ELECTRICAL ENGINEERING DEPARTMENT

California Polytechnic State University

SIGNAL TRANSMISSION LABORATORY

EE 353

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ELECTRICAL ENGINEERING DEPARTMENT
California Polytechnic State University

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ELECTRICAL ENGINEERING DEPARTMENT
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EE 353	The Network Analyzer	Lab 1

Purpose

To become familiar with the operation and capabilities of a Network Analyzer (HP 8754A) for transmission and reflection measurements.

References

HP 8754A	Network Analyzer Operating Manual
HP 8502A	Transmission/Reflection Test Set Operating Manual

Equipment

HP 8754A	Network Analyzer
HP 8502A	Tranmission/Reflection Test Set
Fluke 7220A	Frequency Counter
HP 11851A	RF Cable Kit
GR 874-WO3	Open-Circuit Termination
GR 874-WN3	Short-Circuit Termination
GR 874-W50B	50 Ω Termination
GR 874-G10	10 dB Attenuator
GR 874-FXXXX	Low-Pass Filter (XXXX = cutoff-frequency in MHz)
GR 874-L20	20 cm Fixed-Length Air Line
GR 874-M or ML	Unknown Load (component mount)
Fittings & Accessories	

Part I: Transmission Measurement Calibration of the HP 8754A Network Analyzer

1) Connect the HP 8754A to the HP 8502A Test Set as shown on the next page.

A) HP 8754A Network Analyzer Settings

1) Polar A/R: toggles between complex plane display of the reflection coefficient (over the defined frequency range, see below) and a linear display of gain and/or phase *vs*. frequency. Depress button to obtain polar display. Set origin for polar plots: Press Polar Center button and adjust position of origin. Release to obtain linear display.
2) Freq: select center. Center of linear display (horizontal axis) corresponds to the displayed frequency.
3) Sweep: auto/fast, knob controls sweep speed (turn clockwise to display solid line).
4) Video Filter: turn off (limits bandwidth of sweep frequency).
5) Tuning: initially set to 750 MHz.

