Web-based Remote Semiconductors Devices Testing Laboratory

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Abstract—**This paper presents the web-based remote laboratory that will be used as part of the practice for the Electronic Physics subject at the Electronic Engineering course of the National University of Rosario, Argentina. This remote laboratory was developed as a final project of the course by two students. In this project several semiconductors devices (diodes, BJT, J-FET, and phototransistors) can be tested in order to obtain the output characteristics of each one and to study the behavior in different conditions. The fact that the user (student) does not need to install any software to access via Internet and the low cost for implementation of the laboratory, are the most outstanding advantages of this Lab.**

Index Terms—**remote laboratory, electronic engineering, physics, semiconductors devices**

I. INTRODUCTION

Working in a laboratory is an important way of testing theory through practice, especially for engineering students. The degree of functionality and level of user access to remote laboratories has evolved thanks to advances in web applications and technologies. Current technology gives the possibility of remote access to laboratory equipment and instruments via Internet.

In this web-based laboratory several semiconductors devices (diodes, BJT, J-FET, and phototransistors) can be tested [1]. The implementation of this type laboratory offers quite a lot of advantages as it is not necessary to be present to carry out experiments. Thus, it avoids limitations caused by lack of resources or logistic problems, becoming an effective tool for e-learning purposes [2], [3]. One of the most outstanding advantages of this project is that students do not need of installing any software but a standard web-browser (Internet Explorer, Mozilla, etc.); so the experiments can be carried out using any of the known operative systems (Microsoft Windows, Linux, Mac OS, etc) and making this remote laboratory system-independent.

There are plenty of different tools available to make this possible. National Instrument LabView is the most complete and simple software, but its high cost has made us search for a cheaper alternative.

To carry out this Lab, we use a National Instruments Data Acquisition card already available at our faculty, and a web server with Windows XP Professional, IIS 5.1 and Microsoft Visual Studio .Net 2003. The graphic engine is part of the "Microsoft Office Web Components 10". This software library can be downloaded from Microsoft website.

The use of the .Net platform has provided us a remarkable advantage because the link between the client side and the server is made with HTML, since the ASPX application runs on the server. The server has the DAQ device connected to a 5-channel multiplexer for the five different experiments, and two power sources controlled by the two analog output channels available [4].

On the client side, the information is given by a standard web page, without the need of a plug-in or Java applet. The interface is very simple; it allows the students to choose which of the five semiconductors devices is going to be tested. The result of the experiment is the voltage-current characteristic graph of the requested device. The tests are made in real time; the results shown are given as graphic and as table, and can be reviewed by the user at any time.

II. DEVELOPMENT

This laboratory was developed using a National Instruments DAQ-1200 card installed on a web server running Microsoft Visual Studio .NET 2003 implemented on Windows XP. The device selection and the settings of each experiment were implemented by a custom made PCB.

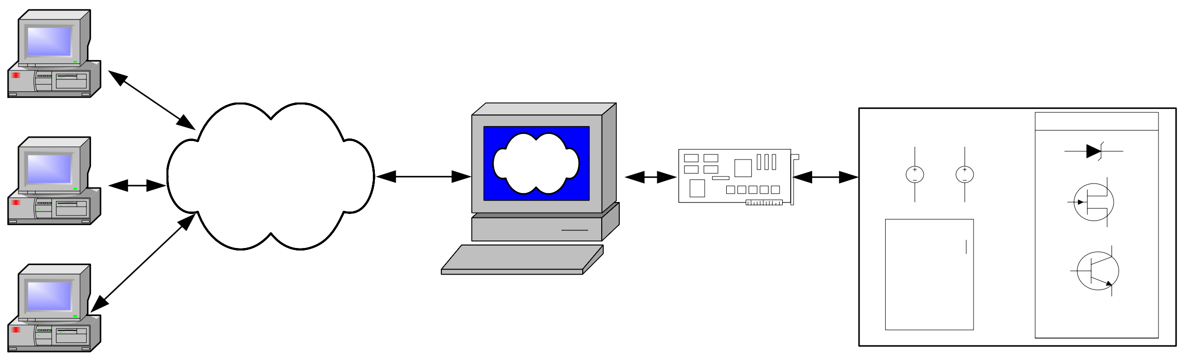


Fig 1 System Architecture

A. Hardware

The National Instruments DAQ-1200 card has eight (8) analog input channels, two (2) analog output channels and three (3) input/output digital 8-bit ports. The analog input channels are used for the voltage measurements and the analog output channels are used to set the power source voltage. We have also used three bits from the output digital ports for the device selection.

