sort of spurous signal generated and mesurement of the signal generators harmonics not possible. First by comparing the -16 and -26dBm sweeeps we can trust the measurements of 2. - 3. - 4. and 5. Harmonics.



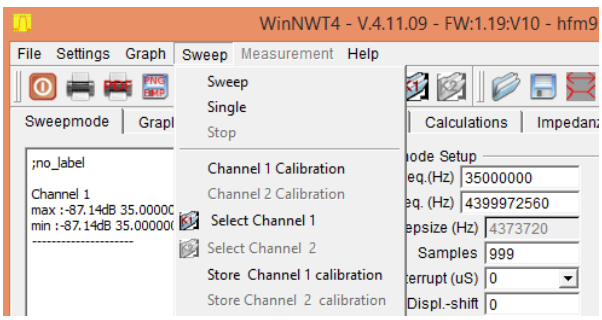


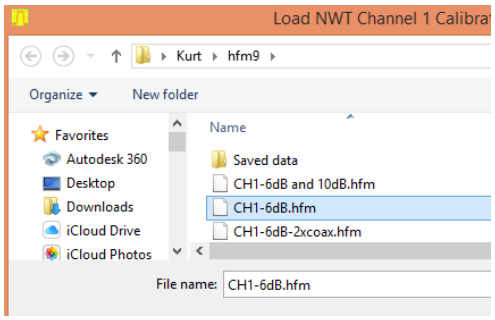


10 Wattmeter

10.1 Wattmeter Functions

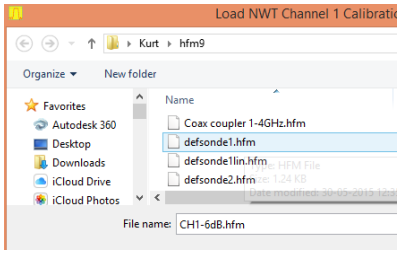
The Wattmeter, when calibrated, is a superb tool as being a selective Wattmeter only measuring the frequency the VFO is tuned to, with a bandwidth of 300KHz to either side of the VFO frequency and then suppressing harmonics and other signal which could create false readings. Tools are provided to compensate for the slight drop off sensitivity above 2.5GHz. Before selection the Wattmeter remember to select the calibration file for “sweep” as calibration data for Wattmeter is stored in the sweep calibration file. Please also do the sweep calibration first before the Wattmeter calibration.





In this case the Select Channel 1 filename is CH1-6dB.hfm chosen, where the file name indicates the sweep calibration performed using a 6dB and a 40dB attenuator as the NWTWin software facilitates to obtained a superb dB linearity.

You might have saved the sweep calibration in the default file name defsonde1.hfm

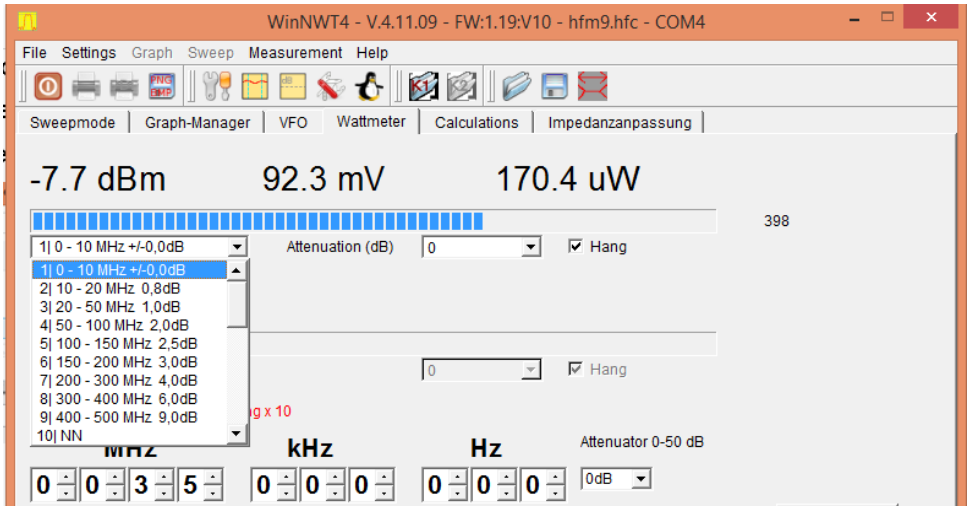


10.2 Wattmeter calibration

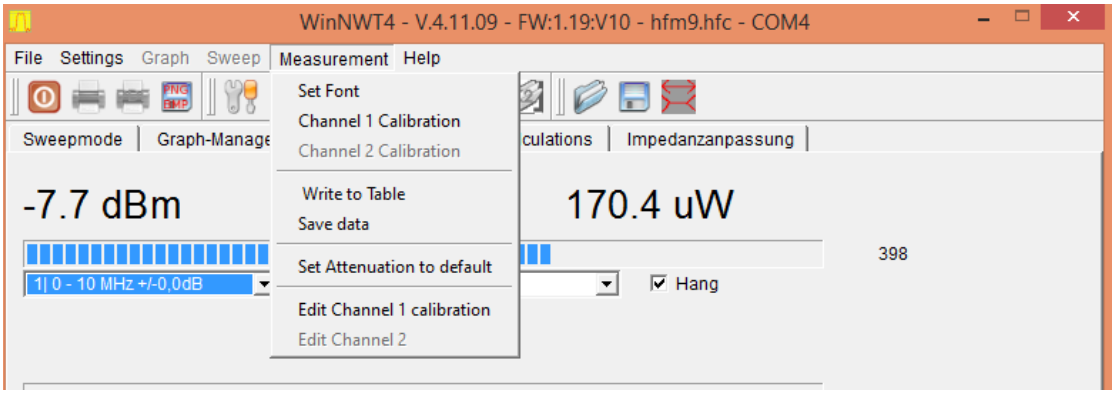
Note: For NWT4000-1 and NWT4000-2 the VFO must be set to the frequency to measure.

Now select Wattmeter and apply a signal source, with known dBm amplitude, to the NWT4000 Input port. You may also chose the signal source to be the NWT4000 output but insert preferably a 20dB attenuator in the signal path, however at least 6dB, to avoid the compression in the mixer/logarithmic detector, of the internal circuitry, as described earlier page 16 under sweep calibration . Observe the dBm reading is pretty

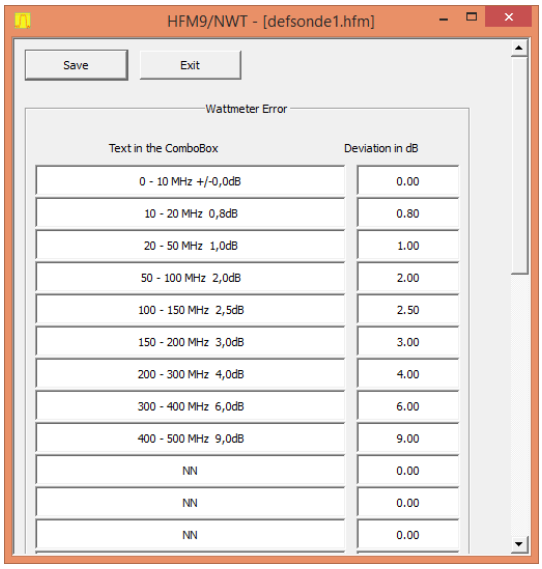
wrong as the Wattmeter not yet calibrated. Below the dBm read out is a drop down list which indicated is is possible to compensate for variation in the sensitivity of internal detection circuitry across the 35MHz to 4.4GHz range, but as seen the list is initially for a quite different product, so the calibration needed both to edit the drop down list and the sensitivity and the procedure described below

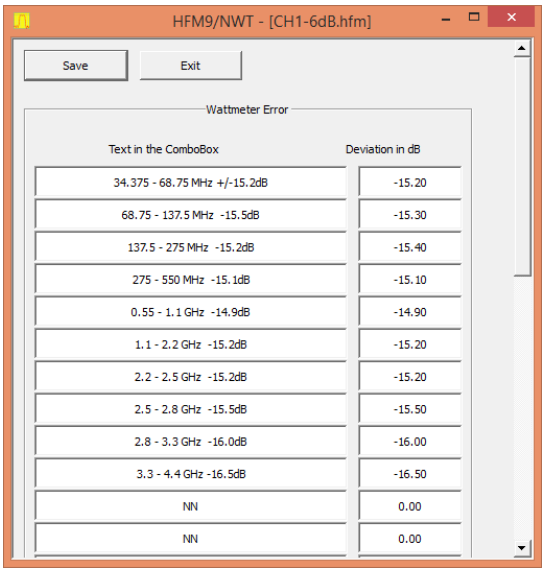


When for Wattmeter we click on ”Measurement” the drop down list allow a number of selections. **DO NOT CHOOSE “Channel 1 Calibration”** as NWT4000 does not support this procedure of the WinNWT software. We will instead choose the “Edit Channel 1 calibration” as perform the calibration manually and edit the prompting as well in the compensation drop down list in a couple of steps.



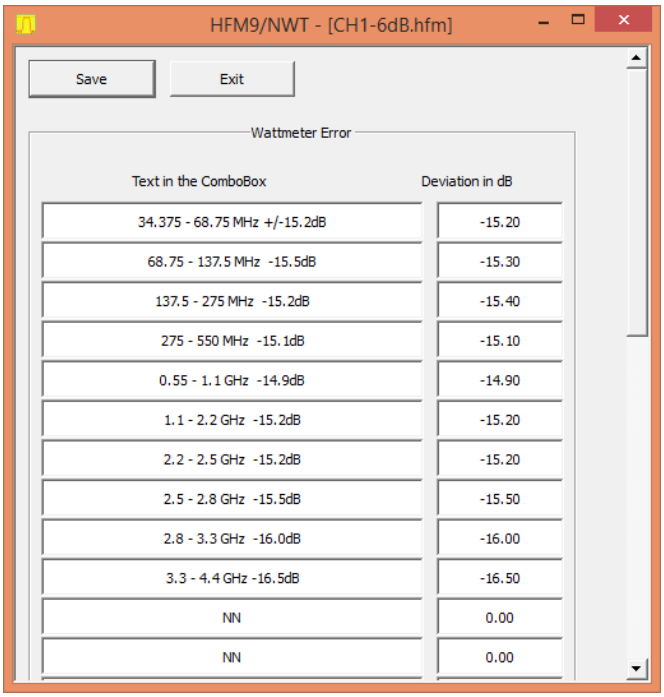
When chosing the Edit Channel 1 calibration the initial setting is seen below next to result the final settings to be explained in the next steps.



