New Laboratory Experiments in Analog Electronics Courses Using Microcomputer-Based Instrumentation and LabVIEW[1]

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ABSTRACT

This paper describes the new laboratory experiments conducted in an analog electronics course by using a microcomputer-based workstation. The microcomputer-based workstation consists of programmable electronic instruments interfaced with LabVIEW through IEEE 488.2 interface. LabVIEW is utilized to build virtual instruments for each laboratory experiment. Experiments related to the temperature effects on the DC power supply and amplifier circuits were conducted. The Microsoft Works and PSpice packages are also integrated into each workstation for report writing and circuit simulation.

I. INTRODUCTION

In recent years, several colleges and universities have integrated the personal computer with modern electronic equipment for automated laboratory measurements [1–4]. The development of Microcomputer-Based Electronic Instrumentation Laboratory (MBEIL) can be accomplished by using the plug-in data acquisition boards or using IEEE 488 interfaced programmable electronic equipment. Even though, the workstation based on the stand-alone instruments controlled by a PC over a IEEE 488 interface is expensive, it has many advantages. First, the instruments could be used either under the computer control or independently, which is a significant benefit in an academic environment. Second, IEEE-488 interface is an industry standard and the programmable instruments satisfy the stringent specifications as well as offer special measurement features. More importantly, the students are exposed to the state-of-the-art electronic equipment and some of the cumbersome analog circuit experiments can be replaced with the automated data acquisition techniques.

In this work, we extend the computer-based data acquisition techniques [6–7] to conduct the new laboratory experiments in analog electronics courses in a two-year electrical engineering technology curriculum. Section II describes the setup of MBEIL workstations and Section III discusses the application software. Section IV outlines the list of experiments along with the plan of study. The results are presented in Section V. Finally, the project is summarized in Section VI.

II. MBEIL WORKSTATION

Figure 1 shows a typical MBEIL workstation. A typical MBEIL workstation consists of programmable equipment such as DMM, digital storage oscilloscope, power supply, and

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function generator all interfaced with a microcomputer and an application software through IEEE 488. interface. The main requirement for developing a microcomputer-based workstation is cost-effectiveness.

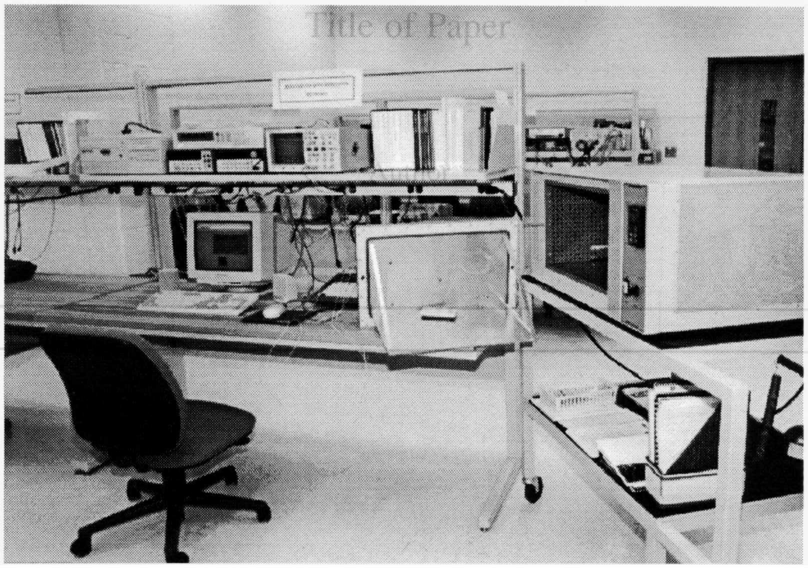

Figure 1. A typical MBEIL workstation.

The cost-effective instruments are:
1. HP 34401A Digital Multimeter
2. HP 6643A Power Supply
3. HP 54601B Oscilloscope with 54657 GPIB module
4. HP 33120A Function Generator

A Pentium 75 MHz Micron PC has been utilized to interface these instruments through National Instruments LabVIEW and AT-GPIB/TNT IEEE 488.2 interface card. At present, four MBEIL workstations have been set up using an NSF-ILI grant. Additionally, the MBEIL workstations share two Okidata LED printers through an automatic switch. A temperature chamber manufactured by Despatch industries is utilized for the temperature experiments.

During the initial phase of the development, the MBEIL workstations were utilized during the Fall 95 semester in an introductory course to EET (EET 196). The fundamental concepts related to GPIB instruments were introduced using National Instruments Win 16 interactive control software. During the Spring 96 semester, the students build the virtual instruments using LabVIEW for the thermal experiments on diode and transistor circuits. Due to the limited number of workstations, the students were asked to work in a team (two students per station) to work on the project experiments.

III. APPLICATION SOFTWARE

An important issue associated with a MBEIL workstation, is the use of software for data acquisition, analysis, and presentation. In this project, we use LabVIEW [5] a graphical programming environment which creates software modules known as virtual instruments. LabVIEW offers an innovative programming methodology in which one can graphically assemble the virtual instruments based on the block diagrams, instead of using the text-based programming. The students can select the functional blocks from the palette menus and connect them with wires to pass the data from one block to the next. The block diagrams range from simple arithmetic functions to several advanced acquisition and analysis routines.

In recent years, LabVIEW has become a popular software package at many college and university laboratories. In addition to LabVIEW software, the Microsoft Works and PSpice software packages have been integrated into each workstation for report writing and circuit simulation respectively. The students were asked to submit the written project report after the completion of each project experiment.

IV. LABORATORY EXPERIMENTS

In this project, we introduce the following new and/or improved laboratory experiments into the analog electronics courses. The experiments are divided into three major categories. The implementation schedule for these experiments along with the corresponding course numbers is shown below.

