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MICROCONTROLLER BASED BLOOD GLUCOSE METER: DESIGN AND DEVELOPMENT

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ABSTRACT

Present paper is a design and development of an electronic system for the measurement of the blood glucose level using microcontroller based on amperometric instrumentation.The electric current from glucose sensed by a sensor module, is converted into voltage and is interfaced with the µc-8051 and then processed towards LCD module that displays the measured value of the blood glucose. Software is developed in C language. The system developed is handheld, rugged with low energy consumption and cost effective compared to other commercially available glucose measuring systems.

KEYWORDS: *Glucose biosensor, amperometric, Microcontroller, Self monitoring of blood glucose*

I. INTRODUCTION

The quantitative estimation of glucose is very much essential in different applications like analysis of blood and urine, food analysis, industries, etc. Diabetes is a serious disease that exposes human body to heart attack, stroke, amputations, nerve damage, blindness and kidney failure. The diabetes epidemic in India, has also shown up a trend. Contrary to the popular belief, more people in rural area have been affected compared to affluent urban Indians.

As a global sceneries millions of people have been suffered from diabetes, which is a kind of metabolic diseases; which is characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both [1].Different methods have been proposed for the detection of glucose, e.g. amperometric [2,3], spectrophotometric [4], fluorometric [5, 6]. Compared to conventional methods, biosensors can provide improved specificity, detection limit and speed of response [7]. The method uses blood glucose test strips made up of plastic strips which are the key component of blood glucose testing. The end of the strip is coated with enzymes, either glucose oxidase or glucose dehydrogenase, that chemically reacts with the glucose in the blood and the strength of the reaction depends on the glucose concentration. These small disposable strips of plastic may look insignificant but provide a very important role in helping the diabetes people to monitor and control diabetes. The quantity of blood required for a test is insignificantly small about 1µl to 2µl. It is our humble efforts through these investigations to measure the blood glucose concentration that uses an amperometric method to design and setup a microcontroller based blood glucose measuring system. Insulin is a hormone produced in the human body needed for the conversion of sugar, starches and other food into energy, without which the body would not be able to receive the amount of energy needed to function, that is why diabetes is such a serious disease [8]. The blood glucose is an important factor to discriminate the health condition of patients in clinical field.

Three main types of diabetes; i) type I diabetes that results from the body's failure to produce insulin and presently requires the person to inject insulin, ii) type 2 diabetes which results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency and iii) Gestational diabetes is when pregnant women (who have never had diabetes before) have a high blood glucose level during pregnancy. Type II diabetes is the more

common type with almost 90% of the people suffer from such metabolic irregularity. There is no cure for diabetes, so lifelong treatment with continuous monitoring and diet control is the only alternative.

II. THE DESIGN AND EXPERIMENTAL SETUP

The design and experimental setup for a 8051 microcontroller based blood glucose measurement system consist of.

a. A hardware Design part
b. A software Design part

2.1 The hardware Design

A block diagram of a microcontroller based system for the measurement of blood glucose level is shown in fig 1 where as an illustrative schematic screenshot of a digital blood glucose meter circuit is shown in fig.2