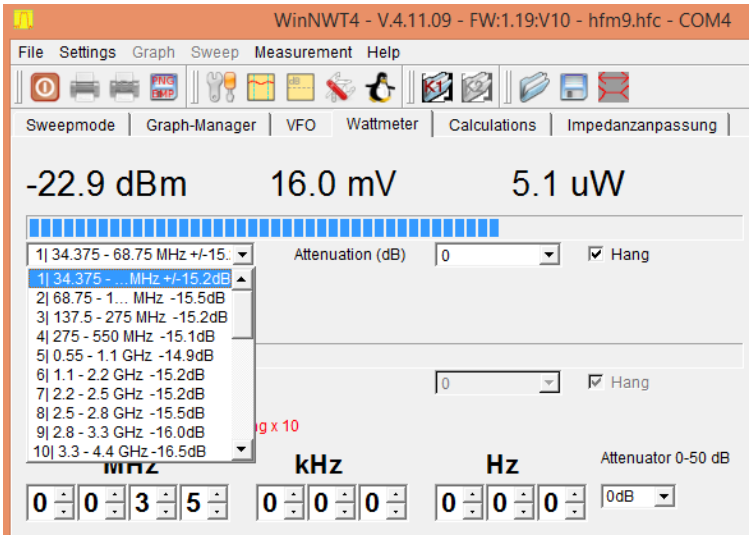


The input to the NWT4000-2 when delivered from the NWT4000-2 output is measured to be - 2.36dBm with a Hewlett Packard powermeter 437B and 8481A power sensor. As the output of the NWT4000-2 is squarewave the theoretical fundamental is 0.707 or 3.01dB lower in level then -5.37dBm. As we have 20dB inserted in the signal path and measures – 7.7dBm with the Wattmeter then the theoretical compensation to apply is 20 – 7.7dB = 12.3dB. The picture above to the right shows a compensation of 15.20dB which is derive when using the signal from a Marconi 2022A Wavegenerator with an accurate measured sinusoidal output of 0dBm using the HP437/8481. I seem like the NWT4000-2 output is not following the theoretical condition and the third and higher harmonics are lower than theoretical levels explaining the difference. It appear the difference is only 1dB. As the output impedance from the NWT4000, deviating somewhat from 50 ohm it is contributing to some mismatch as well.

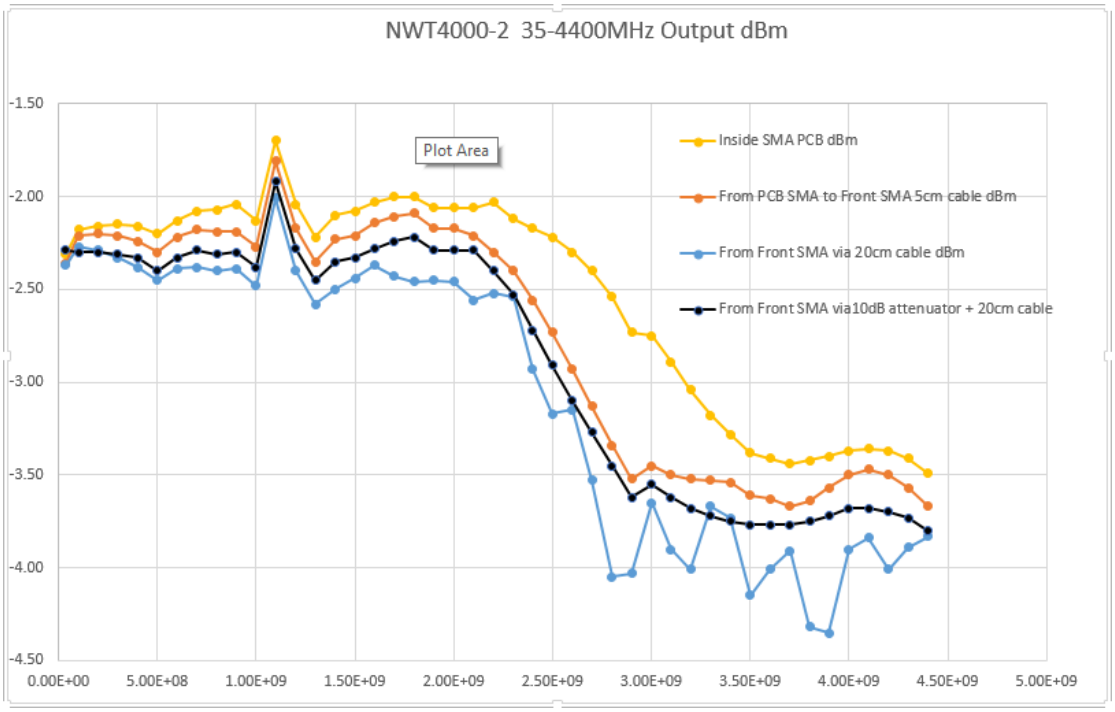
Anyway when using the Marconi 2022A wave generator up to 1GHz with accurate measured output, and the output from the NWT4000-2 from 1GHz to 4.4GHz where output measured with the HP437A as well, the compensation derived as shown in the below image, across the frequency band. The NWT4000-2 VFO is covering 2.2GHz to 4.4GHz and sub-band created by division of 2,4,8,14,32. These limits entered in the edited list. However above 2.2GHz further sub band created according to the measured levels drop off, as seen in a Graph further down. All the data from the editing is automatic saved in the current selected sweep calibration file, when clicking on Save in below screen.



The editing thus results in a new visual drop down list



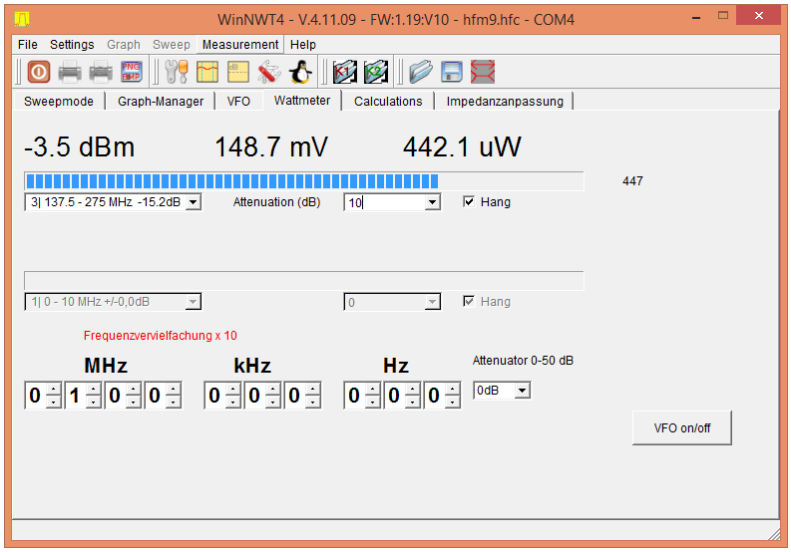
If you do not have a wave generator then use the settings in the table. It is better than nothing done.



Interesting to see the peak at 1.1GHz which is reflections inside the PCB of the NWT4000-2 as well a 5 cm SMA male male cable can create 1.5dB attenuation at 2.8GHz. Also observe that when using an external 20cm SMA male male cable that standing waves develops above 1GHz and how a 10dB attenuator is stabilizing the frequency response with the 20cm cable present.

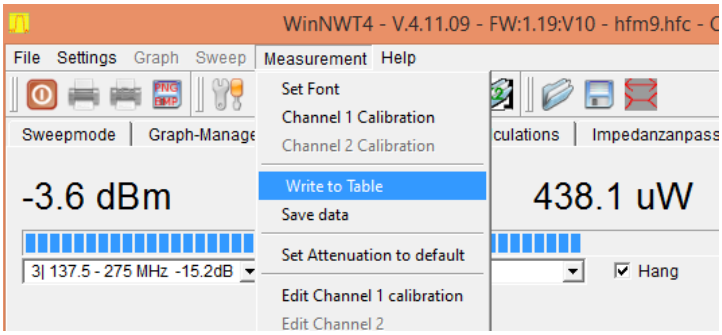
10.3 Saving a single or several Wattmeter measurement.

In case you want to measure a number of Wattmeter levels e.g. at 100MHz the output of an oscillator for various supply voltages or, as in this example, the levels for a step attenuator at various attenuations and later import these data into a spreadsheet, you can add each measurement to a table and when finished save the table to a file.

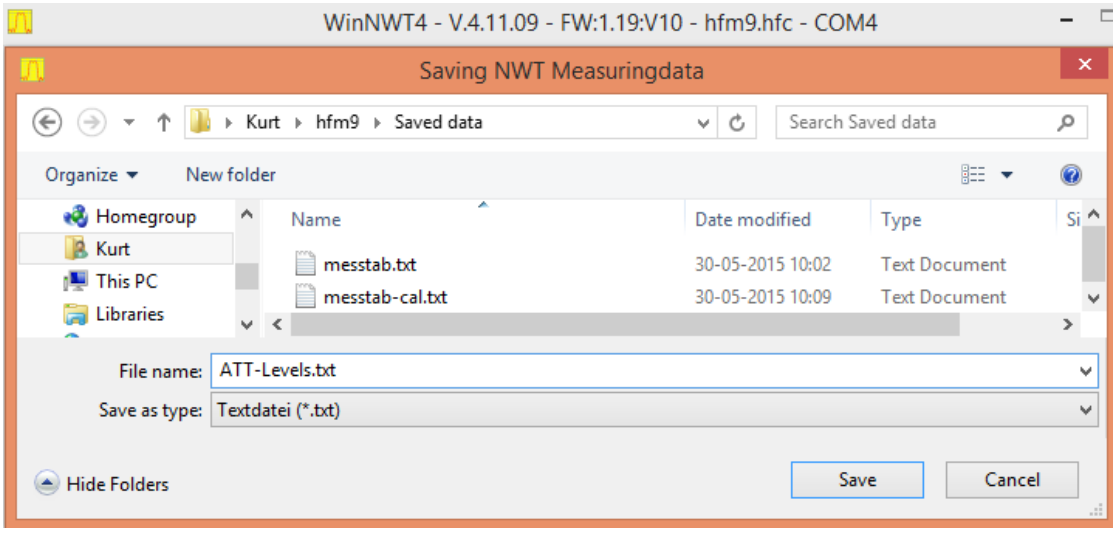


As there is inserted an 10dB attenuator in series it can be compensated for by the “Attenuation (dB)” setting.

Select for each measurement “Write to Table”



When finish with the measurements select Save Data and chose the location for saving and provide a file name.



The format of the data in the saved file is semicolon seperated and directly to import in e.g. Excell.

```
-3.6 dBm; 148.0 mV; 438.1 uW
-14.1 dBm; 44.3 mV; 39.3 uW
-23.6 dBm; 14.8 mV; 4.4 uW
-33.4 dBm; 4.8 mV; 452.5 nW
-42.9 dBm; 1.6 mV; 51.2 nW
```

	A	B	C	D
1	Settings	dBm	mV	uW
2	0	-3.6 dBm	148.0 mV	438.1 uW
3	10	-14.1 dBm	44.3 mV	39.3 uW
4	20	-23.6 dBm	14.8 mV	4.4 uW
5	20	-33.4 dBm	4.8 mV	452.5 nW
6	40	-42.9 dBm	1.6 mV	51.2 nW
7				

As neither the frequency nor step number is included in the data (left picture) such information must be added manually (right image)

