<u>ELEC 518</u>: RF/Microwave Circuit Design and Measurement

Lab1: Component Characterization

1.0 Overview

This first lab will help you start to develop accurate models of component behavior, as well as introduce you to the world of high-frequency measurements. Here are the models you will develop:

1. Coax-to-PCB Subminiature A (SMA) connector discontinuity
2. Via-hole
3. Chip inductor
4. Chip capacitor
5. Chip resistor

The measurement method: PCB test fixture with the Vector Network Analyzer (VNA)

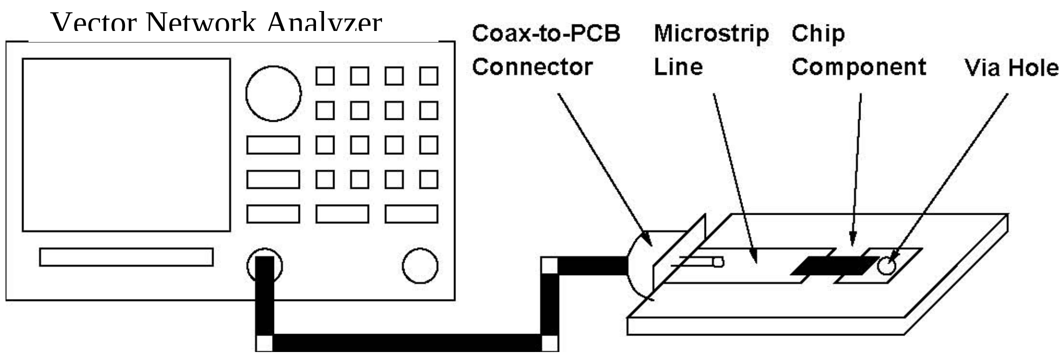


Figure 1. Measurement setup for component characterization.

The laboratory is divided into two parts: A) the S-parameter measurement and B) modeling with Agilent-ADS. You will compare the measured S-parameters with those simulated by ADS, and then develop circuit models for each of the components.

2.0 Microstrip, PCB, Connector Characterization

Coax is currently the best way of connection instrumentation and test sets. Thus, a PCB-based circuit, no matter what kind of transmission line (TL) it utilizes, needs to be interfaced with a coaxial line. Many coaxial connector types are available in the RF and microwave industry, and designed for a specific purpose and application. One most commonly used type is the SMA. This connector naturally introduces a "discontinuity" to the transmission line, even though the coax and microstrip both may be 50Ω.

In order to characterize the discontinuity, perform the following measurements and analysis:

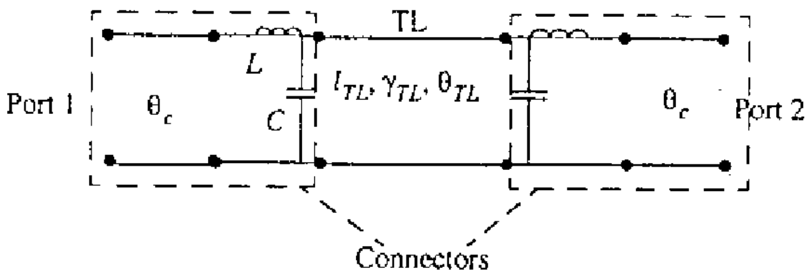
2.1 Measurements

1. The TA will calibrate the VNA for a full two-port measurement with a frequency range of 100MHz-3GHz.

2. Measure the full two-port S-parameters of a PCB with a straight section of microstrip TL and two identical PCB SMA connectors, one at each end connected to the VNA.

2.2 Modeling

1. Model the entire PCB board with connectors using the following model in ADS:



2. The connector introduces a phase shift (because it is a short section of transmission line), plus additional capacitive and inductive parasitics. The values for θ_c, L and C for one connector should be set to be identical to the other connector.

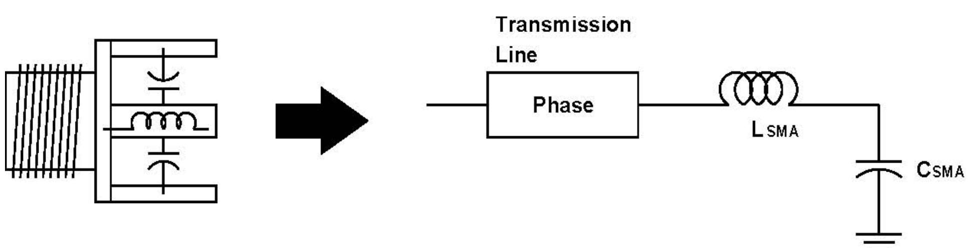


Figure 2. Circuit model of the SMA connector.

3. The characteristics of the PCB substrate are as follow:

   Substrate thickness = 62mils
   Relative dielectric constant = 4.5
   Relative permeability = 1

Conductivity = 5.8×10^{7} S/m
Conductor thickness = 1.38mil
Dielectric loss tangent = 0.017

4. The TL has loss and phase shift. You can use a ruler to accurately measure l_{TL} and other dimensions of the PCB. Put these values into you model.

