

Using virtual instrumentation in the application study of electronic devices

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Abstract. Continuous technological developments require proper training of future specialists through the use of modern training systems. This paper presented in detail both hardware and software structures in a laboratory stand for interactive training of future professionals in the fields related to using electronic devices. Virtual instrumentation is the basics of these applications in terms of data acquisition, processing, and display in a form as explicit and easy to understand of the results. The entire system was created using National Instruments equipment to generate the input stimulus signals to generate both input signals and receive response signals. For various electronic circuits or devices, software applications were created in the LabView graphics development environment. Builds in the form of interactive applications the virtual instruments offer the opportunity for future professionals to benefit from a complete training starting from studying the theoretical part of laboratory work, visualizing the implementation schemes, and making measurements that are then used to make different analyses of results.

1 Introduction

The development of virtual instruments that can be used also for student education and research activities is a growing concern thanks to important facilities of these. Thus, in student education, it is necessary to create virtual instruments that automatically allow measurements on different equipment or process to reduce the actual time spent by users in the physical laboratory. Also, in the same domain, in the case of a hybrid education scenario the virtual instrumentation offers to the students participating in online courses the possibility to be able to benefit from approximately the same training, in experimental activities, in order to reduce the gap between formal and online training.

LabView, one of the most important means of creating the virtual instruments, is the abbreviation for Virtual Instrument Engineering Workbench and is a graphical programming language that allows teachers, scientists, and engineers in various fields to develop and implement interactive programs that will enable the acquisition of data from different equipment, analysis, and data processing and then displaying results with reports, graphs or charts. The LabView programming environment has many functions, libraries,

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and subprograms that allow the creation of highly complex programs that can be used in any branch of engineering [1].

The development of virtual laboratories that allow the training of students in various engineering fields using online technologies based on the LabView programming environment has preoccupied developers for over 20 years [2]. Thus, we meet virtual tools used to train students in the field of power electronics without them having to have the necessary physical equipment, all taking place in a simulated environment [3]. Hardware-in-the-loop simulators for teaching laboratories are also a useful learning aid [4].

For students and also for researchers is most important to repeat an experiment many times to understand all the basic concepts in unfolding the analysed phenomenon or circuit and the use of virtual instrumentation offered by an experimental lab has revealed that students understand the concepts presented much better and their feedback is extremely encouraging in terms of the impact on them of this learning method [5].

There are various ways to create software applications for creating virtual laboratories using the LabView programming environment, so there are virtual tools that allow you to perform various simple experiments from analysing different signals [6] to remote control of a DC motor [7].

Therefore, using LabVIEW can develop applications that can be accessed through a browser with minimum requirements of each computing system [8]. So the engineering training branch cannot fold very well on an online education model, the last two years that have passed, years marked by the pandemic, have highlighted the importance of such a training system. Thus, the training system based on a remote interaction with everything that means laboratory equipment in a space intended for research [9], in a certain field, can be extremely useful both in times when certain restrictions are imposed and as tool adapted to new technological eras [10].

In this paper, we present an application written in LabVIEW used to draw the static characteristic of a rectifier diode. This application is included in a large project on the subject of using virtual instrumentation in studies of electronics devices and circuits.

2 Hardware structure

In electronic devices and circuits studies is most important to know the compartment of these, which can be appreciated by performance characteristics. There are two types of performance characteristics of measuring instruments which are: static characteristics and dynamic characteristics. The static characteristics are used to measure quantities that slowly vary with time or are mostly constant with time and for electronic devices like diodes the current-voltage characteristic or IV characteristic is usually used.

2.1 Some theoretical consideration

For the rectifier diode it is known that the equation of the static characteristic deduced considering the density and mobility of the charge carriers is:

$$I_D = I_0 \left(e^{\frac{q \cdot V_D}{k \cdot T}} - 1 \right) \quad (1)$$

where:

I_D – the direct current flowing through the diode in direct polarisation;

I_0 – the inverse current, the diode leakage current density in inverse polarisation;

V – applied voltage across the terminals of the diode;

- q – absolute value of electron charge;
- k – Boltzmann's constant;
- T – absolute temperature (°K).

