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IMPLEMENTATION OF TAYLOR METHOD BY THE USE OF MICROCONTROLLERS

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ABSTRACT

In recent years, microcontrollers have been used in many areas. Implementation of a circuit by using several discrete analog and digital devices can be done using only one microcontroller. However, industrial microcontrollers have limited resources to implement complex mathematical functions, such as Taylor series.

In this work, implementation of Taylor series on a PIC microcontroller is given. Taylor series algorithm of the function of f(x) = Sinx for the point of a=0, is implemented on a PIC microcontroller board. With PIC micro controller that does not have a floating point as the CPU unit; it was demonstrated by software how the floating-point arithmetic is done. The results of the functions are displayed at the 2x20 lines LCD display.

The input of the function (number input) is made with the button that is connected to the PIC18F452's PORTB. At the same time, the input of the numbers can be made demonstrated with the keypad module.

Keywords: PIC18F452 microcontroller, LCD Display, Taylor Series, Floating Point Arithmetic, C Compiler

1. INTRODUCTION

The heart of a computer is a microprocessor, which handles the computer's requirements for arithmetic, logic, and control. The microprocessor its origin in the 1960s, when research designers devised the integrated circuit (IC) by combining various electronic components into a single component on a silicon "chip" [1].

Microcontrollers are integrated circuit element, which is used in electronic devices as a control unit in many areas. There are many unit in their structure such as timer, counter, input output port, analog and digital converter, RAM and ROM memory, PWM, Serial communication unit, and Arithmetic and Logic Unit (ALU). Control software written by user implements desired control work with the aid of these units. Microcontrollers also have capability of doing arithmetic and logical operation using ALU [2-4]. Thus, without changing hardware part, only changing software in microcontroller, many different processes can be implemented in the same device. This statement supplies the designer easiness and flexibility in circuit design. Furthermore, hardware cost and required board area are reduced and smaller size devices could be done.

The PIC (Peripheral Interface Controller) was developed in the early '90s by Arizona microchip to meet a demand for a cheap, small and practical microcontroller, which was both easy to use, and program [5].
Today, many companies have been producing microcontrollers that have many different properties such as ADC, PWM, the number of input/output port, working frequency, amount of memory. While designing circuits and selecting microcontroller these properties must be taken into consideration especially to decrease the cost of device. PIC microcontrollers are widely used in the world.

2. PIC18F452 STRUCTURE

The product lineup began with 12-bit instruction products using only 33 instructions (i.e., the 16C5x-series parts). The industry's first 8-pin micro also used this 12-bit RISC instruction set, which is referred to as the 12-series.
New devices bragged an increase in instructions to 35 with an increase in instruction width to 14 bits and the addition of interrupts. Reprogrammable parts began to hit production (the PIC16C84) and simplify development. Success triggered a natural progression toward a 16-bit instruction set that used 58 instructions. As a result, the 17-series was born.
C compiler-optimized architectural enhancements gave rise to the 18-series micros and an increase of the instruction set to 75. Meanwhile, flash memory technology has been applied to many devices in the 12-, 16-, and now 18-series of micros.
The MCU used in this architecture is the PIC18F452 manufactured by Microchip. The PIC18F452, also often referred to as a Peripheral Interface Controllerr (PIC), is a high performance Reduced Instruction Set Computer (RISC) Central Processing Unit (CPU). The PIC has a C compiler optimized architecture and instruction set. The MCU is based on the Harvard architecture.
The PIC18F452 is one of the newest members of Microchip's PIC18Fxxx family of micros.

3. LIQUID CRYSTAL DISPLAYS (LCDs)

3.1. Introduction

People use liquid crystal displays (LCDs) every day of their life. A LCD is another type of display. You have probably seen them on watches and calculators [5]. They are also commonly used in instruments panels, videocassette recorder panel, mobile phones, games consoles, photocopiers, vending machines etc. all use LCDs to display information.

