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DEVELOPMENT OF SIMPLE CALCULATOR TO PERFORM ARITHMETIC FUNCTIONS USING MICROCONTROLLER

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ABSTRACT

This report presents a development of a microcontroller based calculator using 4x4 Matrix Keypad and 16x2 Liquid Crystal Display (LCD) as the main components of this design. This system consists of four main units: (input unit, control unit, output unit and power supply unit), which were integrating and interfacing each other to perform a required operation. Input unit, used the 4x4 Matrix Keypad to serves as an input device that allow the user to communicate with system, control unit, used the ATmega328P microcontroller to serve as central processing unit of the calculator that accepts input instructions through the keypad, process it and send the result through the LCD, output unit is the LCD that gives the results. This design will perform simple arithmetic functions that can replace an ancient method of performing calculation such as abacus; stones etc and also reduce to barest minimum the computational errors in arithmetic, algebraic and statistical problem in engineering and science. It makes the program for the arithmetic operations to be simple, reliable, and faster with cost effective.

Keywords: Microcontroller, Calculator, Keypad, LCD display.

1. INTRODUCTION

Improvement in technology has led to building electronic devices with simple circuit and with the introduction of microcontroller has made designing of electronic devices circuit simpler. A computer on a chip is known as microcontroller. It is essential for the operation of devices such as calculator, mobile phones, video cameras, electrical appliances and most self-contained electronic systems. In the designing of calculator, microcontroller has the following elements: memory, central processing unit, ports, bus, serial communication, etc. Adedoyin *et al.* (2014) Memory: Program and data are stored in the memory. Central Processing Unit (CPU) has capability to add, multiply, divide, subtract, and move its contents from Memory locations which are called registers. Registers are memory locations whose role is to perform various mathematical operations or any other operations with data wherever data can be found. Bus is a connection between memory and CPU-the path through which data goes from one block to another. Physically, it represents a group of 8, 16, or more wires. There are three types of buses: control, address and data buses. The first one has many lines as the amount of memory

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to address, and the other one is as wide as data. First one transmits address from CPU memory, and the second connects all blocks inside the microcontroller. Ports have several memory locations whose one end is connected to the data bus, and the other has connection with the output lines on the microcontroller which can be seen as pins on the electronic component. There are several types of ports, input, and output or bidirectional ports. When working with ports, first of all it is necessary to choose which port one needs to work with, and then to send data to, or take it from the port. When working with it the port acts like a memory location. Something is being written into or read from it, and this could be noticed on the pins of the microcontroller. Watchdog is a free-run counter where a program needs to write a zero in every time it executes correctly. Analog to digital converter (ADC) is responsible for converting an information about some analog value to a binary number and follow it through to a CPU block so that CPU block can further process it. Finally, the microcontroller is completed, and all need to be done is to assemble it into an electronic component where it will access.

1.2 SCOPE OF THE PROJECT

The project required the used of hardware and software that related to arithmetic functions software for simple and advance calculation that used ATmega 328P microcontroller, LCD, and Keypad as main components that were integrated to perform both arithmetic operation. In this project, the source code was written using PIC Micro C compiler and easy PIC, and was simulated using Proteus 6.8 professional software to ensure it functionality before it was finally burned into the ATmega328p microcontroller. The delay time for the system responses was 5 seconds to response to every action performed with system.

1.3 RELEVANCE OF THE PROJECT

This design will perform simple arithmetic functions that can replace an ancient method of performing calculation such as abacus; stones etc and also reduce to barest minimum the computational errors in arithmetic, algebraic and statistical problem in engineering and science. It makes the program for the arithmetic functions to be simple, reliable, and faster with cost effective

2. LITERATURE REVIEW

A calculator is a small hand held electronic device used to perform mathematical and logical operations. Electronic calculators are electrically powered, usually by battery or solar cell and different shapes, sizes. It often has a microprocessor or microcontroller chip embedded in it that enables it to functions, Tarun, (2013). The microprocessor can be programmable replacement for control circuits and calculator chips in the 1970s Up to this point, most control systems using digital logic were implemented using individual logic integrated circuits to create the design and as more fun required, the circuits became very bulky unreliable, Shiva, (2014). But with the invention of the microprocessor which has a complete processing unit inside a microchip, the reliability of digital logic circuits were greatly increased as a result of reduced size. Subsequently, there is need to include a permanent memory in the microprocessor which ultimately gave birth to the microcontroller the processor component used in this design. The microprocessor that doesn't have a program or data memory, the microcontroller has a program and data memory in addition to a central processing unit (CPU), Wimshurst, (2007).

