X340994

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

Department of Electrical Engineering

Experiment No.________Slotted Line Measurements

INTRODUCTION

When a transmission line is not terminated in its characteristic impedance (ZO), some of the energy sent down the line will be reflected back. If voltage (or current) measurements were made along the line, the resultant voltage would be the vector sum of the voltage of the incident wave traveling toward the load from the source and the reflected wave traveling back from the load to the source. The ratio of the maximum voltage measured along the line to the minimum voltage measured along the line is call the standing wave ratio (SWR).

$$S = \frac{Vmax}{Vmin} = \left(|E1| + \frac{|E2|}{|E1|} - |E2| \right) \qquad (1)$$

where,

E1 - incident waveform voltage
E2 - reflected waveform voltage.

The ratio of E2 to E1 is call the reflection coefficient.

$$\rho = \frac{E2}{E1} = \frac{ZL - ZO}{ZL + ZO} \qquad (2)$$

where,

ZL - load impedance
ZO - characteristic impedance

or,

$$|\rho| = \frac{S - 1}{S + 1} \qquad (3)$$

The points of maximum voltage and minimum voltage are always a half-wave length ($\lambda/2$) apart along the transmission line, where,

$\lambda = 3 \times 10^8/f$ meters for air

and,

f - frequency of the signal in Hertz.

When comparing the SWR for the voltage along the line and the SWR for the current along the line, they will always be a quarter-wave length ($\lambda/4$) apart. A comparison of these two SWRs is shown in Figure l for different load conditions. Notice that for an open-circuit load, the current is zero at the load, whereas for a short-circuit load, the voltage is zero. Also notice that when the transmission line is terminated in its characteristic impedance, there is no SWR, or there is no reflected wave and all the energy is absorbed by the load. It can also be noticed in Figure 1a through F1gure 1e that the first minimum and maximum points from the load stay at the same point ($\lambda/4$) for resistive loads but shift when the load becomes reactive -- up to one-eighth-wave length ($\lambda/8$) for a purely reactive load (Figure 1f through Figure 1g). It is possible with the aid of a Smith chart to readily determine unknown loads if the SWR and the shift in the minimum or maximum of the SWR is known for that load. A slotted line (or slotted coaxial line) and a SWR detector can be used for this purpose.

For example, a certain load has a SWR = 2 with a minimum at some point along a slotted line. When a short-circuit replaced the load, the minimum moved to a new point toward the load six (6) centimeters from the first. Assuming a wavelength for the signal of sixty (60) centimeters, the shift in wavelength is six divided by sixty or 0.1. To find the unknown impedance, first draw a circle on the Smith chart representing a SWR = 2 as shown in Figure 3. Next, since the distance from a minimum to a minimum was measured TOWARD the load, a line is drawn from the center of the circle to the outer edge of the Smith chart at the point representing that shift. The intersection of this line with the drawn circle gives the impedance, i.e.,

$$ZL = ZO\left(\frac{R}{ZO} \pm \frac{X}{ZO}\right) = 50(0.68 - j0.48) = 34 - j24 \quad \text{ohms} \qquad (4)$$

<u>PRELIMINARY</u>

P-1. Repeat the example in the introduction assuming maximum measurements instead of minimum measurements (Instructor check Smith chart).

P-2. Show on the Smith chart where a load of ZL = 0 + j 100 ohms would be assuming ZO = 50 ohms and zero attenuation (Instructor check Smith chart).

P-3. For P-2 above and assuming a frequency of 500 mHz, how many wavelengths from the load would be the first maximum? The first minimum?

λ-maximum = ___________________

λ-minimum = ___________________

(INSTRUCTOR'S SIGNATURE_____________________________DATE____________)

PROCEDURE

F-1. Connect the slotted-line apparatus as shown in Figure 2.

F-2. For a 500 MHz input signal, take data to plot the standing waves for a short-circuit, an open-circuit, and a 50-ohm load.

F-3. Obtain the minimum and maximum values and locations for three unknown loads.

REPORT

R-1. Plot the normalized data from F-2 above on one sheet of centimeter graph paper, each on a separate axis.

R-2. Use the Smith chart to determine the unknown loads of F-3 above.

R-3. Determine the reflection coefficient and angle for each unknown.

R-4. Discuss the results.