EMBEDDED pH DATA ACQUISITION AND LOGGING

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ABSTRACT

The Accurate measurement and analysis of pH data is necessary for a multitude of applications ranging from agriculture sector to clinical laboratories. Preferably an inexpensive hand-held unit is needed for these applications. This paper presents the sensor data acquisition and data logging system including the details of its construction, capabilities and applications. PIC microcontroller has in-built ADC, which samples the output pH level measured by a pH meter.

KEYWORDS

Embedded System, MPLAB, PIC Microcontroller, pH meter, RTOS.

1. INTRODUCTION

The Hydrogen ion concentration in the solution is measured as pH. The pH scale ranges from 0 to 14. A solution with pH 7 is considered as neutral and with pH 0 as highly acidic and with pH 14 is considered as highly basic. Many important properties of a solution can be determined from accurate measurement of pH, including acidity of the solution and the extent of reaction in the solution [6]. pH is the most common of all analytical measurements in industrial processing and since it is a direct measure of acid content(H+), it clearly plays an important role in food processing Among the reasons for measuring pH include:

- To produce well defined properties products.
- To efficiently produce products at optimal cost.
- To avoid causing health problems to consumers
- To meet regulatory requirements.

Bringing the real-world signal, such as a voltage, into the computer, for processing, analysis, storage or other data manipulation is called as data acquisition. For small and simple application, microcontroller is the best choice because of its low cost. It makes the system small, inexpensive and easily deployable.

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Mathematical definition

The negative decimal logarithm of the hydrogen ion activity in a solution is represented as pH.

$$pH= -\log(aH+)= \log_{10}(1/aH+)$$

Where aH+ is the activity of hydrogen ions in units of mol/L (molar concentration) and activity is always less than the concentration. The activity coefficient for diluted solutions is a real number between 0 and 1 (for concentrated solutions may be greater than 1) and it depends on many parameters of a solution, such as nature of ion, ion force, temperature, etc. For a strong electrolyte, activity of an ion approaches its concentration in diluted solutions. Activity can be measured experimentally by means of an ion- selective electrode that responds, according to the Nernst equation, to hydrogen ion activity. A glass electrode connected to a milli-voltmeter with very high input impedance is used to measure the pH. It measures the potential difference, or electromotive force E, between an electrode sensitive to the hydrogen ion activity and a reference electrode, such as a calomel electrode or a silver chloride electrode. Usually a glass electrode is combined with the reference electrode and a temperature sensor in one body [13]. To get proper results, the electrode must be calibrated using standard solutions of known activity. The difference between the pH of solution X and the pH of the standard solution S depends only on the difference between two measured potentials. By measuring the potential with an electrode calibrated against one or more pH standards, we can get the pH value. We have to adjust the pH meter setting in such a way, that the meter reading for a solution of a standard is equal to the value pH(S).

1.1. Motivation

For many applications ranging from industrial operations to biological processes requires accurate measurement and analysis of pH is needed. Also these application demands a low power and low cost portable devices. Some of the prominent applications include,

Biochemistry: Our body chemistry controls our blood pH within few tenths of a pH unit. Serious illness will occur, if our blood pH changes as much as half a pH unit. Imbalance in skin pH will affect complexion and also proper pH of one’s stomach is essential for a good digestive process.

Agronomy: The availability of nutrients for plant, depend upon the pH content of soil as well as the activity of soil bacteria. It is necessary to have the Knowledge of the pH, through which we can determine the measures to ensure the health of plants.

Food Science: For producing a safe and high quality food, it is necessary to maintain a proper pH range during production and can be achieved by accurate monitoring of pH during food processing. To maintain the quality of food products, the knowledge of pH is needed.

In the Pulp and Paper Industries: For the proper operation of bleaching plants and wet-end processes, pH control is essential. The pH of wastewater from these plants must be controlled to protect our environment.

Chemical Research and Engineering: For the study of many chemical processes and chemical reactions, accurate pH measurement is necessary.

Environmental Research and Pollution Control: To maintain the proper ecological balance of the river or lake, the knowledge of pH is needed. If the ph of the water changes it affects the life of the plants and animals. For proper neutralization of plant wastes and to monitor the final effluent quality, the pH measurement is required.

1.2. Related Works

Various works are done by various research scholars on the pH data acquisition, some of them are as follows. Helena G. Ramos, P. GirZo, O.Postolache, M. Pereira, have developed a distributed water quality measurement system for measuring the quality of water which is much more helpful in the industrial areas for the preparation of the purified water and other medicinapH l appliances [7]. Misal, C.S.; Conrad, J.M.; have designed a pH data acquisition and logging system using a inexpensive microcontroller, but the data logging can be done only by using a external memory which may be difficult to manage[10]. Newberry. B, Cnrad. J.M, have given a data logging system which acted as a solution for the digital signal processors [15]. Tarchanidis, K.N. Lygouras, J.N. Pachidis, T. Kodogiannis, V. Chatziandreoglou, C.G, have made pH neutralizer which can be accessed through internet, even though it is very much useful for alarming situations and also suited to many other purposes, it has a main disadvantage that it cannot work without a proper authenticated internet connection [12]. Ali Ziya Alkar, *Member, IEEE*, and Mehmet Atif Karaca have made an Internet-Based Interactive Embedded Data-Acquisition System for Real-Time Applications, which gives an Embedded system for data acquisition, i.e., for measuring the required data from the specified systems that are connected with the controller. Byung Hwan Chu, B. S. Kang, C. Y. Chang, Fan Ren*, Fellow, IEEE*, Aik Goh, Andrew Sciullo, Wenhsing Wu, Jenshan Lin*, Fellow, IEEE*, B. P. Gila, Steve J. Pearton*, Fellow, IEEE*, J. W. Johnson, E. L. Piner, and Kevin J. Linthicumhave developed a wireless detection system for glucose and pH sensing in exhaled breath condensate by using various electron mobility transistors which helps in finding the dunkers and other medical patients who have low glucose content in their body.

