# Experiment Two
# Fundamentals of Electromagnetics Lab
# EECE2530/1

Michael Brodskiy
Brodskiy.M@Northeastern.edu

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| Partners: | Manas Mahajan & Priyam Modi |
| Instructor: | Professor Marengo-Fuentes |
| TAs: | Nicolas Casilli & Farah Ben Ayed |

**Abstract**

The goal

KEYWORDS:

# 1 Equipment

Available equipment included:

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# 2 Introduction & Objectives

## 3 Results & Analysis

We begin with the values we measured using the single-slot analyzer (length values in centimeters):

| $f$ [GHz] | $l_1$ | $l_2$ | $\lambda_{theor}$ | $\lambda_{exp}$ | $S_{short}$ | $l_{short}$ | $S_{open}$ | $l_{open}$ |
|---|---|---|---|---|---|---|---|---|
| 2.3 | 10.5 | 17.25 | 13.034 | 13.2 | 1.22 | 13.2 | 1.205 | 10.55 |
| 2.7 | 10.7 | 16.7 | 11.103 | 11.8 | 1.12 | 11.8 | 1.205 | 14.3 |

Next, we calculate the magnitude of the reflection constant and phase angle for the two frequencies:

$$|\Gamma_{short,2.3}| = \frac{1.22 - 1}{1.22 + 1} = .099099$$
$$\theta_{short,2.3} = \pi + \frac{4\pi}{.132}[.132 - .105] = 5.712$$
$$|\Gamma_{open,2.3}| = \frac{1.205 - 1}{1.205 + 1} = .092971$$
$$\theta_{open,2.3} = \pi + \frac{4\pi}{.132}[.1055 - .105] = 3.1892$$

We now repeat for the 2.7 [GHz] values:

$$|\Gamma_{short,2.7}| = \frac{1.12 - 1}{1.12 + 1} = .056604$$
$$\theta_{short,2.7} = \pi + \frac{4\pi}{.118}[.118 - .107] = 4.313$$
$$|\Gamma_{open,2.7}| = \frac{1.205 - 1}{1.205 + 1} = .092971$$
$$\theta_{open,2.7} = \pi + \frac{4\pi}{.118}[.143 - .107] = 6.9754$$

Next, we find the full expression for $\Gamma$:

$$\Gamma_{short,2.3} = .099099e^{5.712j} = .083367 - .053577j$$
$$\Gamma_{open,2.3} = .092971e^{3.1892j} = -.092865 - .0044237j$$
$$\Gamma_{short,2.7} = .056604e^{4.313j} = -.022009 - .05215j$$
$$\Gamma_{open,2.7} = .092971e^{6.9754j} = .071572 + .059338j$$

Next, we use these values to find the impedances of such loads:

$$z_{short,2.3} = 50\left(\frac{1 + .083367 - .053577j}{.9166 + .053577j}\right) = 55.8316 - 2.7611j[\Omega]$$
$$z_{open,2.3} = 50\left(\frac{1 - .092865 - .0044237j}{1 + .092865 + .0044237j}\right) = 41.5011 - 0.3704j[\Omega]$$
$$z_{short,2.7} = 50\left(\frac{1 - .022009 - .05215j}{1 + .022009 + .05215j}\right) = 47.5924 - 4.9798j[\Omega]$$

$$z_{open,2.7} = 50\left(\frac{1+.071572+.059338j}{1-.071572-.059338j}\right) = 57.2708 + 6.8559j[\Omega]$$

We know combine the complementary impedance values to find $z_{om}$:

$$z_{om,2.3} = \sqrt{(55.8316-2.7611j)(41.5011-.03704j)} = 48.1502 - 1.2114j[\Omega]$$

$$z_{om,2.7} = \sqrt{(47.5924-4.9798j)(57.2708+6.8559j)} = 52.5352 + 0.3911j[\Omega]$$

We now use these values in the following formula, with $\mu = 1$, $\eta_o = 120\pi$, and coaxial radius values of outer length 7[mm] and inner length 3[mm]:

$$\varepsilon_r = \mu_r\left(\frac{\eta_o \ln\left(\frac{b}{a}\right)}{2\pi z_{om}}\right)^2$$

$$\varepsilon_{r,2.3} = \left(\frac{120\pi \ln\left(\frac{7}{3}\right)}{2\pi(48.1502-1.2114j)}\right)^2 = 1.112638 + .056021j$$

$$\varepsilon_{r,2.7} = \left(\frac{120\pi \ln\left(\frac{7}{3}\right)}{2\pi(52.5352+.3911j)}\right)^2 = .936271 - .013940j$$

Both of the real part values are near 1, as expected for air.

# 4 Conclusion