

Impedance Mismatch between the Microwave Generator and the Plasma Machine

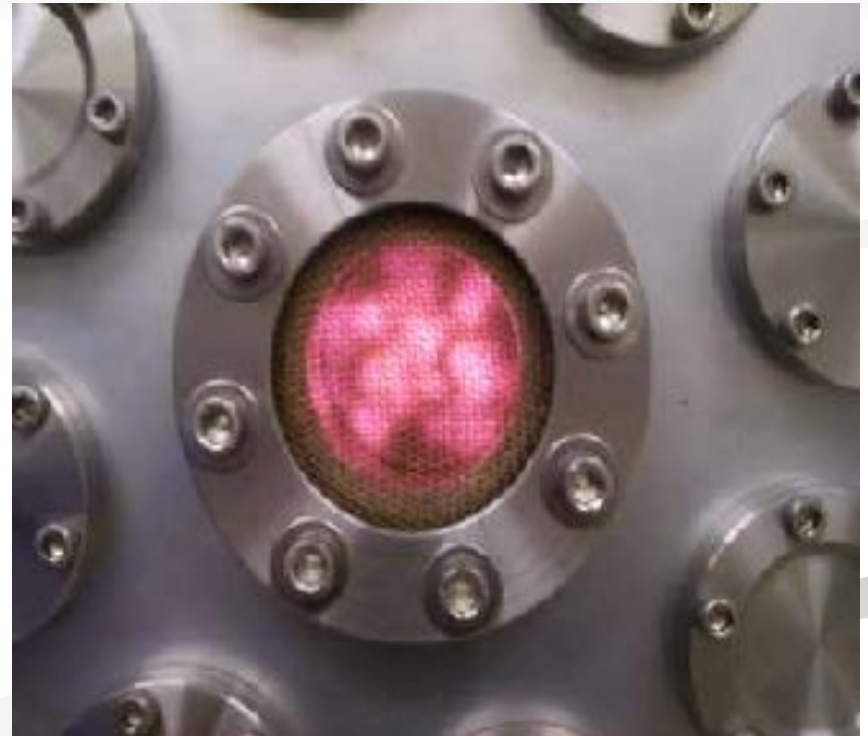


*Jorge Gaudier
Ligeia Castellanos
Kabir Encarnación
Natyaliz Zavala*

Advisor: Nader Farahat

Plasma Machine

Argon gas is injected to the machine. The microwaves heat the Argon ions to initiate ionization and plasma is produced. A dielectric wall is used inside the rectangular waveguide to isolate the plasma machine and maintain vacuum.



Microwave Generator and Plasma Machine

Rectangular
Waveguide

Microwave
Generator

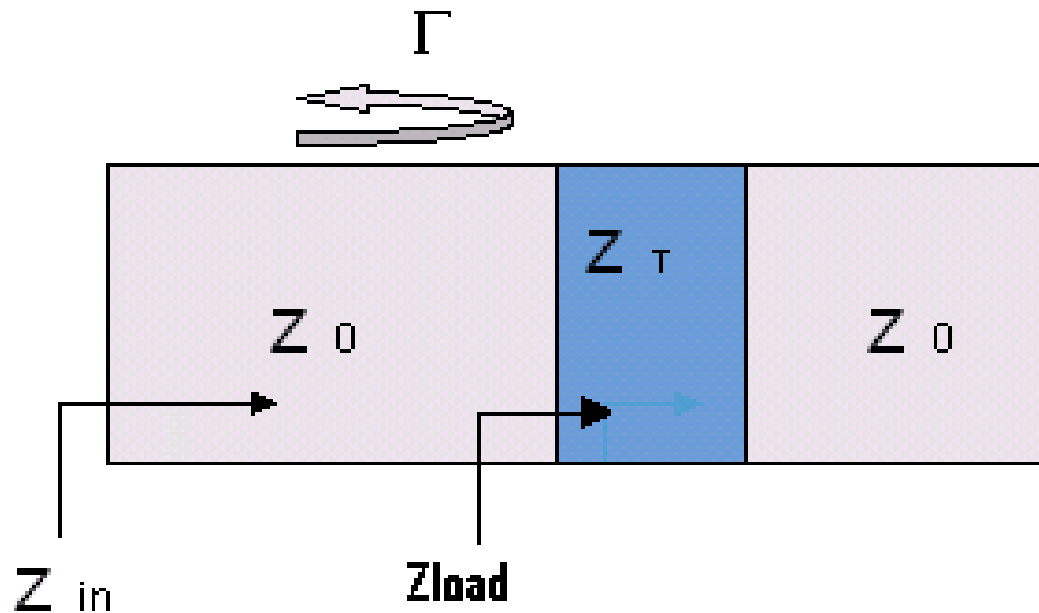


Coupler

Plasma
Machine

Impedance Mismatch

A rectangular waveguide partially loaded with a dielectric has an impedance discontinuity that causes reflection. It is desirable to match the line in order to reduce reflection.



Teflon as Dielectric Isolator

A Teflon layer is used inside the rectangular waveguide to isolate the plasma machine and maintain vacuum, some absorption of microwaves will occur, causing reflection, reducing the efficiency of the power transfer.

Why Teflon ?

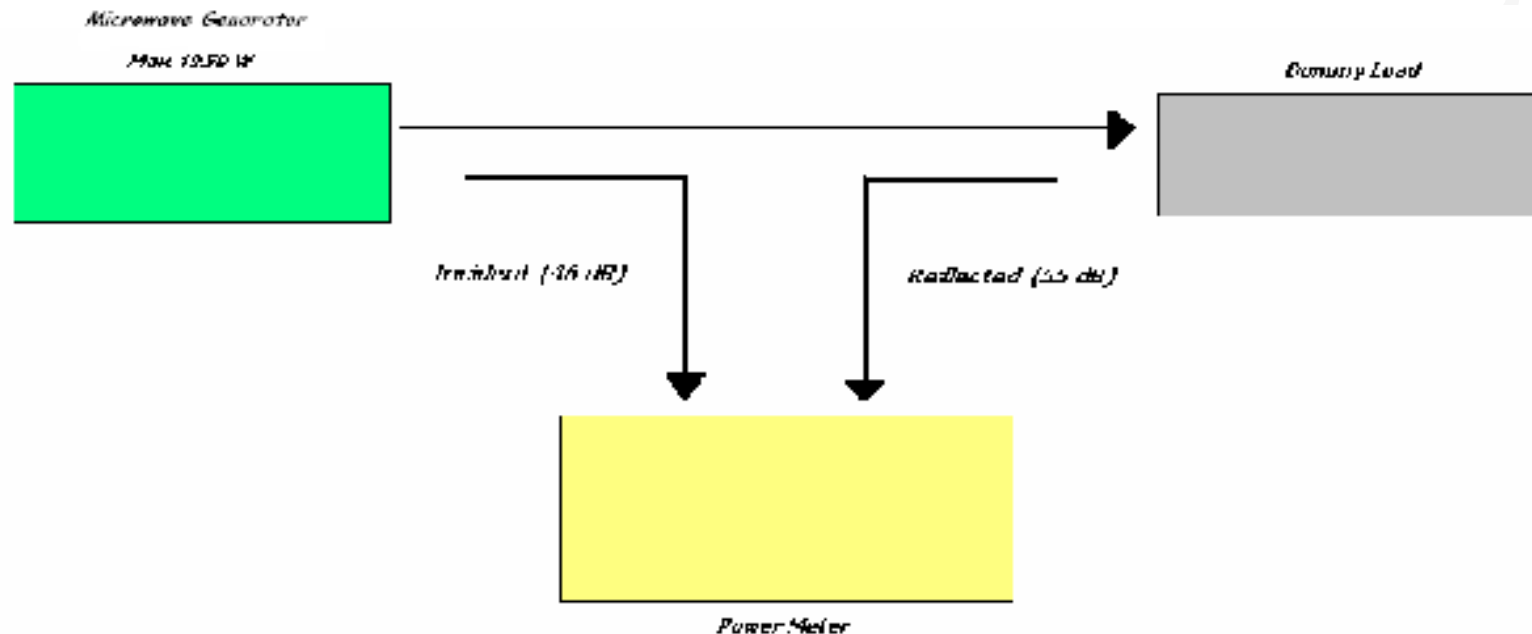
Teflon resists temperatures as high as 300° C during long period of time without suffering any change or modification.



