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Measuring current-voltage (i-v) characteristics for non-linear electrical devices

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Abstract – Measurement and automation technology was changed once the National Instruments company introduced the concept of virtual instruments, using the LabVIEW (Laboratory Virtual Instrument Engineering Workbench) graphical programming. In order to fully describe the behavior of nonlinear electrical devices such as incandescent lamps, photovoltaic cells, ecc., the manufacturer will usually provide a set of one or more current-voltage characteristic curves. In spite of this widespread availability of electrical devices data from the manufacturer, regarding electrical devices we may need to measure the current-voltage characteristics for a particular device in the laboratory.

Keywords: virtual instrument, data acquisition, signal conditioning, curve fitting

I. INTRODUCTION

Data acquisition uses a combination of PC-based measurement hardware and software to provide a flexible, user-defined measurement system. If the system changes, you often can reuse the virtual instrument components without purchasing additional hardware or software. The fundamental task of all measurement systems is the measurement and/or generation of real-world physical signals. Measurement devices help you acquire, analyze, and present the measurements you take. Virtual instruments represent a visualization of complex measurement systems on a standard personal computer in the form of a virtual user interface.

II.DATA ACQUISITION

The term PC-based data acquisition refers to the acquisition of data both by means of PC-based plug-in cards, designed as classical multifunction cards, and external box systems (SCXI, VXI-DAQ, parallel port). A multifunction card is a PC plug-in card handling analog input and output capabilities, digital input/output ports, counters and timers. PC-based instruments combine the advantages of integration into industrial standard PC hosts and bus systems (PCI, VXI, PCMCIA, etc.), offering the flexibility of stand-alone devices, for example, multimeters, oscilloscopes, functional generators, analyzers.

The analog input specifications give you information on both the capabilities and the accuracy of the DAQ product:

- number of channels – the number of analog channel inputs is specified for both single-ended and differential inputs for devices with both input types.
- sampling rate – this parameter determines how often conversions can take place. A faster sampling rate acquires more data in a given time and can therefore often form a better representation of the original signal. Data can be sampled simultaneously with multiple converters, or it can be multiplexed, where the analog-to-digital converter (ADC) samples one channel, switches to the next channel, samples it, switches to the next channel, and so on. Multiplexing is a common technique for measuring several signals with a single ADC.
- resolution – the number of bits that the ADC uses to represent the analog signal is the resolution.

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- range – range refers to the minimum and maximum voltage levels that the ADC can quantize

Before you begin developing measurement applications, you must install and configure the measurement hardware. The software drivers need the hardware configuration information to program the hardware properly. When measuring a physical phenomena, a transducer must convert this phenomena into a measurable electrical signal. Common types of signal conditioning include amplification, linearization, transducer excitation and isolation. Some signal conditioning can be performed in the software in the „Data Acquisition" function palette.

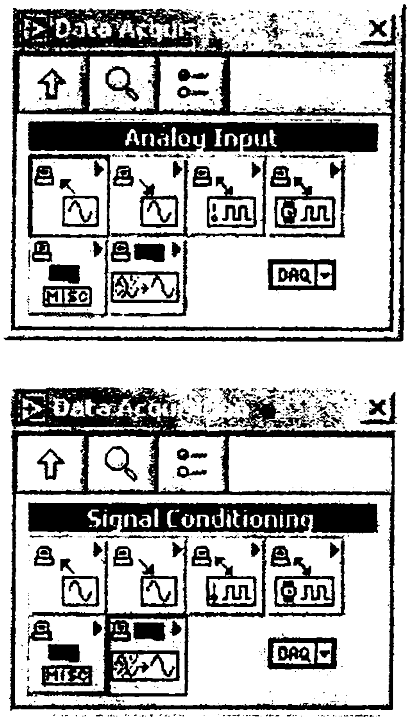


Fig. 1. Data acquisition subpalette

Analog input acquisitions use grounded and floating signal sources.

