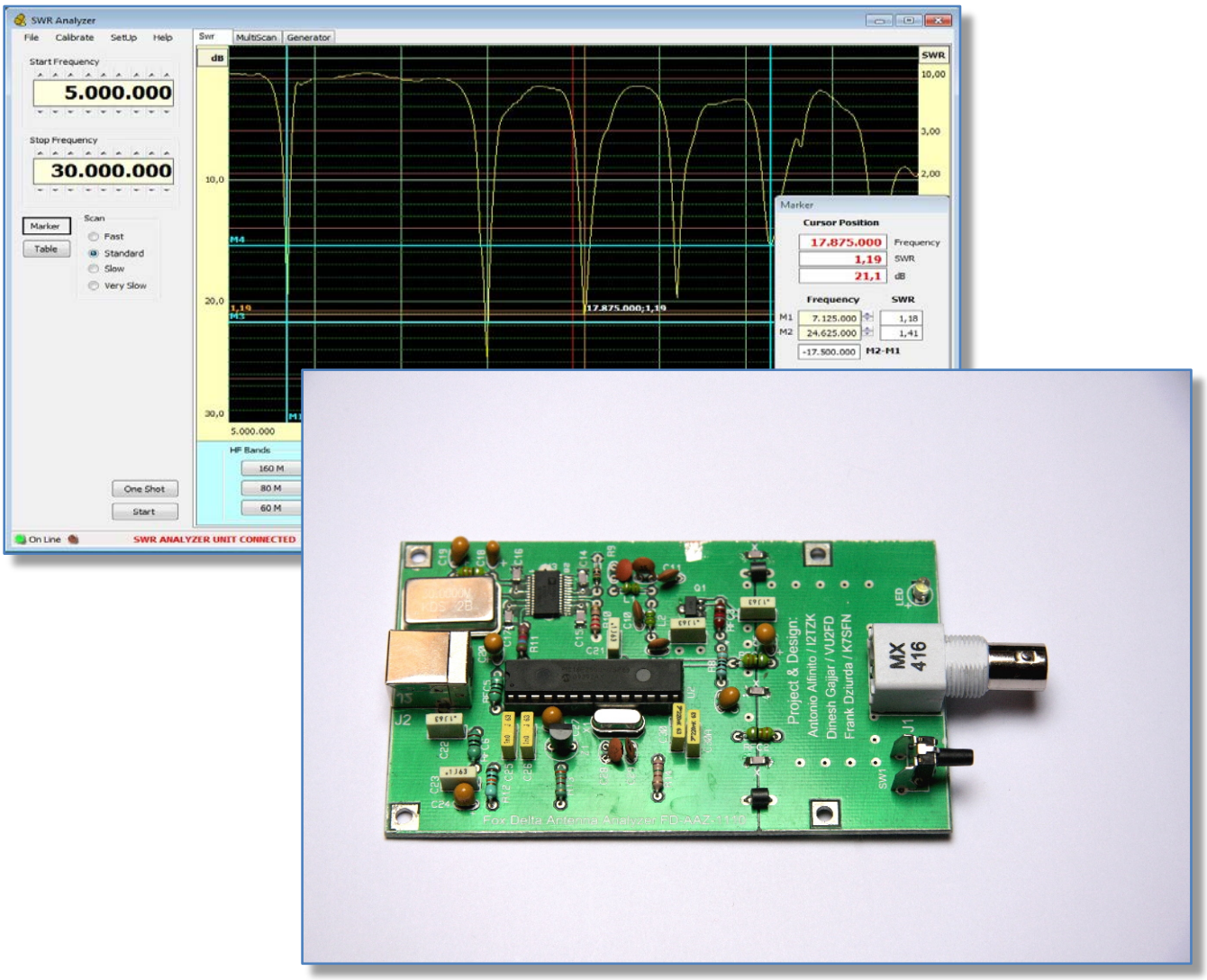
Fox Delta

Amateur Radio
Projects & Kits

SWR ANALYZER



May, 2012

1. Project genesis

I like very much to play with antennas, experimenting new solutions, testing and making my own wired antennas (square, flag, pennant etc.) as well as verticals.

To achieve good results, it is essential for me to plot and analyze the resonance graphic of the device under test.

Correct approach is to use a general purpose instrument like a VNA (Vector Network Analyzer) or choose a dedicate "Antenna Analyzer" that gives you for each frequency the complex impedance of your antenna.

The market offers to the Ham Radio enthusiastic many VNA doing an excellent job, see for example the "miniVNA" (www.miniradiosolutions.com) , the "SARK100" (www.ea4frb.eu) or the "VNA 1280" (www.arraysolutions.com) as well as several models of Antenna Analyzer like the MFJ's product family (www.mfjenterprises.com) or the RigExpert (www.rigexpert.com) etc. etc.

All these instruments are offered at very good price, but, from a long time, I had in my mind the idea to implement a cheap, *simple and easy way to use the PC monitor to plot the resonance dips* of my antenna and offer the project to the Ham Radio community as a very smart and inexpensive device.

The project was just one of my thoughts until I meet Dinesh, VU2FD and Frank, K7SFN.

I talked them about the project, Dinesh offered to take care of the hardware implementation and Frank to test software and hardware. I charged myself to develop the firmware and the software.

Finally my thought became the **SWR Analyzer** project.

Tony, I2TZK

SWR Analyzer main features :

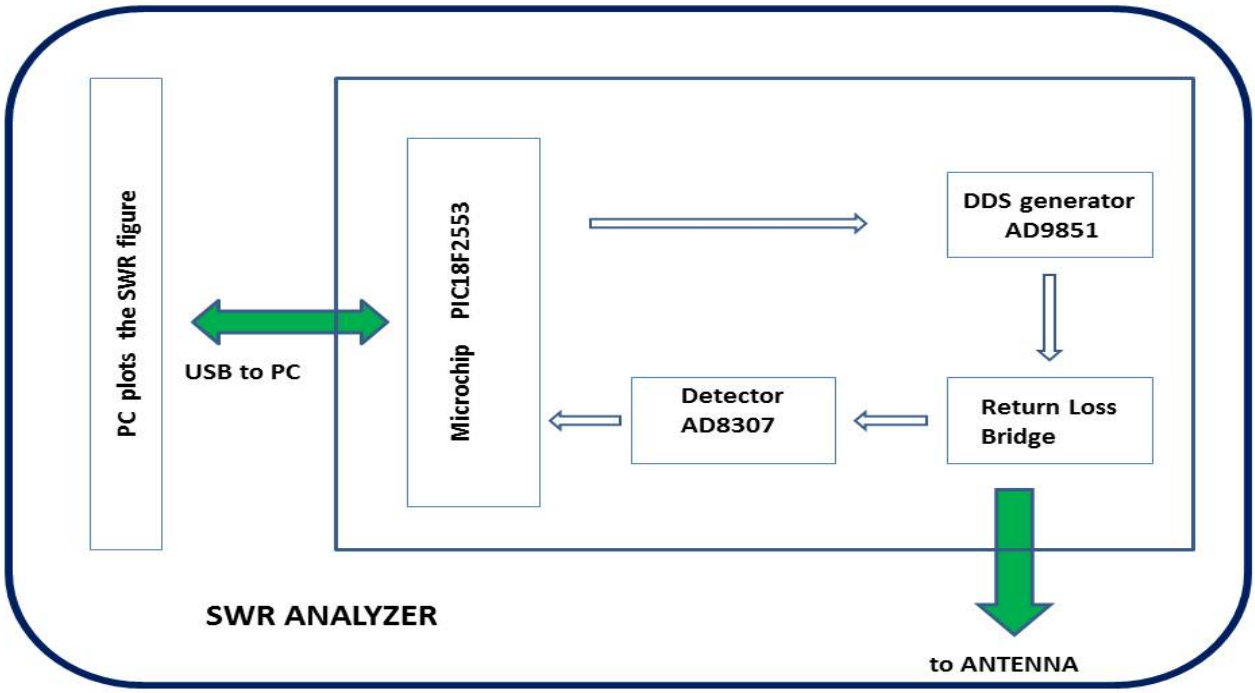
- Smart and very cheap hardware implementation
- Free firmware and software for the Ham Radio Community
- USB connection to the PC
- Plot the resonance dips in any HF Band
- Compare up to 3 resonance graphics
- RF generator from 1MHz to 35MHz
- Export data in csv format
- Print graphics and data table
- Return Loss Bridge: directivity > 50dB, open/short ratio < 1dB

2. SWR Analyzer project's notes

The "SWR Analyzer" is a smart, cheap and easy to assemble "Antenna Analyzer".

The project is focused to measure the antenna performances across the HF Ham radio bands without any need to connect the transmitter to the antenna.

