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Remote Data Acquisition System Using PIC 18F4550 and USB Interface

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ABSTRACT

This whole working of this system can be divided into two parts. First part deals with designing, building and programming an USB device which can acquire the data from the sensor and stores this data in the data memory of the device, and in second part, by connecting this device to the PC or laptop and by reading the data memory of this device, the stored data can be retrieved. This USB device or system is PIC 18F4550 based. Sensors must be connected to this system in order to sense the data. This system is programmed to read analog data available at its input, convert this data into digital value and store this digital data into the data memory of the device PIC. This process is repeated after interval of 1 minute. This system can be installed at places, from where analog data is to be recorded. In second part, by connecting this system to the computer and by reading the data memory of the PIC device, the data can be made available whenever required.

Keywords: Data acquisition, Microcontroller, PIC 18F4550, Sensor, USB

I. INTRODUCTION

Data acquisition is very much necessary in almost all kind of research and technology, as well as in education [1]. Remote data acquisition systems are the need of today's world [2]. There are some inaccessible and remote areas from where manual data acquisition becomes difficult. Also, at certain situations, the data acquisition is required from one place and the acquired data is processed at some another place. So, the aim is to build such kind of system or device, that once it is installed, it can acquire the data on its own after certain interval and store this acquired data in its data memory. So, the data acquisition from remote places can be done. Also, this system should be such that, it can be easily installed, it should be low cost, it should be small in size, compact and robust, it should cause less power consumption and presence of this system shouldn't disturb the original conditions and surrounding from where data acquisition is to be done. Also, the output interface of this system should be

such as, it can easily be interfaced with any kind of PC or laptop in order to retrieve the data.

Now, the real world data like temperature, pressure, humidity, amount of rain fall, wind speed, etc., are in analog form. So this system is designed and programmed to acquire the analog data. After that, system converts this data into the digital value and stores this digital data into the data memory of the device.

The intelligent system that is used to acquire, process and store the data is PIC 18F4550. Microcontrollers like PIC are one of the most significant development miniaturization of electronic hardware [3] and it is affordable. Therefore, PIC is used for serving the purpose of remote data acquisition. PIC 18F4550 [4] is largest memory and pin count device of the PIC18F2455/2550/4455/4550 family. All of these devices implement power-saving nanoWatt Technology, Enhanced Flash Program Memory and features USB modules with USB 2.0 compliance. Along with this, it has built-in 10 bit ADC module. All these features of this PIC make it suitable for this system [4]. For the output interface of this system, USB port is chosen [5], because, USB port is available to any kind of PC or laptop. So this device can be easily interfaced to any PC or laptop through USB interface, in order to read the data stored in data memory of the device PIC 18F4550.

The PIC 18F4550 is pre-programmed once with a bootloader to make it capable for USB communication. The PIC-PG2 programmer is used to load bootloader on device PIC 18F4550. PIC-PG2 programmer is high voltage programmer based on JDM design. This programmer is connected to serial port, i.e., COM port of the PC. Hex file of user program is compiled by using standard compiler “MPLAB” [6] by “Microchip” and then, it is loaded on the PIC through USB interface. The Demo tool [7] provided by “Microchip” is used for reading, erasing and programming of the device.

This system is designed and programmed to record the remote analog data, to convert this data into digital form and to store this digital data in the Data EEPROM Memory of the device PIC 18F4550. This whole process is repeated after interval of 1 minute.

II. EXPERIMENTAL DETAILS

First of all, “PICPgm Development Programmer” application, “MPLAB IDE” compilar and “PICDEM(FS) USB Demo Tool” application are installed on PC or laptop on which all the testing of this system will be carried out. “PICDEM(FS) USB Demo Tool” application will be installed on PC or LAPTOP on which the acquired data reading procedure will be carried out. The PIC 18F4550 is pre-programmed once with a bootloader to make it capable for USB communication. The PIC-PG2 programmer is used to load bootloader on device PIC 18F4550. This programmer with PIC 18F4550 in socket, is connected to COM port of PC and through “PICPgm Development Programmer” software, the bootloader hex file is loaded on PIC 18F4550. After that, this PIC 18F4550 is ready for USB communication.

Fig. (1) shows circuit diagram of USB device using PIC 18F4550. This diagram represents USB is connected to PIC 18F4550. The PIC 18F4550 and USB both are powered with +5V dc power. Data lines, i.e., D+ and D- of USB are connected to data lines of PIC 18F4550. Required switches are connected to PIC 18F4550. Further, by connecting the sensor/sensors to this PIC 18F4550 and by loading appropriate program on this PIC, this device is used to acquire remote analog data.

