Laboratory #9: Single-Stub Tuner Impedance Matching

I. OBJECTIVES

A two element impedance matching network is designed given load specifications.

II. INTRODUCTION

A single-stub transmission line impedance matching network is composed of a short circuited section of transmission line placed along the main signal line. The short circuited section provides an equivalent shunt susceptance. This short circuited section is a attached perpendicular to the main line as shown in Figure 1. The construction of the short circuited section is similar to the main line.

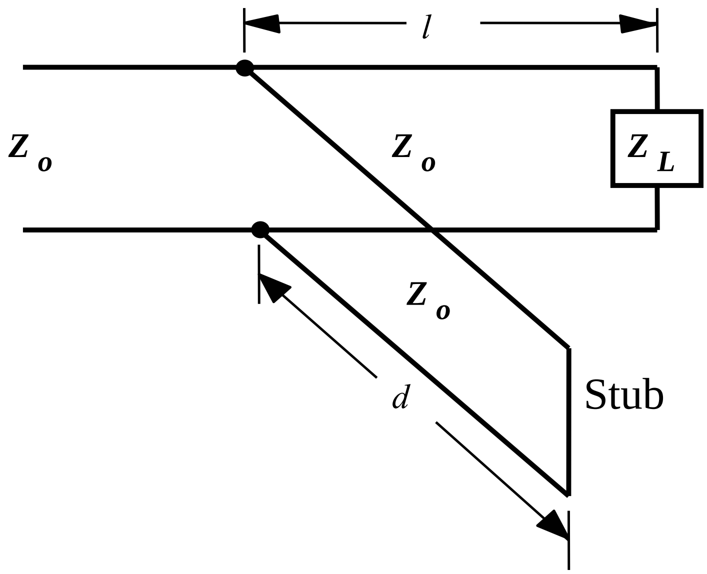

Figure 1. Terminated Transmission Line With Single-Stub Matching Stub

The load impedance is typically dependent on the frequency of operation. The distance, *d*, can be moved back and forth to get a wide range of susceptance values. The distances *l* and *d* can be found in terms of fractions of wavelength of the signal being transmitted using a Smith chart.

IMPEDANCE MATCHING USING SINGLE STUB TUNERS

The load impedance Z_L can be matched to the characteristic impedance of the transmission line Z_O using either a specified length of single short or open circuit stub placed a specified distance from the load. A short circuit single stub tunner is shown in the Figure 1.

The Smith Chart is used to determine the lengths *l* and *d*. Figure 2(a) shows short circuit single stub matching design. The load impedance is normalized relative to such that $Z_{Ln} = Z_L / Z_O$ and plotted on the chart. The Smith Chart is used to add impedances or admittances. Since the stub is parallel to the load, Z_{Ln} is converted to a normalized load admittance by reflecting the point through the normalized Z_O at the center of the chart about a constant SWR circuit to the point P_1. The distance *l* between the load and the stub is determined by moving f from P_1 via a constant SWR circle to P_2 clockwise toward the generator until the circle C_1 intersects the unity conductance circle at P_2 . The distance traveled from P_1 to P_2 via constant SWR circuit C_1 in fractions of λ is the length *l* from the load to the stub. At P_2 , the real part of the load is matched to Z_O . To cancel out the reactive component at P_2 , a constant conductance arc is drawn from P_2 to the normalized Z_O at the center of the chart. Note that traveling this arc corresponds to a movement in reactance of $-X_{P2}$. For a short circuit stub, the stub length *d* is determined by the clockwise distance toward the generator in λ from the right of the chart (indicating a short circuit conductance = ∞) to $-X_{P2}$.

A similar design is used for an open circuit stub shown in Figure 2(b), except that the stub length *d* is determined by the clockwise distance toward the generator in λ relative to left hand side of the chart corresponding to zero conductance.