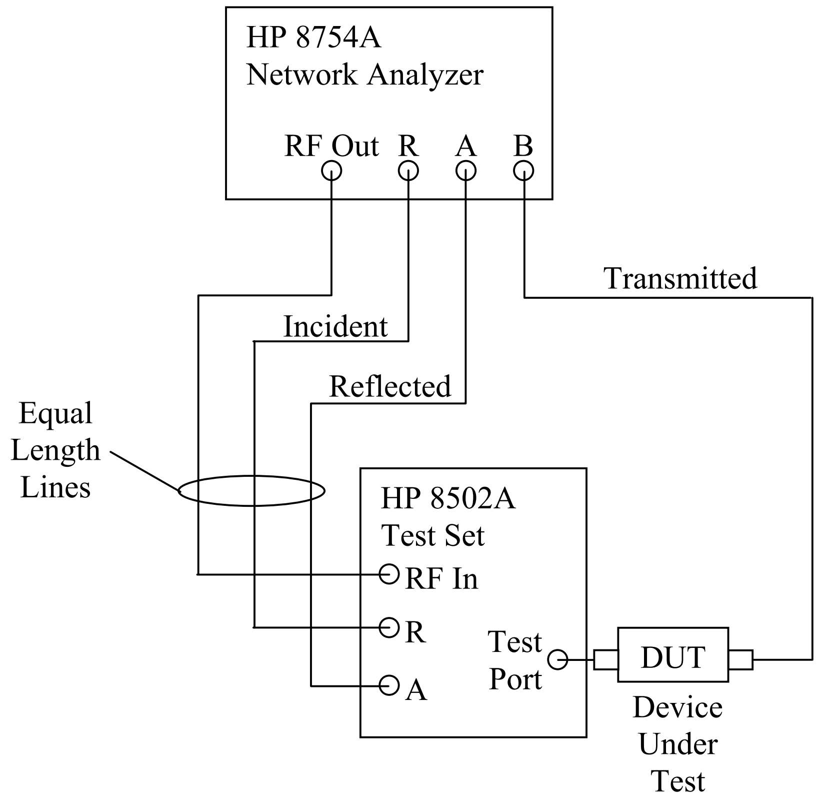

Figure 1: Configuration for Transmission Measurement

6) Markers: set to 50 MHz spacing. Note: with sweep width set to full range (4 – 1300 MHz) and markers off, one marker will remain at the displayed frequency.
7) Output dBm: set to < 0 dBm to avoid saturating the R, A, and B inputs.
8) Intensity: turn clockwise until trace can be seen.
9) Focus: self-explanatory.
10) Stability: N/A
11) Reference positions (Ch 1 and 2): set to desired locations. Release reference buttons to take measurements.
12) Channel 1:
    a) Offset: press button to allow for corrections.
    b) Select B/R ('thru') measurement.
    c) Sensitivity: set to 10 dB/div.
13) Channel 2:
    a) Offset: press button to allow for corrections.
    b) Select Phase B/R measurement (green button).
    c) Sensitivity: set to 45 ^{o}/div (green scale).

The above channel settings enable a simultaneous display of dB magnitude and phase for the device under test (DUT).

B) Transmission Measurement Calibration of the HP 8754A Network Analyzer

1) Connect the RF Output of the HP 8754A to the Fluke 7220A frequency counter (50 Ω input) and calibrate the HP 8754A frequency display.
2) Set the RF Input Attenuation knob for the HP 8502A Test Set to 0 dB.
3) Connect a 'thru' for the device under test (DUT).
4) Set CRT display on HP 8754A to linear (release polar A/R button), sweep: auto, fast, knob turned to right, output dBm: set to < 0 dBm.
5) Channel 1: select B/R, set reference wheel to 0, press offset button and adjust until the Ch. 1 reference level is obtained (calibrates magnitude level to the DUT plane).
6) Channel 2: select Phase B/R, set reference wheel to 0, press offset button and adjust until the Ch. 2 reference level is obtained (calibrates phase level to the DUT plane).

<u>Part II</u>: Transmission Measurements

1) Replace 'thru' with a 10 dB pad (GR 874-G10).
2) Copy CRT display on the HP 8754A. For any CRT display, record gain and phase separately, if desired.
3) Reset sweep width to 200 MHz and copy CRT display.
4) Reset sweep width to entire range (4 – 1300 MHz) and copy CRT display.
5) Replace 10 dB pad with a low-pass filter (GR 874-FXXXX).
6) Reset Freq to 500 MHz or 1000 MHz (as appropriate), widen sweep width (try 500 MHz), and adjust Ch. 1 and 2 reference levels to fit responses within CRT display. Determine the filter's corner frequency, roll-off slope (dB/dec), and sketch the CRT display.
7) Replace low-pass filter with a 20 cm air line (GR 874-L20) and copy CRT display. Calculate expected phase slope (deg/MHz) and compare to measurements.
8) Reset sweep width to entire range (4 – 1300 MHz) and copy CRT display.

<u>Part III</u>: Reflection Measurement Calibration of the HP 8754A Network Analyzer

A) HP 8754A Network Analyzer Settings

1) Polar A/R: Depress to obtain polar display.
2) Freq: select center.
3) Sweep: auto/fast, knob controls sweep speed (turn clockwise to display solid line).
4) Video Filter: turn off (limits bandwidth of sweep frequency).
5) Tuning: set to 750 MHz.
6) Sweep Width: set to 0.
7) Markers: turn off (disabled in polar display).
8) Output dBm: set to < 0 dBm to avoid saturating the R, A, and B inputs.
9) Intensity: turn clockwise until trace can be seen.
10) Focus: self-explanatory.
11) Stability: N/A
12) Reference positions (Ch 1 and 2): N/A in polar display.
13) Channel 1:

a) Offset: press button to allow for corrections.
b) Select A/R (reflection) measurement.
c) Sensitivity: disabled in polar display.

14) Channel 2:
a) Disabled in polar display.

