

EMPLOYING REMOTE ACCESS TEACHING SYSTEM FOR DIODE MEASUREMENT

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***Abstract:** The paper describes a system used for real remote measurements in teaching of electrical engineering. A series of cooperating applications were designed in LabVIEW environment. They are based on Data Socket and Remote Panel technology, while the new idea lies in modular structure. Several couples of modules (called GO and DO module) are needed for a remote operation. GO modules are identical for all workplaces and can be redesigned in the future using other programming tools without modifications of DO modules. The system is suitable for teaching especially in distance learning or as a supporting tool for full-time study. For better interactivity support for web camera was added to our DO module. An overall effect of this educational tool was evaluated using a questionnaire.*

Keywords: LabVIEW, Data Socket, remote experiments, measurement, IMAQ.

INTRODUCTION

Department of measurement belongs to Institute of Electrical Engineering at the Faculty of Electrical Engineering and Information Technology in Bratislava. We are dealing with subjects of measurement and electrical engineering. It is inevitable for an electrical engineer to have deep knowledge about electrical phenomena and components. Depending from specialization our students need to obtain skills with real measurement instruments and knowledge about measurement devices and principles. A thorough study of electrical phenomena is also important for students to be able to understand an inner construction of an instrument.

In the best case every student comes with similar knowledge and could have his own workplace in the laboratory where he/she is present at the right time. However, level of initial knowledge of students entering our subjects is very different. Remote access software system designed at our institute can serve here as

an additional tool for home study. It allows access to real measurement instrument and brings more working time.

For the development of the software system we used experience of our department especially with LabVIEW environment. It is one of the best programming environments for measurement applications (Mokhtar, Mikhail, Seong-Joo (2014); García-Guzmán, Villa-López, Vélez-Enríquez, García-Mathey, Ramírez-Ramírez, 2017). We chose modular structure for our design allowing addition of modules programmed in other languages. Furthermore, the way of cooperation of modules achieves high software security and simplifies the design of new workplaces controlled by so-called DO modules. In this case we designed a DO module for measurement ampere-volt characteristic. Using this module after measuring in the faculty laboratories students can continue with the work from home and supplement the knowledge.

1. CONCEPT OF REMOTE ACCES SYSTEM

In the academic community, some developments have already taken place in the field of remote measurement. There are authors like (Samuelson, Graven (2016)) describing design based on original web-publishing tool integrated in LabVIEW (known as a remote panel) as outdated because it is based on non-http protocol requiring installation of LabVIEW Run-Time Engine on client side which is furthermore not available in mobile phone version. However, there are many other new works based on this technology, e.g. (García-Guzmán, Villa-López, Vélez-Enríquez, García-Mathey, Ramírez-Ramírez, 2017) or (Singh, Chatterji, Shimi, Gaur, 2015). The reason for this contradiction is the fact that LabVIEW offers high efficiency for development of small applications interacting with laboratory equipment especially for non IT oriented community while usage of more programmatically oriented tools for web publishing of final application depreciates this advantage. Then, relevant problem for some universities is also to keep IT-area oriented stuff which can find very attractive workplaces in commercial sphere. And designers are naturally looking for tools intended for the same environment which they use for the type of work – like Matlab2Web for Matlab in (Gula, Žáková, 2017); this topic also reflects the general issue that dedicated web publishing tool is in development and there is no steady solution. If a department decides to invest time and money into more sophisticated system of applications with the front-end Learning Management System (LMS) usually based on HTML5 like in (Luthon, Larroque, 2014), it is still possible that LMS just redirects the client to URL of selected workplace where against the designer needs take care about web publishing strategy. And we still need to keep in mind the problem of security (Mokhtar, Mikhail, Seong-Joo, 2014; García-Guzmán, Villa-López, Vélez-Enríquez, García-Mathey, Ramírez-Ramírez, 2017) usually skipped in paper presentations but often limiting the real life usage of the system.

