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Non Invasive Glucose Monitoring System Using Nanosensors

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Received: 28 December 2015 /Accepted: 29 February 2016 /Published: 31 March 2016

Abstract: The most existing future technology is an outcome of the fields of computer science, electronics and Biology. Health inequalities have become the focus of a number of descriptive and analytical studies. One of the health related problem is diabetes. Diabetes at its serious stage leads to blindness. Monitoring glucose level in blood is one preventive measure to check diabetes. Increase in Glucose is a common risk factor which leads to hyperglycemia, Hypoglycemia, heart attack, stokes and aneurysms. A glucose monitoring system continuously measures and monitors the glucose level in a patient's blood. Normal blood glucose level of human is 70-110 milligram/deciliter. The level is maintained by using the secretion of insulin inside the body. When the insulin level gets increased it leads to hyperglycemia, and hypoglycemia when the level gets decreased. Hyperglycemia disease includes cataract,edema, hypertension, polyuria and polydipsia. Hypoglycemaia disease includes confusion, giddiness, unconsciousness, coma and death. The proposed system finds a new way for measuring the glucose level. The work uses Nanopellets which measure's the glucose level, when the glucose level gets increased or decreased, it will be automatically get monitored and processed using microcontroller (MSP430G2553). The information is then send to the doctor through GSM. *Copyright © 2016 IFSA Publishing, S. L.*

Keywords: Glucose, NanoPellet, MSP430G2553, GSM SIM900, LCD Display.

1. Introduction

According to 2013 survey by the International Diabetes Federation, 382 million people worldwide are affected by diabetes and the number can reach 592 million by 2035 (55 % increase) [1]. 5.1 million diabetes-related deaths occur globally during 2013 which is one death every 6 s, an 11 % increase over 2011 [2]. Early diagnosis, on-time treatment and continuous management helps to avoid complications like circulatory problems, kidney failure, heart disease, stroke, and blindness [3-4]. Yi-Ting Wang, *et al.* [5] developed highly sensitive and stable glucose sensor based on the synergetic effect of multi wall carbon nanotubes and ZnO nanoparticles. Xiaowang Liu and Qiyan Hu, *et al.* [6] proposed the Amperometric glucose biosensor fabricated on the basis of aligned Zno nanorod film grown on ITO. This biosensor displays excellent analytical performance over a wide linear range along with good selectivity. Anju Latha, *et al.* [7] developed a microcontroller based system for the measuring blood glucose. The MAX232 is a dual line driver/receiver, converts signals from an RS-232 serial port to TTL compatible signals. C language program using for MPLAB IDE is developed by Microchip Technology with inherent language flexibility to support its portability across a wide range of hardware. Cuauhtemoc and Medina Rimoldi [8] proposed a working principle of the amperometric blood glucometer. S. A Hari Prasad, *et al.* [9] proposed a single phase PWM inverter using 8051 microcontroller. The main features of 8051 based PWM inverter are simpler to design, low cost, maximum range of voltage control and compact in size. The designed PWM inverter is tested on various AC loads like AC motor and intensity control of incandescent lamp in a closed loop environment. The microcontroller based air thrust monitoring instrumentation system using optical fiber sensors is used to monitor the air pressure. D. Hazarika, *et al.* [10] proposed the instrumentation system consists of a laser source, a beam splitter, two multimode optical fibers, two light dependent resistance (LOR) based timer circuit and AT89S8252 Microcontroller. The microcontroller samples the frequencies of the times circuit using its counter 0 and counter I and counter values are then processed to provide the measure of air pressure magnitude.

