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DESIGN OF AUTOMATIC INSULIN DOSAGE INDICATOR FOR DIABETIC PATIENTS USING BMI

Ms. R. Kanimozhi
PG Scholar

Dr. S. Saravanakumar
Assistant Professor

Department of Electronics and Communication Engineering,
Anna University Regional Campus,
Coimbatore, Tamilnadu, India

Abstract* – Diabetes Mellitus is a serious and chronic health disease. It occurs in all age group of people, especially in adults and aged persons. It is important to measure blood glucose level frequently for the diabetes affected persons which in need to determine the appropriate insulin dosage. Along with this, the continuous glucose monitoring is vital to know whether the glucose level is in normal range. The conventional method used to measure the glucose level in blood is invasive which is infectious and a painful process. Nowadays, the non-invasive blood glucose monitoring methods are widely used. In this work, the blood glucose level is measured non-invasively using IR sensor. Besides that, the indication of insulin dosage to be taken is done by determining blood glucose concentration (non- invasively) and comparing it with Body Mass Index (BMI) of the patient. The implementation is based on the variations in the intensity of the IR LED, BMI and blood density. The method is more reliable than the invasive techniques.

***Keywords* – Blood Glucose Level, Continuous Glucose Monitoring, Non-invasive, Insulin, IR Sensor, Body Mass Index.**

I. INTRODUCTION

1.1 Overview

Diabetes Mellitus is delineated as autoimmune demolition of beta cells produced by pancreas which secretes insulin for the conversion of glucose into energy. The destruction of such cells leads to continuous dependency on exogenous insulin and also results in several hazardous diseases like coma, kidney failure, stroke, blindness and sometimes death might be occurred. According to the statistics of 2017, china is ranked first with high population of 114 million diabetes affected persons [1][2][3]. The count may be varied based on the human lifestyle. Heart diseases and nerve damage occurs due to smoking.

1.2 Blood Glucose Monitoring

Long and short-term complications can be reduced through proper diet, physical exercise and medication. But to know the pattern of glucose changes of a diabetic patient, concentration of glucose in blood needs to be monitored. Blood glucose

Glucose is the main source of energy for the human body. Glucose levels are regulated to keep the body homeostasis so that the blood glucose level remains stable and relatively constant. There are many hormones that are involved in this process but the insulin is the most important one. Insulin is produced by the beta cells of pancreas and it is provided to remove excess glucose from the blood.it also acts as a controlling signal to breakdown glucose into glycogen for internal storage in blood.as the blood glucose level increases, insulin stimulates the cells to utilize more glucose and sending the signal to the liver to convert excess to glycogen for the later use so that when there is a fall in blood glucose level, glucagon helps to breakdown of glycogen into glucose. In this way both insulin and glucagon work together to maintain the glucose level constant and stable as shown in figure 1.

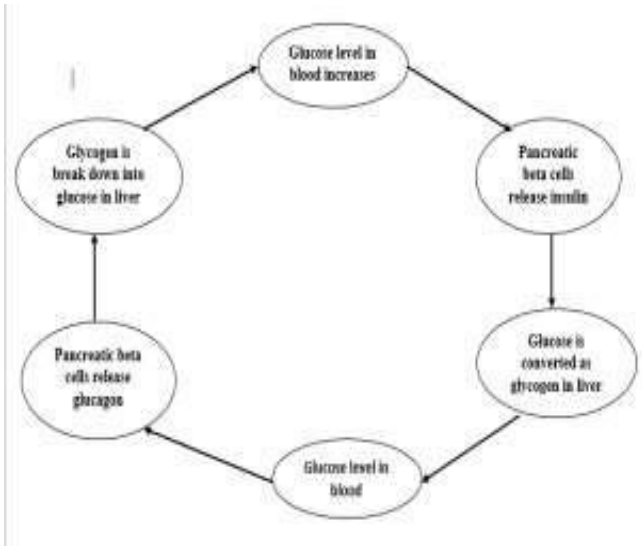

Fig 1: Regulation of Glucose In Blood

concentration is currently measured using three broad categories of techniques which are

Insulin is the main anabolic hormone produced by the pancreas, Insulin injection is used to control blood sugar in people who have diabetes. It works by moving sugar from the blood into other body tissues where it is used for energy.