Considering of all described attitudes we decided to design a modular system of applications with remote access. For developing phase we use just LabVIEW environment, however the modular structure described in (Červeňová, Králiková, Kamenský, 2016) allows later addition of modules designed in another environment. Our system is based on pairs of GO and DO module. To access the remote workspace or the target application called DO module the user communicates over a superior GO module, which is placed on a dedicated server computer. Its purpose is to accept commands from a remote user and forward them to a target application or to distribute results to the remote user. The user actually accesses remotely one of the GO modules placed on the server computer while the connection with the PC controlling requested workplace is managed by the GO module application. For every DO and GO module pair the GO module is identical. As we divided the part controlling measurement from the module providing web publishing, once a GO module will be updated, it can be employed for all DO modules without any code change.

DO modules are unique, every carrying its own identifier (ID). On the central server computer several copies of GO modules are running allowing connection to the target DO module with the right ID. The target application could be located on any computer within the local network, which stays not directly visible from outside and hence protected against software attacks.

LabVIEW programming environment with graphical G language offers features which shortens initial time of system development. It is intuitive and includes libraries for interfacing the PC with measuring equipment and for processing of the data to evaluate measurement output. E.g. for analogue interfaces it supports data acquisition cards (DAQ) mostly with USB, PCI or PCIe interface. For communication with standalone digital laboratory devices we can employ VISA (Virtual Instrument Software Architecture) library covering GPIB, USB, LAN or RS-232 interfaces or even lower level GPIB library. On the other hand two important technologies available in LabVIEW significantly simplify network distribution of measurements: Data Socket and Remote Panel. DataSocket is a software interface that provides easy access to several I/O mechanisms without low-level programming and was used for communication between GO and DO modules. Remote Panel already discussed above is a simple and popular way how to publish the front panel of a LabVIEW program for use in a standard Web browser. If remote connection without local installation of LabVIEW Runtime Engine is required (Samuelson, Graven (2016)), similar tool AppletVIEW could be considered instead (Mokhtar, Mikhail, Seong-Joo, 2014).

The internal concept of a DO module for measurement ampere-volt characteristic is presented by the block diagram in Figure 1. Similarly to the GO module (described in (Červeňová, Kamenský, Králiková (2016)) it works as a state machine. A state is called mode here and modes 1 till 5 are designed for managing communication with GO module. The application starts in mode 0 waiting for initial command coming into opened DataSocket buffer. In mode 1 the application

is prepared for cooperation with GO module, especially other DataSocket variables are initiated, as we use separate variables for commands and data and for every direction. In this phase we want to initiate also button labels visible for remote user therefore we send the “Button Init” command to GO module and jump to mode 6 where the labels are sent over data variable. Mode 2 is then dedicated for maintaining of the communication checking if a new command was received or time expired which means the connection with GO module is interrupted. Note that every data exchange is initiated by GO module which also has to send “Refresh” command within time out for the case there is no action from a remote user. Otherwise the connection and the variables are closed in mode 3. After regular command was received in mode 2 it is subsequently recognized in mode 5.

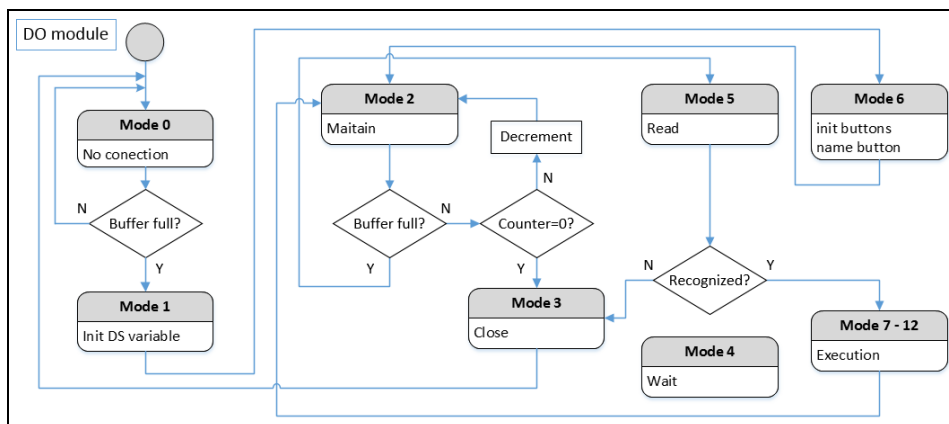


Figure 1. Block diagram of DO module

Source: Own work

According to the command value the application jumps from mode 5 to one of execution modes starting from 6. Actually mode 6 was already used for sending initial button labels, however it is generally possible to jump again into mode 6 and resend those labels. In our case we do not change labels after initialization and we jump to modes 7-12 during execution of GO module commands in reactions to user actions. (Mode 4 is skipped and can be implemented later e.g. when the system functionality will be extended by command sequencing.) Despite this is a structure of our particular DO module it can serve as a guide for other DO module designers.