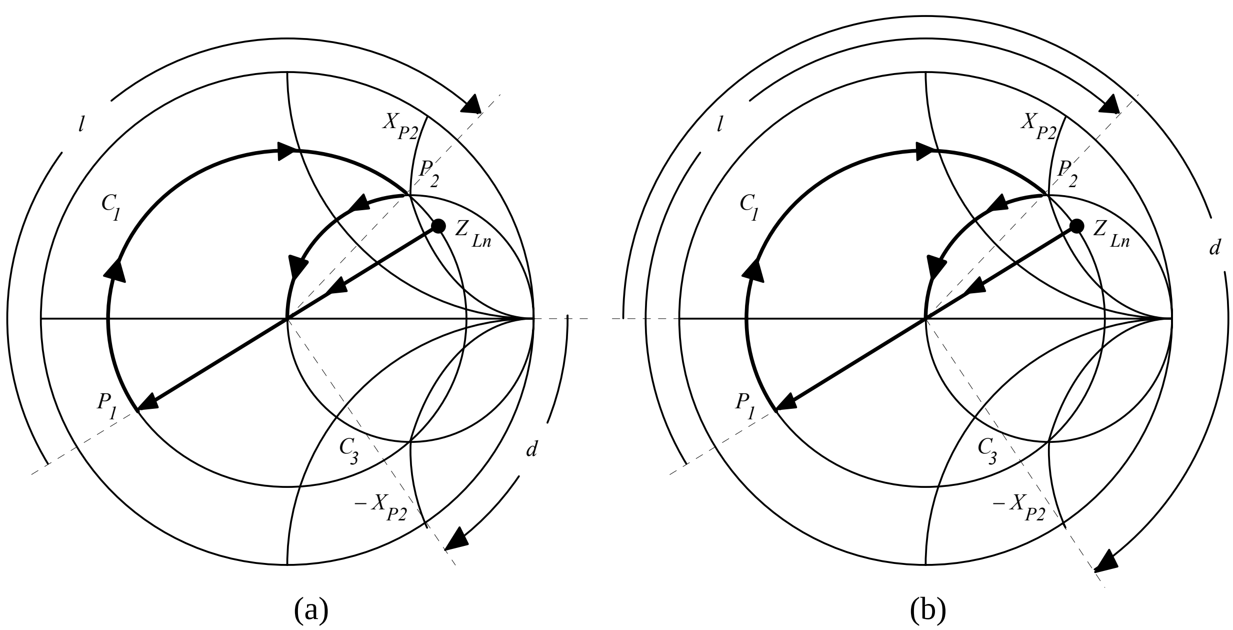

Figure 2. (a) Short and (b) Open Circuit Single Stub Tuner

Figure 3 shows an alternate length *l* that can be found for open circuit single stub tuner. In this case, the constant SWR arc of C_1 is extended to the lower half of the chart to intersect with the constant conductance circle. The lengths *l* and *d* are found as before, with both lengths being longer that the example in Figure 2(a).

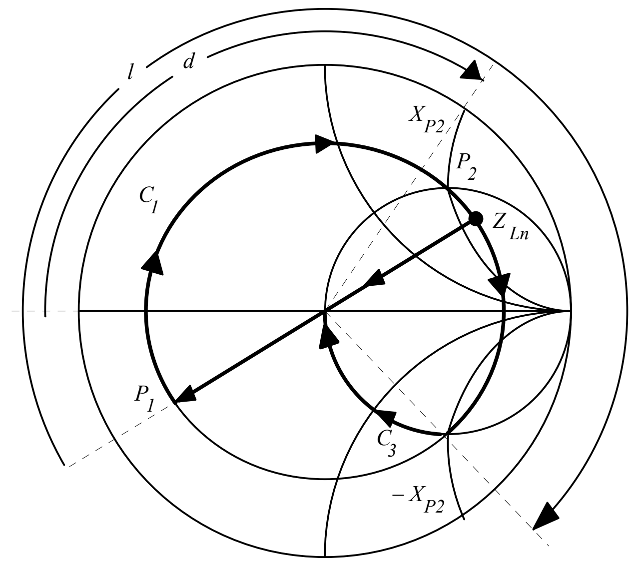

Figure 3.
Alternate Open Circuit Single Stub Tuner

III. PROCEDURE

A. Design a Single-Stub Tuner

Design a single-stub transmission line impedance matching network to match a 50 Ω source and line to a load with a resistance $R \approx 100$ Ω in parallel with an inductor of $L = 10$ nH.

1. Use a Smith chart (with Berner Smith Program) to design the matching network at 900 MHz.
2. Verify the matching network (at 900 MHz) using the Berner Smith Program.

How reasonable will the match be at 500 MHz?

B. Construct The Single-Stub Tuner

Design a microstripline with a single-stub tuner at 900 MHz using the board and copper tape provided. The microstripline should be matched to the 50 Ω source. The underlying assumption is that the metal conductors are significantly thinner than the dielectric. Metal thicknesses of 1.37 mils (0.00137 inches) is typical for 1 oz. copper plating. The board is made of FR-4 (or G-10) material with a nominal relative dielectric of 4.6. The dielectric thickness is approximately 63 mils. Use 1/8" or 1/16" copper tape to build the approximately 50 Ω transmission lines.

C. Measure the Impedance Matched Network

Determine the transmission and reflection coefficients matched network.. Determine reflection coefficient S_{11} and *SWR* of the network. Find S_{11}, and *SWR* of the microstripline at 500 MHz and 900 MHz. Make sure the pigtail from Port 1 is calibrated. How good is your match?

D. Comment On Your Results