Design and Development of Microcontroller Based Digital pH Meter

M. A. A. Mashud, M. A. Masud, Md. Serajul Islam

Abstract— A Microcontroller based digital pH meter was designed and developed to measure the value of pH (acidity or alkalinity) for any type of solution. Two op-amps of high input impedance and low output impedance were used to design the pH meter: one is used as a buffer and the other as a summing amplifier. The output of the summing amplifier is connected to the microcontroller as an input. The pH value of a solution microcontroller provides the output value. A microcontroller PIC12F675 was used to control the developed system's function. A C language program was developed to control the function of the microcontroller, using the PCWH Compiler. The output of the microcontroller is displayed as a pH value that ranges from 0.0 to 14.0 in the three seven segment display.

Keywords— microcontroller, PCWH, Ulcer, Gastric, pH probes, clinic, patients.

1 INTRODUCTION

A pH meter is an electronic instrument that measures a liquid's pH. A typical pH meter consists of a special measuring probe (a glass electrode) [1] which is connected to an electronic meter that measures and displays the pH reading. Typical applications include ulcer and gastric tests in clinics, purification of drinking water, manufacturing of sugar, pharmaceuticals and cosmetics industries, effluent treatment plants, dyes and chemicals plants, biotechnology laboratory, electroplating centers, food and beverage industries, circuit board etching laboratories, flue gas scrubbers, boilers and cooling towers, pulp and paper manufacturing industries and fermentation (wine, beer, alcohol) centers.

A pH meter measuring the gastric of patients is explained in D. Meiners et.al [2]. S.J. Taylor et.al [3] explains how to test a pH for a nasogastric tube. For improved performance, pH probes are used to measure the intragastric of patients, which is explained in R.L. Levine et.al [4] and A. Baghaie et.al [5]. However the above systems are quite costly and complex and involve fabrication processes.

This paper's objective is to develop a typical pH meter, which is a microcontroller based digital pH meter. The output of the microcontroller is displayed as a pH value by the seven segment display throughout BCD to the seven segment decoder. The pH probe technique for intragastric pH measurement appears to be straightforward in a technical sense and it is applicable for patients at risk of stress ulcer bleeding.

2 DESIGN

The system is divided into six parts: the low voltage power supply, sensor circuit, buffer amplifier, summing amplifier, microcontroller unit and display circuit. Low voltage power supply produces 5 volts for the buffer amplifier circuit, summing amplifier and microcontroller. The signal from pH electrode goes to the buffer amplifier circuit. The amplified signal is the input of the summing amplifier, which goes to the microcontroller. The output of the microcontroller operates the display circuit. The block diagram and the complete circuit diagram of the developed system are shown in Figure 1 and Figure 2 respectively.

2.1 Low voltage power supply

The microcontroller, BCD to seven segment decoder and other electronic components are used in designing the complete pH meter, and require a dc voltage (+5v & -5v). A highly stable regulated dc power supply was designed for this purpose. The complete circuit of a regulated dc power supply is shown in Fig 2, using IC1 and IC2 as a voltage-regulating device [6]. It contains four diodes, D1, D2, D3 and D4, which are connected to the a.c. supply [7] for +5V. Similarly, D5, D6, D7 and D8 are connected to the a.c. supply for -5V.

2.2 Buffer Amplifier

The buffer amplifier [8] circuit consists of IC3 and VR1. The signal from the pH electrode is connected to pin 3 of IC3. VR1 is connected between pin 1and 5 for a null setting.

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Manuscript received on 30 July 2011 and accepted for publication on 31 October 2011.

