

Laboratory #5: Impedance Matching With A Double-Stub Tuner

I. OBJECTIVES

A double-stub transmission line impedance matching network is designed given a load components and the results simulated using the Agilent ADS simulation software package. Equivalent passive components are used in place of stubs and their results compared to the double stub tuner simulation results.

II. INTRODUCTION

In some instances, the distance determined for the single stub tuner may not be convenient for implementation. In those cases, a double stub tuner may be required as shown in Figure 1. In designing double stub tuners, the distances l_1 and l_2 are pre-determined by the designer.

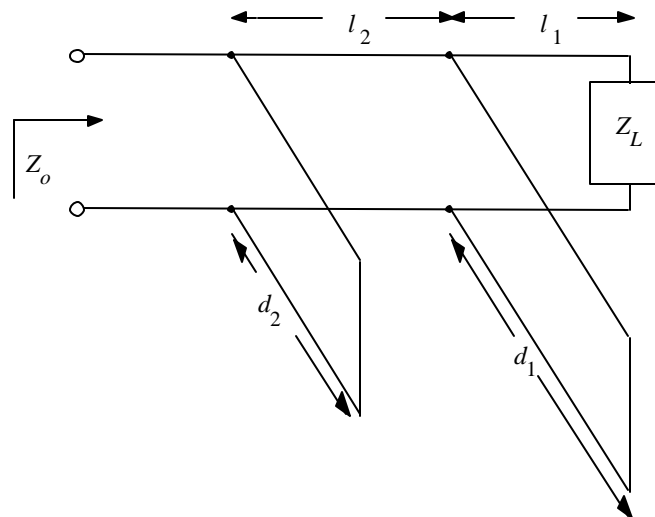


Figure 1. Double Stub Short Circuit Tuner

A double-stub transmission line impedance matching network is composed of two short circuited sections of transmission line, separated by a length of transmission line, placed along the main signal line. The short circuited sections provides an equivalent shunt susceptance. The short circuited sections are attached perpendicular to the main line as shown in Figure 1. The construction of the short circuited section is similar to the main line.

The load impedance is typically dependent on the frequency of operation. The distance, d_2 , can be moved back and forth to get a wide range of susceptance values. The distances d_1 and d_2 can be found in terms of fractions of wavelength of the signal being transmitted using a Smith chart.

In designing the double-stub impedance matching network, the familiar procedure of “Z – Y – SWR – G – SWR- G” method on the Smith Chart is used. That is, (a) Plot the impedance Z of the load, (b) Find the Admittance Y of the load, (c) follow a constant SWR circle a length l_1 , (d)

follow a constant conductance G circle for the length of the stub d_1 , (e) follow a constant SWR circle a length l_2 , and (d) follow a constant conductance G circle for the length of the stub d_2 . Figure 2 shows a generalized Smith Chart analysis for a double-stub tuner.

