Lab Write-up 1: Transmission Line Basics

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1 Role of Wavelength

1.1 Measured Data

$R_1 =$ 2212 Ω
$R_2 =$ 1808 Ω

Frequency	**Cable**	v_1 (V)	v_2 (V)	ΔT (ns)	$\Delta\varphi°$
$f_1 = 100$ 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

1.2 Analysis

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

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

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

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.

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

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

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

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

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.

2.3 Questions

3 Network Analyzer

3.1 Measured Data

3.1.1 Reflection Coefficients

3.1.2 Scanner Antenna SWR

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

	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	434	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

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

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