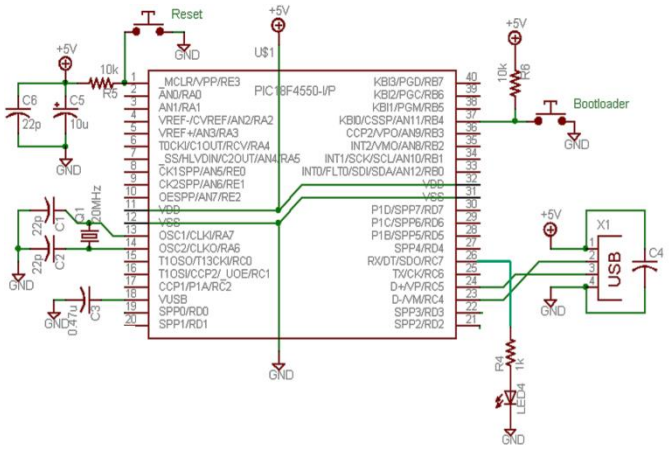

Fig. (1): Circuit diagram of USB device usinf PIC 18F4550

Fig. (2) shows the actual prototyping board of USB device using PIC 18F4550.

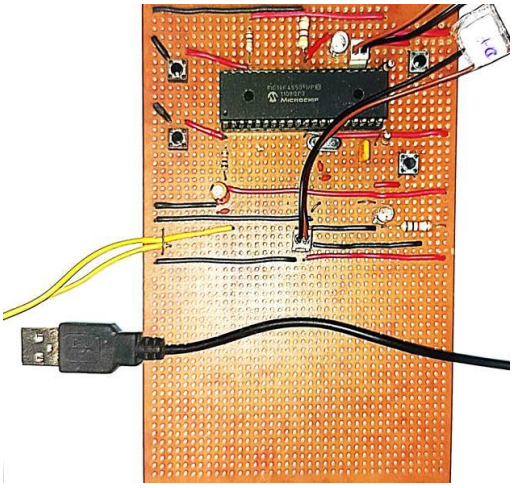

Fig. (2): Photograph of prototyping board of USB device using PIC 18F4550

After building up this USB device, this device is connected to USB port of PC. When the first time this device is connected to any PC, "Found New Hardware Wizard" window will be prompted on PC screen, which basically tells that, this connected USB device is a new type of device and PC will not recognize this device, till the driver installation for this device is done on that PC. In order to recognize this device by the PC, its driver must be installed on that PC. Once the driver installation on that PC is done, next time when this device is connected to the same PC, it will not ask for driver installation and PC will recognize this device.

A standard compiler "MPLAB" by "Microchip" is used to write system program to acquire analog data available at the input channel and to store this data in the data memory of the device. The program is written in assembly level language. After compiling a program, hex file of this program will be created by compiler.

"PICDEM(TM) FS USB Demo Tool" application by "Microchip" is used for reading, erasing and programming of the device. After loading a hex file of required program on this USB device through this application, this device can be used to acquire analog data and to store this data into its data memory.

The assembly language program to collect remote analog data and to store this data in data EEPROM memory of the device PIC18F4550 is divided in following three parts:

1. Timer Operation to generate suitable time delay between successive data acquisitions
2. Acquisition of analog data from sensors and conversion of this analog data to digital form
3. Writing the data in data EEPROM memory of the device PIC18F4550 in hexadecimal form

Following is the algorithm of assembly language program to acquire remote analog data, to convert it into digital form and to store this data in the data memory of this device - is as follows:

1. Configure port C of PIC 18F4550 as output port which is connected to indication LED and port A as input port which is connected to sensor which will acquire remote analog data. Also configure RA0 as analog input.
2. Clear Data EEPROM memory of PIC 18F4550.
3. Initialize "EEADR" register which will hold the memory address of certain location in Data EEPROM memory of device PIC 18F4550 and

"EEDATA" register which will require while writing data to Data EEPROM memory of PIC 18F4550. Only the data written "EEDATA" register will be written in Data EEPROM memory of device PIC 18F4550.