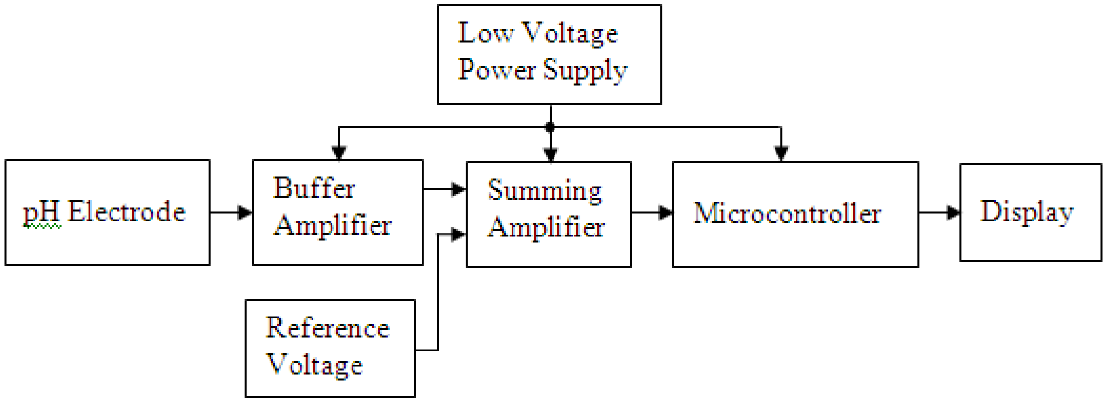

Figure 1: Block diagram of the developed system

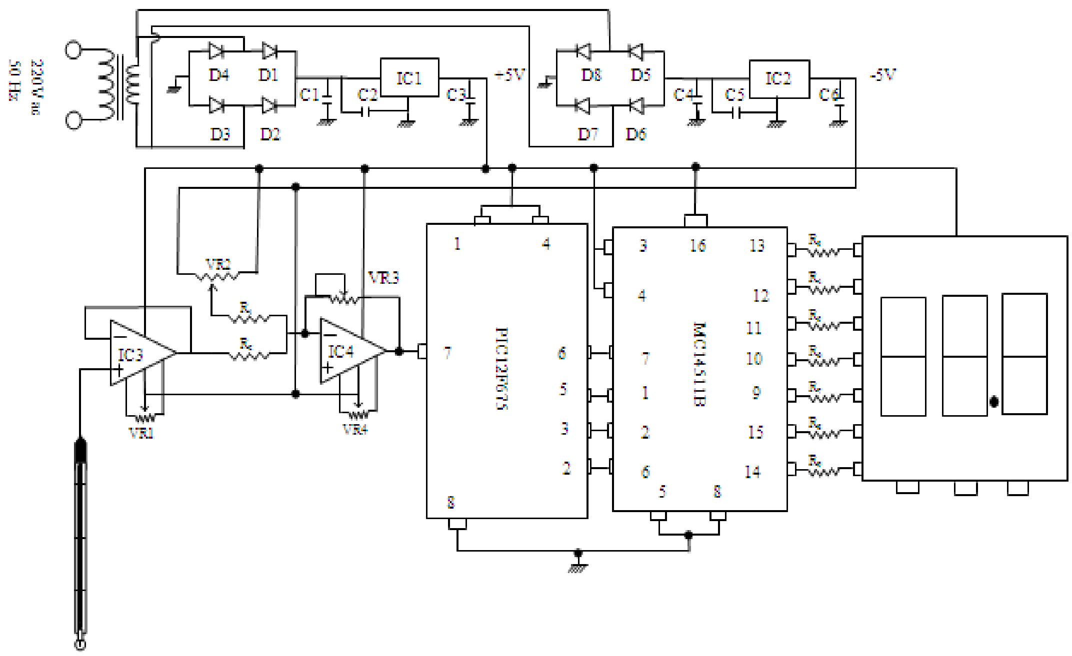

Figure 2: Complete circuit diagram of the developed system

2.3 Summing amplifier

The summing amplifier [9] consists of IC4, VR2, VR3, VR4, R1 and R2. The output of the summing amplifier is used as a microcontroller. This system uses two input summing amplifiers with inverting configuration.

2.4 Microcontroller Unit

The output of the summing amplifier is connected to microcontroller PIC12F675. The microcontroller converts data from analogue to digital, analyses data and displays data. Pin diagrams of microcontroller PIC12F675 are shown in Figure 3.

The PIC12F675 is an 8-pin package [10]. It has an A/D converter with 10-bit resolution. A "C" language program was developed to control the function of the microcontroller, using PCWH Compiler [11].

2.5 Display System

Three common cathode 7-segment LED modules display the pH value of the solution. Efficiently using the pin of PIC microcontroller allows for the display to be accomplished with a BCD 7-segment decoder (MCI4511B) [12]. The microcontroller sends the output signal to the input pins 7,1,2,6 of BCD to the seven segment decoder, whose output pins 13,12,11,10,9,15,14 are connected to the input of common anode seven segment LED[13].

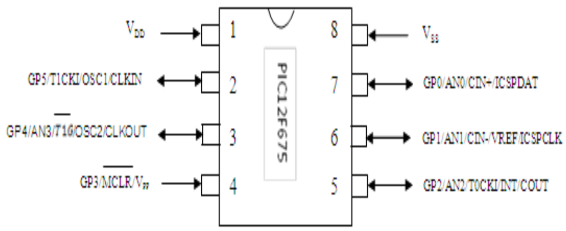

Figure 3: Pin diagram of microcontroller PIC12F675

3 System Program

The system program is depicted in the flow chart below:

