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MEASUREMENT SET-UP FOR TRAPS

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1 DESCRIPTION

I have been searching for some time for a system to measure traps but actually I could not find a satisfactory one. For this reason I searched the Internet for ideas and hints: I could not find anything original, as there are lots of replicated ideas already tested and rejected due to insufficient accuracy. In fact, many use the inductive coupling in order to check where the RF absorption is, and therefore to fix the trap resonant frequency. Unfortunately the inductive coupling creates a mutual inductance that alters the resonance measurement. Indeed, by varying the coupling, it varies the mutual inductance too, as well as the resonant frequency. Moreover, the method is not very workable when applied to coaxial traps, in which the external plate of the capacitor screens the internal coil from the RF.

In other words, this method is not suitable for each kind trap and it is strictly related to the operator, in such a way that the measurement of the same trap will not be replicable.

Therefore it is necessary to find a more accurate way of measurement: a method that can provide replicable results as independent from the operator as possible, and, if possible, suitable for any kind of trap.

Last year at the Friedrichshafen exposition, at the stand of a well-known trap producer, I saw one of their traps installed on a test bench to a NetWork Analyzer. They had represented the Bode diagram of the frequency response: it was this that gave me the idea which I am going to describe.

2 DEVELOPMENT OF THE PROJECT

It took a year from the basic idea to the solution of the problem, which was spent on tests and comparisons with the most expert OM friends. But let's start from the beginning.

The first problem to tackle was having a trap with all the electrical parameters known. Therefore I made one that I will call "reference trap". I have selected a trap characterized by: air inductance, because it is more linear than a ferrite one, with the most stable capacity possible and resonant frequency in the band of 80m, in order to make a few centimetres of the connection wire non influential.

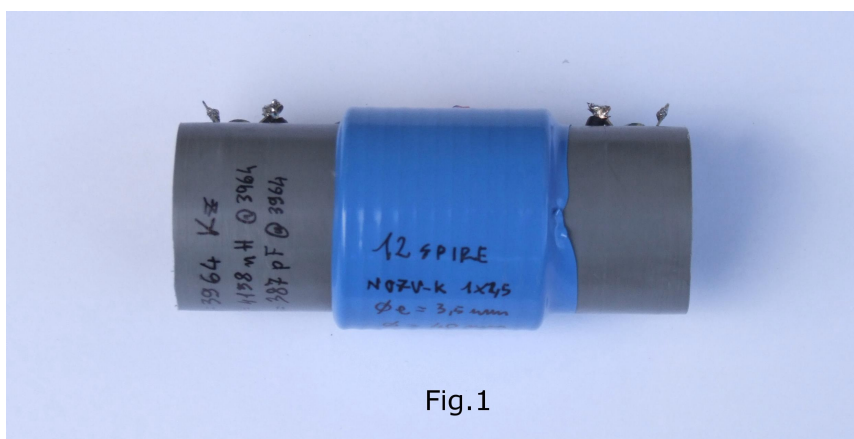


Fig.1

Fig.1

The sample trap in Figure 1 has been realized with part of a Rehau pipe with an external diameter of 40 mm, and a length of 110 mm, in which 12 close turn of electrical wire for installations N07V-K 1x2,5mmq have been wrapped up. The length of the winding resulted in 45 mm and the inductance calculated with SW [1] resulted 4158nH. Inside the support of the coil I soldered a 390 pF tube capacitor, the longest I had in order to have the wires as short as

possible. Then, I fixed the winding with the heat shrink and I calculated the resonant frequency: $F_0 = 3952\text{KHz}$.

Before soldering the capacity in the interior part of the coil I measured with RigExpert AA54 the two separate components, with a theoretical resonant frequency of 3952Khz, and I found, after the capacity and the parasitic inductance, some slightly different values: $L = 4187\text{nH}$ and $C = 387\text{pF}$. The resulting resonant frequency will be $F_0 = 3964\text{KHz}$.

The second problem I had to face was trying to eliminate the interference from the measurement instrument on the trap. As I intended to use the MiniVNA in transmission mode as "network analyzer" I had to work with connectors characterized by an impedance of 50 Ohm. It is very unlikely that a trap located in the context of an antenna sees at its terminals an impedance of 50 Ohm: usually it is higher. In fact, the impedance that a trap sees at the resonance depends on many factors, being usually more than 50 Ohm.

Therefore I decided to insert the trap in the middle of an Pi-attenuator of -20dB realized divided in two halves (see Figure 2), and to connect the DUT output of the MiniVNA to the entrance of the filter and the exit of the filter to DET input of the MiniVNA.

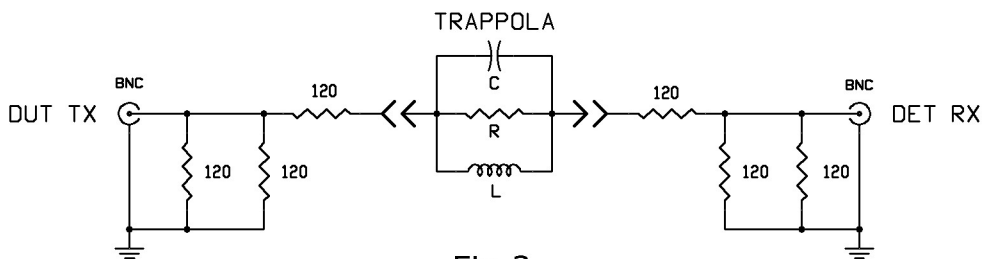


Fig.2

The Pi-attenuator, as shown in Figure 2, can be easily realized with 6 resistors of 120 Ohm (the attenuation be slightly different of -20dB). The attenuator performs the double effect of showing to the MiniVNA a 50 Ohm impedance and keeps the trap "floating" between two 120 Ohm resistances. This value of resistance is enough for don't see the trap from the MiniVNA. On the other hand, being far from the resonance, the trap will be a short circuit and the MiniVNA will have a 50 Ohm impedance and a -20dB attenuation, while being near to the resonance will cause the trap to increase its impedance. This will also increase the filter attenuation, highlighting a significant decrease of the trasmission loss (TL) and the MiniVNA will have at its terminals an impedance of around 60 Ohm. At the end of the deep it will be possible to see the resonant frequency of the trap.