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An embedded microcontroller (also called a microcomputer and sometimes abbreviated μC MCU) contains a processor core, memory, and programmable input/output peripherals integrated circuit Tanshi *et al*, (2014). An integrated circuit is a complete electronic circuit made semiconductor material (also called a encapsulated in plastic and used as one component. The simple calculator realized in this design is capable of performing four arithmetic operations: addition (+), subtraction (-), multiplication (*) and division (/) and can perform computation on a maximum of 16 digits at a time.

3. METHODOLOGY

This chapter describes the methodologies used for the design of the hardware and software parts. The main hardware parts are the microcontroller interfacing with the Keypad and the LCD through connecting wires.

3.1 Selection of Design Tools and Components

The design tools were selected and procured. Below are the lists of components selected and used for the design:

1. LM7805 Regulator
2. 9Volts Battery
3. 16MHz Crystal Oscillator
4. 10KΩ Resistors
5. Capacitors
6. ATmega328P Microcontroller
7. On/Off Switch
8. 16x2 LCD
9. Wires/Cables
10. 4x4 Matrix Keypad
11. Easy-way Printed Circuit Board (PCB).

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3.2 Hardware System Design

The methodology, considerations/ specifications of Microcontroller based calculator and its functional components are reported. The development stages and modes of operation of the software application developed for the hardware, was also reported here. This System consists of mechanical, electrical, and electronic components, which are integrated to complete the system design, as follows:

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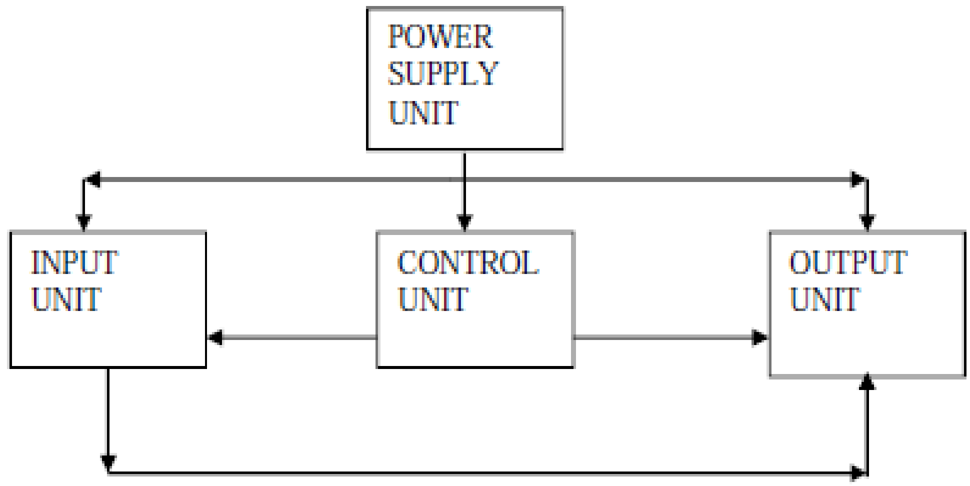

Figure3.1: Shows the Block diagram of the Calculator

The block diagram shows how the following units were integrated;

(i) Power Supply Unit

(ii) Microcontroller unit

(iiii). Input unit (KEYPAD)

(iv). Output unit (LCD)

3.2.1 Power Supply Unit

For a proper functionality of any microcontroller, it is necessary to provide a stable source of power supply, a sure reset when it is turned on and an oscillator. According to technical specification by the manufacturers of ATmega328P microcontroller. Supply voltage should move between 2.7volts to 5.5 volts in all versions. The simplest solution to this is to use an LM7805 stabilizer which gives +5volts on its output.

3.2.2 Input Unit

The 4x4 Matrix Keypad used in this design serves as an input device through which the user communicates with the system. The keypad interfacing with the microcontroller through, pins 28, 27, 26 and 25 with pins (4-7) columns on keypad respectively and pins 21, 22, 23 and 24 were connected with pins (0-3) row on keypad respectively.