. Study of Temperature Effects (EET 157, Spring 96)
. Study of Noise and Nonlinear Circuits (EET 207, Fall 96)
. Study of Advanced Devices (EET 257, Spring 97)

The main objective of this paper is to present the results pertaining to the study of temperature effects on the diode and transistor circuits. The following experiments were conducted.

. Effect of temperature on the diode and transistor characteristics
. Thermal analysis of power supplies and amplifiers with different heat sinks

The pn junction diodes and bipolar junction transistors were utilized to study the effect of temperature on these devices. The scope trace of voltage-current characteristics were obtained at various temperatures. The performance parameters such as the diode threshold voltage, and transistor hybrid parameters are extracted from the obtained characteristics.

To study the effect of temperature at the subsystem level, the students were asked to design and build the modular power supplies and transistor amplifiers. Each module was placed in a temperature chamber and the module was tested for its performance characteristics over a wide temperature range. In the case of a power supply, voltage regulation, ripple, and power dissipation were measured at various load conditions. The amplifier parameters such as input impedance, output impedance, and voltage gain were measured. These experiments were conducted with aluminum heat sinks. These experiments were introduced in EET 157 (Electronic Circuit Analysis) laboratory.

V. RESULTS

At the time of writing this paper, students finished the experiment on the diode characteristics and therefore, the results pertaining to the diode experiment are presented. The results pertaining to the other experiments will be presented during the presentation. The circuit diagram for the diode experiment is shown in Figure 2.

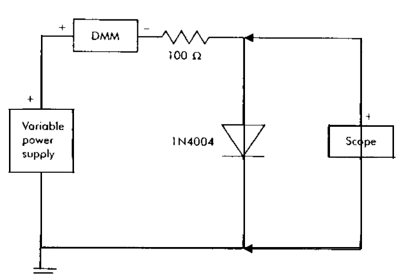

Figure 2. Circuit diagram for the diode experiment.

The front panel of the virtual instrument built by the students to acquire the diode current and voltage data is shown in Figure 3, along with the obtained diode forward-biased characteristics at different temperatures.

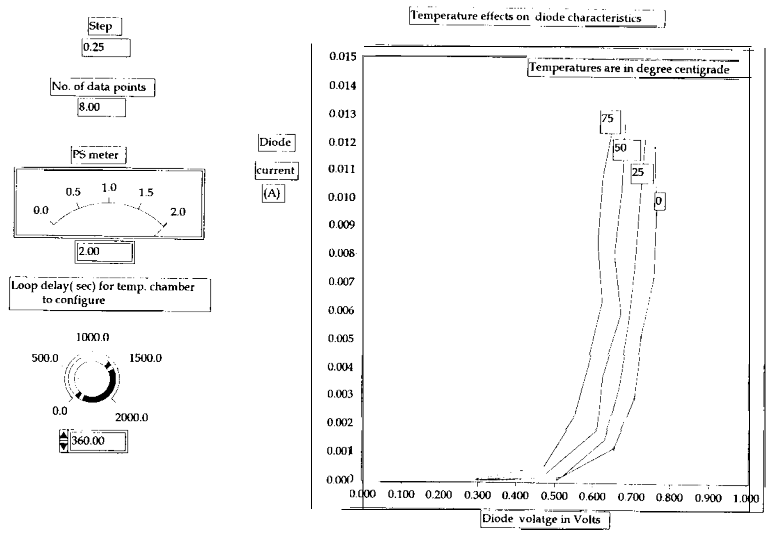

Figure 3. Front panel of the virtual instrument for the pn junction diode characteristics.

The corresponding block diagram of the virtual instrument built by the students for the above experiment is shown in Figure 4.

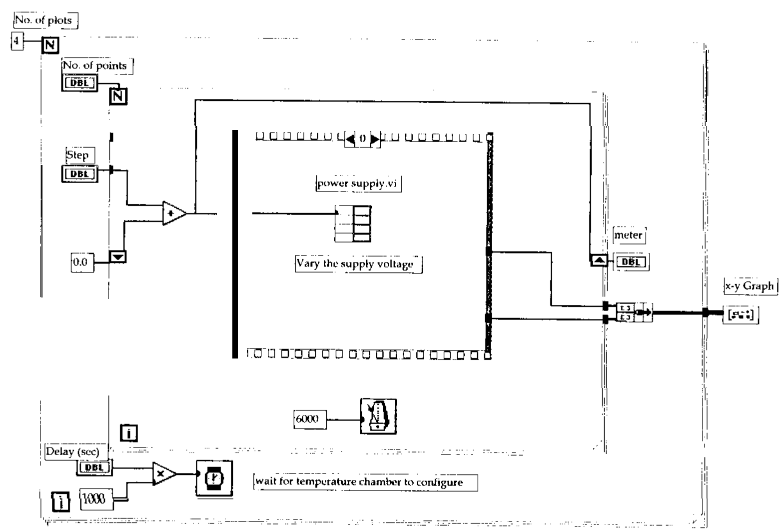

Figure 4. Block diagram of the virtual instrument for the diode characteristics (only the top layer of the diagram is shown).

VI. CONCLUSION

This paper described the set up of an on going NSF-ILI project, microcomputer-based electronic instrumentation laboratory at Purdue University North Central. The microcomputer-based workstations consists of Hewlett-Packard programmable electronic instruments interfaced with LabVIEW through IEEE 488.2 interface. Experiments related to the temperature effects on diode and transistor circuits are studied. The virtual instruments built by the students pertaining to the temperature effects on diode and transistor circuits are presented. The results pertaining to the study of noise, nonlinear circuits, and advanced devices will be presented in future conferences.

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