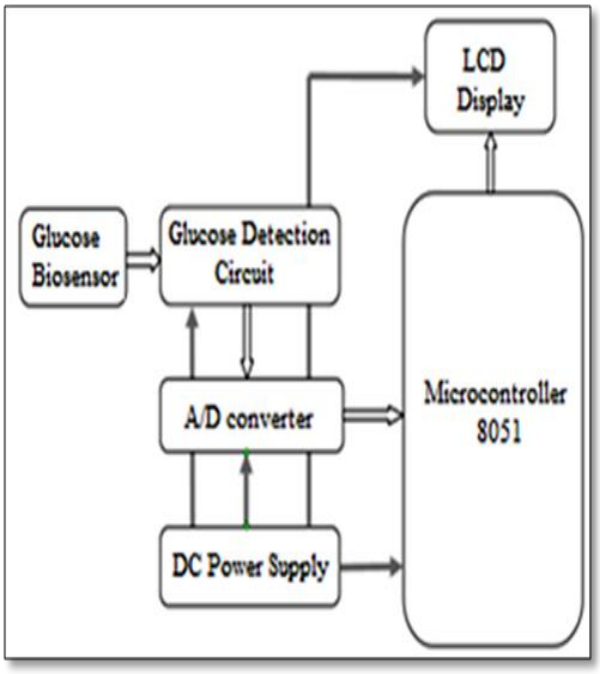

Fig.1 Bloc diagram of a digital blood glucose meter system circuit

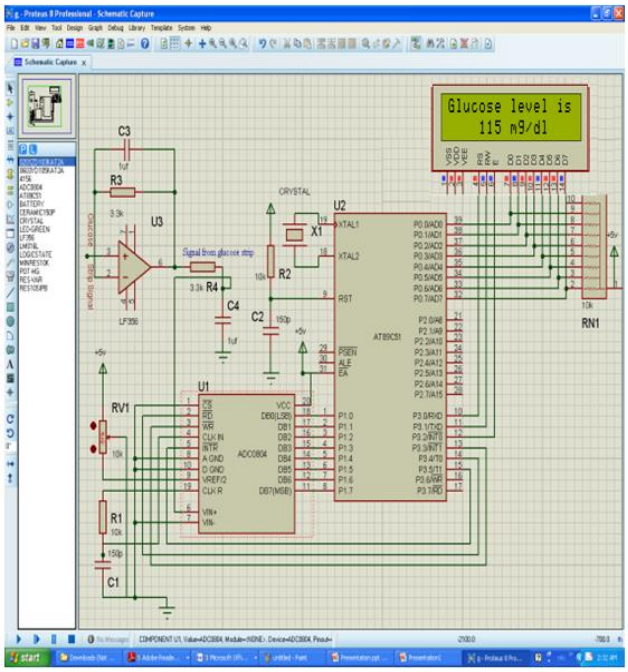

Fig.2 Schematic screenshot of a digital blood glucose meter

Microcontroller

In the present study the microcontroller we have chosen for this design is the AT89S51 manufactured by ATMEL, used to connect each component of the meter. The microcontroller uses a 11.0592 MHz clock for synchronous operation of all the circuits within the microcontroller [10]. This particular microprocessor incorporates all of the functions necessary to meet our specifications. The Microcontroller is responsible for analog-to-digital conversion, control the glucose test circuit and drive the LCD display.

Liquid crystal display unit

The display unit that has been chosen for our design is a 16x2 character LCD display. This screen is ideal for this system because it will easily integrate with the chosen Microcontroller. It is also of sufficient size that is needed to display the intended information. Liquid Crystal Display (LCD) is very commonly used electronic display module and having a Different types of it, widely used in such as calculators, laptops, mobile phones etc. It is very basic module which is commonly used in electronics devices and projects. It can display 2 lines of 16 characters. Each character is displayed using 5×7 or 5×10 pixel matrix [11]. The LCD display will be controlled by the Microcontroller using the Parallel Data Port. The screen will display results after test completion.

2.2 The software design

For the development of digital blood glucose meter the microcontroller is programmed in C language using µVision IDE-Kiel. This chip will be easy to program due to the equipment and development software available in the lab. Programming modules will be needed for the calculation of glucose values as well as to have communication with LCD display device to get the results in visual form. The code has been written in 'C' and transferred to the microcontroller with the help of ISP programmer.