3 REALIZATION

In the beginning, I soldered the resistors arms between an alligator and an BNCalligator like Figure 3.

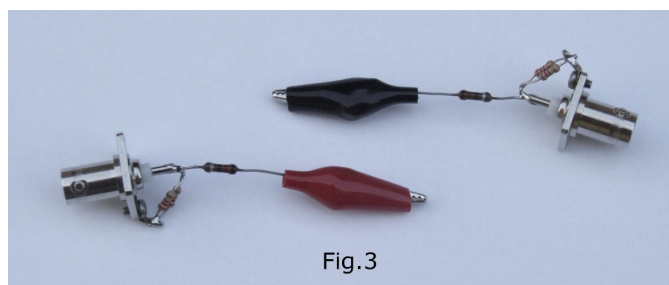


Fig.3

I wanted to see what would happen, so I connected the sample trap to the table lamp using the Scotch tape, Figure 4, and then I measured the TL without any calibration for the MiniVNA, Figure 5. The measurement passed from 3.0 to 5.0 MHz, with 1000 steps and a 60dB scale.

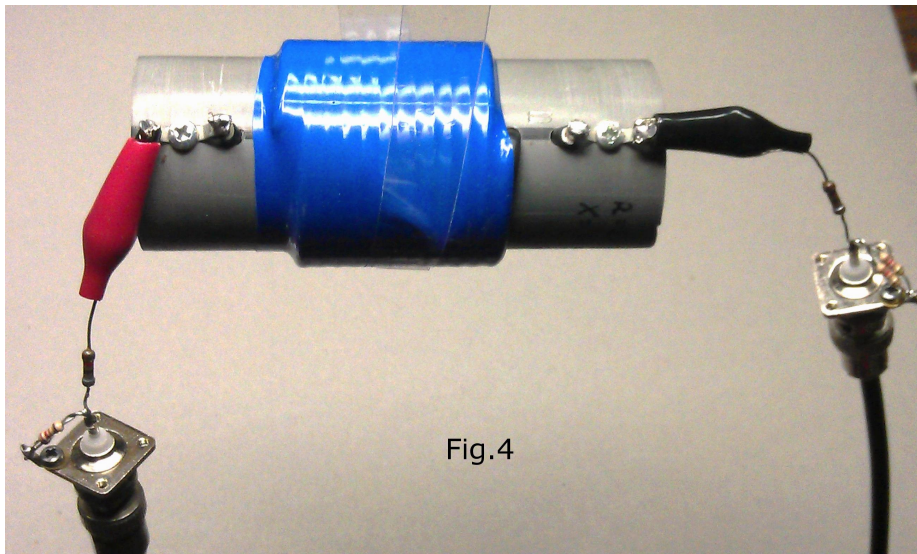


Fig.4

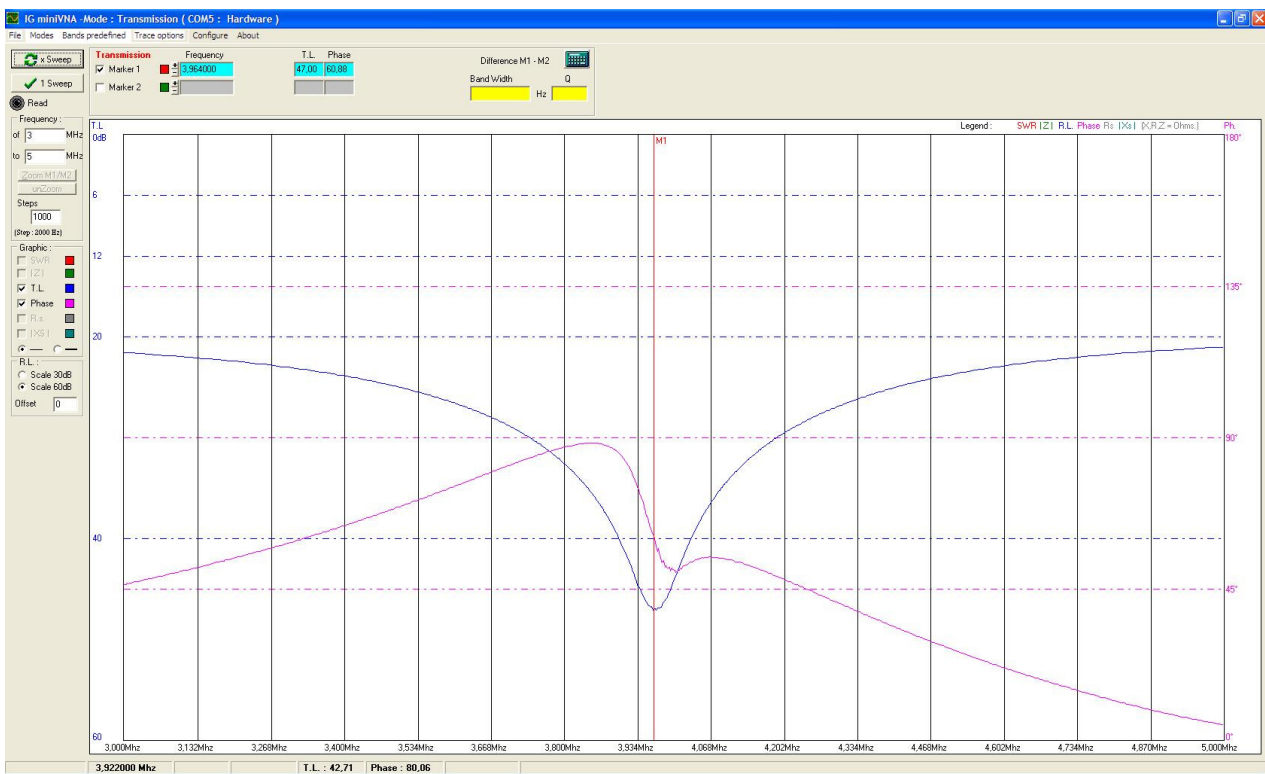


Fig.5

As you can see from Figure 5, the frequency response is very encouraging, since the TL curve corresponds to the resonant frequency $F_0 = 3966$ kHz, which is very similar to the theoretical one of 3964 kHz.

