Implementation of the Component Characteristic Curve Tracer Using PC-based Acquisition Card

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Abstract – The component characteristic curve tracer consists of hardware and software parts. Hardware part is a PC-based acquisition card mounted in standard personal computer. Software part is developed in National Instruments LABVIEW package. The tracer can be used for educational purposes, as well as in science purposes, for testing semiconductor or any other nonlinear electronic component.

Keywords - The component characteristic curve tracer, PC-based acquisition card.

I. INTRODUCTION

Computer based acquisition instruments followed development in personal computer industry. There are several types of acquisition equipment from various vendors. Most new implementations of legacy instruments like oscilloscopes, $AV\Omega$-meters and spectrum analysers have interface for connection with computer and software for data acquisition and manipulation. New types of stand-alone instruments and measurement equipment are embedded systems with adapted operating systems and acquisition software.

Measurement equipment based on computer hardware is realised as PCI card for desktop or rack-mounted computers or PCMCIA acquisition card for portable or PDA computers. The acquisition card needs device driver for operating system that runs on host machine and application software which provides data acquisition and manipulation.
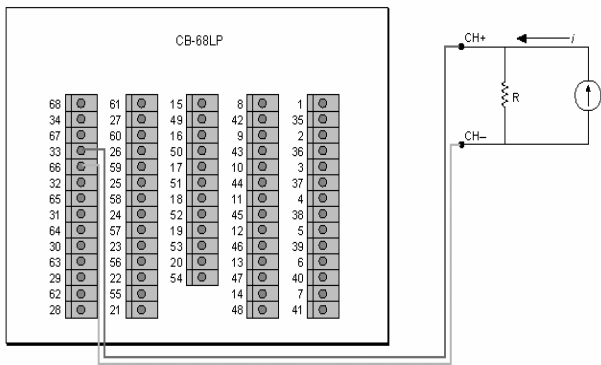

Fig. 1. CB-68LP connection block

The component characteristic curve tracer is implemented using *National Instruments NIDAQ PCI-6014* acquisition card [1]. This card has 16 analog inputs with 200kS/s sampling rate, two analog outputs with 10kS/s sampling rate, 8 digital I/O channels and two 24-bit counters. PCI-6014 is PCI based acquisition card. External signals or devices under testing can be connected with acquisition card using CB-68LP block panel (figure 1) and SH68-68-EP cable.

Software part is developed in LABVIEW package. LABVIEW provides intuitive developing interface with possibility of developing GUI applications. *National Instruments* provides other development platforms such as *Measurement Studio* for Microsoft Visual Studio, and ANSI compatible LABWINDOWS. The operating system driver is common for all developing packages. It provides basic application interfaces, and elementary functions for configuring acquisition card.

II. HARDWARE

The analog outputs are used as DC voltage generators for power supply and stimulus voltage. Maximal DC output voltage is limited to ±10V. This voltage is adequate for power supply, polarisation and measurement of static characteristics of the semiconductor components (figure 2).
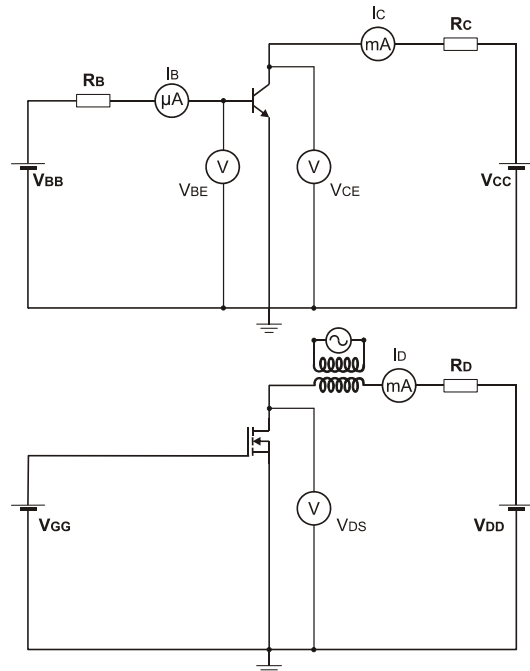