Problem

Power loss due to reflection may damage the generator in the long run. We intend to optimize the dielectric to minimize the reflection.

$$1\text{Db} = 10^{-12}\text{W}/\text{m}^2$$



Microwave Generator

- ▶ Power Output: 5kW
continuous
at 2.45 GHz



Power Meter

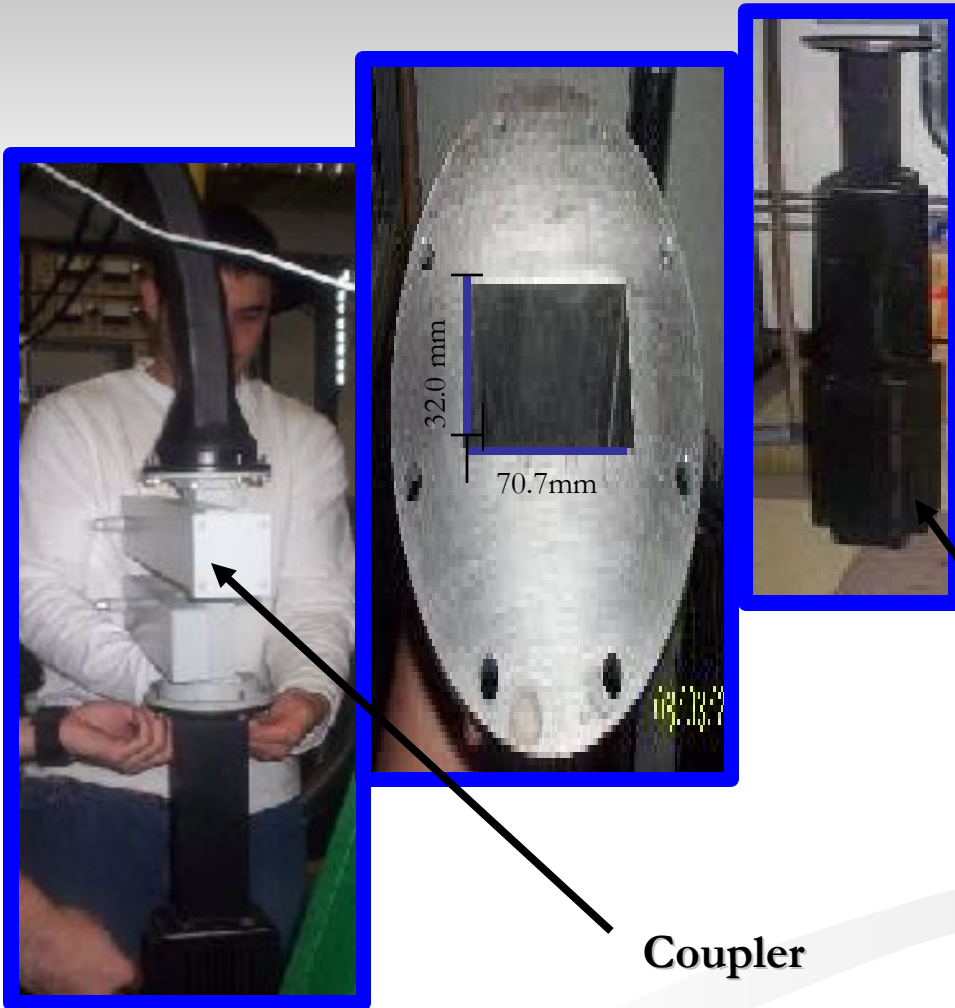
- ▶ Model HP 432B
- ▶ Over Range Reading in 1-10mW
and 10 μ W
- ▶ Waveform Sine Wave etc.
- ▶ Frequency 50/60Hz

Coupler

Incident and Reflected



Dummy Load & Coupler



Description

- + Dimension:
48''H x7.5''W
- + Weight:
Approximately 60lbs
- + Purpose:
Only Test

Dummy Load

Coupler

Reflection Measurement

The term **reflection coefficient** is used in physics and electrical engineering when wave propagation in a medium containing discontinuities is considered.

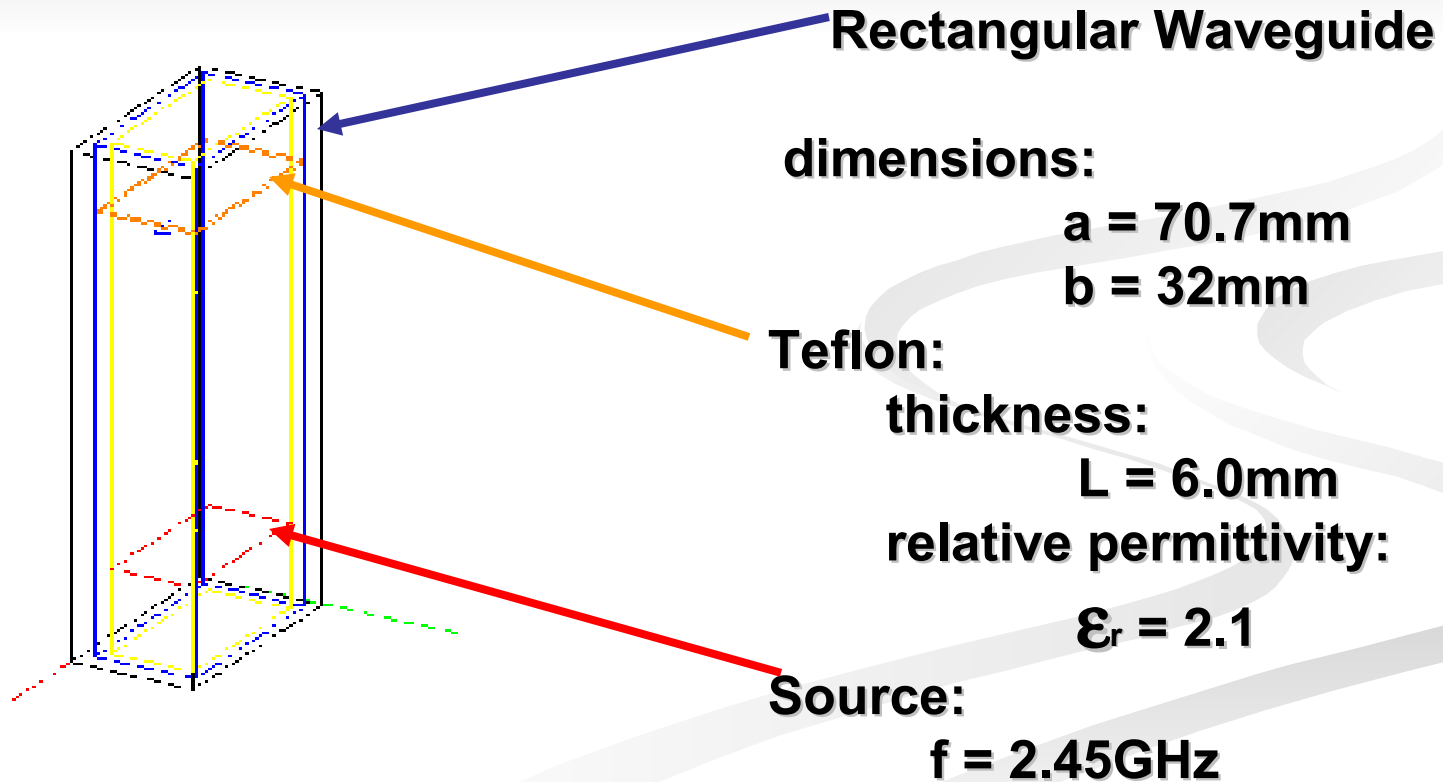
In general, the reflection coefficient is the ratio of the reflected wave to the incident wave.



$$\frac{P_{av,reflected}}{P_{av,incident}} = |\Gamma_L|^2 = .1$$

$$\Gamma_L = .316$$

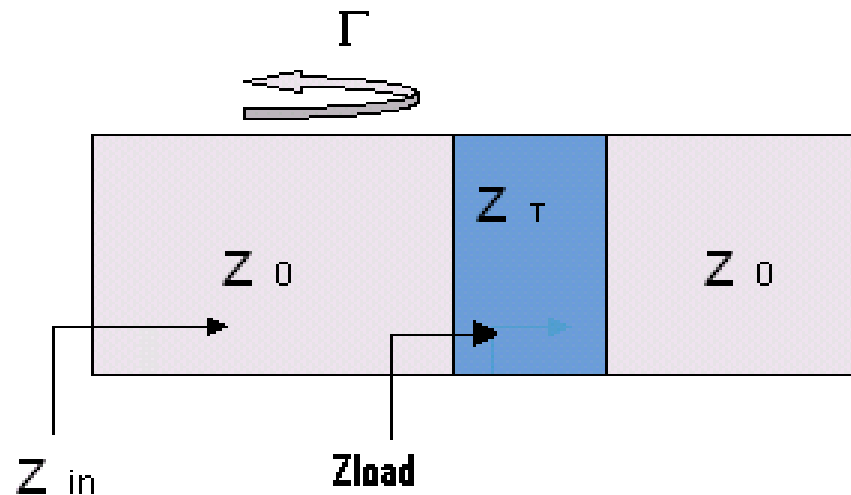
Finite-Difference Time Domain (FDTD) Solver



