Computer Based Virtual Engineering Laboratory (CBVEL)
And
Engineering Technology Education

Nikunja K. Swain, James A. Anderson, Raghu Korrapati

School of Engineering Technology & Sciences (SETS)/School of Business and Technology
South Carolina State University/Webster University

Abstract

This paper describes an innovative and cost-effective method of modernizing undergraduate technology and sciences education so that our graduates can be well trained with the latest technology. This will also help the technology and science programs to satisfy the TAC of ABET 2000 accreditation criteria and other accreditation needs to maintain accreditation of their programs. This paper discusses the hardware/software used in each group of this Computer Based Virtual Engineering Laboratory (CBVEL), and its use in education and research.

I.   Introduction

Advanced electronics and computerization are revolutionizing today's industries and the engineering technology and science programs are under pressure to modernize their programs to meet the challenges of this changing technology or to maintain the accreditation of the programs. This requires upgrading laboratories with modern equipment and calls for increased funding and resources. But in recent years there is an increase in enrollment and decrease in resource allocation making it increasingly difficult to modernize the laboratories to provide adequate levels of laboratory and course work. The CBVEL described in this paper is designed to address these. This CBVEL will help us in providing an interdisciplinary Integrated Teaching and Learning experiences that integrates team-oriented, hands-on learning experiences throughout the engineering technology and sciences curriculum, and engages students in the design and analysis process beginning with their first year. This will modify our existing laboratories, and help us better educate and train our graduates to serve the needs of the technological and engineering community. Students can use this CBVEL along with existing software (MATLAB™ from MathWorks Inc., PSPICE™ from MicroSim Corporation, LOGIC WORKS III™ from Capilano Computing, C/C++, Visual Basic™ from Microsoft Corporation etc.) and test equipment. This CBVEL can also be accessed from remote sites using Internet.

The CBVEL consists of IBM compatible computers with appropriate software and hardware (LabVIEW, HI-Q, Virtual Bench, PXI Systems, DAQ Cards, etc.) from National Instruments (NI), and is connected to School of Engineering Technology and Sciences (SETS) network and existing equipment [1, 2]. Virtual Instrument (VI) modules for different courses and research areas are currently developed. Examples of some of these VIs are Circuit Analysis, Electronics, Communications, Digital Signal processing, and Digital Filters. These modules will be used to better train the engineering technology, sciences, and information technology graduates. Some of the research areas that will be benefited by this laboratory are Non Destructive Testing, Power Quality Analysis, Control and Robotics, Intelligent Sensors and Distributed Control, Fuzzy Logic, and Space Science. This paper is arranged as follows: Section II discusses various components used in CBVEL, and LabVIEW application areas. Section III discusses some of the VIs for circuit analysis course. Section IV deals with conclusion and discussion. Section V deals with acknowledgement and Section VI presents the bibliography.

II.   Components used in CBVEL and application areas of LabVIEW

   a.   Components in CBVEL

The following are some of the components of CBVEL. The major components of this CBVEL are 12 PXI, 166 Mhz computers from NI and 20, 350 Mhz INTEL Pentium computers from Gateway. Besides these the PXI systems are equipped with NI components such as Function Generator Cards, Multimeter Cards, Oscilloscope Cards, Training Modules, Stepper and Servo Motion Control Cards, Virtual Bench Software, IMAQ Vision Cards, Field Point Dist. Systems, and Switches.

The PXI systems are industry standard systems with high-speed data acquisition cards. It has number slots with Windows 95 operating system. The multimeter, function generator, and oscilloscope cards are primarily for student and faculty use in different technology and science courses. Virtual Bench software is used to use these cards for different simulation and laboratory exercises. The motion control, vision, and distributed control cards are primarily for research. All these cards are installed in different ports of this PXI system. The Gateway computers are equipped with LabVIEW and HI-Q software and other software like PSPICE, Visual Basic, C/C++, MatLab, etc. The student and faculty use these computers for simulation purposes.

