
**DESIGN AND DEVELOPMENT OF ELECTRONICS
WORKBENCH (CPUBENCH) FOR EE/ECE LABORATORY**

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ABSTRACT

The Electronic workbench (CPUBENCH) for EE/ECE Laboratory was designed based on the basic requirements for the electronics laboratory. This workbench is used when performing the laboratory experiments in electronics, basic electrical engineering and allied subjects. This has two major components: the analog section and the digital section. The analog section is composed of AC and DC power supply circuits for analog signal experiments and design. The digital section has eight-bits data switch, eight-LED logic indicator, square wave generator, and two debounce switch with indicator, used in digital logic experiments, and design and implementation of digital logic circuits. The CPUBENCH was tested for one week of continuous operation at En 204 EE/ECE Laboratory to determine the performance and reliability of the design. The parameters tested were the voltage output of the power supply, frequency output and pulse width of the square wave generator, testing for the data switch, and the LED indicator. The regulated power supply has the following measured outputs: 5 V, 12.06 V, and -11.95 V, which are closer to the expected value of 5V, 12 V, and a -12 V, respectively. Square wave generator frequency output is 1075 kHz, with a pulse width of 53.76 % which is closer to the expected value of 1 kHz, and 50 %, respectively. The data switch and the LED were tested for output logic and logic indicator. For logic 1, the switch is closed and the LED lit up; for logic 0, the switch is off and the LED also turned off. All the functional block of the CPUBENCH were tested and they function normally and are ready for use.

INTRODUCTION

Background of the Study

The College of Engineering of Central Philippine University is one of the top Engineering schools in the region. It offers seven engineering courses namely: Bachelor of Science in Civil Engineering (BSCE), Bachelor of Science in Chemical Engineering (BSChE), Bachelor of Science in Electronics and Communication Engineering (BSECE), Bachelor of Science in Electrical Engineering (BSEE), Bachelor of Science in Mechanical Engineering (BSME), Bachelor of Science in Software Engineering (BSSE), and Bachelor of Science in Packaging Engineering (BSPkgE). Of the seven Engineering courses, five are accredited level III by PAASCU (Private Association Accreditation of School Colleges and Universities). The College of Engineering's mission is to offer educational programs of the highest standard. By preparing the students for their future work in their chosen field of study and by providing them with the best education in theory and practical work (Student Handbook, SY, 2007 - 2008). This means that lecture in the classroom should be coupled with experiments and application through laboratory works. A complete and modern user-friendly laboratory room therefore is necessary.

Of the seven courses being offered the total of 946 students are enrolled in Electrical Engineering and Electronics and Communication Engineering (EE and ECE); the biggest which is nearly one-half of the population of the college. Due to the large number of students enrolled in the EE and ECE courses who are using the laboratory, the low number of equipment for students use in the EE and ECE laboratory has become a major problem. Some of the equipment and instruments in the laboratory are obsolete and upgrading is necessary. The EE/ECE department has three laboratory rooms: one room each for the electronics and microprocessor, communication, and the Electrical power.

The equipment to student ratio of about 25:1 is a major problem especially in the use of power supply and digital logic trainer. The following subjects use the laboratory: Basic Electrical Engineering (EE 329), Basic Electronics (EE 5a), Circuits 1 (EE 311), Electronics 1 (EE 322), Circuits 2 (EE) 411, Electronics 2 (EE 412), Electronics 3 (ECE 421), Logic Circuit (ECE 423), Energy Conversion (EE 424), Microprocessor and Microcontroller (ECE 522), Wire Communication (ECE 524), Broadcast Engineering and Acoustics (ECE 523), Wireless Communication (ECE 526), and Digital Signal Processing (ECE 413). Two sections in each subject with an average of 40 students use the laboratory, such that the number of

equipment is not enough to accommodate all groups of students. The student to trainer ratio is about 10:1. This trainer was acquired abroad such that schools like public, technical and vocational colleges which offer related technical courses in Western Visayas can hardly acquire it.

For this reason, there is a need to design, develop and construct an electronic workbench for EE/ECE laboratory. This will not only help Engineering and Computer Studies students but will also help other schools to improve their laboratory facility. This electronic workbench has the following features: DC power supply, 8-bit data switch, 8-bit LED logic display, clock circuit, and debounce switch. The users of the CPUBENCH are the students and instructors using the EE/ECE laboratory for electrical and electronics experiments.