B) Reflection Measurement Calibration of the HP 8754A Network Analyzer

1) Connect the RF Output of the HP 8754A to the Fluke 7220A frequency counter and calibrate the HP 8754A frequency display, if necessary.
2) Connect the HP 8754A to the HP 8502A Test Set as follows:

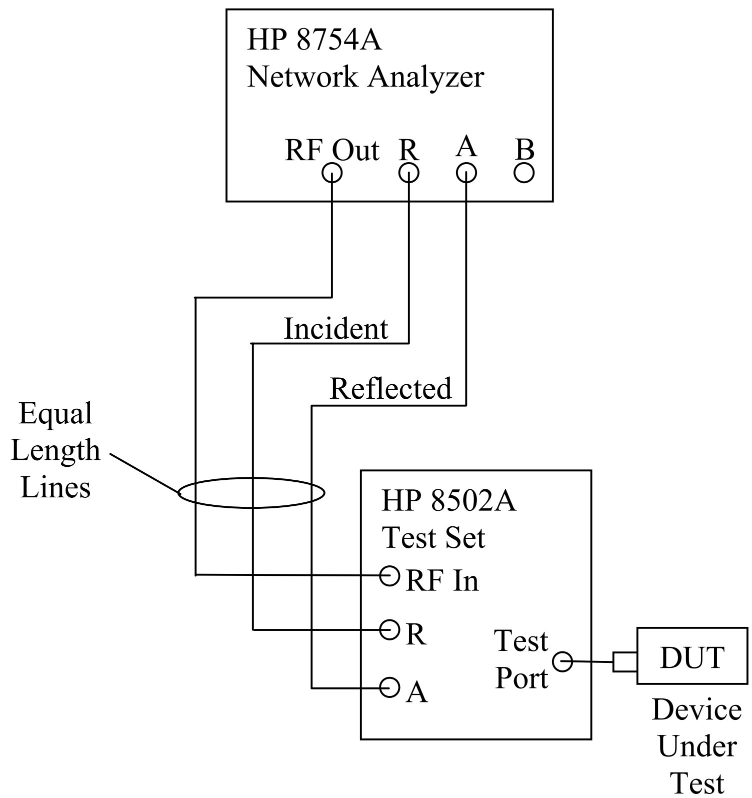

Figure 2: Configuration for Reflection Measurement

3) Set the RF Input Attenuation knob for the HP 8502A Test Set to 0 dB.
4) Connect a short (GR 874-WN3) for the device under test (DUT).
5) Adjust Ch. 1 offset to obtain a magnitude of 1.
6) Adjust Ch. 1 line length to obtain phase of 180^{o}. May also require an adjustment of the Ch. 2 reference wheel: use Ch. 1 line length to fine tune.

<u>Part IV</u>: Reflection Measurements

1) Replace short with unknown load (GR 874-M or 874-ML).

2) Record the value (magnitude and phase) of the reflection coefficient for the unknown load. Convert to the actual load impedance.
3) Replace the unknown load with a 50 Ω termination (GR 874-W50B) and repeat step #2 above.

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EE 353 | Impedance Measurement by λ/2 and λ/4 Lines | Lab 2

<u>Purpose</u>

To use λ/2 and λ/4 lines as measurement aids and to verify transmission line theory for λ/2 and λ/4 lines.

<u>References</u>

EE 313 Text	*Fundamentals of Microwave Transmission Lines*, Jon C. Freeman
HP 8754A	Network Analyzer Operating Manual
HP 8502A	Transmission/Reflection Test Set Operating Manual

<u>Equipment</u>

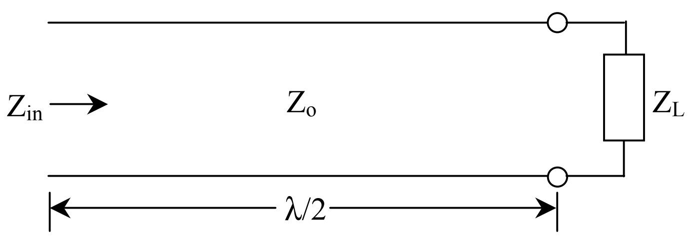
HP 8754A	Network Analyzer
HP 8502A	Tranmission/Reflection Test Set
Fluke 7220A	Frequency Counter
HP 11851A	RF Cable Kit
GR 874-WO3	Open-Circuit Termination
GR 874-WN3	Short-Circuit Termination
GR 874-L20	20 cm Fixed-Length Air Line
GR 874-LK10	10 cm Adjustable Air Line (35 cm to 45 cm)
GR 874-LK20	20 cm Adjustable Air Line (60 cm to 80 cm)
GR 874-M or ML	Unknown Load (component mount)
Fittings & Accessories	