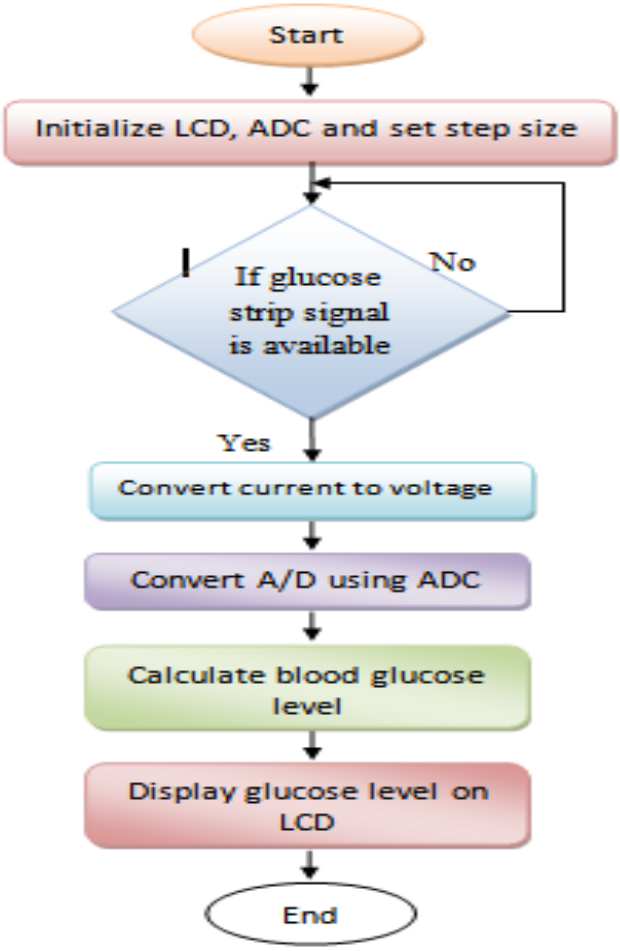

Fig.3 Flowchart for design and development of a digital blood glucose meter based on microcontroller 8051

III. SIGNAL PROCESSING UNIT

The electronic circuit designed to measure glucose concentrations must perform several functions. First, a constant voltage (400 mV) is applied to the reference electrode of strip using LM358 Op-Amp. The circuit will monitor the potential difference across working and reference electrodes to determine the presence of the blood sample, which reacts with enzyme resulting flow of electrons is known as current and is collected by working electrodes built into the test strip. The current is converted to voltage through a current-to-voltage converter made with the help of LF356. A current-to-voltage converter is simply an op amp with a feedback resistor. The LM358 dual operational amplifier, low power drain, a common mode input voltage range extending to ground/VEE, eliminating the necessity for external biasing components [9]. The op amp is used as a high impedance source that forces all of the current to flow through the resistor and input to the microcontroller through analog-to-digital converter (ADC 0804),

IV. RESULT AND DISCUSSION

When blood is placed onto the test strip, it reacts with a enzyme due to that amount of glucose in the blood turns either into gluconic acid or gluconolactone, depending on the type of reagent used on the strip.

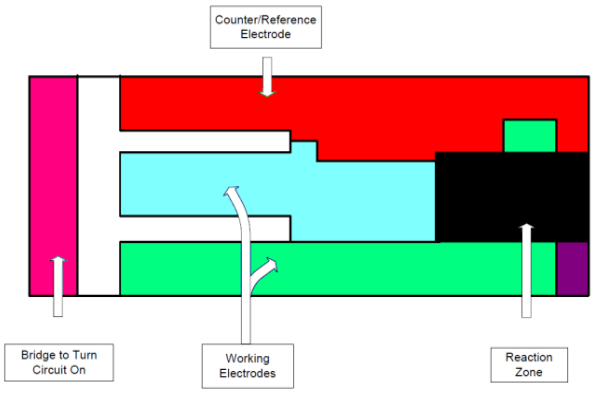

Fig.4 Glucose Test Strip Schematic

Chemical reaction at reaction zone

$$\text{Glucose} + O_2 + H_2O \xrightarrow{\text{GOD}} \text{Gluconic acid} + H_2O_2$$

$$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$$

This chemical reaction produces electrons. When the strip is placed in the meter, the test meter sends an electric current through the sample. The test strip has three electrically conductive electrodes. Two of these electrodes are 'working' electrodes meaning they are the measured electrodes, and the third is a reference electrode. Electric terminals which allow the meter to measure the current between the terminals. The amount of electric current that the test strip can transmit is related to the amount of glucose concentration present in the blood. This amount of current is calculated to be a blood glucose concentration reading that the meter displays on the screen (16x2 LCD module) through microcontroller-8051.

