To : Dr. Huggins

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Subject: Functional Description

Project Title: Low-Cost, Compact Microwave Reflectometer for Non-Destructive Testing

Overview:

The objective of this project is to design a low cost reflectometer for non-destructive testing as shown in Figure 1. This instrument will be capable of measuring the phase and magnitude of the reflection coefficient of an unknown load. When used for non-destructive testing, an open ended coaxial cable is inserted in a liquid or pressed against a material. Then through additional analysis, the reflection coefficient from the material can be related to physical properties of the material. The reflectometer will consist of a six-port passive microwave circuit integrated with a PC workstation to obtain these measurements. The PC workstation will sample four output voltages and calculate the phase and magnitude of the reflection coefficient using a specified algorithm.

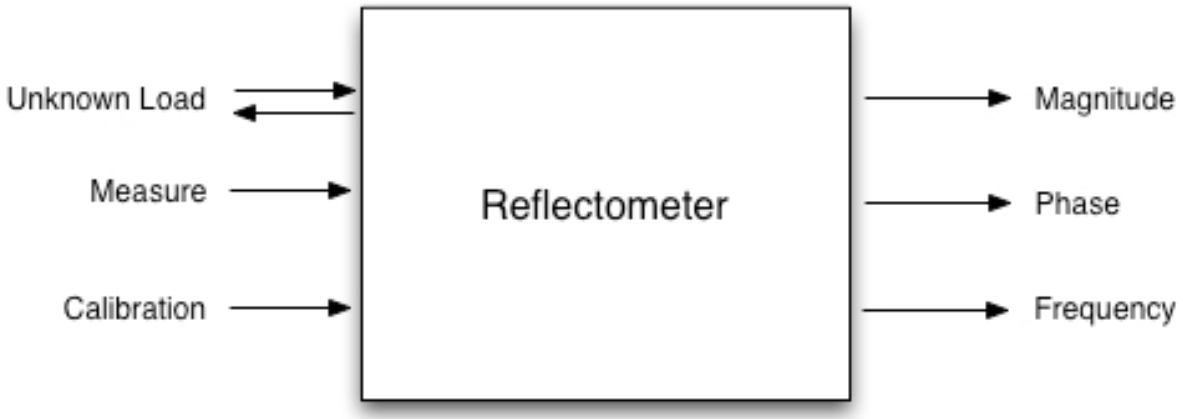

Figure 1: Fundamental Block Diagram

Modes of Operation:

There are two modes of operation: measurement and calibration. The measurement mode will allow the user to determine the reflection coefficient of the unknown load at different specified frequencies. The calibration mode will allow the user to determine system parameters by the use of known loads. These parameters are utilized in the algorithm to find the reflection coefficient of the unknown load.

Inputs/Outputs:

The system consists of an RF subsystem and computer software subsystem as shown in Figure 2. The RF block input consists of an RF source (not shown), which generates a signal that is routed by a six port passive circuit to five other ports. An unknown load is attached to one of these ports. A signal exits this port and is incident on the unknown load. Due to the mismatch, a reflected wave is generated and propagates back into the RF subsystem. The incident and reflected waves exit simultaneously in a coaxial cable. At four other ports of the passive circuit, the various signals combine delivering power to detectors, which result in voltages V_1, V_2, V_3, and V_4. The frequency control signal sets the frequency of operation. Table 1 describes the inputs and outputs to the RF block.

The software inputs consist of the following: reset, increment frequency, decrement frequency, measure, measure mode, and calibrate mode. Connected internally between the RF block and the computer software block are four voltages V_1, V_2, V_3, and V_4. The software will sample these four voltages, which will be used in a series of computations to find the reflection coefficient of the unknown load. Another internal connection between the subsystems is a frequency control signal and this will determine the frequency at which the system will operate. The outputs are the magnitude, phase, and frequency of the unknown load. Table 2 describes the inputs and outputs to the computer software block.

Methods:

The design team plans to build an optimal micro-strip design layout for the six-port passive circuit that is within the RF subsystem. This design will allow for a small, low-cost device that will use a workstation to allow convenient measurement of the reflection coefficient of an unknown load. If an open ended coaxial cable is used, then the reflection coefficient can be related to physical parameters of the material that is in contact with the open end of the probe. A software package will be designed that will use a computer to perform the necessary calculations. The PC will be used for convenience, speed, and capabilities of producing superior results. Figure 2 shows the detailed flow of the inputs and outputs for entire system.

Table 1: RF I/O and Mode of Operations

Inputs	Outputs	Operations
Reflected Signal		Created from the incident signal which is used to calculate the Reflection Coefficient.
Frequency Control		Sets the frequency of operation.
	V_1, V_2, V_3, and V_4	Sampled voltages to calc. Reflection Coefficient.
	Incident Signal	Sent to the load.

