

Low-Cost, Compact Microwave Reflectometer for Non-Destructive Testing

System Block Diagram

This project involves a low-cost reflectometer for non-destructive testing as shown in Figure 1. This instrument is 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 consists of a six-port passive microwave circuit integrated with a PC workstation to obtain these measurements. The PC workstation samples four output voltages and calculates the phase and magnitude of the reflection coefficient using a specified algorithm.

The system consists of a RF Block and a Software Block. The RF Block is designated by a dashed boundary in figure 1. The system is controlled by software installed on the PC. The RF Block will be discussed followed by the software flow charts.

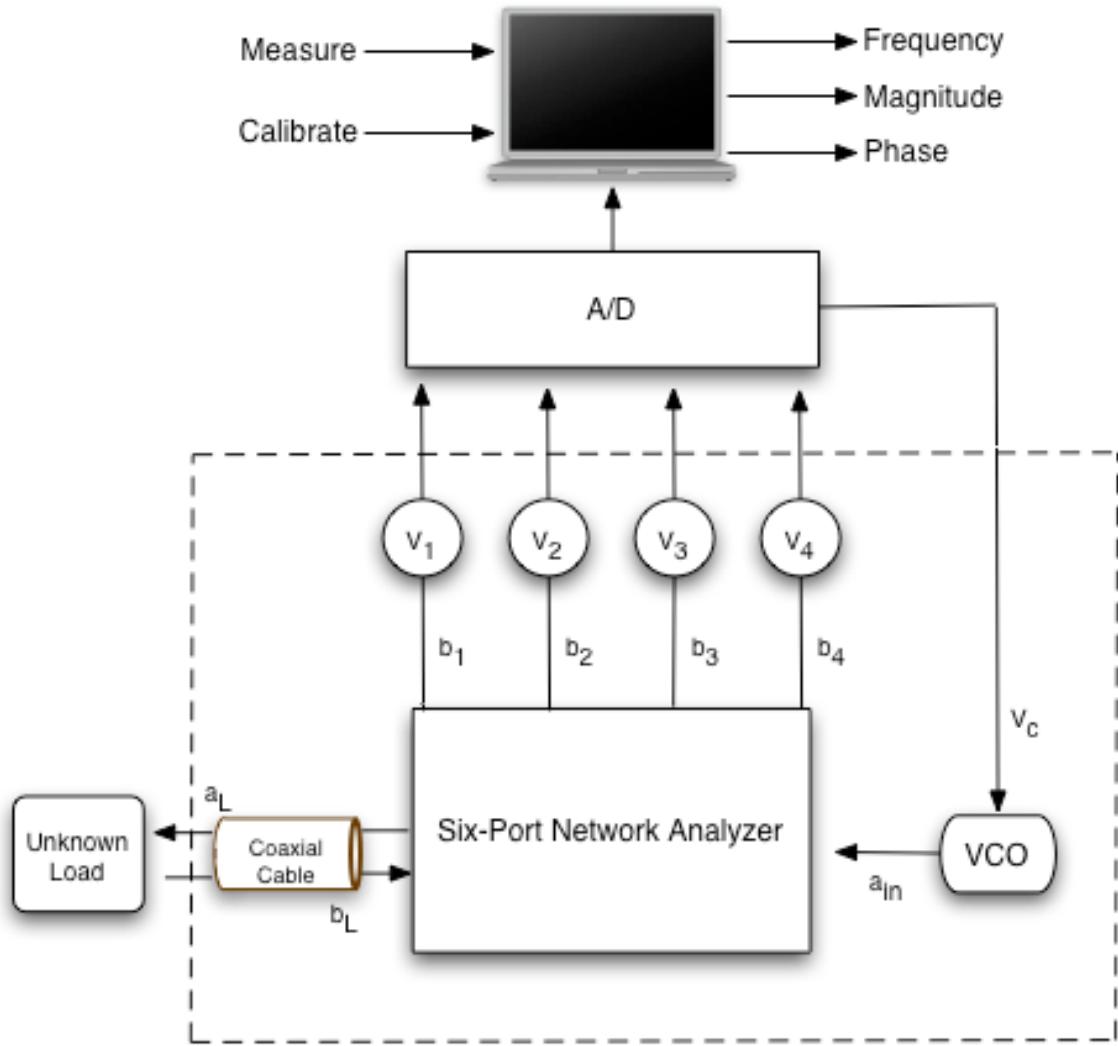


Figure 1: System Block Diagram

The radio frequency (RF) component consists of the six-port function, voltage controlled oscillator (VCO), four microwave detectors, and a coaxial cable. The six-port network analyzer uses an optimal, passive micro-strip design with quadrature hybrids. The VCO produces a DC signal (V_c) to an RF reference signal, in gigahertz. The signal from the VCO (a_{in}) enters the 6-port junction at port S and, in general, is split among all the other ports. At port L, two signals exist simultaneously. One exits the port and is the incident wave (b_L) on the unknown load. The other enters the port and is the reflected wave (a_L) from the unknown load. The ratio of the reflected wave to the incident wave (relative to the load) is the reflection coefficient. These distributed voltages are related to the load and will help determine the reflection coefficient. Using a scattering matrix model for the 6-port junction, it can be shown that the signals exiting ports 1 through 4 contain information concerning (a_L) and (b_L). The detectors V_1, V_2, V_3 and V_4 on the ports convert the RF signal to low frequency voltages proportional to the RF power detected. These signals are sampled and stored in the PC where a complex algorithm computes the reflection coefficient of the unknown load.

