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Design and Implementation of Microcontroller Based Calculator

Adedoyin M. A.[1], Olopade o.I.[2], Shoewu O. O.[3] , Ogunlewe A.O.[4]

*Corresponding author: Shoewu O. O
Department of Electronic and Computer Engineering,
Lagos State University, Lagos Nigeria.
E-mail: engrshoewu@yahoo.com

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ABSTRACT

This paper focused on design and implementation of a microcontroller based calculator which will perform simple arithmetic using a calculator keypad and a 16x2 Liquid Crystal Display (LCD). The program is limited to single digit input and double-digit results. This allows the program for the arithmetic operations to be simple, while the same principles can be extended to multi-digit calculations.

Keywords: Microcontroller, Calculator, keypad, LCD display.

INTRODUCTION

Advancement in technology has led to building electronic devices with simple circuit. 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 mobile phones, video cameras, electrical appliances and most self-contained electronic systems. Microcontroller has the following elements: memory, central processing unit, ports, bus, serial communication, etc.

Memory: Program and data are stored in the memory. Central Processing Unit (CPU) has capability to 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 two types of buses: address and data buses. The first one has many lines as the amount of memory 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, 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.

Theory of Design

The circuit for a calculator which will perform simple arithmetic operations in the PIC 16F887 Microcontroller, using a calculator keypad and 16X2 LCD display, is shown in Figure1. The keypad has 16 keys: 10 numeric buttons, 4 arithmetic operations, equals and clear. The results obtained are displayed on the LCD display.

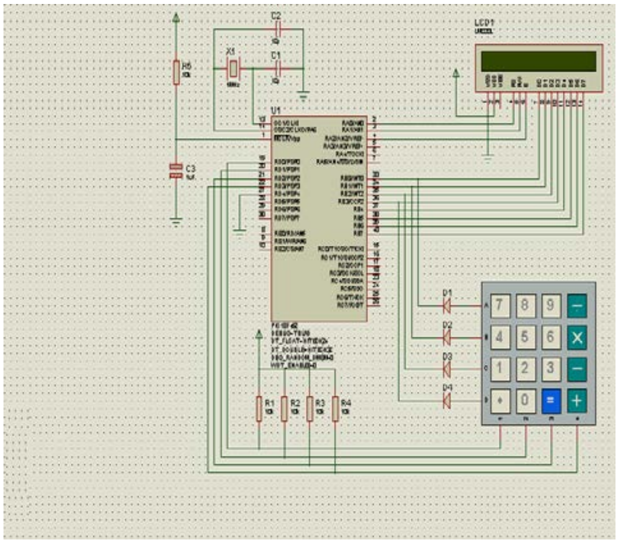

Figure 1: Calculator Circuit Diagram

The calculator operates as follows:

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

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

• 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.

The calculation routine uses the operation input code to select the required process: add, subtract, multiply or divide. The binary result of the calculation is passed to a routine to convert it into BCD, then ASCII, and send it to the display. The result of the divide, being a single digit result and remainder, is sent direct to the display. The clear operation sends a command to the display to clear the last set of characters.

Design Overview

The design overview is divided into two, hardware and software.

A.Hardware design

The Hardware Design is into the modules for easy design, analysis and integration.

- Power Supply unit
- Control Unit
- Input Unit
- Output Unit

Each module was design individually and then joined together to form a calculator. The different modules are controlled by a series of C-programs linked into the control unit. Figure 1. shows the system block diagram.

Power Supply Unit

power supply unit provides the electronic circuit with necessary direct voltages and current with low level of A.C ripples and good stability. The power supply comprises of a transformer, a rectifier, a filter and a regulator.

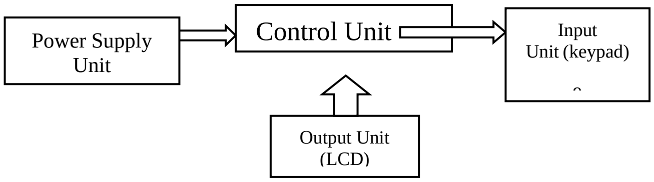

Figure 2. Block Diagram of the calculator

Input Unit

The 4 x 4 keypad used in this design serves as an input unit through which the user communicates
with the system.