2. DESIGN OF WORKPLACE

One of most important topics of our basic laboratory courses is measurement ampere-volt characteristic. It teaches the students principles of semiconductors as an inevitable step for later study of complex inner circuits of precise devices. On the other hand it is good laboratory for learning operation of digital multimeter (DMM), bench top DC power supply or more complex source measurement units (SMU). We usually use this measurement for teaching programming of

measurement instruments too when DMM and DC source are connected to a PC and controlled from LabVIEW via SCPI (Standard Commands for Programmable Instruments) commands. Therefore such workplace with remote control has widespread usage at our institute.

For the particular case described in this paper we connected DMM HP 34401A and DC Power Supply Agilent E3640A to PC over GPIB interface for measurement of diode characteristics. The workplace is represented by schema in Figure 2. It is controlled by DO module placed on local PC, while the user interface (UI) for remote user is given by front panel of GO module – like the one depicted in Figure 4. Therefore operation of DO module application has to refer to UI graphical components. The UI comprises five buttons for general usage, three tabs (Graph, Listing, Image) and edit line. Labels of buttons indicating their function are sent in initialization phase of modules communication as described above. Those labels sent in mode 6 are: *Initialize, Measure, Listing, Image, Clear Data, Help*.

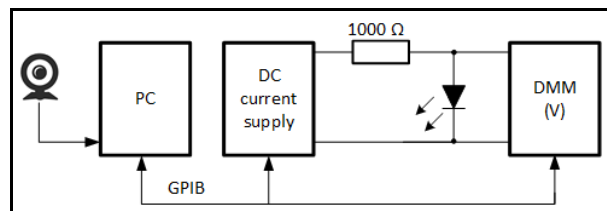


Figure 2. Schema of workplace

Source: Own work

The main portion of functionality of the workplace is accomplished in mode 7 after *Measure button* is pressed. Here new point of ampere-volt characteristic is measured and added to the internal array. The application exists in tree versions (one selected by internal parameter) differing in mode 7 implementation. In all cases it engages number entered by the user and shifted from the edit line of UI (*Parameter*). In simulation version the voltage is determined by the user and the current (mA) is calculated by internal mathematical equation. In voltage source version the parameter is sent via VISA Write function and SCPI command “*volt Parameter*” to DC source as desired output voltage. Subsequently current is measured with a query “*meas:curr:dc?*”. In this voltage source version a protective resistance R_s is supposed to be connected in series with the measured component, therefore the voltage drop on R_s is finally subtracted from DC output voltage before using for ampere-volt characteristic. In the case of current source version of DO module the input parameter is limited to predefined range and sent to DC source as requested current using SCPI command “*curr Parameter*”. The voltage is then directly measured with a query “*meas:volt:dc?*” and no serial auxiliary component is supposed to be connected in the circuit. After measurement the graph is refreshed. If the user wants to see besides the graphical characteristic also the measured number in written form, the array of measured results is displayed in the

listing in mode 8 after *Listing button* was pressed. The internal array is cleared in mode 10 (*Clear Data button*).

To see the impact of voltage and current combination on measured component especially if it is LED the camera image is obtained and sent to image tab of UI in mode 9 activated with *Image button*. The critical part of the block diagram of mode 9 is shown in Figure 3. National Instruments offers plenty of functions for working with cameras and images in NI Vision Acquisition Software (VAS). The NI-IMAQdx driver software is needed to use third-party image acquisition for USB 2.0 Cameras Supporting Microsoft DirectShow. Figure 3 shows how the camera can be used for Grab acquisition. After opening the camera session the function IMAQdx Configure Grab starts capturing the image to an internal software buffer. The IMAQdx Grab function copies one image to a LabVIEW image buffer and can be called multiple times for capturing several subsequent images. Finally the camera is closed. The output of grab is converted into form suitable for displaying in Image tab of our front panel.