The custom made PCB allows us to set the power sources voltages and select which of the five experiments is going to be carried out (diode, zener diode, BJT, J-FET, phototransistor). To avoid damages on the DAQ Card, the PCB also includes a power stage to provide the current the circuits need.

B. Software

We have utilized a PC with Windows XP, IIS 5.1 as a web server and .Net Framework 1.1. Because of the nature of the National Instruments DAQ-1200 card (it is an old card without .Net support), we had to make an application that works as a TCP/IP Server, in Visual Studio 6 to be able to use the NIDAQ Legacy driver [5]. This communication server receives the orders from the application built in Visual Studio 2003, makes the acquisition and presents the results back to the web server.

The application is in standard HTML language, so it can be accessed by using any of the well-known web browsers (Internet Explorer, Mozilla Firefox, Opera, etc). There is no need to download or install any additional plug-in or Java applet.

The system is very easy to work with. The user enters his login and password and then, selects which of the devices is going to be tested. He can also see the results of the tests already done before.

The tests consist on getting the static characteristic of the selected device automatically. On the diode, the user can also select different current values to point by point making the test more interactive (Fig. 4). The next version of the system, will allow making different kind of tests to all the devices. For example, on the bipolar junction transistor, it would be possible to test the device on different ambient temperatures, so the student can view how the hfe is increased with more heat on the device.

When the selection of the experiment is done, the web server transfers the parameters to the communication server so the acquisition can be accomplished. After a few seconds, the results are shown. The student can see the static characteristic as a graphic and as a table. Also the user can also choose if he wants the complete curve or only the points. The table can be exported to a XLS file (Excel) and the graphic to a GIF file (picture).

Any of the experiments can be performed the times the user wants.

As a consequence of the way each device is being tested with any combination of power sources (current to test the diode, positive voltage/positive voltage on the BJT, positive voltage/negative voltage on the J-FET and positive voltage/current on the phototransistor), in the future the devices can be replaced by new ones.

The software can also be improved to allow the user make new kind of tests without modifying the hardware.

III. TESTS

A. Diode

A zener diode has been chosen, so we can obtain the full static characteristic of the device.

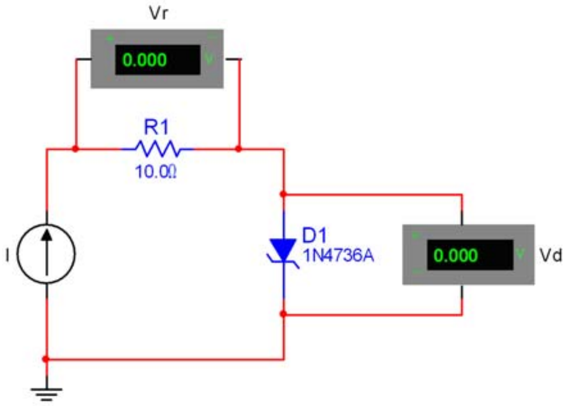


Fig. 2 Schematic circuit for the diode

To make the measures as accurate as possible and due to the characteristics of the device, a current source was chosen. In this way, we can have better resolution on the acquisition.

For each of the currents we establish the system acquires two voltages: one on the resistor and the other on the diode. Only sixteen different values of current are needed to obtain the full curve. The current source is controlled by one of the output channels on the DAQ Card.

When the process is completed, the static characteristic of the diode in direct polarization is presented. It can also be obtained the characteristic equation of the diode.

$$Id = Is(e^{vd/\eta VT}-1) \quad (1)$$

That can be simplified to:

$$Id = Is(e^{vD/\eta VT}) \text{ when } Id >> Is \quad (2)$$

To obtain the regulation characteristic of the diode zener, the system switches the anode and cathode. The acquisition process is the same as done before.