4. Do following ADC Configurations in order to acquire remote analog data:
   i. Select A/D input channel.
   ii. Select reference voltage source.
   iii. Select A/D acquisition time.
   iv. Select A/D conversion clock.
5. Enable all unmaskable interrupts.
6. Enable Timer2 interrupt.
7. Load three registers of PIC 18F4550 by appropriate timer counts and decrement these registers in order to get 1 minute time delay between two successive data acquisition events.
8. As Timer2 interrupt flag sets, it means required time delay has been implemented. After that, clear Timer2 interrupt flag.
9. Turn ON A/D module to acquire analog data available at the input channel of ADC and toggle the indicating LED.
10. Check if A/D conversion flag is set. If not, wait till A/D conversion is completed.
11. After A/D conversion is completed, disable all unmaskable interrupts.
12. Enable Data EEPROM Write interrupt. The result of A/D operation is stored in "ADRESH" (MSB) and "ADRESL" (LSB) registers. The result of this A/D operation is 10-bit. Copy the content of "ADRESL" register to the "EEDATA" register and then copy the content of "EEDATA" register to the address hold by "EEADR" register. Wait till memory write operation is completed by checking appropriate flag bit. If data is written, clear this flag bit. Then increment the content of "EEADR" register by 1 and copy the content of "ADRESH" register to the "EEDATA" register and then copy the content of "EEDATA" register to the address hold by "EEADR" register. Wait till memory write operation is completed by checking appropriate flag bit. If data is written, clear this flag bit. Then increment the content of "EEADR" register by 1, so the next byte from next data acquisition should be stored at next memory location. This data will be stored in data EEPROM memory of PIC 18F4550 in hexadecimal form.
13. Repeat steps 5 to 12, so that, this operation of data acquisition and writing data to the Data EEPROM memory of PIC 18F4550 will be repeated after suitable time interval.

The whole working of this system can be divided into two steps:

1. At remote place: This system connected with sensor/sensors is installed at remote place. It acquires the remote analog data, converts it into digital form and stores this data in data EEPROM memory of device PIC 18F4550. This is shown in Fig. (3).

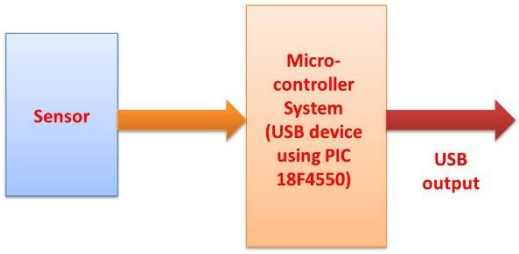

Fig. (3): Block diagram of system at remote place

2. At laboratory place: By connecting this USB device to laptop or PC, by reading data memory of device PIC 18F4550 through "PICDEM(FS) USB Demo Tool" application, the data can be retrieved. This is shown in Fig. (4).

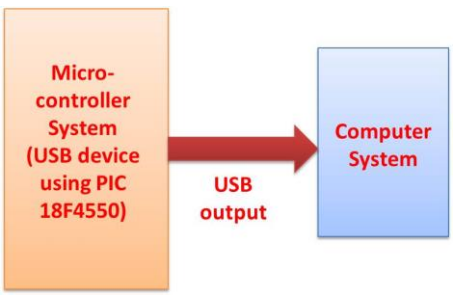

Fig. (4): Block diagram of system at laboratory place

The working of this system is tested for capacitor charging. The circuit diagram for series CR dc circuit is shown in Fig. (5). The system is made to record voltage across capacitor while charging.

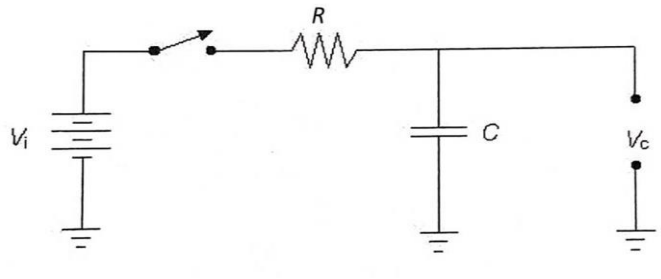

Fig. (5): Circuit diagram of series CR dc circuit

The capacitor is allowed to charge through serier CR dc circuit and the system is made to record voltage across capacitor after interval of 1 minute. Here, value of C is taken to be 1000 μF, value of R is taken to be 330 MΩ, supply voltage V_i = 5 V and V_c is the voltage across capacitor provided to pin 2/ RA0 of PIC 18F4550. The voltameter is also connected across C in order to collect analog data manually. According to assembly language program, whenever data acquisition step takes place, the indication LED is made to toggle. At the same time, the data on voltmeter, i.e., voltage across capacitor is recorded manually for the testing and verification of the system.

