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REMOTE WIRING AND MEASUREMENT LABORATORY

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Abstract

In this project, a new architecture called "Remote Wiring and Measurement Laboratory (*RwmLab*)" is proposed that will allow students to physically wire up electrical and electronics circuits using an Internet access. Likewise, they will be able to take real measurements over their Internet access. In this way, students will experience the nuts and volts, frustrations, and hands-on experience of a real-world laboratory environment while accessing the laboratory remotely. The *RwmLab* interface will be greatly simplified by using a graphical wiring environment. However, the system will physically wire the components together at the host lab site.

1.0 Introduction

The concept of advanced technologies used for remote monitoring is not new. The Web has become an invaluable long distance active learning tool[1-4]. Remote, web-based laboratories have been developed in areas ranging from nuclear magnetic resonance spectrometry[5] to introductory chemistry courses[6,7]. Other areas of Web-based laboratory activities developed under NSF funding range from the control of a scanning electron microscope[8] to control engineering[9]. A Web-based laboratory that allowed remote programming of manufacturing[10] was even successfully developed under a NSF funded project.

An electronics laboratory was developed at Rensselaer Polytechnic Institute (RPI)[11] where virtual instrumentation is used. In the RPI lab, the electronics circuits were already wired. All that the students do is collect data for analysis.

The goal of our project is to establish Web-based instructional modules and other visual multimedia that will enhance the quality of basic electronics and circuits education at Western Michigan University (WMU) and Tuskegee University (TU), and to promote active teaching and learning among students and faculty. Just as it has been proven that a web-based laboratory can be used to link together educational facilities that would otherwise be unable to support a laboratory, the *RwmLab* will enable delivery of a laboratory experience to locations that could not otherwise support an electrical and electronics laboratory[12].

An Internet Web-based *RwmLab*, treated as a local multi-circuit board[4] on a common distributed panel, is shown in Fig. 1. A data acquisition, data processing and analysis, and graphical unit interface enabled device will characterize the *RwmLab*. The multi circuit board will contain various electronic components such as Power Supplies (AC & DC), Resistors, Capacitors, Inductors, Transformers, Diodes (including Zener), Transistors (including BJT, MOSFET, and JFET), SCRs, and Op-amps. The enabled device would allow the connectivity and control of these embedded electronics devices. The data acquisition interface would allow measurements to be made at the nodes. The data collected at the nodes would then be processed at the host computer.

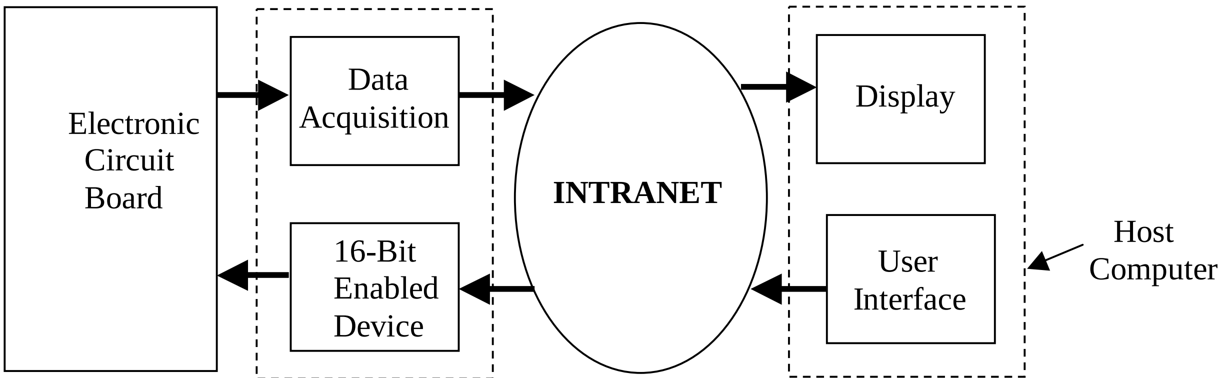


Fig. 1 Block Diagram of VI-Based *RwmLab*

The circuits would allow remote performance of WMU's ECE 221 (Electronics I Laboratory) and ECE 420 (Power Electronics I laboratory). All activities are PC-based and therefore the student would have total control over the process of performing an experiment without relying on any structured steps already designed or laid down. In this way the student would be able to be more creative in doing the wiring because the student would experience the nuts and volts, frustrations, and hands-on experience from a real-world laboratory environment – while being able to perform this laboratory remotely over the Web. The main strategy with *RwmLab* is to remotely put the student in the laboratory environment and make the laboratory available to students anywhere in the World. The whole *RwmLab* procedure will be PC-based so that only software at the PC will be necessary to run the laboratory. It would not be dependent any client-server.