The principle electrical diagram for drawing the diode characteristic for direct polarisation is presented in fig. 1.

The procedure for drawing the characteristic consists in modifying the voltage provided by the variable power supply and registering the pairs of current-voltage values. By interpolating them, the characteristic graph is drawn.

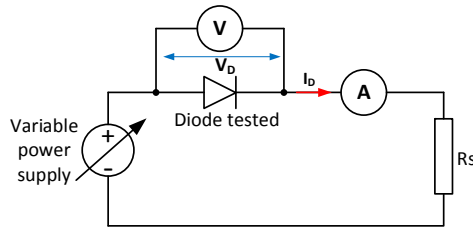


Fig. 1. The principle electrical diagram.

Based on these principle electrical diagram and procedure the static characteristic can be draw using a proper software application like NI Multisim how is shown in fig.2.

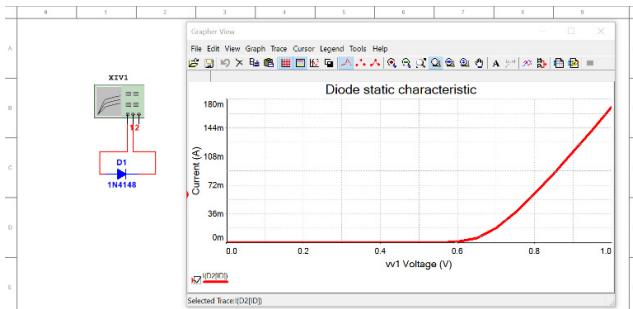


Fig. 2. Static characteristic drawn in Multisim

2.2 Experimental assembly

For the realization of the virtual instrument, specialized equipment produced by Agilent and National Instruments were used, as follows: Analog Discovery Studio for the implementation of the adjustable power supply function and the MyDAQ acquisition module for the implementation of the voltage and current measurement functions.

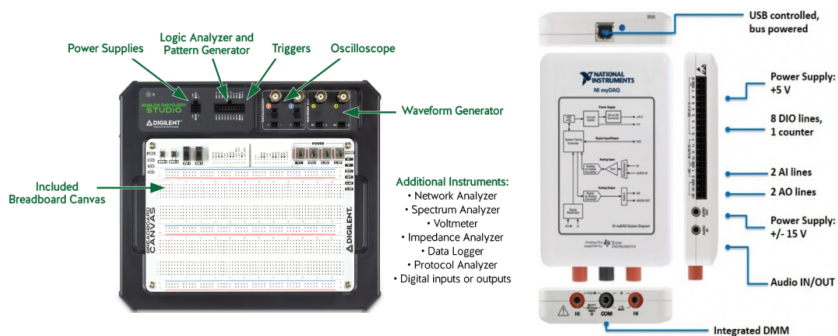


Fig. 3. Equipment used in experimental assembly.

The Analog Discovery Studio is a fully functional, portable test and measurement device that can turn any cross-functional space into a pop-up electronics laboratory. This equipment includes the Power Suppliers and other 13 instruments such as Oscilloscope, Logic Analyzer, Spectrum Analyzer, Waveform Generator, and more. The Analog Discovery Studio provides an entire stack of bench-top instruments with a convenient, replaceable, and breadboardable interface. For this application, one of the 3 available power sources is used, namely the Variable power supply for which the generation, with a resolution of 12 bits, of a voltage in the range (0 ... 5) V can be programmed.

MyDAQ is a data acquisition device that combines a comprehensive set of plug-and-play computer-based lab instruments with high portability and usage. This device is used for the virtual realization of the voltmeter by using the analog input AIO in differential connection as well as the ammeter by using the current input of the included DMM multimeter.

The experimental electrical connections of the tested diode to the used device and software host computer are shown in fig.4.