Basically the "**SWR Analyzer**" is a Scalar (or single port) Network Analyzer, the following figure shows the hardware architecture.



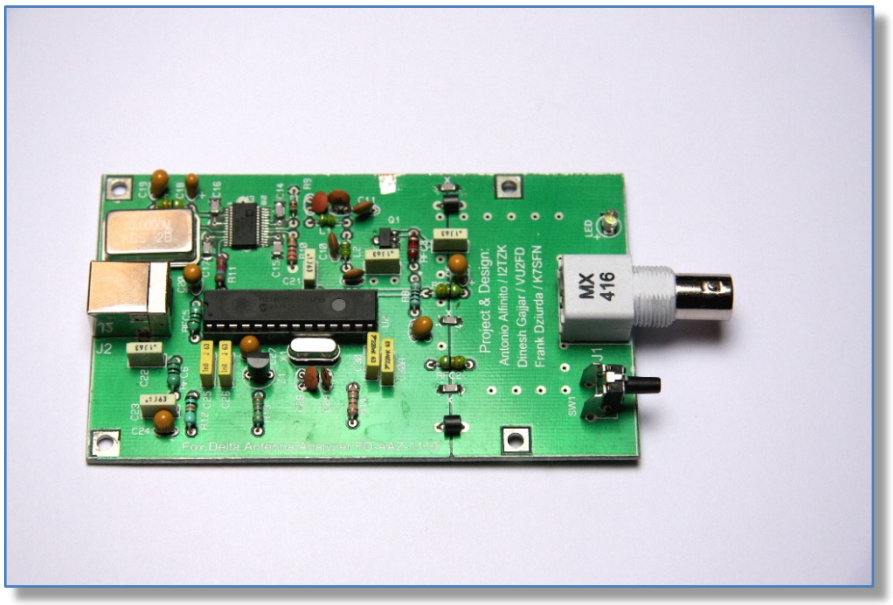
The main elements of the diagram are :

- **Microchip PIC18F2553**
- **DDS generator AD9851**
- **Return Loss Bridge**
- **Detector AD8307**

The microcontroller PIC18F2553 interfaces the PC receiving commands to drive a RF generator (DDS) and sending back the voltage values read from the Return Loss Bridge.

The Analog Devices AD9851 is a Direct Digital Synthesizer (DDS) device which can generates a sinusoidal wave output up to 180MHz. The microcontroller drives the DDS to generate the RF signal sweepped in the HF frequency range from 1MHz to 35MHz, that feeds one end of the Return Loss Bridge.

The return loss bridge is the wideband resistive bridge network used to verify the impedance at the antenna connector. It works by comparing the "unknown" antenna impedance to a purely resistive 50 ohms, the output DC voltage corresponds to the level of impedance mismatch between the 50 ohms and the antenna impedance.

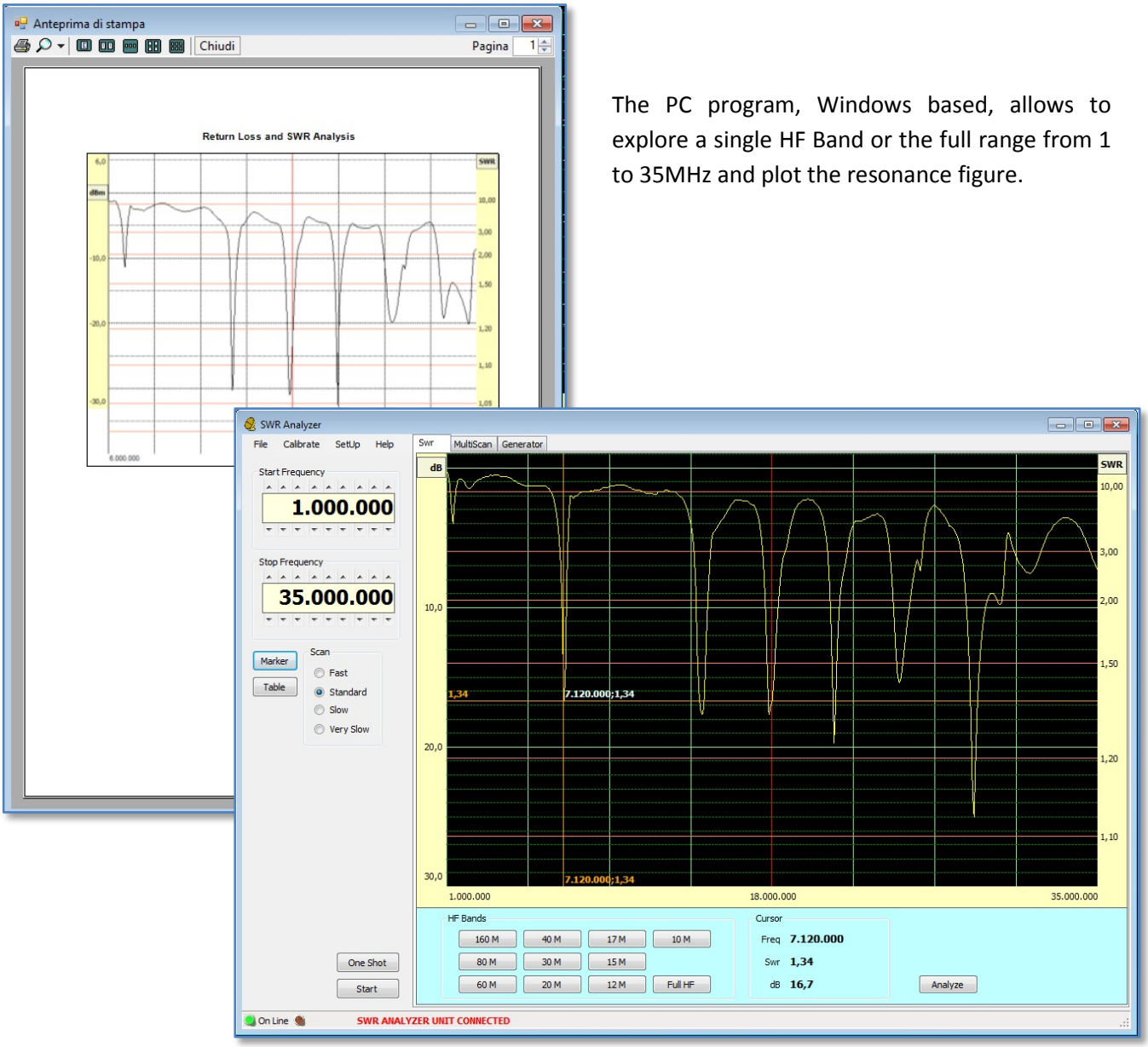


Generally speaking, the higher the DC voltage output, the worst the impedance mismatch is.

The following stage (AD8307 configured as detector/differential comparator) amplifies the RLB output converting the signal level to a decibel form and delivering it to the microcontroller.

The Analog to Digital Converter (ADC) embedded into the microcontroller provides to generates the digital measure of the impedance, the measure is sent back to the PC.

Finally the PC program calculates the dB values, translates the measure in a SWR figure and plots the mismatch diagram of the antenna.



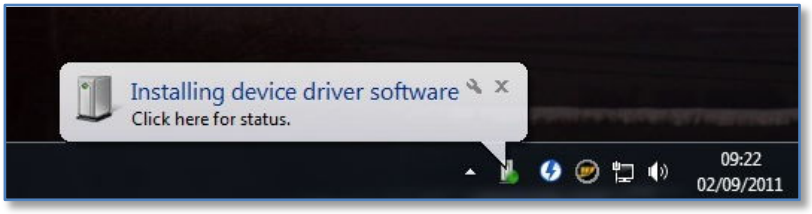
The PC program, Windows based, allows to explore a single HF Band or the full range from 1 to 35MHz and plot the resonance figure.

3. Connect the Hardware

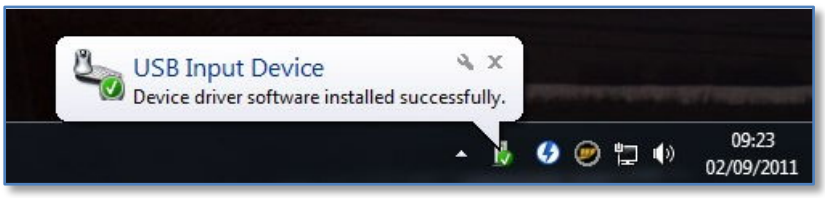
Connect the SWR Analyzer Unit to the PC using a standard USB cable (printer cable), **after a while the blue led close to the BNC connector will light on** stating that the board is ready to be linked by the PC program.

If this is the first time you attach this device, Windows will start to search and install the required drivers. To communicate with Windows, the SWR Analyzer uses the USB port embedded into the microcontroller PIC18F2553, so **drivers are the standard ones developed by Microchip and Windows Microsoft.**

Windows is searching the driver



You should listen to the Windows announcement sound that indicates a new device has been detected and the corresponding driver is loading.