B. Bipolar Junction Ttransistor (BJT)

A BC548B BJT has been chosen. As well as the diode, the test consists on getting the static characteristic (Fig. 3) of the device.

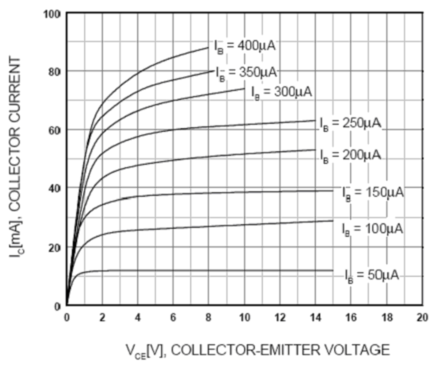


Fig. 3 Static Characteristic of BC548B according datasheet

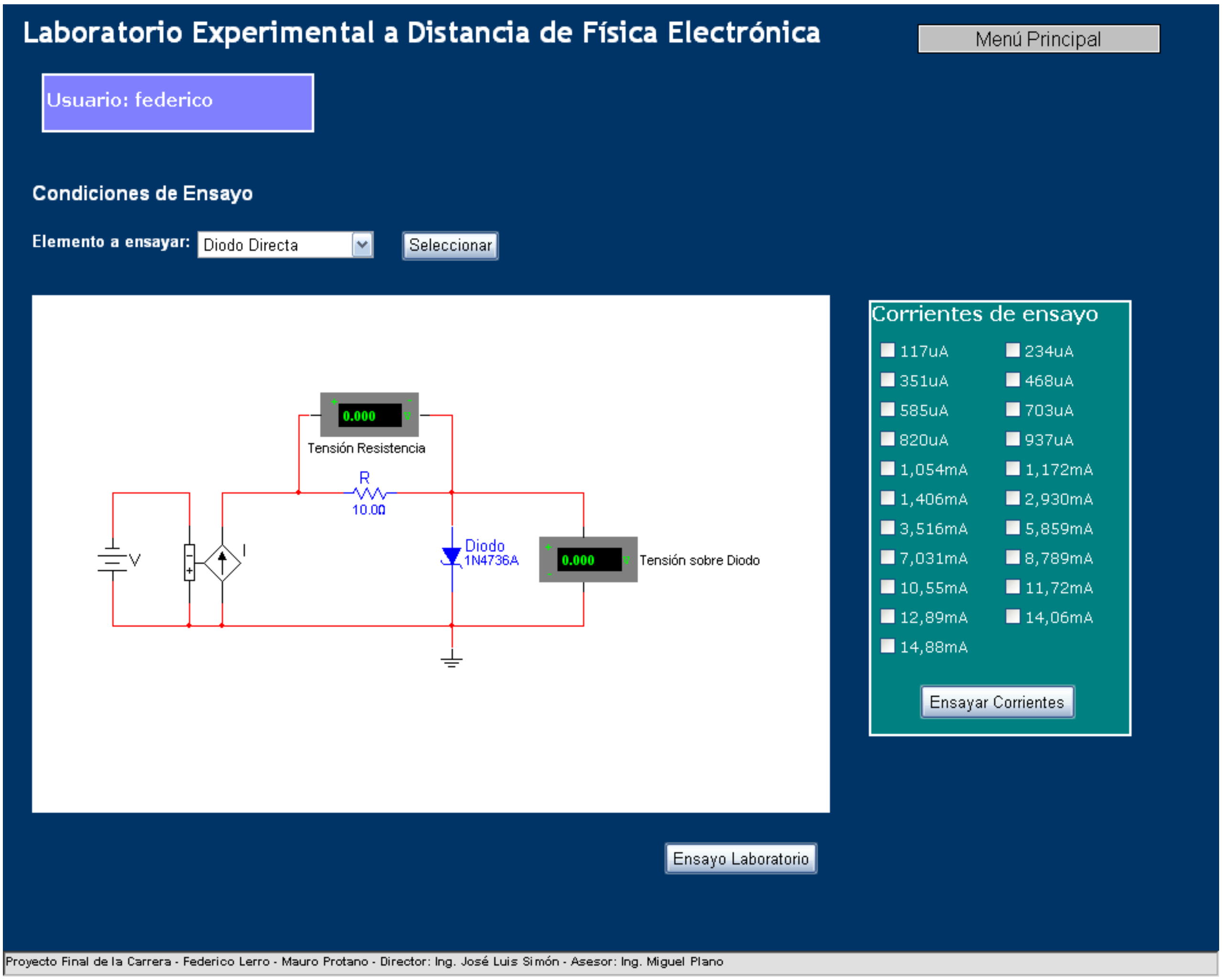


Fig.4 Diode's Test Selection Screen

The BJT is connected as a common-emitter amplifier (Fig. 5). Both power sources are variable, positive voltages and independent. These voltages are controlled by the two analog output channels of the DAQ.

In order to obtain the static characteristic of the BJT, the system measures the collector current, the base current and the collector-emitter voltage on each