2.0 Methodology

Figure 2 was easily adapted for the "Remote Wiring and Measurement Laboratory (RwmLab)" mentioned in the CCLI program. This simplified diagram can be used to wire remotely by using solid-state, low resistance relays such as the opto22 isolators. Embedded web-controllers will provide the signals to switch the solid-state relays ON and OFF, and to collect data from the nodes. In this way, circuits such as the one shown in Fig. 3(a) can be wired remotely. Fig. 3(a) is an example taken from ECE 221 - Electronics I Laboratory, a required course taken by electrical and computer engineering students as well as students from other engineering disciplines and departments at Western Michigan University.

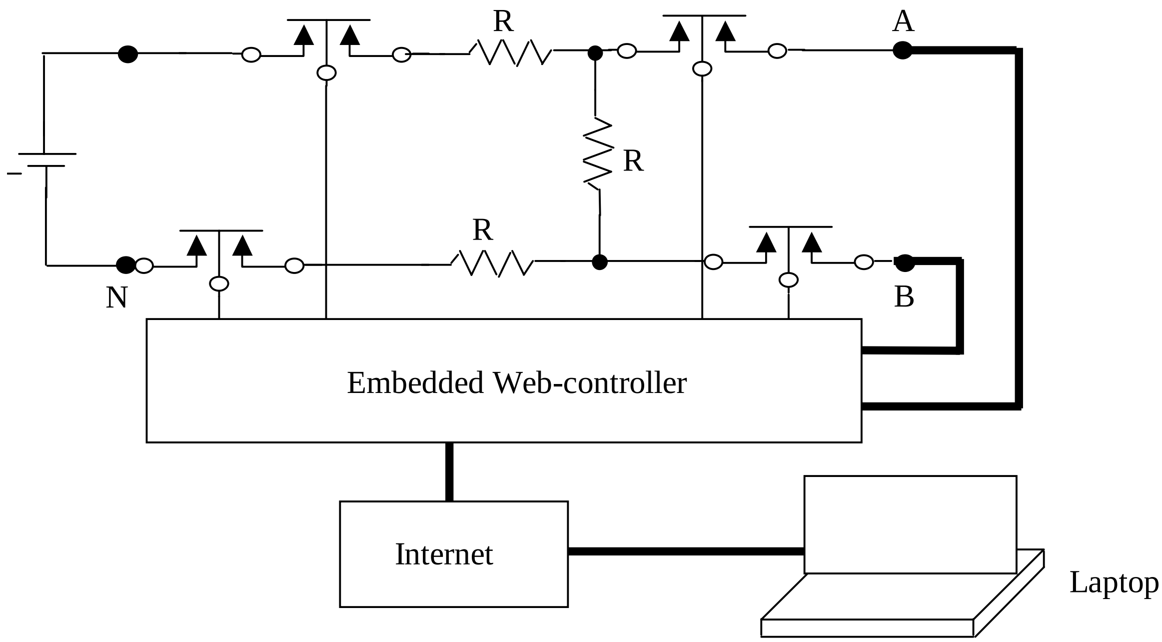
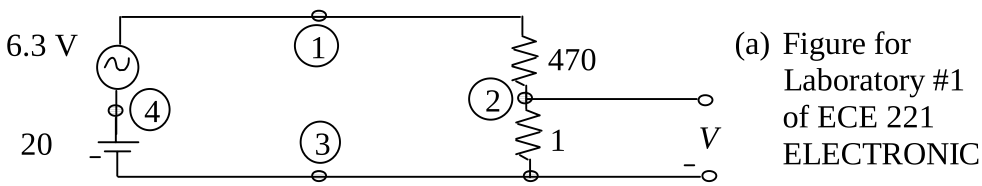
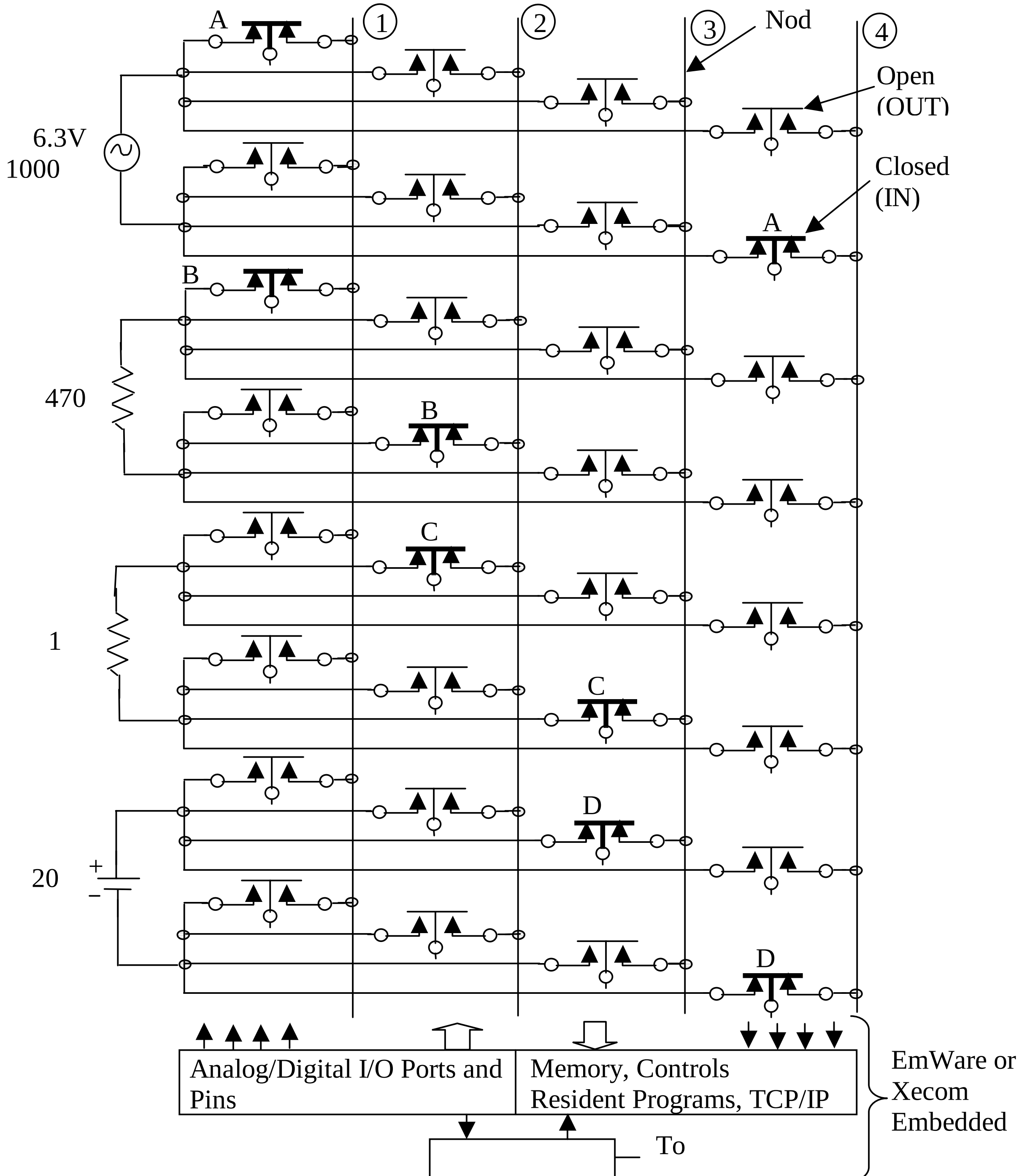


