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Labview in Assumption University's Engineering Curriculum

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Abstract

The use of Labview *as an educational tool in engineering curriculum was explored in this work. Toward this end,* Labview *interfaces and the experimental setup to extract relevant model parameters of passive components and diode were developed and described using the standard tools of* Labview *suitably augmented by Code Interface Nodes linked by appropriate Visual C++ codes. It was found that there is a close fit between experiment and theory in the case of diode. The developed experimental system is flexible enough to be adapted for a variety of measurement and interfacing tasks arising regularly in engineering studies.*

Keywords: Labview, *instrumentation interfacing, device modeling, capacitance, inductance.*

Introduction

Graphical User Interfaces (GUI) have become a common and versatile tool for quite a lot of engineering applications. Students should be confronted with the challenges of GUI's and Engineering Faculties should consider these tools as an inherent part of the curriculum in order to adequately prepare the students for their professional career. In this paper some measurement applications and equipment interfacing using the commercially available package *Labview* are presented. In the first paragraph two measurement setups dealing with diode and passive components modeling are discussed. The next few paragraphs consider the versatile tools offered by Labview and, toward the end, some elaborated examples are presented.

Device Modeling

The fundamental goal of device modeling is to obtain a functional relationship among the terminal electrical variables of the device under test. These electrical characteristics depend on a set of parameters including both geometric variables and the device technology and physics. For the convenience of the circuit designer, it is also often required that the device models have electrical characteristics in close accordance to those of relatively simple circuits composed of basic circuit components.

Diode Model

The diode is characterized by the eqn.

$$I = Is\,(\exp(q(V-I\,Rs)/\alpha\, kT) - 1)$$

where the parameters Is, α and r are the reverse saturation current, the emission coefficient andthebulk resistance. The diode model consists of an ideal diode in parallel with a capacitor (Fig.1). The current is represented by:

$$I_{theor} = C\, dV/dt + Is\,(\exp(q(V-I\,Rs)/\alpha\, kT) - 1)$$

Here C is the parallel capacitance. One can now compose the following functional after sampling over a time interval of one or two test signal periods.

$$F = \Sigma (I_{exp,i} - I_{theor,i})^2$$

which is to be optimized in order to retrieve the model parameters C, Rs, α and Is.

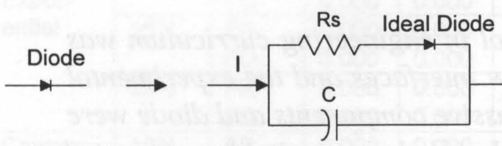

Fig. 1. Equivalent circuit for a diode.

In a more practical aspect another two adjustable parameters are to be included in the functional, V0s and Vs, which represent the potential uncertainties in the function generator source and in the test-fixture.

Capacitance and Inductance Models

A capacitor or inductor model at low frequencies is a plane capacitor or inductor. However, for many circuits (oscillators, filters) it is important to know the parallel or series resistance of these devices. Secondly, at high frequencies a capacitor will behave inductive due to the inductance in the wires

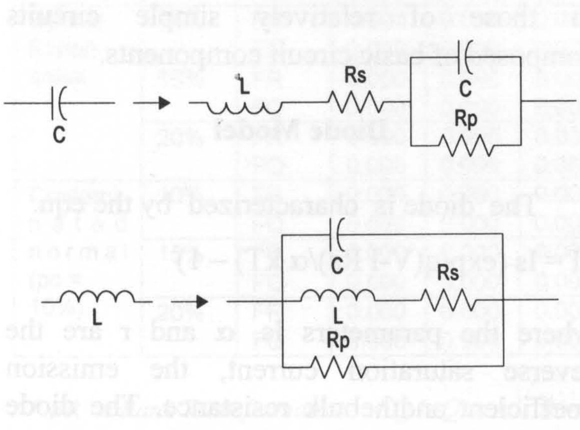

Fig. 2. Equivalent model of a capacitor and an inductor.

and an inductor will behave capacitive due to the capacitance between the wires. This changes the behavior of the device drastically and more accurate models have to take this resonant behavior into account. Therefore we use the equivalent models of Fig. 2 to model low and high frequency behavior and to dimension the quality factor.

Numerical Method for Parameter Extraction

A proper numerical method for minimization of the functional is the Downhill Simplex Method in Multi-dimensions since the functional depends on more than one independent variable. The main advantage of the method is that it requires only function evaluations, not derivatives, which causes its stability.