   b.   Application Areas of LabVIEW Software

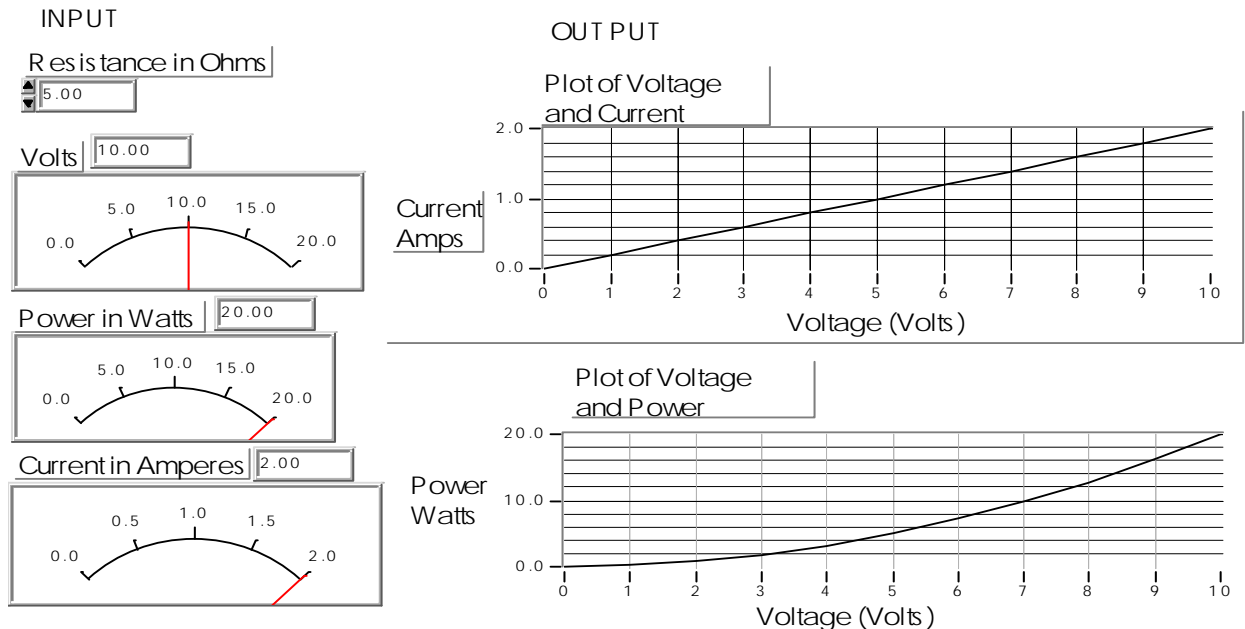The following are some of the application areas of LabVIEW[4,5]:

Simulation; Data Acquisition; Data Processing - built in analysis library that includes signal generation, measurement, filters, windows, curve fitting, probability and statistics, linear algebra, numerical methods; Instrument and Control; Object oriented/graphical programming; Fuzzy Logic; Genetic Algorithm; and Joint Time and Frequency Analysis. Many industries, academic institutions, and federal agencies such as DOD, DOE, and NASA use it.
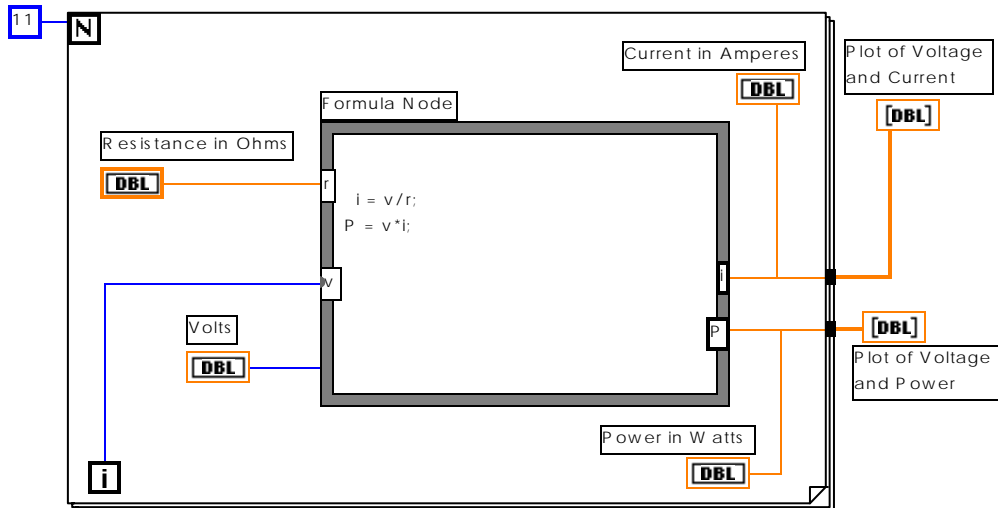
III.   Circuit Analysis VIs