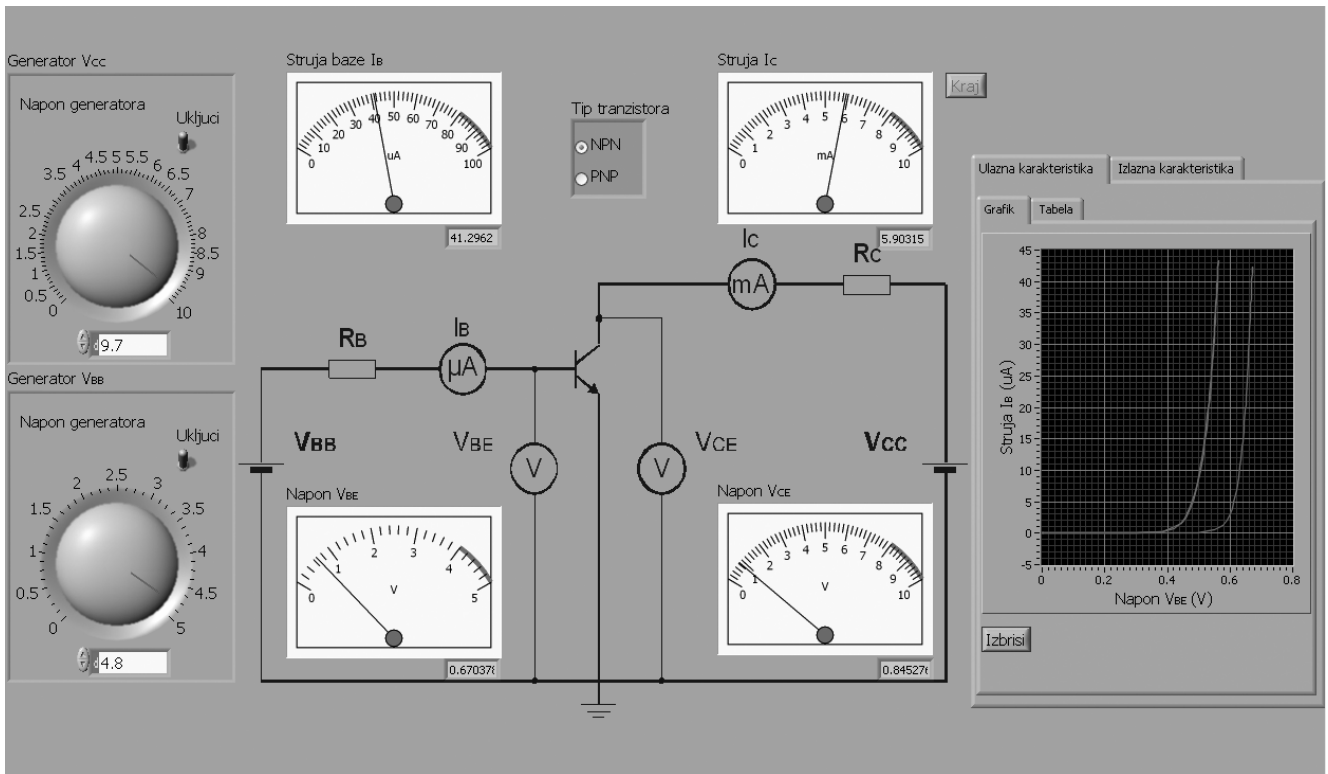Fig. 2. Circuits for BJT and MOSFET characteristic measurement

