

Remote Experiments in Resistor Measurement

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Abstract – The paper describes blended learning approach to teaching resistor measurement. It is based on “Learning by Doing” paradigm: interactive simulation, laboratory plants, real experiments accessed by Web Publishing Tools under LabVIEW. Studying and experimenting access is opened for 24 hours a day, 7 days a week under Moodle booking system.

Keywords: internet-based remote experimentation, resistor measurement, upstream, downstream, bridge.

I. INTRODUCTION

Efficient learning in engineering assumes a mixture between theory and practical work. The drawback of a pure theoretical approach in a curriculum is that less attention is paid to the phenomena looming around laboratory experiments and real components. The result of this was that computer simulations gained more and more attention. However, it is of crucial importance for the student to gain practical experience. Physical experiments help the students in practical testing and allow them to see the influence of second and higher order effects or parasitics that are often difficult to simulate as in reality.

Although classical laboratories are very useful, they may have limitations regarding space, time and staff costs. These problems can be significantly alleviated by using remote experiments and remote laboratories when the students operate with real systems, although they are not present in the laboratory. The proliferation of web based distance education courses involves new challenges for teaching of disciplines involving a high level of practical work.

For engineering related distance education the use of a web-based delivery mechanism is the only realistic method of providing hands-on experience, allowing remotely located students to complete laboratory assignments, unconstrained by time or geographical considerations. In this way access to the experiments is

available 24 hours a day, giving the users the possibility to access the laboratory when they most need it, sitting comfortable in a remote location. They can change parameters, perform experiments, observe results in graphical or numeric view and download them.

II. LEONARDO DA VINCI PROJECT

The Leonardo da Vinci project is approved to create a full set of distance experiments called PEMCMebLab in an integrated learning platform, providing the user with a practical experience in Power Electronics and Electrical Drives education. The participants are twelve universities with the span across the EU. The expected results are:

- elaboration of clear learning objectives for distance experimental education;
- guidelines for project oriented measurements;
- synthesis oriented experimental work;
- technology and technical documentation for distance practical education and measurements via Internet;
- different experiments, each with its own specificity.

Each experiment has its own server because it is located at a different location. Remote users first log onto a main booking server, located at the University of Maribor, after which they will be directed to the specific server. The booking system is based on the Moodle course management system. In addition to the original booking system, some modifications have been made [1], enabling easy booking.

The users are divided in two groups: authorized users and guests. Only authorized users can control the experiment. The guests can only observe measured values and waveforms but they have not control of any part of the system.

The learning issues addressed in the PEMCWebLab integrated learning platform are:

- learning objectives;
- education;
- animation and simulation;
- experiment.

The order of these issues is important. For safety reasons no student will be allowed to perform any experiment until he has proofed adequate knowledge of the requested experiment.

The structure of the distance laboratory is shown in Fig.1 in the situation when the chosen module is “DC Circuit Measurements”.