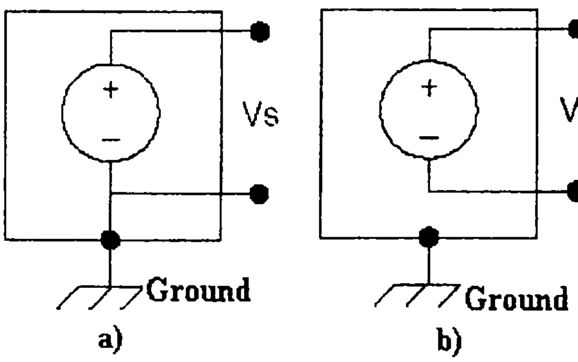


Fig 2. Signal source reference configuration

Grounded signal sources have voltage signals that are referenced to a system ground, such as earth or a building ground. Grounded signal sources share a common ground with the DAQ board. Floating signal sources contain a signal that is not connected to an absolute reference. Some common examples of floating signals are batteries, thermocouples, transformers, PV cells.

A measurement system can be placed in one of three categories: differential, referenced single-ended, nonreferenced single-ended. In a differential measurement system, you do not need to connect either input to a fixed reference. DAQ devices with instrumentation amplifiers can be configured as differential measurement systems. An ideal differential measurement system, reads only the potential difference between its two terminals inputs. A referenced single-ended measurement system measures a signal with respect to building ground. DAQ devices often use a nonreferenced single-ended measuremen system, wich is a varia ion of he referenced single-ended measuremen. system. In t.ese case, all measuremnts are made with respect to a common reference, because all of the input signals are already grounded (AISENSE is the common reference for taking measurements and all signals in the system share this common reference. AIGND is the system ground).

LabVIEW for Windows installs a configuration utility for establishing all board and channel configuration parameters. This utility is known as the Measurement & A...m...n Exp... – ...AX. Aft... ...n...ng ... DAQ board in computer, MAX utility reads the information the Device Manager records in the Windows registry and assigns a logical device number to each DAQ board. The configuration of channels for this application is presented in figure 1.

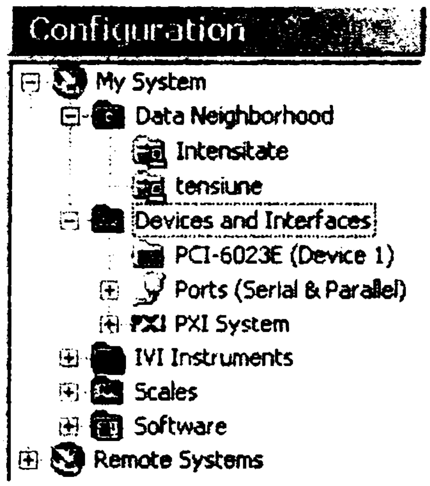


Fig. 3 Channels configuration

III. EXPERIMENTAL RESULTS

The semiconductor diode is a device that will conduct current in one direction only. A bias refers to the application of an external voltage to a semiconductor. There are two ways a P-N junction can be biased:

- A forward bias results in current flow through the diode (diode conducts). To forward bias a diode, a positive voltage is applied to the anode lead (which connects to P-Type material) and the negative voltage is applied to the cathode lead (which connects to N-Type material).

- A reverse bias results in no current flow through the diode (diode blocks). A diode is reverse biased when the anode lead is made negative and the cathode lead is made positive.

The P-N Junction region has three important characteristics:

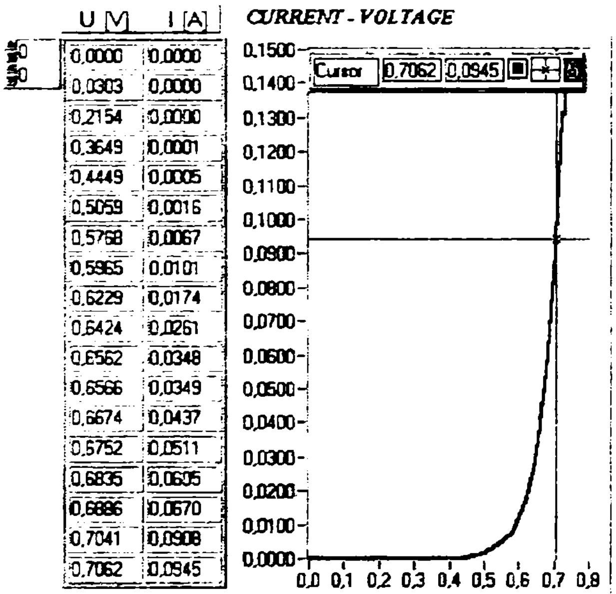
1) The junction is region itself has no charge carriers and is known as a depletion region.

2) The junction (depletion) region has a physical thickness that varies with the applied voltage. A forward bias decreases the thickness of the depletion region; a reverse bias increases the thickness of the depletion region.