1.3. Embedded System

An embedded system is a computer system designed to do one or a few dedicated and/or specific functions often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. Embedded software rules the entire hardware responds them in real time. If it fails to respond in time then the system produces false output or even damages the hardware. This is made even more difficult by the lack of resources available. In all embedded systems the tasks are categorized as low and high priority tasks. The high priority tasks pre-empts the low priority tasks such as UI in favor of high priority tasks like hardware control. By contrast, a general-purpose computer, such as a Personal Computer (PC), is designed to be flexible and to meet a wide range of end-user needs. Difference between computer and embedded system is shown in Table 1. Embedded systems control many devices in common use today.

The design engineers optimize the product size and cost and in turn increase the reliability and performance, since embedded system is designed to do a specific task. Some embedded systems are mass produced, benefiting from economies of scale [3]. The main difference between the embedded controller and a PC is that the embedded controller is dedicated to one specific task or set of tasks but a PC is designed to run many different programs and to connect many different external devices. An embedded controller has a single program and as a result, can be made cheaply to include just enough computing power and hardware to perform that dedicated task. A PC has a relatively expensive generalized processing unit as its heart and many other external devices. While designing an embedded system there are some challenges encountered due to the technological and temporal constraints. The constraints are like amount of hardware needed, minimizing the power consumption, meeting the deadlines, upgradability and reliability of the system.

1.4. RTOS Verses OS

A Real-Time Operating System (RTOS) is an OS for embedded system, which allows the system to respond to the real time interface within pre defined time. The real-time system response should be instantaneous since the deadline is too small. The main functions of RTOS are real time task-scheduling and interrupt-latency control. In a small scale embedded system, RTOS may not always be necessary. However, RTOS is necessary in case of scheduling multiple processes that provides perfection, correctness, protection and security features of any kernel in OS. The biggest difference is determinacy. An RTOS will have a deterministic scheduler. In a multi task scheduling, for any given set of tasks the process will always execute every number of microseconds or milliseconds exactly. There are various RTOS available and are pSOS, VRTX, VxWorks, LynxOS and so on. WindowsXP claims to have hard-real-time by use of process priorities. In an RTOS the designers have taken care to ensure that the response times are known but not in a general purpose OS. This is not as simple as it may sound. Modern general purpose operating system kernels are very large, with several million lines of code and are difficult to trace through them to find all the possible sources of delay in response. RTOS guarantying the response time more practical than the general purpose OS [6]. Real-time and embedded systems operate in constrained environments in which computer memory and processing power are limited. RTOS are strict in time deadlines to their users and to the surrounding world. Due to temporal and technological constraints in embedded system that dictates the use of real-time operating systems in embedded software.

Table1. Difference between Desktop computer and Embedded System

Desktop System	Embedded System
Runs different programs at different times depending upon the needs of the user.	Runs a single, dedicated application at all times.
Has large amounts of (RAM) memory and disk space, both can be readily and cheaply expanded if required.	Has sufficient memory, but no excess; adding more is difficult or impossible.

All PCs have essential identical hardware architecture and run identical system software is written for speed.	Embedded systems are highly variable, with different CPUs, peripherals, operating systems and design priorities.
Boot up time may be measured in minutes as the OS is loaded from disk and initiated.	Boot up time is almost instantaneous measured in seconds.

The system response time get affected by the deliberate design decision because of the difficulties in predicting response time of the system for a user interface. A real-time operating system (RTOS) is an operating system (OS) intended to serve real-time application requests. A key characteristic of a RTOS is the level of its consistency concerning the amount of time it takes to accept and complete an application's task. A real-time system is classified as hard real-time system and soft real time system. If the system fails to meet its deadline then it endangers the human lives, this system is represented as hard real-time system. The soft real-time system is a system which produces false output whenever it fails to meet the dead line. The chief design goal is not high throughput, but rather a guarantee of a soft or hard [9].

- The RTOS (Real Time Operating System) requires only the basic functionalities of the OS which are needed for the specific application.
- The RTOS differ from other desktop OS by taking the control of application.
- The main characteristic RTOS is its defined response time to the external stimuli.

2. HARDWARE DESCRIPTION

The proposed system consists of PIC microcontroller with in-built ADC, pH meter, LCD display, Amplifier, PC and a power supply circuit. The power supply circuit built using filters, rectifiers, and then voltage regulators. Starting with a voltage, a steady DC (direct current) voltage is obtained by rectifying the AC (alternating current) voltage, then filtering to a DC level, and finally, regulating to obtain a desired fixed DC voltage. A step down transformer connected with AC voltage typically 220v RMS, steps down to the level of the desired DC output. A full-wave rectified Voltage is provided by the diode rectifier that is initially filtered by a simple capacitor filter to produce a DC voltage since the resulting DC voltage usually has some ripple or AC voltage variation. Block diagram of the proposed system is shown in figure 1.