There are companies and individuals, who developed their features and are different from those of the designed. Most of the workbenches were designed specifically for placing electronics equipment and as working table for the implementation of the electronics circuit design. These workbenches have no additional features found in the CPUBENCH like the low voltage regulated and unregulated power supply, clock generator, 8-bit data switch and logic indicator and the debounce switch.

Industrial Work Benches-A Plus Warehouse Equipment is a source for Industrial work benches. Stock industrial workbenches are used by schools, factories and electronics fabricators. The widest variety of industrial work benches include Lista, Lyons, Penco, Hodge, Tennsco, Edsal, and Pucel. These Industrial workbenches come pre-assembled or unassembled, as preferred by the users. Many Fortune 500 companies use A Plus Warehouses' Industrial Work Benches (*from <http://www.aplushs.co/-script/ap-123benchA.cgi>*).

The Lista technical electronic workstation standard features include: greater productivity and efficiency, reduces safety risk and inconvenience of multiple wires and extension cords, incorporates ergonomic design, worksurfaces, including ESD, creates a static-safe environment, flush drawer handles, superior organization and faster retrieval, customized work environment, and easy-access leveling adjustments. Workbench riser shelves standard features are: shelves are 13-1/2" high, in either a 10-1/2" or 15" depth, shelves can be adjusted in 1-1/2" increments from 12" to 18" above the work surface, keeps items from falling off back of shelf, supports available with 15 amp, 20 amp, 15 amp GFCI, 20 amp GFCI, or no power, These technical electronic workbenches offer a rich array of customizable features

to suit any technical environment that requires access to electrical power (from <http://www.listaintl.com-/files/tekbench.aspx>).

BenchPro is a popular line of workbenches and tables. With a 16 gauge tubular steel frame, these tables can withstand up to 5000 lbs, making them some of the strongest tables available. BenchPro benches are also the easiest bench to assemble, the top and apron is factory assembled and the legs attach with two bolts each (from <http://-www.gotopac.biz/SearchResults.asp?Cat=1418>).

Arlink provides a wide range of technical furniture solutions that solve problems throughout the modern workplace. From single workbenches to complete facility wide installations, Arlink's adaptable system architecture enables users to create productive workstation environments for almost any person performing almost any task. Arlink's ergonomic and adaptable systems are designed to enable easy customization of individual workstations and fast configuring of complex, multi-station systems. Arlink products assemble and reconfigure with a minimum of tools in significantly less time than others while providing a consistently high return on your investment (from <http://-www.gotopac.biz/SearchResults.asp?Cat=1417>).

Compmark workbenches have 1/2 bottom shelf with 4" back support, 2" sq. tube frame construction optional power strip (10 outlet), 14 ga. steel pegboard - 19" high, plastic bins (5" H x 5-1/2"W x 11"D), 5" rubber casters with 2 swivel and brakes, 2 rigid; 16 ga. louvered panel - 19" H., half tool box shelf at eye level and drawers are available on fixed and mobile workbenches (from <http://www.compmark.com-/items/workbenches-/fixed-mobile-workbenches-tables-stands/>).

Within limits, the designer is allowed to customize the size of their bench to fit individual requirements; however, mass-production techniques will not be sacrificed. In addition, a broad review of woodworking vises and other bench accessories have been conducted so that students will be able to further customize their own benches (from <http://www.palomar.edu/woodworking/html/-CFT170.nm>).

The CPUBENCH design has a dimension of 4 ft long, 2-1/2 ft wide and 4 ft in height with open slots at the bottom for the provision of electronics equipment and component. Built in power supply of 220Vac/60Hz 10A, 12Vac/60 Hz 2A, 12V dc unregulated, 12V regulated, 5V dc regulated, with additional features of 8-bit logic switch, LED indicators, debounce switch, and clock generator circuit with an output of 1Hz, and 1 kHz square wave with 50 % duty cycle.

All the electronic workbench designs are good but they do not have built-in features like the electronics workbench design for EE/ECE laboratory (CPUBENCH) which has dc supply, regulated and unregulated, 8-bit logic switch and indicator, debounce switch, and clock circuit.

Objectives of the Study

The general objective of the study was to design, develop and construct an Electronics Workbench (CPUBENCH) for EE/ECE Laboratory.

Specifically, the study aimed to:

1. Design the blocks and components of a CPUBENCH with the following: the regulated and unregulated power supply, 8-bit logic switch and 8-bit LED logic indicator, debounce switch, and clock circuit;
2. Design and draw the schematic diagram of a given circuit of a system and implement each circuit component;
3. Evaluate the circuit design using breadboard;
4. Construct and test the CPUBENCH; and,
5. Evaluate the performance of the CPUBENCH.