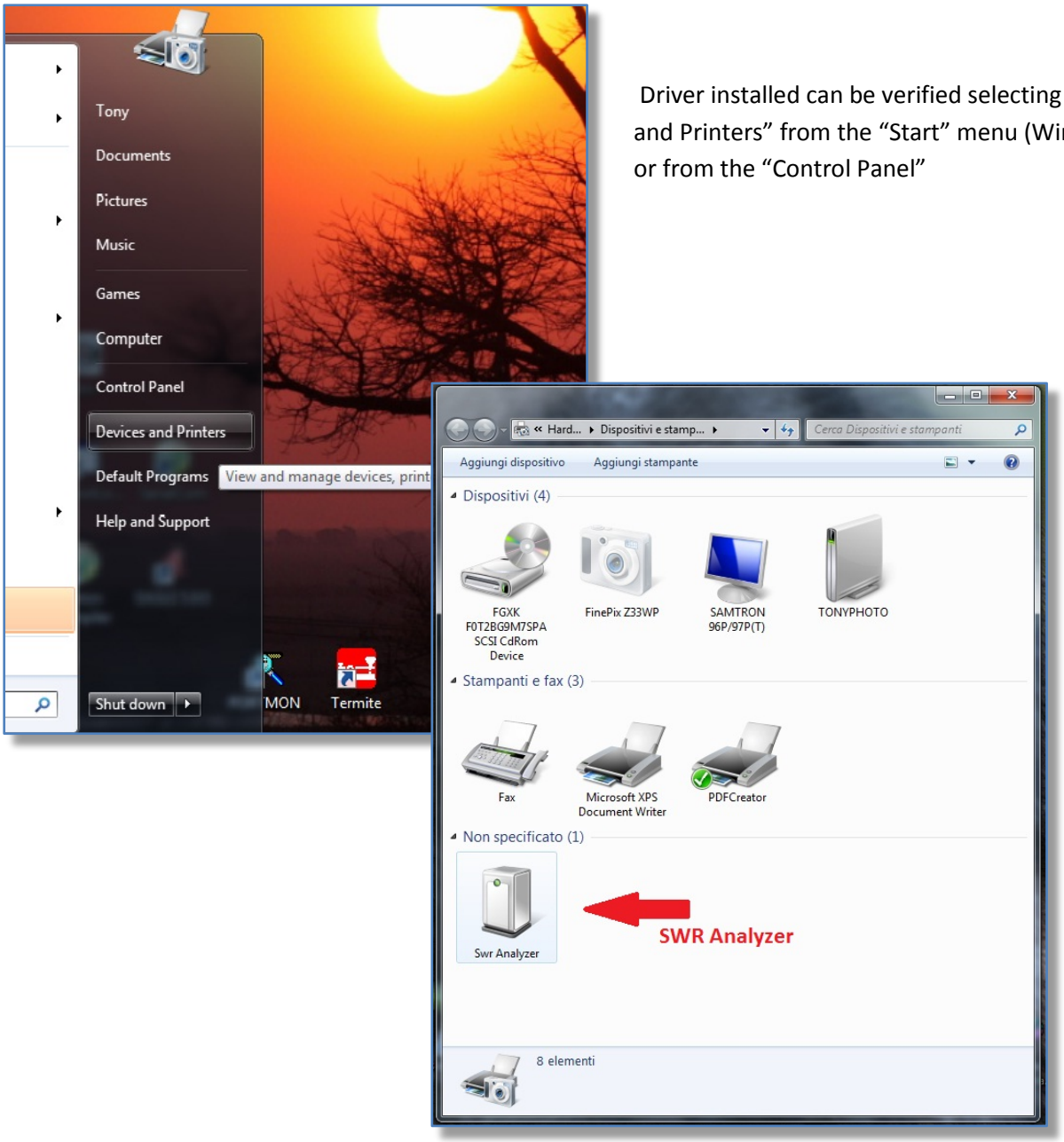


Driver successfully found and installed

After a while, as soon as Windows has installed the drivers, the **BLU LED lights on**.

Now the unit is ready to be linked by the PC program. **The above operation can take several seconds** depending on the time needed by Windows to find the right drivers.

Usually this happens only once, next time you connect the SWR Analyzer all needed parameters are already know by Windows.

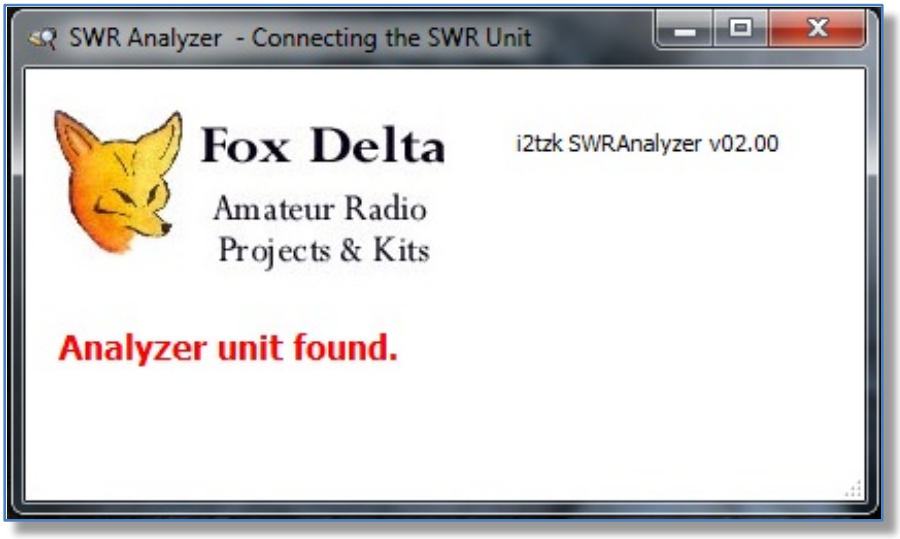


Driver installed can be verified selecting “Device and Printers” from the “Start” menu (Windows 7) or from the “Control Panel”

4. Launch the PC program

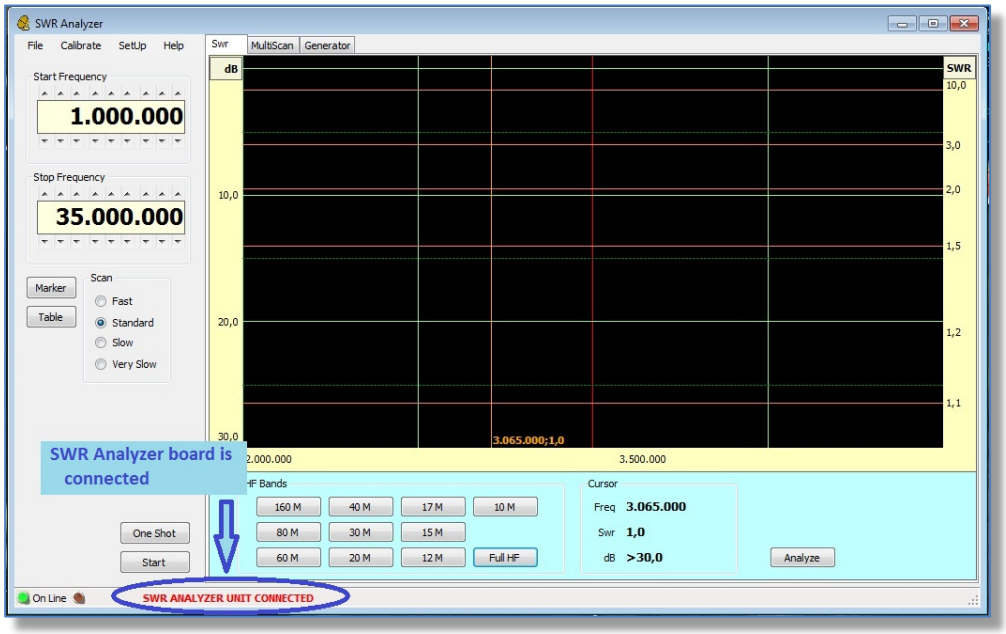
The software application doesn't need any installation procedure, just create a new folder and unzip there the file "SWRAnalyzer.zip" you've downloaded from the FoxDelta server.

To launch the program, navigate to this folder and DoubleClick "SWRAnalyzer.exe".
For your convenience you can create a link to the desktop right clicking on "SWR Analyzer.exe" and selecting "Send to Desktop".