The main motivation of this system is to critically discuss the technical and clinical aspects of glucose sensors and to briefly review current technical developments. NANOPELLETS are used to measure the glucose level. Continuous glucose monitoring will help the diabetic patient with requried insulin therapy and have good metabolic control. The system will help in detecting hypo- and hyperglycemia episodes. Technological innovations have embraced clinical criteria for analytical systems with the introduction of the recent complete laboratory automation systems. During the last 30 years numerous attempts have been made to develop glucose sensors, and new major breakthroughs are announced repeatedly. Nanopellets will acts as a glucose detecting system. Selection of the detection system needs rigorous criteria for acceptance, that included versatility, rapidity and accuracy with the ability to cope with multiparameter analysis. Nanopellets is a semicondutive device made of strontium titanate (pervoskite crystal). As a result of recent scientific and technological progress, such devices are likely to plan an increasingly important role in generating analytical information in all sectors of human endeavour, from medicine to the military. Many glucose level monitoring system [11] are available in the market. The system mentioned above which needs a sofisticated fabrication facility and are high cost. The idea of the project submitted is to detect BGO parameters using biochip [12-13]. The cost of biochip are too high [13] and fabrication needs a special laboratory. To overcome this Nanopellets are used and fabricated which helped in obtaining a cost effective system for monitoring the glucose level.

1.1. Technical Background

People currently use a skin prick and a hand held blood test, and then medicate themselves with insulin depending on the result. The method of testing the blood glucose level in the olden days is peircing and hand held blood test. The blood sample is taken by the human body, and it is tested using clinical devices and the time taken for the analysis of the blood sample will be long. Our objective is to reduce the drawbacks of the previous system and to develop a miniaturized system, which is a collection of miniaturized test sites (microarrays) arranged on a solid substrate that permits many test to be performed at the same time. The nano pellet is an electrode for measuring the blood glucose level. A relatively small drop of blood is placed on a disposable medium, which interfaces with LCD Display and GSM Module. The level of blood glucose will be shown on the digital display in a short duration. When the glucose level is not normal, the message will send to the Doctor through the GSM Module. The cost of using nano pellets is low, time taken by the proposed system is low. The proposed system has responded with helpful devices such as home use clinical device. The time and effort required for testing is reduced and the compliance of diabetic people to their testing regimens is improved.

1.2. Proposed Solution

The proposed method is tested in water with and without glucose. The overall block diagram is as shown in Fig. 1. The Nanopellet is initially fabricated and the conductivity of the pellet is identified using water without glucose. Then the glucose level is increased by adding glucose from 0.5 mg to 5 mg. The conductivity of the pellet is checked. The observation indicated that the Nanopellet is successful in detecting the increase in glucose level in the water. The observed parameters are voltage, current, power and energy level in water with and without glucose.

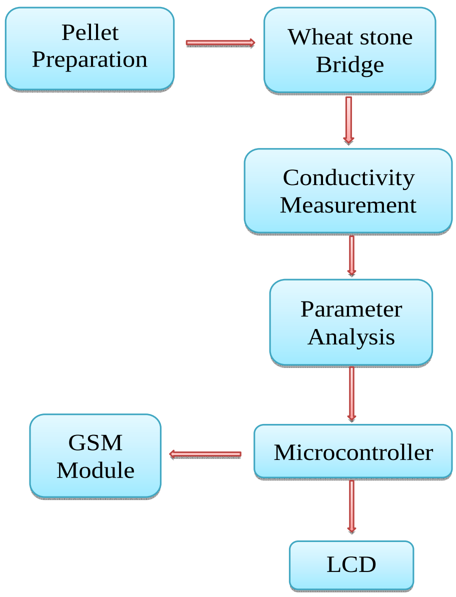

Fig. 1. Overall Block Diagram.

2. Pellet Preparation

Nanopellets is a semiconductor material, prepared by using the Strontium Titanate (SrTiO3) and it used as an electrode. The chemical of Nanopellet are Strontium Nitrate, Titanium (IV) Butoxide, Ethanol, Isopropyl Alcohol, Acetic Acid Glacial (100 %). 30 ml of Acetic Acid Solution is taken in a beaker, the Magnetic Pellet is used which acts as a stirrer with a rotating speed of 320 rpm. After a few seconds, 15 ml of Titanium(IV) Butoxide and 30 ml of Ethanol is added into the beaker. Then, 5 g Strontium Nitrate is dropped, and the rotating speed of magnetic pellet is increased by 440 rpm. A chemical reaction is obtained by heating the beaker and it is placed in the oven at 103 degree celsius. When the chemicals gets dried, it is grinded and a hydralic pellet pressing machine is used to obtain the tablet which is like pellet. The pellet is then placed in the furnace at 1000 degree celsius for making the pellet as a hard material.