Analytical Formulas used in Matlab

$$Z_{in} = Z_0 * \left(\frac{Z_{inload} + jZ_0 \tan \beta_{in} l_{in}}{Z_0 + jZ_{inload} \tan \beta_{in} l_{in}} \right)$$

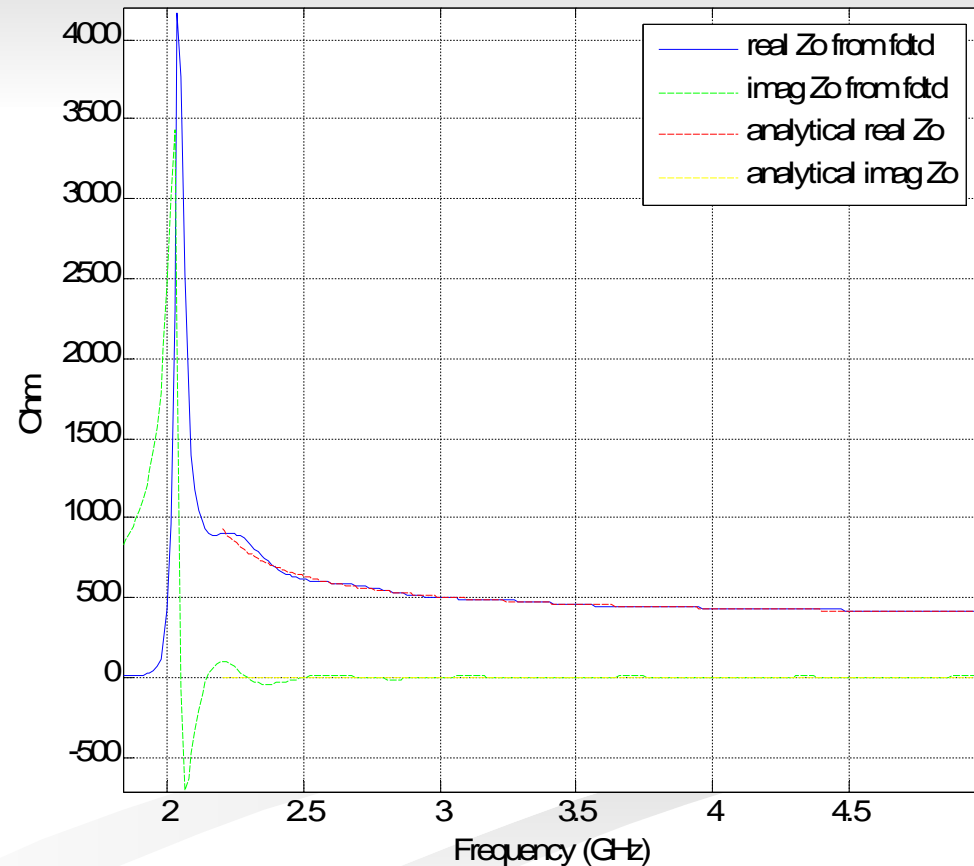
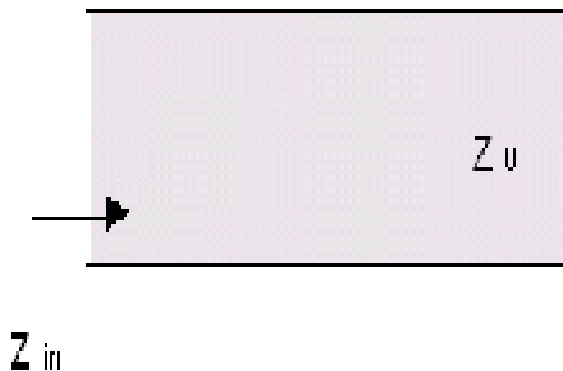
$$\Gamma = \left(\frac{Z_{in} - Z_0}{Z_{in} + Z_0} \right)$$



Characteristic Impedance

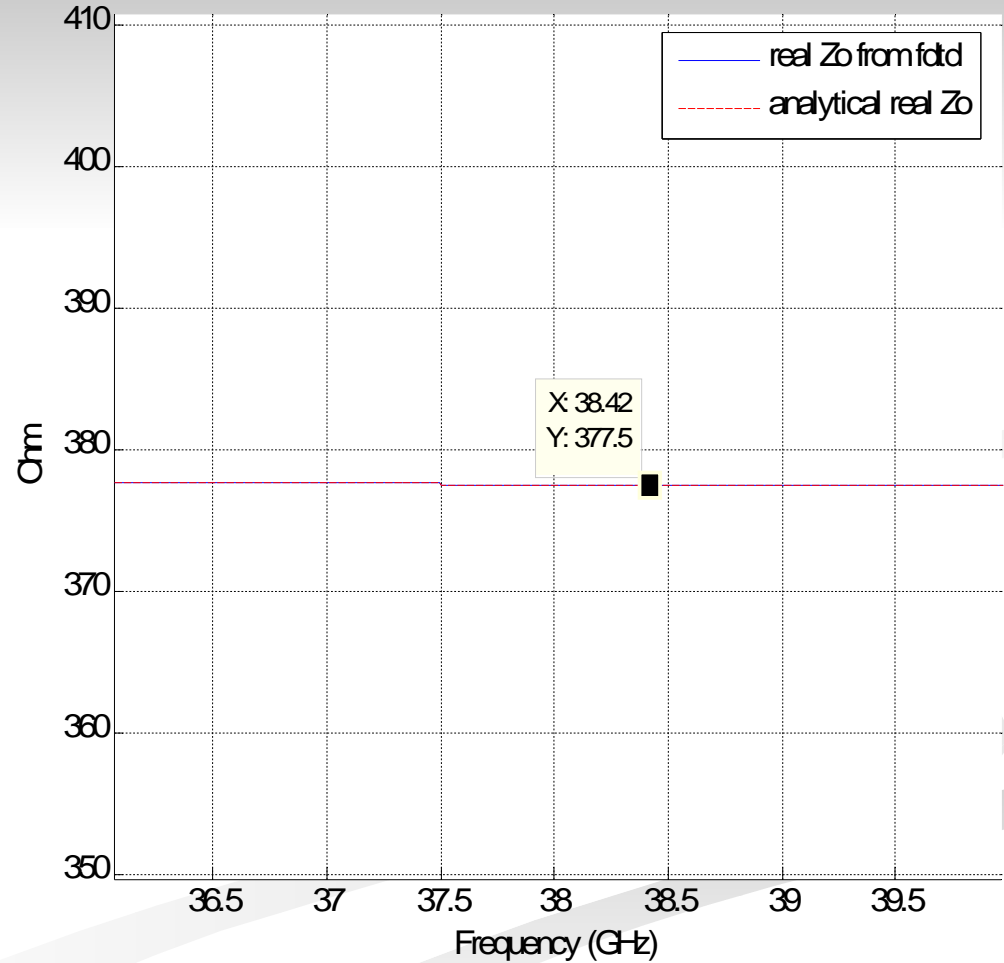
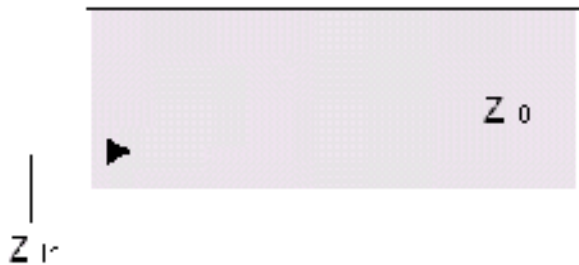
The term *impedance* is a general expression which can be applied to any electrical entity which impedes the flow of current. In general, is the ratio between voltage and current.