3.2. LCD Connector

This connector is intended for various types of alphanumeric LCD modules. RD0, RD1, RD2, RD3, RD4, RD5, RD6, RD7 are the 8-bit data bus, RE0, RE1, RE2 are the control signals. All these lines can be used as general purpose I/O. RE0-RE2 can serve as analog inputs.
A PIC 18F452 microchip will control the LCD. A C complier will be used to write the code and it will be programmed into the PIC. The LCD model that will be used for our device is LM020L. The display format will be 20 characters x 2 lines.

Table 1. Pin out functions

Pins	**Description**
1	Ground
2	Vcc
3	Contrast Voltage
4	"R/S"_Instruction/Register Select
5	"R/W" _Read/Write LCD Registers
6	"E" Clock
7-14	Pins

Tabel 2. LCD Connector

Signal	**Pin**	**Pin**	**Signal**
Ground	1	2	VDD
VEE	3	4	RE0
RE1	5	6	RE2
RD0	7	8	RD1
RD2	9	10	RD3
RD4	11	12	RD5
RD6	13	14	RD7

3.3. LCD Module

In Circuit design, LCD display or seven segment LEDs can used to see operation result or to show required message. Although LED elements can only show numerical characters, LCD displays can show all the numerical and none numerical characters. It is also easy to control the LCD display. Therefore, it is more preferable than LED elements. All of the LCD displays have enable (E), read/write(R/W), registers select (RS) and data input pins. The LCD display and structure is shown in Figure -1.

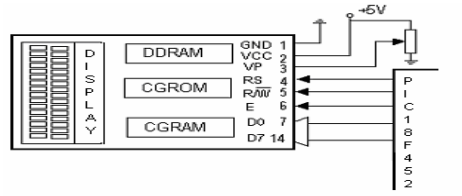

Figure -1. a) LCD in structure

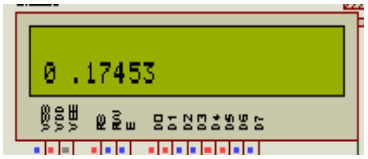

Figure -1. b) LCD Display

3.4. LCD Control Operations

The data that is sending LCD display is either a character or a command. The operation such as clearing display, cursor home, selecting DDRAM address and resetting display are command data. Therefore, it must be stated that the data is a command or a characters. The timing diagram of writing data to the LCD is shown in Figure - 2. If RS pin is pulled down, the operation is a sending command else sending characters [7].

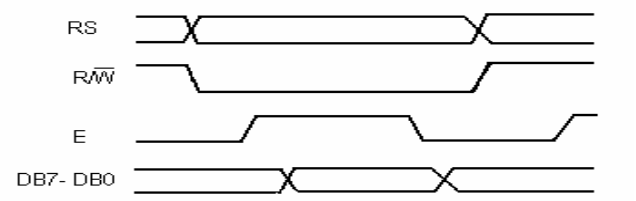

Figure- 2. Timing diagram of writing data to LCD

4. CALCULATION OF TAYLOR SERIES WITH PIC MICROCONTROLLER

A truncated Taylor series is a special case of a polynomial approximation to a function. It is well known that for polynomial approximation of any order of a function, better polynomials exist than the Taylor series.

The increasing number of the terms showed that it is a better approach to the function of sin(x). The trigonometric function sin(x) can be shown to be represented by the Taylor series expansion which is at the point of a=0 is called Maclaurin Series and it is showed as

$$\sum_{n=0}^{\infty} \frac{f^{(n)}(0)}{n!}x^n = f(0) + f'(0)x + \frac{f''(0)}{2!}x^2 + \frac{f^{(3)}(0)}{3!}x^3 + \ldots\ldots \quad (1)$$

The Taylor series, which is the more general case of the Maclaurin series, involves expanding about a point "a", instead of about zero as in the Maclaurin series [6]. The Taylor series for the function sin(x) is given by

$$\text{Sin(x)} = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)!} = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \ldots. \quad (2)$$