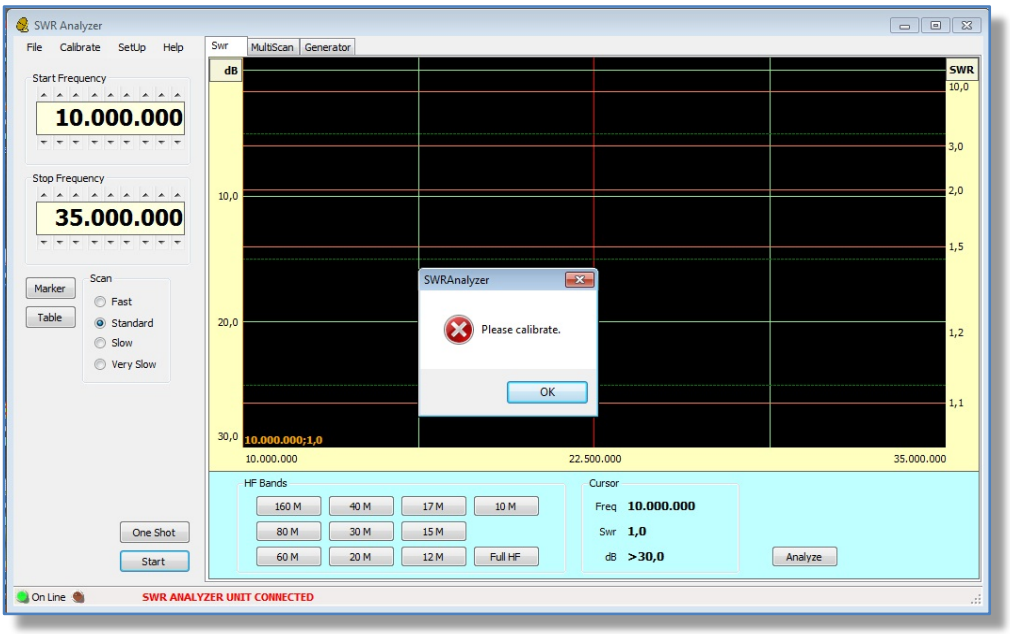
When program starts, it automatically searches for the SWR Analyzer board exploring all the USB devices.

When the board has been found, the **blue led next to the BCN connector starts blinking,** and the main screen is presented.



5. Calibration

First time the “SWR Analyzer” program runs, calibration of the hardware is requested.



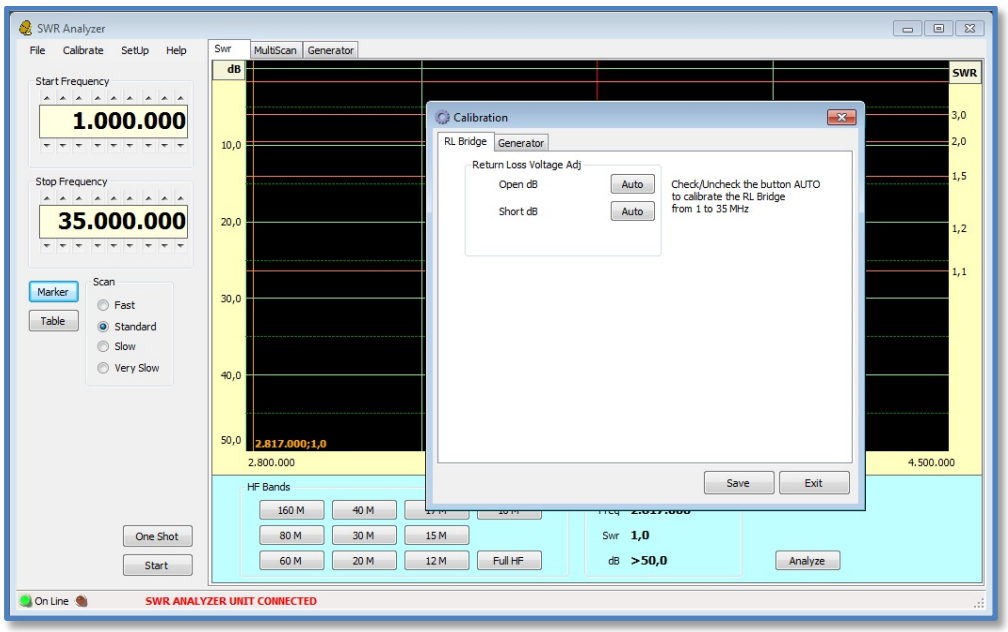
Return Loss Bridge

Connect the SWR Analyzer, select the menu “Calibrate” and the tab “RL Bridge”

The calibration process requires two steps: calibration **Open** and **Short** circuit.

Open circuit *means that the Antenna connector must be left as it is, open, no cable, dummy load or any device connected.*
Short circuit *requires that the Antenna connector is 0 Ohms terminated.*

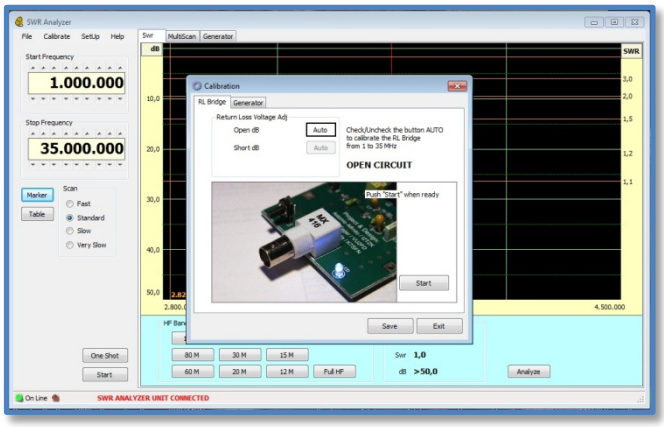
Push/release the button “Auto” next to the field “Open Circuit” or “Short circuit” to access the corresponding calibration process.

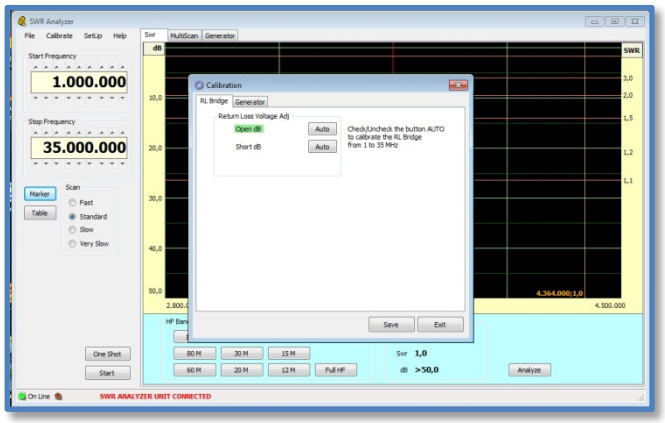


Be sure that *no cable is plugged* into the Antenna connector, select the option “Open” then run the automatic calibration process by pushing the button “Start”.

Do not interrupt or unplug the USB cable during this phase.

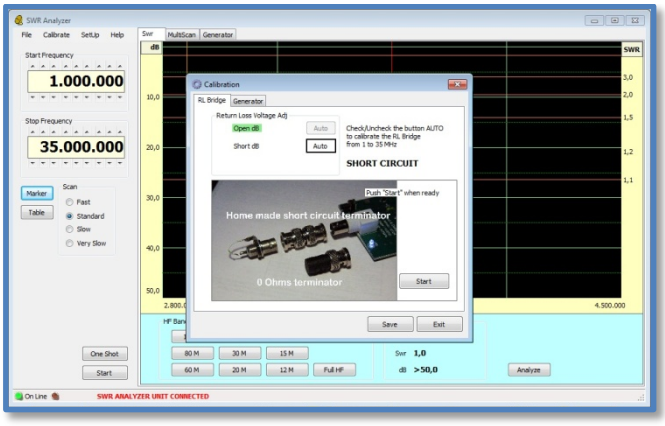
When the measure “Open circuit” is succesfully completed the panel “OPEN CIRCUIT” closes and the **green color** of the value field indicates that this step has been succesfully executed.