3) There is a voltage, or potential hill, associated with the junction. Approximately 0.3 of a volt is required to forward bias a germanium diode; 0.5 to 0.7 of a volt is required to forward bias a silicon diode.

Semiconductor diodes are made by joining two different types of semiconductor materials in a special way so that when a proper polarity voltage is applied, electrons readily pass through one material to the other. However, if the voltage is reversed, there is very minimal electron flow.

In other words, a semiconductor diode allows current to pass through when in forward bias, and blocks current when in reverse bias. They also have properties or characteristics that enable them to perform many different electronic functions.



U [V]	I [A]
0.0000	0.0000
0.0303	0.0000
0.2154	0.0000
0.3649	0.0001
0.4449	0.0005
0.5059	0.0016
0.5768	0.0067
0.5965	0.0101
0.6229	0.0174
0.6424	0.0261
0.6562	0.0348
0.6566	0.0349
0.6674	0.0437
0.6752	0.0511
0.6835	0.0605
0.6886	0.0670
0.7041	0.0908
0.7062	0.0945

Fig 4 Semiconductor diode - IV characteristic

The general characteristics of a semiconductor diode can be defined by the ideal diode equation for forward and reverse bias regions which is given as

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

where q is the electronic charge and is equal to 1.602×10^{-19} coulombs, k is the Boltzmann constant with a value of 1.381×10^{-23} J/K and T is the temperature in Kelvin.

The zener diode uses a p-n junction in reverse bias to make use of the zener effect, which is a breakdown phenomenon which holds the voltage close to a constant value called the zener voltage.

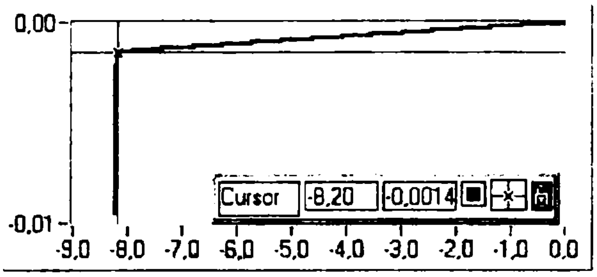


Fig 5 Zener diode

The social strong involvement of the energy systems and the complex boundaries between these system and all other technical systems, or the environment, have imposed the development of some researches on unconventional process of producing electric energy.

Nowadays there are many unconventional methods for obtaining electric energy, based on much or less studied physical or chemical phenomena. Photovoltaic systems convert sunlight energy into electric energy and they are characterized by modularity, functional autonomy and long function period.

To ensure the accuracy of the measurement, the operating parameters of the photovoltaic system and the configuration of the acquisition system are taken into account and have imposed the signal conditioning and the setting of the signal source, of the field and of the channels.

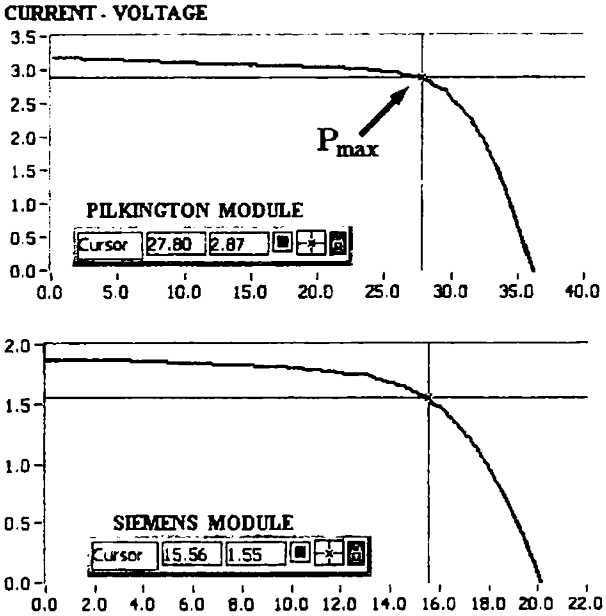


Fig. 6 PV module current-voltage characteristics

As we have to determine the operation characteristics of the photovoltaic panels and the panel arrays, the application allows to measure the values of current and voltage, to simultaneously trace characteristics (current-voltage, power-voltage, power-charge resistance), to present the measured parameters (during the data acquisition) in tables, continuous acquisition, to save data into files for future processing.