If a student needs help with the remote measurement the help can be shown in the same *Image tab* by pressing *Help button* causing jump to mode 11. Finally the mode 12 is selected after “Refresh” command was received in DO module and it just writes information string “Communication refreshed at TIME”, where TIME is obtained by LabVIEW function Get Date/Time String.

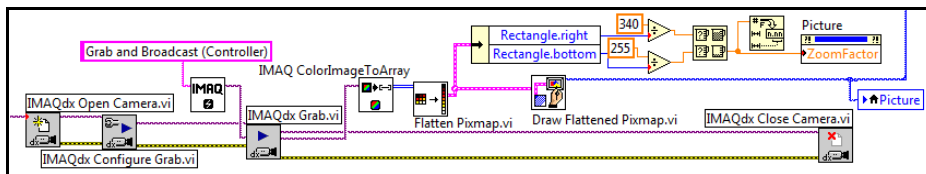


Figure 3. Sequence of blocks for obtaining image from web-camera

Source: Own work

3. USAGE OF THE SYSTEM IN EDUCATION

Designed remote access system can help teaching in different ways. It can be employed during laboratories to allow access to unique equipment over local network, when every student could acquire data to his/her PC from the seat. It can also add additional working time even for home study. Similarly when used before laboratories it can serve for preparation for a topics. The open and modular structure of the system gives the prospect of creating a wider community of designers also from different institutes and universities which can provide the opportunity to work on special devices located outside our institute.

The remote access system with DO module for measurement of diode ampere-volt characteristic was in our case used after laboratories to offer more working time especially for students with lower level of initial knowledge. In subject “Electrical engineering 1” students measured ampere-volt characteristic of a rectifying diode

during laboratories. Before leaving the room they obtained special links for access to two separate workplaces installed permanently at our institute. One of them was installed with similar rectifying diode, the other one with LED. During one next week they were allowed to perform remote measurements and collected data which has been obligatory added to their report.

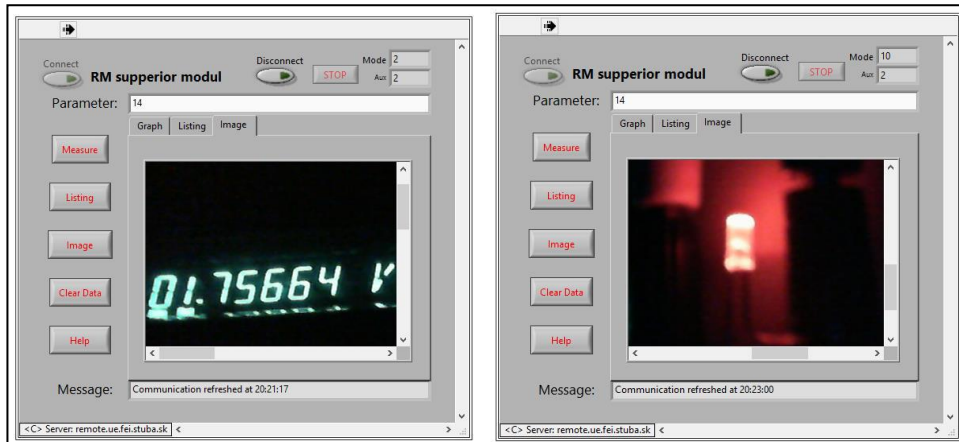


Figure 4. Left - View to multimeter display, Right - View to lighting LED diode *Source: Own work*

In Figure 4 left a GO module connected to the workplace of rectifying diode is presented. After pressing *Measure button* new point for current shifted as parameter (14 mA in this case) is added to characteristics in *Graph tab*. For numeric listing of all collected points *Listing button* has to be pushed. The *Image button* shows snapshot grabbed from web camera in *Image tab*. We can see measured voltage directly on display of the multimeter. For the case of LED measurement (Figure 4 right) also actual diode light can be observed. The graph is cleared after pressing *Clear Data button* when also internal array is erased. *Help button* offers useful hints for the user displayed in *Image tab*.

