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A Circuits II Laboratory Accessible by Internet

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Abstract

A remotely accessible laboratory for the Circuits II course has been developed to permit students to access the laboratory from their home computers. The equipment is based on a Cytec switch matrix and a dsp SigLab 20-22. The laboratory exercises familiarize students with the operations of signal generators, oscilloscopes, network analyzers, spectrum analyzers and remotely operated instruments. The advantages of the laboratory are that the cost is less than the cost of one moderately well equipped station in a typical laboratory. Also, the lab can be accessed at any time. The laboratory, as currently configured, supports 10 different exercises, including characterization of RC and LRC circuits. A limitation is that the system as currently configured will accommodate only one student at a time but we believe can be expanded to accommodate four at a time.

I. Introduction

The authors believe that development of distance learning courses for engineering technology has been impeded by the necessity for laboratories. This paper describes one development for remote electronics laboratories that is both economical and provides for additional learning experiences for the students. To develop this laboratory, ten exercises were taken from the popular text and laboratory manual by Robert L. Boylestad and Gabriel Kousouru[1]. The exercises taken from the manual were related to circuit characterization of alternating current circuits that involved resistive, capacitive, and or inductive components. The instrumentation in these experiments was limited to sine wave signal generators and oscilloscopes.

II. The Equipment For The Remote Laboratory

The remote laboratory requires only three major components. The first is a personal computer capable of web connection and able to run Windows 98 or a later version. The next component is a switch matrix; the one used in this project is a Cytec model PX512-1. The critical component that makes the laboratory work is a model 20-22 SigLab from Spectral Dynamics. Minor components include the resistors and capacitors and BNC to alligator clip wires. For this project, components for all experiments were set up simultaneously on a small breadboard.

Figure 1 shows the equipment setup in its laboratory setting. Note that the footprint is fairly small, about one half of a desktop.

Figure 1. The Equipment of the Remote Electronics Laboratory

Note that the circuits for testing are in the foreground. The small black box is the SigLab 20-22 and the box with all the wires protruding from it is the switch matrix. The components of the personal computer are readily identifiable.

The hardware cost of the system is as follows:

Item	Approximate Cost
Cytek Switch Matrix model PX512-1	$6,000
SigLab 20-22	$5,000*
Personal Computer (free)	$1,500
Cables and Connectors	$320
Total	$12,820

* A 10% academic discount is available for single units

This total should be compared to the approximately $6,000 per station to equip an electronics laboratory (typically, 20 stations per laboratory, or $120,000) which actually has less substantially less capability because the SigLab includes other features such as a spectrum analyzer and a network analyzer.

III. Software for the Remote Laboratory

The software required to make the remote laboratory operate successfully is an outgrowth of Windows technology which permits several programs to operate simultaneously in background mode. The operating system for the laboratory computer is Windows 98. Operating in the Windows environment is MATLAB, within which the instrument control program (SigLab) generates signals and collects data from the dsp 20-22; and then prepares presentations of the data. The communications program was downloaded from the internet and is named VNCViewer. This program, when proper passwords are entered, permits remote control of the laboratory computer by a student computer which duplicates the monitor display on the remote computer and provides complete control of the dsp 20-22.

The Cytec Switch matrix is handled differently. A control program was written in C++ to select the points on the circuits to be measured through the different ports of the switch matrix. This program is initiated before the start of measurements by allowing the student to select which point of measurement, or port, is opened to him for response measurement. The menu is shown in Figure 2. At this point in development, the port numbers correspond to experiment numbers.

Figure 2. The data port menu for selection of experiments.

IV. Method of Operations

We intend to make the operation of the instruments as simple as possible for the beginning students; so upon entering MATLAB, the instrument selection is set up by typing in VIRUN (Virtual Instruments Run). This gives the student the following partial display:

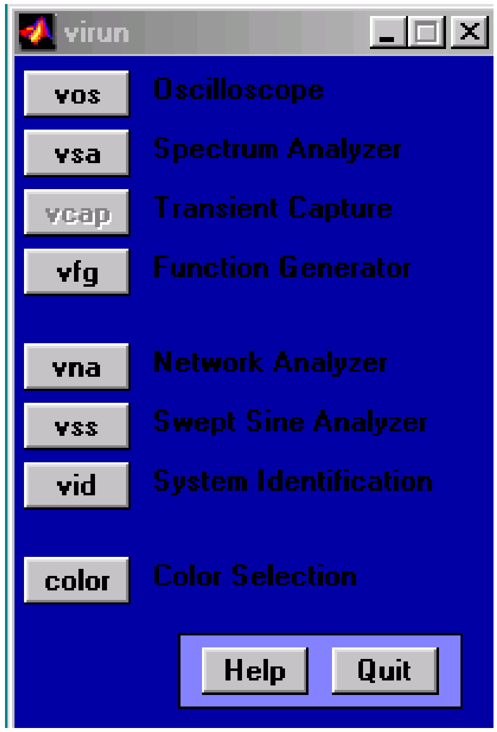

Figure 3. The VIRUN (virtual instrument menu).