<u>Theory</u>

Using equation (5.24a) in the text for lossless transmission lines:

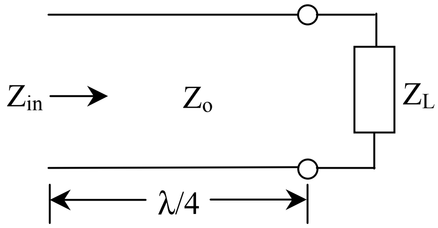
$$Z_{in}(-l) = Z_o \frac{Z_L + jZ_o \tan(\beta l)}{Z_o + jZ_L \tan(\beta l)} \tag{1}$$

the input impedance for a transmission line λ/2 long is



$$Z_{in} = Z_L$$

For transmission lines λ/4 long,



$$Z_{in} = \frac{Z_o^2}{Z_L}$$

<u>Part I</u>: Reflection Measurements using λ/2 line

1) Connect the HP 8502A to the HP 8754A as shown in Figure 2 of Lab #1 for reflection measurements. Set sweep width to 0.
2) Choose an operating frequency between 500 MHz and 800 MHz and calibrate for reflection measurements as per Part III of Lab #1.
3) Connect an adjustable air line (GR 874-LK10L or 874-LK20L) to the test port of the HP 8502A.
4) Terminate the line with a short (GR 874-WN3). Adjust the length of the air line to obtain a –1 display on the CRT (may require additional fixed-length air lines). This sets the length to a multiple of a half-wavelength.

   Note: the adjustable lines have a locking clamp which can be used to fix the length. Loosen the clamp for adjustment and tighten when the correct length has been found.

5) Replace the short-circuit termination with the unknown load (GR 874-M or 874-ML). Record the reflection coefficient (polar display, magnitude and phase).
6) Convert the reflection coefficient into the actual load impedance. Assume Z_o = 50 Ω.

<u>Part II</u>: Reflection Measurements using λ/4 line

1) Replace the unknown load with an open termination (GR 874-WO3). Adjust the length of the air line to obtain a –1 display on the CRT (may require additional fixed-length air lines). This sets the length to an odd multiple of a quarter-wavelength.
2) Replace the open with the unknown load (GR 874-M or 874-ML) and record the position of the reflection coefficient (polar display, magnitude and phase).
3) Convert the reflection coefficients obtained into the actual load impedance. Assume Z_o = 50 Ω. Compare to the value obtained in Part I and explain any discrepancies.

<u>Part III</u>: Propagation Velocity

1) Replace the adjustable air line with a fixed-length 20 cm line (GR 874-L20) and terminate the line with a short (GR 874-WN3).
2) Adjust the signal frequency of the HP 8754A to obtain a –1 display on the CRT. This sets the length of the line to λ/2.
3) Compute the propagation velocity V_p using the formula $V_p = f\lambda$. Compare to *c*.

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EE 353	Transmission Line Parameters	Lab 3

Purpose

To determine the transmission line parameters for an RG-8U cable.

References

EE 313 Text	*Fundamentals of Microwave Transmission Lines*, Jon C. Freeman
HP 8754A	Network Analyzer Operating Manual
HP 8502A	Transmission/Reflection Test Set Operating Manual

Equipment

HP 8754A	Network Analyzer
HP 8502A	Tranmission/Reflection Test Set
Fluke 7220A	Frequency Counter
HP 11851A	RF Cable Kit
GR 874-WO3	Open-Circuit Termination
GR 874-WN3	Short-Circuit Termination
RG-8U Cable	
Fittings & Accessories	
Smith Charts	

Theory

Using equation (5.24a) in the text for lossy transmission lines ($\alpha \neq 0$):

$$Z_{in}(-l) = Z_o \frac{Z_L + Z_o \tanh(\gamma l)}{Z_o + Z_L \tanh(\gamma l)} \tag{1}$$

the input impedance of a transmission line of length *l* terminated in a short-circuit has the value

$$Z_{in}^{short} = Z_o \tanh(\gamma l) \tag{2}$$

For the same line terminated in an open-circuit, the input impedance is given by

$$Z_{in}^{open} = Z_o \coth(\gamma l) \tag{3}$$

where $\gamma = \alpha + j\beta$, γ = propagation factor, α = attenuation factor (Np/m), β = phase factor (rad/m). Multiplying equation (2) by (3) yields,

$$Z_o = \sqrt{Z_{in}^{short} Z_{in}^{open}} \tag{4}$$

Dividing equation (2) by (3) results in,

$$\tanh(\gamma l) = \sqrt{\frac{Z_{in}^{short}}{Z_{in}^{open}}} = \frac{e^{2\gamma l} - 1}{e^{2\gamma l} + 1} \tag{5}$$