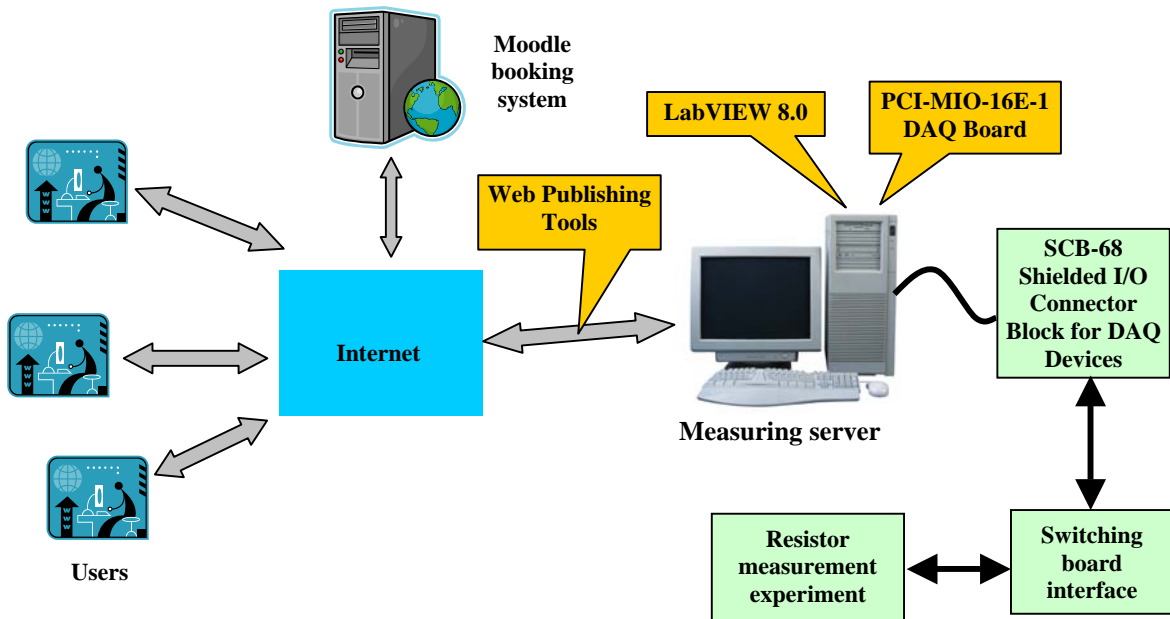


Fig.1. Structure of the distance laboratory for E-learning practical teaching of resistors measurement.

III. MODULE AND EXPERIMENT DESCRIPTION

The course module “DC Circuit Resistor Measurements” with the hardware arhitecture presented in Fig.2, is dedicate to understanding resistor measurements.

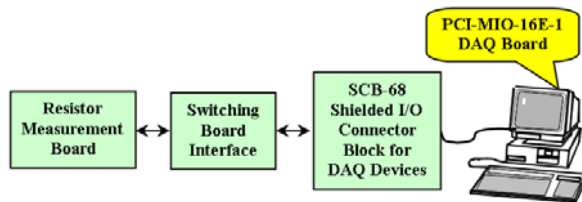


Fig.2. Hardware structure of the “DC Circuit Resistor Measurements” module.

The local server uses LabVIEW [2] for controlling the experiment. The Web Publishing Tools that come with LabVIEW are used both for interfacing and remote controlling the experiment. The proposed solution is based on “Resistor Measurement Board” module hardware. The PCI-MIO-16E-1 DAQ card together with the SCB-68 shielded I/O connector block for DAQ devices are used for acquisition and measurements.

The Switching Board Interface – SBI – is controlled from LabVIEW and is used for configuring the desired resistor measurements topology and the signals for data acquisition. The block diagram of the SBI is present in Fig.3. Functionally, it consists of a 32 bit serial-in,

parallel-out shift register with output register, followed by buffers that switch on and off a relay matrix.

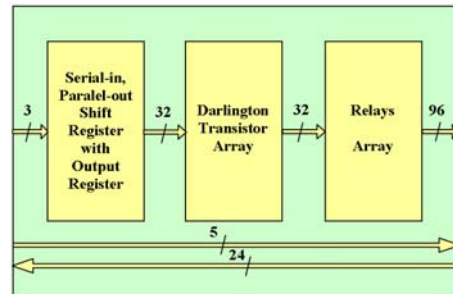


Fig.3. Block Diagram of Switching Board Interface.

The 32 bit shift register is with four 74HCT594 devices designed. This device contain an 8-bit, non-inverting, serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. Separate clocks (SCLK and RCLK) and direct overriding clears (SCLR and RCLR) are provided on both the shift and storage register. A serial output (Q’H) is provided for cascading purposes. Both the shift register and storage register use positive-edge triggered clocks.

The buffers, NPN Darlington transistor arrays, contain four ULN2804A devices that are ideally suited for interfacing between low logic level digital circuitry (TTL or CMOS) and the higher current/voltage requirements of lamps, relays, or other similar loads for a broad range of computer, industrial, and consumer applications. All devices have open-collector outputs and free wheeling clamp diodes.

The relays array isolate the controlling circuit (low voltage digital logic) from the controlled circuit (controlled rectifier). These arrays contain:

- eight relays with two change-over (double-throw) contacts;
- 32 relays with one normally-open contact;
- one force relay with three normally-open contacts.

