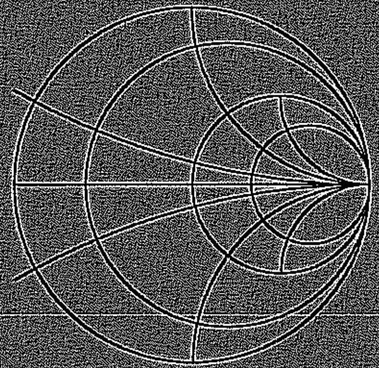

Microwave Measurements Laboratory

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Stripline Measurements

Laboratory Notes

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PART A: TIME-DOMAIN MEASUREMENTS

Introduction

The objeact of this part of the lab is to gain experience in the use of Time-Domain Reflectometry (TDR) and Time-Domain Transmission (TDT) a) as an exploratory troubleshooting technique, and b) as a measuring tool. The time-domain signals are useful for locating faults in devices that are under development, and in guiding one in taking corrective measures. One should be aware that the step function is a very broad-band signal, and consequently not all the responses seen are of interest in the operating band of the device under test (DUT). A corollary of this is that the precision of time-domain measurement of impedance is limited because the power in any given (limited) frequency range is not great.

Procedure

Interpretation of TDR Signals

1. Connect a signal cable to the TDR, set the vertical scale to 400 mV full scale, and adjust the time scale (and delay; reference the delay to the left hand side rather than the center)) so that you can see both the step corresponding to the launching of the input pulse and the one corresponding to the reflection from the unterminated end of the cable.

2. Verify that the TDR is calibrated (the initial step should correspond to 200 mV; what should the open-end reflection be?); if it is not, remove the signal cable and calibrate the TDR using a 50 Ω termination and a short.

3. Readjust the time delay so that the reflected pulse is just visible at the left edge of the display, and the vertical scale to 200 mV full scale with a 200 mV offset (so that the input pulse is at the vertical baseline of the display). Remove the upper half-tube of the wire assembly, connect the TDR scope to the input end, leaving the downstream end *un*terminated, and re-adjust the time scale (but *not* the delay) so that the reflection from the unterminated end of the wire is fully visible at the right-hand edge of the screen. (You can confirm the identity of this reflection by attaching a terminating resistor and noting the point at which it affects the TDR response.)

Q. Is the step from the unterminated end of the wire the same size as that seen in step 2? If not, why not?

4. Identify the sources and nature of the reflections by first grounding yourself, and then locating the positions corresponding to the various reflections by contacting the circuit with a conducting probe. In particular,contact the cable at various points along its length to confirm that you correctly identified the end-reflection in step 3, and, using an expanded time scale, examine in detail the region in the neighborhood of the input matching network. Save the original (probe-less) trace as a reference.

Q. Referring to Figure 5 in the supplementary notes on Wire Measurement of Impedance, assuming that $R_1 = 164\ \Omega$ *and* $R_2 = 58\ \Omega$*, and that the downstream series resistor is* $R_s = 140\ \Omega$*, estimate the line impedance* R_W.

5. Repeat step 4 with the TDR connected to the *downstream* end of the wire (examining in detail the region in the neighborhood of the series resistor.

Q. From the new data, estimate the line impedance . Do you feel that this measurement is more accurate than the one made in step 4? If so, why.

6. Replace the upper half of the reference tube and note any changes in the trace.

Q. How much did the impedance change? Does the result surprise you?

Q. Will any of the reflections introduce significant error in the NWA measurement of this device at frequencies below about 2 GHz? (Hint: Look for reflections lasting more than about a half-period)

7. Record as a new reference the trace from (3). Replace the upper half of the reference tube by the shell which contains the (single-sided)stripline; terminate the two outputs of the stripline, and compare the new trace with the reference.

Q. Is the stripline visible on the new trace?

Measuring the Pickup Response (TDT)

For these measurements, it is necessary to use a matched input, i.e. to inject the signal at the *up*stream end. Because of the input network attenuation, the output current is a poor reference, although it is the proper one. Instead, we will reference (divide) the pickup signal to (by) the *input* pulse.