III.RESULTS AND ANALYSIS

Table (1) shows the manually recorded values of voltage across capacitor in volts. These values are recorded from dc voltmeter connected across capacitor in series CR dc circuit. The table also shows the digital readings in hexadecimal form recorded by PIC 18F4550. These are stored in data EEPROM memory of device PIC 18F4550. For verification purpose, these values are further converted into decimal form and then the corresponding analog value for this decimal value is obtained. This analog value represents voltage across capacitor in volts.

Table (1) : Time variation of voltage across capacitor recorded from voltmeter, Hexadecimal readings recorded by PIC 18F4550, Decimal equivalent for these readings, Analog values for these decimal readings

Time (min)	Voltage across capacitor measured by voltmeter in volts	Digital reading recorded by PIC 18F4550 in Hex form (x)	Decimal equivalent of x (y)	Analog value for (y) (Voltage across capacitor in volts)
0	0	0	0	0
1	0.1	0003	3	0.01468
2	0.84	00A9	169	0.82697
3	1.46	0127	295	1.443528
4	1.92	0187	391	1.913286
5	2.27	01CF	463	2.265605
6	2.54	0207	519	2.53963
7	2.75	0231	561	2.745149
8	2.9	0251	593	2.901735
9	3.03	026C	620	3.033855
10	3.12	027D	637	3.117041
11	3.19	028D	653	3.195334
12	3.25	0298	664	3.249161
13	3.3	029F	671	3.283414
14	3.34	02AD	685	3.35192
15	3.37	02AF	687	3.361707
16	3.4	02B8	696	3.405747
17	3.42	02BC	700	3.42532
18	3.44	02BF	703	3.44

Table (1) shows that, voltage across capacitor - recorded from voltmeter and recorded by PIC 18F4550 are well in agreement with one another. Fig. (5) shows the graphical variation of voltage across

capacitor - recorded from voltmeter and recorded by PIC 18F4550 - with time.

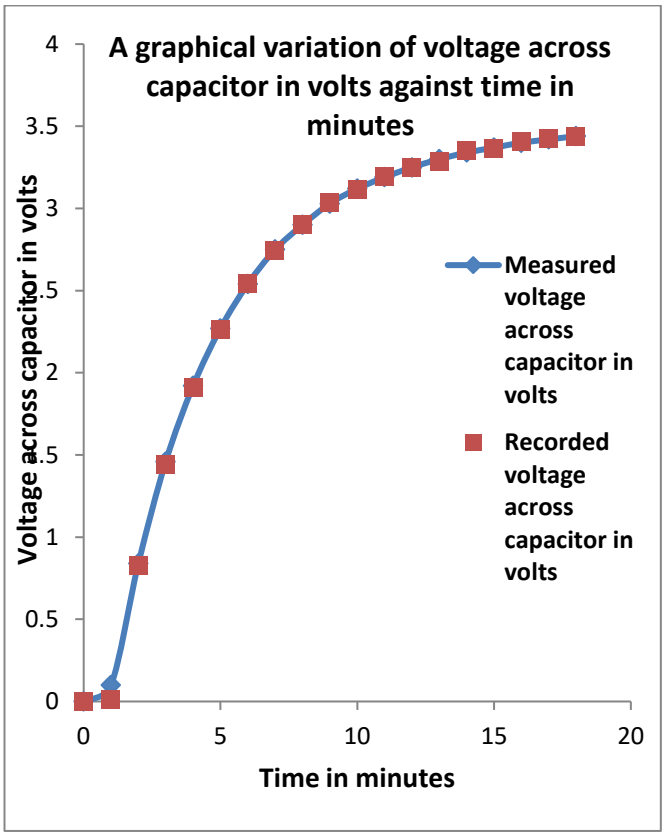

Fig. (5): Graphical variation of voltage across capacitor -recorded from voltmeter and recorded by PIC 18F4550 with time

IV. CONCLUSION

Microcontroller PIC 18F4550 is used for serving the purpose of remote data acquisition. The PIC 18F4550 is pre-programmed once with a bootloader to make it capable for USB communication.

Then, assembly language program to acquire remote analog data and to store this data in the data EEPROM memory of device PIC 18F4550 is compiled by using standard compilar "MPLAB" and hex file of this program is created. This hex file is loaded on PIC through USB interface.

This system is made to record voltage across capacitor in series CR dc circuit. These values are verified with voltage across capacitor manually recorded from voltmeter.

Thus, the system "Remote Data Acquisition System Using PIC 18F4550 and USB Interface" is designed, built, programmed and tested successfully.

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