Solving for the exponential in (5),

$$e^{2\gamma l} = \frac{1 + \sqrt{\frac{Z_{in}^{short}}{Z_{in}^{open}}}}{1 - \sqrt{\frac{Z_{in}^{short}}{Z_{in}^{open}}}} \tag{6}$$

and taking the natural logarithm of both sides of (6) yields,

$$\gamma l = \alpha l + j\beta l = \frac{1}{2} \ln\left(\frac{1 + \sqrt{\frac{Z_{in}^{short}}{Z_{in}^{open}}}}{1 - \sqrt{\frac{Z_{in}^{short}}{Z_{in}^{open}}}} \right) \tag{7}$$

Defining

$$x = \frac{1 + \sqrt{\frac{Z_{in}^{short}}{Z_{in}^{open}}}}{1 - \sqrt{\frac{Z_{in}^{short}}{Z_{in}^{open}}}} \tag{8}$$

and solving for α in (7) yields,

$$\alpha = \frac{1}{2l} \ln(|x|) \tag{9}$$

Solving for β in (7),

$$\beta = \frac{1}{2l} \left[angle(x) + 2\pi n \right] \tag{10}$$

Part I: Reflection Coefficient Measurements

1) Connect the HP 8502A to the HP 8754A for reflection measurements as shown in Figure 2 of Lab #1.
2) Set the HP 8754A to 35 MHz and calibrate for reflection measurements as per Part III of Lab #1.
3) Connect the RG-8U cable to the test port of the HP 8502A Test Set.
4) Terminate the cable with a short (GR 874-WN3) and record the reflection coefficient (polar display).
5) Determine the value *n* in equation (10):
   a) Reduce the frequency setting on the HP 8754A to zero (cursor should be close to -1). At zero frequency, the electrical length of the cable is 0λ.
   b) Slowly increase the frequency up to the test frequency and note the number of full revolutions on the display. This is the value *n*: the electrical length of the cable at the test frequency is *n* full half-wavelengths.
6) Replace the short with an open termination (GR 874-WO3) and record the reflection coefficient (polar display).
7) Convert the reflection coefficients obtained in steps #4 and #5 above into Z_{in}^{short} and Z_{in}^{open} using a Smith Chart. Assume $Z_o = 50\ \Omega$.
8) Repeat steps #2 (cal only), and #3 through #6 above for frequencies of 500 MHz through 1000 MHz in steps of 100 MHz. For step #7, use a computer program to compute Z_{in}^{short} and Z_{in}^{open} from the measured reflection coefficients.

Part II: Computation of Transmission Line Parameters

1) Calculate Z_o, α, and β for all frequencies using equations (4), (9), and (10), respectively. A computer program may be used to facilitate these calculations.
2) Compute the velocity factor for the cable using

$$velocity\ factor = \frac{propagation\ velocity\ on\ transmission\ line}{velocity\ of\ light\ in\ free\ space} \tag{11}$$

3) Calculate the distributed component values *L* and *C* using the relations

$$\beta = \omega\sqrt{LC} \tag{12}$$

$$Z_o = \sqrt{\frac{L}{C}} \tag{13}$$

4) Compare the calculated parameters Z_o, α, β, *L*, and *C* for all frequencies and justify any discrepancies. Include a derivation for α and β using equations (6) and (8).

5) In Part I, step 5b, why does the trace rotate in the clockwise direction as the frequency is increased?

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EE 353	Use of the Smith Chart for Line-Length and Line-Loss Corrections	Lab 4

Purpose

To learn Smith Chart techniques to correct for line-length and line-loss errors caused by transmission lines.