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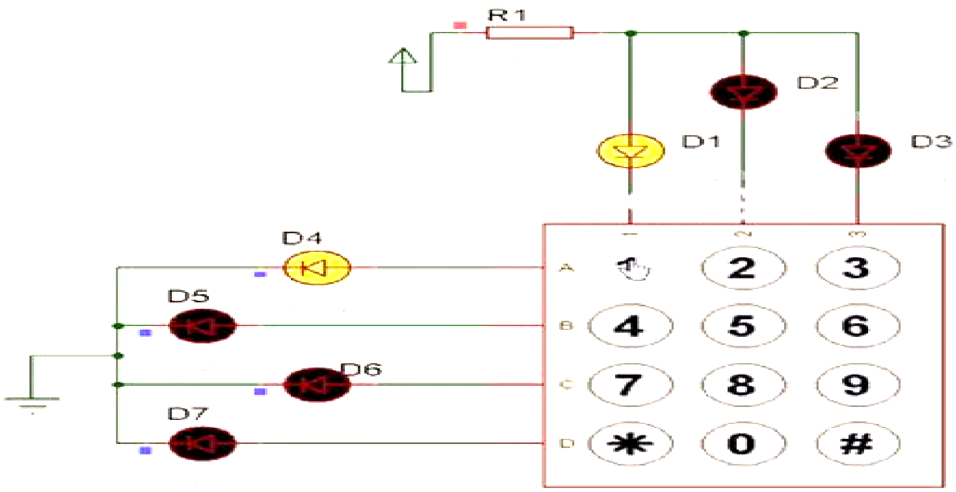

Figure3.2: showing the interfacing of Keypad with microcontroller

The Control Unit

The microcontroller is CPU of the calculator. It gives instructions, accepts inputs through the keypad, process it, and displays the processed output through the LCD.

The microcontroller ATmega328P is the main control unit. ATmega328P microcontroller was picked for several reasons. Firstly, it is operated on a +5 V DC supply and draws very little current. Furthermore, it has a very low power dissipation and high speed of operation and still maintains its data in case of power loss. Finally it has a large storage memory. It processes and verifies the keypad inputs (Entered pin), and generate control signals to display unit. Thus, this is done by comparing the digits with the right PIN number in the EEPROM memory (internal), if it is correct, it activates the port RD1which is connected to the keypad (this represents the load), and also send an output text display on the LCD, indicating "Enable mode. ATmega328P is used in Arduino Uno boards, and it was to install the Arduino bootloader into the chip. This IC with bootloader can be placed on Arduino Uno board and burn the program into it. Once Arduino program is burnt into the IC, it can be removed and used in place of Arduino board, along with a Crystal oscillator and other components as required for the project. Below is the pin mapping between Arduino Uno and ATmega328P chip**.**