From Figure 5 it is possible to deduce that attenuation TL - beyond resonance - tends to an asymptotic value of -20dB. In effect, a parallel resonant "trap" circuit has a high impedance at resonance, while as it gradually moves away from the resonance it always becomes a short circuit. At lower frequencies of resonance, the inductive reactance will decrease more compared to capacitive one, while at upper frequencies of resonance the capacitive reactance will

decrease more, see scheme in Figure 2. At resonance, the inductive reactance is the same as the capacitive one, but with the opposite sign, so that they cancel each other leaving the resistive part (parasitic) of both reactive components (inductance and capacity) only.

The Q value of the trap can be easily worked out by finding the stop band at -3dB from the maximum attenuation - which you have at resonance - and dividing it by the resonant frequency. The MiniVNA easily works out the Q value by setting the two symmetric cursors around the resonance, in order to read the TLTL that increases by 3dB compared to the maximum attenuation. The SW will highlight the Q value in the yellow box.

We will actually see that with equal frequency scales, the trap with a higher Q value will have a sharp deep, while a trap with a lower Q value will have a large deep. As far as I am concerned, the Q value is about 60, Figure 6.

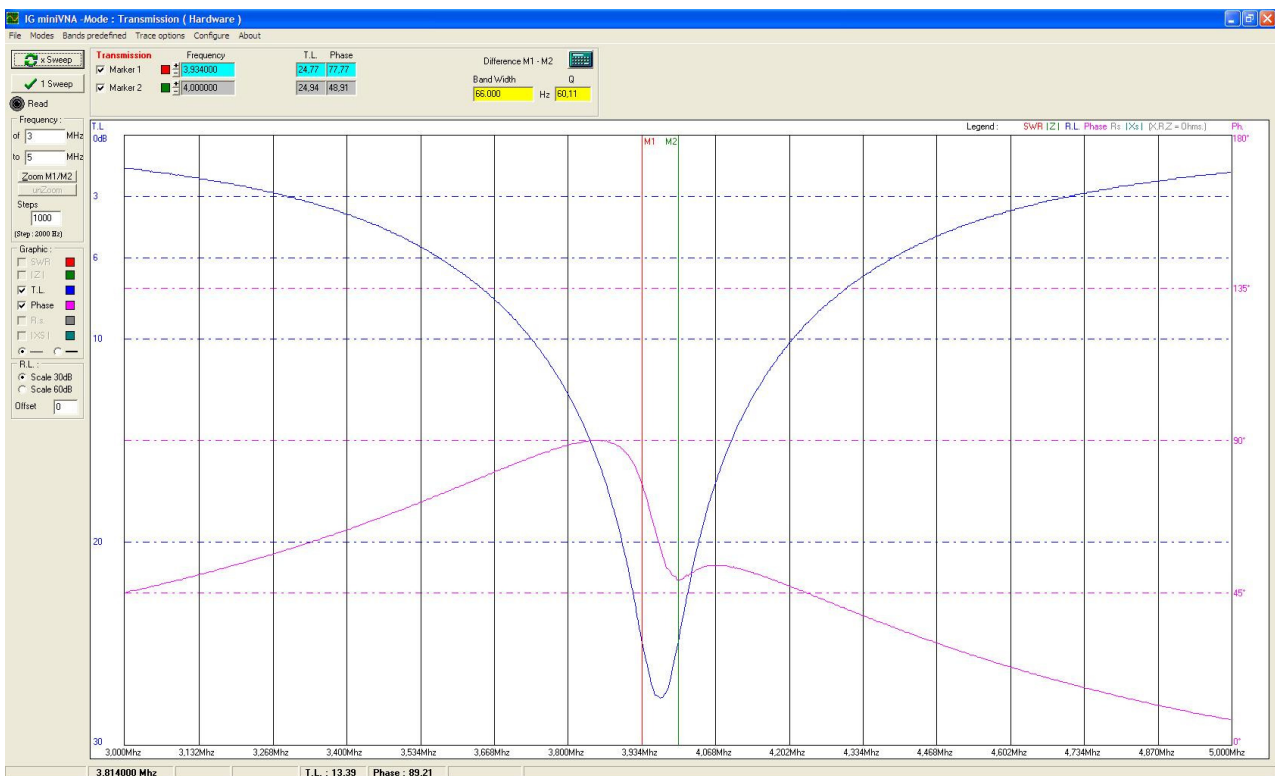


Fig.6

4 TESTS

After the euphoria of this result, I tried to check how good the set-up was using some important tests.

The first one was to verify that the attenuation was about -20dB without the presence of the trap and with the alligator connected together, Figure 7.