Building integrated photovoltaics, the integration of photovoltaic cells into one or more of the exterior surfaces of the building envelope, represents a small but growing photovoltaic application. In order for building owners, designers, and architects to make informed economic decisions regarding the use of building integrated photovoltaics, accurate predictive tools and performance data are needed. At Valahia University of Targoviste, enclosed in the ICOP DEMO 4080-90 European research program, a photovoltaic system has been realized, with an installed power of 10 kWp, composed by 66 OPTISOL SFM 72 Bx photovoltaic modules made by Pilkington Solar International and 24 ST 40 modules produced by Siemens. These modules are connected to Sunny Boy invertors.

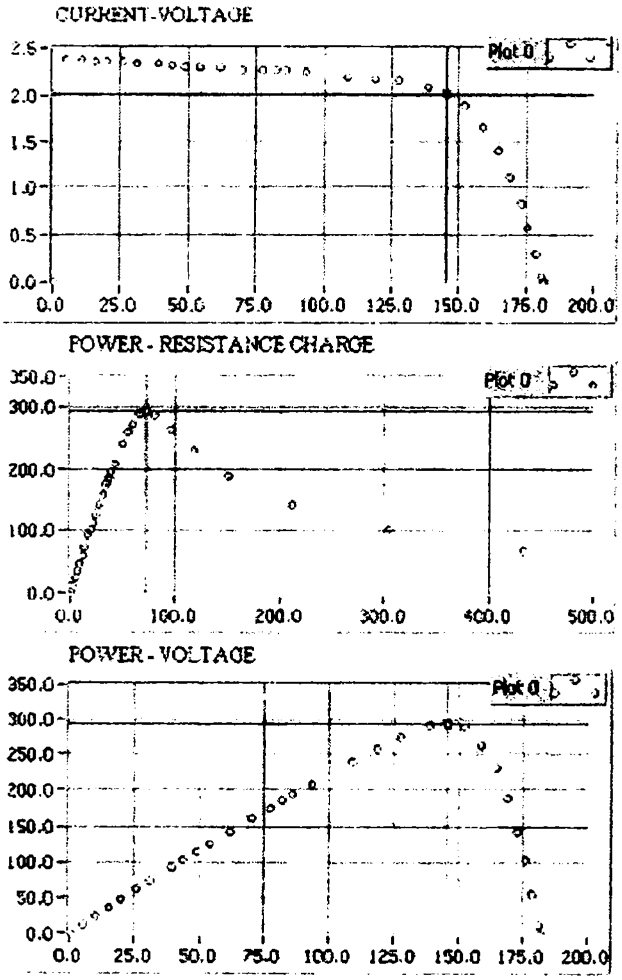


Fig. 7 PV array (5 modules) characteristics

- current - voltage
- power - resistance charge
- power - voltage

The Sunny Boy Control device and the Sunny Data Control data acquisition soft-ware are used to monitor the operating parameters of the unit. By using the acquisition system and the software, there can be determined the operation characteristics of photovoltaic panels. After shutting off the experiment, the investigators apply appropriate curve fitting techniques to determine the functional relationship I=f(U) manifest in their data. Curve fitting represent a technique for extracting a set of curve parameters or coefficients from the data set to obtain a functional description of the data set. LabVIEW provides built-in VIs that perform a least-squares fit of data to commonly used equations including a strainght line, an exponential curve and a m^{th} order polynomial. As an illustrative example of how these curve-fitting VIs function, see the image shown in fig.8.

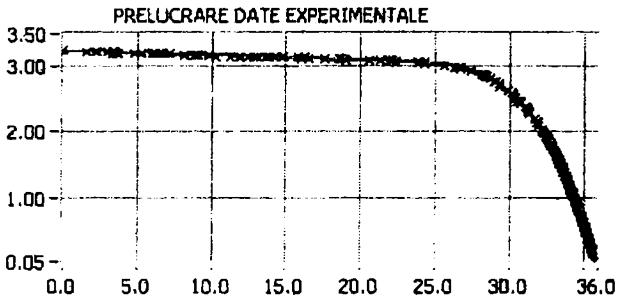


Fig. 8. Curve - fitting

IV. CONCLUSIONS

In this paper, a LabVIEW graphical program is designed to measure the current and voltage in dc circuit, for ploting characteristic curves for non-linear devices. LabVIEW is the most powerful measurement and control language available to execute the control algorithms and to present the results is a user-friendly format.

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