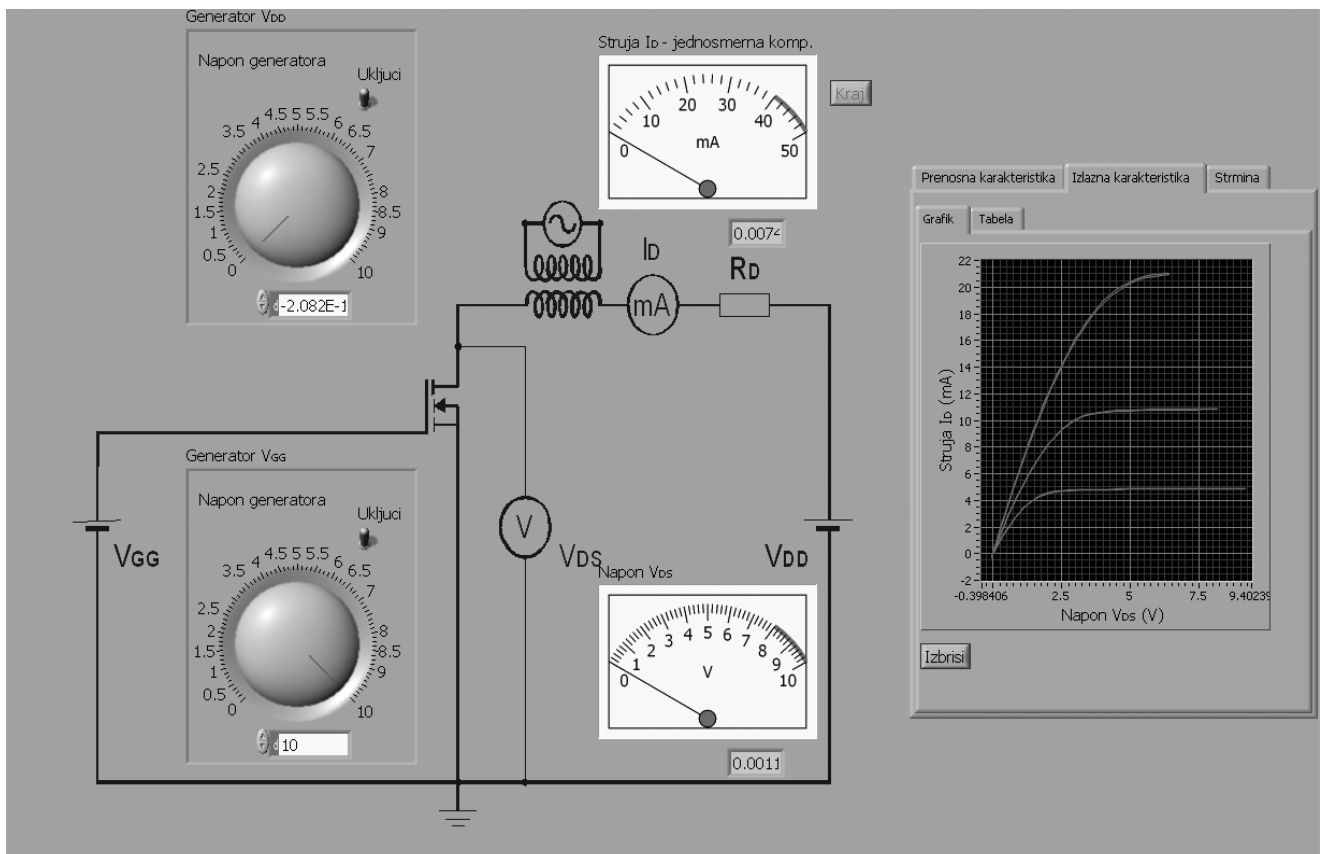**Fig. 3.** User interface – measurement of BJT input characteristic