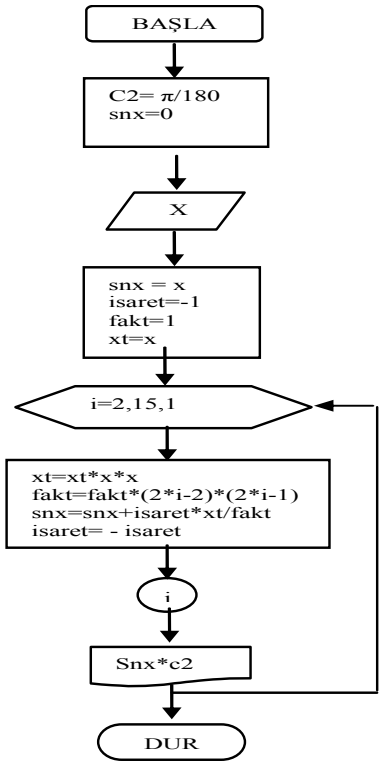

Figure 3. Flow chart subroutine and Pseudocode for the subroutine sin(x) function by the Taylor Series expansion (Algorithm for C language)

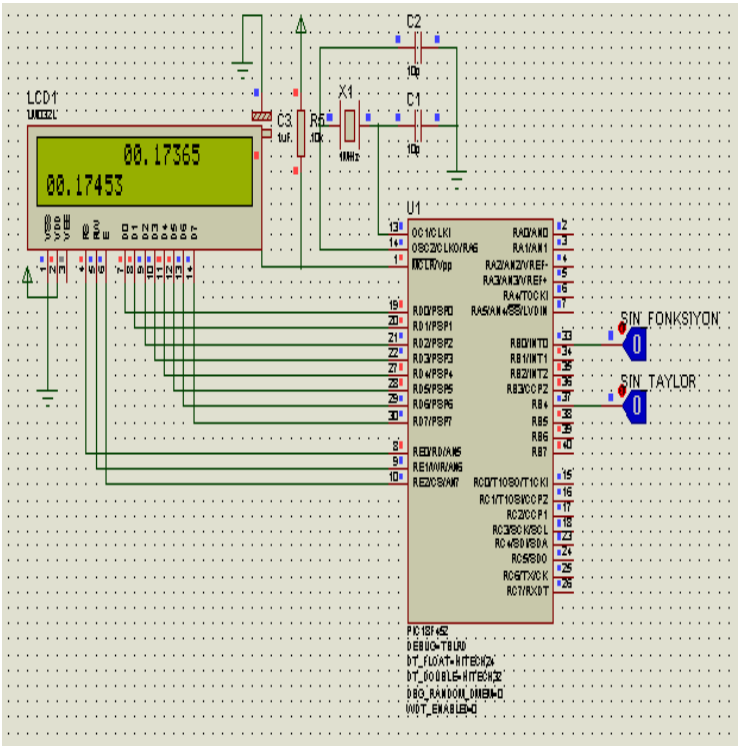

Figure 4. System block diagram

5. CONCLUSION

The industrial microcontrollers have limited resources to implement complex mathematical functions, such as Taylor series. In this work, implementation of Taylor series on a PIC microcontroller is given. In this study, the structures of PIC MCU and LCD programming are studied in details as course notes. With PIC micro controller that does not have a floating point as the CPU unit; it was demonstrated by software how the floating-point arithmetic is done.

Taylor series algorithm of the function of f(x) = Sinx for the point of a=0, is implemented on a PIC micro controller board. The increasing number of the terms has shown that it is a better approach to the function of sinx. The input of the function is done using the button connected to the PIC18F452's PORTB. At the same time, the input of the numbers can be demonstrated with the keypad module. The results of the functions are displayed at the 2x20 lines LCD display. In the demonstration of high value numbers, different results are obtained because of the insufficiency of data and program memory of PIC MCU.

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