All the relays have a 5V coil voltage and a 1N4148 diode installed across the coil, to suppress the surge voltage produced when switching the coil current.

IV. RESISTOR MEASUREMENT

The resistors used in power electronics have very different values, beginning from a few mΩ to MΩ. Because of this, measuring methods present a large variety, each method suiting a certain type of resistors. Generally, measuring resistors is done in DC, using various methods depending on their type and size. For all linear resistors, choosing the supplying dc voltage for the circuit is arbitrary, with the only condition that the resistors nominal power not to be exceeded.

The dc measurement of the resistance, using a voltmeter and an ampermeter may be done depending on the way the two instruments are connected. Namely there are two procedures: upstream and downstream methods. The schematic diagrams are given in Fig.4. It can be noticed that when dividing the voltage that voltmeter indicates by the current indicated by the ampermeter, a different values will be obtained. The reason for this is the internal resistance of the instruments.

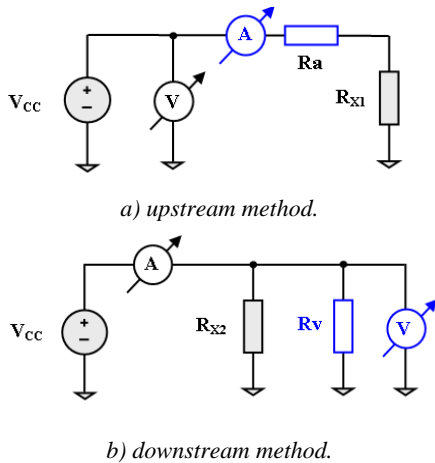


Fig.4. Measurement of the resistance.

In the first case, the unknown value R_x of the resistor is:

$$R_x = V_{cc} / I_x - R_a = R_{x1} + C' \quad (1)$$

The absolute systematic method error is:

$$\Delta R = R_{x1} - R_x = R_a \quad (2)$$

Equations (1)-(2) show that the upstream method leads to small measuring errors of the “large” resistors (resistors which satisfy the relation $R_x \gg R_a$).

In the second case the unknown value R_x of the resistor is:

$$R_x = \frac{R_{x2} R_v}{R_v - R_{x2}} = R_{x2} + C'' \quad (3)$$

$$\text{where: } C'' = \frac{\left(\frac{U_x}{I}\right)^2}{R_v - \frac{U_x}{I}} \quad (4)$$

The absolute systematic method error is:

$$\Delta R = R_{x2} - R_x = -\frac{\left(\frac{U_x}{I}\right)^2}{R_v - \frac{U_x}{I}} \quad (5)$$

Equations (3)-(5) reveal that the downstream method provides small systematic errors, if the relation $R_x \ll R_v$ is fulfilled, therefore in case of “low” resistor values.

Measuring resistors with simple bridge is used for measuring medium resistors. Its diagram is presented in Fig.5. This method is based upon the principle of comparing the unknown R_x resistance, with a known R resistance of the same size, passed by the same current. NI represents a null indicator, with internal resistance R_{NI} , and V_{cc} is the voltage of a DC source, which in practice can be assimilated with an ideal voltage generator.

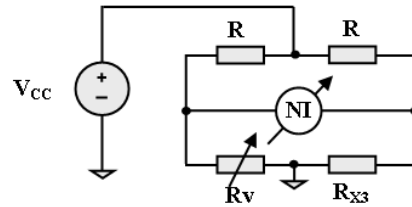


Fig.5. Measurement of the resistance with bridge method.

Imposing bridge balance $I_{NI} = 0$, the resistance R_x is obtained as:

$$R_x = R_v \quad (6)$$

In reality, the bridge is only apparently in balance, because the current through the null indicator is nonzero, but lower than its sensibility threshold. Therefore it can be written that:

$$R_x \pm \Delta R_x = R_v \quad (7)$$

where ΔR_x is the quantity that can modify the resistance so that the bridge stays in apparent balance. This means that ΔR_x represents an absolute error that cannot be showed by the bridge, being determined by the limited sensibility of the null indicator.

The Resistor Measurement Board is present in Fig.6.