Fig. 2 A Modular Four-node System

When relays A1-A2, B1-B2, C1-C2, and D1-D2 of Fig. 3(b) are switched ON, the circuit of Fig. 3(a) is completed. The relays would be switched IN and OUT by programming the analog/digital I/O pins of the embedded web-controller. Resident programs in the embedded web-controller would continuously collect and store several cycles of voltages at the nodes, perform all measurements, process controls, and other functionality required. In addition, the embedded web-controller would provide the TCP/IP and other protocol between the embedded web-controller and the Server/Remote PC. The Sever/Remote PC would have total control over the activities of the embedded web-controller. The web-controller and the Sever/Remote PC would be interfaced using a standard web browser such as Microsoft Internet Explorer or Netscape Navigator. The data transmitted from the embedded web-controller to the Server/Remote PC would be in several different formats: raw data or dynamic web pages containing the data information as defined by the host.

Each embedded controller would add devices such as: a fully integrated microcontroller; analog and digital I/O function pins that are software selectable and configurable; serial ports; timers; IRQs; channels; A/D and D/A converters; various sizes and combinations of RAM and ROM (including Flash memories); supporting circuitry; and network connectors. In addition, object codes could be embedded into the modules of these devices. More recent embedded web-controllers incorporate multi-user and multi-tasking operating systems and TCP/IP stacks with Ethernet access for networking and web browser interface. We have contacted several manufacturers of web-controller boards, including EmWare and Xecom. These manufacturers provide various embedded web-controllers specifically for use with the Internet. Several other manufacturers also make embedded web-controllers. However, we have proposed building our system using the controllers from EmWare (http://www.emware.com) and Xecom (http://www.xecom.com/_PageFiles/telefamily.htm).





(b) Structure of

Fig. 3 Features of the

Figure 4 shows a typical experiment outline; Laboratory #4 of ECE 221 Electronics I. In the outline, the purpose and objectives of the experiment are defined, suggestions are given to students on how to build their circuits but no suggestions on the design.

Fig. 4 ECE 221 - Electronics I Laboratory (Rectifier Circuit)

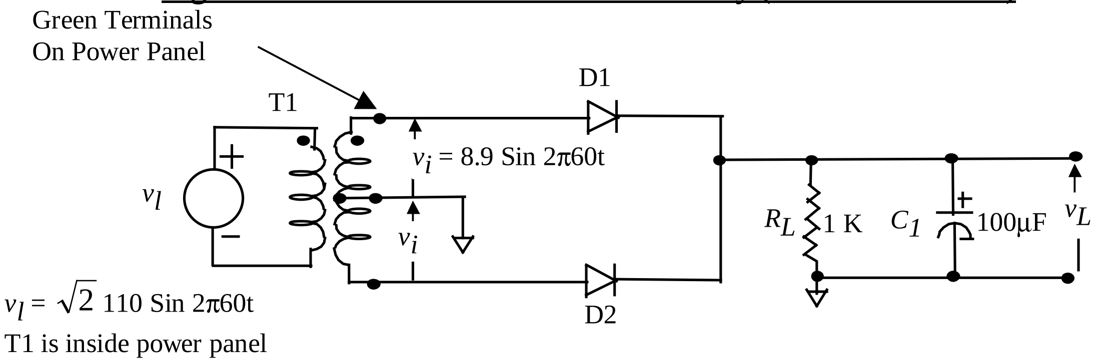


Fig. 5

Purpose

You will learn how to design a full-wave center-tapped transformer rectifier circuit. You will see that the input sine wave is rectified. You will also see the plot of the input voltage vs. the output voltage; transfer function between the output and input.

Objective

At the end of this experiment, you should be able to:

- Remotely wire up an electronics circuit on your PC; you will see this on your PC
- Use your PC as a scope.
- Use diodes to shape waveforms.
- Learn about the concept of rectified circuits and transfer functions.