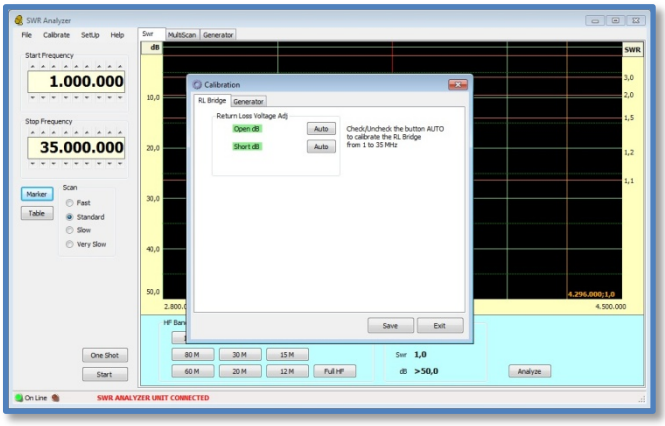




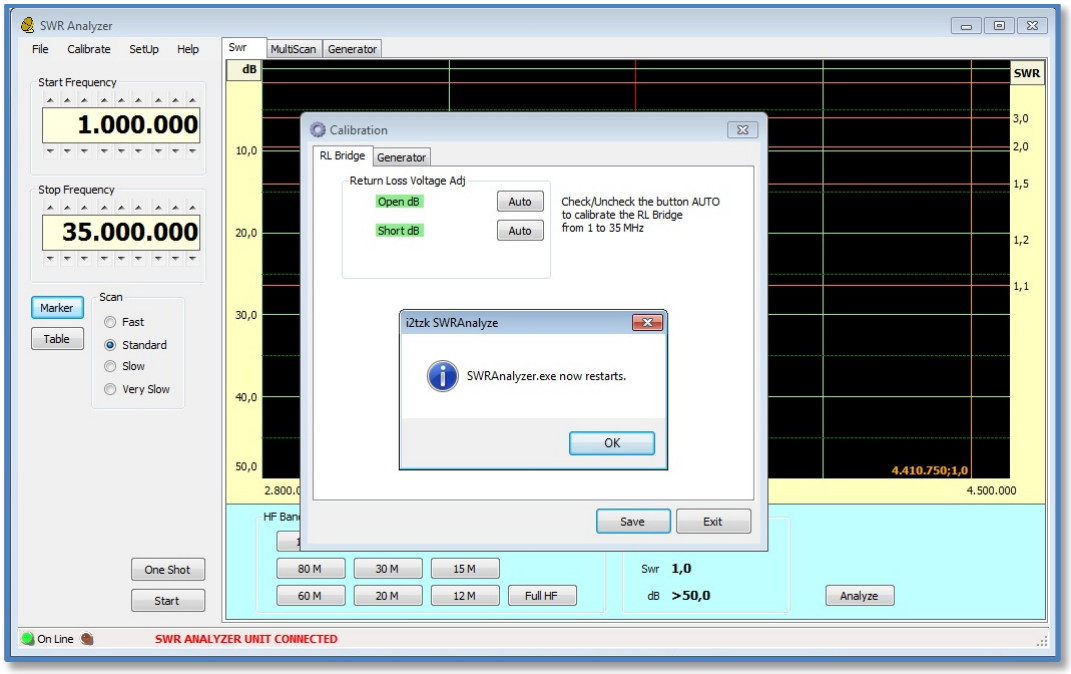
Select now the “Short circuit” calibration and connect a *0 Ohm terminator* to the Antenna input.

Once again, when the measure “Short circuit” is succesfully completed the panel “SHORT CIRCUIT” closes and the green color of the value field indicates that this step has been succesfully executed.





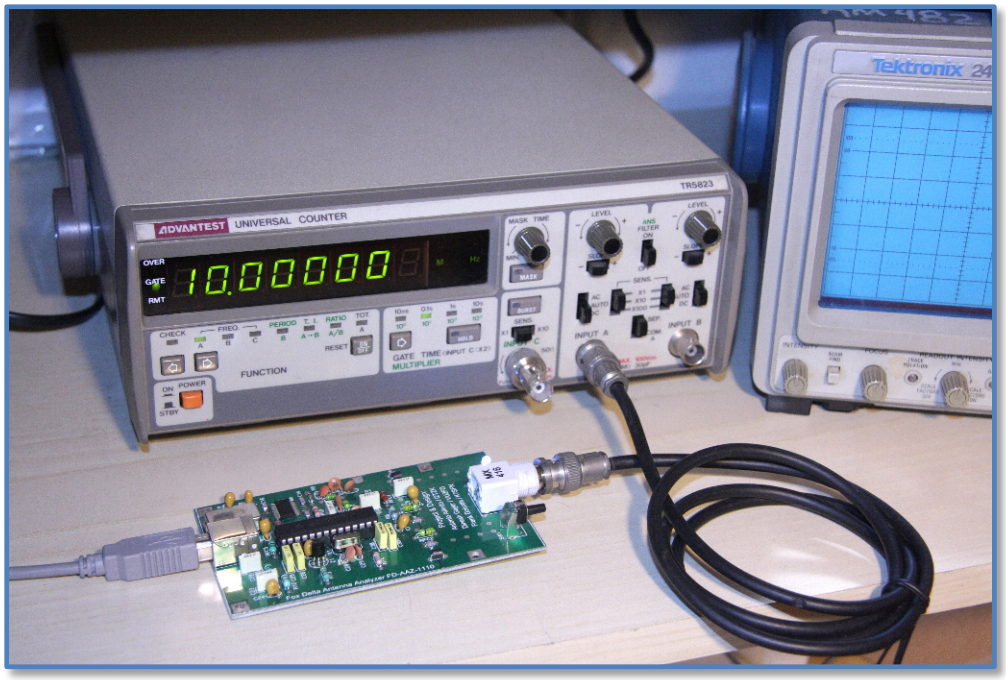
Don’t forget to “Save” and restart program.



Frequency Generator

The clock of the DDS Generator is driven by a crystal oscillator, the frequency generated is stable and precise, generally speaking it is no necessary any adjustment, nevertheless a fine tune is possible.

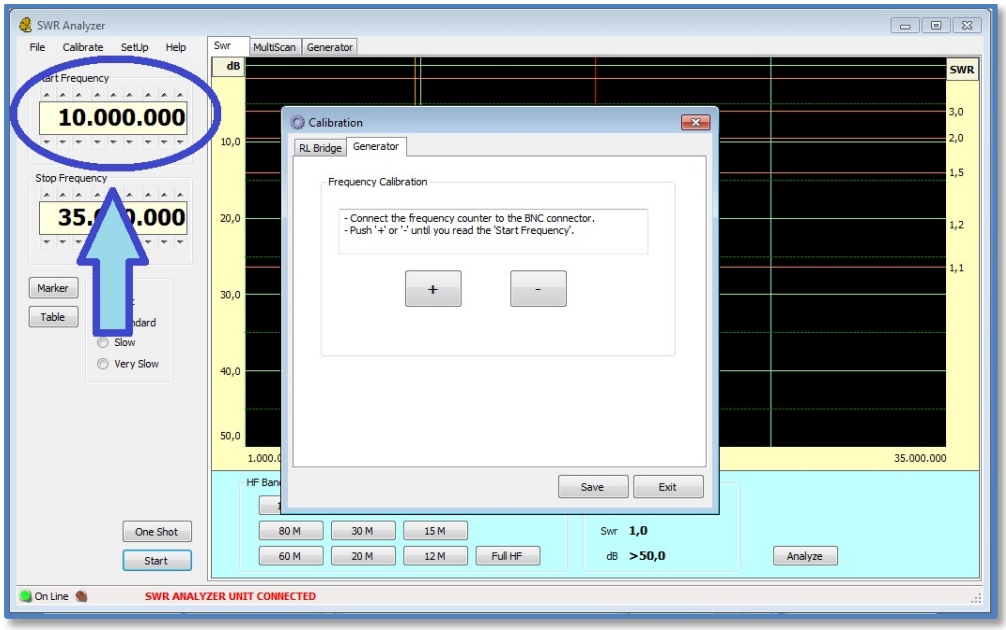
Connect the SWR Analyzer and select 10Mhz as Start Frequency.



Connect the antenna output to the frequency meter.

You should read a frequency very close to 10MHZ.

Select the menu “Calibrate” and the tab “Generator”
Push the button “+” or “-“ until your frequency meter reads the “Start Frequency” .

