Measurement of cavities and permittivities

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I. IMPLEMENTATION OF THE PRACTICE

1. *Simulation of a resonator and the excitation network.*

First of all we are asked to assemble the schematic of a resonant circuit, more specifically in this first part of the practice we study the excitation network of such a resonant circuit at a given resonance frequency fu = 2.447 GHz and to provide a quality factor Qu = 900.

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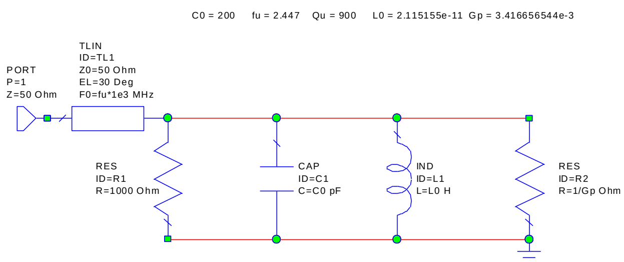

Fig. 1. Schematic of the excitation network and resonant circuit.

Once this first step has been carried out, we can proceed to the graphical representation of both the input impedance Zin in Cartesian and the reflection coefficient $S11$ in the Smith chart. All this in the frequency range around the resonance frequency. By doing this we can see how the maximum position varies, as well as the circles of the Smith chart according to the length of the line and the parallel resistance Rp. An example of this occurrence is shown in the figures below:

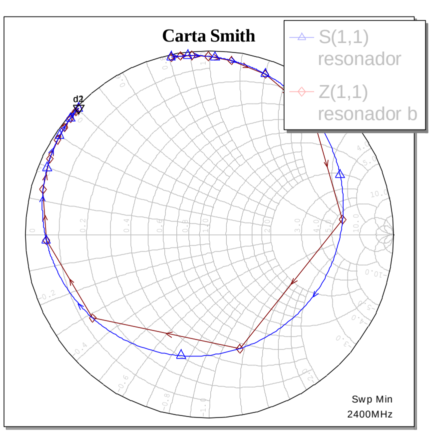

Fig. 2. Smith chart of the reflection factor.

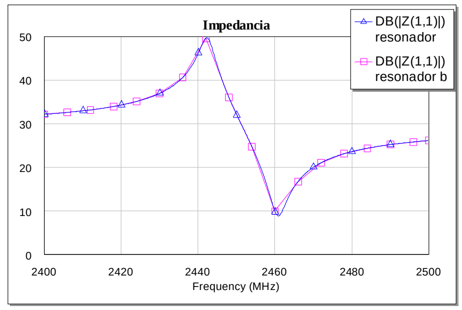

Fig. 3. Impedance RLC.

Where in these graphs the blue line is represented with 1001 points while the pink line only consists of 18 points.

Next, the output file of type '.s1p' will be generated in order to process the S parameters with Matlab, thus verifying the process carried out with many and few points. Then, the data obtained from the function 'Calculate_Draw_fr_Qr' will be the resonance frequency of the unloaded network, without the feeding network, and the quality factor in this same situation.

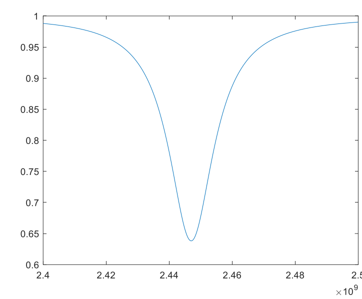

Fig. 4. Resonador 1001.

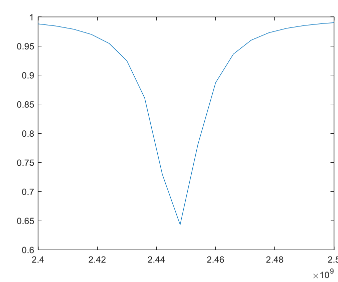

Fig. 5. Resonador b 18.

Frequency points	fu	Qu
1001	2.447 GHz	693,9579
18	2.447 GHz	701,3102

2. Rectangular cavity

Before starting to measure the cavities, the measuring system is calibrated. This procedure is very important to reduce measurement errors. This is done by using a short circuit, an open circuit and an adapted load. It is then checked that the measurements of the matched load are located around the centre of the S.C.