3. Conductivity Measurement

The Wheat stone Bridge is used for calculating the unknown resistance of nanopellets. Fig. 2 shows the circuit diagram for conductivity measurement. The resistivity of the pellet is calculated by using the formula: Rx=(R1*R3)/R2, where R1=Variable Resistance, R2, R3=Fixed Resistance, Rx=Unknown Resistance.

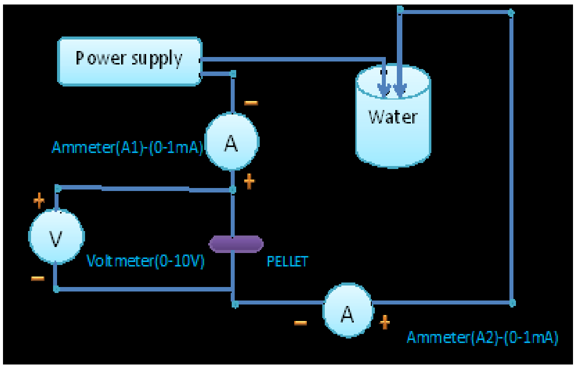

Fig. 2. Circuit Diagram for conductivity measurement.

The Pure water is taken in a beaker. Two Ammeter (A1, A2) and one voltmeter is taken for the study. The Power Supply (0-30 V). The negative end of supply is connected to the negative end of Ammeter (A1), the positive end of Ammeter (A1) is connected to the beaker, the positive end of Ammeter (A2) is given to the beaker containing water. The Voltmeter is connected across the pellet. The initial conduction of the water is checked and parameters are calculated, the obtain results is without Glucose addition. Now the Glucose is added to the water with an increase in 0.5 g for each second. The Observation shows the conductivity with the addition of Glucose in the water increases as the temperature decreases.

4. Microcontroller (MSP430)

MSP430 Microcontroller is used with 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The analog input is digitalized using the inbuilt ADC controller and the glucose level indication is send to the doctor through GSM and also displayed on LCD.

5. Hardware Implementation

The Hardware Implementation is done as in Fig. 3. The conductivity of pellet is checked and the readings including voltage and current are taken. The voltage value are given as input to ADC, which is inbuilt in the Microcontroller. The program is written to display the glucose level present in the water, and it is displayed in LCD, when the level gets increased or decreased, an Alert message (“Glucose Level is Low”) will send to the doctor.

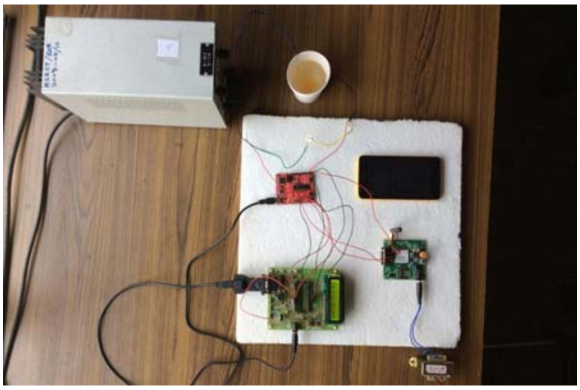

Fig. 3. Hardware Setup.

MSP430 Microcontroller is chosen because, it is used with 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The excellent performance of MSP430 in-system programmable flash memory, 4 kB of RAM, two 16-bit timers, a high-performance 12-bit analog-to-digital converter (ADC) with eight external inputs plus internal temperature and battery sensors on CC430F613x devices, a comparator, universal serial communication interfaces (USCIs). In Pellet Preparation, the chemical substance Strontium Titanate ($SrTiO_3$) is taken, because it is insoluble in water, the Melting point of the chemical is 2080 degree Celsius and Thermal Conductivity is about 12. The material have the Cubic Perovskite Structure, which increases the Conductivity of the material. The flow diagram of the hardware implementation is shown in Fig. 4.