Fig. 4. User interface – measurement of MOSFET output characteristic

The analog inputs can be connected using NRSE – non-referenced single-ended, RSE – referenced single-ended and differential measurement method. Differential method is used in implementation of the characteristic curve tracer, in order to decrease noise and increase the CMRR. This noise influences to measurement precision of small current and voltage values, such as saturation current of the germanium diode. Both of the connection points of a differential system are tied to instrumentation amplifier. There are no terminals connected to a fixed reference. With differential method, the number of analog inputs is limited to 8. In order to increase CMRR, a resistor can be connected between inverted input of instrumentation amplifier and ground. The resistance must have value of hundred equivalent Thevenin's resistance between connection points (inverted and non-inverted terminal of instrumentation amplifier). It is also possible to connect the second resistor between non-inverted terminal and ground. This configuration provides greater CMRR, but there is a systematic error in measurement caused by serial connection of resistors.
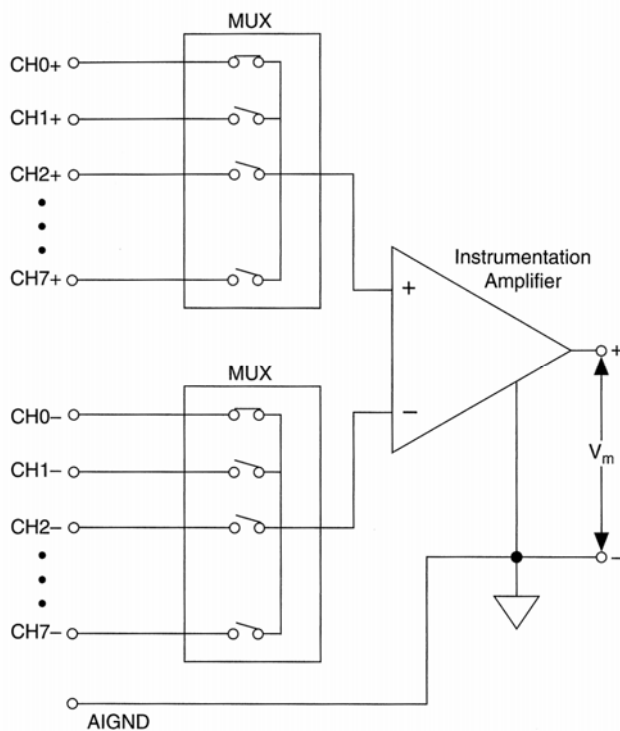

Fig. 5. Differential measurement method

The measurement of voltages can be performed directly. Maximum input voltage is limited to ±10V. The measurement of currents can be performed only indirectly, by transforming current into voltage using parallel resistor. In this implementation we used 100Ω, 1% tolerance metal-film resistor, due to better precision of measurement. Consequently, the value of 1mA is equivalent to 0.1V. The value calculation is performed as software function.

III. SOFTWARE

Software part of the characteristic curve tracer is realized in National Instruments LABVIEW developing package, which provides simple realization of virtual instruments. Virtual instruments consist of interface to acquisition card and application with graphic user interface.

Interface to acquisition card is realized as device driver. PCI 6013/6014 cards are supported by *Traditional NI-DAQ* and *NI-DAQmx* drivers. All the measurements are performed using *virtual channels*. A virtual channel is collection of property settings that can include name, a physical channel, input terminal connections, the type of measurement or generation, and scaling information. A physical channel is a terminal or pin at which an analog signal can be measured or generated. Virtual channels can be configured globally at the operating system level, or using application interface in the program. Every physical channel on a device has a unique name.

When using NI-DAQmx drivers, a number of similar virtual channels can be aggregated into a *task*. A task is a collection of one or more virtual channels with the same timing, triggering, and other properties. A task represents a measurement or generation process. As well as virtual channels, tasks can be configured globally at the system level, as well as using application interface.

The user interface (figure 3 and figure 4) of the component characteristic curve tracer consists of visual controls and indicators. It provides basic functions for measurement. Visual controls – knobs and switches – provide control of analog signal generation. The indicators – gauges and graphs – show measured values. All measured values are placed in a table, and after the measurement process in appropriate file. User interface also provides controls for data manipulation and saving measured values.