Table 2: Software I/O and Mode of Operations

Inputs	Outputs	Operations
Reset		Initialize the entire system.
Increment Freq.		Increase frequency of the reference signal.
Decrement Freq.		Decrease frequency of the reference signal.
Request		Take measurement.
Mode1: Measure		Set the system to measure.
Mode2: Calibrate		Set the system to be calibrated.
	Magnitude	Displayed on user's workstation.
	Phase	Displayed on user's workstation.
	Frequency	Displayed on user's workstation.
	Calib. Disp.	Direct the user to calibrate the device properly.

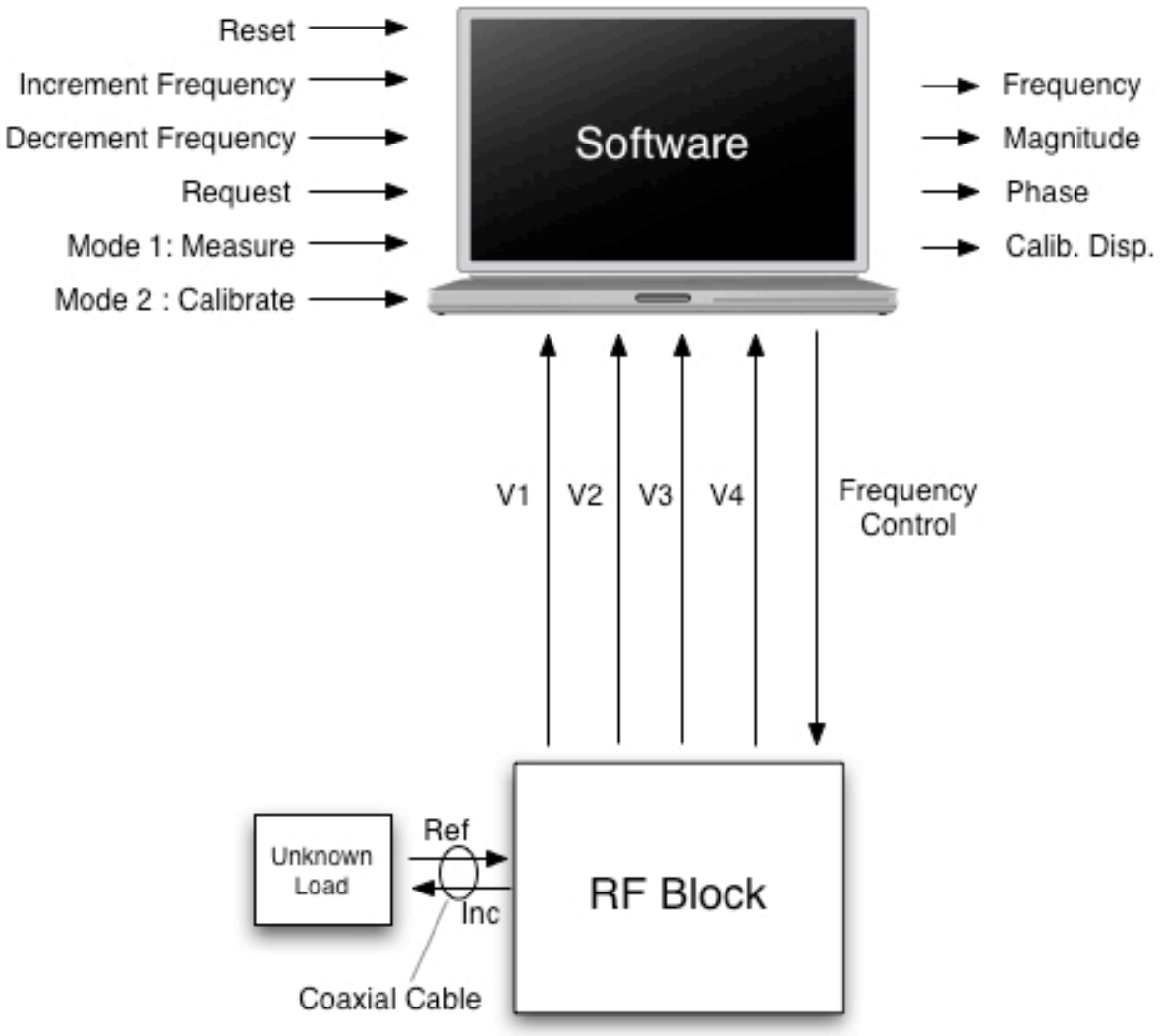

Figure 2: Overall Detailed Block Diagram