5. Connect the pulse to the TDT input through a "barrel" and record the pulse amplitude.

6. Connect the pulse to the *up*strem (input) end of the reference wire, and the TDT to the *upstream* stripline (pickup) port. Observe the double-pulse nature of the signal; measure the amplitude and duration of the signal.

Q. Calculate Z_p using

$$Z_p = \frac{2R_o}{A_1}\frac{V_p}{V_{in}}$$

(This result will probably not be very accurate.)

Q. From the pulse duration, estimate the length of the stripline.

Observing the Quality of the Stripline

7. Move the TDT to the *downstream* stripline port.

Q. Is there significant content at frequencies below 2 GHz in the signal? (How directional is the stripline in its fundamental band?)

8. Connect the TDR to the *upstream* end of the stripline (and leave the downstream end *unterminated*)

Q. What is the line impedance of the stripline?

Q. What is the apparent length of the stripline? Is this different from the result in 6? If so, why?

9. Terminate the downstream end of the stripline.

Q. What differences do you notice? Which configuration gives you a more accurate answer to the questions in 8?

PART B: FREQUENCY-DOMAIN MEASUREMENTS

Introduction

The object of this part of the lab is to learn to use the NWA to measure the characteristics of a stripline electrode, as well as to become familiar with the wire-method of impedance measurement. The results of these measurements can be compared for internal consistency, as well as with the calculated (idealized) values.

Procedure

1. Set up the NWA as follows:

Sweep-300 kHz to 2.3 GHz, 801 points

and do a full 2-port calibration using the same cables you will be employing for the actual measurement. (Use the female-female "barrel" for the "thru" calibration; omit the "isolation" measurement.)

2. Set up the wire reference assembly (i.e. use the upper half-cylinder *without* the stripline electrode), connect the NWA to the wire with port 2 attached to the *downstream* end (the one with the single series resistor, rather than the matching network), measure S_{21}, and store it (use the DATA TO MEMORY key) for use as S_{REF}.

Q. Does S_{21} *agree with the expected attenuations of* $A_1 = .14$ *and* $A_2 = 1$*?*

3. Replace the bare upper half cylinder with the one containing the stripline electrode, and terminate both its outputs. Measure S_{21} of the wire (S_{THRU}),and take its ratio to S_{REF} (use the "DATA/MEM" display on the NWA).

Q. Calculate Z_B *at the two minima of the ratio; use*

$$Z_B = 2R_w\left(\frac{S_{REF}}{S_{THRU}} - 1\right) \qquad \text{(B.1)}$$

(Eqs. B.1 and B.2 are just Eqs. 1b and 2 in CBP Tech Note-122, with S_{21}*replaced by* S_{THRU}*)*

4. Store S_{THRU} (replacing S_{REF} in memory). Connect port 2 of the NWA to the *upstream* output of the stripline and terminate the downstream end of the wire. Measure S_{21} (= S_{p1}) and take its ratio to S_{THRU}

Q. Calculate

$$Z_p = \frac{V_p}{I_e} = R_o \frac{S_{p1}}{S_{THRU}} \tag{B.2}$$

at the first two impedance maxima of the ratio.

Q. How does the above value for g compare with the numerically calculated value of g = 0.31?

Q. Assuming the g-factor to be purely geometric, i.e. $Max[Z_p] = R_w \varphi_w / 2\pi$*, calculate the effective width* φ_w *of the stripline*

Q. Calculate $Re[Z_B]$ *from the power balance,*

$$P = 1/2\, I_e^2\, Re[Z_B] = 1/2\, (I_e Z_p)^2/R_o \tag{B.3a}$$

i.e.

$$Re[Z_B] = (Z_p)^2/R_o \tag{B.3b}$$

Compare this with the result in (3) above and with an idealized

$$Z_B = R_{\|}/4 = g^2 R_L/4, \text{ with } g = 0.31$$

5. Observe the frequency at the two zeroes of S_{p1} /S_{REF}

Q. Calculate the effective length of the stripline. Is this the expected value of l + 1/2 end gap? Why do we expect the effective length to be l + 1/2 end gap?