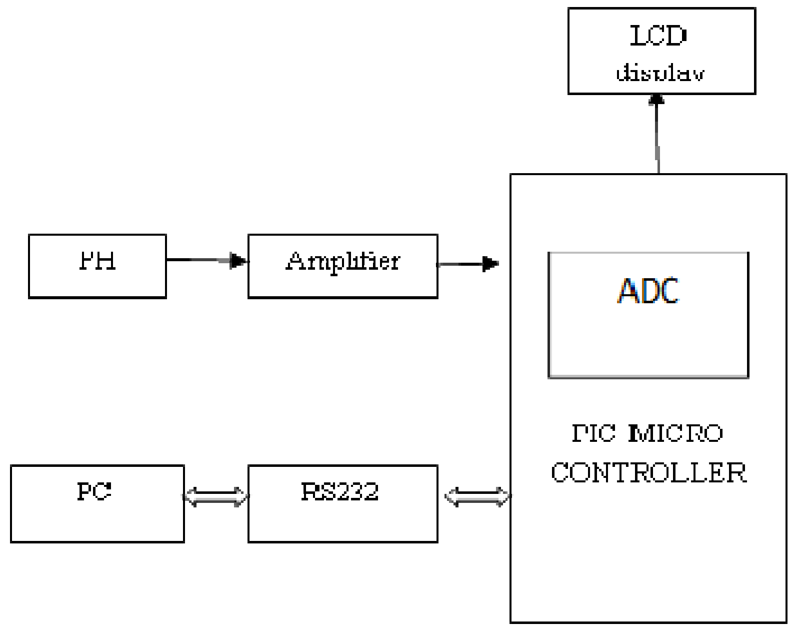


Figure 1: Block diagram of the proposed system

2.1. pH Meter

A pH meter is an electronic instrument used for measuring the pH (acidity or alkalinity) of a liquid (though special probes are sometimes used to measure the pH of semi-solid substances). A typical pH meter consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading. The pH level is measured by using the pH electrode. Depending on the pH level in the water it generates the corresponding voltage signal. This voltage signal is in the range of mV, so it is amplified by the operational amplifier. The amplifier is constructed by the OP07 operational amplifier. Then the amplified signal is given to inverting input terminal of the operational amplifier. The amplifier is constructed by LF356 operational amplifier. Then the +12v to -12V reference signal is generated by the pair diodes D1 and D2 which is given to non-inverting input terminal. Then the output signal is given to filter section in which the noise in the output is filtered. The filter section is constructed by the LM324 operational amplifier and the capacitor C1 and C2. Then the noise free signal is given to the comparator in which the pH level is compared with the reference level then the final voltage given to gain amplifier in which the variable resistor is connected in the feedback path. Then the final gain voltage is given to related circuit in order to find the pH level in the water or solution [13].

2.1.2. pH Measurement

The measurement of pH requires a pH meter, which includes a measuring electrode (pH) electrode and a reference electrode. The pH sensor components are usually combined in to one device, which is called as a combination pH electrode. A successful pH measurement can only be achieved by choosing the correct system to meet the demands of the sample under examination. For a precise and continuous measurement of pH in a solution, a pH meter is always recommended. For the optimal pH measurement the criteria's like, chemical composition, homogeneity, temperature, pH range and the container size must be considered. Depending on the continued maintenance of the pH electrode, experimental conditions and state of the sample will provide the accuracy of pH. A pH meter has a battery in which the positive terminal is the measuring electrode (pH electrode) and the negative terminal is the reference electrode. The pH electrode develops a voltage directly related to the hydrogen ion concentration of the solution, which is highly sensitive to hydrogen ion. A stable potential (voltage) is generated by the reference electrode against the measuring electrode. The measurement of pH in a aqueous solution can be made by immersing the pH meter in that solution. The potential of the reference electrode does not change with the changing hydrogen ion concentration. But the measuring electrode potential changes with the temperature and therefore a temperature sensor is necessary to correct this change in the output. The measuring electrode is usually a glass electrode but now-a-days it is replaced with solid-state sensors.

2.1.3. Temperature Compensation

The pH electrode and measurements are temperature sensitive and can be compensated either manually or automatically. The temperature affects the pH measurement in two ways. One is, if a solution temperature changes then the pH value also gets changed. The other one is due to glass electrode resistance that is the glass electrode is an ionic conductor. If the solution temperature changes then the resistance of the glass will also be change. That is increase in solution temperature, decreases the resistance across the glass bulb. The theoretical ph of a solution is assumed as a constant, the changing electrode resistance will incorrectly affect the pH reading, which requires the use of temperature compensation in the measurement circuit. Automatic Temperature Compensation (ATC) is generally used in laboratories, except when both calibration and pH measurement occur at a constant temperature.

2.1.4. Buffer Solutions

A buffer solution is an aqueous solution in which the pH remains unchanged when small amounts of acid or base are added. It is either a mixture of weak acid and its conjugate bases or a mixture of weak base and its conjugate acid. It has the property that will not readily allow a change in pH value when being neutralized or changed by dilution. Buffers are solutions that have nearly constant pH value in a wide variety of chemical applications and ability to resist the changes in that pH level.