We have developed VIs for circuit analysis, electronics, communication, signal processing and filters, power and control systems, and information technology courses [1, 2]. The faculty and students use these VIs in various lecture and laboratory courses. The students build systems in breadboard and develop appropriate VI modules to test their design. They connect the design to the equipment (multimeter, function generator, oscilloscope etc.) in the PXI system module and verify their design. The circuit analysis VIs cover Ohms law, series circuit, voltage divider, parallel circuit, current divider, series-parallel circuit, capacitor charging and discharging, inductors, series and parallel RLC circuits, resonance, and frequency response. These VIs use different built in LabVIEW functions such as digital controls for input, formula node and for loop for mathematical equations, and digital indicators, graphs and charts for output. The circuit analysis VIs (Ohm's law, series-parallel circuit, and frequency response of series RLC circuit) presented below demonstrates the use of these functions.

Ohm's Law

VI Control Panel

Ohm's Law – VI diagram

Formula Node

Resistance in Ohms

Volts

Current in Amperes

Power in Watts

Plot of Voltage and Current

Plot of Voltage and Power

i = v / r;
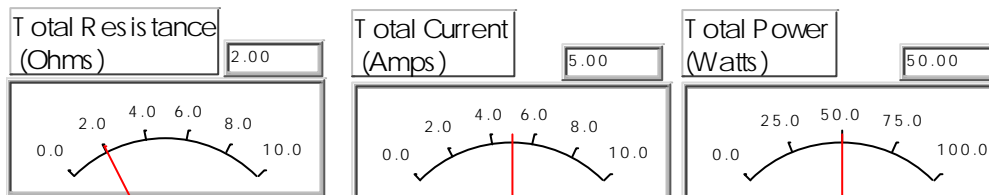P = v * i;

Series-Parallel Circuit

Resistor 1 is in series with the parallel combination of resistor 2 and resistor 3.

VI Control Panel

INPUTS
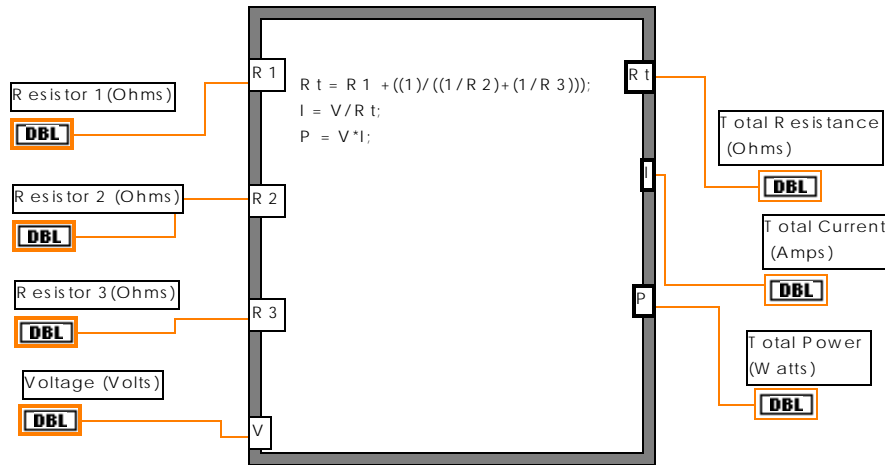
Resistor 1 (Ohms)
1.00

Resistor 2 (Ohms)
2.00

Resistor 3 (Ohms)
2.00

Voltage (Volts)
10.00

OUTPUTS

Total Resistance (Ohms)
2.00

Total Current (Amps)
5.00

Total Power (Watts)
50.00

Series Parallel Circuit – VI diagram

R 1

R t = R 1 + ((1) / ((1 / R 2) + (1 / R 3)));
I = V / R t;
P = V * I;

Resistor 1 (Ohms)

DBL

Resistor 2 (Ohms)

DBL

R 2

Resistor 3 (Ohms)

DBL

R 3

Voltage (Volts)

DBL

V

R t

I

P

Total Resistance
(Ohms)

DBL

Total Current
(Amps)

DBL

Total Power
(Watts)

DBL

Frequency response of series RLC circuit

VI Control Panel

OUTPUT

INPUT

Impedance (Ohms) at
Final Frequency

1705.81

Resonant Frequency
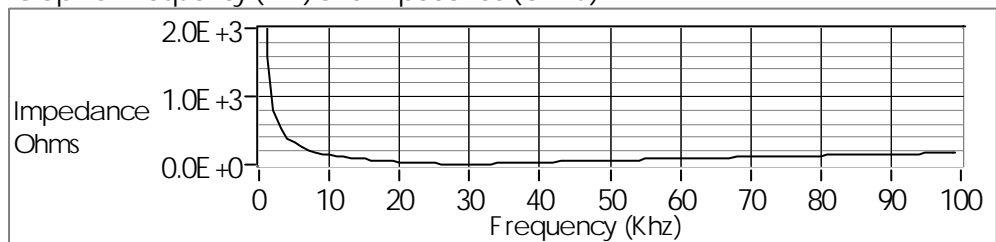(Hz)