In order to run remote experiments for DC Circuit Measurements, the remote student must have LabView Run Time Engine 8.0.1 installed on his personal computer. When booking the experiment the Selection front Panel window will appear. In the initial default setting the experimental devices are inactive (no voltage

supply is provided). The user will switch between two front panels: Selection Front Panel and Measurement Front Panel [3].

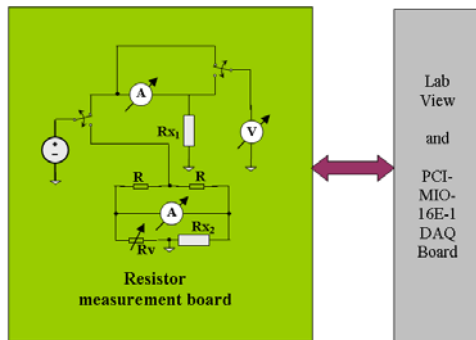


Fig.6. The Resistor Measurement Board.

For starting the application, user must push the Run button. Choose Experiment selection pop-up window, it allows “Upstream”, “Downstream” or “Bridge” method to be chosen. After selecting one experiment (one measure method) the corresponding schematics is shown in the Schematics window (Fig.7, Fig.8, Fig.9).

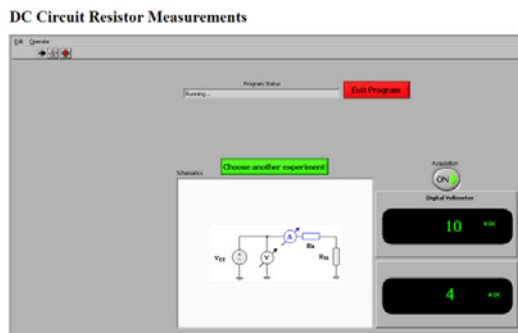


Fig.7. Measurement front panel for upstream method.

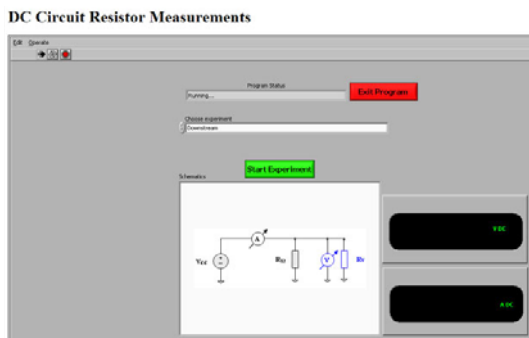


Fig.8. Measurement front panel for downstream method.

After the Start Experiment button is pushed-on a pop-up window will appear informing the user to wait for the proper circuit configuration to take place. By pressing the OK tab after some delay the devices are active and the values of the voltage and current will be displayed on the voltmeter and ampermeter indicators.

Acquisition ON/OFF button: when entering the Measurement Front Panel window its default state is ON meaning that the values of the DC voltage and DC current are continuously acquisitioned and displayed. In

the OFF state the acquisition is stopped and the displayed values are frozen for easier calculation.

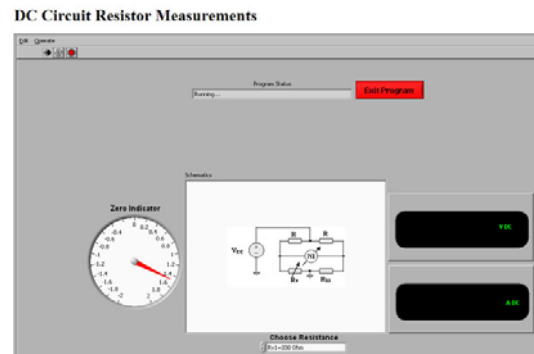


Fig.9. Measurement front panel for bridge method.

Choose Another Experiment button, allows the user to select another experiment from the list. When this button is pressed the application starts from step 3 and the same stages can be performed.

V. CONCLUSIONS

The PEMCWebLab was conceived as a complete educational solution in the field of Power Electronics and Electrical Drives. Based on “Learning by doing” philosophy it allows the students to perform experiments independently and safely without any time limitation due to a centralized booking system. The “DC Circuit Resistor Measurements” module described in the paper offers three measurement methods to be studied. The real experiment allows the user to perform measurements on the acquired signals.

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