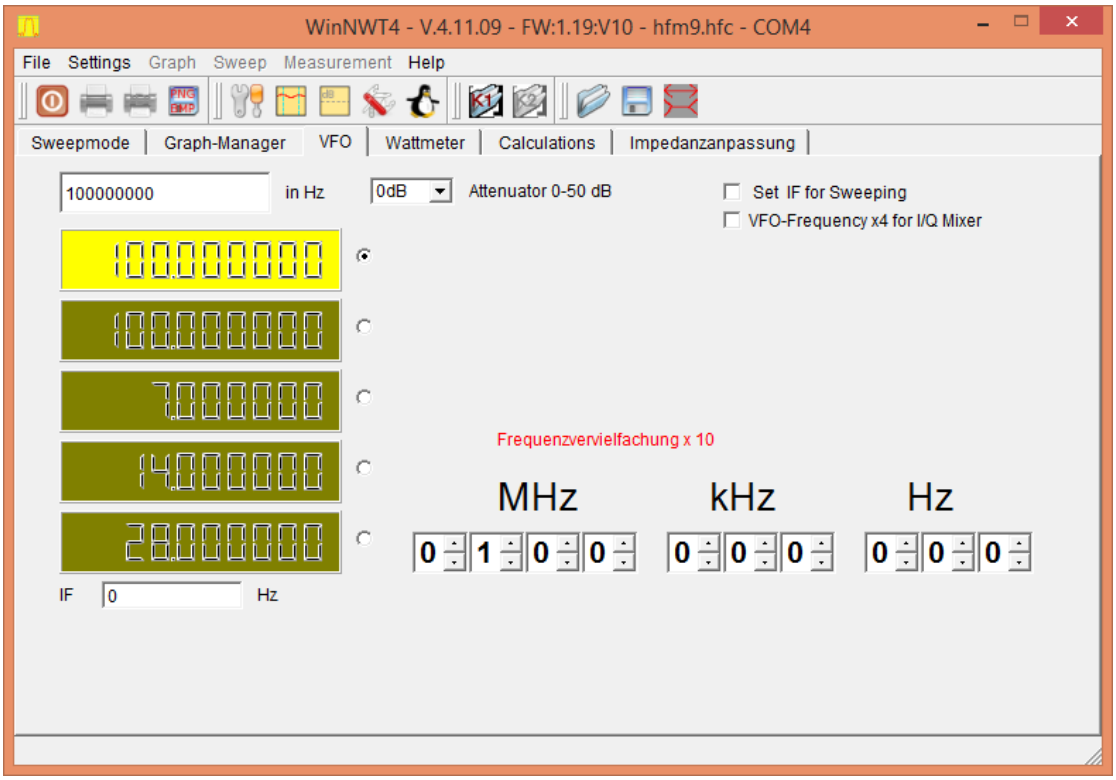
11. The VFO mode

11.1 VFO signal level on the output

The output is documented in section 10.2 page 52 as the level into 50 ohm

11.2 VFO frequency setting

The frequency setting is quite simple to understand and need no further explanation. They is selextion possiblity for five quick access frequencies which in combination with the tick in VFO-Frequnecy x4 for “I/Q Mixer” (as VFO for a SDR radio), where the output frequency is 4 times higher then the setting, can be quite handy for quick band changes
The minimum frequency steps are dependant of the frequency and the dicvision rate in the PLL going from 1:1 , 1:2 1:8 1:16 1:32 to 1:64 for the lowest band
From 2.2GHz to 4.4GHz they are 1KHz
From 1.1GHz to 2.2GHz they are 500Hz
from 550MHz to 1100MHz thety are 250Hz
From 275MHz to 550MHz they are 125Hz
From 137,5MHz to 275MHz they are 62.5Hz
From 68.75MHx to 137,5-mhz they are 31.25Hz
From 34.375MHz to 68.75MHz they are 15,635Hz
That os not entirely the thruth because the PLL is binary and not exactly in 1KHz steps.



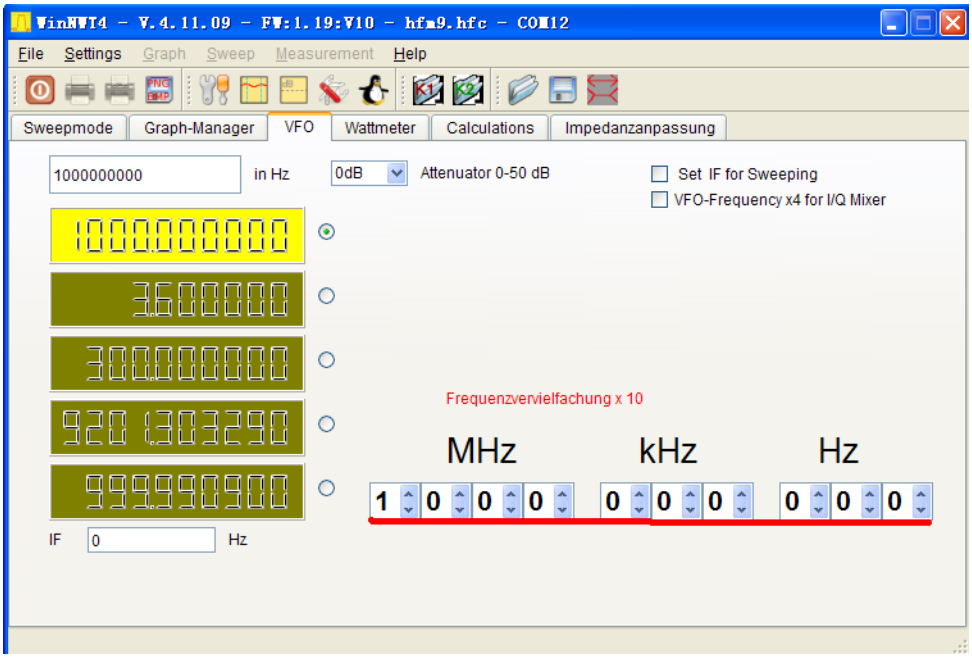
12. Frequency calibration (Note!! Read appendix 4 if you counter only can measure 100MHz)

12.1

Prepare a 1GHz frequency counter, allow enough warm-up time, for NWT4000 electric power up for 30 minutes（NWT3000，NWT4000-1.NWT4000-2 used 1GHz calibration, for others models use 10MHz calibration）

12.2

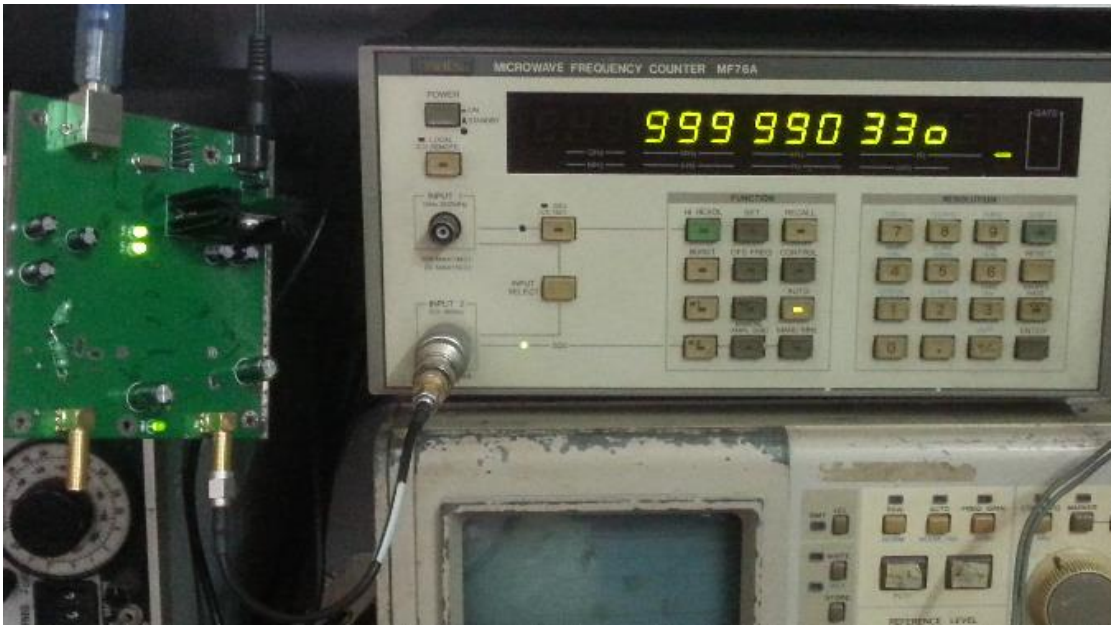
Enter VFO mode , output 1GHz/10MHz



Input 1GHz/10MHz

3

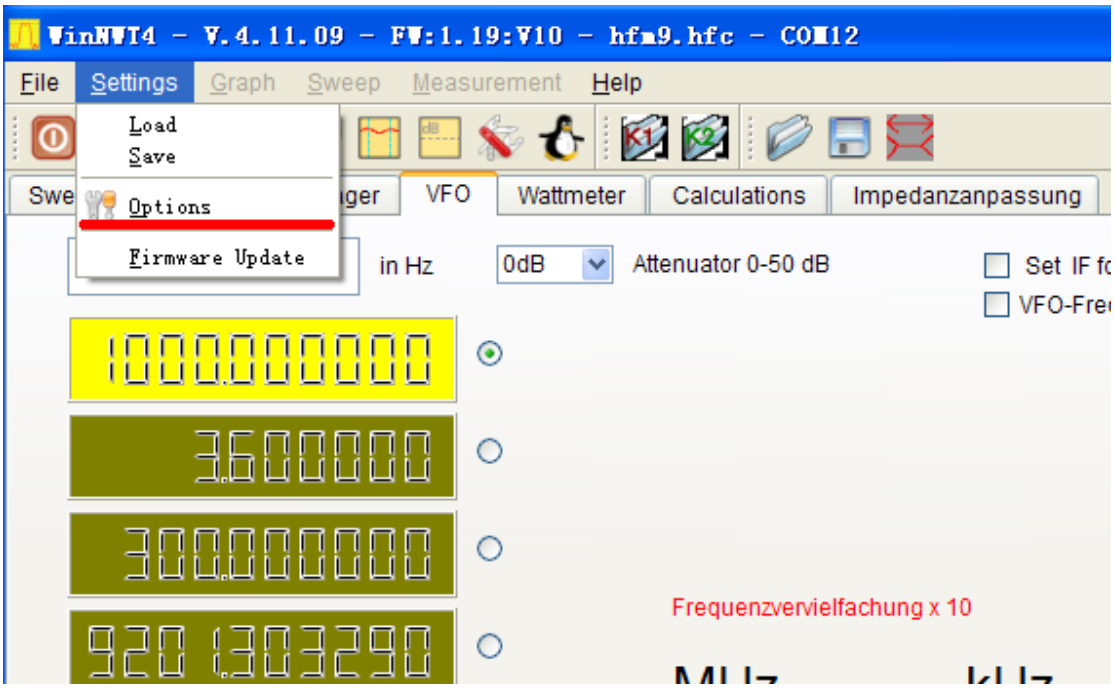
Use frequency counter to test nwt4000 output frequency