References

EE 313 Text	*Fundamentals of Microwave Transmission Lines*, Jon C. Freeman
HP 8754A	Network Analyzer Operating Manual
HP 8502A	Transmission/Reflection Test Set Operating Manual

Equipment

HP 8754A	Network Analyzer
HP 8502A	Transmission/Reflection Test Set
Fluke 7220A	Frequency Counter
HP 11851A	RF Cable Kit
GR 874-WN3	Short-Circuit Termination
GR 874-M or ML	Unknown Load (component mount)
RG-8U Cable	
Fittings & Accessories	
Smith Charts	

Part I: Reflection Coefficient Measurements

1) Connect the HP 8502A to the HP 8754A for reflection measurements as shown in Figure 2 of Lab #1.
2) Set the HP 8754A to 1000 MHz and calibrate for reflection measurements as per Part III of Lab #1.
3) Connect the RG-8U cable to the test port of the HP 8502A Test Set and terminate the cable with a short (GR 874-WN3). Record the reflection coefficient (polar display).
4) Plot the reflection coefficient on a Smith Chart and find the electrical length in wavelengths and return loss of the cable in dB.
5) Replace the short-circuit termination with the unknown load (GR 874-M or 874-ML). Record the reflection coefficient (polar display), Γ_{+cable}.
6) Remove the RG-8U cable and connect the unknown load directly to the test port of the HP 8502A Test Set. Record the reflection coefficient (polar display), Γ_{load}.
7) Plot the reflection coefficients obtained from steps #5 and #6 on a Smith Chart. Apply line-length and line-loss corrections to Γ_{+cable} and compare to the actual reflection coefficient, Γ_{load}.

8) Convert both the corrected and actual reflection coefficients into the load impedances $Z_{L(corrected)}$ and $Z_{L(actual)}$, respectively. Assume $Z_o = 50\ \Omega$.
9) Repeat steps #2 (cal only), and #3 through #8 above for a frequency of 35 MHz.

Part II: Conclusions

1) Compare the pairs of values for Γ and Z_L computed at 1000 MHz and 35 MHz. Determine length and loss errors in λ and dB, respectively, and justify any discrepancies.

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EE 353	The Slotted Line Technique in Impedance Measurements	Lab 5

Purpose

To learn the use of the slotted line in impedance and SWR measurements.

References

EE 313 Text	*Fundamentals of Microwave Transmission Lines*, Jon C. Freeman
GR 874-LBA or LBB	Slotted Line Operating Manual
HP 415B	Standing Wave Indicator Operating Manual

Equipment

GR 874-LBA or LBB	Slotted Line
HP 415B	Standing Wave Indicator
Fluke 6060B	RF Signal Generator
GR 874-WN3	Short-Circuit Termination
GR 874-D20	Adjustable Stub (26 cm to 46 cm)
GR 874-M or ML	Unknown Load (component mount)
RG-8U Cable	
Fittings & Accessories	
Smith Charts	

Part I: SWR Measurement Calibration of the GR 874-LBA or LBB Slotted Line and HP 415B Standing Wave Indicator

A) HP 415B Standing Wave Indicator Settings

1) Input Selector: set to Xtal, 200 kΩ (this is the type of detector used on the slotted line)
2) Range: 30 dB position
3) Bolo Bias Current: N/A when selector is set to Xtal.
4) Meter Scale: Normal (black scale). Allows measurement of SWR from 1 to ∞ (expanded scale only allows a maximum of 1.3: this is for precision measurements on well-matched lines).
5) Gain: to be adjusted while taking measurements. Initial setting: turn completely in the clockwise direction.
6) Indicator: shows detected power (square-law detector: $indicator \propto |E|^2 \propto P$)

B) Fluke 6060B RF Generator Settings

1) Parameter data entry: press function key (i.e.: Freq, Ampl, AM, etc.), enter value, then press unit (i.e.: MHz/V, dBm, etc.)
2) Set Freq to 500 MHz, Ampl to 0 dBm, and AM to 50%.
3) Press INT AM and select 1000 Hz by pressing the 400/1000 key. The INT AM key turns on the amplitude modulation function (internally triggered). The AM setting specifies the duty cycle of the waveform.