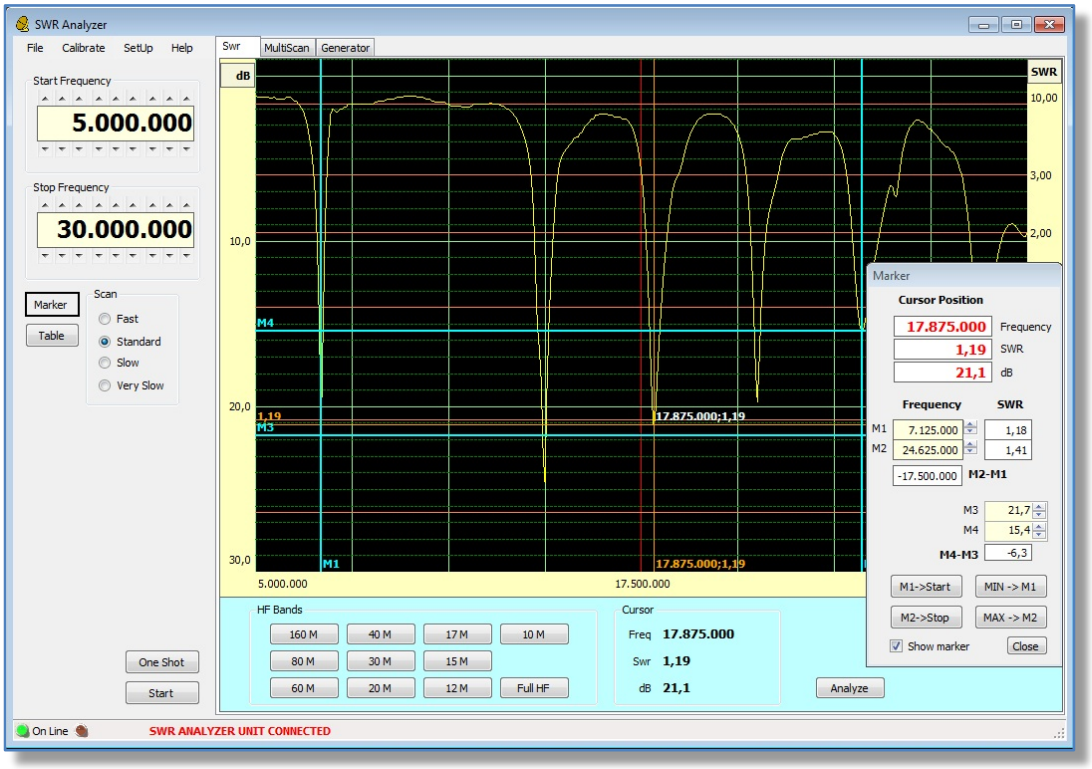


6. Explore the antenna resonance

Select the tab “SWR” and the frequency range you want to analyze by pushing the corresponding “HF Band” button or choosing the “Start” and “Stop” frequencies by clicking on the thumbswheel.

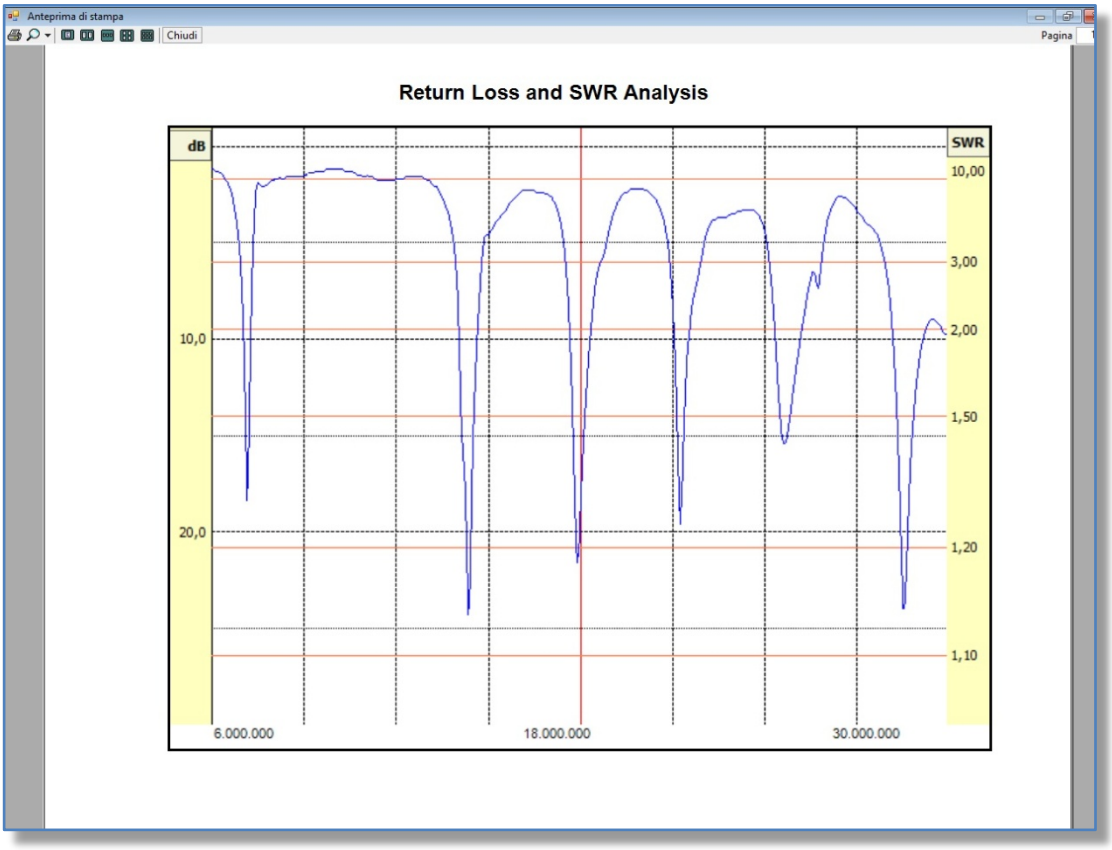
For a continue real time analysis press “Start” (usefull while you are calibrating your antenna) the SWR figure will be refreshed a couple of time per second depending on the “Scan” speed you selected.

Press “One Shot” for a one time single static graphic.



If the Start or Stop frequency has been changed during the continue analysis phase, the graphic can be updated to the new frequency range, pushing the “Refresh” button that will appear changing the frequency .

To print the graphic: File/Print Graphic

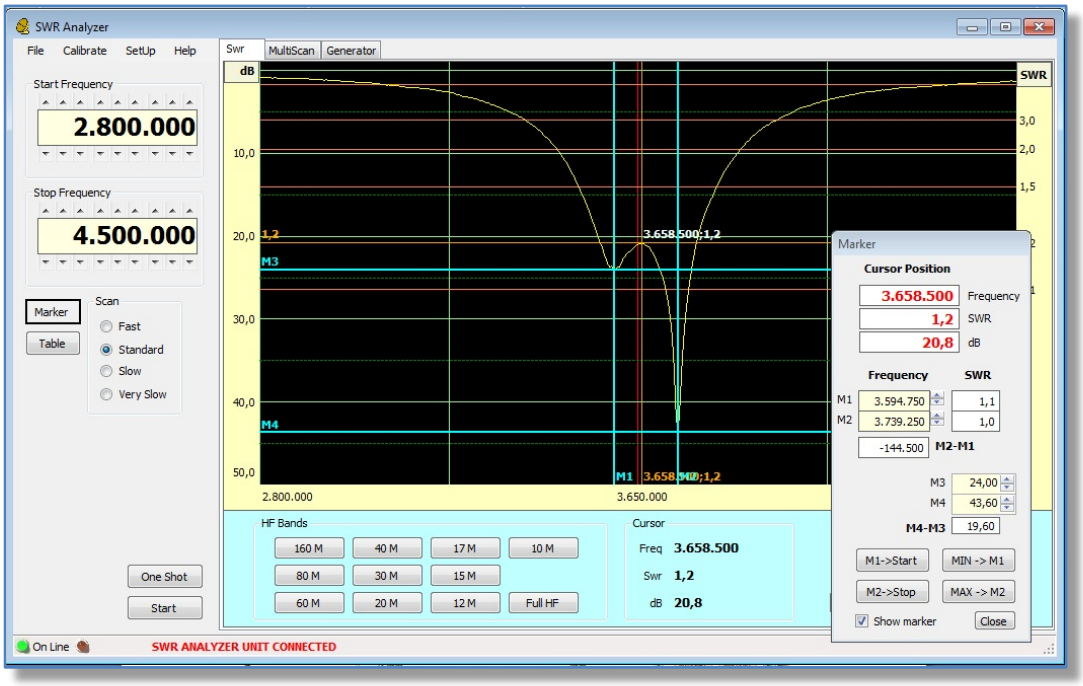


Markers

Four markers are available:

- Two vertical (M1 and M2)
- Two horizontal (M3 and M4)