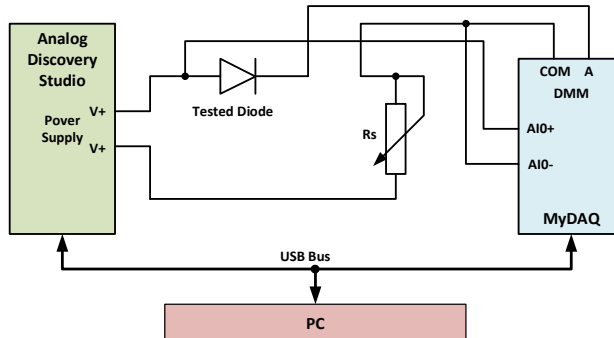


Fig. 4. The experimental electrical connections.

The control of the power supply, as well as the acquiring and the processing of the measured values, are performed by resident software in the PC computer to which the used devices are connected via the USB bus.

3 Software structure

The virtual instrument that we propose in this paper is built in the LabVIEW graphical programming environment. This consists of the program through which is possible to draw the static characteristic of the electronic device based on the hardware experiment structure described above.

3.1 Algorithmic description of the program used

In fig.5. exemplified is the realization algorithm for this experiment that involves setting the values of the DC voltage organized in an array and reading the resulting DC current.

For this experiment, a series of values is established, in the form of an array, of an independent parameter that is the voltage V_D across the diode. The acquisition of the current through the diode is made by adjusting the value of the V_{Di} until reaching the prescribed value through the mentioned table of values, also with specified tolerance.

The effective realization of a measurement supposes the fulfillment of the condition by which by adjusting the parameter $val[V_{Di}]$ the set value V_{Di} is reached, with the tolerance tol also established to it:

$$val[V_{Di}] = V_{Di} \pm tol \tag{2}$$

Once this condition is met, the other value that's mean I_{Di} is read from the MyDAQ device through USB bus. All read values, including those of the considered parameter, are deposited in arrays $\{V_{Di}\}$ and $\{I_{Di}\}$ for a later use.

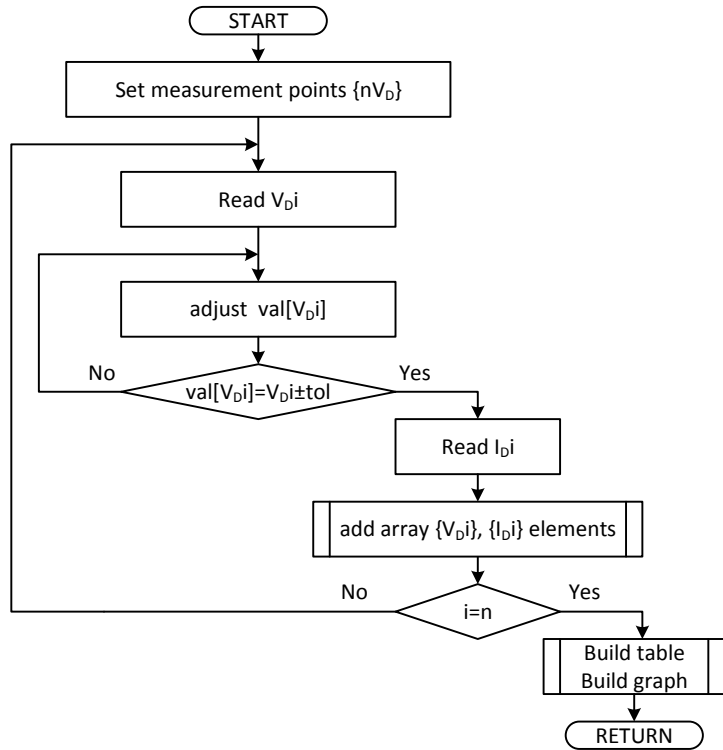


Fig. 5. Algorithm of the experiment.

The number of loops, and thus implicitly the number of read values is determined by the size of the array initially established by setting the parameter values. The program reads the number of set values nV_D of the parameter and thus sets the number of loops through which the bus is read.