Inspired by (Tripathi, Mohan, Gangadharan (2012); Luthon, Larroque (2014)) we prepared a questionnaire completed by our students after laboratories. They presented opinions about the usage of designed remote access system. They answered following questions:

a) *Benefit*: The use of remote access to the workplace within the exercise is in your opinion: (great benefit - little benefit - unnecessary burden). See Figure 5 left.

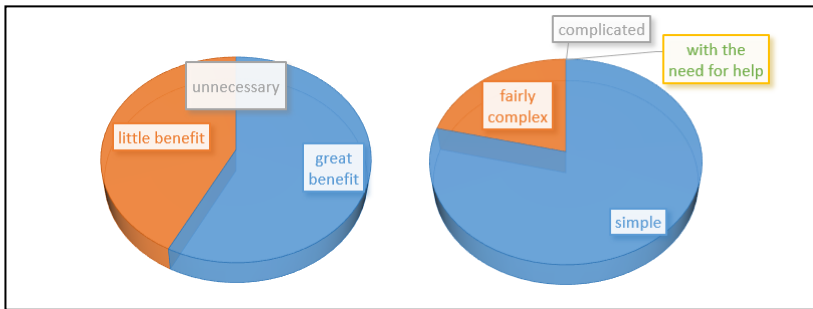


Figure 5. Benefits and orientation in app of remote measurement

Source: Own work

b) *Learning*: Remote measurement of ampere-volt characteristic of diodes helped you understand the subject: (better - less - not at all - not interested). The answer depended on whether students from a technical school or grammar school had come. For students from technical schools it was not a big benefit, for other it was good help.

c) *Simplicity*: The orientation in the app was for you: (simple - fairly complex - complicated - with the need for help). See Figure 5 right.

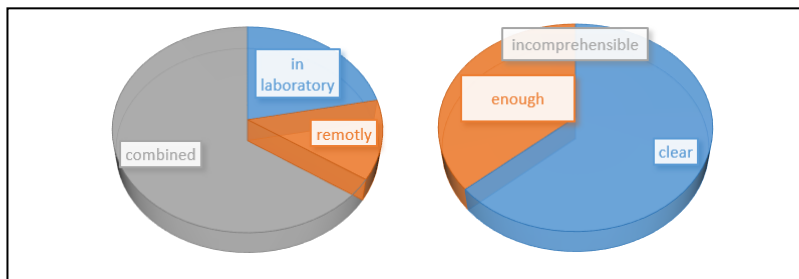


Figure 6. Preference of measurement and understand ability

Source: Own work

d) *Clarity*: Has your guide been understandable: (enough - sufficiently comprehensible - incomprehensible). See Figure 6 right.

e) *Preference*: If you could choose which exercise method would you prefer? (attendance - distance - combined: more presence measurements - more remote measurements). See Figure 6 left.

f) *Contribution*: Specify the advantage / disadvantage of remote access for you personally - it was good for student to measure out of the house at any time. They considered as a disadvantage that they could not personally ask questions.

Students also proposed in questionnaire new suitable topics for remote access. The results encourage us to continue in preparation of other topics and workplaces into the system especially as support mean employed in combination with standard

laboratory exercises. One of advantages of our system is the same GO module type and hence unified user interface of applications (including both presented here) which finally reflected in positive votes of Clarity and Simplicity. The problem of need of LabVIEW Run-time Engine did not much influenced Simplicity votes probably because there is university licence and our students are using LabVIEW to a great extend during education process. However, for the future we plan to find the best solution how to update or rebuild GO modules to allow remote connection from Android devices.

CONCLUSION

Practical experience with our remote access teaching software system has been presented in this paper. The system is based on communication between DO module controlling a workplace and GO module for distribution of data and access. We designed a complex software DO module controlling workplace for ampere-volt characteristic measurement. This DO module represents a pattern for other designers of workplaces and of their control within our modular system.

The system was employed in the subject “Electrical engineering 1” as a tool offering additional working time after laboratories of diode measurements. The system has stable functioning during one week of remote usage while the students were collecting data for their laboratory reports. The feedback from student experience was taken over a questionnaire. According to their opinions we can claim it has significant meaning especially for students with lower level of initial knowledge about electronics and skills. We plan to design next set of DO modules paired with GO modules all running at the same server computer and just a simple step is needed to comprise all GO modules into a simple Learning Management System.

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