Procedure

1. Remotely wire up the circuit shown in Fig. 5 without the capacitor C_1. Use your own judgement in the wiring.
   a) Put the scope on your PC in direct coupled, dual channel, chopped, time-based mode and simultaneously display and carefully record at least 1 full cycle of $v_i(t)$ (on channel 1) and v_L(t) (on channel 2). Trigger the trace with channel 1. Be sure to record the zero voltage reference level for each channel.
   b) Put the scope on your PC in direct-coupled X-Y mode and display v_L on the ordinate and v_i on the abscissa. Carefully print v_L vs. v_i for your notebook. Be sure to identify the origin of the coordinate system (x = 0, y = 0) on your printout by noting the beam position when both the vertical and horizontal inputs are “grounded”.
   c) Slowly decrease the frequency (f) of $v_i(t)$ while observing the scope and attempt to interpret this Transfer Function display in terms of the time-base display in part 1 a) above.
2. Repeat 1(a) - (c) with the capacitor C_1 connected.

Students will have adequate time to complete the laboratories and perform hands-on real-time experiments. Students will be shown how to use the PC as an instrument tool. The student will have more time to experiment with different circuit configurations and therefore identify the best solution to a design in senior projects.

3.0 Conclusion

Although the proposal presents a novel idea, it adapts existing, proven, and workable technologies to implement an electrical and electronics, and power electronics laboratory. The intention here is not try to reinvent the wheel but rather to adapt and implement existing technology to enhance active learning using the Internet. An added advantage is that the web now becomes a medium for active teaching and learning.

Bibliography

[1] M. Shor and A. Bhandari, "Access to Instructional Control Laboratory Experiment Through the World Wide Web", Proc. Of the 1998 American Control Conference, Philadelphia, pp. 1319 - 1325.

[2] P. Arpaia, A. Baccigalupi, F. Cennamo, and P. Daponte, "A Measurement Laboratory on Geographical Network for Remote Test Experiments", *IEEE Instrumentation and Measurement Technology Conference IMTC/98 Conference Proceedings Vol. 1,* St. Paul, Minnesota, USA May 18 - 21, 1998 pp. 206 -209A.

[3] L. Cristaldi and A. Ferrero, "A Virtual Instrument For The Determination of The Electric Power quality", *Proc. IMTC/94*, Hamamatsu, pp. 1309 - 1312, May 1994.

[4] Chung-Ping Young and M. J. Devaney, "Virtual instrument Based Distributed Power Metering Manifold", IEEE Instrument and Measurement Technology Conference Proceedings Vol. 1, St. Paul, Minnesota, USA May 18 - 21, 1998 pp. 115 - 118.

[5] A. Grushow, P. Schuler, H. Tanzini, B. S. Burnham, and J. E. Sheats. "NMR Collaborative Training Partnership", NSF Award #9952369, 1999. http://nsf.gov/cgi-bib/showaward?award=9952369

[6] J. E. Pemberton, "An Interactive Web-based Materials Characterization Project for Undergraduate Education in Analytical Chemistry", NSF Award #9753237, 1997. http://nsf.gov/cgi-bib/showaward?award=9753237

[7] J. M. Henry and J. R. Cunnigham, "Chemical and Environmental Systems Laboratory", NSF Award #9951024, 1996. http://nsf.gov/cgi-bib/showaward?award=9951024

[8] J. E. Salah and P. Pratap, "Strengthening Undergraduate Education through Research in Radio Astronomy", NSF Award #9952246, 1999. http://nsf.gov/cgi-bib/showaward?award=9952246

[9] W. C. Messner and D. Tilbury, "Web-Assisted Experimentation: Enhancing Controls Education", NSF Award #9752392, 1999. http://nsf.gov/cgi-bib/showaward?award=9752392

[10] G. Frederick, Sang-Shiun Chan, and L. Liles, "Web-based Laboratory Experiments for Manufacturing Engineering and Technology Programs", NSF Award #9950469, 1999. http://nsf.gov/cgi-bib/showaward?award=9950469

[11] D. L. Millard, G. O. Burnham, K. A. Connor, and W. C. Jennings, "Science, Mathematics, Engineering and Technology Learning Modules for an Electronics Curriculum", NSF Award #9950356, 1998. http://nsf.gov/cgi-bib/showaward?award=9950356

[12] R. S. Lamba and A. Trujillo, "Reforming the Undergraduate Curriculum: Adapting Fruits of the Modular Chem consortium and ChemLinks at Minority Institutions", NSF Award #9752894, 1997. http://nsf.gov/cgi-bib/showaward?award=9752894

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