Once determined the sets of values $\{V_{Di}\}$, $\{I_{Di}\}$ they can be used, depending on the application necessary, in this case for the construction of value tables and graphs of evolution of the voltage and current quantities.

3.2 Front Panel of the Virtual Instrument

The front panel of the virtual instrument represents the user interface and includes controls for generating commands and data as well as indicators for displaying the results obtained from data processing.

For this application on the front panel, presented in fig.6, the user has at his disposal a set of numerical type controls through which he will establish:

- the number of points based on which the static characteristic will be drawn;
- the set of values V_{Di} (**Measurement points**) of the voltage on the diode in relation to which the set of I_{Di} values of the current through the diode will be measured;

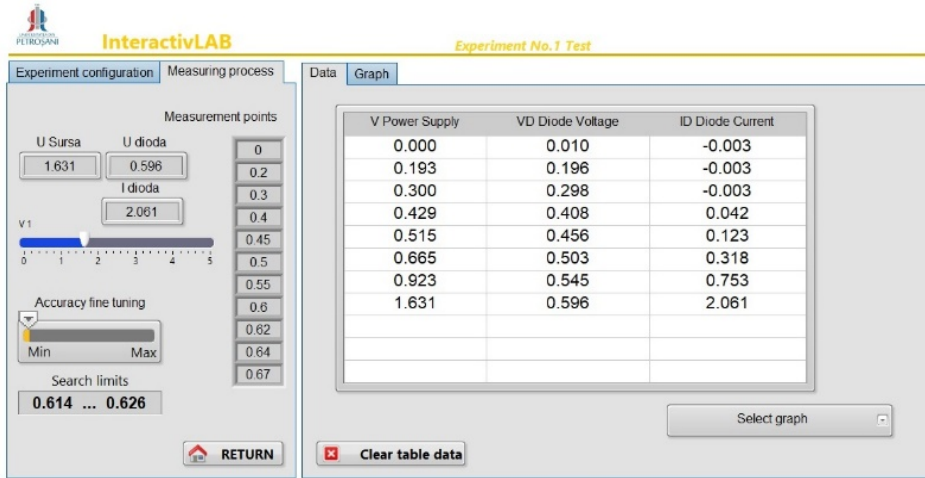


Fig.6. Front Panel of the virtual instrument.

- two Slide controls for the control of the supply voltage (**V1 Power Supply Voltage**) and respectively for the choice of the tolerance *tol* (**Accuracy Fine Tuning**) for establishing the V_{Di} values;

Also on the front panel exist:

- two Tab controls through which the user can switch between the configuration of the experiment (**Experiment configuration**) or effective measurement (**Measurement process**) windows, respectively the tabular (**Data**) or graphical display of the values (**Graph**);
- two Boolean controls for the end of the process (**RETURN**) and respectively for the deletion of the values and the resumption of the acquisition and processing process (**Clear table data**);
- a Ring control for choosing the graph (**Select graph**).

To display the measured data and the processing results, numerical and graphical indicators are arranged on the front panel, depending on the window chosen by the user, as follows:

- the indicators **V Power Supply**, **VD Diode Voltage**, and **ID Diode Current** which will display the current values of these quantities;
- a tabular indicator that displays the values as they are acquired;
 - a graphical indicator whose orthogonal axes can be set by choosing the sizes whose dependence is displayed.

Fig. 7 shows some screenshots during the operation of the virtual instrument.

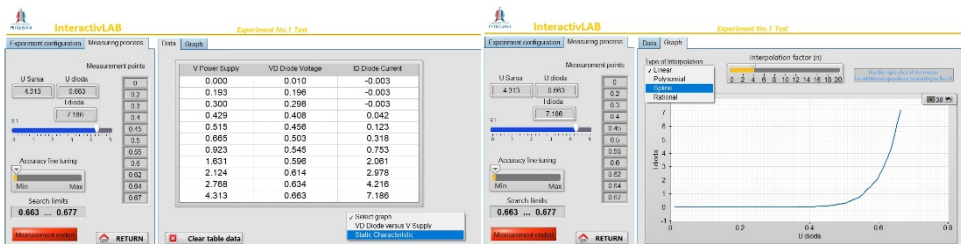


Fig.7. Screenshots of the front panel.