Measurement Setup

For the diode parameter extraction we use the circuit of Fig. 3 and do a readout of the voltage over the resistor (which gives us the current I_{theor}) and the diode with a Digital Storage Oscilloscope. The voltage source is a simple Function Generator or a RF Generator. The data of the Oscilloscope is then imported into Labview for further treatment (parameter extraction)

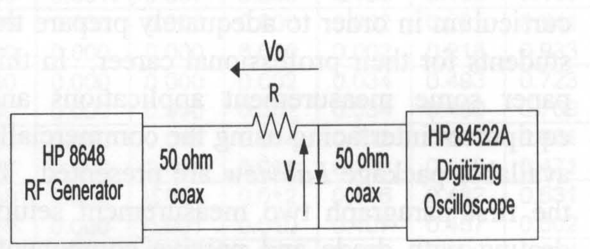

Fig. 3. Diode measurement setup.

The capacitor is modeled and measured as a parallel load of a 50 Ω RF Generator with a 50 Ω load from the Spectrum Analyzer (Fig. 4). The inductor is measured in series (fig. 4). The connection between the equipment and the devices is made with 50 Ω coaxial cables. The power over the 50 Ω load is measured by the Spectrum Analyzer and imported into Labview. A calibration measurement (short circuit) is performed to normalize the measurement for the cable losses.

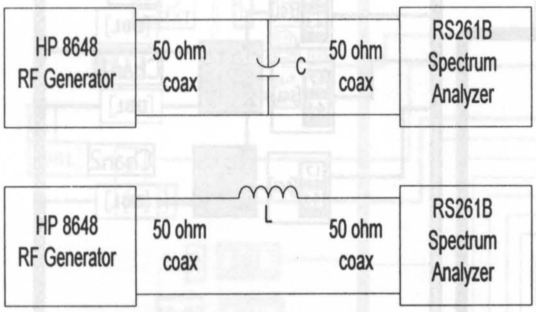

Fig. 4. Capacitor and inductor measurement setup.

Virtual Instruments (vi) and GPIB Interface.

Labview Instrument Driver is a collection of *vi*'s that controls a particular programmable instrument. Each routine handles a specific operation such as reading data, writing data, or configuring the instrument. By using instrument drivers the experimentalist disposes of user friendly access to all the instruments included in the experimental set, because they encapsulate complex, low-level hardware setup and communications protocols.

The National Instruments Instrument Library contains drivers for hundreds of instruments using a variety of hardware standards such as GPIB, RS-232/422, VXI and CAMAC. The General Purpose Interface Bus (GPIB) is a powerful, flexible and very popular communications standard supported by thousands of commercial instruments and computer systems, first developed by Hewlett Packard (HPIB). Based on the variety of Labview Standard Library Tools the driver packages are designed to support the following functions:

- Sending commands – commanding the instrument to perform a function or change a setting.
- Transferring data – if the instrument is a measurement device like a voltmeter, oscilloscope etc., the data or the waveform should be transferred, scaled and presented in a useful fashion.
- Configuration management – the ability to load and store the settings of many of the particular instrument's important controls all at once.
- Important controls – there are always a few basic controls that the driver should support, like the mode and range on a DMM etc.

Labview vi for Data Acquisition from the Experimental Setup

Fig. 5 presents a *vi* aimed to acquire experimental data from the HP 54522 digital oscilloscope. The driver on the left while loop is designed as a sequential cycle of IEEE commands in the usual string format.

Standard Library Tools and Additional Packages

As a high level language *Labview* semantic contains the standard library expressions like Sequencing and Data flow, Looping, Global & Local Variables, Strings, Arrays, Clusters, Timing, File Operation, Data Types & Conversions. In addition applications *Labview* provides specialized software packages (Toolkits) for many engineering applications like:

- GMAT – intended for a complex mathematical calculations,
- DAQ (with a interface card only) – provides a variety of measurement facilities: Multiplex Analog Input, Multiplex Analog Outputs, Multiplex Digital I/O, Precise Counters & Timing, Triggering, and Conditioning.