2.2. PIC Microcontroller

PIC is referred as "Peripheral Interface Controller" a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. PIC microcontrollers are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability. In the several flavors the one used here is the 16F877 PIC. The Architecture of PIC microcontroller is shown in figure 2.

2.3. PIC Features

2.3.1. High performance RISC CPU

- Only 35 single word instructions to learn.
- All single cycle instructions except for program Branches which are two cycle.
- Operating speed: 20MHz clock input,200 ns instruction cycle.
- Up to 8k x 14 words of FLASH program memory, up to 368 x 8 bytes of Data memory (RAM). Wide operating voltage range:2.0V to 5.5V

2.3.2. Peripheral Features

- Timer0: 8-bit timer/counter with 8-bit prescaler.
- Timer1: 16-bit timer/counter with prescaler,can be incremented during SLEEP mode.
- Timer2: 8-bit period register, prescaler and postscaler

2.3.3. Analog Features

- 10-bit, up to 8-channel Analog-to- Digital Convertor (A/D)
- Brownout Reset (BOR)
- Analog Comparator module with:
    - Two analog comparators.
    - Programmable on-chip voltage reference (VREF0 module.
    - Comparator outputs are externally accessible.

2.3.4. Special Micro Features

- 1,000,000-erase/write cycle Data EEPROM memory typical.
- Data EEPROM retention > 40 years
- Self-re-Programming under software control
- In-circuit Serial Programming (ICP) via two pins
- Watchdog Timer (WDT0 with its own on-chip RC oscillator for reliable operation.
- Programmable code protection
- Selectable saving sleep mode
- Selected oscillator options
- In-circuit Debug (ICD) via two pins

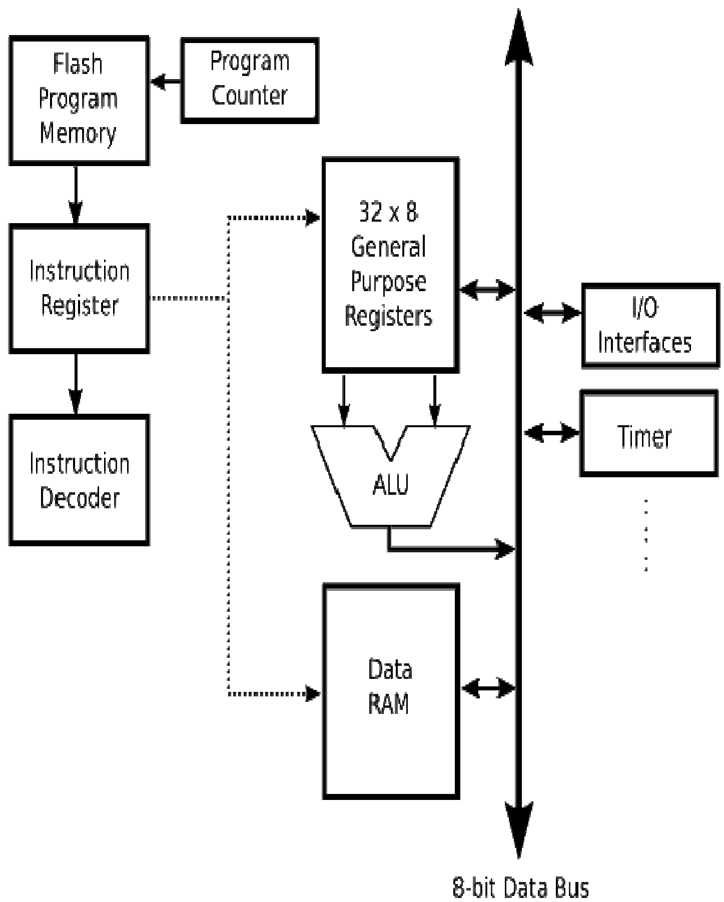


Figure 2: Architecture of PIC Microcontroller

2.3.5. Cross Compilation

A cross compiler is a compiler that runs on the host system but produces binary instructions suitable for the target system. That is machine on which we are compiling the software cannot natively run the software it compiles and the software is compiled for another processor. This is one of the first challenges of cross-compiling. Some people prefer native compiling to avoid the challenges of cross-compiling, but it is very slow and hence it cannot be preferred. Some programs may need to run during the compiling process which then of course crashes the build process. Cross-compilation tools commonly have their target architecture as prefix of their name. Cross compiler tools are used to generate executable for embedded system or multiple platforms. These tools used to compile for a platform upon which it is not feasible to do the compiling, like microcontrollers that do not support an operating system. In this embedded computers where a device has extremely limited resources. The main difference between the Native and the Cross Compiler is that the Native compiler is the compiler that is used in a PC, and the Cross Compiler is the one that is used to compile an object code in an embedded system. Cross assemblers and cross compilers generate executable code to be placed in ROM, EPROM, EEPROM, or flash memory of a PIC-based product.