The flowchart for the calibration mode of the six-port network analyzer is shown in figure 2. The user first selects a frequency at which the system will measure the reflection coefficient. Once the frequency has been entered, the program prompts the user to set a specific load at port one. The program then samples the voltage readings (V_1, V_2, V_3 and V_4) and stores the binary values into memory. The program notifies the user by a prompt if it is processing the data. This is repeated for each specific calibration load as the program prompts the user for each load. The program sends all of the sampled voltage readings into an algorithm. This algorithm uses the voltage readings and calculates the system parameters used for measurement. Once this is finished, the user may then proceed to the measurement mode and begin taking measurements of an unknown load. This measurement is only to be used at the one frequency initially entered by the user. The system must be recalibrated to be used at a different frequency.

Once the calibration has been completed, the user will then proceed to the measurement mode of the software, which is shown in figure 3. The user is notified to put the unknown load at port L. The system will then proceed to take measurements of the voltage levels (V_1, V_2, V_3 and V_4) and store binary values into memory. An algorithm then processes the values stored in memory in correlation with the calibration results and the reflected signal. The user is prompted with results showing the magnitude, phase, and frequency of the measured system.

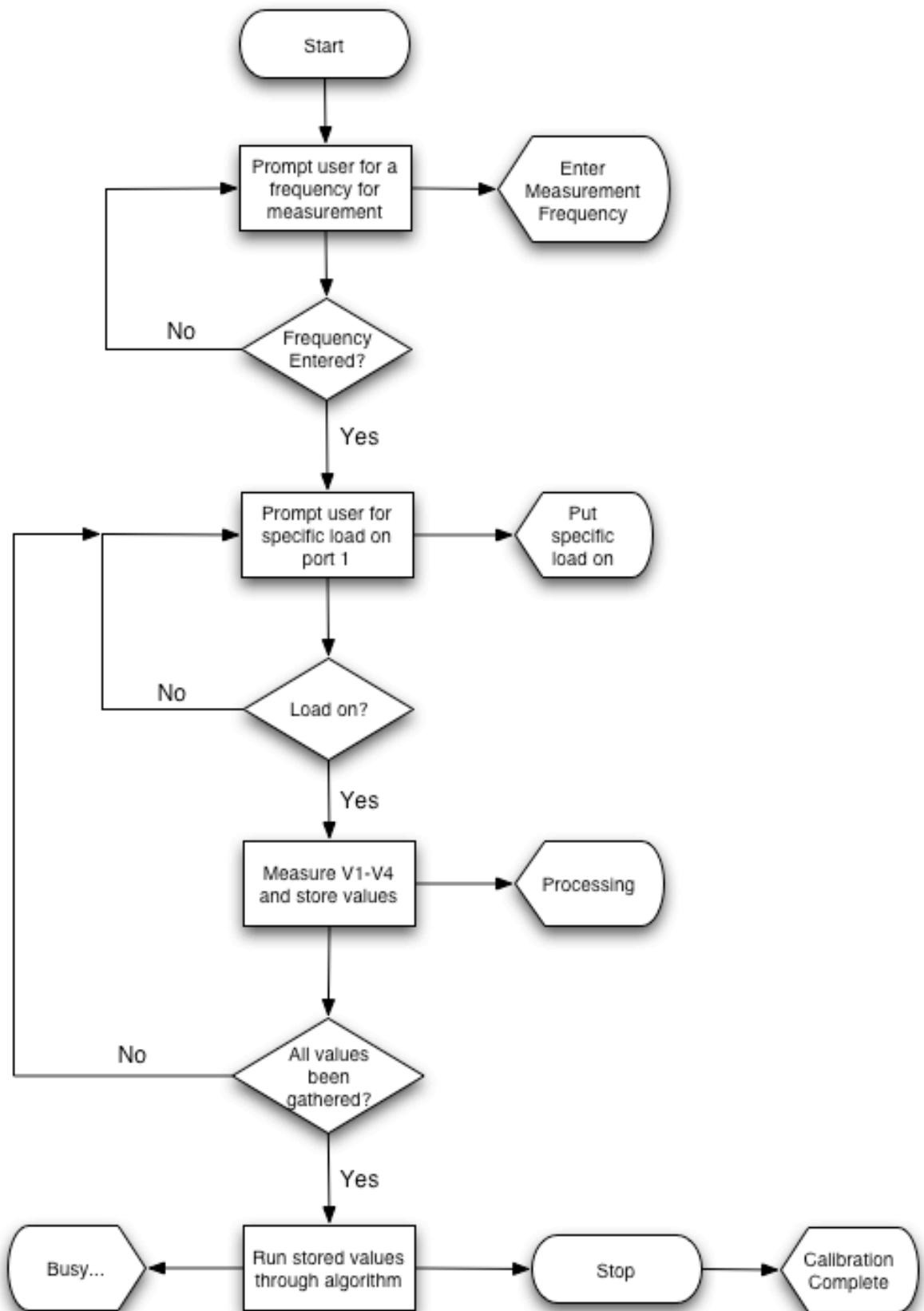


Figure 2: Calibration Flowchart

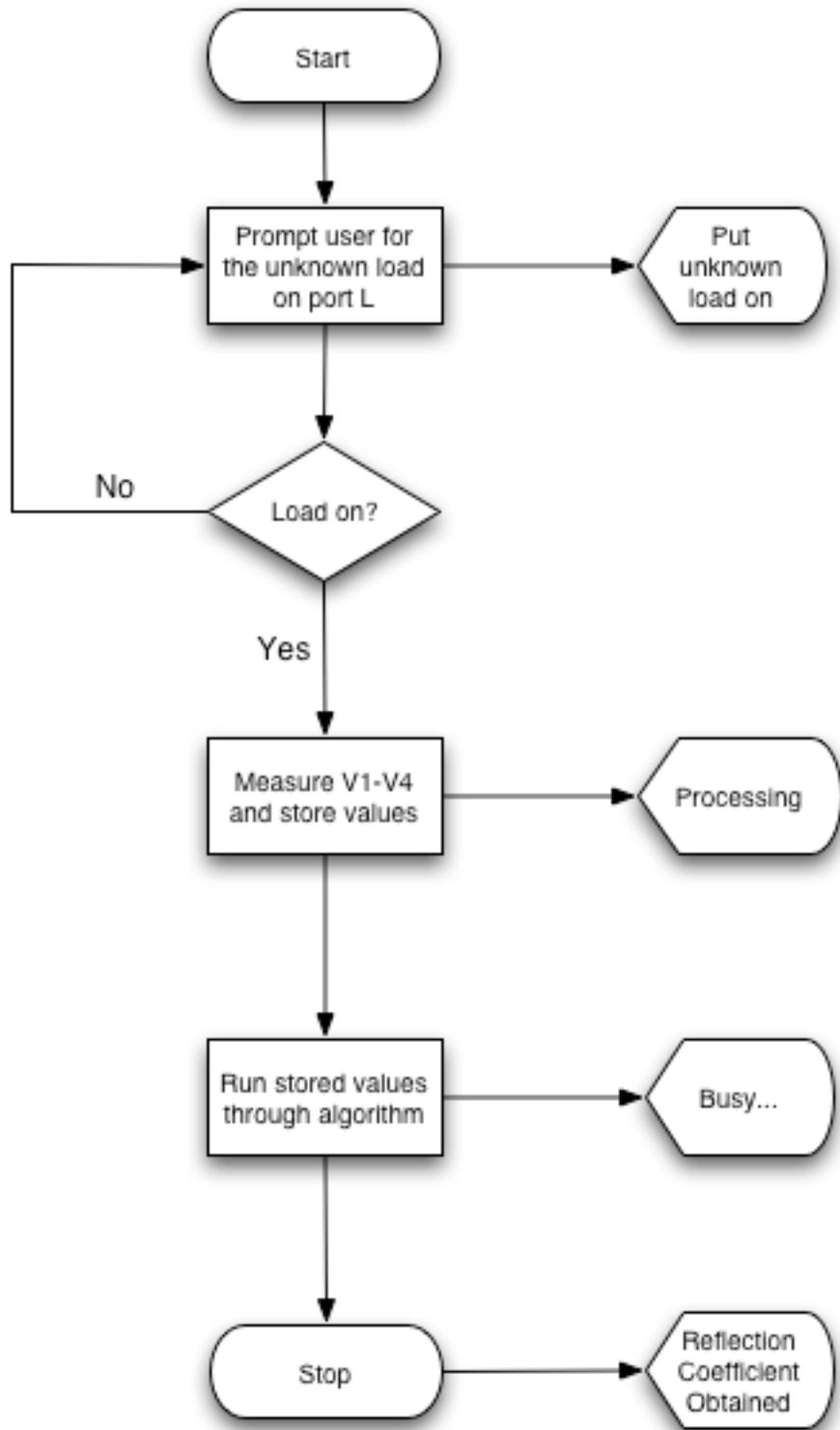


Figure 3: Measurement Flow Chart