For better performance, the main application has been separated in two threads. The first thread has functions for file manipulation and saving measured values (figure 6). All measured values will be saved in HTML file format.
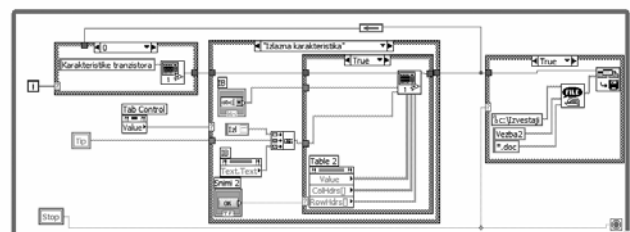

Fig. 6. Data manipulation and saving thread

Main thread (figure 7) performs the measurement process. It is a connection between user interface and low level device driver which controls acquisition card. Processes of signal generation and acquisition are controlled by DAQ Assistant. Main thread also includes
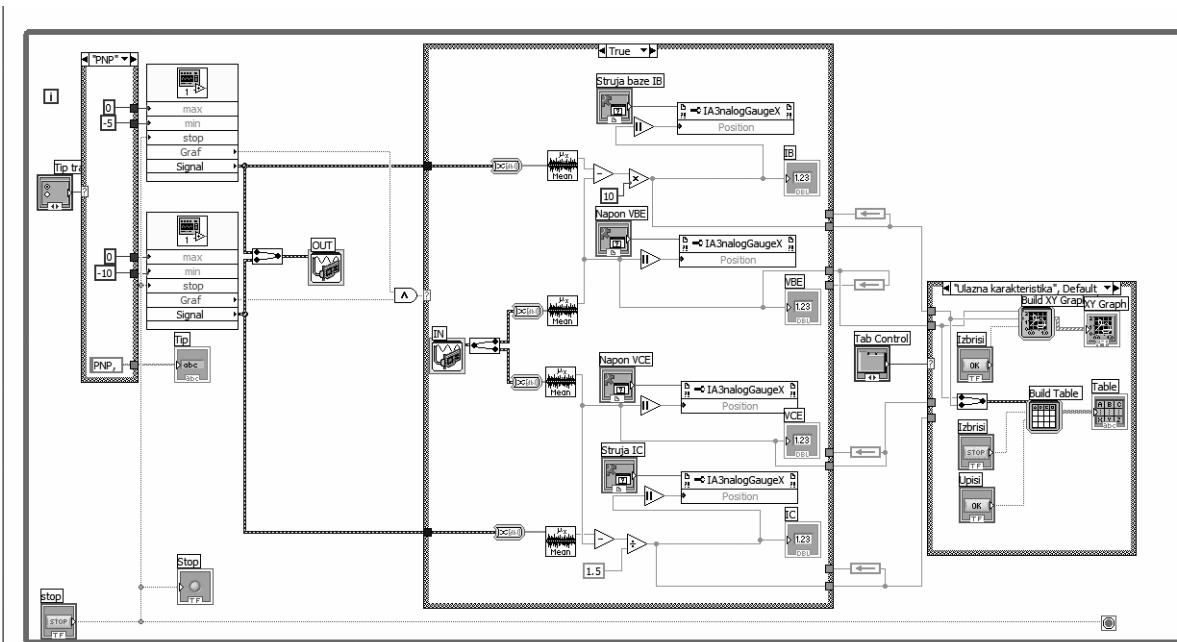
Fig. 7. Main thread

functions for signal manipulations, range calculations, calculations of measured current, building data table and characteristic graphs.

IV. CONCLUSION

The component characteristic curve tracer has educational purpose. It is a part of computer system for laboratory exercises in Electronics [2 and 3]. The main goal of this system is to simplify manipulation of instruments, faster measurement and notation of the results, providing students to concentrate on measurement essence.

This system can also be used in science purposes for characteristics measurement of low-power semiconductor electronic components.

REFERENCES

[1] *National Instruments PCI 6014* Product Data Sheet, http://ni.com.
[2] Dimitrijević M., Litovski V., Jovanović S., „Računarski sistem za izvođenje laboratorijskih vežbi iz Elektronike", V simpozijum Industrijska Elektronika Indel 2004, Banja Luka, 11-12 novembar 2004, pp.156-160.
[3] Litovski V., Petković P., Milenković S., Milovanović D., Glozić D., Mrčarica Ž., Maksimović D., Ranđelović Z., „Praktikum laboratorijskih vežbi iz Elektronike I", šesto izdanje, Elektronski fakultet Niš, 1998.