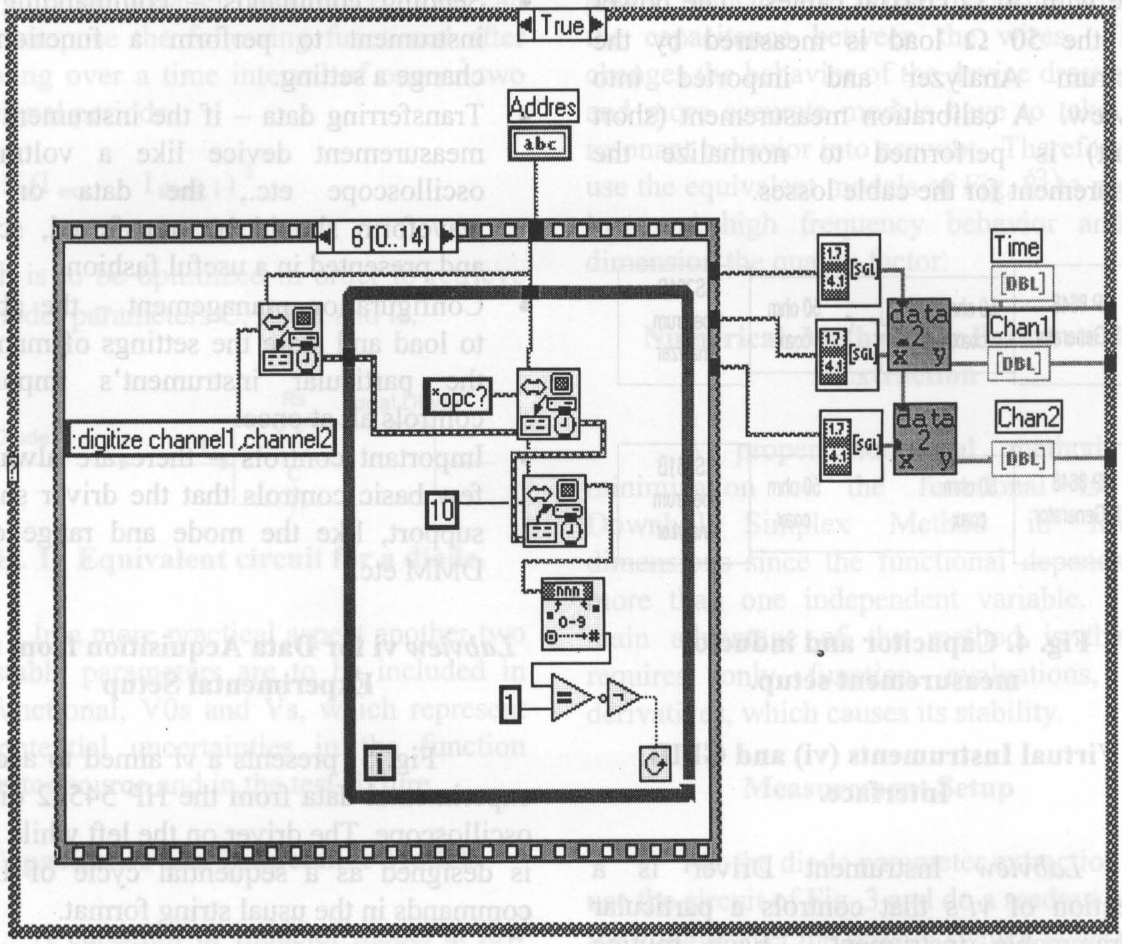

Fig.5. Labview vi for data extraction from the digitizing oscilloscope HP 54522.

- PID – The following PID control applications can be developed: Proportional (P), Proportional Derivative (PD) and Proportional Integral Derivative (PID) algorithms- Error squired PID, PID with external reset feedback, Lead-Lag compensation, Setpoint ramp generation, Multiloop cascade control, Feedforward control, Override control (minimum/ maximum selector), and Ratio/bias control.
- DSP – contains VI's for Digital Signal Processing, Filtering, Numerical and Statistical Analysis.

Advanced Code Interface Nodes (CIN)

For most of the practical applications *Labview* supports sufficient mathematical library tools, but still in some very specific cases the conventional mathematical libraries cannot be adapted properly or completely. In such cases *Labview* provides Code Interface Nodes (CIN), a node that links external code written in a conventional programming language to Labview. The user compiles and links the source code in a predefined way accessible by *Labview*. *Labview* calls the executable code when the node executes, passing input data from the block diagram to the executable code, and returning data from the executable code to the block diagram. It is