working point. The process is very simple: the system establishes the base current and then obtains thirty-two different working points by increasing Vcc voltage. The same process is repeated for each base current (Fig. 6).

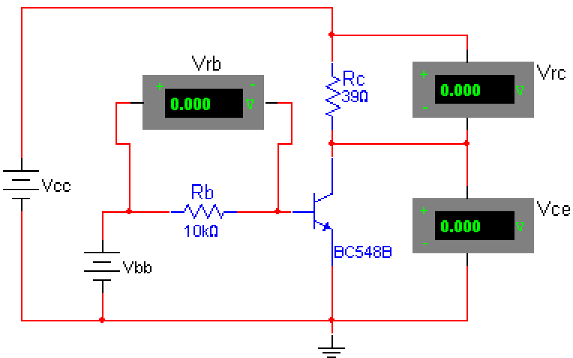


Fig. 5 Schematic circuit to test the BJT

C. Junction Field-Effect Transistor (J-FET)

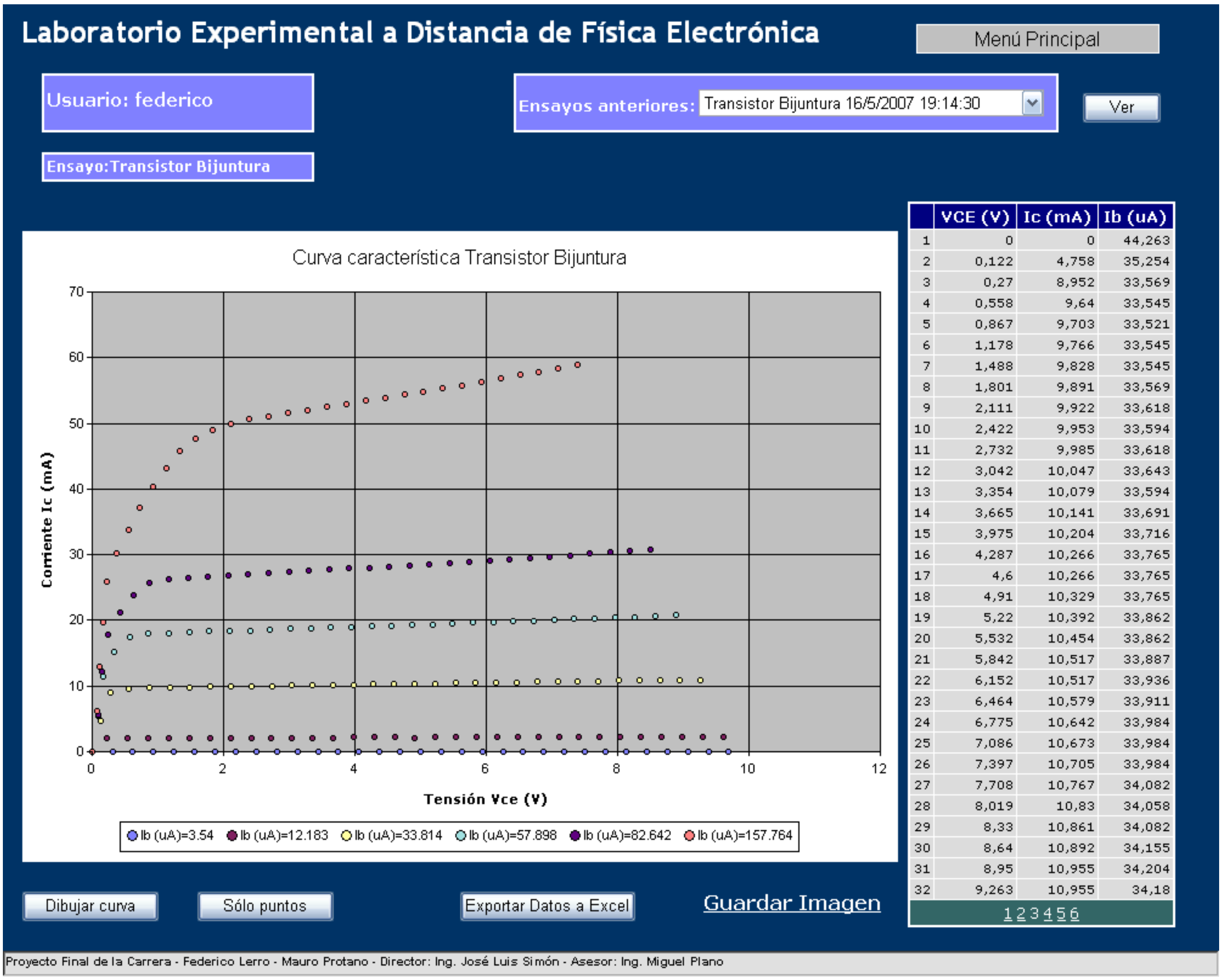
The J-FET (2SK117) is connected as a common-drain amplifier. It is polarized by setting a negative Ground-Source voltage controlled by one of the analog output channels of the DAQ. Moreover, the power source also is variable and controlled by the other analog output channel through a power stage on the custom made PCB.