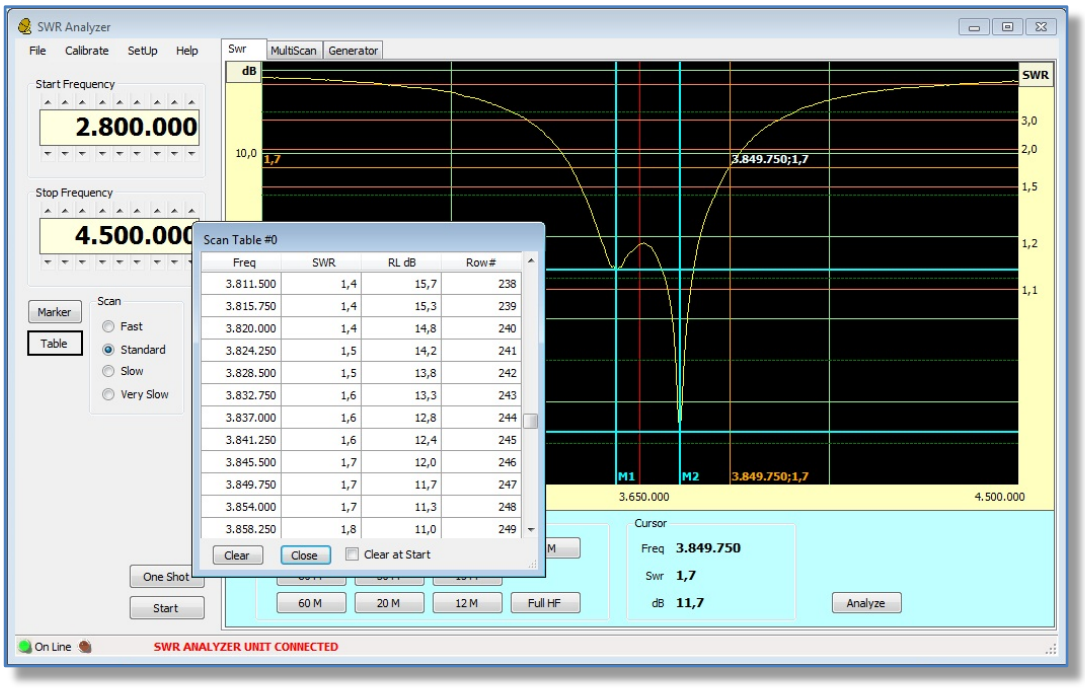
To activate the markers press the button “Marker” and check the box “Show marker” in the small floating “Marker” window.



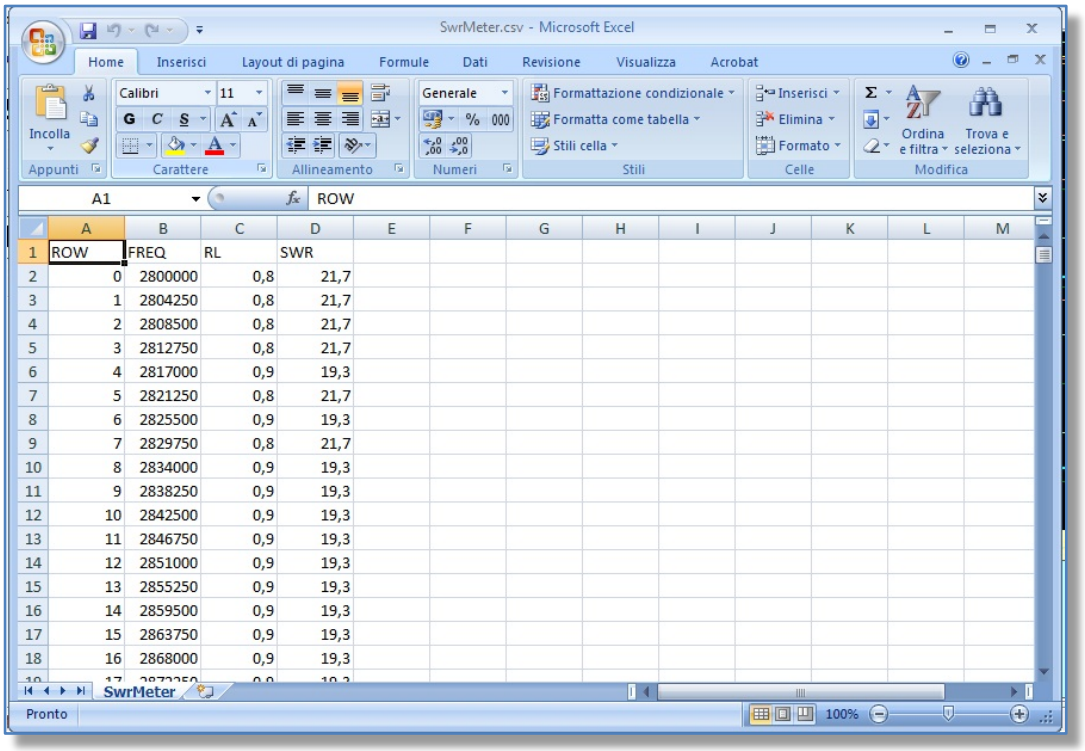
- Right or left clicking the mouse button, moves the vertical marker M1 or M2 over the pointer position.
- Ctrl+right and ctrl+left click moves the horizontal marker M3 or M4 over the pointer position
- Shift+right or shift+left click moves the couple M1/M3 or M2/M4 to the point of the SWR figure closest to the pointer position

Data Table

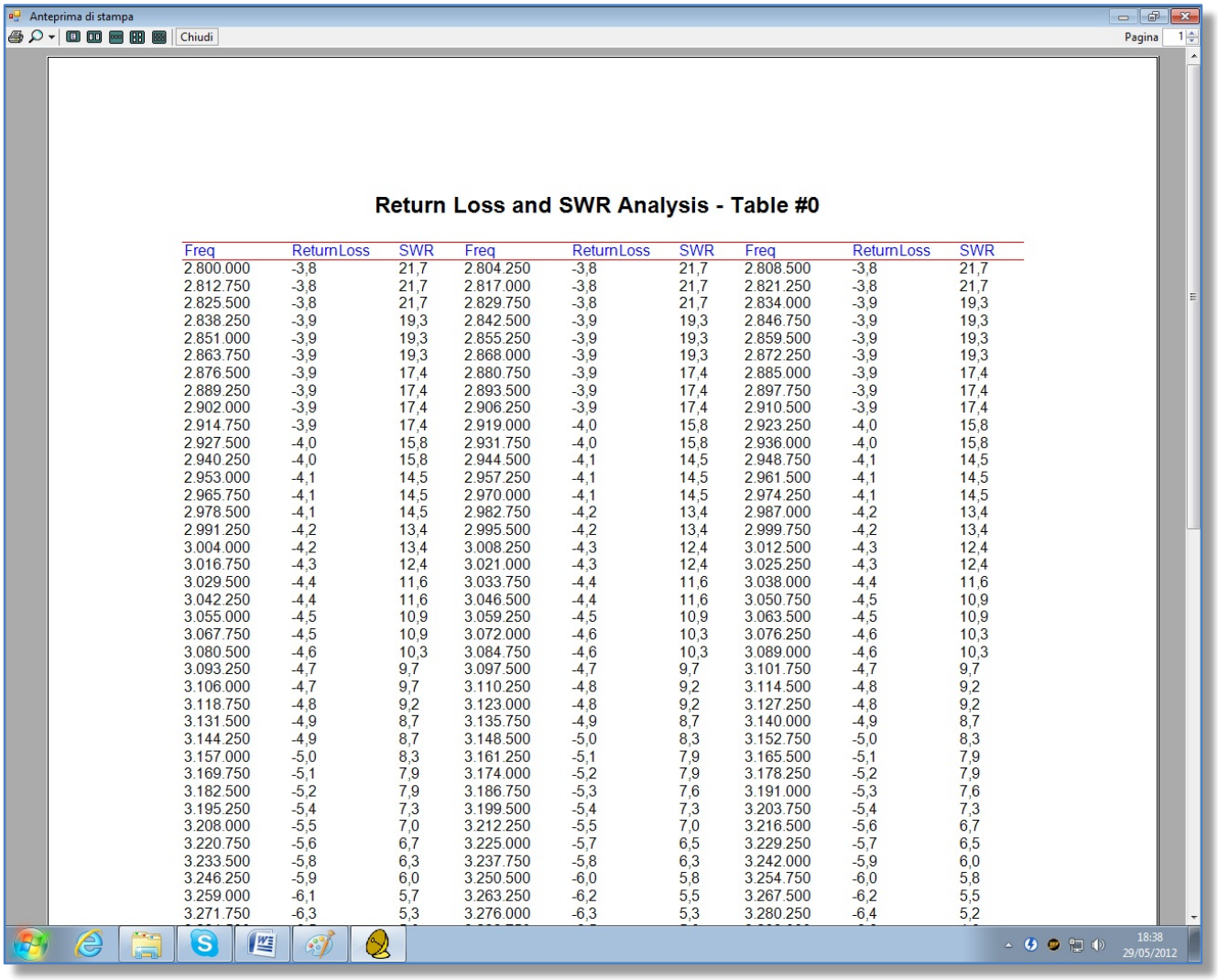
The SWR Analysis is stored into a Data Table, push the button “Table” to view the data.



For a more detailed analysis the Data Table can be exported (menu File/Export) and imported in any spread sheet (Excel like) that can read the CSV format.



To print the Table: File/Print Data Table.