C) SWR Calibration and Measurement Procedure

1) Connect the Fluke 6060B, adjustable stub (GR 874-D20), and short (GR 874-WN3) to the slotted line (GR 874-LBA or LBB) as follows:

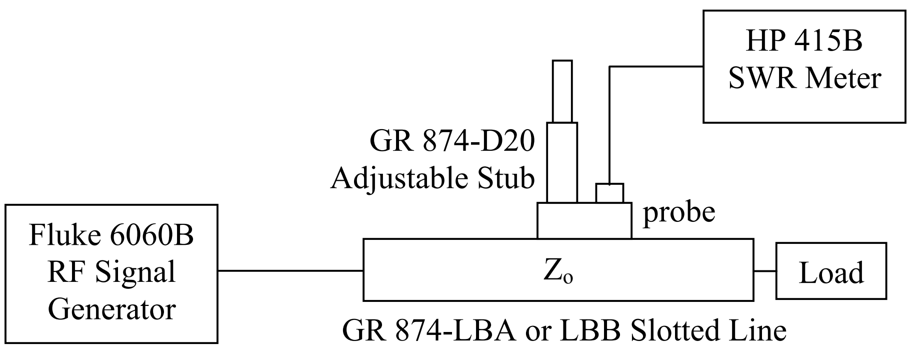

Figure 3: Configuration for Slotted Line Measurements

2) Adjust probe position on the slotted line until the HP 415B detects a peak. This may require adjustment of the stub (GR 874-D20) length.
3) Adjust stub (GR 874-D20) length for maximum deflection on the HP 415B SWR meter. Simultaneously adjust the gain knob to avoid 'pinning' the SWR indicator needle. Note: the stub length adjustment is very sensitive. The proper length improves the match from the slotted line to the probe which enhances power transfer to the SWR meter.
4) Adjust the gain dial to obtain a needle deflection at exactly SWR=1. Verify that the peak has been found by moving the probe along the slotted line around the peak position and resetting to SWR=1 if necessary.
5) To measure SWR, move the probe to the minimum power position (left deflection) and note SWR. For a short-circuit termination, the SWR should be very high (theoretically infinity).

Part II: Wavelength and Load Measurement using the Slotted Line

1) Record two adjacent voltage minimum positions l_1 (nearest the load) and l_2 in cm on the slotted line.
2) Replace the short with the unknown load (GR 874-M or ML) and measure the SWR. Note: must recalibrate for SWR measurement (set to SWR=1 at the peak power position).

3) Record the position d_1 of the voltage minimum between l_1 and l_2.
4) Repeat steps #1 through #3 above for frequency intervals of 50 MHz to 700 MHz.

Part III: Computation of the Wavelength and Load Impedance

1) Calculate the free-space wavelength in cm for the frequencies specified in step #4 of Part II above.
2) Calculate the distance between two voltage minimums (l_1 and l_2) and compare to the expected value.
3) Plot the SWR circle on a Smith Chart for each frequency tested.
4) Compute the distance between the load and voltage minimum between l_1 and l_2 produced by the unknown load (l = distance between l_1 and d_1).
5) Beginning at the voltage minimum point on the SWR circle, move along the circle in the WTL direction the distance l in λ to obtain the reflection coefficient at the load plane. Alternatively, the distance between l_2 and d_1 can be used in which case the movement along the SWR circle should be in the WTG direction. Repeat for all frequencies.
6) Convert the load plane reflection coefficient to the actual load impedance. Repeat for all frequencies.
7) Measure the load impedance with the network analyzer at all frequencies for comparison purposes.
8) Compare the calculated load impedances to the values measured by the network analyzer at all frequencies and discuss results.

ELECTRICAL ENGINEERING DEPARTMENT
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EE 353	Impedance Matching by the Single-Stub Tuning Method	Lab 6

Purpose

To match a load impedance to a transmission line using the single-stub matching technique.

References

EE 313 Text	*Fundamentals of Microwave Transmission Lines*, Jon C. Freeman
HP 8754A	Network Analyzer Operating Manual
HP 8502A	Transmission/Reflection Test Set Operating Manual

Equipment

HP 8754A	Network Analyzer
HP 8502A	Tranmission/Reflection Test Set
Fluke 7220A	Frequency Counter
HP 11851A	RF Cable Kit
GR 874-WN3	Short-Circuit Termination
GR 874-WO3	Open-Circuit Termination
GR 874-L10	10 cm Fixed-Length Air Line
GR 874-L20	20 cm Fixed-Length Air Line
GR 874-LK10	10 cm Adjustable Air Line (35 cm to 45 cm)
GR 874-LK20	20 cm Adjustable Air Line (60 cm to 80 cm)
GR 874-D20	Adjustable Stub (26 cm to 46 cm)
GR 874-M or ML	Unknown Load (component mount)
Fittings & Accessories	
Smith Charts	