Test output frequency in this case 999.990 330MHz

4

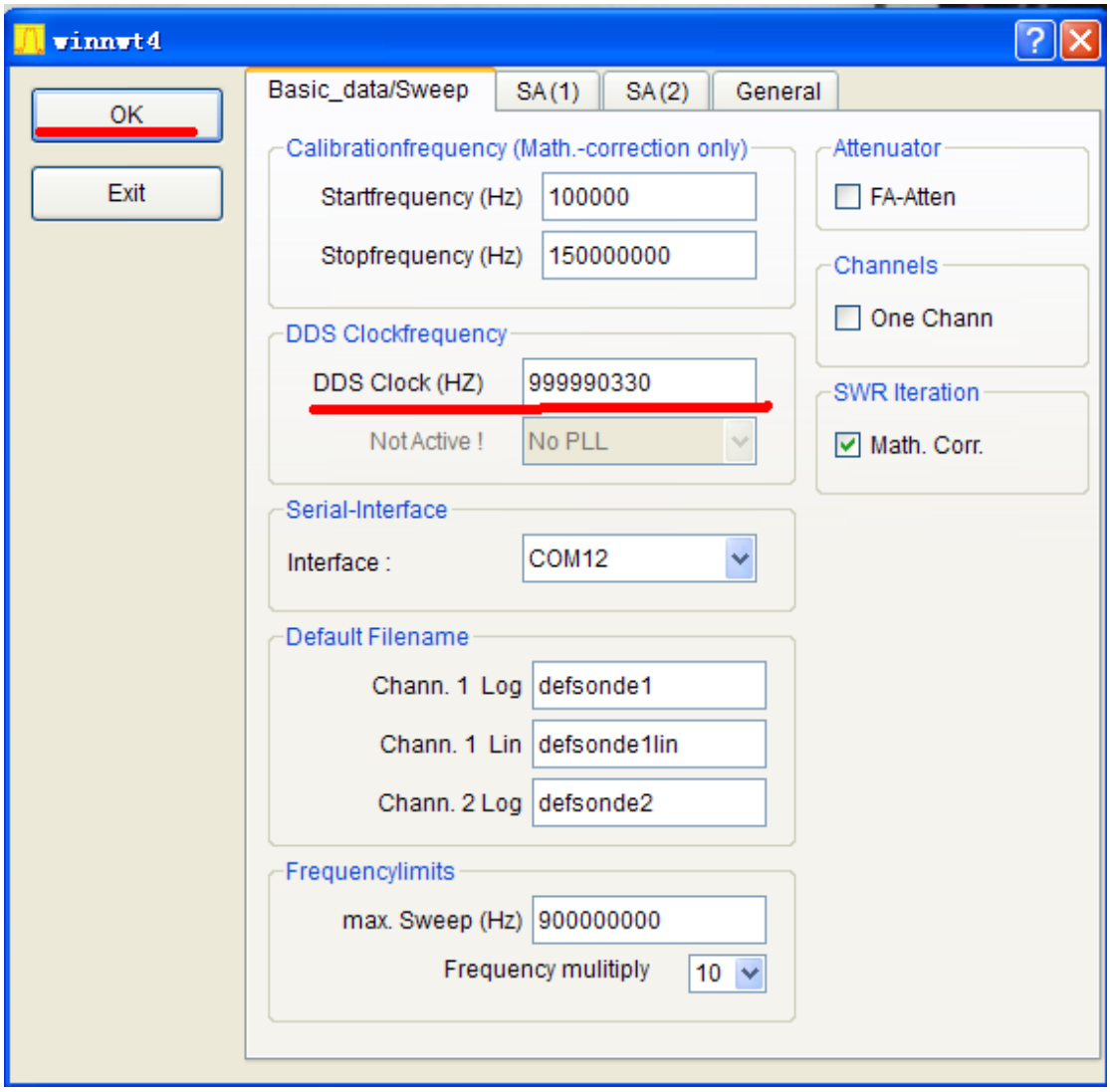
Enter option



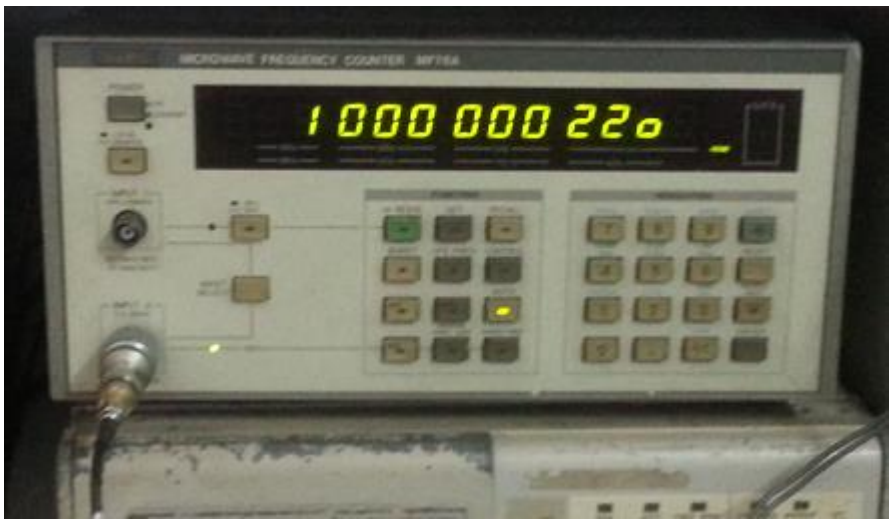
Enter OPTION

5

Input frequency counter frequency with units in Hz, press OK, then the frequency calibration is complete, result as shown below.



Input test frequency



Frequency reading has changed

Frequency calibration complete.

The user should pay attention to:

1. Read the manual at first.

2. NWT series digital virtual frequency sweeper is a precision instrument and has been vibration tested, splash proof, and corrosion resistant.

3. Do not short circuit signal the output port, as easy to cause internal damage to parts.

4 During testing, do not use a soldering iron in the device under test.

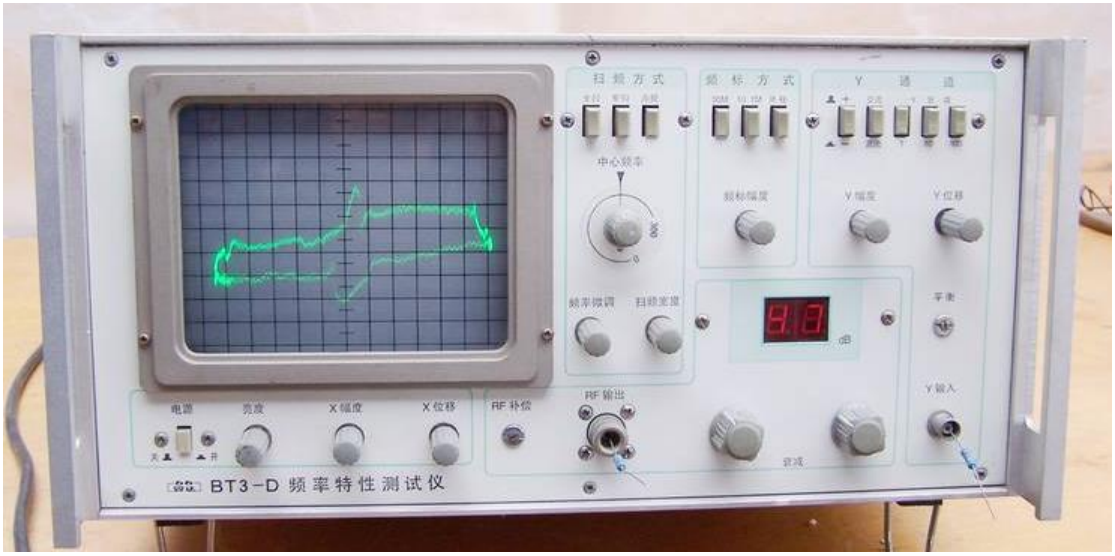
Appendix 1: FAQ

1. What is this device used for ?

A sweeper is a frequency characteristic tester, it is a test set which test devices for frequency and amplitude characteristics as curves, such as test of a LC tank's frequency and amplitude curve.

2. What is the difference of a NWT sweeper and a BT3 (CHINA TYPE) CRT sweeper.

A NWT serial sweeper is a digital sweeper, with small frequency steps, connected to a PC via USB which performs the calculation of data and present the curves. It can act as VFO (signal generator) and as a power meter and are lighter than the old sweeper. NWT4000-1, NWT4000-2 can be used as a simple spectrum analyzer.



CRT sweep

3,

NWT sweeper is connected to the PC but non-responsive，How to know the sweep analyzer is OK?

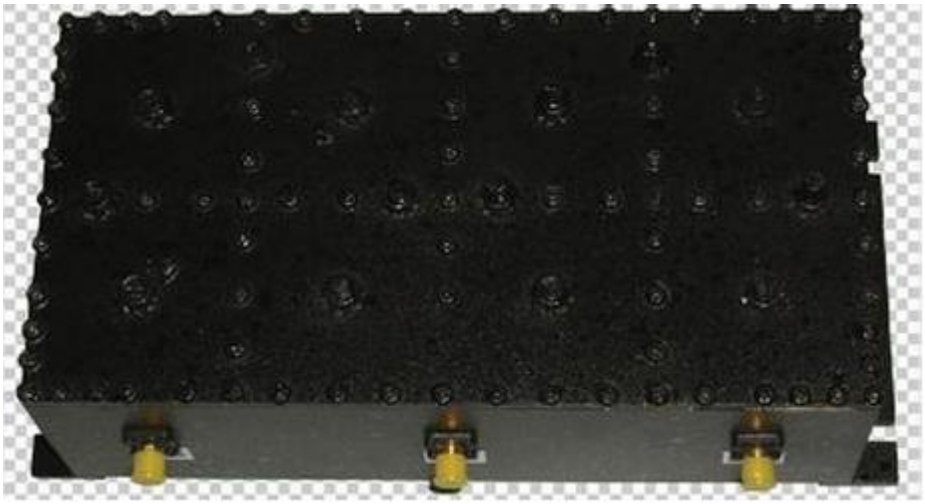
Check USB driver, check external DC power supply, check USB cable, check software setting about what port number is allocated to the sweeper in control panel/system/hardware settings. When responsive then:

Disconnect input and output. The curve is displayed in the bottom of the display area. Connect input and output with shielding cable. The curve is displayed in the top of the display area. If these two displays/curves are normal then the sweeper is OK.

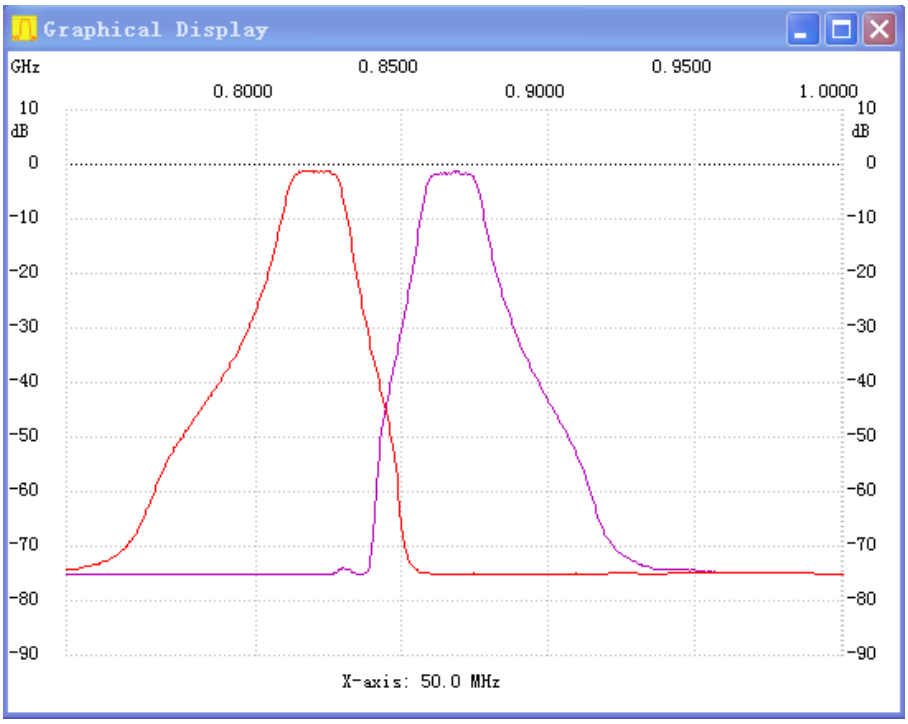
4, Can the sweeper test a duplexer and how to test ?

A duplexer is a filter. The NWT sweep analyzer input is connected to the output of the duplexer antenna connector and the NWT OUT connected to the Low or High antenna connector (the unused connector terminated with 50 ohm). The high and l ow frequency response thus measured as shown below.