II. RELATED WORK

Huang C et al. (2007) presented a new microfluidic system for real-time measurement of glucose concentration and automatic insulin injection. This technique provides a potential for on-line monitoring of glucose concentration and precise injection of proper doses of insulin [6]. In 2007, Tura A et al. described. various non-invasive glucose monitoring technology with a detail of advancements, principles and limitations for the benefit of diabetic patients [11]. Ferrante C.E and Wolf B (2008) presented an overview and performance analysis on the non-invasive glucose monitoring. A performance enhancement is suggested Photo Acoustic Spectroscopy (PAS). This system is based on ultrasonic waves. When the light beam meets cell, it reflects optical properties of glucose in blood with respect to specific incident wavelengths of light beam [4]. Anas M.N et al. (2012) presented a four-electrode method for measuring blood glucose. Blood electrical impedance is varied with the blood glucose in a human body. bioelectrical voltage output shows a difference between fasting and non- fasting blood glucose measured by using designed four tin lead alloy electrodes [3]. Haxha S et al. (2016) reported a non-invasive measurement technique to determine the glucose level in human body. The system introduced a spectroscopy based non-invasive method to measure the glucose concentration. Near infrared transmission spectroscopy is used in both in-vitro and in-vivo cases. The experimental study confirms the correlation between the sensor output voltage and the glucose concentration levels. There is a change in concentration of glucose with the output of the sensor [5].

In this paper, the design of automatic insulin dosage indicator by measuring blood glucose non- invasively and comparing it with the Body Mass Index (BMI) of the diabetic patients. The proposed device is designed to detect blood glucose concentration non-invasively using IR Sensor and also able to recommend a reasonable dosage of insulin based on their BMI.

III. METHODOLOGY

3.1 Block Diagram

Figure 2 illustrates the proposed design of automatic insulin dosage system.

The figure 2 represents the block diagram of the proposed design.it includes the IR LED, PIC microcontroller and other such units that are used to indicate the insulin dosage automatically.

3.1.1 IR sensor

An infrared sensor emits and detects infrared radiation in order to sense some aspect of its surroundings. Infrared (IR) light is electromagnetic radiation with a wavelength longer than that of visible light, measured from the nominal edge of visible red light at 0.74 micrometres (µm), and extending conventionally to 300 µm. Figure 3 represents the emission and reflection of IR LEDs. The basic idea is to use IR LEDS for both transmitting and receiving IR radiation from any object in front of the sensor. In this work the IR LED is used to sense the human finger.

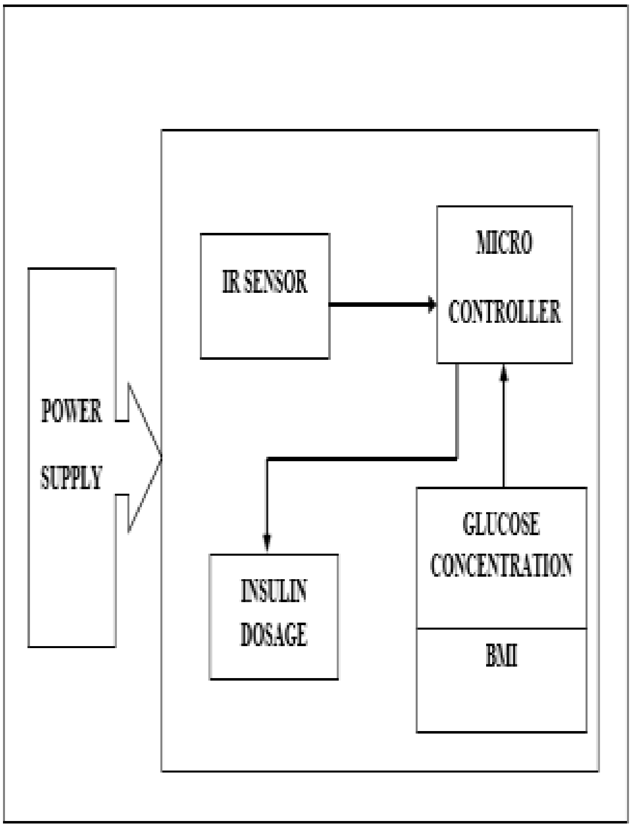

Fig 2: Block Diagram of Automatic Insulin Dosage System

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It calculates the blood glucose concentration of the patient in the form of output voltage and sending the sensed output to the PIC microcontroller.