2905.76

Impedance (Ohms) at
Resonant Frequency

40.00

R (Ohms)
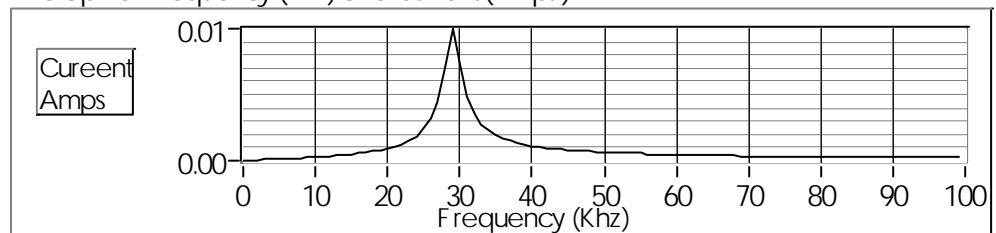
40.00

L (Henrys)
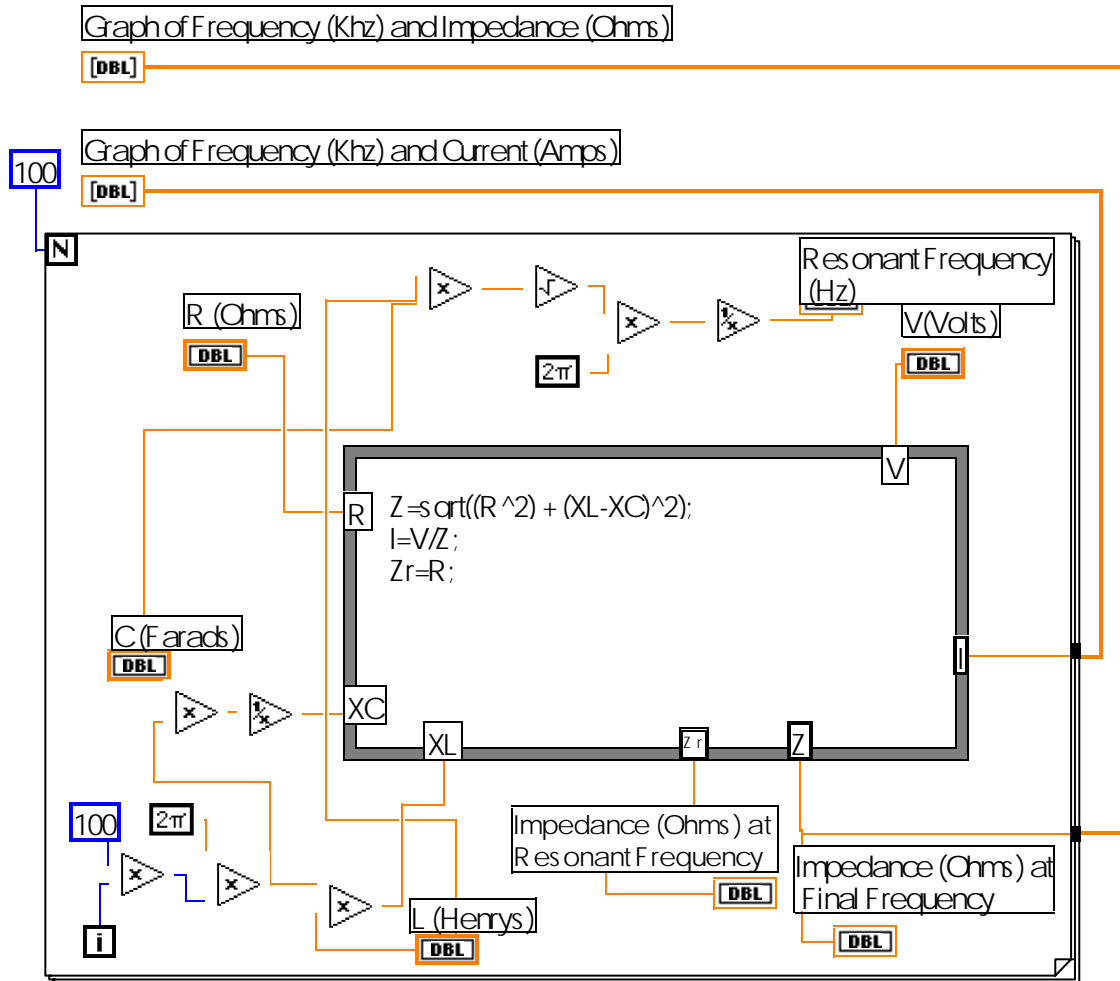
30.000E-3

C (Farads)