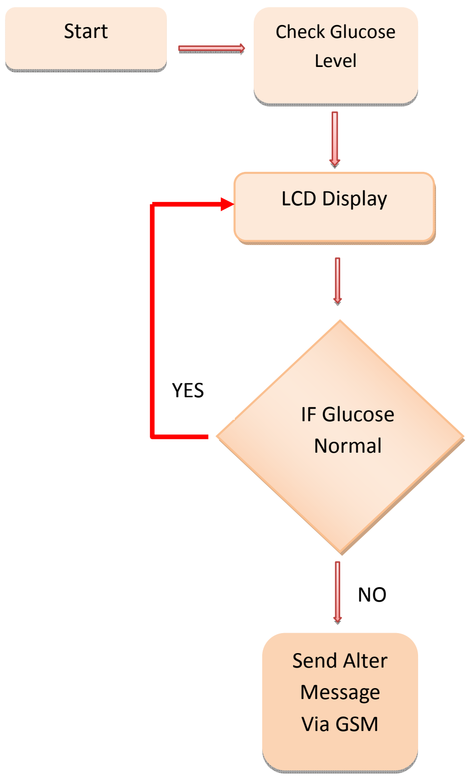

Fig. 4. Flow Diagram of Hardware Implementation.

6. Results & Discussion

A hardware implementation is done. The glucose level identification using Nanopellet are obtained. The hardware testing of the pellet is explained in previous sections. The results of the conductivity calculation obtained are tabulated as in Table 1. The results of the resistivity calculation of glucose level in normal and distilled water which shows the resistivity decreases as the voltage level increases which in turn, helps in increase in the glucose level and is tabulated and is shown in Table 2 and Table 3.

Table 1. Conductivity of Nanopellet without & with glucose.

Glucose level	Voltage (Volt)	Current (Amps)	Resistance (Ohms)	Energy (mJ/Mol)	Power (watt/kg)
Without glucose	2	0.22	10.52	2	**2.3144**
0.5 g	2.4	0.23	10.43	24	**0.552**
1 g	2.6	0.26	10.41	31.2	**0.676**
1.5 g	2.7	0.26	10.35	40.5	**0.702**
2 g	2.9	0.28	10.34	58	**0.812**
2.5 g	3	0.29	10.30	75	**0.87**
3.5 g	3.2	0.31	10.29	102.4	**0.992**
5 g	3.4	0.32	10.27	176.8	**1.088**

7. Conclusions

The main aim of the project is to design the Glucose monitoring system. Maintaining blood glucose level is an important issue which help in detecting various diabetic related diseases. The project is successful in detecting the glucose level in water. The further work is extension of the same procedure in detecting the glucose level in blood. The project can be extended to detect the other two parameters (blood pressure and oxygen) using nanopellets. Nanopellets can be better monitoring system in detecting various other pathologies in human.

Table 2. Resistivity Calculation without Glucose.

	Voltage (Volt)	Current (mA)	Resistance (Ohms)
Normal Water without Glucose	5	15	0.075
	10	18	0.18
Distilled Water without Glucose	12	42	0.504
	15	56	0.84

Table 3. Resistivity Calculation with Glucose.

	Glucose level	Voltage (Volt)	Current (mA)	Resistance (Ohms)
Normal Water Glucose	0.5 g	5	26	0.13
	1 g	5	24	0.12
	1.5 g	5	22	0.11
	2 g	5	21	0.105
	2.5 g	5	20	0.10
	3.5 g	5	18	0.09
	5 g	5	16	0.08
	0.5 g	10	20	0.2
	1 g	10	18	0.18
	1.5 g	10	18	0.18
	2 g	10	17	0.17
	2.5 g	10	16	0.16
	3.5 g	10	14	0.14
	5 g	10	13	0.13
Distilled Water Glucose	0.5 g	12	42	0.504
	1 g	12	40	0.48
	1.5 g	12	39	0.468
	2 g	12	36	0.432
	2.5 g	12	33	0.396
	3.5 g	12	30	0.36
	5 g	12	28	0.336
	0.5 g	15	56	0.84
	1 g	15	54	0.81
	1.5 g	15	53	0.795
	2 g	15	50	0.75
	2.5 g	15	48	0.72
	3.5 g	15	47	0.705
	5 g	15	46	0.2

Acknowledgements

We would like to thank Nano Technology and EEE departments of K. S. Rangasamy college of technology for the Nanopellets preparation.

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