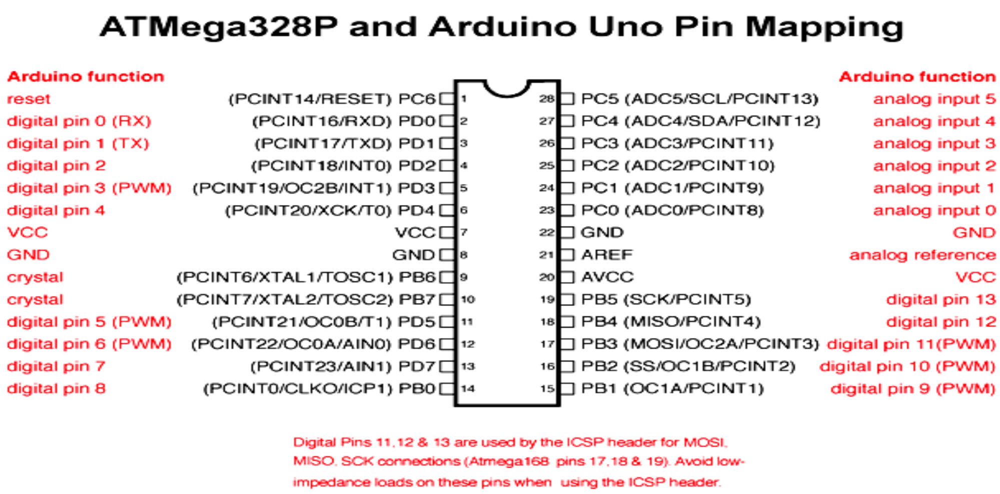

Figure 3.3: Diagram of microcontroller unit

3.2.4 The Output unit (LCD).

The display unit(output unit) used for the design is Liquid Crystal Display (LCD) because of its ability to display numbers, character, graphics, ease of programming for characters and graphics and low power consumption. The 2 x16 character LCD has two rows of 16 characters each. It has a back-ground light which enhances readability in low light conditions. The LCD pins and functions are given in the table 2. It has 16 pins with register select, read/write and enable control lines. In addition, it has a display contrast voltage line. The 4-bit interface was employed because it saves on port pins which could otherwise be used for other additional functions. Pins 15 and 16 were employed to enable visibility in the dark and for characters to be viewed with ease from a distance. The R/W (Read/Write) pin is connected to ground indicating that the LCD is receiving data only. The display receives ASCII codes for each character at D4 to D7 which is connected directly to the 4 PORTB pins of the ATmega 328p roller. To initialize the LCD, the register selects line RS must be set to logic 0.

The 8-bit code for each ASCII character is sent in two halves; high nibble first, low nibble second. Although this makes the software only slightly more complex, it saves on I/O pins and allows the LCD to be driven using only six lines as shown in figure 5.

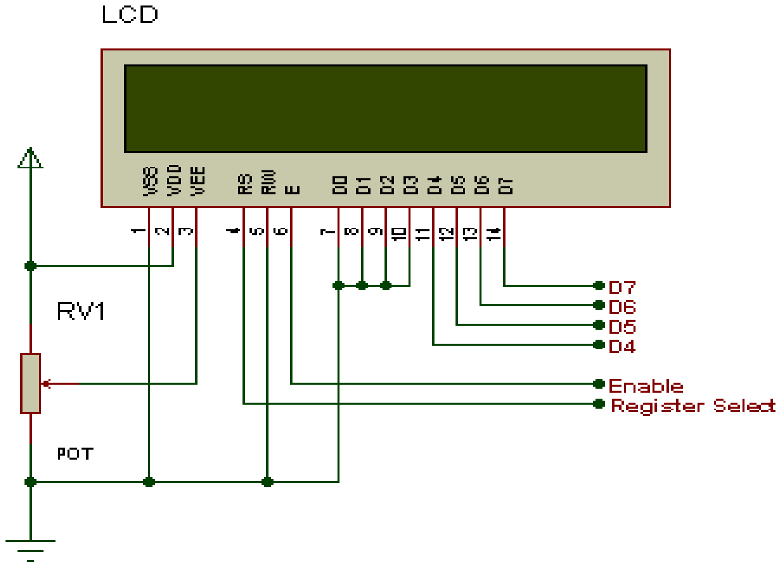

Figure3.4: Liquid Crystal Display to ATmega328P microcontroller interface

3.3 Complete Circuit Description

The 9V power supply was used and connected to the voltage regulator which was used to step down the voltage to the required voltage for the microcontroller that ranges from 4.5v to 5.5v. The voltage regulator has three legs, the first leg was connected to the 9V battery on positive terminal, and second leg was grounded and has to be connected to pin8 of the microcontroller. The last leg was connected to microcontroller pin7. A 10KΩ resistor was used and connected to pin1 through pin 7 of microcontroller. The two capacitors of each 22pF were connected to 16MHZ crystal oscillator in parallel connection with the microcontroller on pin 9 through pin10 respectively. This is to synchronize the operation of the microcontroller and other electronics on the board.

The pin 1 of Microcontroller is described as a master clear (MCLR) which is used for reset button. The LCD with 16 pins connected pin 4 (RS) pin 6 (EN) and the last 4 pins of the 8bit ASCII code: D4, D5, D6 and D7 with microcontroller at pins: 13, 14, 18, 17, 16, and 15 which are data bus respectively. while pins:1 (Vss), 3 (Vee), 5 (R/W) connected in series with pin D0- D3 alongside with 10KΩ resistor were grounded, pins 15 and 16 are for the backlight of the LCD and pin 2 only connected to the power supply, pin 8 and pin 22 on microcontroller were also grounded. The keypad has 8 pins in which pins 0-3 are rows and pins 4-7 are for the columns (A…D), they were interfacing with the microcontroller on port assignments.

