Lab Write-up 1: Transmission Line Basics

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1 Role of Wavelength

1.1 Measured Data

$$R_1 = 2212\ \Omega$$
$$R_2 = 1808\ \Omega$$

Table 1: Role of Wavelength - Measured Data

Frequency	**Cable**	v_1 (V)	v_2 (V)	ΔT (ns)	$\Delta\varphi^\circ$
f_1 = 100 kHz	12”	5.65	2.55	-16	-0.5
	180”	5.85	2.55	60	2.7
f_2 = 100 MHz	12”	4.35	0.133	1.48	50
	180”	3.35	0.116	1.48	50

Table 2: Role of Wavelength - Measured Data

1.2 Analysis

1. $$\lambda = \frac{c}{f\sqrt{\varepsilon_r}} \tag{1}$$

   From equation 1 and the fact that $\varepsilon_r = 1.9$,

   $$\lambda_1 = 2176.43\ m$$
   $$\lambda_2 = 2.17643\ m$$

   Table 3: Analysis 1.1

2.

3.

4. For f_1 = 100 kHz, the computed v_{out} is almost identical to the measured v_2 in lab using the 12” cable and very similar using the 180” cable. There is a 0.39 % difference for the 12” cable and a 3.09% difference for the 180” cable. On the other hand, v_{out} is completely different from the measured v_2 in lab for f_2 = 100 MHz.

5. As the ratio between the length of the cable and the wavelength in the circuit increases past 0.01, basic circuit analysis fails and we must use transmission line theory. If we do not, the phase delays of the signal and the interferences on the line from the reflected wave become significant, resulting in otherwise unexpected results.

Frequency	Cable	$l : \lambda$
f_1 = 100 kHz	12"	0.00168
	180"	0.0252
f_2 = 100 MHz	12"	1.68
	180"	25.21

Table 4: Analysis 1.2

Frequency	Cable	v_1 (V)	v_2 (V)	v_{out} (V)
f_1 = 100 kHz	12"	5.65	2.55	2.54
	180"	5.85	2.55	2.63
f_2 = 100 MHz	12"	4.35	0.133	1.96
	180"	3.35	0.116	1.51

Table 5: Analysis 1.3

1.3 Questions

1. Would you expect
2. Which of
   (a) Integrated circuit
   (b) Electrical lines
   (c) Electrical lines
   (d) VHF antenna
3. Why is it necessary

2 Standing Waves on the Slotted Line

2.1 Measured Data

2.1.1 Short Termination

Location	|v| (V)	Position (mm)
1^{st} minimum	0.020	116
1^{st} maximum	3.08	190
2^{nd} maximum	0.020	266

Table 6: Standing Waves - Measured Data

2.1.2 Loads

2.2 Analysis

1. Since the signal was 1 GHz and we are assuming $\varepsilon_r = 1$, $\lambda = 300\ mm$ (Eq. 1, pg. 1). Then, the distance between the minima is 266 mm - 116 mm = 150 mm or $\frac{\lambda}{2}$. This is equal to the theoretical value of $\frac{\lambda}{2}$.
2. The distance between the first minimum and maximum is 190 mm - 116 mm = 74 mm or 0.247λ. This is very similar to the theoretical value of $\frac{\lambda}{4}$.
3. Insert Plotsssssszzsss

2.3 Questions

1. What would you expect
2. Why was it acceptable

Resistive termination value = 10 Ω
Capacitive termination value = 39 (pF)

Table 7: Standing Waves - Loads

Probe Position (λ)												Minimum	
Load	0	$\frac{\lambda}{20}$	$\frac{2\lambda}{20}$	$\frac{3\lambda}{20}$	$\frac{4\lambda}{20}$	$\frac{5\lambda}{20}$	$\frac{6\lambda}{20}$	$\frac{7\lambda}{20}$	$\frac{8\lambda}{20}$	$\frac{9\lambda}{20}$	$\frac{10\lambda}{20}$	Pos.	Vol.
Probe Position (mm)	116	131	146	161	176	191	206	221	236	251	266	X	X
Short	0.02	0.81	1.79	2.49	2.89	3.00	2.77	2.29	1.65	0.76	0.02	116	0.02
Open	2.75	2.59	2.19	1.59	0.736	0.032	0.643	1.53	2.21	2.61	2.73	193	0.02
Matched	1.42	1.42	1.43	1.45	1.45	1.46	1.45	1.43	1.42	1.4	1.39	266	1.39
Resistor	1.89	2.27	2.41	2.33	2.03	1.57	1.01	0.434	0.591	1.25	1.87	227	0.346
Capacitor	2.79	2.61	2.17	1.53	0.687	0.02	0.79	1.65	2.31	2.69	2.77	191	0.02

Table 8: Standing Waves - Loads

3 Network Analyzer

3.1 Measured Data

3.1.1 Reflection Coefficients

3.1.2 Scanner Antenna SWR

3.2 Analysis

1.

2. Using Eq. XXX for the reflection coefficient and the fact that $Z_0 = 50\ \Omega$,

$$\Gamma = \frac{Z_L - Z_0}{Z_l + Z_0} \tag{2}$$

The theoretical values for Γ are shown in Table XXX. Furthermore, by converting our measured data from the network analyzer from the dB scale to the linear scale using Eq. XXX,

$$|\Gamma|_{linear} = 10^{|\Gamma|_{dB}/20} \tag{3}$$

3.

3.3 Questions

1.

2. (a)
   (b)
   (c)

Probe Position (λ)											
Load	0	$\frac{\lambda}{20}$	$\frac{2\lambda}{20}$	$\frac{3\lambda}{20}$	$\frac{4\lambda}{20}$	$\frac{5\lambda}{20}$	$\frac{6\lambda}{20}$	$\frac{7\lambda}{20}$	$\frac{8\lambda}{20}$	$\frac{9\lambda}{20}$	$\frac{10\lambda}{20}$
Probe Position (mm)	116	131	146	161	176	191	206	221	236	251	266
Short	0.0065	0.26	0.58	0.81	0.94	0.97	0.90	0.74	0.54	0.25	0.0065
Open	0.89	0.84	0.71	0.52	0.24	0.010	0.21	0.50	0.72	0.85	0.89
Matched	0.46	0.46	0.46	0.46	0.46	0.47	0.47	0.46	0.46	0.45	0.45
Resistor	0.61	0.74	0.78	0.76	0.66	0.51	0.33	0.14	0.19	0.41	0.61
Capacitor	0.91	0.85	0.70	0.50	0.22	0.0065	0.26	0.54	0.75	0.87	0.90

Table 9: Analysis 2.3

Load	$\mid \Gamma \mid$	$\Delta\Gamma^\circ$
Short (uncal)	0.751	97.872
Short (cal)	1	173.25
Open	1	-7.425
50 Ohm (matched)	0.001	26.735

Table 10: Network Analyzer - Reflection Coefficients

Frequency of SWR minimum	170.5 MHz
Minimum SWR value	1.513
Lower Frequency of 2.5 SWR	156.7 MHz
Higher Frequency of 2.5 SWR	222.7 MHz

Table 11: Nework Analyzer - Scanner Antenna

Load	$\lvert\Gamma\rvert_{dB}$	$\lvert\Gamma\rvert_{linear}$	$\lvert\Gamma\rvert_{theoritical}$
Short (uncal)	0.751	1.09	1
Short (cal)	1.00	1.12	1
Open	1.00	1.12	1
50 Ω (matched)	0.001	1.00	0

Table 12: Analysis 3.2