$$Z_0 = \frac{-E_y}{H_x}$$



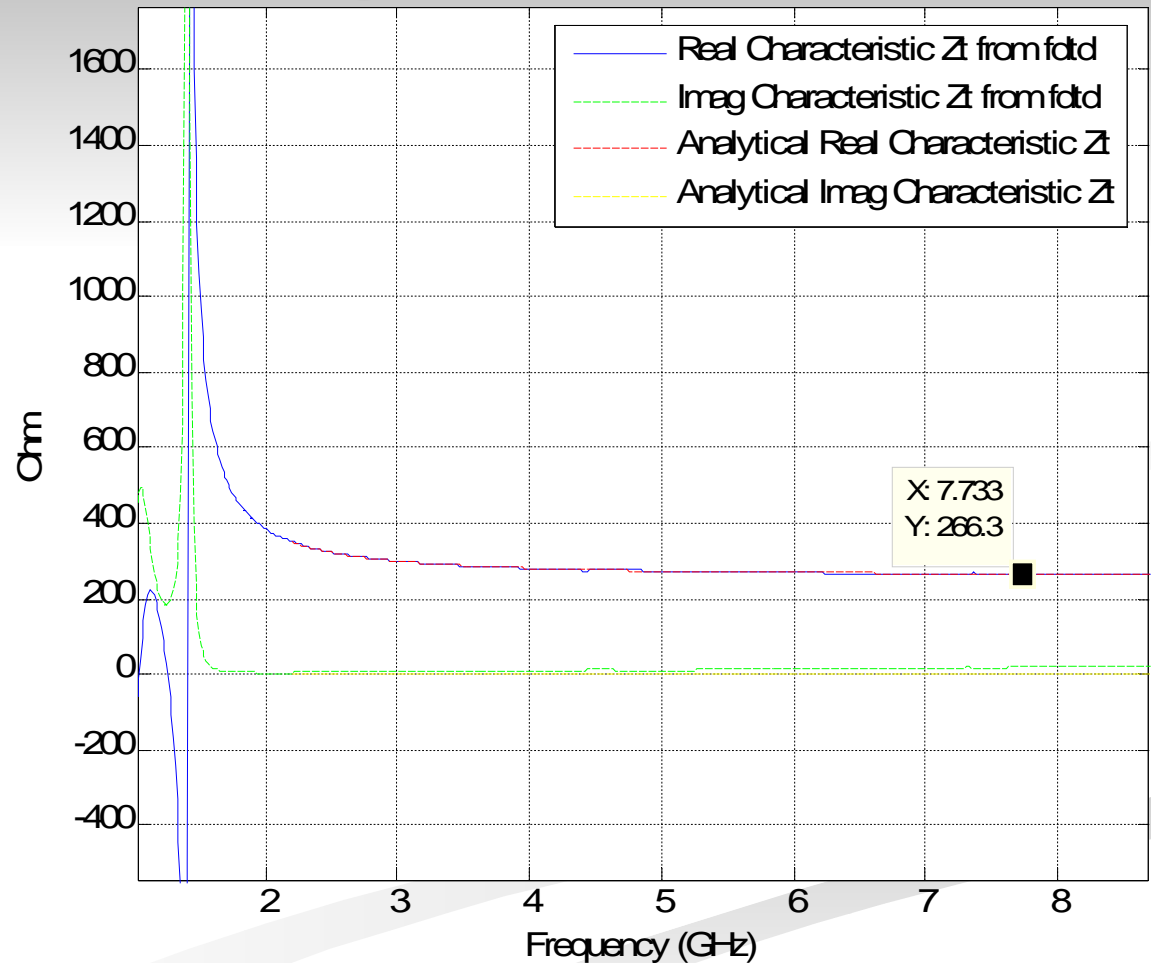
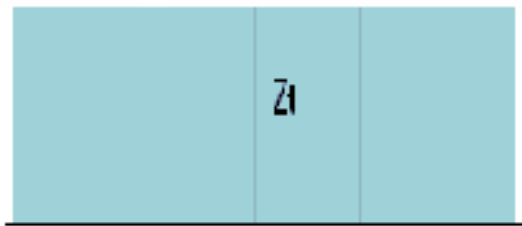
Free space characteristic impedance

(Free Space = 377)



Characteristic impedance of Teflon-filled Waveguide (Z_{0T})

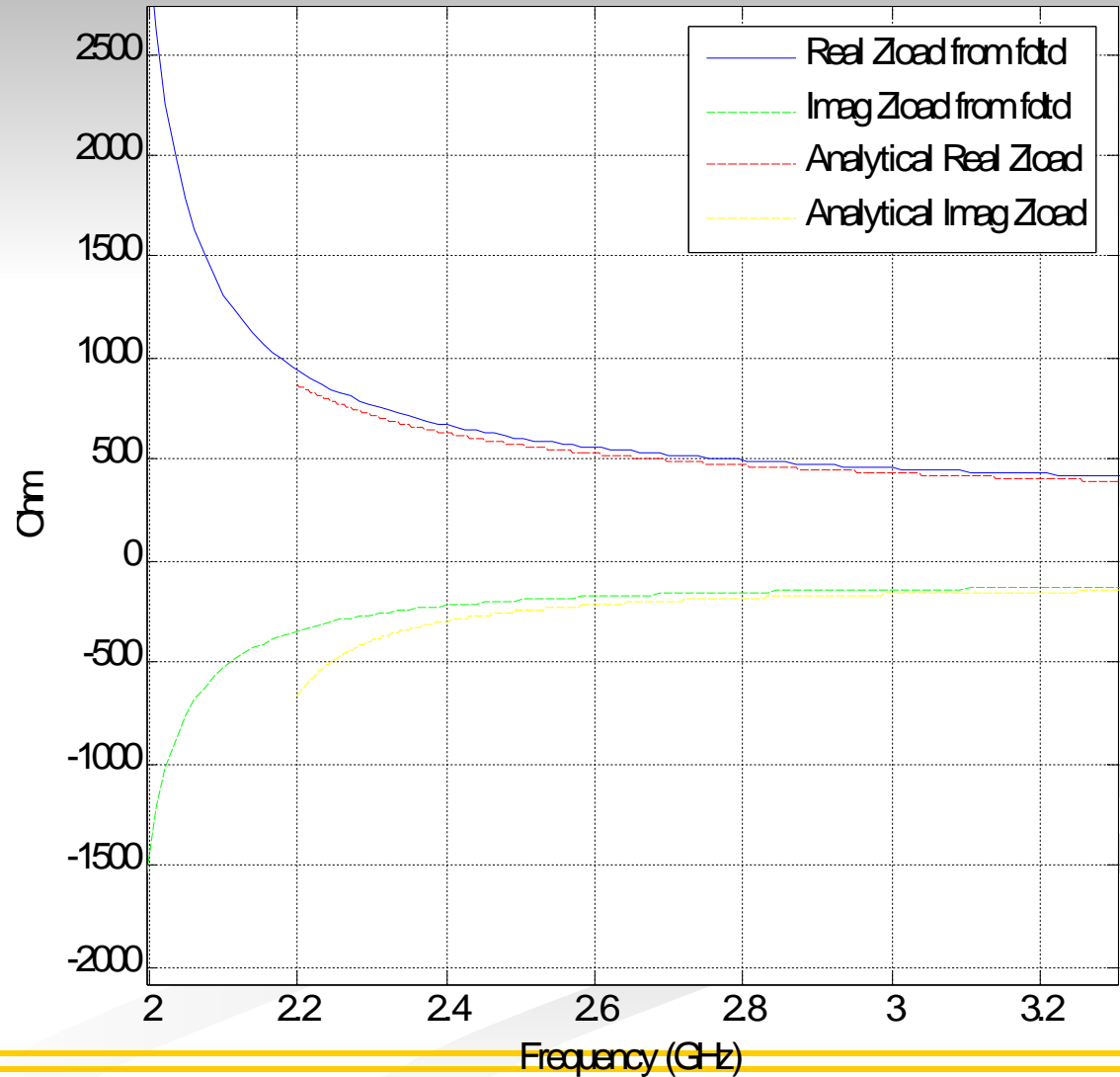
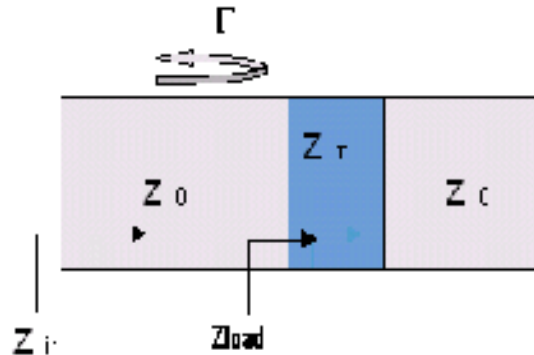
$$Z_{0T} = \left(\frac{K * 377}{\sqrt{\epsilon_r}} \right) \beta$$