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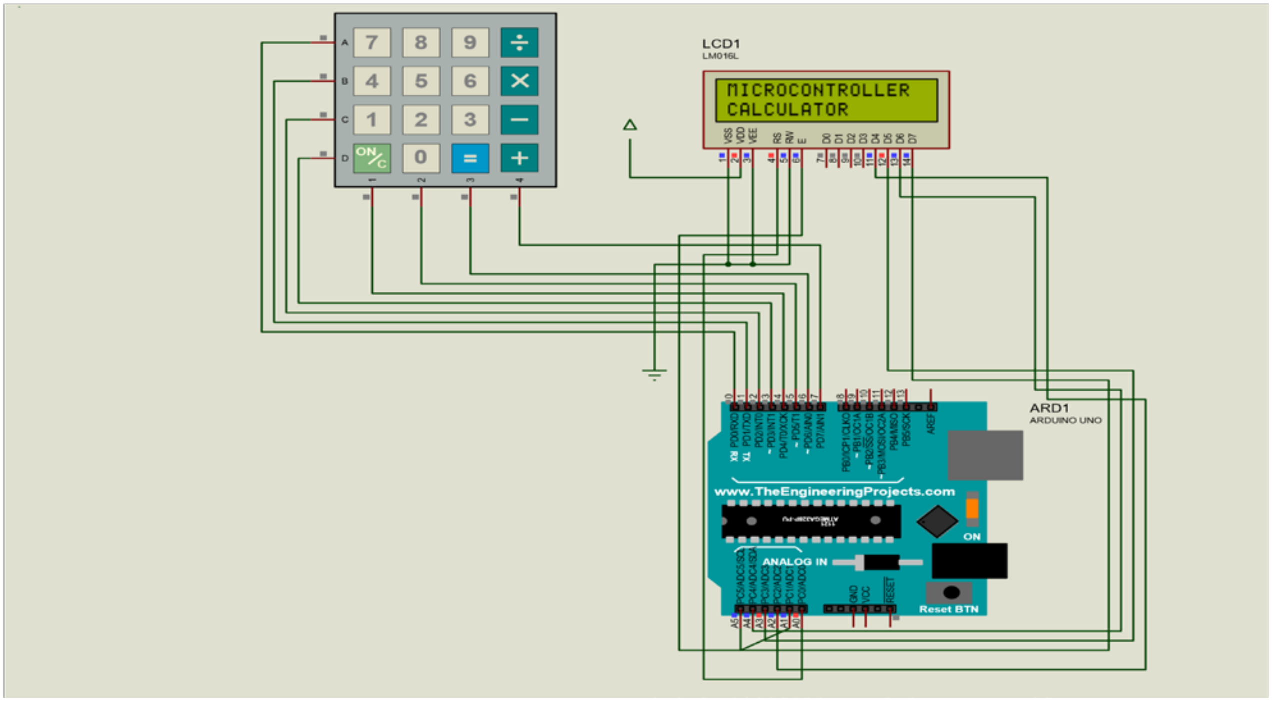

Figure 3.5: complete circuit of calculator

The Mode of operation of the calculator:

i. In order to perform a calculation, press a number key, followed by an operation key, then another number and then equals.

ii. The calculation and result are displayed. For the divide operation, the result is displayed as result and remainder.

iii. The clear key erases the current display, and a new calculation can be entered. If an invalid key sequence is entered, the program should be restarted.

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4.1Testing

After the integration of various sub- units of the complete prototype of this system, the implementation of practical circuit has been tested with the help of Proteus software to ensure the proper connection of the circuit.

The simulation is a decision analysis and support tool, which is used to know the performance of the circuit. The hardware is the cost-effective equipment, so the proposed action cannot be directly observed by the hardware. The simulation software has helped to know the circuit performance and find & rectify the errors of the program. Open the project in the Proteus software:

4.2 Physical Testing

Initial testing of the board was carried out using continuity meter to ensure all short circuit fault are properly cleared. The sensory circuitry was tested to ascertain the level of sensitivity as expected. In the connection each component on the PCB was then tested. The implemented design was initially tested on an open area after construction and the system performed as expected. The device was further install to determine how effective the device can perform simple arithmetic's and logic functions