In the early laboratories, only the VFG (Virtual Function Generator) and VOS (Virtual Oscilloscope) buttons need be operated to activate the instruments necessary to this laboratory.

In the VFG display, the student need only select the amplitude and frequency (up to 20 kHz) and turn on the function generator. Once finished with this task, the student can minimize the display. For this set of experiments, only sine functions are necessary. A complete assortment of waveforms, including random is available behind the flyout menu behind the sine notation. Figure 4 shows the Function Generator operations controls.

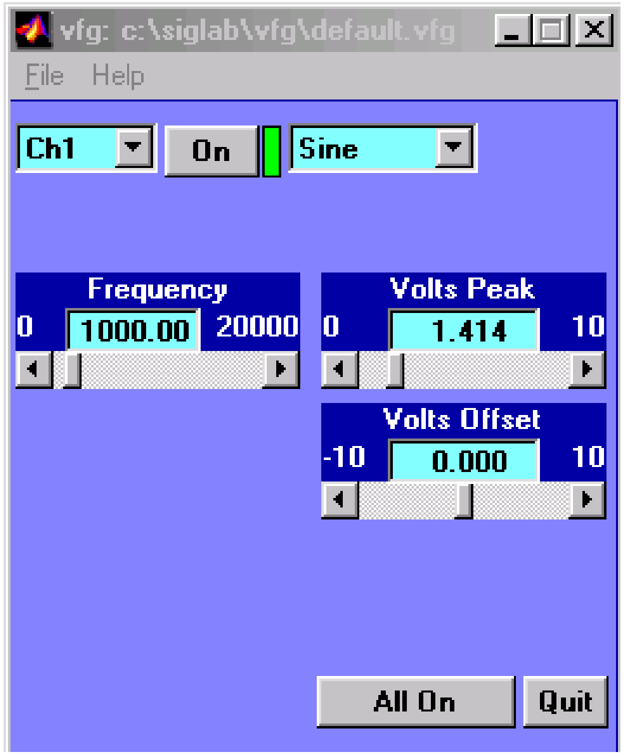

Figure 4. The control panel for the Virtual Function Generator

The next step is to call up the virtual oscilloscope by pressing VOS on the VIRUN menu. The oscilloscope display really has two parts to it. The first half (on the left in Figure 5) is the oscilloscope control panel. The second (On the right) is the oscilloscope display. Figure 5 shows these two together.

Note that the Oscilloscope has a full set of control functions and two channel display capability. The display has voltage and time readout cursors available to support the experiments.

We found that the most effective way to make Oscilloscope displays that were Web compatible was to take a triggered average of one and display that. The transfer of dynamic data displays is simply not possible with current bandwidth and other limitations.