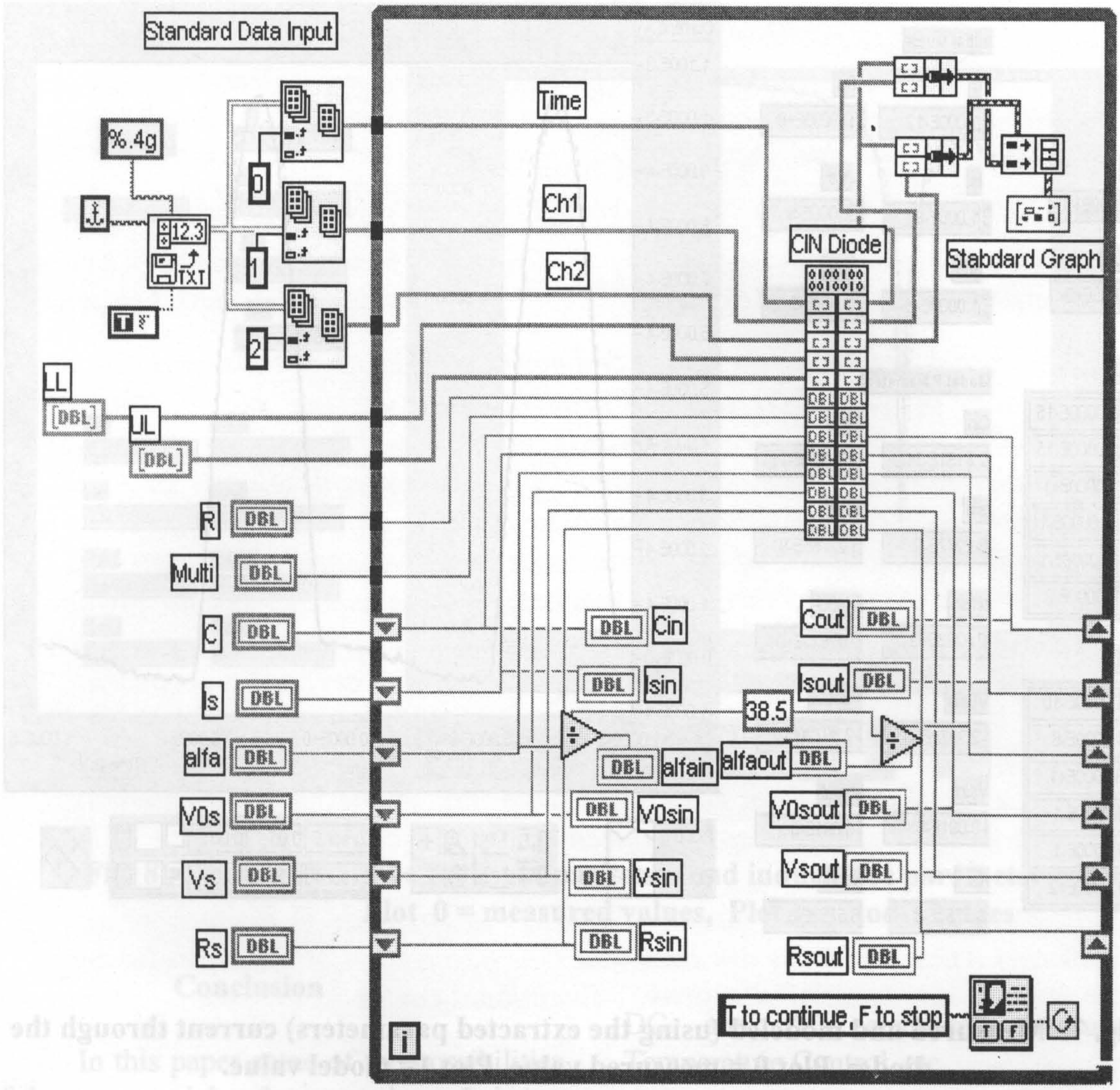

Fig. 6 . Code Node Interface incorporated in *Labview*.

worthwhile if the task is time critical or needs a great deal of data manipulations. *Labview* diagram, containing a CIN developed in the BTL laboratory, is presented in fig. 6. The CIN icon embeds three input – output arrays, depicted on the figure as Time, Ch1, Ch2. All these arrays are one dimensional arrays, containing the time scale, Channel 1 and Channel 2 retrieved from the digital oscilloscope by the driver part of vi. The input Time-array does not change, while the Ch1-array and Ch2-array – the experimentally measured diode current and the theoretical current fit respectively – obtain new values.

The graph presentation (Fig. 7) uses standard *Labview* tools. Two other Labview input controls are embedded in the CIN icon – the load resistor value and the corresponding multiplication of the oscilloscope probes. As a Labview indicator, the output values are the calculated diode model parameters α, C, Is, Rs, V0s and Vs. The program code was written in Visual C++.