Output Unit (LCD)

The output unit is the LCD the calculator is a 16 x 2 LCD. It has a back-ground light which enhances readability in low light conditions.

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.

B. Software Design

In the software design, the program outline and flow diagram show how the system works. It carefully illustrates the flow of instructions from one step to the other during operation.

Program outline for implementing the calcultor

The program outline used to implement the the calculator is shown below:

1. Single digit calculator produces two digit results.
2. Hardware: x12 keypad, 2x16 LCD, P16F887 MCU
3. MAIN
4. Initialise
5. PortC = keypad
6. RC0 – RC3 = output rows
7. RC4 – RC7 = input columns
8. PortD = LCD
9. RD1, RD2 = control bits
10. RD4– RD7 = data bits
11. CALL Initialise display
12. Scan Keypad
13. REPEAT
14. CALL Keypad input, Delay 50ms for debounce
15. CALL Keypad input, Check key released
16. IF first key, load Num1, Display character and restart loop
17. IF second key, load sign, Display character and restart loop
18. IF third key, load Num2 Display character and restart loop
19. IFfourth key, CALL Calculate result
20. IF fifth key, Clear display
21. ALWAYS

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22. SUBROUTINES
23. Included LCD driver routines
24. Initialise display
25. Display character
26. Keypad Input
27. Check row A, IF key pressed, load ASCII code
28. Check row B, IF key pressed, load ASCII code
29. Check row C, IF key pressed, load ASCII code
30. Check row D, IF key pressed, load ASCII code
31. ELSE load zero code
32. Calculate result
33. IF key = '+', Add
34. IF key = '-', Subtract
35. IF key = 'x', Multiply
36. IF key = '/', Divide
37. Add Add Num1 + Num2
38. Load result, CALL Two digits
39. Subtract Subtract Num1 – Num2
40. IF result negative, load minus sign, CALL
     Display character
41. Load result, CALL Display character
42. Multiply
43. REPEAT
44. Add Num1 to Result
45. Decrement Num2
46. UNTIL Num2= 0
47. Load result, CALL Two digits
48. Divide
49. REPEAT
50. Subtract Num2 from Num1
51. Increment Result
52. UNTIL Num1 negative
53. Add Num2 back onto Num1 for Remainder
54. Load Result, CALL Display character
55. Load Remainder, CALL Display character
56. Two digits
57. Divide result by 10, load MSD, CALL Display character
58. Load LCD, CALL Display character
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Construction of the Project

The system is constructed on the board after the circuit has been analysed and simulated in proteus ISIS Professional 7.8 portable simulation software.

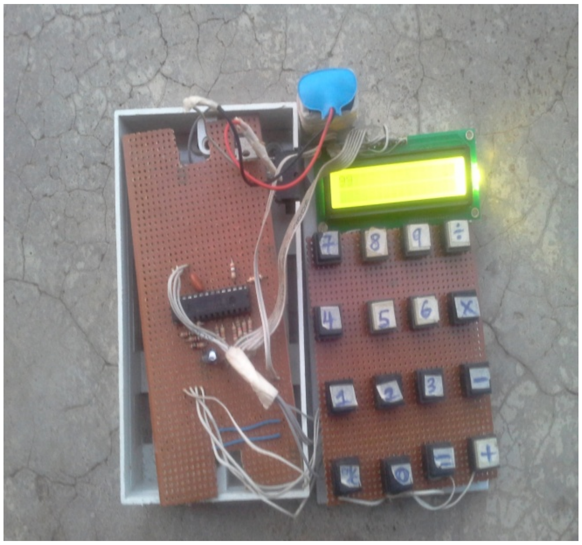

Figure 4: The system construction

Implementation and Testing

The system is successfully implemented based on the system design, Microcontroller PIC 16F783A was programmed with C-language and compiled using CCS_PCWH_V3.203 PIC C Compiler Series of programs were written and simulated using PIC simulator IDE and MPLAB before the working program was finally achieved and then transferred to the microcontroller chip using PICCALL software / hardware parallel port interface PIC 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.

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 PIC 16F887 was programmed with C-language and compiled using CCS_PCWH_V3.203 PIC C Compiler and proteus ISIS Professional 7.8 portable simulation software. Results of the calculator were found to agree with the other calculators.

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