2.3.6. Programming the PIC

step1: Click the Start Menu and select the MPLAB IDE from the program Menu and a window will be opened.
step2: Click Project→ new project (a window will be opened)
step3: Enter the PROJECT NAME, PROJECT DIRECTORY where the program to be stored in the corresponding fields and clicks ok.
step4: Click Configure→ Select device (a window will be opened)
step5: Select the device name as PIC16f877 and click ok
step6: Click project→ set language tool locations
step7: Expend CCS C compiler for PIC12/114/16/18 in line displayed window. Further expand the executable and select the CCS C compiler (CCSC.exe) and click ok.
step8: Click Project→set language suits
step9: Select CCS C compiler for PIC12/14/16/18 in the active tool suite and click ok
step10: Click file→ new file. Now type the corresponding program and save it as <filename.c> in the corresponding location where the project name is denoted.
step11: Click project→ add file to the project
(Select the saved file and click open)
step12: Click project→ build option→ project (an window will be opened)
step13: Select CCS C compiler in the window, click none in the debug option, tick the use alternate settings and enter +p in the space provided and click ok.
step14: Click Project→ build all the CCS C-compiler will denote the result if any errors indicated, go to step 10 else continue.
step15: Click Start menu and select the PIC ISP from the program menu and a window will be opened.

2.4. Three terminal voltage regulator

Figure 3 shows the basic connection of a three-terminal voltage regulator IC to a load. The fixed voltage regulator has an un regulated DC input voltage, Vi is applied to one input terminal, a regulated output DC voltage, Vo coming out from the second terminal, with the third terminal connected to the ground. For a selected regulator, IC device specifications list a voltage range of load current. The specifications also list the amount of output voltage change resulting from a change in load current (load regulation) or in input voltage (line regulation).The fixed regulated voltages from 5 to 24V is usually provided by 78 series regulators. Figure 3 shows the connections of fixed positive voltage regulators.

