Design of Wireless Monitoring and Controlling System of Insulin Pump

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Abstract – *Insulin pump is a small electronic device used to help diabetes patients to control the glucose level, it can be carried easily and place under clothes. The important of insulin pump due to the risks of ignoring monitoring diabetes disease which caused the side effects on human health such as heart disease and eyes problems. Improving the operation mechanism of insulin pump considered a big challenge for designers in order to reduce the effects of diabetes disease. The objective of this paper is designing a closed loop insulin pump which monitoring glucose and pumped insulin. The design provided with wireless monitoring system. The system in this paper combined two parts hardware and software. The hardware based on Arduino microcontroller which processed the collected data from the sensor and controlled the pumping of insulin. Visual basic language was used to design the monitoring page which only can be accessed by using the correct password and username to guarantee secure information between the doctor and the patient. The monitoring page connected wirelessly via XBee unit. The simulation results tested the system in different operation cases. The obtained results reveal that the system provides high performance and achieved the required goals.*

Keywords*: Design; Control; Wireless transmission*

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I. Introduction

Insulin is an important hormone that the human body produces it continuously to assist the cells in using glucose for energy. If the human body failed to provide the enough amount of insulin so this occurred high level of glucose which call diabetes disease [1]. The first insulin product presented to the market was in 1923[2]. Insulin pump has been used early age. The first insulin pump invented in the beginning of the beginning of 1970.It has large size but it proves monitoring of glucose in blood [3]-[4]. The early pump which referred as biostator was only used for researches reasons [5]. Several designs appears since that date, some of them was only pumping insulin but it did not included with monitoring glucose issue [6]. The important progress of designing insulin pumps starts in 1990_s the design of insulin pumps became smaller in size and included with display unit [7].The insulin pump became more important for the patients whom required to inject by insulin several times in a day[8]. This paper aims to design insulin pump and wireless monitoring system of glucose to help nurses and doctors in monitoring the patient all the time. The design contributes in economy because it helps the diabetes to continue their life without medical problems so this part of society will not be disable to continue working and supporting the economy, it also improved the managing system in hospitals by reducing the manpower and the required time in monitoring diabetes all the time. The design used to organize glucose level by providing constant insulin dose depending on the glucose level in the blood. The system includes monitoring page which designed using visual basic and connected wirelessly through XBee unit.

II. Survey of Related Works

Recently there is an increasing demand of insulin pumps due to the increased number of diabetes over the world thus researchers were concerned to provide efficient technology to overcome the problems of this disease. Most of these works have different in terms of monitoring strategies or in operating techniques some of them used open loop design which only concerned of injection insulin while others used closed loop design

which provide injection insulin and monitoring the glucose. Hawłas et al [9] planed the requirements materials of designing insulin pump. The paper listed the problems of close loop insulin pump. Ahmed et al [10] design close loop system of insulin pump the control strategy based on fuzzy control logic. Zameera et al [11] presented an embedded system of insulin pump based on microcontroller; this design did not include wireless connection. Cocha et al [12] presented a prototype of insulin pump without providing monitoring or wireless technique. Hu et al[13] presented open loop insulin pump using stepper motor also it did not include wireless monitoring.

III. Methodology

The proposed insulin pump provides an insulin dose according to the measured value of the glucose. This operation repeated in fixed time and for the simulation purpose it assumed to repeat every two hours. The proposed design divided of two main parts: The hardware section, which discussed the electronic circuit that fixed on the body. The hardware in this paper simulated and build on by using the proteus program. The main unit is the Arduino controller. The second section is the software algorithm which controls the operation of the circuit. Visual basic language used to create monitor page of the pump.

A. Hardware design

The complete design of the proposed insulin pump is shown in Fig. 1, the circuit consists of:

- Monitoring circuit using LEDs
- Control Unit
- Display unit (LCD).
- Stepper motor and driver circuit.
- Equivalent circuit of the sensor.

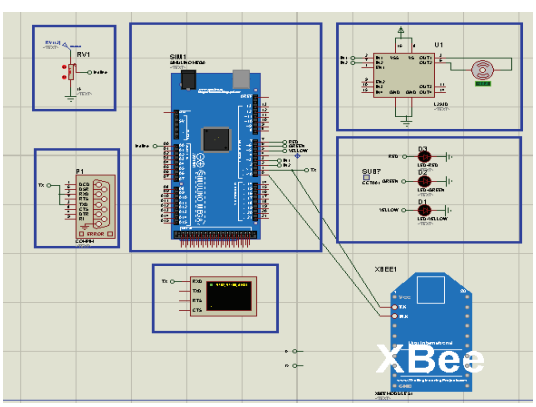

Fig.1. Electronic circuit

Three different colors LEDs the green, yellow and red were used as indicators to indicate a specific values of the glucose levels in the blood where three status of glucose were considered in respectively the normal , the low and the high level of glucose. In this paper the glucose sensor operation is simulated using a variable resistance as shown in Fig. 2.