Load Impedance

$Z_{in_{load}}$ = Input Impedance with Teflon

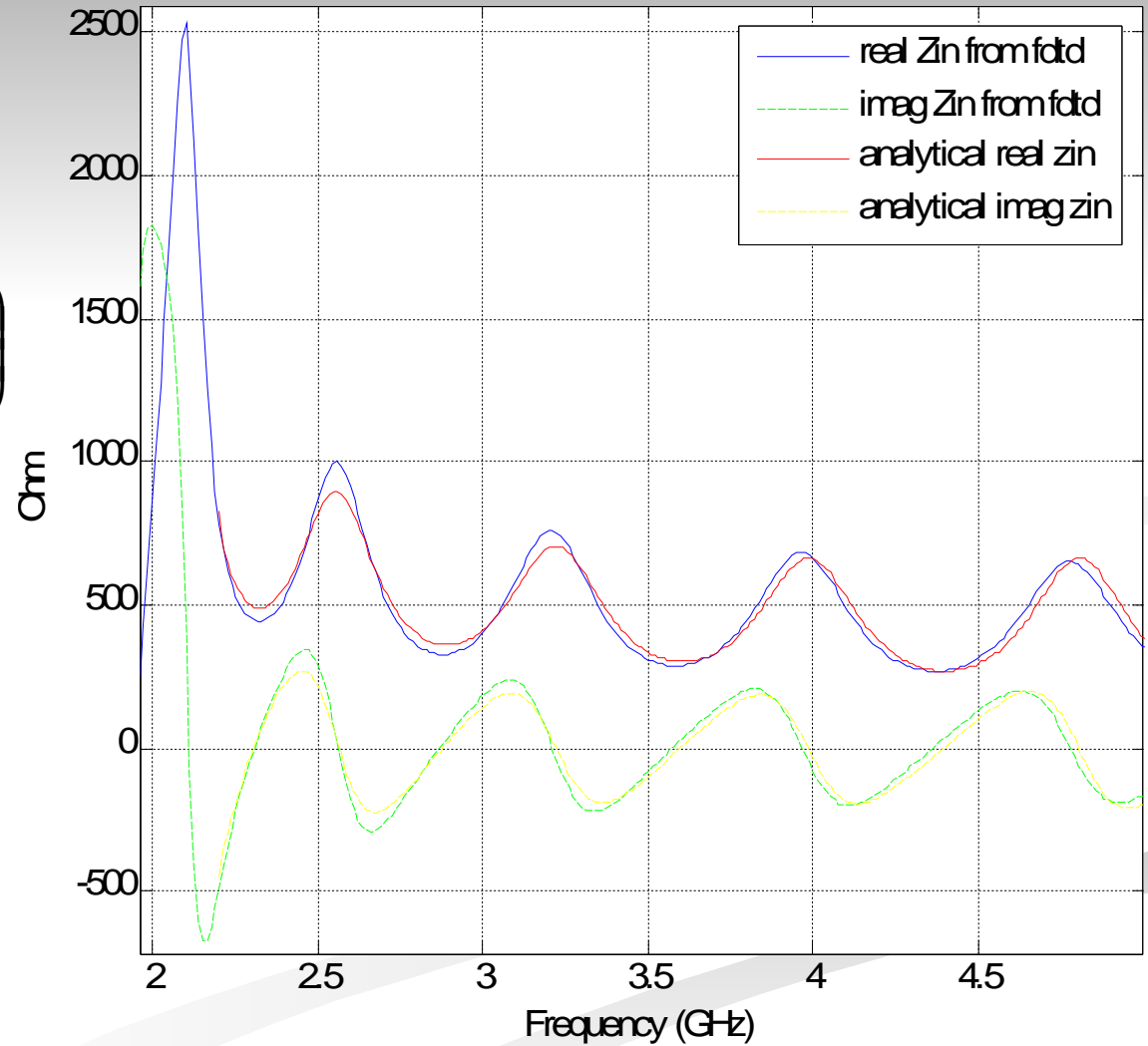
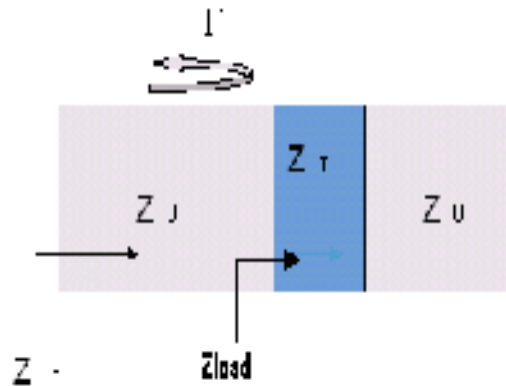
$$Z_{in_{load}} = Z_{0T} * \left(\frac{Z_0 + jZ_{0T} \tan \beta_T l_T}{Z_{0T} + jZ_0 \tan \beta_T l_T} \right)$$



Input Impedance

Z_{in} = Input Impedance

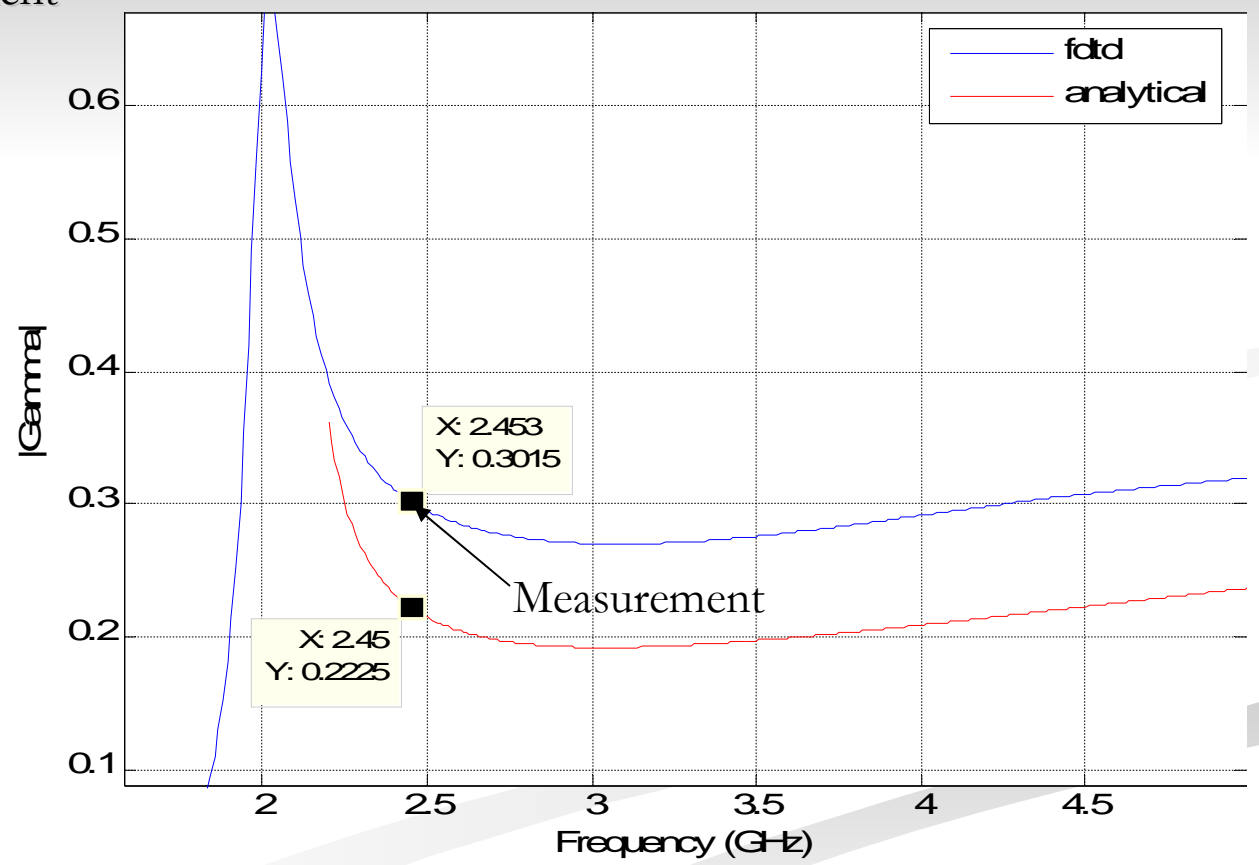
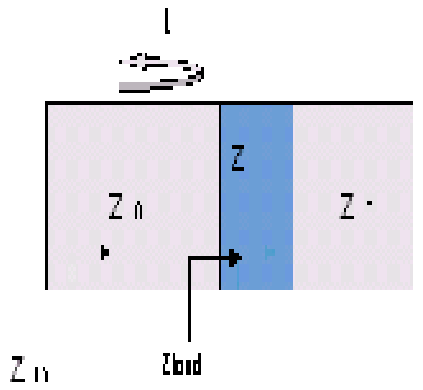
$$Z_{in} = Z_0 * \left(\frac{Z_{in_{load}} + jZ_0 \tan \beta_{in} l_{in}}{Z_0 + jZ_{in_{load}} \tan \beta_{in} l_{in}} \right)$$



Reflection coefficient Gamma (Γ)

→ Γ = Reflection Coefficient

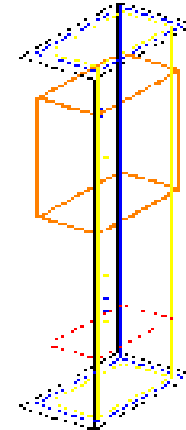
$$\Gamma = \left(\frac{Z_{in} - Z_0}{Z_{in} + Z_0} \right)$$



Future Work

- ◆ Change the thickness of the Teflon to know the maximum and minimum reflection (Γ).
- ◆ Change the material .