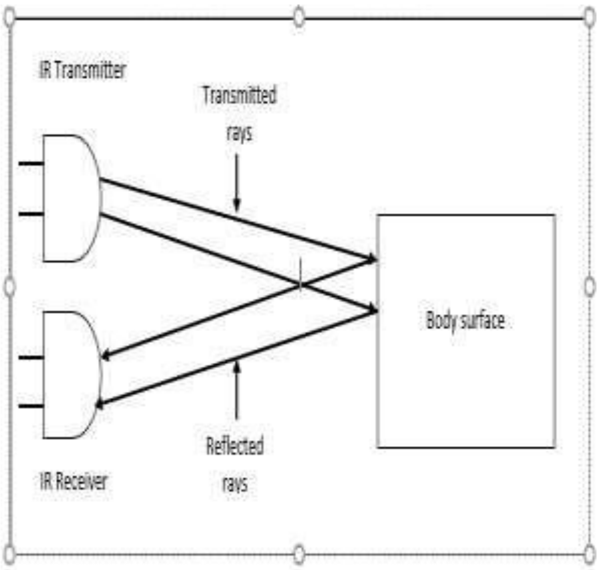

Fig 3: Emission and Reflection of IR LED

3.2 PIC microcontroller

The name PIC is referred to as Peripheral Interface Controller. The PIC microcontroller incorporates all of the functions necessary to meet the specifications of the work. The PIC is used to control the glucose test circuit, analyse measurements, handle user input. PIC is used as a control over the design.

3.3 Glucose concentration and BMI

The micro controller is indicating the insulin dosage by comparing the glucose concentration, blood density and BMI of the patient. The BMI is varying with each and every human. So, the BMI is categorized as three proportions for the effective comparison with blood glucose concentration. According to the three categories of BMI, the insulin dosage is varied with different patients. The blood density is determined by heart beat count for 30 seconds for proper prescription of dosage of insulin.

3.4 Insulin dosage

This unit comprises the insulin injection system. The output injection system is processed by all the individual units of the proposed design. By comparing the glucose concentration, blood density and BMI of the patients, the insulin is automatically recommended by the proposed design. It is programmed to the PIC to give proper insulin according to the above given parameters. The system is also helpful to the non - diabetic person for checking his/her glucagon cycle.

3.5 Power supply

The entire proposed design is provided with a supply voltage of 5v DC. The regulated power supply accepts unregulated inputs from 9V to 15V AC or DC and gives regulated output of 5V and 3.3V suitable for microcontroller which needs precise voltage to work.

3.6 Hardware Implementation

The main hardware components in the system include a transmitter (IR7373C), a photodiode (FDGA05), an operational amplifier (OP491), microcontroller (PIC16FXX40). IR detection circuit (as shown in Figure 4 and 5) consists of a transmitter circuit and a receiver circuit. Transmitter and Receiver circuits are operate at a supply of 5 V and are powered by the PIC microcontroller. The receiver circuit consists of a photodiode, a noise filter and an operational amplifier. The FDGA05 photodiode is suitable to be used with the transmitter as it has a wavelength sensitivity which is within940 nm-1800 nm. The photodiode is used to converts the optical power from the transmitter to an electrical current value. The output voltage depends on the intensity of the IR signal it receives, which is between up to 5 V. The Op-Amp is use to amplify the output signal.

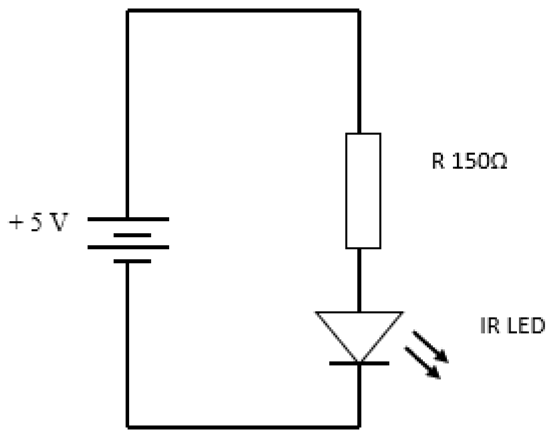

Fig 4: IR Detection (transmitter circuit)

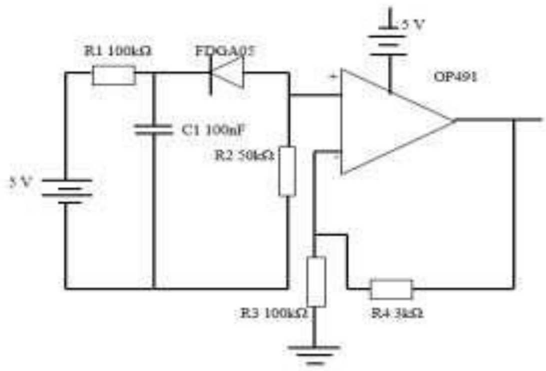

Fig 5: IR Detection (receiver circuit)

3.7 Software Implementation

The main aim of the software development is on the algorithm design of the microcontroller. The control of the device PIC microcontroller with fourteen (40) digital input and output pins. It can be powered by a battery or by a serial connection to the computer.

