

Lab Write-up 1: Transmission Line Basics

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1 Role of Wavelength

1.1 Measured Data

$$\begin{aligned} R_1 &= 2212 \, \Omega \\ R_2 &= 1808 \, \Omega \end{aligned}$$

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

1.2 Analysis

1.

$$\lambda = \frac{c}{f\sqrt{\epsilon_r}} \quad (1)$$

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

$$\begin{aligned} \lambda_1 &= 2176.43 \, m \\ \lambda_2 &= 2.17643 \, m \end{aligned}$$

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	$l : \lambda$
$f_1 = 100 \text{ kHz}$	12"	0.00168
	180"	0.0252
$f_2 = 100 \text{ MHz}$	12"	1.68
	180"	25.21

Frequency	Cable	v_1 (V)	v_2 (V)	v_{out} (V)
$f_1 = 100 \text{ kHz}$	12"	5.65	2.55	2.54
	180"	5.85	2.55	2.63
$f_2 = 100 \text{ MHz}$	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 $\epsilon_r = 1$, $\lambda = 300 \text{ mm}$ (Eq. 1, pg. 1). Then, the distance between the minima is $266 \text{ mm} - 116 \text{ mm} = 150 \text{ mm}$ 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 $190 \text{ mm} - 116 \text{ mm} = 74 \text{ mm}$ 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 = $10\ \Omega$
 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	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

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	

Load	$ \Gamma $	$\Delta\Gamma^\circ$
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