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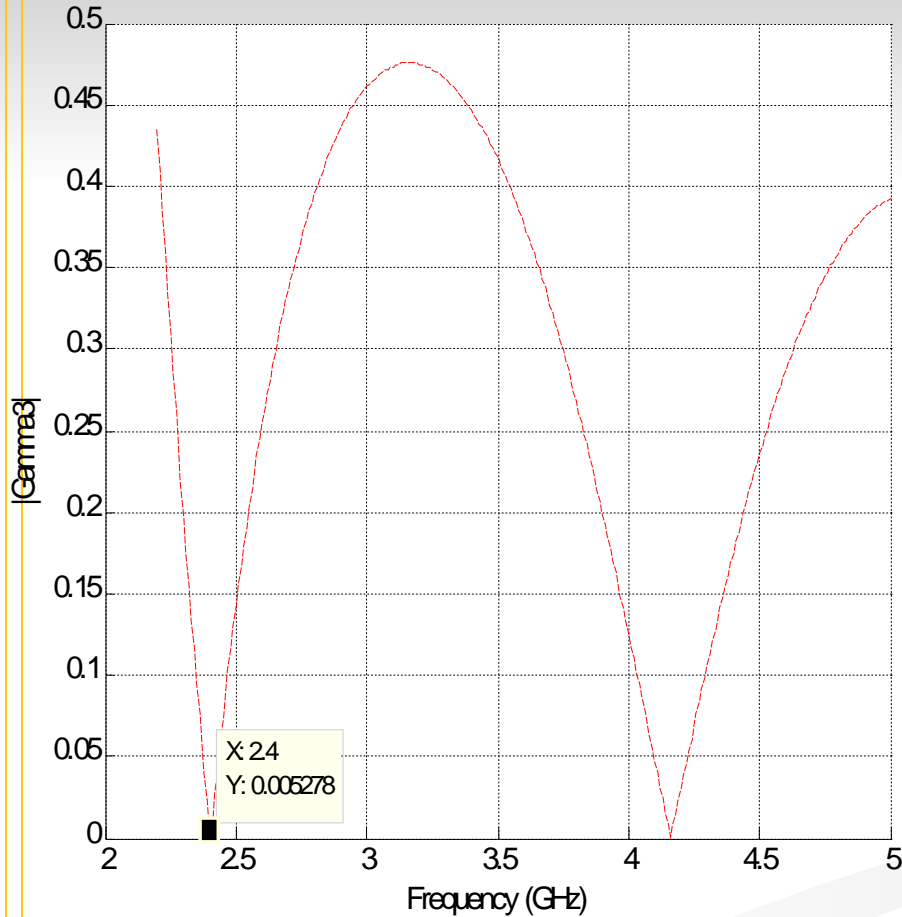


<u>MATERIAL</u>	<u>ϵ_r</u>
Plexiglas	3.45
Quartz	3.8
Polystyrene	2.56
Polyvinyl	3.0
Teflon	2.1