The analysis has been carried out for frequencies between 2 and 3 GHz. In this question, we measured the resonance closest to 2.45 GHz in the rectangular cavity, and those closer to it both above and below, and the closest ones above and below it, identifying the mode of each, as well as measuring their quality factors.

Fres GHz	Quality Factor QL	Quality Factor Qu	Mode
-	-	-	TE03
2.2169	11103,2596	20423,7858	TE04
2.4470	25216,4687	60571,3307	TE05
2.7016	4307,6514	10354,0020	TE06
-	-	-	TE07

Table. 1. Resonance frequencies and quality factors of the rectangular cavity.

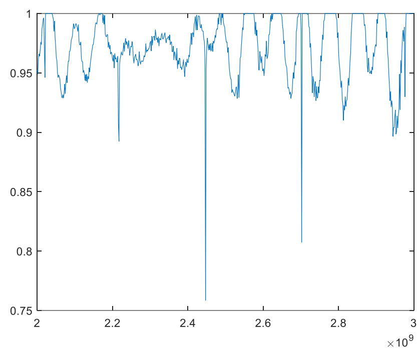

Fig. 6. Resonances in the vacuum rectangular guide

5 resonances should really be visible but as shown in the figure above only 3 are visible, exactly the three central ones. This is due to the accuracy and precision of the measurements, but they are still considered good measurements.

3. Circular guide

In the same way that we have proceeded to analyse the resonances of the rectangular guideway, we will analyse the resonances of the circular guideway from the measurements taken. In this case, according to the previous calculations, only one mode is propagated.

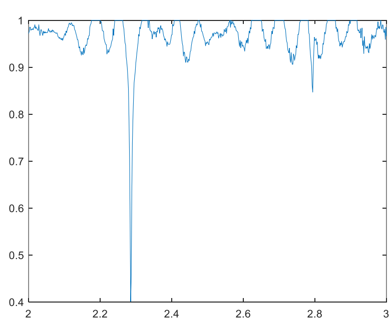

Fig. 7. Resonances in the vacuum circular guide

Fres GHz	Quality Factor QL	Quality Factor Qu	Mode
2.2858	281,3334	911,2979	TE010

Table. 2. Resonance frequencies and quality factors of the circular guide.

4. Working samples.

Four materials were used in the laboratory to manufacture the samples: Teflon, PVC and wood. samples: Teflon, PVC, nylon and wood. Circular and rectangular samples are available in the laboratory, the dimensions of which are recorded in table form.

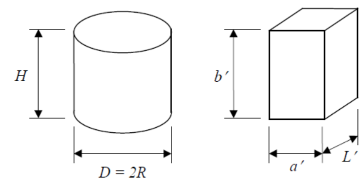

Fig. 8. Shape of the samples used.

Material	D (mm)	H (mm)
wood	10	60
PVC	13	60
teflon	12	60
nylon	11	60

Table. 3. Cylindrical samples.

Material	a' (mm)	b' (mm)	L'(mm)
wood	8.61	8.67	45
PVC	6.76	8.79	45
teflon	8.74	8.84	45
nylon	8.67	8.86	45

Table. 4. Rectangular samples.

5. Measurements in reflection in rectangular cavities

In the following, the study will focus on the T E105 mode. The virtual laboratories will then be used to calculate the real and imaginary part of the permittivity by perturbation theory.

Material	Fres GHz	Quality Factor QL	Quality Factor Qu	ε'	ε''
Cavity Empty	2.447	22211,5604	53941,9227	1	0
PVC	2.4302	1597,3504	2415,1965	4,2375	0,077301
Teflon	2.4376	5745,4412	13104,8686	2,6209	0,011027
Wood	2.4282	291,0943	300,0012	3.8305	0.49651

Table. 5. Material properties rectangular cavity.

6. Material properties rectangular cavity

Now we must look at TM010 mode, the resonance given around 2.3 GHz.

Material	Fres GHz	Quality Factor QL	Quality Factor Qu	ε’	ε’’
Cavity Empty	2.2858	282,2406	918,2078	1	0
PVC	2.1884	335,4549	453,3503	6,2575	0,0077548
Teflon	2.4443	28,8942	713,7353	6,1533	0,0063924
Nylon	2.2137	255,1176	405,4713	8,0915	0,012016

Table. 5. Material properties rectangular cavity.