Part I: Reflection Measurements and Single-Stub Matching

1) Connect the HP 8502A to the HP 8754A for reflection measurements as shown in Figure 2 of Lab #1.
2) Select a frequency between 500 MHz and 800 MHz and calibrate the HP 8754A for reflection measurements as per Part III of Lab #1.
3) Replace the short-circuit termination with the unknown load (GR 874-M or 874-ML) and record reflection coefficient (polar display). Use a Smith Chart to convert to load impedance.
4) Use a Smith Chart and the load impedance information obtained in the previous step to calculate the required lengths and locations of a single short or open-circuit

matching stub for both possible solutions. Select realizable configurations with respect to the adjustable and fixed length air line lengths (see equipment list above).

5) Insert the stub lines terminated with short (GR 874-WN3) or open circuit loads (GR 874-WO3) and series lines. Adjust the stub length and location to the design lengths calculated in step #4 above for both solutions. Record the return loss and VSWR. Determine the bandwidth for both solutions within which the return loss is greater than 10 dB.

Part II: Conclusions

1) Show all details of the load impedance determination in step #3 of Part I above.
2) Show all details of the single-stub design procedure described in step #4 of Part I above. Include Smith Chart diagrams.
3) Discuss the return loss and VSWR for both solutions. Was one design better than the other? Why?
4) Determine which of the two designs yields the widest bandwidth and why.

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EE 353	Impedance Matching by the Double-Stub Tuning Method	Lab 7

Purpose

To match a load impedance to a transmission line using the double-stub matching technique.

References

EE 313 Text	*Fundamentals of Microwave Transmission Lines*, Jon C. Freeman
HP 8754A	Network Analyzer Operating Manual
HP 8502A	Transmission/Reflection Test Set Operating Manual

Equipment

HP 8754A	Network Analyzer
HP 8502A	Tranmission/Reflection Test Set
Fluke 7220A	Frequency Counter
HP 11851A	RF Cable Kit
GR 874-WN3	Short-Circuit Termination
GR 874-WO3	Open-Circuit Termination
GR 874-L10	10 cm Fixed-Length Air Line
GR 874-L20	20 cm Fixed-Length Air Line
GR 874-LK10	10 cm Adjustable Air Line (35 cm to 45 cm)
GR 874-LK20	20 cm Adjustable Air Line (60 cm to 80 cm)
GR 874-D20	Adjustable Stub (26 cm to 46 cm)
GR 874-M or ML	Unknown Load (component mount)
Fittings & Accessories	
Smith Charts	

Part I: Reflection Measurements and Double-Stub Matching

1) Connect the HP 8502A to the HP 8754A for reflection measurements as shown in Figure 2 of Lab #1.
2) Select a frequency between 500 MHz and 800 MHz and calibrate the HP 8754A for reflection measurements as per Part III of Lab #1.
3) Replace the short-circuit termination with the unknown load (GR 874-M or 874-ML) and record reflection coefficient (polar display). Use a Smith Chart to convert to load impedance.
4) Use a Smith Chart and the load impedance information obtained in the previous step to calculate required lengths for a double-stub design (both solutions) with two stubs terminated with open-circuit, short-circuit, or a combination of open and short-circuit

loads. Account for the distance between the load and the first T adapter. Choose one of the fixed-length or adjustable air lines for the g=1 circle rotation. Select realizable configurations with respect to allowable air line lengths (see equipment list above).

5) Insert the stubs and adjust both stub lengths to the lengths calculated in step #4 above for both designs. Record the return loss and VSWR. Determine the bandwidth for both solutions within which the return loss is greater than 10 dB.

Part II: Conclusions

1) Show all details of the load impedance determination in step #3 of Part I above.
2) Show all details of the double-stub design procedure described in step #4 of Part I above. Include Smith Chart diagrams.
3) Discuss the return loss and VSWR for both solutions. Was one design better than the other? Why?
4) Determine which of the two designs yields the widest bandwidth and why.