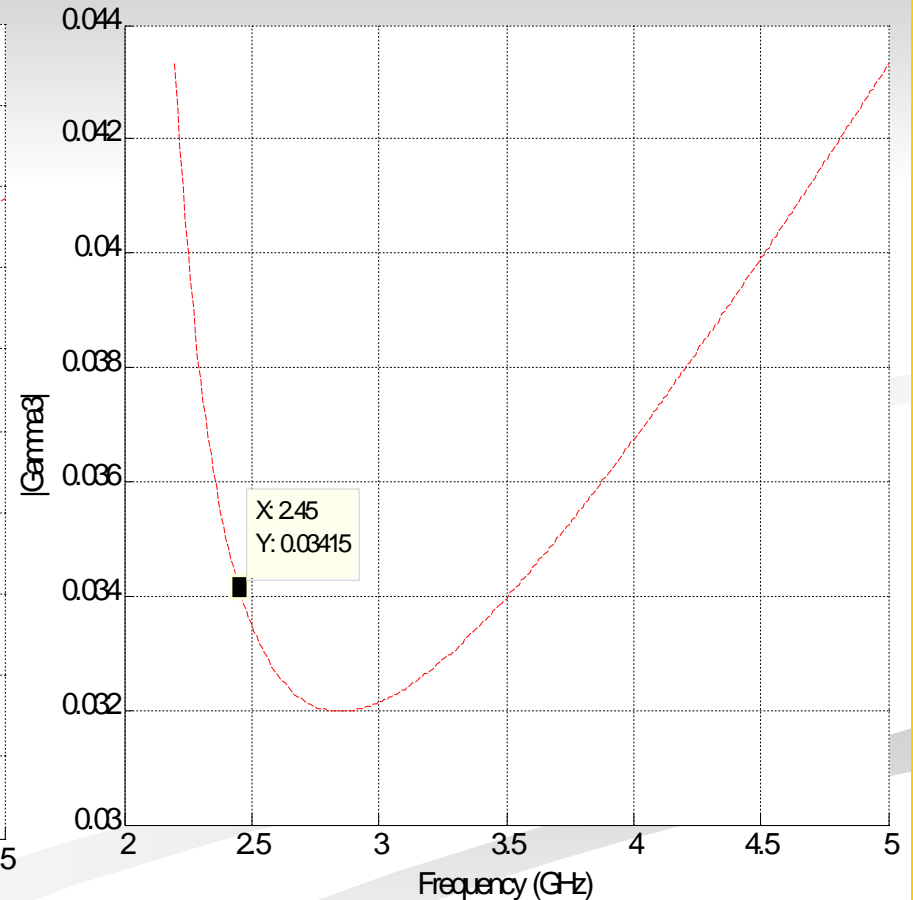
Analytical

7.65cm vs. .1cm

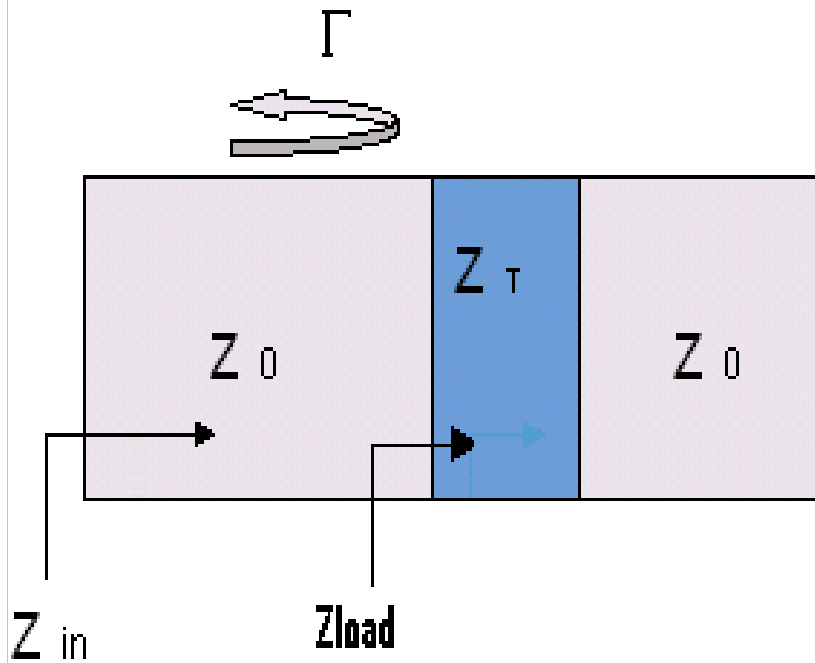
Gamma en IE con l2=16cm



Gamma en TE con l2=16cm

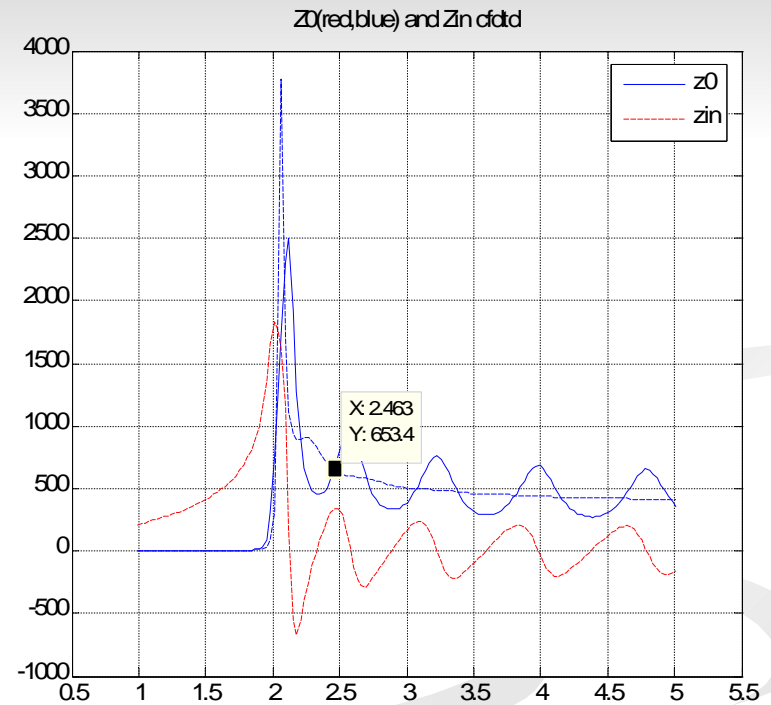
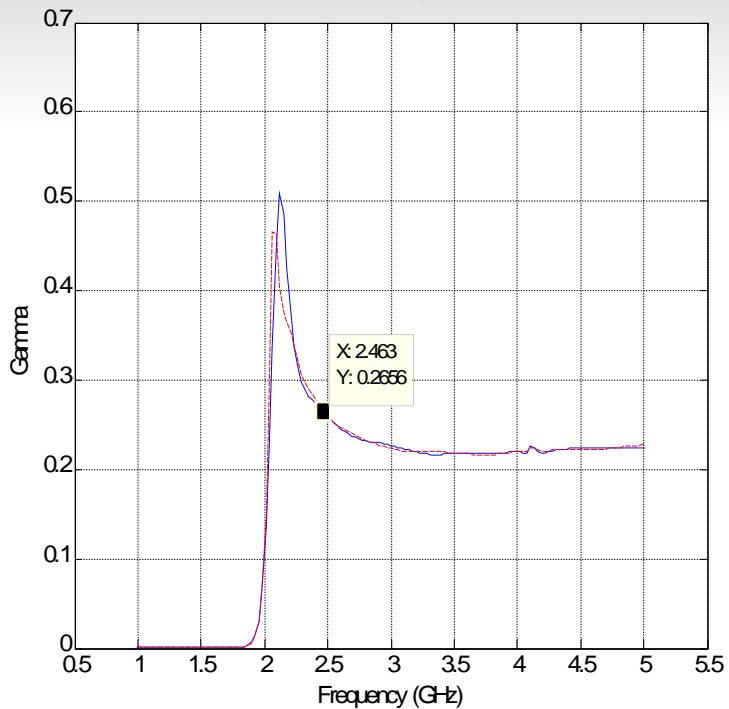


Questions?