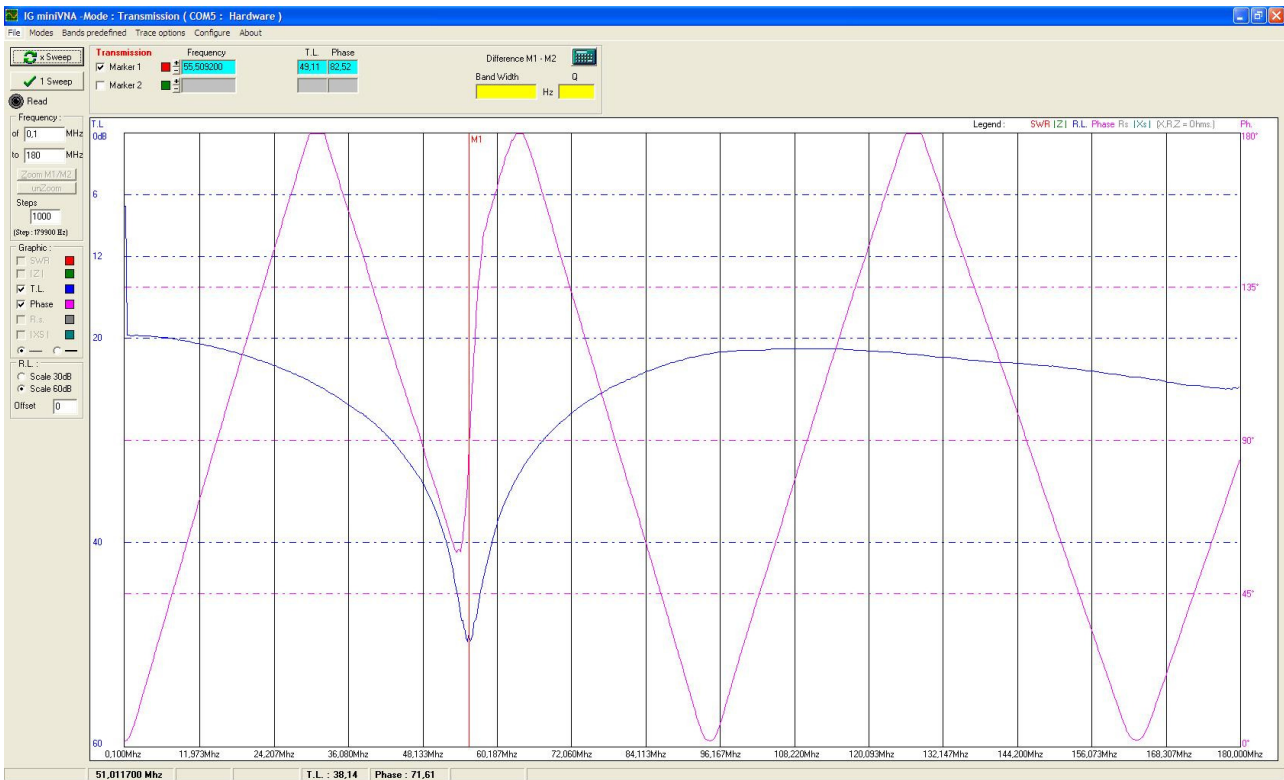


Fig.7

From Figure 7 you can immediately see that the Blue line of the TL is anything but flat! Actually, it has a resonance around 55 MHz.

In order to reduce the parasitic capacities and inductance, I temporarily short circuited the two BNC ground conductors. This gave me an improved response, Figure 8.

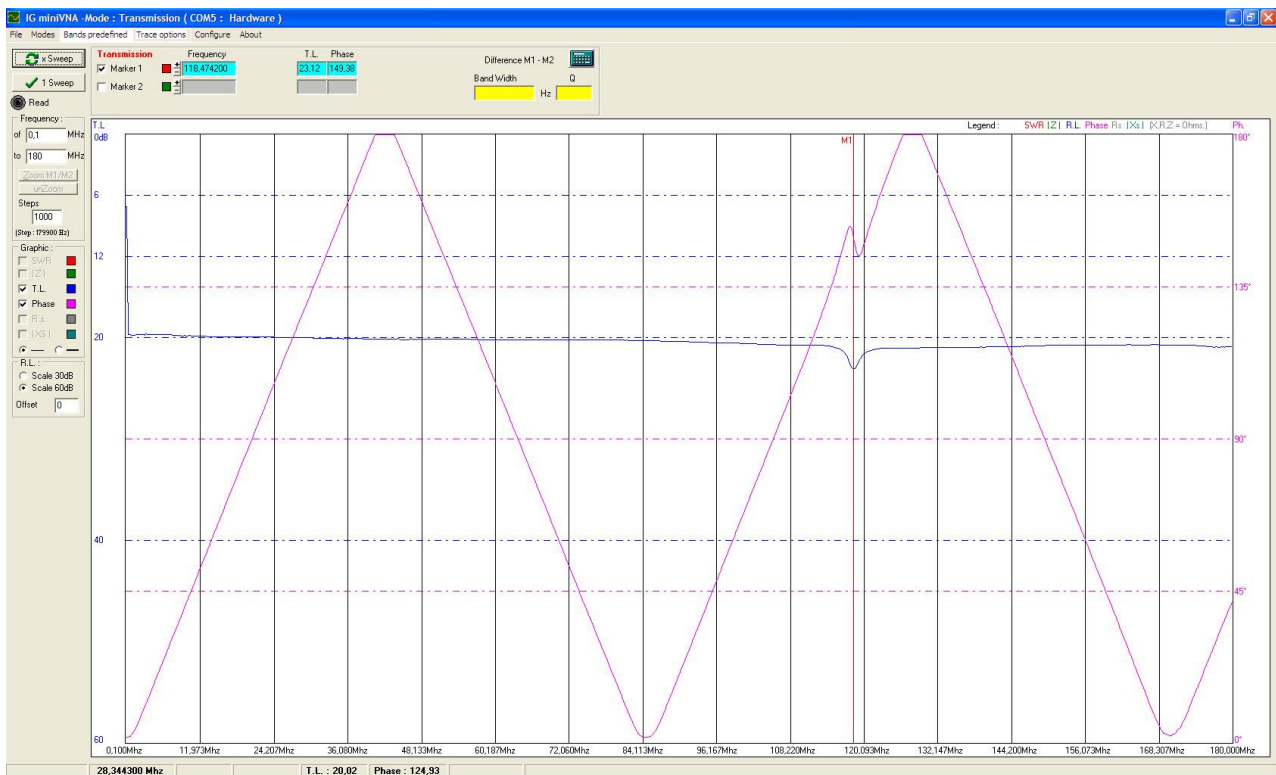


Fig.8

By putting together the two BNC ground conductors, you get a curve that is more similar to a -20 dB attenuator, except for a little resonance of around 118 MHz which does not disturb HF devices.

Having the ground conductors connected, I again inserted the sample trap, Figure 9.