3.3 Block Diagram of the Virtual Instrument

The block diagram represents the actual program based on which the virtual instrument works. It is made using programming structures, functions and operations available in LabVIEW libraries.

The block diagram of this application, shown in fig.8, determines the operation of the virtual instrument in a sequence of logical sequences made by using the Sequence structures.

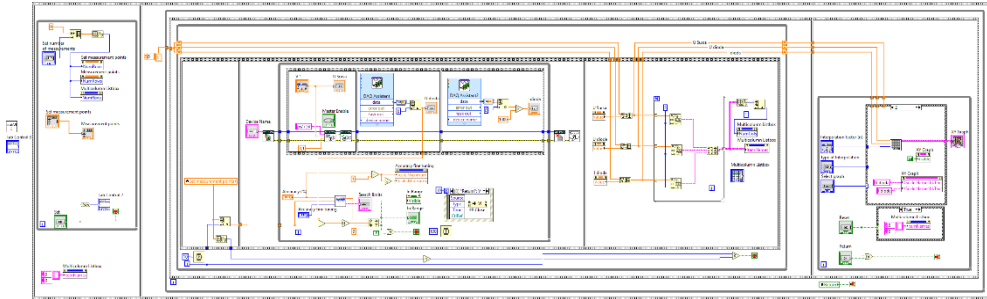


Fig.8. Block diagram of the virtual instrument.

Thus, a first such structure consists of two sequences through which the setting of the operating parameters of the instrument is performed, in the first sequence, and respectively the data acquisition and processing in the second sequence is performed.

The end of the first sequence is made at the user's request, through the **NEXT** button, after completing the procedure for setting the operating parameters. Also the end of the second sequence is made at the request of the user, through the **Return** button and which becomes active only after acquiring the entire package of values $\{V_{Di}\}$ and $\{I_{Di}\}$. For both sequences, the stop conditions correspond to a While loop.

The operation of the program in the second sequence is also done through its sequencing in three sequences.

Thus in the first sequence, it is done simultaneously with the setting of the values of the vector $\{V_{Di}\}$ through the values of the supply voltage and the measurement of the corresponding values of the current through the diode resulting in the values of the vector $\{I_{Di}\}$.

In the second sequence in this part, the table of values is constructed by populating it with each pair of values after each reading.

In the third sequence from the same part of the program, the graph is built according to the user's options.

4 Conclusions

The results obtained and the operation of the virtual instrument by combining the two hardware and software components are prerequisites for the development of the instrument so that the functional study can be applied to various systems by the "black box testing" method. The concepts of the black box testing method come from the analysis of software applications that focus on testing systems mainly on their inputs and outputs and are based entirely on their requirements and specifications. It is also known as behavioral testing. Even if this paper presents a minimalist example of system implementation, the paper has achieved its goal by highlighting the new concepts used as well as presenting new generation hardware equipment used. The graphical interface of the entire program presented in this paper is very intuitive and can be used without problems in an extremely

short time. The possibility of creating executable kits of the program together with the possibility of creating a web server dedicated to the entire system, will bring a special portability of the solution and will guarantee easy access to the entire suite of training resources of all those interested. Within the current concepts related to IoT and Smart City technologies, the concepts regarding the monitoring and control of remote processes tend to be more and more successful. In the same vein, although engineering education cannot be perfectly adapted to an online training system, different applications can be made with which students can interact in situations of force majeure exactly as in the physical laboratory. Perhaps the most important achievement of this work is the opening of new research directions in terms of remote control with state-of-the-art equipment that can be used on several types of applications available through the project CNFIS-FDI-2022-0160 which provides development of an interactive laboratory for the control by virtual instrumentation of the students' practical training activities, generically called InteractivLAB.

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