100.000E-9

V (Volts)

400.00E-3

Graph of Frequency (Khz) and Impedance (Ohms)

Impedance
Ohms

2.0E+3
1.0E+3
0.0E+0

0 10 20 30 40 50 60 70 80 90 100
Frequency (Khz)

Graph of Frequency (Khz) and Current (Amps)

Cureent
Amps

0.01

0.00

0 10 20 30 40 50 60 70 80 90 100
Frequency (Khz)

Frequency response of series RLC circuit –VI diagram

Graph of Frequency (Khz) and Impedance (Ohms)

Graph of Frequency (Khz) and Current (Amps)

Resonant Frequency (Hz)

R (Ohms)

V (Volts)

Z = sqrt((R^2) + (XL-XC)^2);
I = V/Z;
Zr = R;

C (Farads)

XC

XL

Zr

Z

L (Henrys)

Impedance (Ohms) at Resonant Frequency

Impedance (Ohms) at Final Frequency

IV.   Conclusion and Discussion

We have developed a number of other VIs for other courses. We could present only a fraction of the VIs here because of the page limitation. The remote access component of the CBVEL is under development. The remote access feature of our CBVEL will enhance the existing distance learning courses. The Computer based Virtual Engineering Laboratory at South Carolina State University, once fully developed, will be one of its kind in the State of South Carolina. It will provide a truly modern environment in which students and faculty members can study engineering, technology, and sciences at a level of detail, and this will be possible because of the versatility of LabVIEW and other products from NI. A number of software packages are currently being used in engineering, technology, and sciences curriculum. LabVIEW has features and VIs identical to most of the features found in all these software packages.

Therefore, one can use LabVIEW only to address the needs of various courses. This will be beneficial for students and faculty and introduce standardization across the curriculum.

V.   Acknowledgement

VI.   Bibliography

1. Swain, N. K. & Anderson, J. A.(1998). "Computer Based Virtual Engineering Laboratory (CBVEL)", ASEE/GSW Annual Conference, New Orleans, Louisiana, 1998.
2. Swain, N.K., Anderson, J.A., & Korrapati R.(1999) "Application of Graphical Programming, Object Oriented Programming, and Virtual Instruments in Education", Conference on Information Technology (CIT 99), Bhubaneswar, India, 1999.
3. Swain, N. K. & Tobin G.(1998). "Developing a LabVIEW based Ultrasonic Test & Evaluation unit for Materials Testing", NASA/MUSPIN 8th Annual Conference, Albuquerque, NM, 1998.
4. URL: http://www. natinst.com
5. Wells, Lisa & Jeffery Travis.(1996). LabVIEW for Everyone, Prentice-Hall, New Jersey, 1996.

NIKUNJA K. SWAIN

Nikunja Swain is currently associate professor and academic program coordinator of the EET program at South Carolina State University. He received his B.Sc. and M.Sc. in Electrical Engineering from India, M.S. in Electrical Engineering from North Carolina State University, and a Ph.D. in Energy/Electrical Engineering from University of North Dakota. He is registered professional engineer (PE) in South Carolina. He has published number of papers on the application of LabVIEW in education and research. He is a member of IEEE and ASEE

JAMES A. ANDERSON

Dr. Anderson's areas of specialization are in Electro-Optics, Solid-State Devices/Microelectronics, and Microwave and Optical Communications. He has performed research and design at these companies, worked as a consultant and professional engineer, and has been a University Professor. He has published and developed patents in his specialties, and he has managed design, development, and manufacturing units in high-tech environments. He currently serves as Professor and Dean of the School of Engineering Technology & Sciences (SETS) at South Carolina State University.

Raghu Korrapati

Raghu Korrapati is currently a faculty of business and technology at Webster University, at Fort Jackson, SC. He is also the faculty coordinator of this program. He has completed number of Microsoft certification examinations and is a MCSE. He has worked for CHE and local industries. His research interests are in the area of computer applications.