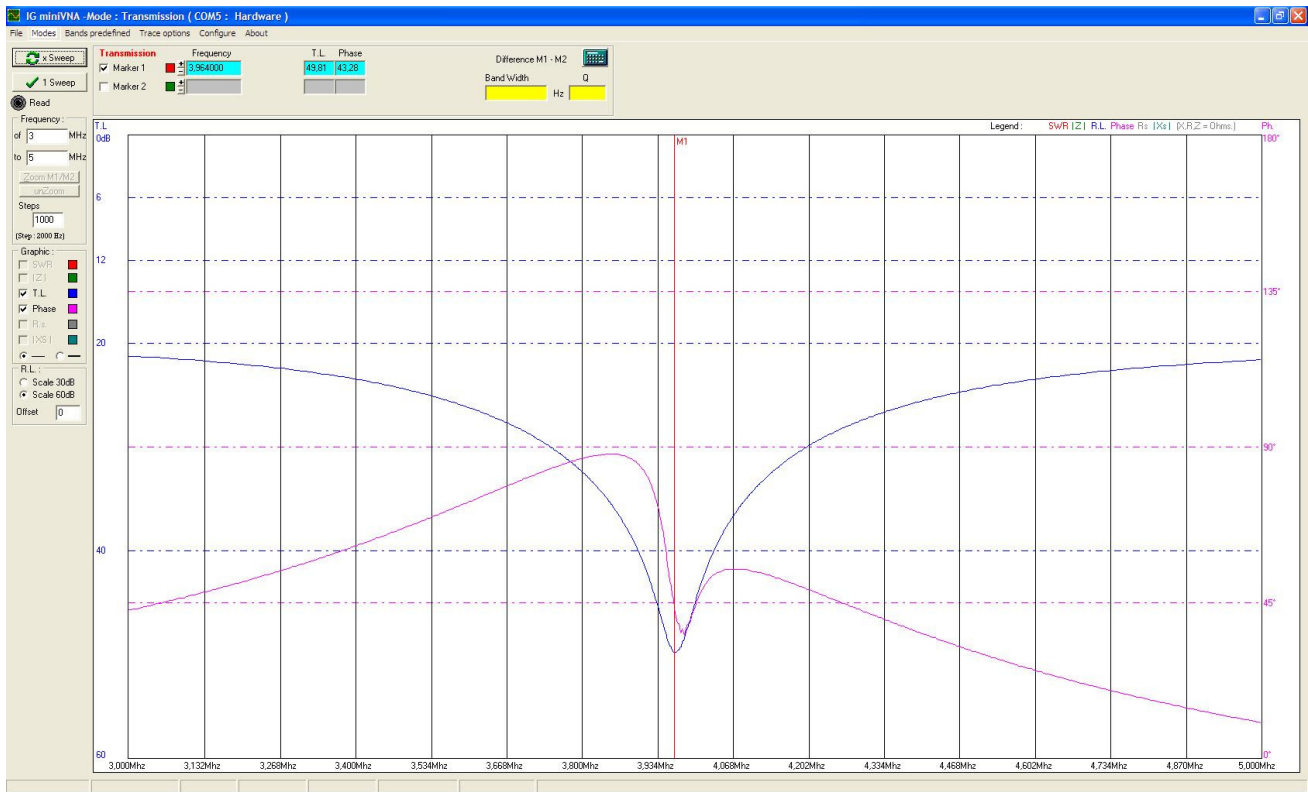


Fig.9

The result did not change and the resonance did not move. This shows that if you short circuit the BNC ground conductors does not change the resonance of the trap, but it is useful for bandwidth.

The second test was to short circuit the BNC ground conductors with the alligator connected together without the trap, calibrate the MiniVNA in order to set at zero the -20dB offset and put the reference trap again: Figure 10.