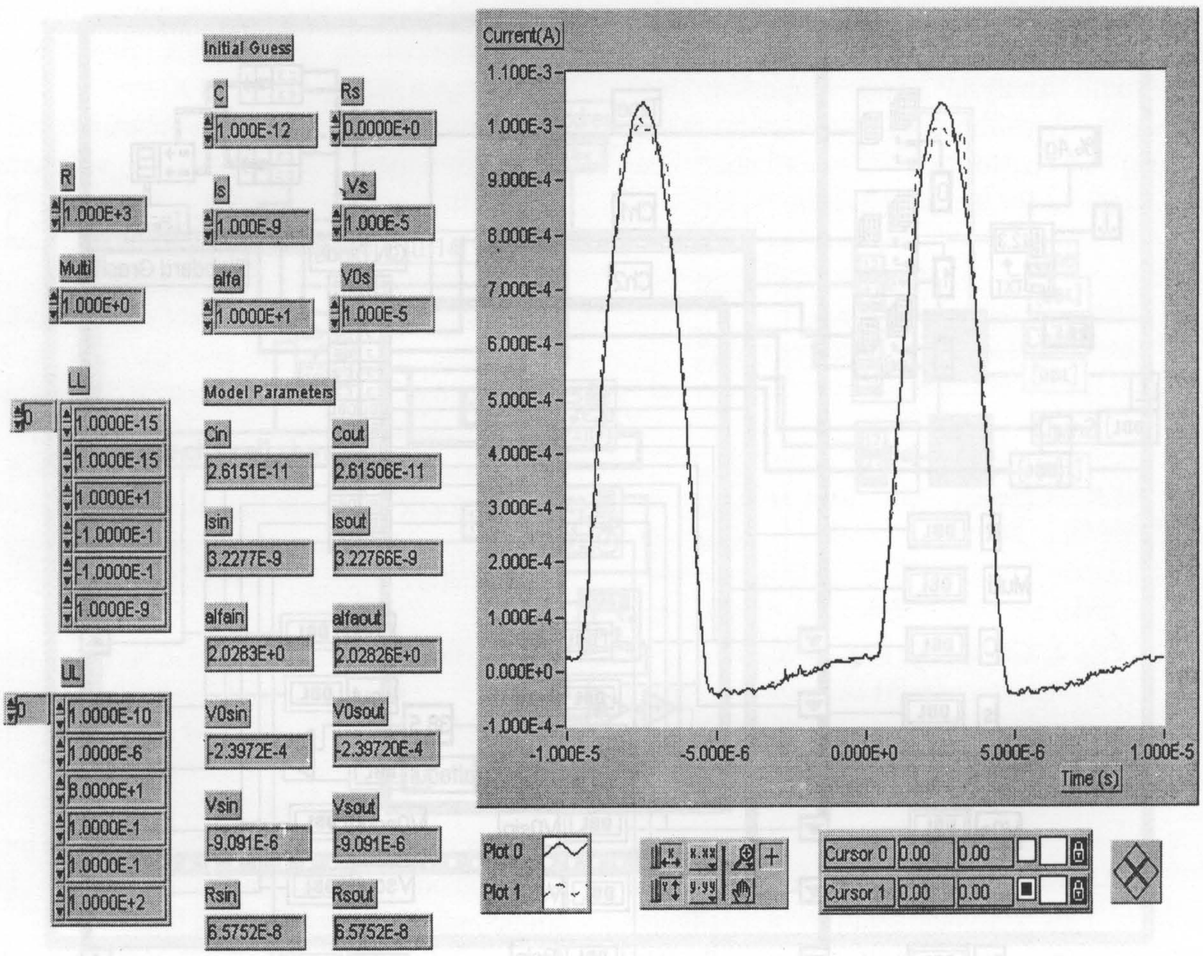

Fig. 7. Measured and modeled (using the extracted parameters) current through the diode: Plot 0 = measured value, Plot 1= model value.

The *Labview* control panel of the vi is presented in Fig. 7. Plot 0 visualizes the experimental diode current, while Plot 1 the corresponding theoretical fit. The calculated model data can be observed on the left side of the graph. The following values were obtained: for the diode capacitance C = 26 pF, for the saturation current Is = 3.2 nA, for the emission coefficient = 2.0, for the bulk resistance Rs = 65 nΩ, for V0s = - 240 μV and for Vs = -9.1 μV. The retrieved diode data coincide satisfactorily with the initial available data and there exists a close fit between the experiment and theory.