Duplexer for UHF band



GSM band duplexer

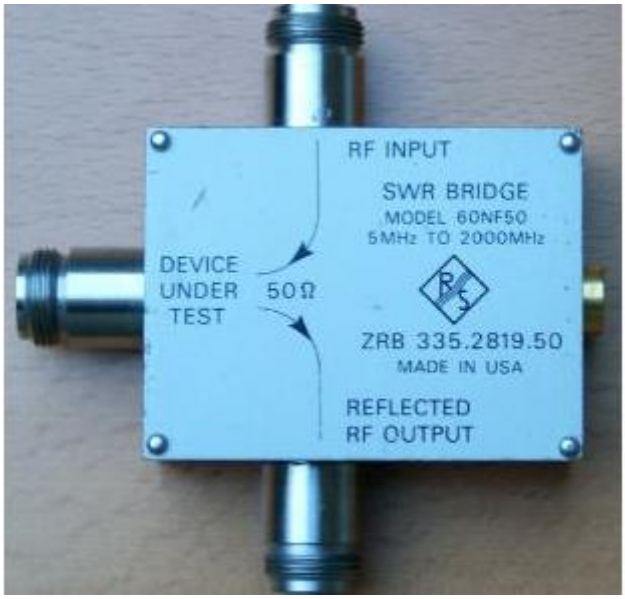


GSM band duplexer curve

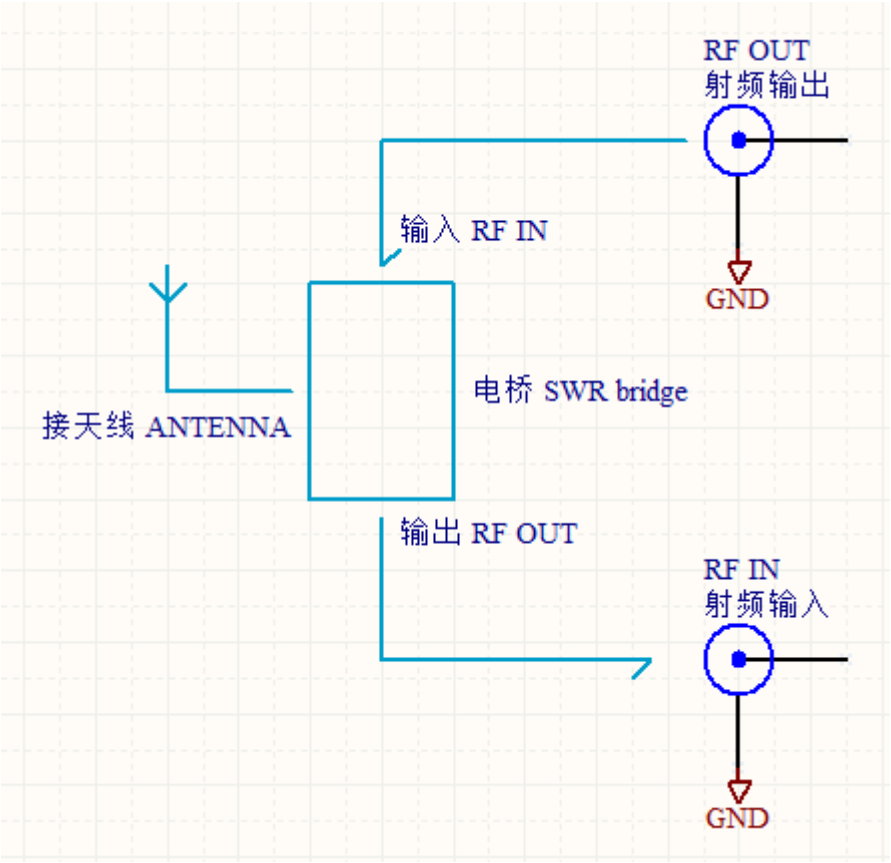
5，How to test antenna ?

Used a SWR bridge or a three port connector.

SWR bridge test:

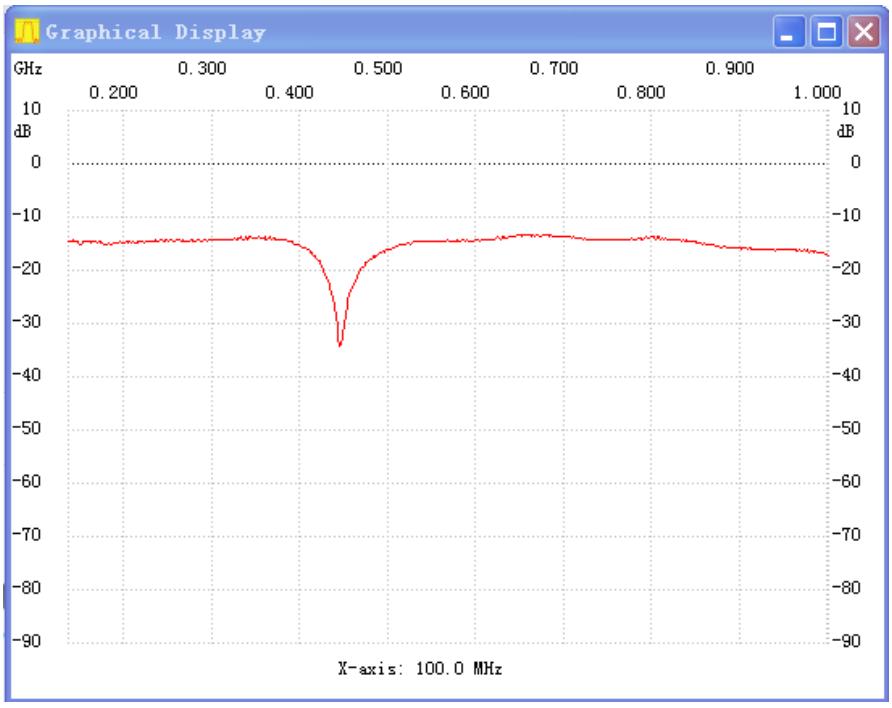


Swr bridge, RF output



Diagram

When using the SWR bridge you can measure in the transmission sweep mode, as a qualitative measurement, but you need to pay attention, frequency sweep analyzer can only use the RF Output of the Bridge, not the Bridge band detection output.



SWR bridge test of UHF antenna with three port connector

Use a three port connector replacing the SWR bridge, and you can test an antenna , but only for a qualitative test just a showed above

SMA three port

6. Attention when using the Sweep analyzer.

.

When connected to the computer and the DUT, then you need to pay attention that grounding is good, to prevent too high level input to the detection circuitry, otherwise it will damage the detecting element.

7. Power supply from the USB port is inadequate, what to do?

According to USB2.0 protocol the current is 0.5A, which should be enough. If the USB power is not enough, check USB cable connection is good, or change to a high quality USB cable, change to a USB 3.0 port (current is 0.9A) or use an externally powered USB HUB.

8. The impedance is not matched, creating problems, how to solve.

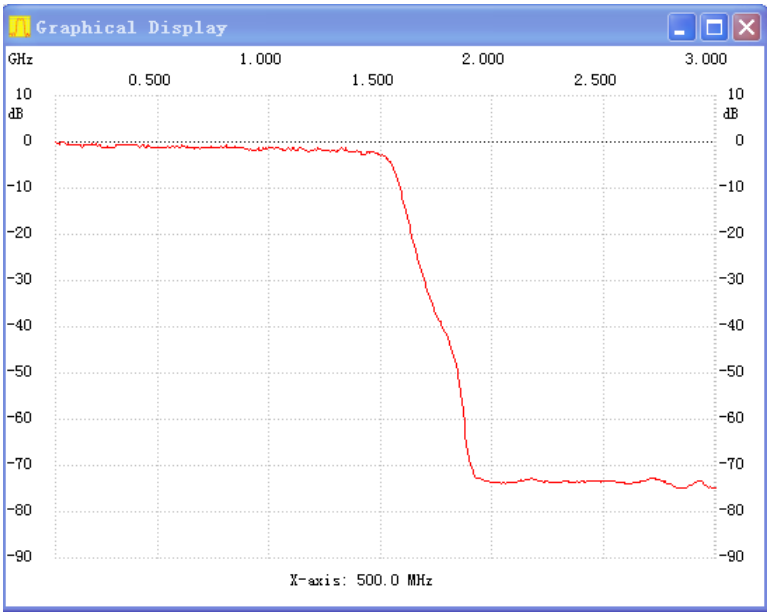
If there is an impedance mismatch, power is not 100% transmitted, and reflection will cause the measured parameters (gain, fluctuation, insertion loss, bandwidth) and other parameters being incorrect, then you can consider using external transformers or resistors as impedance matching, then measure again.

9. I need to improve the NWT input and output impedance precision, how to do ?

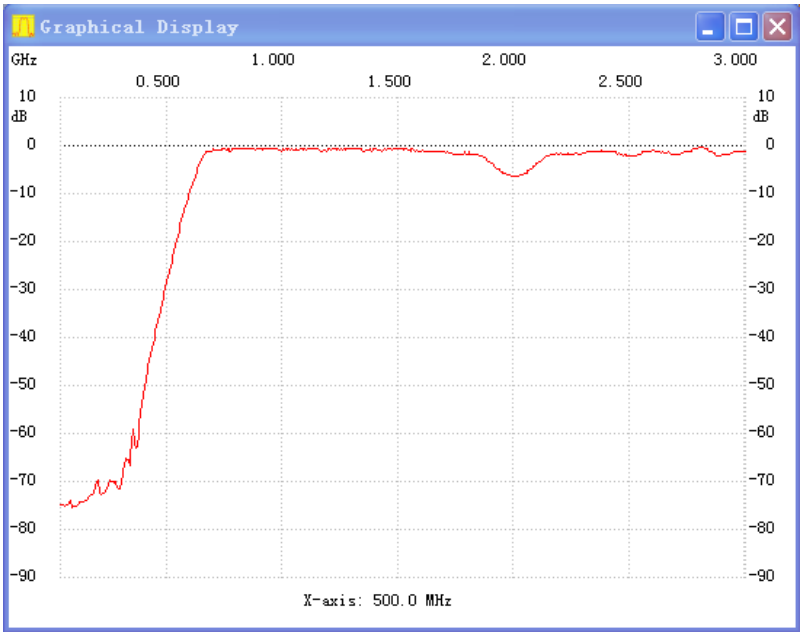
Insert an inline attenuator in the instruments input and output terminals, attenuator

normally of 3 dB will be adequate but if you want to have more precise, they can be replaced by 6-10 dB attenuators or even higher dB levels but the disadvantage is loss of dynamic range.