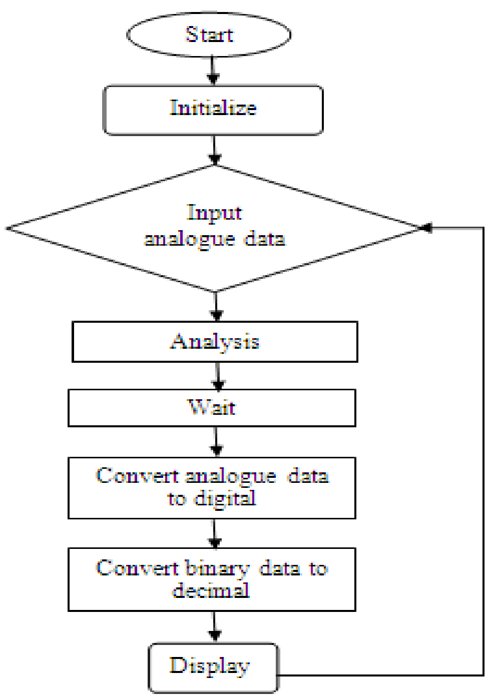

Figure 4: Flow chart of the system program

4 Results and Discussion

The microcontroller based digital pH meter was successfully designed and developed, as its performance was strong. The result of pH is compared with the actual result. The model of the laboratory pH meter is PHM83, with an accuracy of +/-0.1%. Figure 5 provides a graphic representation of the comparison between the designed system and the laboratory pH meter. The graph illustrates that the developed system has sound stability and accuracy.

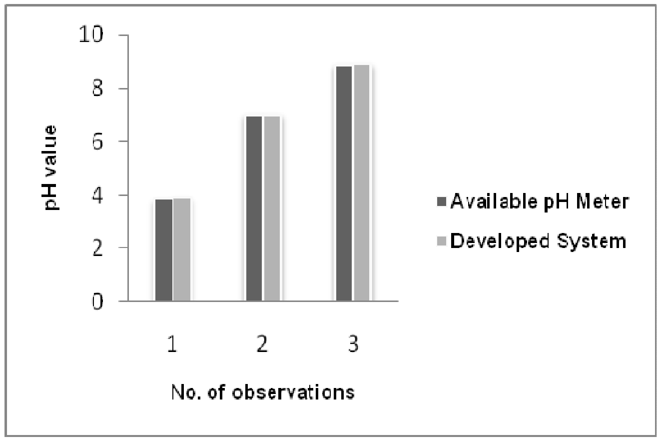

Figure 5: Graphic representation of a comparison of the two systems

Our designed pH meter was tested in the pathological unit of Gono Bishwabidyalay. Fifteen patients (seven male, eight female) took part in our study. The patients' demographics are contained in Table 1.

TABLE 1
PATIENTS' DEMOGRAPHICS

Patient No.	Gender	Age (Yr)	Weight (Kg)	'gastric pH
1	Female	23	59	3.1
2	Male	26	70	3.3
3	Female	28	62	2.9
4	Female	25	61	2.4
5	Female	53	69	1.7
6	Female	40	64	1.3
7	Male	67	60	3.1
8	Male	69	63	2.1
9	Male	60	59	2.3
10	Male	63	72	1.23
11	Female	56	68	0.99
12	Male	27	64	1.21
13	Female	25	60	1.05
14	Male	55	65	2.08
15	Female	46	70	1.53

If successful treatment depends on accurate intragastric pH measurement, the probe method may be preferable to the conventional aspiration method. A study by Lugo et al. concluded that gastric pH should be monitored by nanogastric pH probe and the dose of ranitidine adjusted accordingly [14].

The advantages include a reduction in the number of tubes passed into the stomach, improved patient comfort levels, and the possibility of decreased tube-related esophagitis. A single tube can provide long-term pH monitoring and gastric feeding/decompression. An additional advantage of the combination pH probe-NG tube is its ability to obtain measurements without handling gastric secretions. This decreases the exposure of hospital personnel to potentially infectious agents. The new technique for obtaining intra-gastric pH measurements appears technically simpler, clinically applicable, and potentially more accurate than conventional monitoring of gastric contents by aspiration and testing with pH paper. The technical specifications of the developed digital pH meter are provided in Table 2.

TABLE 2

SPECIFICATION OF THE DIGITAL PH METER

Technical Specifications	
Power Requirements	230 V ac ±10%, 50 Hz
Range	0.0 to 14.0 pH
Accuracy	+/- 0.1 pH
Probe	pH electrode
Display	Seven Segment Display
Relative Humidity	5 to 90% non-condensing

5 CONCLUSION

The price of electronic equipments has fallen significantly in recent times, though the cost of medical equipment remains expensive. However due to the rapid development of micro electronics, all the designed component and instruments are available at a lower price. The device is reliable in operation and it costs approximately U$100 for fabrication, whereas the price of a similar instrument in the international market is no less than U$500. Moreover, the comparison of the features of the presently used system shows that the developed system is a better choice in terms of cost, portability and design. Therefore, the opportunity to use the designed instruments will be open to many users, particularly in developing countries.

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