The algorithm is designed to calculate blood glucose concentration of and the recommended insulin dose, according to the BMI of the diabetic patient. Blood glucose is determined from the output of photodiode. Figure 6 illustrates the algorithm of the insulin dose for different BMI such as

underweight (BMI < 25) normal (25 ≤BMI≥30) overweight (BMI > 30).

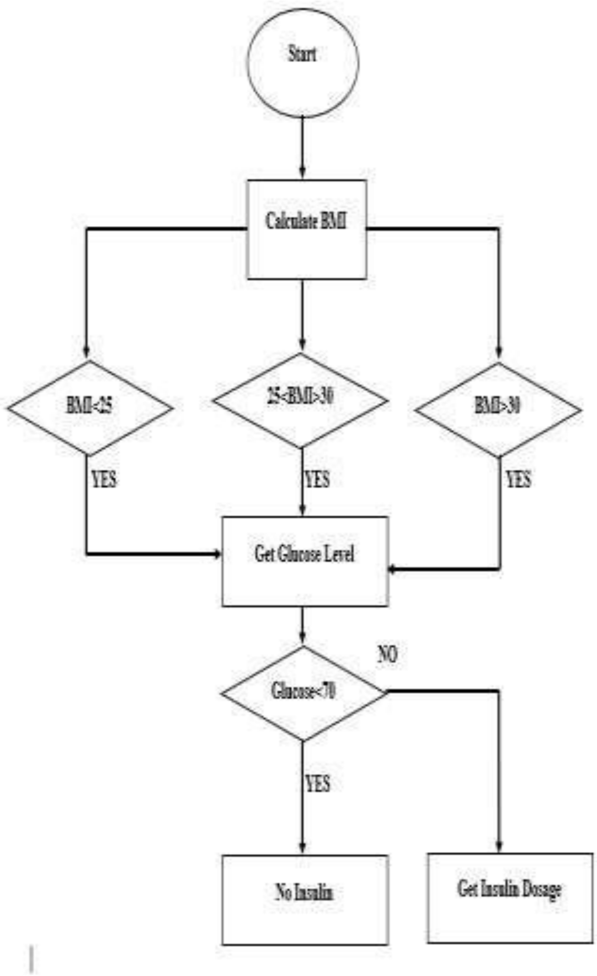

Fig 6: Algorithm of Inulin for Different BMI

Step 1: calculate the BMI of the person using the formula weight/(height)^2.

Step 2: If the BMI is less than 25, Get the glucose level.

Step 3: If the glucose level is less than 70 mg/dl, , then no insulin is needed.

Step 4: Else if, get the recommended insulin dosage.

Step 5: If the BMI is lies between 25 and 30 or else above 30, go to step 2.

IV. RESULTS AND DISCUSSION

4.1 Glucose Concentration Vs Output Voltage

The blood glucose concentration increases with increase in output voltage of IR sensor. It is measured using a photodiode. The following figure 7 shows the plot between the measured blood glucose concentration and output voltage of the photodiode.