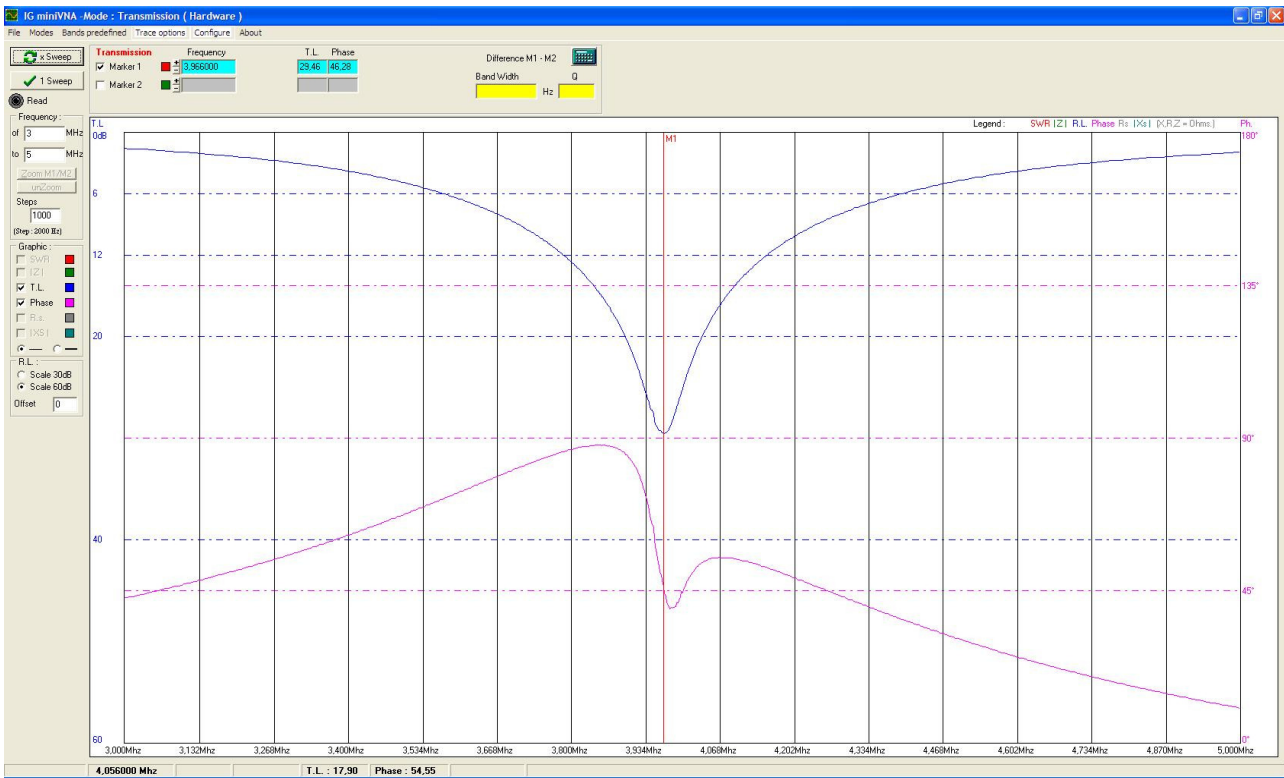


Fig.10

In this case too, the resonance of the trap is still the same, but you set the diagram at 0 dB again and attenuation becomes the actual attenuation of our trap.

Then I made a test bench that was more stable and suitable for measuring the traps made with coaxial pipes and the coil screened by the external plate of the capacitor. In order to do so, I used wood and aluminium, since the latter is a good conductor with a low magnetic permeability. Aluminium was necessary in order to have the BNC ground conductors short circuited between them, according to the previous experiences; Figure 11.

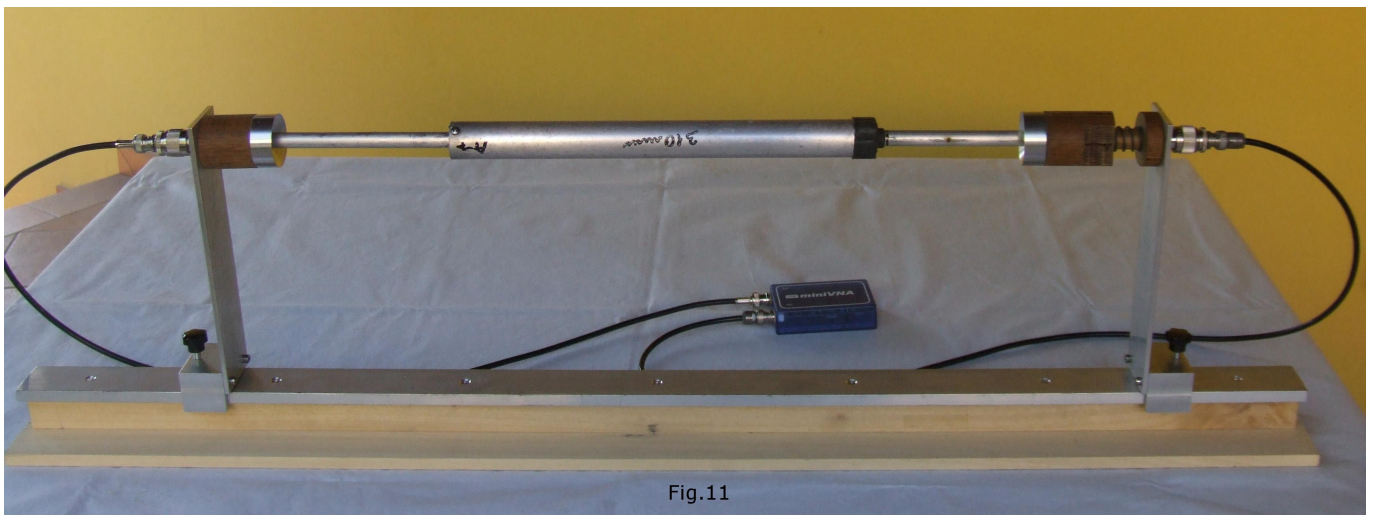


Fig.11

Fig.11

Then I tested the set-up in Figure11 using the short circuit only, Figure 12.