Figure 4.1: Showing the continuity test of the design circuit with multimeter

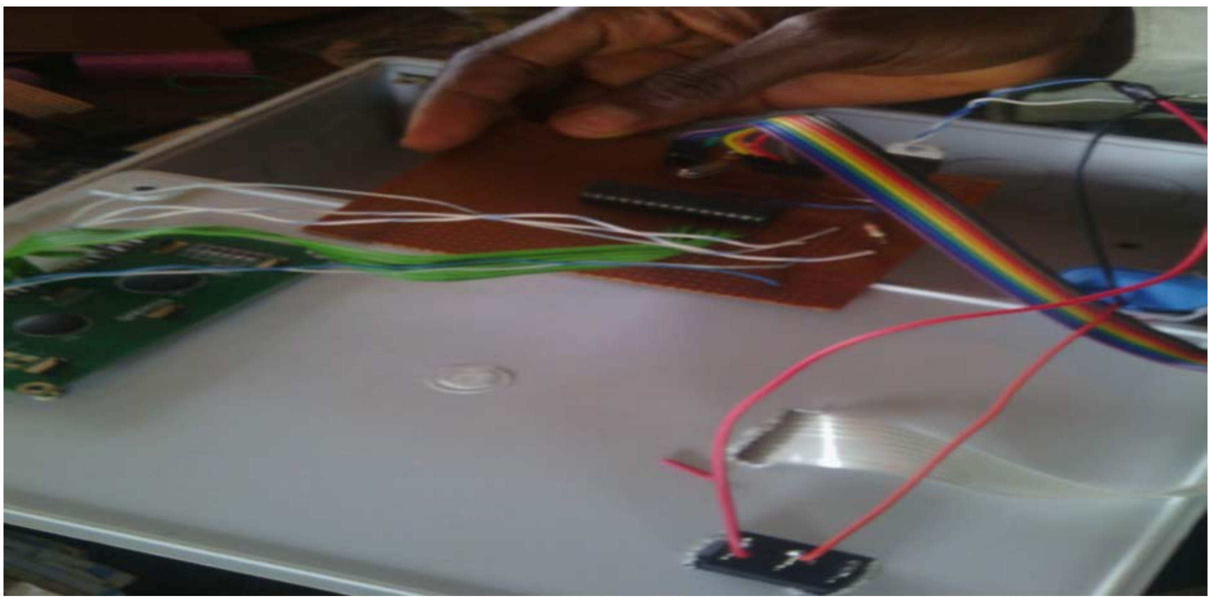

Figure 4.2: Showing the connection of microcontroller with LCD and control switch

4.3 Results

The system is successfully implemented based on the system design, Microcontroller ATmega328P was programmed with C-language and compiled using Atmel studio 6.0 Mikro C Compiler Series of programs were written and simulated using simulator arduino IDE before the working program was finally achieved and then transferred to the microcontroller chip using MIROC PRO software / hardware parallel port interface SPI programmer. **T**he actual prototype implementation, simulations were carried out to test if the codes were working correctly. A sampled result was obtained and this was compared with that of other calculators and the results were the same.

Figure4.3: Showing the ON display of the calculator

Figure 4.4: Showing the addition operation of the Keypad of the Calculator

Figure4.5: Showing the subtraction operation of the Keypad of the Calculator

Figure 4.6: Showing the multiplication operation of the Keypad of the Calculator

Table4.1: Showing the character on keypad performing various operations

Character on Keypad	Assumed to be
"A"	Addition (+)
"B"	Subtraction (-)
"C"	Multiplication (*)
"D"	Division (/)
"*"	Clear (C)
"#"	Equals (=)

4.4 Discussion

This project is majorly designed on the basic function of performing arithmetic, logical and statistical calculation in order make easy and alleviates errors in mathematical problems. This calculator is to be implemented by the combination of a microcontroller as control unit, LCD to display information on the screen and the keypad allows the entry of the defined codes. The result is indicating according to the operation of the embedded codes in microcontroller, and corresponding construction were evaluated and some observations that were observed were putting in consideration during the different stages of testing to ensure effective design of the system.

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5.1 Conclusion

There is need for a portable, reliable, low cost and faster means of calculation with simple design. This study designed and implemented a Microcontroller based calculator for easy and speedy calculation. The Microcontroller ATmega328p was programmed with C-language and compiled using Atmel studio 6.0 ATmega328p C Compiler and proteus ISIS Professional 6.8 portable simulation software. Results of the calculator were found to agree with the other calculators.

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