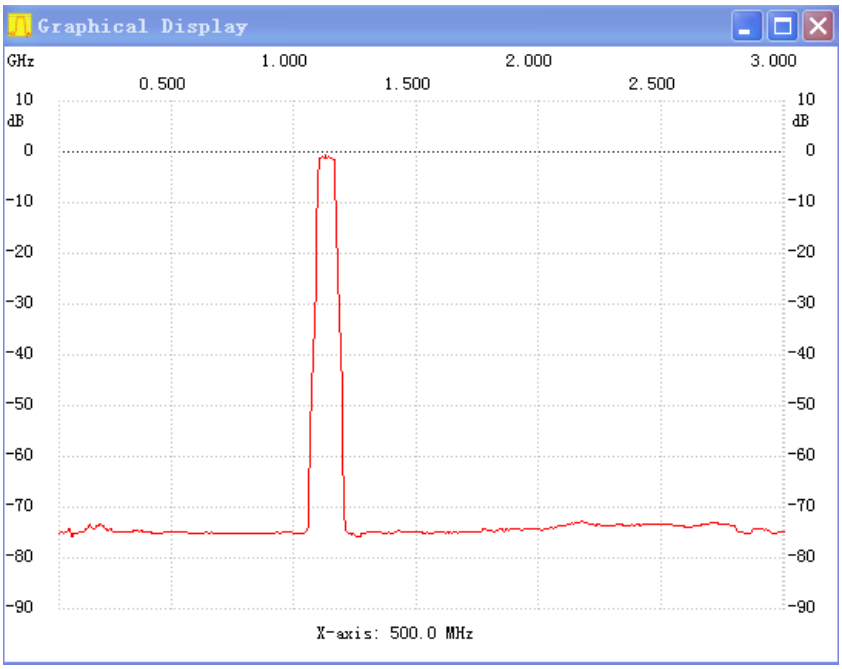
10. Some component curves tested with the NWT4000-2 equipment



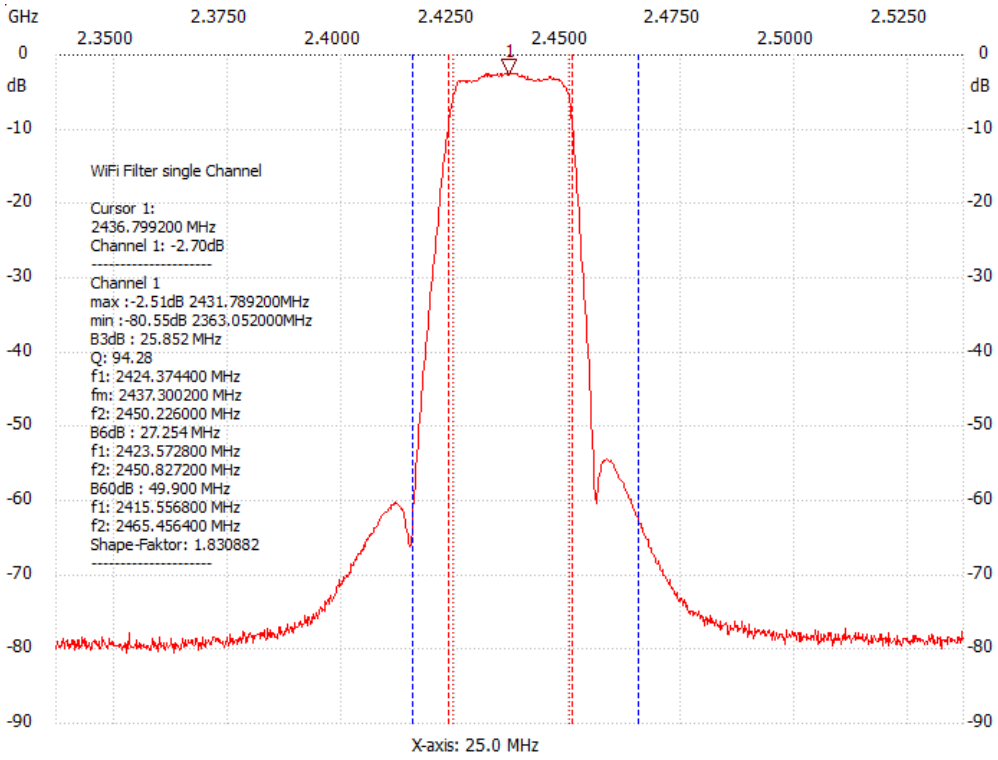
HP 5086-7051 LPF



Mini NHP-700 HPF



REACTEL 1.1-1.15G BPF



BPF24-806A

Appendix 2: return loss, reflection coefficient, voltage standing wave conversion tables

VSWR	反射系数 ρ	反射损耗 dB	VSWR	反射系数 ρ	反射损耗 dB
17.3910	.8913	1	1.0580	.0282	31
8.7242	.7943	2	1.0515	.0251	32
5.8480	.7079	3	1.0458	.0224	33
4.4194	.6310	4	1.0407	.0200	34
3.5008	.5623	5	1.0382	.0178	35
3.0005	.5012	6	1.0322	.0158	36
2.6146	.4467	7	1.0287	.0141	37
2.3229	.3981	8	1.0255	.0126	38
2.0999	.3548	9	1.0227	.0112	39
1.9250	.3162	10	1.0202	.0100	40
1.7840	.2818	11	1.0180	.0089	41
1.6709	.2512	12	1.0160	.0079	42
1.5769	.2239	13	1.0143	.0071	43
1.4985	.1995	14	1.0127	.0063	44
1.4326	.1778	15	1.0113	.0056	45
1.3767	.1585	16	1.0101	.0050	46
1.3290	.1413	17	1.0090	.0045	47
1.2880	.1259	18	1.0080	.0040	48
1.2528	.1122	19	1.0071	.0035	49
1.2222	.1000	20	1.0063	.0032	50
1.1057	.0891	21	1.0057	.0028	51
1.1720	.0794	22	1.0050	.0025	52
1.1524	.0706	23	1.0045	.0022	53
1.1347	.0631	24	1.0040	.0020	54
1.1192	.0562	25	1.0036	.0018	55
1.1055	.0501	26	1.0032	.0016	56
1.0935	.0447	27	1.0028	.0014	57
1.0829	.0398	28	1.0025	.0013	58
1.0738	.0355	29	1.0022	.0011	59
1.0653	.0318	30	1.0020	.0010	60

Appendix 4 NWT4000 Sweep flatness and frequency calibration

1. NWT4000 sweep calibration steps

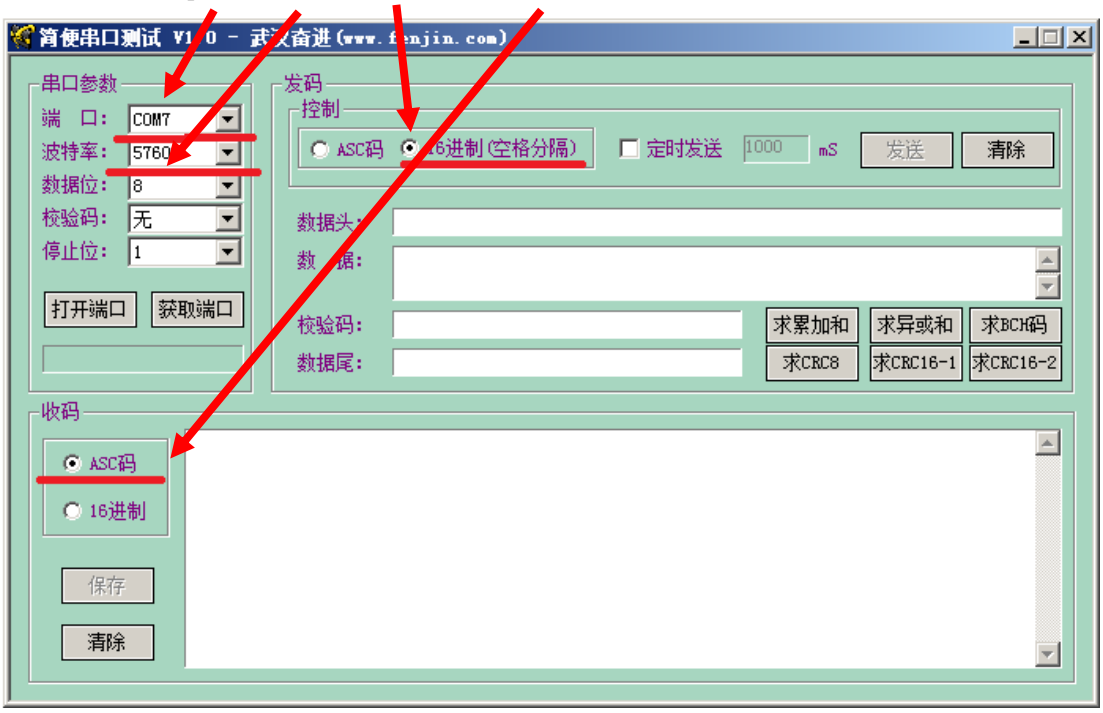
Appendix 4.1 Flatness calibration

ATTENTION: If curves is not flat or the linearity from -10dB to 0 dB is too compressed, then insert two 3dB attenuation to input and output both when instrument is used and when calibrated as described below. Then the linearity from 0dB down to -70dB is very accurate. The dynamic range is of course reduced by 6dB. Alternatively a single 6dB attenuator can be used and if so then place on the output not to reduce the sensitivity when used as spectrum analyzer.

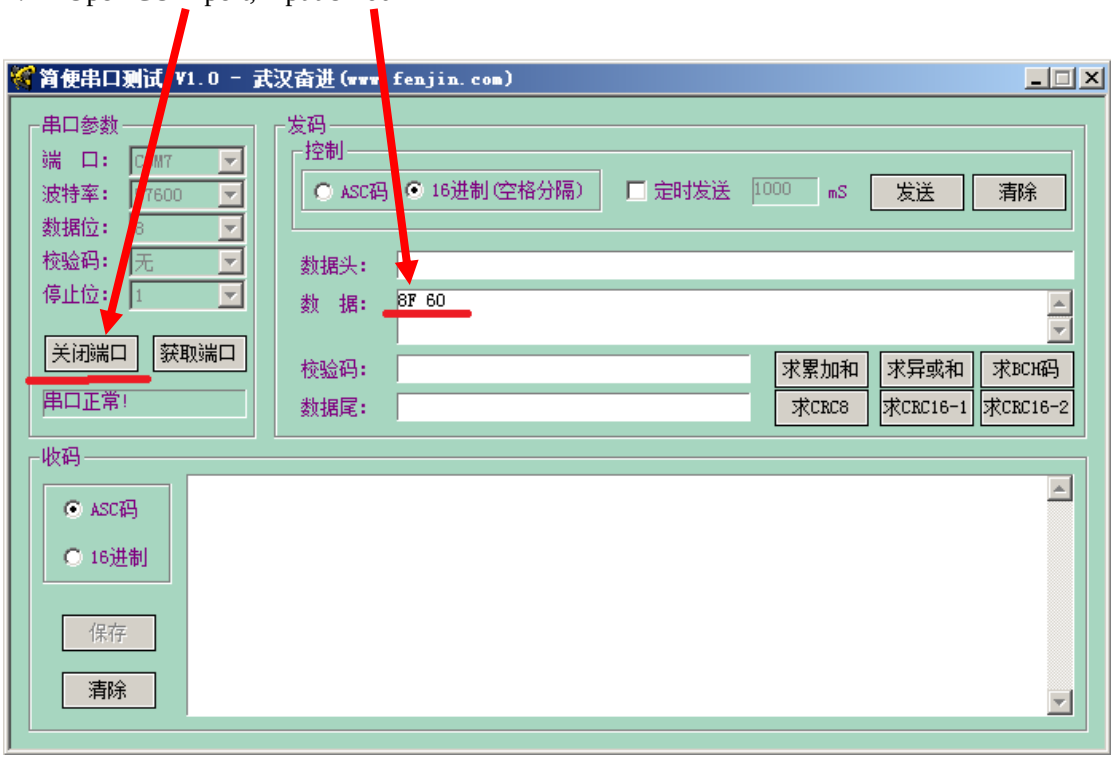
1. Connect power and connect USB to PC, Power on for 30 minutes.