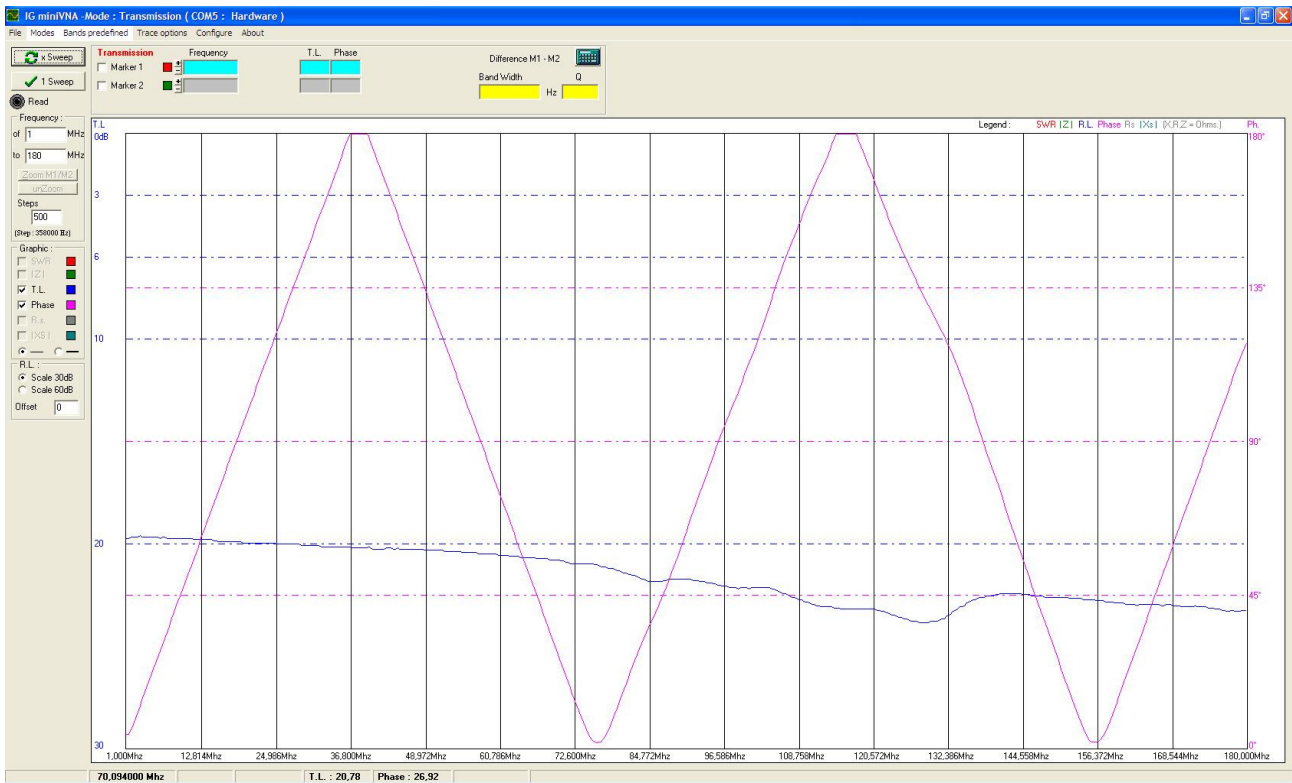


Fig.12

The TL is not so good, but it does not have significant resonances and it is quite near the -20dB attenuator in the HF band. Obviously, by calibrating the MiniVNA you get an excellent correction of the response curve, Figure 13.

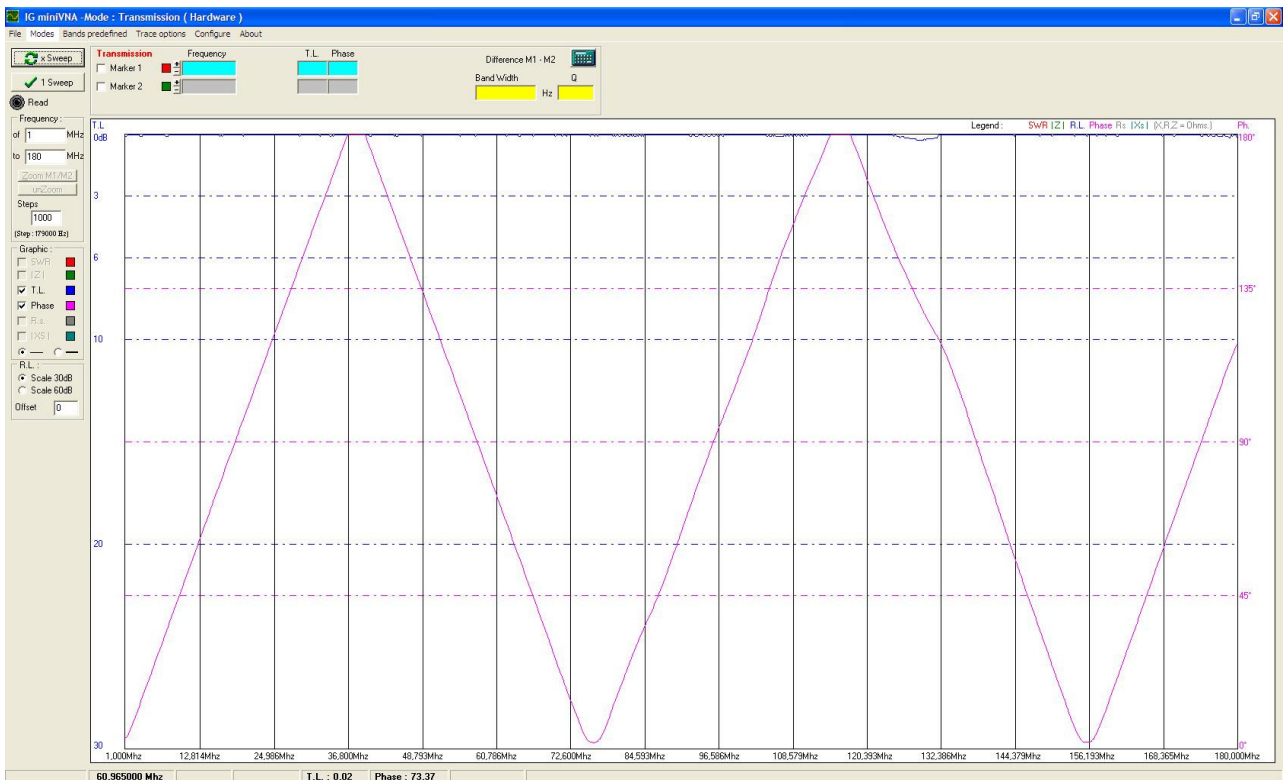


Fig.13

Having calibrated the set-up, I verified that the curve of the reference trap would be the same, Figure 14.