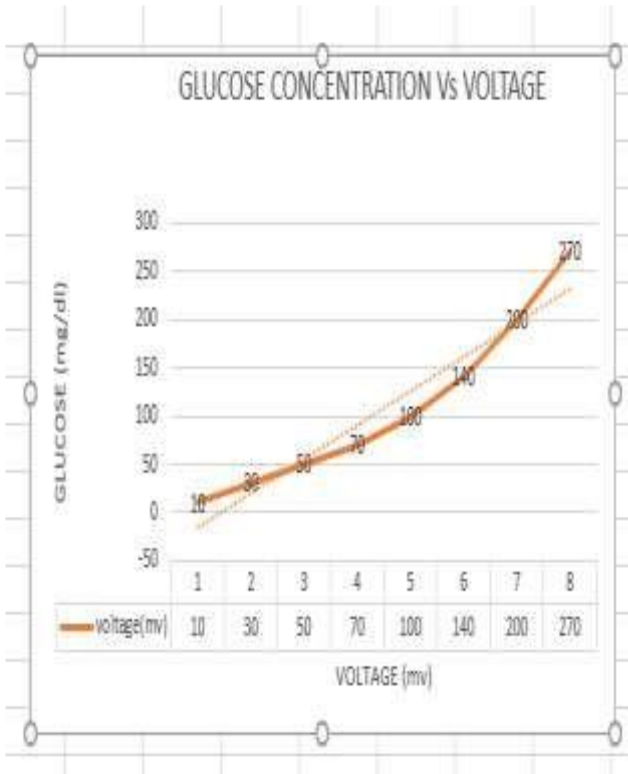

Fig 7: Glucose Concentration Vs Output Voltage

4.2 Recommended Insulin Dosage

The following Table 1 gives the effective details about the amount of insulin recommended to the diabetic patient according to their BMI and blood glucose concentration. It shows that insulin dosage varies with variation in both BMI and various concentration of blood glucose level. The insulin is given by considering both BMI and glucose eel for each person, because it varies according to their physical activities, diet, gene, etc…

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Table 1: Recommended Insulin Dosage

BMI	GLUCOSE LEVEL(mg/dl)	RECOMMENDED INSULIN DOSAGE(ml)
BMI<25	70-150	0.5
	150-250	1.5
	>250	5.5
25<BMI<30	70-150	0.5
	150-250	2.5
	>250	6.5
BMI>30	70-150	0.6
	150-250	7.6
	>250	8.5

The following figure 8 illustrates the graphical representation of the recommended insulin dosage.

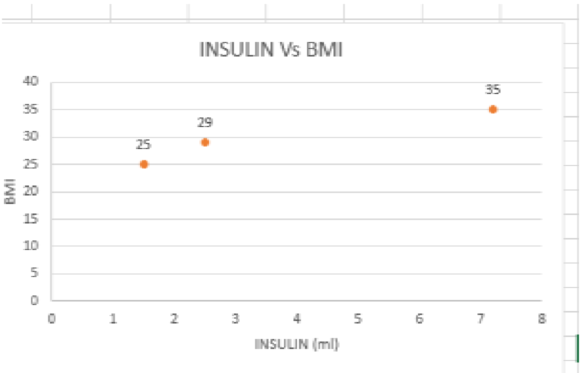

Fig 8: Recommended Insulin

It varies with person to person according to their height and weight.

4.3 Hardware Setup

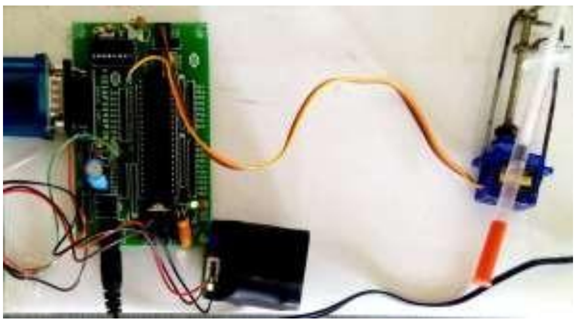

Fig 9: Hardware Setup

A novel non-invasive blood glucose monitoring design which involves indication of insulin dosage automatically according to the blood glucose concentration and BMI was implemented as shown in figure 9. By giving a supply voltage of 5v, the IR sensor senses the finger of the diabetic patient and determines the blood glucose of the patient. The insulin dosage is predicted according to the normal and less pulse rate, BMI in that time.

V. CONCLUSION AND FUTURE WORK

Thus, the proposed design measures the blood glucose concentration using IR LED and the PIC controller determines the amount of insulin dosage by comparing the BMI and blood density of the patient. The results show that the proposed design is given the appropriate blood density of the blood and proper insulin is prescribed. So that the proposed design is helpful for all diabetic patients especially, for children and aged persons. The proposed work is very essential to a diabetic patient for daily life for determining the condition of hyperglycemia and hypoglycemia and providing appropriate insulin to the blood glucose concentration.

In future, the proper insulin dosage is prescribed by combining both the BMI and blood glucose concentration with some linearization techniques. The proposed design is developed into a wearable prototype. Various non-invasive techniques will be developed further with the following requirements:

- To reduce the risk of infection
- To increase the automation in medical applications.
- To reduce major causes of diabetes.

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