2. Opened COM assiter and select COM port
   (You may remove the Chinese characters by renaming/editing the file name)

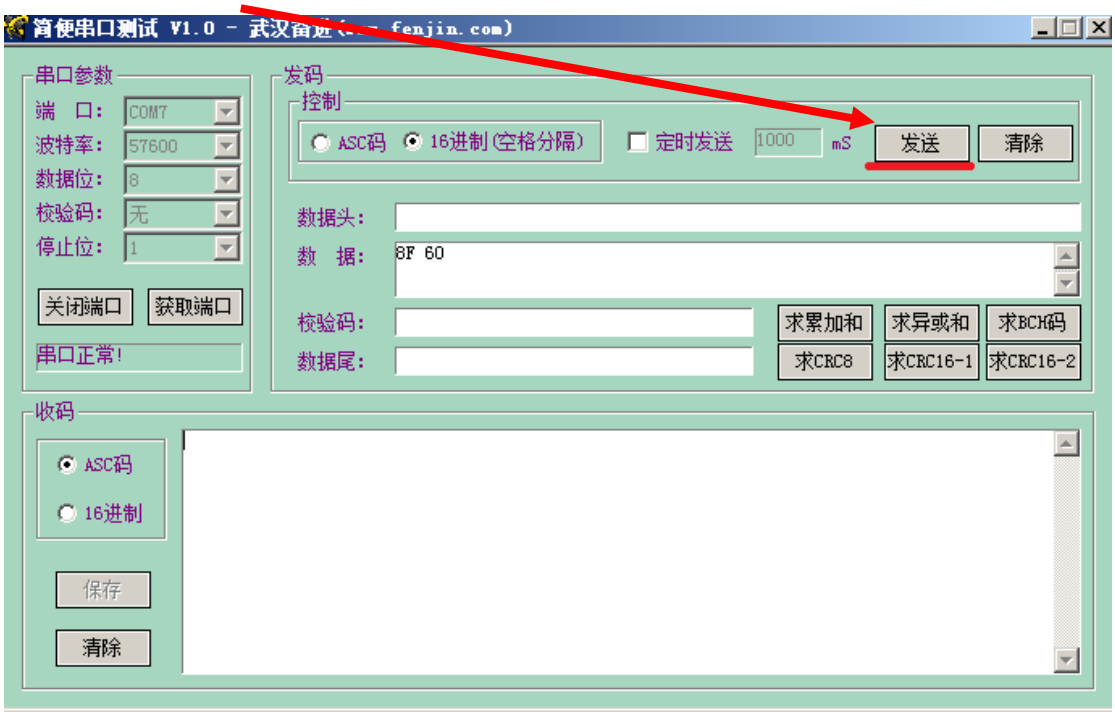
3. Select COM port, baudrate, hex, ASCII code



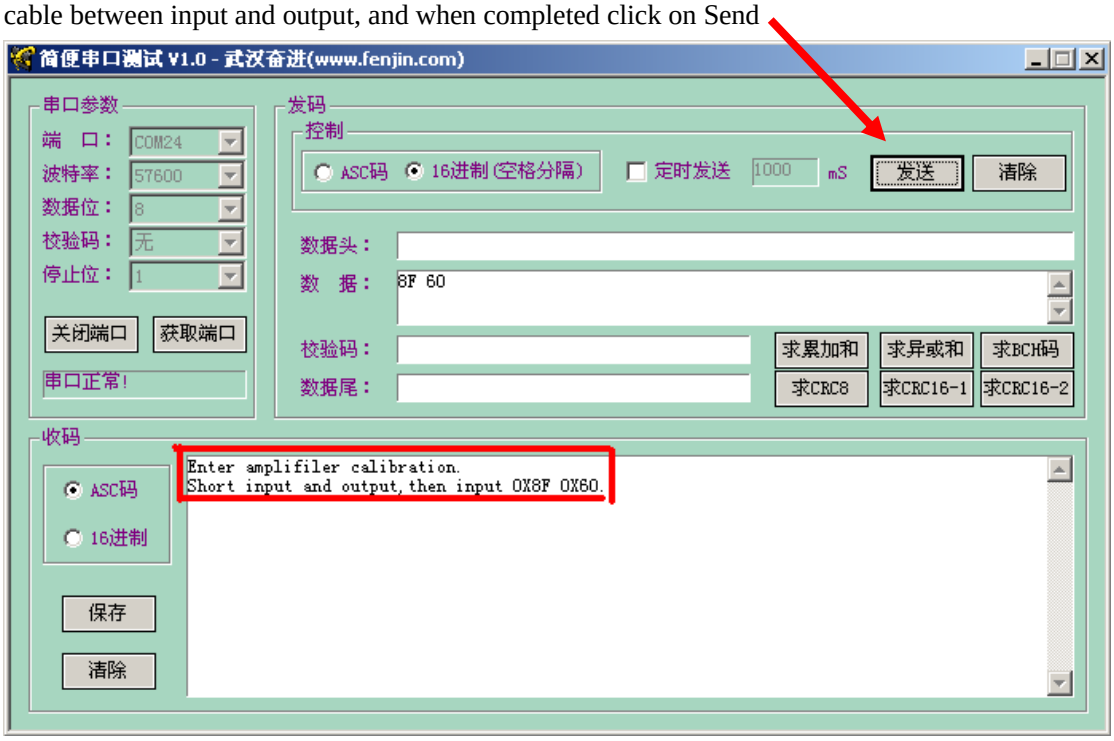
4. Open COM port, input 8F 60



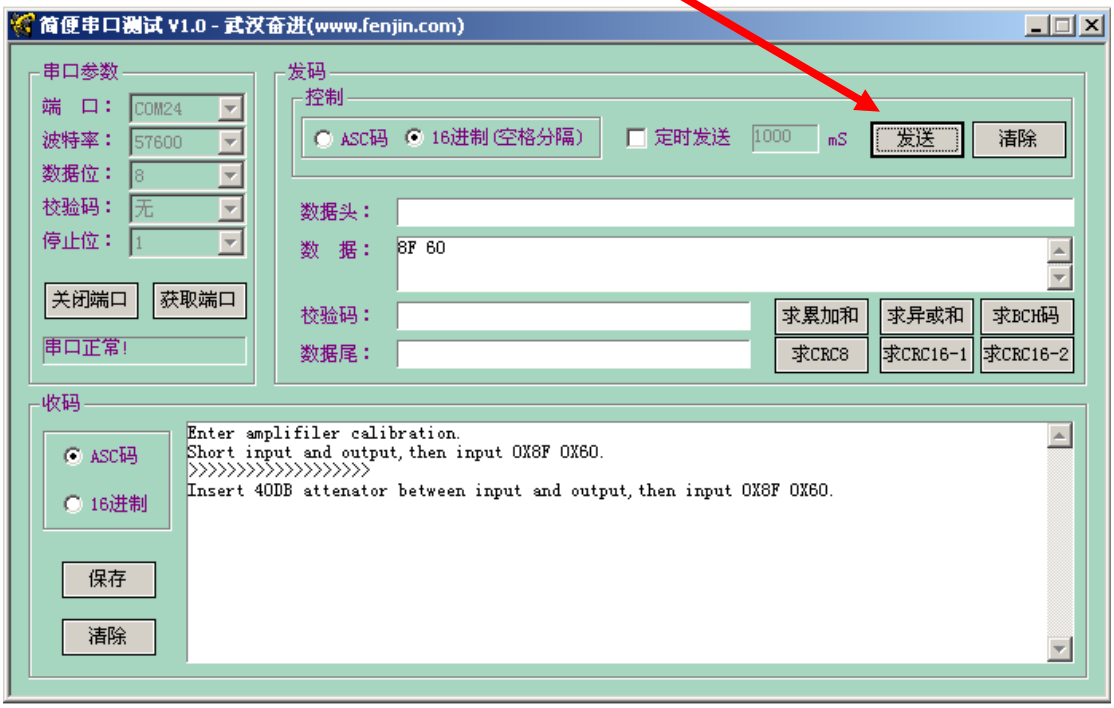
5. Click on Send



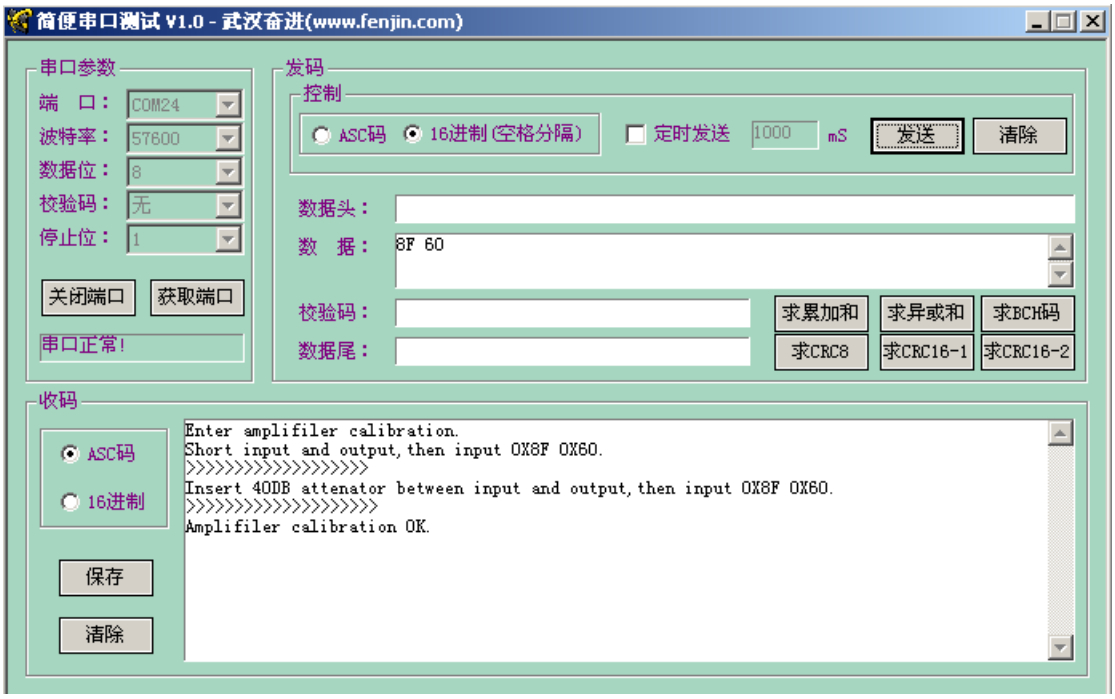
6. According to the prompt, “short circuit” input output by connection a SMA male-male test cable between input and output, and when completed click on Send



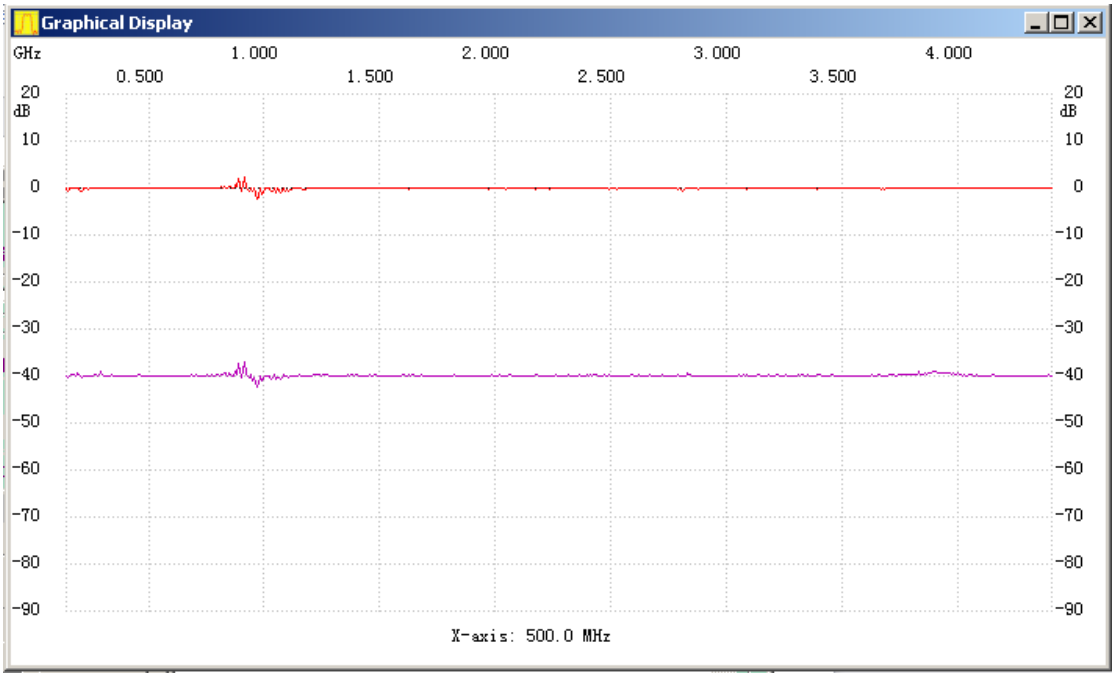
7. Insert 40dB attenuation and when done click on Send