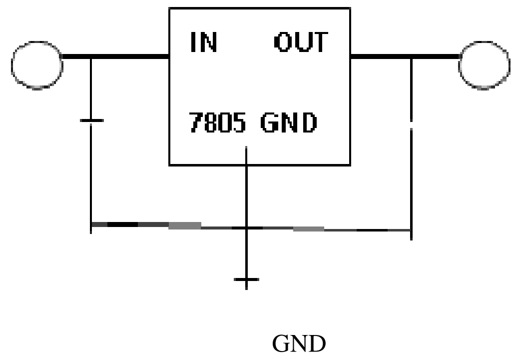


Figure 3: Fixed positive voltage regulators

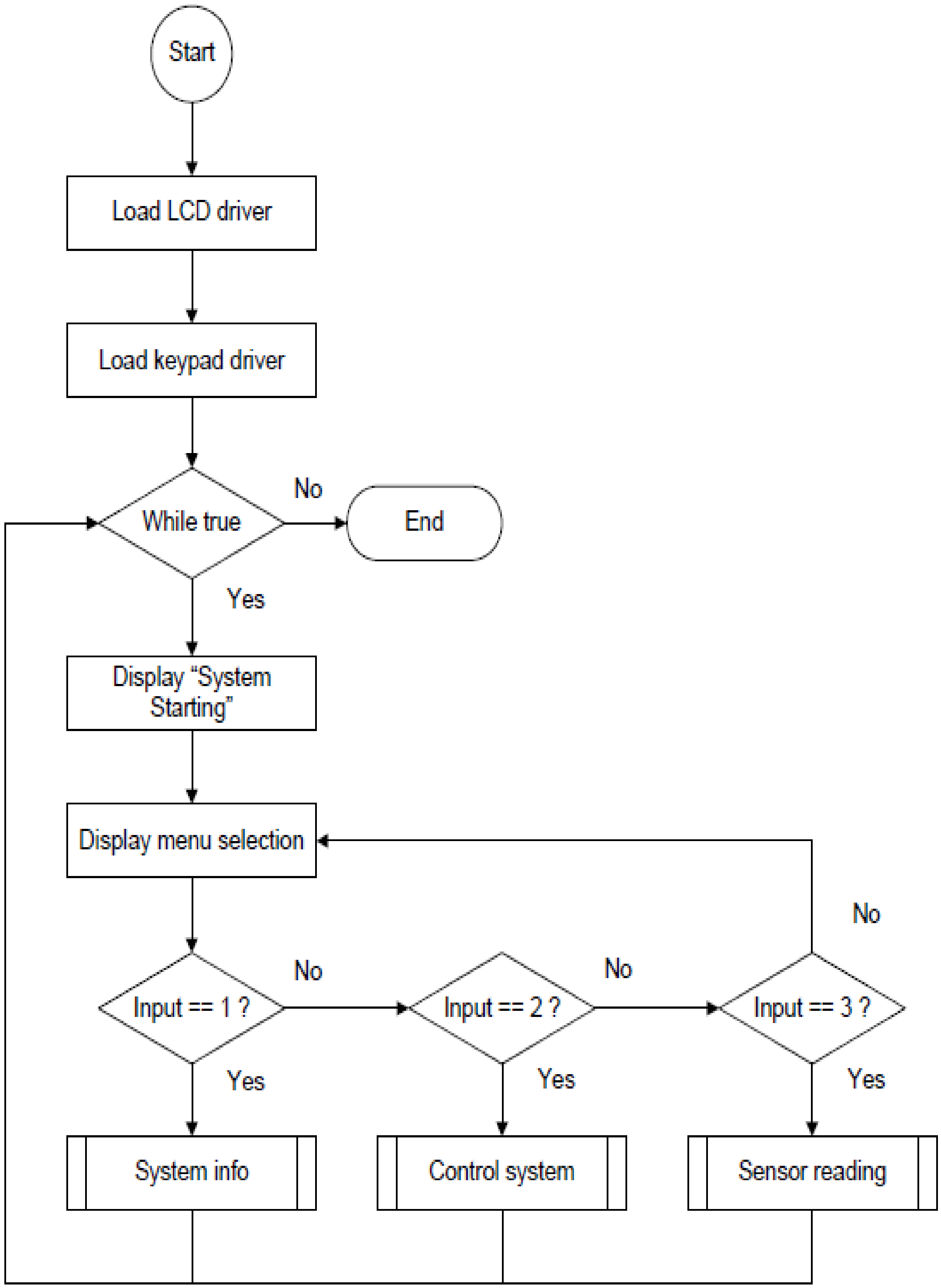
2.5. Liquid Crystal Display

Liquid Crystal Displays (LCD) have materials, which combine the properties of both liquids and crystals. LCD is a flat electronic visual display. Light modulating properties of liquid crystals are being used for the video display in the LCD. An LCD consists of two glass panels, with the liquid crystal materials sand witched between them LCD are more reliable and energy efficient. Its low power energy consumption makes it to be used in battery powered electronic devices. LCD consists of array of small pixels. Each pixel of an LCD consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axis of transmission is perpendicular to each other. With no actual liquid crystal between the polarizing filters, light passing through the first filter would be blocked by the second (crossed) polarizer. The Liquid Crystal Display is intrinsically a passive device it is a simple light valve. The managing and control of the data to be displayed is performed by one or more circuits commonly denoted as LCD drivers. LCD with top polarizer removed from device and placed on top, such that the top and bottom polarizer are parallel.

2.6. RS232 Communication

Serial communication is basically the transmission or reception of one bit data at a time. The RS232 (Recommended Standard 232) standard supports both synchronous and synchronous transmission as full duplex. This standard defines the voltage levels that correspond to one and logical zero levels for the data transmission. It is commonly used in computer serial ports. The serial port contains a electronic chip that actually does the conversion of each byte to a stream of ones and zeros and vice versa. That chip is called as Universal asynchronous Receiver/Transmitter (USART). The RS232 device is classified as Data Terminal Equipment (DTE) or Data Communication Equipment (DCE). The device that connects to the RS232 interface is called as a DCE and the device to which it connects is called as DTE. The RS232 is used to create data link between Microcontroller Unit (MCU) based projects and standard PC. An RS232 serial port can communicate to some embedded systems such as routers as an alternative to network mode of monitoring. In the embedded system, if the device communicates at TTL (Transistor to Transistor Logic) level, the connection between the embedded system and external device is simple. But if the device needs RS232 level signaling, and then it needs to insert a RS232 line Driver/Receiver between the processor and the device. Now a days most of the devices need three wires, that is transmit data, receive data and Signal ground. The hardware flow control signal is not necessary; this simplifies the hardware connection as well as the software design.

3. Flow Chart


Start
Load LCD driver
Load keypad driver
While true
No
End
Yes
Display "System Starting"
Display menu selection
Input == 1 ?
No
Yes
Input == 2 ?
No
Yes
Input == 3 ?
No
Yes
System info
Control system
Sensor reading

4. DATALOGGING

Computer data logging is the process of recording events, with an automated computer program, in a certain scope in order to provide an audit trail that can be used to understand the activity of the system and to diagnose the problems. Logs are essential for understanding the activities of complex systems particularly in the case of applications with little user interaction such as server applications. It can also be useful to combine log file entries from multiple sources. This approach, in combination with statistical analysis, may yield correlations between seemingly unrelated events on different servers. Other solutions employ network-wide querying and reporting. Many operating systems and multitudinous computer programs include some form of logging subsystem. The system we presented here takes the logged pH data over the time and also takes the preventive measures for the specific function required.

5. SOFTWARE DESIGN

5.1. Embedded Software Development

Software development plays an important role in the electronics background. Embedded software's principal role is not Information technology, but rather the interaction with the physical world. It is mainly written for the electronics computers. Embedded software is 'built in' to the electronics in cars, telephones, audio equipment, robots, home appliances, toys, security systems, pacemakers, televisions and digital watches. This software can become very sophisticated in applications like aircrafts, missiles, process control systems, and so on. In embedded system we are dealing with two things, embedded software and non embedded software, both are totally different. In embedded software development the development architecture is totally different from the target system and also the hardware and the software both are developed simultaneously for the target system. There may be real-time constraints which are likely to be threading issues. Typical human-computer interfaces are not used. There may be resource constraints such as limited memory space or processing power.