Significance of the Study

This study was developed to further enhance the skill and knowledge of the researchers, instructors, and students in the development, experimentation, demonstration, and implementation of electronics and electrical circuits, assist the students in performing their laboratory experiments and implementing their circuits designed, improve flexibility and accessibility for the students as well as the instructors in performing their laboratory experiment and their circuit design without borrowing several equipment from the stockroom; and help develop the laboratory of other schools offering related courses.

The college will benefit from the improvement of the laboratory room and the university can generate savings from related equipment for this purpose.

Scope and Limitation of the Study

This study is limited only in the design, development, and construction of an electronic workbench for EE/ECE laboratory. The CPUBENCH is specifically designed for use in electronics and electrical laboratory for the implementation of design and experiment. The bench was designed for low power applications. The users of the bench are the faculty and students of EE/ECE laboratory, other schools offering related courses and the individuals who want to acquire this bench.

METHODOLOGY

Conceptualization of the Design

The block diagram of a CPUBENCH shown in Figure 1 is composed of the 220 Vac line, DC supply, 8-LED (Light Emitting Diode) logic indicator, and 8-bit data switch.

The 220 Vac line is the main supply line for the circuit built-in in the bench as well as for the equipment used in the laboratory experiments. The DC supply is the built-in power supply of the workbench; it is also used as DC power supply for the internal and external circuitry. The 8-bit LED display is used as the logic display, 8-bit data switch for logic input, ammeter and voltmeter bank used to measure current and voltage in a circuit, and the breadboard is the built in board for circuit implementation.

Design of the Specific Circuit Component and Workbench

The design of a specific circuit component and schematic diagram is found (Figure 2). The workbench design has a dimension of 4 ft long, 2 -1/2 ft wide and 4 ft high with open slots at the bottom for the provision of electronics equipment and component.

Circuit Implementation, Test, and Evaluation Using Breadboard

Testing and evaluation was done at En 204 College of Engineering CPU. The power supply circuit was first implemented to test and evaluate its

performance and circuit parameters. The parameters tested were the output voltages and these were compared to the expected output voltage shown in specification sheets of each IC voltage regulator. The logic indicator and the data switch were implemented and tested for their functionality and reliability by testing for a period of one week of continuous operation. The clock circuit was tested for its output waveform, pulse width, duty cycle and operating frequencies. There is no standard for this data but this is the typical parameter needed for the performance evaluation of a system because this data was based on the specifications sheets of individual devices.

Construction of the Final Design

The construction of the CPUBENCH was split into three categories: the construction of the bench, PCB, and assembling of the actual circuit component. A hired carpenter did the painting and construction of the bench while an electronics technician did the construction and actual assembly of the PCB .

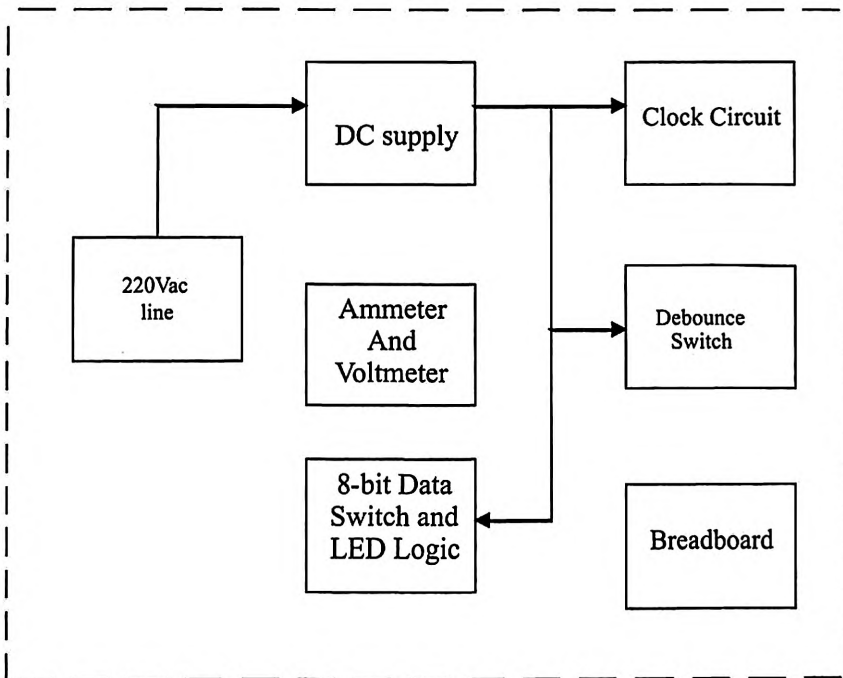


Figure 1. CPUBENCH Block Diagram

Final Test and Evaluation

The faculty and the designer conducted the final test and evaluation of the CPUBECH at En 204 EE/ECE Laboratory, College of Engineering, Central Philippine University for a period of one week. The students tested the reliability of the finished bench by using it in their laboratory experiments. The faculty and the designer tested and evaluated the parameters for voltages, pulse width, duty cycle, and the output frequency right after the students used the bench for a period of one week.