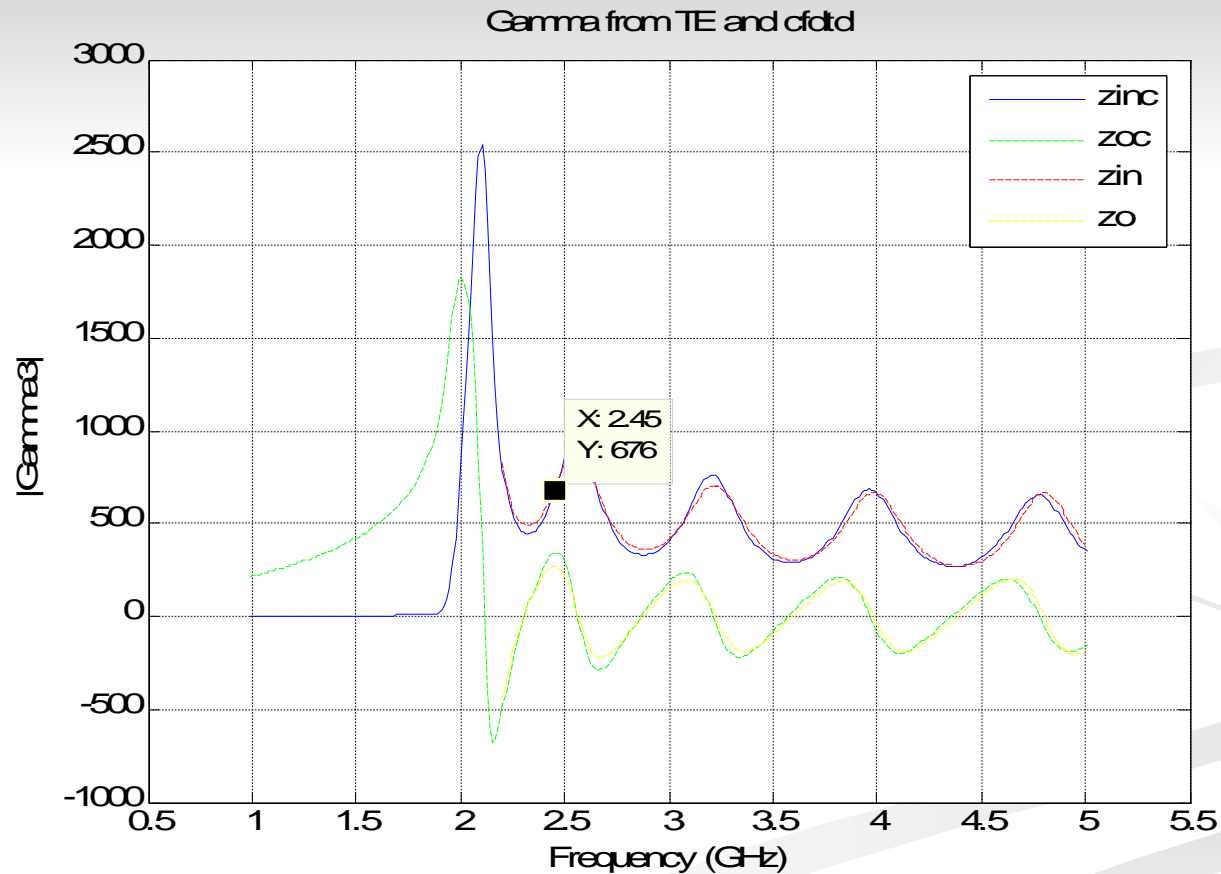


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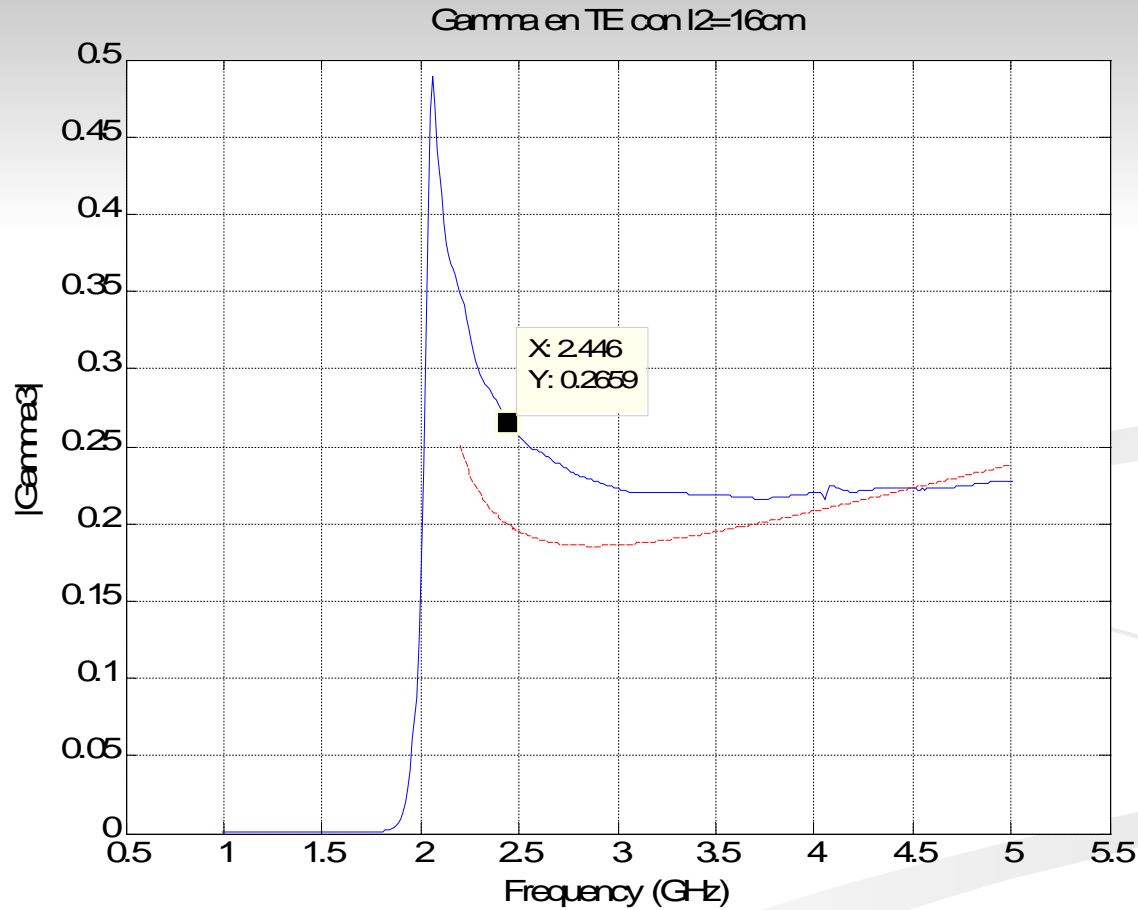
$$(z_{in}-z_0)/(z_{in}+z_0) = (e_{y,rf} - e_{y,rf})/e_{y,rf}$$



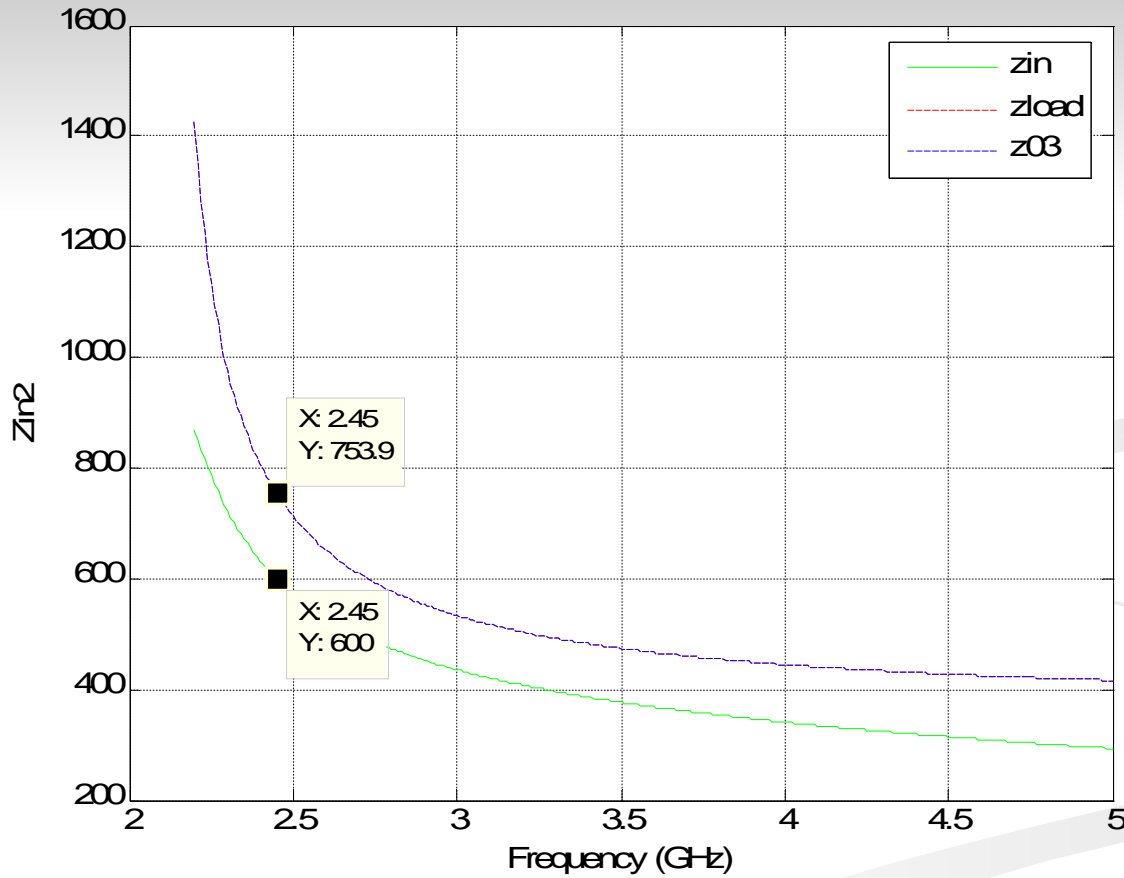
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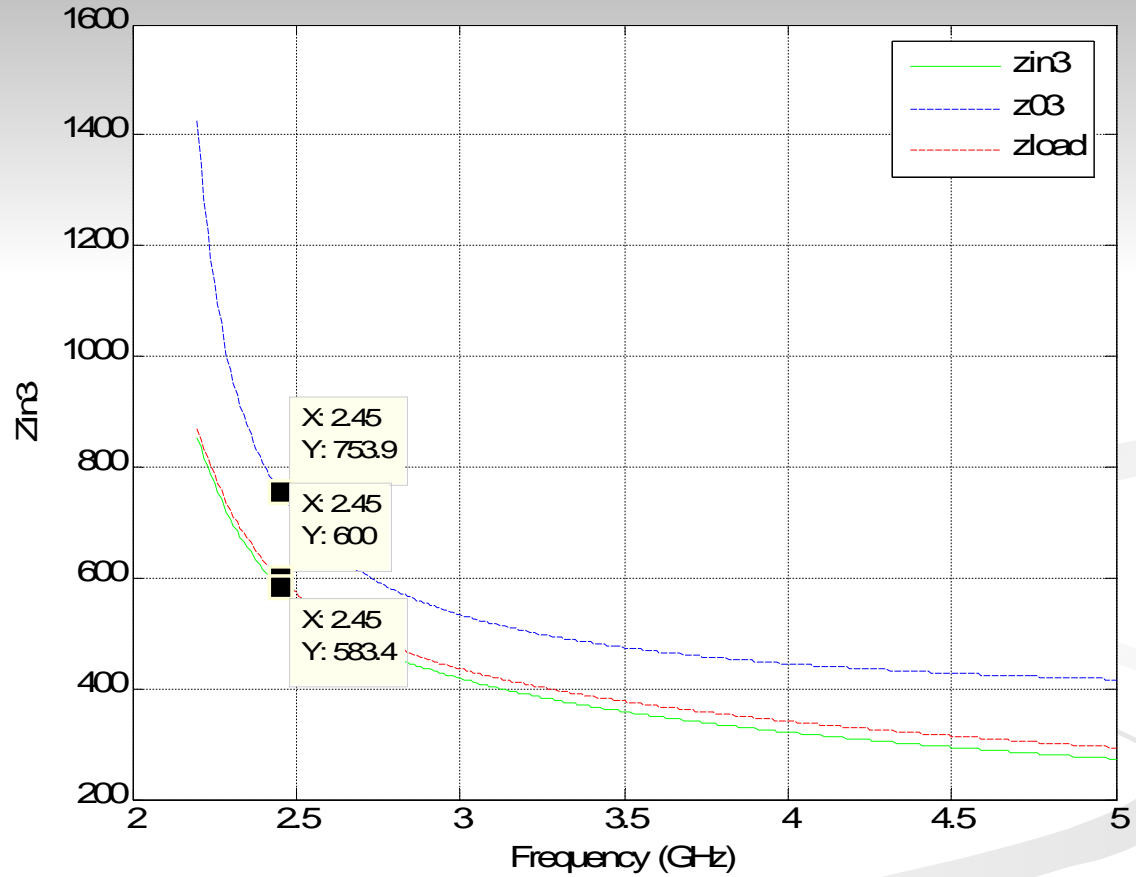
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TE $a=70.7\text{mm}$



Gamma en TE con $l_2=16\text{cm}$