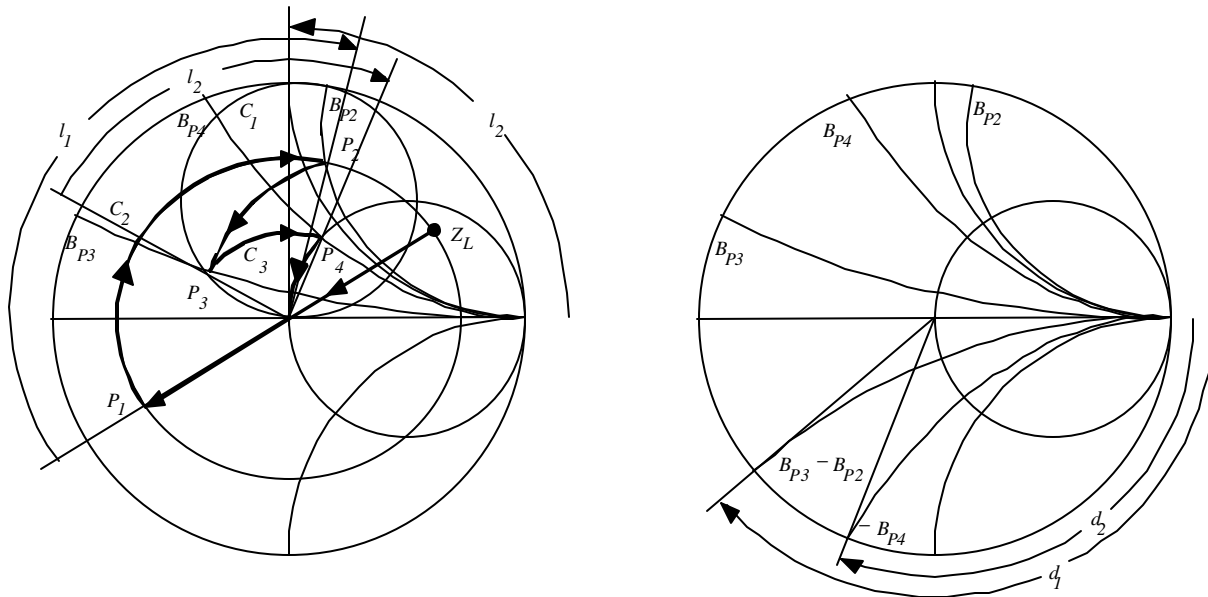


Figure 2. (a) Generalized “Z – Y – SWR – G – SWR - G” Double Stub Tuner Analysis
 (b) Determination of the stub lengths

Only the susceptance is altered when following the constant conductance circle; The conductance remains unchanged. In this instance, the stubs can be replaced with either inductors or capacitors.

Recall that the impedances of an inductor and capacitor are:

$$Z_{CAP} = -\frac{j}{\omega C} = -jX_{CAP} \quad \text{capacitor}$$

$$Z_{IND} = j\omega L = jX_{IND} \quad \text{inductor.}$$

Noting that all impedances are normalized to Z_o , the normalized capacitor and inductor impedances are:

$$Z_{CAPN} = -\frac{j}{\omega C Z_o} = -j \frac{X_{CAP}}{Z_o} = -jX_{CAPN} \quad \text{capacitor}$$

$$Z_{INDN} = \frac{j\omega L}{Z_o} = j \frac{X_{IND}}{Z_o} = jX_{INDN} \quad \text{inductor}$$

and
$$B_{CAPN} = \frac{Z_o}{X_{CAP}} = \omega C Z_o$$

$$B_{INDN} = \frac{Z_o}{X_{IND}} = \frac{Z_o}{\omega L} .$$

So the lumped parameter replacement components are inductive susceptances. The circuit then consists of a length l_1 of waveguide attached to a load. On the other side of the waveguide is an inductor L_1 to ground. Attached to L_1 is another length l_2 of waveguide. On the other side of the waveguide of length l_2 is an inductor L_2 to ground.

The values of the lumped parameter components can be calculated using the susceptances determined from the Smith Chart.

III. PROCEDURE

A. *Design a Double-Stub Tuner*

Design a 50 Ω microstripline double-stub transmission line impedance matching network to match a 50 Ω source and line to a load with a resistance $R = 25 \Omega$ in series with a capacitance $C = 33$ pF. Let the distance between the load to the stub closest to load be $l_1 = 0.250\lambda$ and the short-circuit stub length closest to the load be $d_1 = 0.204\lambda$. The relative permittivity of the G-10 printed circuit board is $\epsilon_r = 4.5$. Metal thicknesses of 1.37 mils (0.00137 inches) is typical for 1 oz. copper plating. Use a Smith chart to design the matching network at 965 MHz

B. *Verify the Design*

Verify the matching network (at 965 MHz) using the Agilent ADS software package. How reasonable will the match be at 500 MHz? Plot S_{11} in both rectangular and Smith Chart formats, as well as the SWR.

C. *Replace the Stubs With Lumped Parameter Passive Components*

Re-design the matching network by replacing the stubs with lumped parameter passive components (inductors or capacitors).

D. *Measure the Impedance Matched Network*

Verify the re-designed matching network (at 965 MHz) using the Agilent ADS software package. How reasonable will the match be at 500 MHz? Plot S_{11} in both rectangular and Smith Chart formats, as well as the SWR.

F. *Compare the results of parts (B) and (D).*