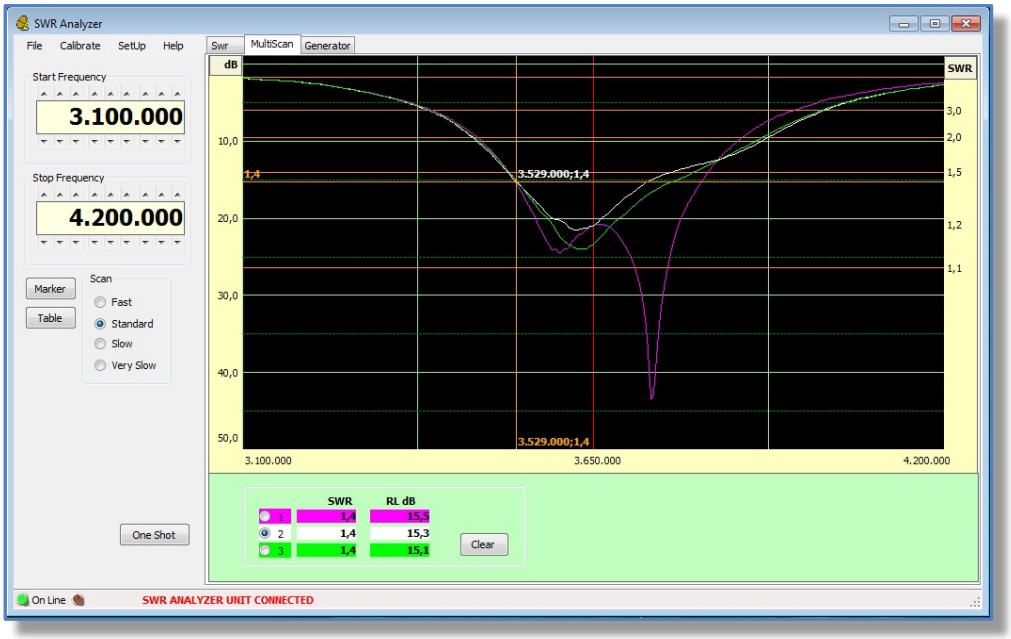


Return Loss and SWR Analysis - Table #0

Freq	ReturnLoss	SWR	Freq	ReturnLoss	SWR	Freq	ReturnLoss	SWR
2.800.000	-3,8	21,7	2.804.250	-3,8	21,7	2.808.500	-3,8	21,7
2.812.750	-3,8	21,7	2.817.000	-3,8	21,7	2.821.250	-3,8	21,7
2.825.500	-3,8	21,7	2.829.750	-3,8	21,7	2.834.000	-3,9	19,3
2.838.250	-3,9	19,3	2.842.500	-3,9	19,3	2.846.750	-3,9	19,3
2.851.000	-3,9	19,3	2.855.250	-3,9	19,3	2.859.500	-3,9	19,3
2.863.750	-3,9	19,3	2.868.000	-3,9	19,3	2.872.250	-3,9	19,3
2.876.500	-3,9	17,4	2.880.750	-3,9	17,4	2.885.000	-3,9	17,4
2.889.250	-3,9	17,4	2.893.500	-3,9	17,4	2.897.750	-3,9	17,4
2.902.000	-3,9	17,4	2.906.250	-3,9	17,4	2.910.500	-3,9	17,4
2.914.750	-3,9	17,4	2.919.000	-4,0	15,8	2.923.250	-4,0	15,8
2.927.500	-4,0	15,8	2.931.750	-4,0	15,8	2.936.000	-4,0	15,8
2.940.250	-4,0	15,8	2.944.500	-4,1	14,5	2.948.750	-4,1	14,5
2.953.000	-4,1	14,5	2.957.250	-4,1	14,5	2.961.500	-4,1	14,5
2.965.750	-4,1	14,5	2.970.000	-4,1	14,5	2.974.250	-4,1	14,5
2.978.500	-4,1	14,5	2.982.750	-4,2	13,4	2.987.000	-4,2	13,4
2.991.250	-4,2	13,4	2.995.500	-4,2	13,4	2.999.750	-4,2	13,4
3.004.000	-4,2	13,4	3.008.250	-4,3	12,4	3.012.500	-4,3	12,4
3.016.750	-4,3	12,4	3.021.000	-4,3	12,4	3.025.250	-4,3	12,4
3.029.500	-4,4	11,6	3.033.750	-4,4	11,6	3.038.000	-4,4	11,6
3.042.250	-4,4	11,6	3.046.500	-4,4	11,6	3.050.750	-4,5	10,9
3.055.000	-4,5	10,9	3.059.250	-4,5	10,9	3.063.500	-4,5	10,9
3.067.750	-4,5	10,9	3.072.000	-4,6	10,3	3.076.250	-4,6	10,3
3.080.500	-4,6	10,3	3.084.750	-4,6	10,3	3.089.000	-4,6	10,3
3.093.250	-4,7	9,7	3.097.500	-4,7	9,7	3.101.750	-4,7	9,7
3.106.000	-4,7	9,7	3.110.250	-4,8	9,2	3.114.500	-4,8	9,2
3.118.750	-4,8	9,2	3.123.000	-4,8	9,2	3.127.250	-4,8	9,2
3.131.500	-4,9	8,7	3.135.750	-4,9	8,7	3.140.000	-4,9	8,7
3.144.250	-4,9	8,7	3.148.500	-5,0	8,3	3.152.750	-5,0	8,3
3.157.000	-5,0	8,3	3.161.250	-5,1	7,9	3.165.500	-5,1	7,9
3.169.750	-5,1	7,9	3.174.000	-5,2	7,9	3.178.250	-5,2	7,9
3.182.500	-5,2	7,9	3.186.750	-5,3	7,6	3.191.000	-5,3	7,6
3.195.250	-5,4	7,3	3.199.500	-5,4	7,3	3.203.750	-5,4	7,3
3.208.000	-5,5	7,0	3.212.250	-5,5	7,0	3.216.500	-5,6	6,7
3.220.750	-5,6	6,7	3.225.000	-5,7	6,5	3.229.250	-5,7	6,5
3.233.500	-5,8	6,3	3.237.750	-5,8	6,3	3.242.000	-5,9	6,0
3.246.250	-5,9	6,0	3.250.500	-6,0	5,8	3.254.750	-6,0	5,8
3.259.000	-6,1	5,7	3.263.250	-6,2	5,5	3.267.500	-6,2	5,5
3.271.750	-6,3	5,3	3.276.000	-6,3	5,3	3.280.250	-6,4	5,2

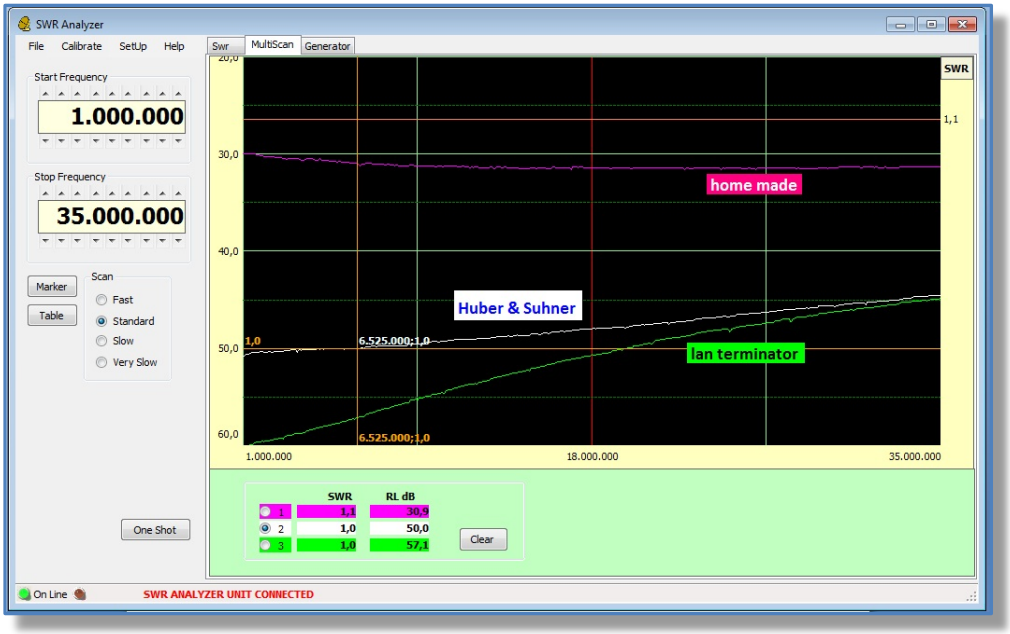
7. Compare plots

“Multiscan” function allows to compare up to 3 different graphics on the same frequency range.



Pass band filter response to open, 50 ohm and 25 ohm terminator.

Low power 50 ohm terminators.



8. Signal Generator