Performance Evaluation

Performance evaluation of the CPUBENCH was done at En 204 EE/ECE Laboratory College of Engineering, Central Philippine University. The data gathered at each stage of a given circuit were the nominal output voltages that were based from the specification sheets of the given active components and devices, specifically IC voltage regulator.

The circuit parameters of a clock circuit output frequencies, pulse width, and duty cycle were evaluated. The digital logic circuit indicator, 8-bit LED, and 8-bit data switch were also tested for functionality and reliability.

Data Gathered

During the performance evaluation of the CPUBENCH, the following data were gathered:

1. output voltage of the power supply at specified operating conditions;
2. output frequency of a clock circuit, duty cycle, and pulse width;
3. actual measurement of the output voltage of a voltage regulator and unregulated power supply;
4. specification of an IC Voltage regulator the 7812, 7805, LM317, LM337, and 7912; and,
5. specification of the LM555 IC.

Other data were provided by the manufacturer for each device used specifically for active components and Integrated Circuits (IC).

RESULTS AND DISCUSSION

Testing and Evaluation

The performance evaluation was done at En 204 with testing of individual circuit component for its function and operation based on the standard operating condition and the specifications of the workbench. Most of the parameters were based on the specification sheet of a given active component used like transistors, integrated circuit (IC), voltage regulators and diodes which were provided by the manufacturers. The CPUBENCH was tested using the 220 Vac line voltage in order to supply the entire circuit of the bench. To measure the output voltage of the power supply, the digital multimeter (DMM) was used. In testing the function and operation of the clock generator circuit, the oscilloscope was used. The digital logic indicator and the logic switches were tested based only on functionality testing. To test the functionality of the LED indicator, logic switches were used, when the logic 1 switch is “OFF”, logic 0, the LED, is “OFF” and when the switch is “ON”, logic 1, the LED, is turned “ON”.

The result of testing and evaluation of the unregulated power supply circuit is shown in Table 1. These data were based on the actual measurement and standard operating conditions and were compared to the expected value. The positive output voltage is +16.98 V dc and the expected value is 12 V, the negative output voltage is -16.98 V dc and the expected value is -12 V dc. This value may vary depending on the source voltage and the load current. The ac output of 12.62 V ac and 12.64 V ac may also vary depending on the source voltage since this voltage is not regulated.

Table 1. Result of testing and evaluation of the regulated power supply

Regulated Power Supply		
Positive Voltage Regulator (VR)	Measured Value	Expected Value
+5V	5V	5V ±5%
+12V	12.06V	12V ±5%
Variable Positive VR	1.24V-18.98V	1.2V-16.98V ±5%
Negative VR		
-12V	-11.95 V	-12V ±5%
Variable negative VR	-1.27 V-18.98 V	-1.2V-16.98V ±5%

The testing of the clock circuit as shown in Figure 2 and the results in Table 2 show the expected output frequency and the duty cycle of a clock generator circuit. The expected output frequency is 1 kHz with 50 % duty cycle while the measured value is 1075 kHz with 53.76 % duty cycle.

Table 2. Result of testing and evaluation of clock circuit.

Square Wave Generator		
	Measured Value	Expected Value
Frequency	1075 kHz	1 kHz
Duty Cycle	53.76%	50%

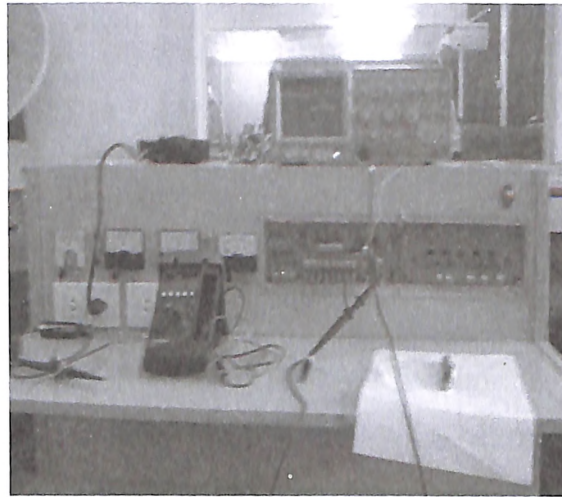


Figure 2. The screen capture of the clock circuit during testing

The results of testing the functionality of the logic switches and LEDs show that when the switch is “OFF” (down position) the LEDs are “OFF”, and when the switch is “ON” (up position) the LEDs are “ON”. All circuits featured in the CPUBENCH are working properly and are ready for use.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS**CONCLUSIONS**