The *Labview* interface for the capacitance or inductance measurement is shown in Fig. 8. The adjustable settings were the sweep range and power of the RF Generator and the number of measurement points. At each measurement point, the start and stop frequency of the Spectrum Analyzer were set and a peak detection was done to find the power dissipated in the 50 Ω load. The Downhill Simplex Method was implemented as a CIN and could be run several times to find the absolute minimum.

In Fig. 8, a nominal capacitance of 56 pF was measured. The following values were found: C = 55 pF, L = 16 nH, Rs = 0.8 nΩ, and Rp = 8 GΩ. From the result, it can be stated that the capacitor is only useful for frequencies below 150 MHz.

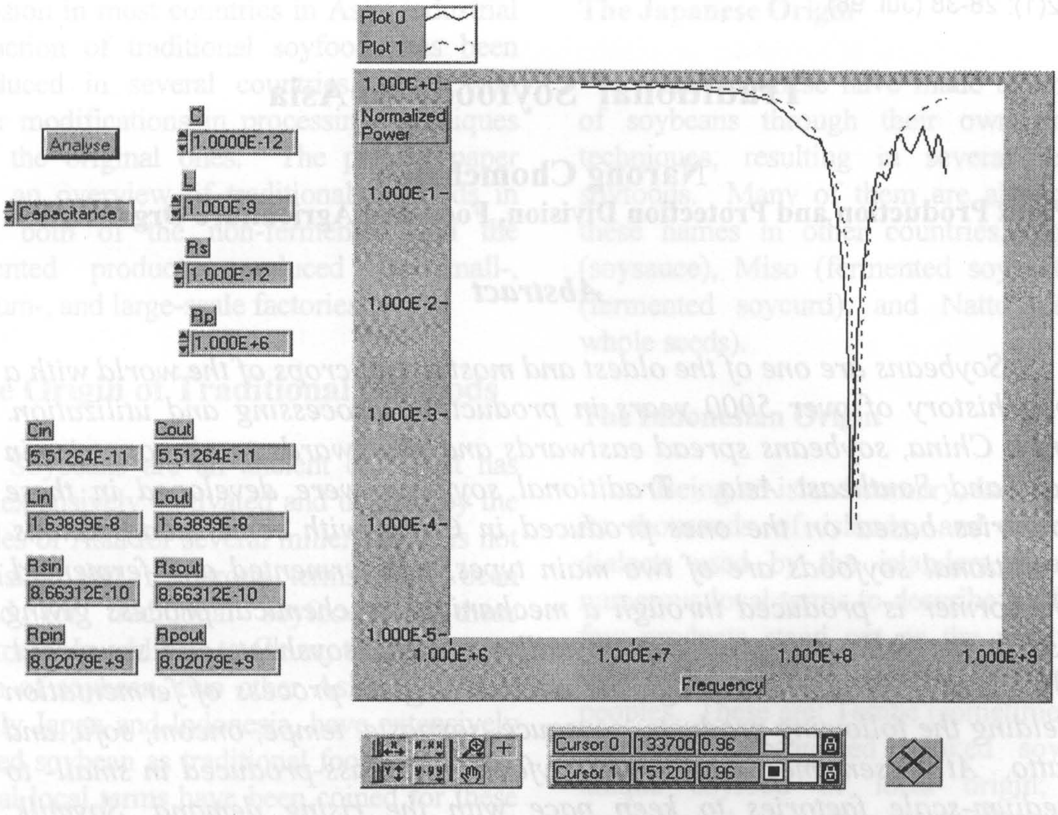

Fig. 8 . *Labview* interface for the capacitance and inductance parameter extraction: Plot 0 = measured values, Plot 1 = model values

Conclusion

In this paper some of the possibilities of the commercial software package *Labview* are presented. These include: instrumentation interfacing, data acquisition and advanced data processing. Two measurement setups have been developed dealing with diode and passive components modeling. Due to its flexibility, the package is very suitable, not only for particular scientific purposes but also for upgrading engineering laboratories and giving students a versatile tool for modern electronic design, measurement, data acquisition and data processing *in situ.* A variety of practical applications is possible, as well in the upgrade of the physics laboratory, such as Timing and Counting (necessary for kinematic experiments and transient processes), DC and AC electrical measurements, Temperature Control, etc.

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