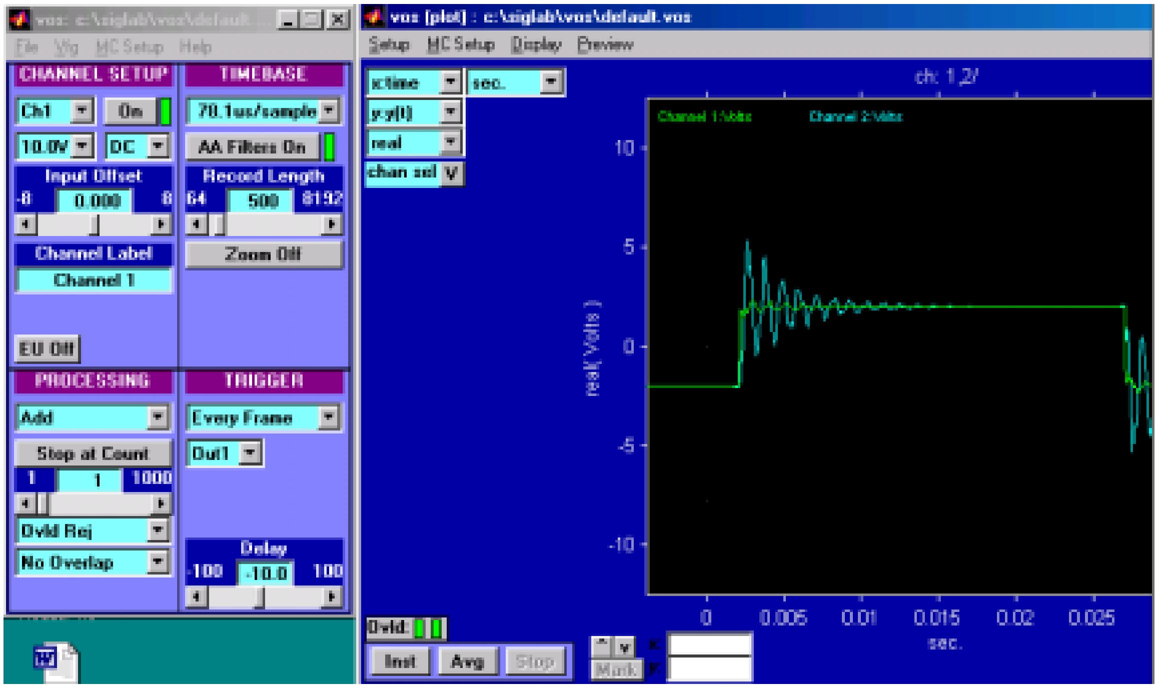

Figure 5. The Virtual Oscilloscope display and control panel.

The 10 experiments taken from Boylestadt are as follows:

1. The Oscilloscope
2. R-L-C Components
3. Frequency Response if the Series R-C Network
4. The Oscilloscope and Phase Measurements
5. Series Sinusoidal Circuits
6. Parallel Sinusoidal Circuits
7. Series Resonant Circuits
8. Parallel Resonant Circuits
9. Passive Filters
10. Pulse Waveforms

The one modification that we were forced to make to Boylestadt's experiments was to change out components so that the maximum frequency was 20kHz. This change does not appear to detract from the learning experience.

V. Testing of Student Response

The student test of the system has been done on ten students to date. Five of these were deeply involved in the construction of the system or similar laboratory exercises. All of that five, perhaps out of pride of authorship, expressed confidence that the system was usable to support the Circuits II class for which it is intended. The other five students were drawn from the Spring of 2002 class who were expected to use this system for completion of some laboratory exercises. Of these five, two insisted that it was more convenient to do the experiments in the labs. Three thought they would definitely use this method as much as possible for future labs. The difference in student response appeared to depend solely on how far the student lived from campus. Those living more than thirty minutes from campus supported the new system, while those only a few minutes form the laboratory were more reluctant to adapt the new system.

VI. Possible extensions of student learning

The great flexibility of the dsp 20-22 with its MATLAB based software should make it possible to greatly extend the students knowledge within a comparable amount of time, especially if eliminated commute time to laboratory is counted. This system permits the introduction of the concepts random and swept sine for circuit characterization. Also, instead of manually constructing the frequency response functions, the network analyzer of the dsp 20-22 can be introduced and phase effects in RC and RLC circuits can be conveniently demonstrated.

VII. Conclusions and recommendations

The system presented in this paper makes it convenient to perform most of the experiments of a Circuits II class remotely. The cost of building a remote lab is 10 to 20%, depending on the number of stations equipped, of a conventional Circuits II laboratory and that is excluding the cost of construction. The limitations of the system are that the maximum frequency range of experiments is 20kHz and that the displays must be relatively static to be transmitted. The authors believe that this system could be used for construction of other remotely operated laboratories for the entire spectrum of electronics and controls classes.

VIII. References

1. Robert L. Boylestad and Gabriel Kousouru, "Experiments in Circuit Analysis to Accompany Introductory Circuit Analysis", 9th edition. Prentice Hall, 2000.

Author Biographies

MITTY C. PLUMMER is an associate professor at the University of North Texas since 1992. He earned his BSEE, MENE, and PhD from Texas A&M. He worked in a variety of industrial positions for 22 years before UNT.

CHARLES C. BITTLE has been a Lecturer at the University of North Texas since 1997. He earned his B.S.E.E. at Lamar State School of Technology in 1960 and his M.S.E.T. at the University of North Texas in 2000. Mr. Bittle served in the U.S. Federal Service for 32 years as System Engineer, Program Manager and General Manager. He is a registered Professional Engineer in Texas.

VICTOR KARANI was the 2001 outstanding Electronics Engineering Technology Graduate at the University of North Texas. He is currently working on a master's degree.