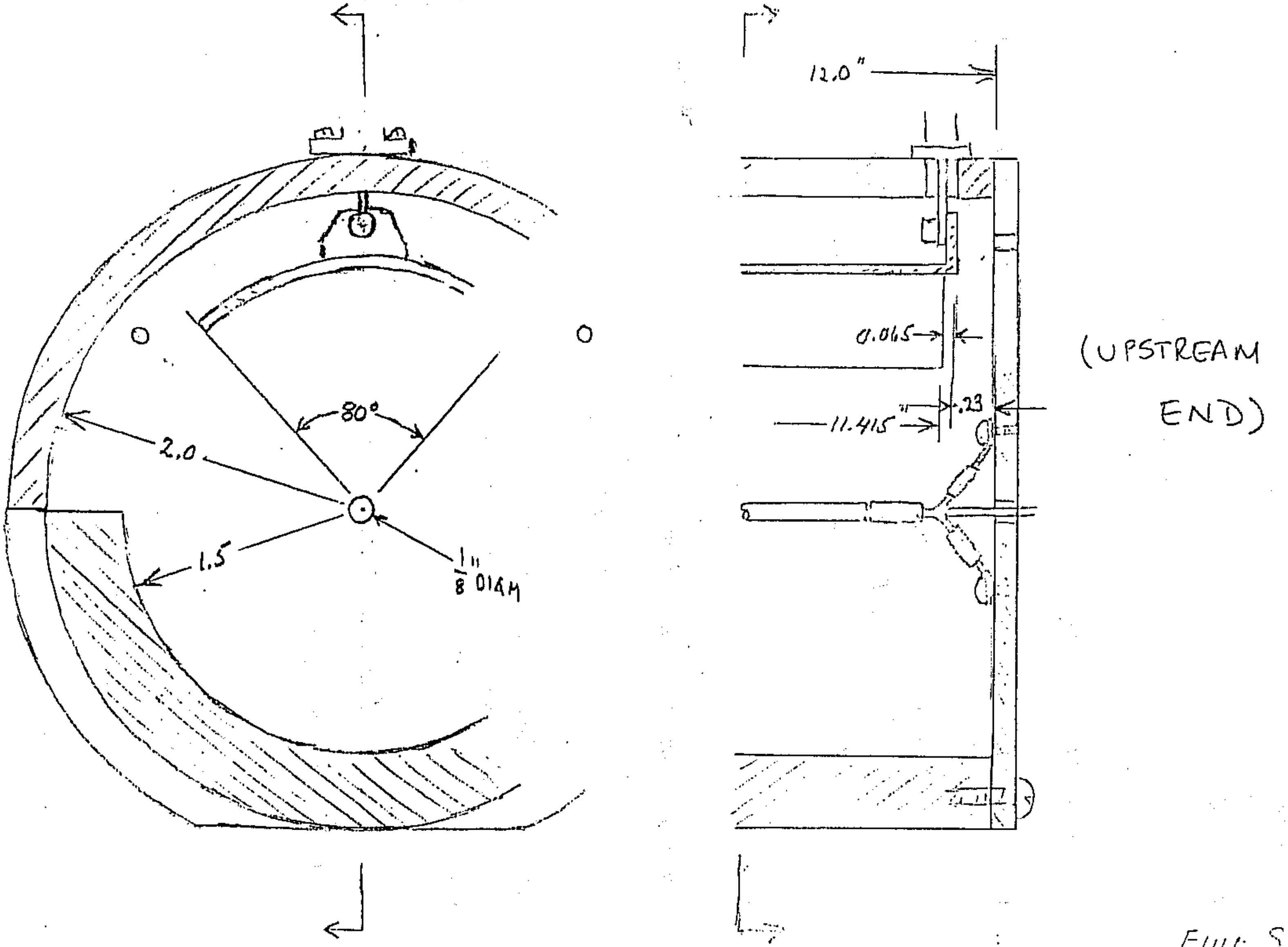
6. Connect port 2 of the NWA to the *downstream* stripline port (and terminate the upstream port)

Q. Why is this output not zero?

Q. What fraction of Z_p *and* P_p *appears here?*

AMPAD 22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

STRIPLINE ASSEMBLY



FULL SIZE