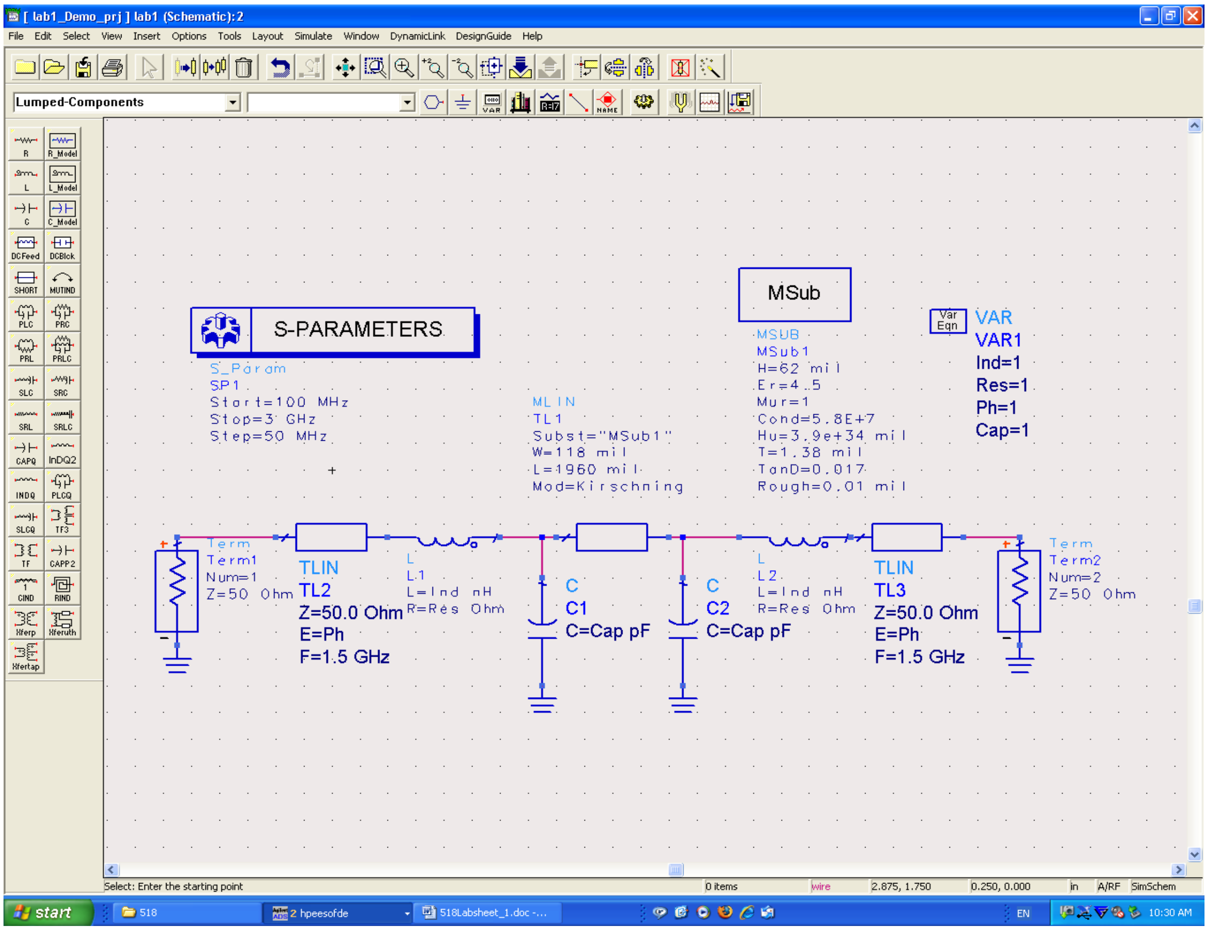


Figure 3. Equivalent circuit for the test structure in ADS: 2 inches microstrip line with two SMA connectors at both ends.

5. Read the measurement data into ADS and manually **adjust** the values of **L, C, R and phase shift** to match S_{11} and S_{21} for both "*magnitude*" & "*phase*". Be especially careful that these values are physically sensible.

3.0 Lumped Element Components

The PCB test fixture consists of a section of microstrip transmission line ending in the middle of the board, where components are attached. The electrical length (i.e. phase shift or delay) of the line and its impedance can be calculated using **LineCalc (ADS tool)** in conjunction with your measurements in Section 2.0. The connector and transmission line models you developed must be used to remove their effects from your measurements. This process is known as “deembedding”.

3.1 Via holes

A microstrip-based circuit requires multiple ground connections, which are drilled through the PCB. These are called vias, or via holes, and the performance of these connections has a very important effect on the overall circuit behavior. It makes sense to characterize the vias next.

1. Place a via connection close to the end of the TL and measure S_{11} of the test fixture with via. The via is made by drilling a small hole (or more) and inserting as short a section of thick wire as possible. Make sure you write down the physical dimensions of the via wire.

2. In ADS, model the via as a parallel LC circuit. Include the TL phase shift, loss, and connector discontinuities in your model. Compare these with your measurement results and determine the values for L and C.

3.2 Lumped components

All components are of surface-mount type and supplied by the TA.

Use the same characterization procedure as for the via hole, but include the via hole in series with your measurement.

1. Determine the nominal value for the component being measured.
2. Determine its parasitic values using an appropriate model.
3. Determine self-resonance (if occurred).
4. Note that the valid frequency range for the measurements.

END