8. Calibration complete.



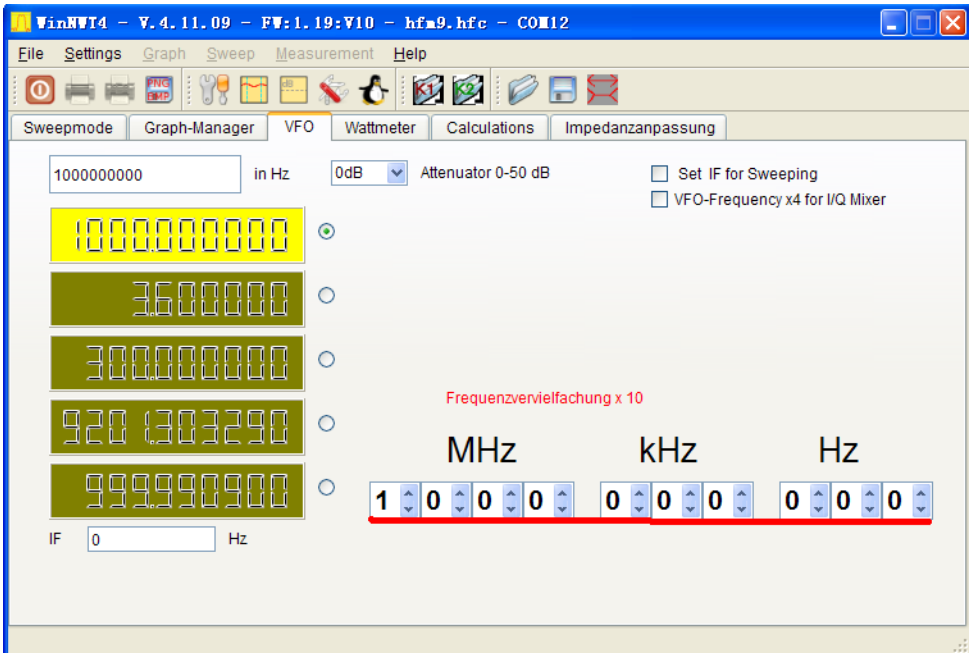
9. Calibration complete the curve is flat for 0 and 40dB



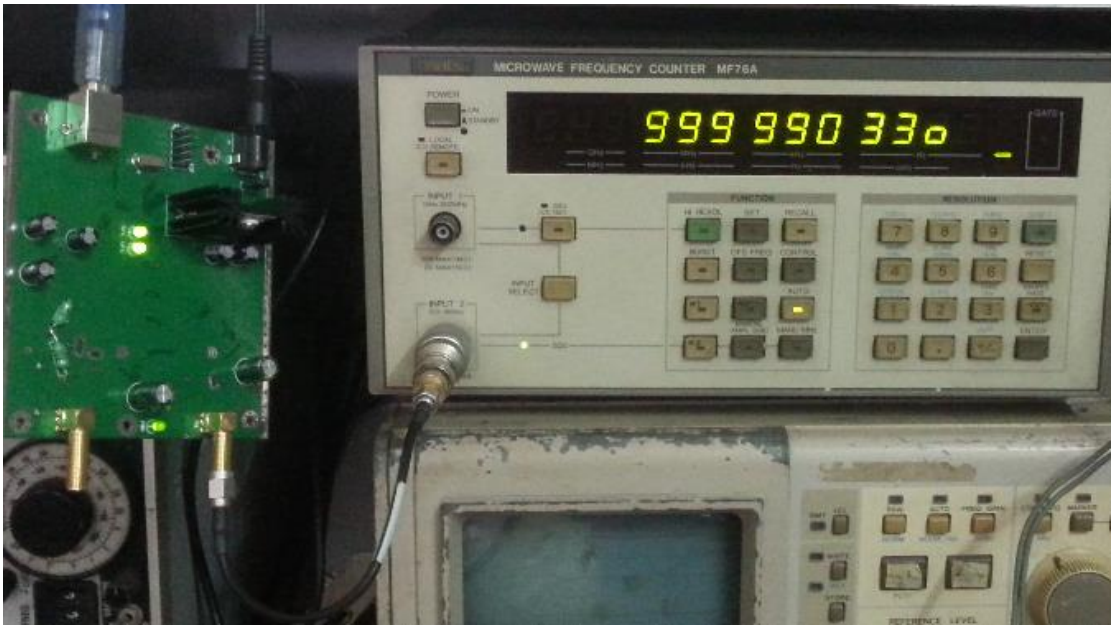
Appendix 4.2 Frequency calibration

1. Prepare a 1GHz frequency counter, warm-up time enough, NWT4000 electric power up for 30 minutes

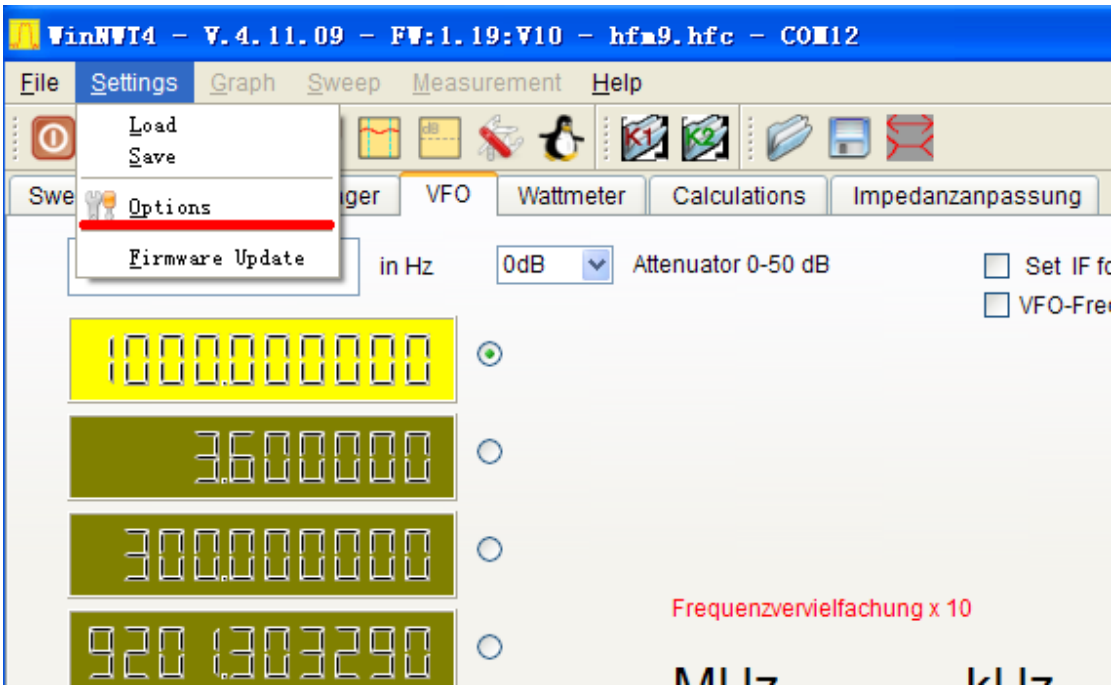
2. Enter VFO mode ,output 1GHz



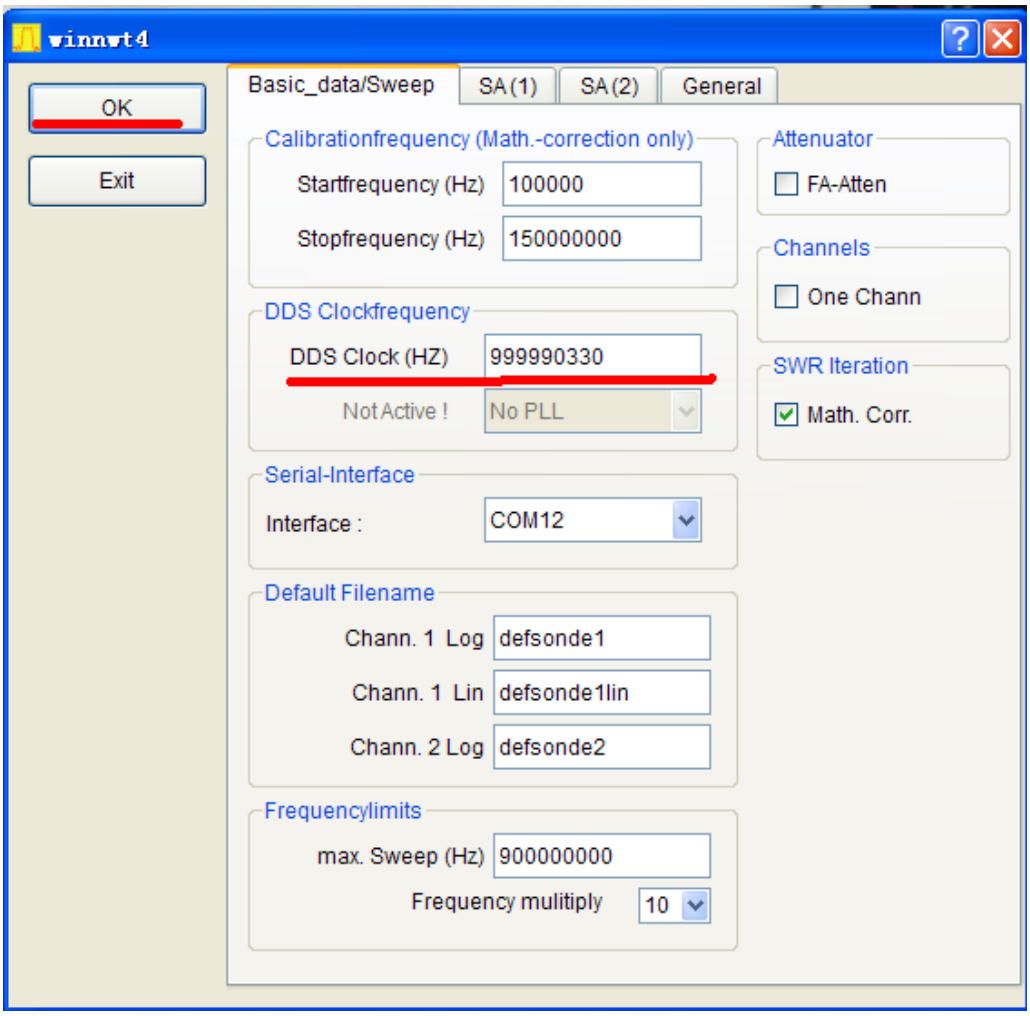
3. Used frequency counter test nwt4000 output frequency



4. Options:



5. Input frequency counter frequency with unit Hz，press OK, frequency calibration complete。



<u>Special tricks if your counter does not go to 1GHz:</u>

If you counter does cover 100MHz then use a gate time of 10sec to read the frequency with at least 10Hz resolution , set the VFO to 100MHz and write down the measured frequency e.g. 99.99931MHz . Then write down the frequency as if it was 10x higher with 1 Hz resolution

e.g. 999999310Hz and set the VFO to 1GHz and enter 999999310 into the DDS (PLL) Clock (Hz) in the Settings/Options/ menu point. Then the frequency is calibrated to within 1kHz at 4.4GHz. When measuring the 100MHz output after calibration You may experiment with the 1 Hz settings to get closer to 100MHz. Most likely, you will hit the correct frequency with less than 50Hz error.