The procedure is identical as the BJT. Once the J-FET is polarized, the system increases Vcc after each measure. Ground-Source voltage (Vgs), Drain current (Id) and Drain-Source voltage (Vds) are the points of interest to obtain the static characteristic of the device.

D. Phototransistor

In order to obtain the characteristics of a phototransistor as accurate as possible, we have chosen a DIP optoisolated transistor (4N28) for the selection of the device. The emitter diode is optically coupled to a phototransistor detector.

The proceeding to make the measures is equivalent as the BJT and the J-FET.



	VCE (V)	Ic (mA)	Ib (uA)
1	0	0	44,263
2	0,122	4,758	35,254
3	0,27	8,952	33,569
4	0,558	9,64	33,545
5	0,867	9,703	33,521
6	1,178	9,766	33,545
7	1,488	9,828	33,545
8	1,801	9,891	33,569
9	2,111	9,922	33,618
10	2,422	9,953	33,594
11	2,732	9,985	33,618
12	3,042	10,047	33,643
13	3,354	10,079	33,594
14	3,665	10,141	33,691
15	3,975	10,204	33,716
16	4,287	10,266	33,765
17	4,6	10,266	33,765
18	4,91	10,329	33,765
19	5,22	10,392	33,862
20	5,532	10,454	33,862
21	5,842	10,517	33,887
22	6,152	10,517	33,936
23	6,464	10,579	33,911
24	6,775	10,642	33,984
25	7,086	10,673	33,984
26	7,397	10,705	33,984
27	7,708	10,767	34,082
28	8,019	10,83	34,058
29	8,33	10,861	34,082
30	8,64	10,892	34,155
31	8,95	10,955	34,204
32	9,263	10,955	34,18

Fig.6 BJT's Static characteristic and data table

IV. CONCLUSION

A remote laboratory allows a user (student) to make experiments in a similar way as if he was at the laboratory, but comfortably placed at home or any place provided with an Internet connection; even it is not needed to be in the same city or country.

A strong feature of this project is that the user needs only a web browser and Internet connection to make the tests. There is no necessity to install extra software to access the lab.

In each test the user can verify the different properties of each device, confirming in the practice some of the theoretical contents applied to them. Those are: the static characteristic curves, and some parameters extracted from the equation fitting that curves.

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