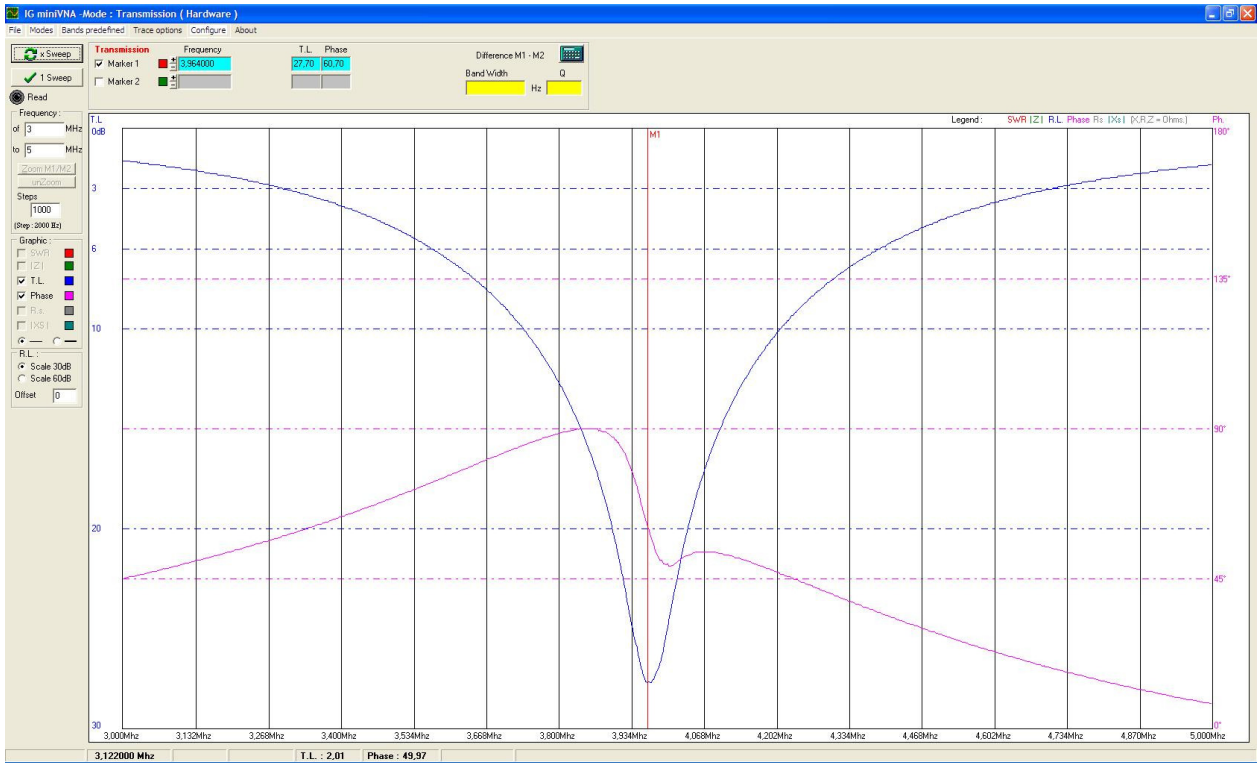


Fig.14

Since there were no changes in the reference trap compared to the previous tests, I decided to verify one of the famous traps of I1UJX, the middle one whose length is 320mm. As far as TL is concerned, you can see the response graph in Figure 15.

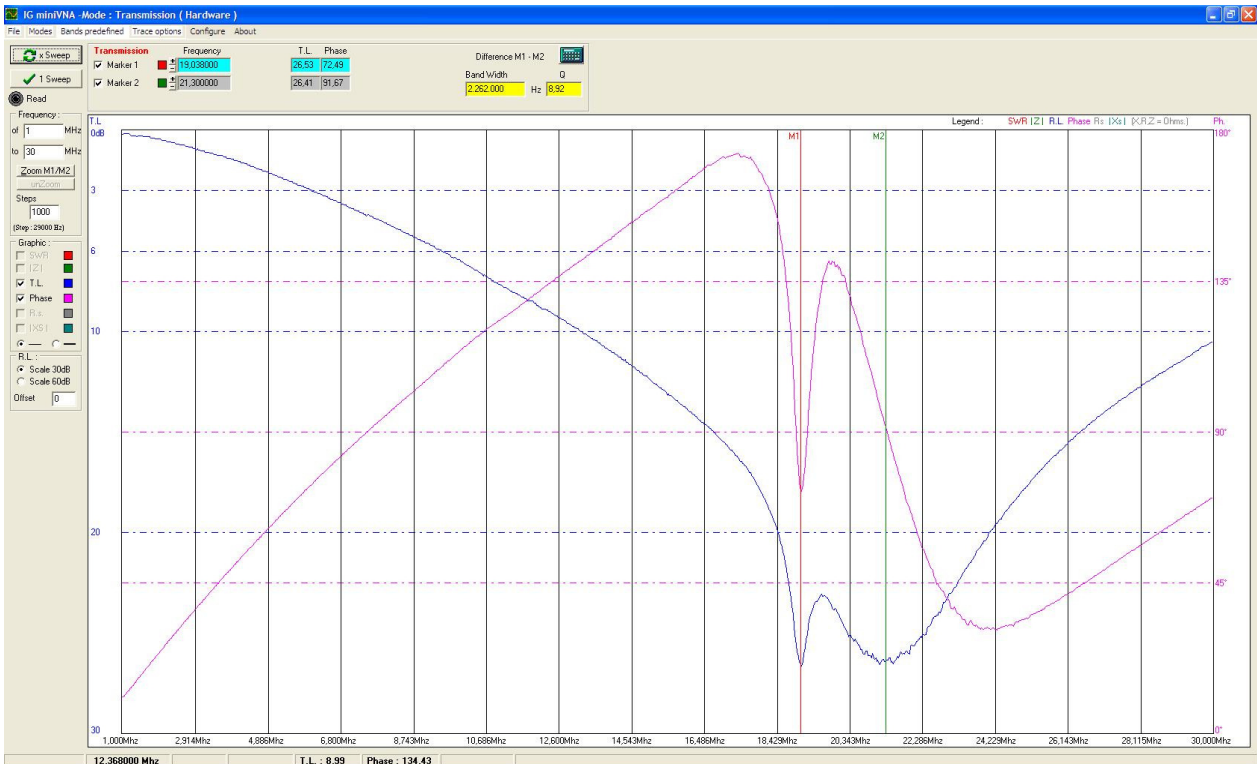


Fig.15

This is a double resonant frequency trap, so you have to respect the input signal direction. As you can see, it resonates at about 19.0 and 21.3 MHz.

5 CONCLUSIONS

In conclusion, I think that the sample set-up of the traps in Figure 11 is best and it definitely reaches the goals I set at the beginning: accurate and precise measurements; it is suitable for every kind of trap and its results are replicable and do not change according to the operator.

I made more tests than those I listed, but according to them it is clear that even the simpler method - where BNC ground conductors are connected together, Figure 4 - produces acceptable results that are good for the most common traps (e.g. coaxial traps).

Finally, according to the metal set-up in Figure 11, I made another one in wood. Its results were worse than those produced by the set-up in Figure 4 without the BNC ground conductors connected between them. I say this to clear any doubt and discourage the realization of totally isolated set-ups.

6 BIBLIOGRAPHY

[1] Mini Ring Core Calculator 1.2 downloaded from <http://www.dl5swb.de>