THE SIMULATION OF AN EDUCATIONAL MICROPROCESSOR USING SOLID STATE CIRCUITS AND ITS APPLICATION IN PHYSICS

A THESIS

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BY

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To

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I kneel humbly to ALLAH thanking HIM for showing me the right path . Without HIS help my efforts would have gone astray.

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بسم الله الرحمن الرحيم

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ABSTRACT

Many researches have been done in the field of education to find the best and optimum approach to the demonstration of theoretical materials to undergraduate students in different scientific colleges and schools . The most important and effective method is laboratory testing. The innovation of microcomputers offers tremendous laboratory facilities in the procedures of calculation and representation of different characteristics in a physical manner. The main object of this research is to use these facilities as a tool for educational purposes in the laboratory.

In this thesis, digital techniques, their advantages and applications are reviewed , followed by a summary of the history and classifications of computers. The basic fabrication sequence and the classification of the solid state integrated circuits are outlined. A special discussion on the bipolar and unipolar electronic circuits of the basic gate in seven integrated circuit logic families are introduced. This discussion is followed by the presentation of large scale integration circuits and their application in digital systems.

A general description of microprocessor based computer is presented. The description covers computer architecture, instructions, software, interfacing, microprocessor selection, and a typical educational microprocessor kit.

Two experiments are introduced as an application of the use of microcomputers as laboratory tools in education. The first one is to design an energy spectrum analyzer. The circuit is built and tested using it in counting pulses of different frequencies and different amplitude levels and for different periods.

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An educational microcomputer is used to read the output of the energy spectrum analyzer and display the radiation spectra of some radiation sources on the CRT.

In the second experiment, a new approach for representing physical characteristics,using the microcomputer, is applied . A variety of illustrative experiments in the different fields of physical electronics are performed to prove this point of view.

The different transistor characteristics are programmed and displayed on the microcomputer CRT. The students are allowed to vary the individual parameters of the transistor to show their effects on its characteristics and to deduce new meaningful relationships .

Also in this experiment, the voltage gain frequency response of a double tuned transformer circuit is displayed on the CRT of the TRS-80 microcomputer. Too, the primary current of this circuit is displayed for different values of coupling coefficients.

Finally, this experiment was carried out to programme and display the voltage distribution along a transmission line on the CRT of the microcomputer. The experiment was repeated using different conditions of termination: properly terminated , open, and short circuited lines.

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1.1.2 Digital Techniques Advantages:

The primary cause for the widespread use of digital techniques has been the availability . low cost digital integrated circuits (ICs) . Advances in integrated circuit technology have produced many excellent low cost, small size , inexpensive and very reliable circuits. Recent medium scale and large scale (MSI and LSI) integrated devices can replace different circuits and instruments. Electronic equipment designers recognize the availability of such powerful tool. By using digital ICs , many equipment improvements can be made such as reductions in size , weight , cost and power consumption. In general, digital techniques offer the following advantages.[2]

a- Accuracy: Digital techniques permit greater precision and resolution in representing quantities as well as in measurements than with analogue methods.

b- Dynamic Range :The dynamic range is the difference between the upper and lower data values that a system or instrument can handle. Analogue systems have a limited dynamic range because of component capabilities and noise (less than 100.000 to 1) . while digital techniques can ensure any desired dynamic range.

c- Stability: Analogue or linear circuits are subject to drift and component tolerance problems. Temperature and other environmental factors affect resistors, capacitors and inductance values. Transistor biases vary causing non-linear operation and distortion to occur. Component imperfections and ageing cause drift which result in different problems. Digital methods greatly minimize such problems.

d- Convenience: Digital techniques make instruments and equipment more convenient to use. The direct decimal display of data is more convenient than reading or interpolating analogue meters or in setting analogue dials.

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e- Automation : Many electronic processes can be fully automated using digital techniques.Special control circuits or a digital computer can be used to set up , control and monitor many operations. Data is readily recorded, stored and displayed .

f- Design Simplicity : Digital equipment is relatively easy to design. Little or no breadboarding is required in this case while in analogue or linear circuits breadboarding is mandatory to ensure a workable circuit.Digital equipment can go from paper design to finished product in a very short time.

g- New Approaches : Digital methods permit new approaches to the solution of electronic equipment design. In addition, some impossible analogue design techniques are applied with digital circuits.

1.2 DISCRETE COMPONENT LOGIC AND IC CIRCUITS:

1.2.1 Discrete Component Logic Circuits:

A discrete component logic circuit is a logic circuit made up of individual electronic components such as transistors,diodes,resistors, capacitors and other devices.[3] These are assembled to form a complete circuit like the diode gates and inverter (see Appendix A) . For many years digital logic circuits were implemented with discrete components. They offered small sized, good performance and reasonable power consumption. Nowadays, such discrete component circuits are rarely used. They have essentially been replaced by logic elements with better performance,lower cost and improved features. We may still encounter discrete component logic circuits in some high power applications or in older digital equipment. However , most digital logic functions are implemented with integrated circuits.

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1.2.2 Integrated Circuits:

An integrated circuit (IC) is a semiconductor device which combines transistors, diodes, resistors, and capacitors in ultra-miniature form on a single silicon chip. The advances in semiconductor technology have permitted the semiconductor manufacturers to design , develop and produce electronic circuits on a single silicon wafer that is generally less than one tenth of an inch square. These circuits are not only significantly smaller in size than discrete component logic circuits but also lower in cost. Many offer significant savings in power consumption in addition to the elimination of the need for circuit wiring. When discrete components are used, the components must be interconnected physically on a printed circuit board and then tested. With an integrated circuit the entire circuitry, all components included, are manufactured simultaneously. Thus reducing manufacturing costs and improving reliability. Integrated circuits implementing the basic logic functions, such as NAND , NOR and flip-flops, are known as small scale integrated circuits(SSI) . Complete functional circuits of either the combinational or sequential type are generally designated as medium-scale integrated circuits (MSI). Large Scale Integration (LSI) technology permits even greater flexibility. Complete circuits and systems can be constructed on a single chip. For example , an entire Central Processing Unit of a microcomputer is available as a single integrated circuit.

1.3 COMPUTERS:

1.3.1. The Evolution of Computers:

Today's smallest microcomputer and largest mainframe computer share a common ancestor- the univac 1 [4] which was built out of vacuum tubes in 1950 , and filled a room; yet it had less computing capabilities than most of today's microcomputers.

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