The Embedded software development steps are shown in figure 4. The Embedded software is actually written, complied, assembled, linked, debugged and tested at the host system. Then the software is downloaded in to the PIC microcontroller using the PIC programmer. The PIC programmer is connected with the host system through the RS232 serial port communication. The PIC microcontroller is removed from the PIC programmer socket and then the microcontroller is placed in to the embedded target system. The Embedded software development and testing were usually done at the host system rather than the target system, since the target system may not have a keyboard, screen, disk drive and the other peripherals necessary for programming. The embedded computing machines make their design more difficult due to complex testing, limited observability and controllability and also with restricted development environments

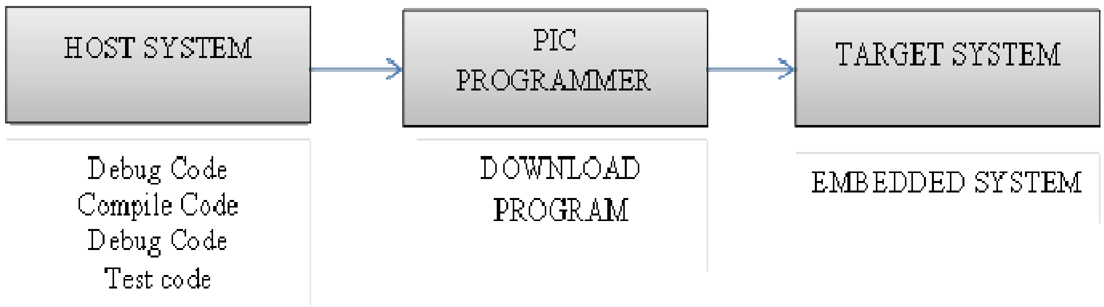


Figure 4: Embedded Software Development

5.2. PIC programmer

A PIC programmer is a circuit which interfaces the PC to the microcontroller using the PC's different port. It can read and write the data and converts the digital logic levels from the PC to suitable logic levels for the microcontroller. For high and low volt programming of a PIC microcontroller 13.5 (MAX) voltages at the MCLR pin is needed. As the voltages from the parallel port and the serial port are not that much high so the 13.5 volt level complicates the interface circuit. To generate the higher voltage usually programmer requires the external source because of the nominal digital logic level is 5v. Among the three ports serial ports generates the higher voltage and this fact used by the JDM PIC programmers. All PIC programmers work the same way (except the boot loader) they generate a serial data stream using two signal lines clock and data. Another pin controls the programming voltage and others two assigned to power and ground. The program running on the PC (the programming software) takes the hex file generated from the compiler and translating it into a serial data stream. This is routed to the programmer through the correct interface (Serial, Parallel or USB). After all the data is sent, a serial configuration word is sent, the microcontroller is programmed and ready for use.

5.2.1. PRO MATE II PIC programmer

The PRO MATE II is a microchip which is a microcontroller device programmer. PRO MATE II interchangeable programming socket module provides the easy program of the microchip PIC microcontroller devices and many of the memory parts. High level language like C will be converted into PIC micro MCU machine code by a compiler and some time machine code is also suitable for the PIC microchip development products like MPLAB IDE. The PRO MATE II device programmer is easy to use and operates either as a stand-alone unit or in conjunction with a PC-compatible host system. When connected to a host system, PRO MATE II provides an exceptionally user-friendly interface to give the developer complete control over the programming session. This time-saving tool comes complete with all the accessories needed to connect to a host system, including interface cables and a universal input power supply. In the programmer unit, PROMATE II system contains MPLAB and IDE with built in editor as well as assembler and window based MPLAB-SIM simulator. PRO MATE II is CE compliant, meaning it meets or exceeds all the directives for safety, emissions, electrostatic discharge (ESD) and susceptibility (to radiated emission) requirement. The PRO MATE II device programmer is designed to be robust and reliable, with enhanced socket module alignment with four auto alignment pins, three levels of over current protection and superior ESD immunity for rugged environments, a small and compact universal IEC power supply, and improved LCD display and buttons.

5.2.2. Features

- Programs EPROM and/or EEPROM program and data memory for all Microchip PIC microcontroller MCU's, HCS Security Products, and 2- and 3-wire serial EEPROM products.
- It deals with the three operating modes namely
  Host Mode
  Safe Mode
  Stand alone Mode.
- The object files can be automatically downloaded in to the PRO MATE II with the help of the MPLAB project manager.
- MPASM Assembler translates assembler source code to object code for all PIC microcontroller MCU devices.
- Windows based simulator MPLAB-SIM designed to model operation of all PIC microcontroller MCU'S
- Indexed on-line help.
- Supports the serial programming mode in PIC microcontroller MCU's.

5.2.3. PICSTART plus Programmer

PICSTART Plus is a microchip microcontroller development programmer, which enables us to program the user software in to PIC microcontroller devices and is integrated in to the MPLAB IDE. The PICSTART plus development system requires connecting the hardware to the PC and the installation of the MPLAB IDE software. PICSTART plus development programmer has the following features,

- Communicates with the PC via a standard RS-232 cable.
- With MPLAB IDE, the user can create, display and edit data to be programmed in to PIC microcontrollers.
- Reads and verifies all programs in program memory and also verifies data memory.
- Reads, programs, verifies all configuration bits.
- Programs and verifies an address range.
- MPLAB project supports automatically download the object files to PICSTART Plus.