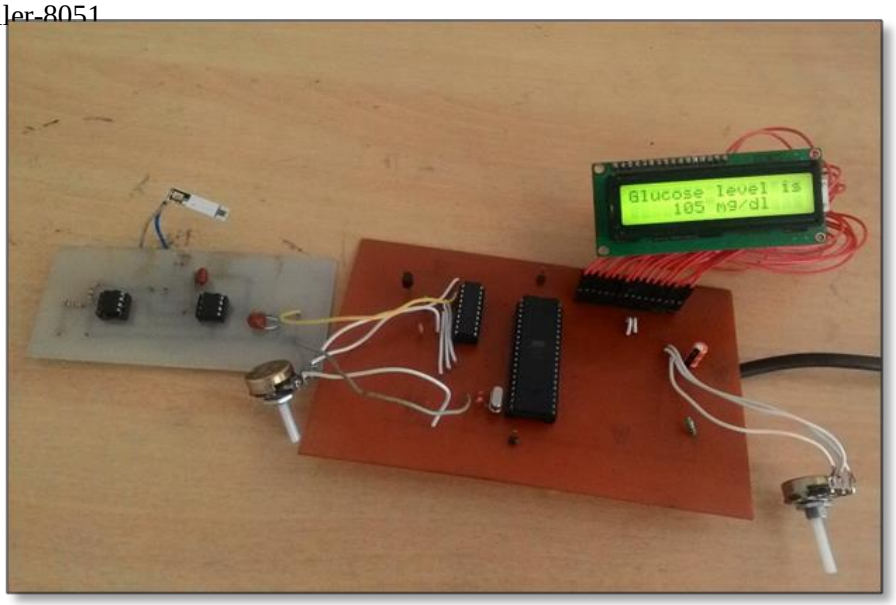

Fig.5 Experimental setup of for the blood glucose measurement

The digital blood glucose meter was tested with the blood sample and compared to the Arkray Glucocard Vital Meter Results. Constant attention has been made on applying blood sample. The blood sample is applied correctly in a reaction zone; the enzyme becomes catalytically active and mediator compound transfer electrons to the electrode. A preliminary measurement was taken on the Arkray Glucocard Vital Meter to establish the glucose concentration of the blood sample. The present designed meter was then tested using the same blood sample. Low power consumption, long shelf life, and environmental operating parameters (least affected by temperature and humidity), were very important considerations in system design. The results of the present study are good as compared with the standard blood glucose meters (Arkray Glucocard Vital Meter & One Touch ultra meters).A microcontroller based system, which converts the glucose concentration in the blood sample into voltages compatible with microcontroller input requirements. Fig.6 shows the present designed glucose meter test results.

Table 1: Blood glucose values

Sr. No	Actual glucose values mg/dl	Arkray glucose meter mg/dl	Present designed glucose meter mg/dl
1	81	81	78
2	97	97	94
3	110	109	109
4	135	136	134
5	128	127	125
6	116	115	115

V. CONCLUSIONS

In this study, the hardware and software features of Microcontroller 8051 based system designed and developed to determine the approximate concentration of glucose level in the blood is described. The system is quite successful for the measurement of blood glucose with an accuracy of less than ± 3%. We used glucose test strip bio sensor (for monitoring blood glucose levels) designed for the Arkray Glucocard Vital Blood Glucose meter made by Arkray healthcare pvt.ltd. The necessary software is developed in C, using µVision IDE-Kiel. When a drop of blood is placed on the test strip it interacts with the enzymes on the strip that causes a reaction and an electric current is generated. The current is sensed by LF356 Op-Amp and convert to voltage. This voltage is sent to Microcontroller 8051 for further processing and LCD to display result.

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REFERENCES

[1]. Y. Lia, J. Fua, R. Chena, M. Huanga, B. Gaoa, K. Huoa, L. Wangb, P. K. Chuc, Sensors and Actuators B 192 (2014) 474– 479.
[2]. C.M.C.M. Couto, A.N. Araujo, M.C.B.S.M. Montenegro, J. Rohwedder,I. Raimindo, C. Pasquini, Talanta 56 (2002) 997–1003.
[3]. Q. Yang, P. Atanasov, E. Wilkins, Sensors and Actuators B 46 (1998) 249–256.
[4]. H. Ukeda, Y. Fujita, M. Ohira, M. Sawamura, Journal of Agricultural and Food Chemistry ,44(1996) 3858–3963.
[5]. M. Lepore, M. Portaccio, E.D. Tommasi, P.D. Luca, U. Bencivenga, P.Maiuri, D.G. Mita, Journal of Molecular Catalysis B: Enzymatic. 31 (2004) 151–158.
[6]. X.J. Wu, M.M.F. Choi, Anal. Chim. Acta 514 (2004) 219–226.

[7]. S.K. Shukla a, SwapneelR.Deshpande b, Sudheesh K.Shukla b, Ashutosh Tiwari Talanta 99 (2012) 283–287.
[8]. N. Anju Latha1*, B. Rama Murthy1, U. Sunitha " Design And Development Of A Microcontroller Based System For The Measurement Of Blood Glucose" International Journal of Engineering Research and Applications (IJERA) Vol. 9.Issue 5, September-October 2012, pp.1440-1444.
[9]. LM358 datasheet, www.national.com
[10]. AT89S51 microcontroller datasheet, http:// www.atmel.com.
[11]. https://electrosome.com/interfacing-lcd-with-8051

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