The design and development of the CPUBENCH were successfully made by creating the block diagram of each component. Each block was identified and designed carefully to meet the following specifications and requirements: for unregulated power supply the expected output voltage of at least 12V DC, for regulated power supply the expected output voltage of +5V, 12V, and 1.25V to 12V with 5 % tolerance, the clock generator circuit output frequency is designed to have 1kHz square wave, logic indicator with transistor buffer used to indicate digital logic signal 0 or 1, 8-bit toggle switch or data switch used to select logic levels for digital input, and two debounce switches. Based on the testing and evaluation of the workbench the parameters measured were closer to the expected output. For unregulated power supply, the measured value is 16.9V, this value was not regulated and it would depend on the source voltage. The regulated power has an output voltage of +5V, +12.06V, -11.95 V, 1.24V to 18.98V, and -1.27 V to -18.98 V and all values are within the 5 % tolerance. The frequency output of a clock generator circuit is 1075 kHz with 53.76 % duty cycle. The logic indicator and the data switch can successfully indicate the logic levels, when the switch is set to logic "low" or "0" the LED is "OFF" and when the switch is set to logic "HIGH" or "1" the LED is "ON". These values show that the circuit components of the CPUBENCH are working properly, reliable, and ready for use.

RECOMMENDATIONS

Since CPUBENCH is locally made at low cost, it is easy to acquire, personalize, develop, design and implement the circuit. If this workbench is mass-produced, it can lower the cost and improve the design to become more reliable. It can also generate income for the school and individuals who are interested in the design. Although this design for the workbench is reliable and was tested based on the performance of the circuit components, certain specifications of the active component are to be followed due to its limitations. It is also a standard operating procedure not to operate the components of the equipment up to its maximum operating value for it will

cause permanent damage to active devices like IC, transistor and diodes. Operate only the equipment based on what is being specified and follow the instruction manual to avoid errors that would cause damage or shorten the life of the components.

To further improve the design, it is recommended to use switching regulated power supply instead of linear regulated power supply. The addition of short circuit protection will also eliminate the problem of blown-out fuse for a more versatile design. It cannot be assured that 100 % reliability will be accomplished because the reliability of the design circuit depends on the active component, specifically the IC used. IC's cannot be tested unless they are mounted on specific circuit applications, therefore there is no complete assurance on the performance of the IC's used.

The parameters of the designed workbench are subject to changes, which are caused by variations in the temperature of the operating environment, and operating conditions like maximum and minimum load current.

ACKNOWLEDGMENT

The author wishes to express his utmost gratitude to the following who in one-way or another had contributed to the success of this study:

First and foremost, to the Almighty God, for giving life, strength, wisdom, and unending blessings which made this work possible;

To Dr. Randy Anthony V. Pabulayan for the encouragement to do research;

To the Central Philippine University Research Center for supporting this research.

To the EE/ECE Laboratory Supervisor, Mr. Reylin Manajero, and the Laboratory assistants for the help they extended during the construction of the prototype; and the researcher's family, relatives, and friends for the unceasing encouragement and support.

REFERENCES

- A-Plus Warehouse. Retrieved March 6, 2008 from
http://www.aplushs.com/script/ap_123benchA.cgi
- BenchPro. Retrieved September 8, 2008 from
<http://www.gotopac.biz/SearchResults.asp?Cat=1418> and [Cat=1417](http://www.gotopac.biz/SearchResults.asp?Cat=1417))
- Boylestad, R., & Nashelsky, L.(1997). *Electronic devices and circuit theory*. (8th ed.). Printice Hall International Edition.
- Central Philippine University Student Handbook, SY, (2007 - 2008)
- Compmark workbenches. Retrieved September 8, 2008 from
<http://www.compmark.com/items/workbenches-/fixed-mobile-workbenches-tables-stands/>)
- Lista technical electronic workstations. Retrieved September 8, 2008 from
<http://www.listaintl.com/files/tekbench.aspx>).