5.3. MPLAB

MPLAB IDE is an integrated development environment that provides development engineers with the flexibility to develop and debug firmware for various microchip devices. MPLAB IDE is a window-based integrated development environment for the microchip technology incorporated PIC microcontroller (MCU) and dsPIC digital signal controller (DSC) families. In the MPLAB IDE it is possible to create, assemble, compile and link various language tools. We also debug the executable logic and make timing measurements. MPLAB SIM is a discrete-event simulator for the PIC microcontroller (MCU) families. It is integrated into MPLAB IDE integrated development environment. The MPLAB SIM debugging tool is designed to model operation of microchip technology's PIC microcontrollers to assist users in debugging software for these devices. It is a software program that runs on a pc to develop application for microcontrollers. It provides a single integrated "environment" to develop a code for embedded microcontrollers and hence it is called as an Integrated Development Environment (IDE).

A development system for embedded controller is a system of program running on a desktop PC to write, edit, debug and program code- the intelligence of embedded system applications into a microcontroller. MPLAB IDE runs on a PC and contains all the components needed to design and deploy embedded systems applications. A typical task for developing an embedded controller application is to create the high level design. The desired PIC or dsPIC is selected for the application, based on its features and performance and then the associated hardware circuitry is designed. After determining which peripherals and pins control the hardware, write the firmware-the software that will control the hardware aspects of the embedded applications. A language tools such as assembler or compiler is used to convert the source code in to its object code. Assemblers and compilers make the code indestructible, allowing function labels to identify the code routines with variables. The variables have names associated with their use that helps to organize the code in a maintainable structure.

5.3.1. MPLAB Features and Installation

MPLAB IDE is a Windows OS based Integrated Development Environment for the PIC micro MCU families and the dsPIC Digital Signal Controllers. The MPLAB IDE provides the ability to

- Create and edit source code using built-in editor.
- Assemble, compile and link source code.
- Fix the bug by watching program flow with the built-in simulator.
- Perform timing measurements with the help of simulator or emulator.
- View variables in watch windows.
- Program firmware into devices with device programmers.

6.IMPLEMENTATION AND TESTING

6.1. System Design

The pH value of any liquid can be measured accurately using this system. When the pH system is inserted into the solution sample, the microcontroller gets the input from the sensor and pH value of the liquid is ascertained. The pH value is displayed in the LCD module. A LCD display which is present in the testing kit makes it handy and portable. The pH value is logged in the system through a RS-232 cable. The system is designed in such a way that, the pH sensor module can be tested and the results are displayed in the LCD module without logging the result in PC. Prototype of the developed system is shown in figure 5.

6.2 User Interface Design And Testing

The results are logged in the system only when user wishes to log them. User interface is done by using the “REPORT” Button. The user has two windows. The first window is for testing, which displays the pH value of the solution being tested with system’s date and time. This contain details of the comport connection, where the RS-232 cable is connected in set in this window. When the comport number is entered, the system starts reading from that comport. The second window provides a “SEARCH DATE” option to browse through the data accumulated over a period time. To search the result observed on a particular data, the date is entered in a communication window, which opens upon clicking the “SEARCH DATE” button.

7.pH Sensing for various solutions

Table 2: Sensed values of various solutions

Solution	**Normal Value**	**Sensed Value**
Ground water	6.0-8.5	7.6
Milk	6.3-6.6	6.1
Glucose	7.0	6.8

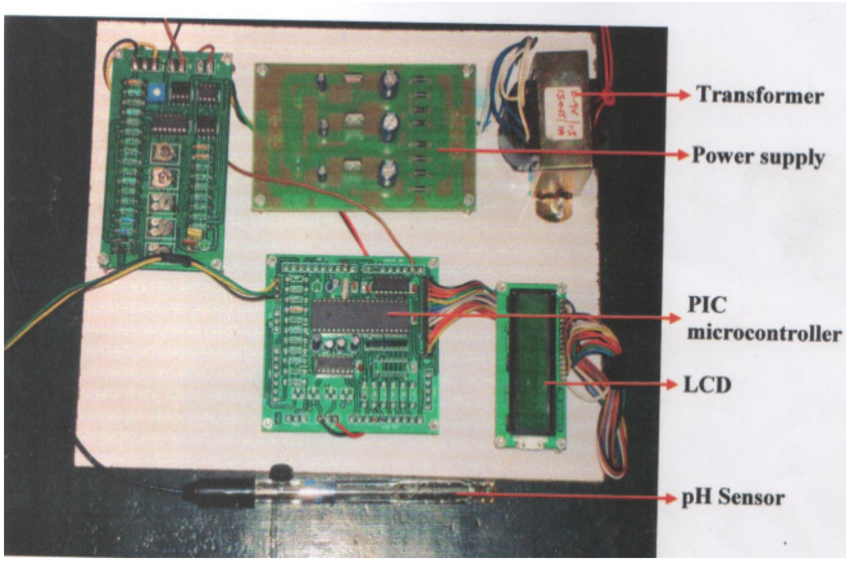


Fig 5: Prototype of the developed system

8.CONCLUSION

The data acquisition and data logging technique for the analysis and data sharing purpose has been successfully implemented. The low cost signal conditioning circuit was designed using inexpensive components and without external memory by utilizing on-chip and unused flash memory. Timers have been used to trigger the pH sensing and processing of the data versus polling for the same operation, which ultimately results in reduction in power consumption. By the introduction of the sleep modes in the microcontroller the efficiency of the device can be extended. Also by monitoring the variation in sensor output voltage with respect to changes in environment temperatures the accuracy can be increased.

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