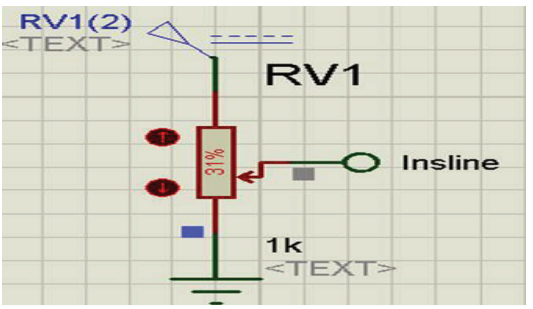

Fig.2. Glucose sensor

The driver circuit and the motor are controlled by the Arduino mega control unit in order to organize the operating of the insulin pump.

B. Software implementation

The proposed design includes two main functions: organizing the glucose level in the blood and monitoring the glucose in the blood. The first function is done by using predefined dose of insulin specified according to the measured value from the sensor as shown in Table I.

TABLE I
INSULIN DOSE

Dose	Glucose Level mg/L	Description
-	G< 80	Low
-	80≤G≤120	Normal
2 unit	120<G<250	High
4 unit	G>250	Very High

The operating algorithm which controls the pump is shown in Fig. 3. The first step starts entering the username and password to open the monitoring page of the system the inserted username and password are compared with the stored data. If the does not match, returns to the beginning and if it matches, the system goes to the next stage. The sensor reads the glucose level and then the measured data is sent directly to the controller which processed it and decides the required insulin dose according to the glucose level as it shown in Table I. The pump starts to pump insulin and measuring the glucose level continuously this function repeats at specified time. The color of LED selected according to

the specific level of glucose and the insulin value is displayed on the screen.

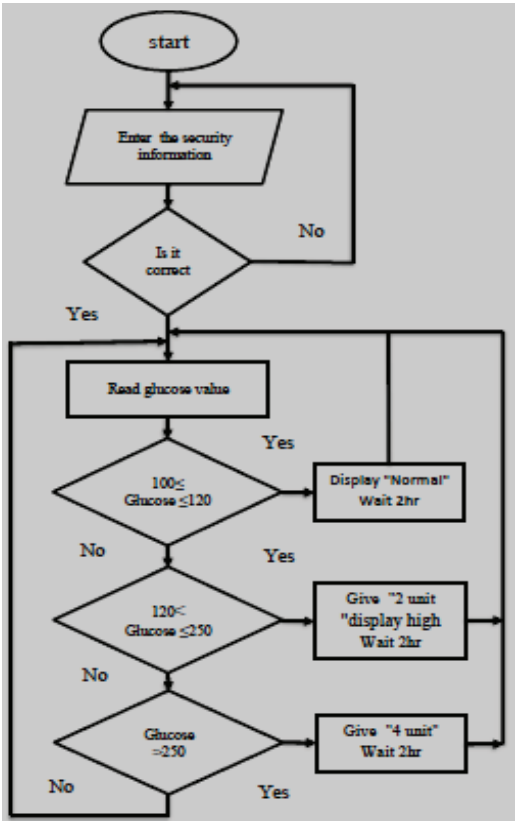

Fig.3. Algorithm

C. Monitoring Page

This section of the paper discussed the interface monitoring screens which connected wirelessly to the hardware circuit, and main page. Which displays the received information from the hardware. In the security page as shown in Fig. 4, user must enter the correct information to login towards the main page.

Fig.4. Security page

If the login information is correct, a successful massage appeares as shown in Fig. 5.

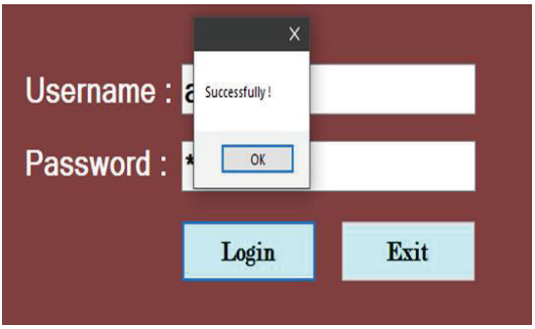

Fig.5. Successful Login

Similarly an error message is displayed if the login data is incorrect as shown in Fig. 6.

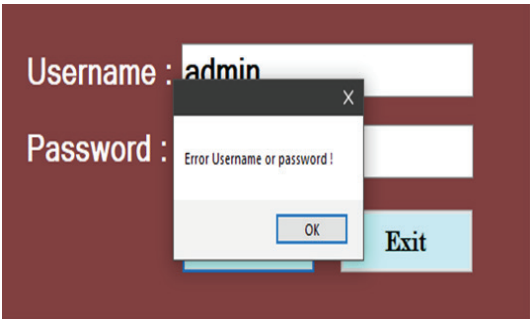

Fig.6. Incorrect Login

The main screen to monitor the insulin readings contains connection button as shown in Fig. 7.

Fig.7.Main page

The monitoring page at the receiver side connected wirelessly to the transmitter circuit and connected through the serial port at the receiver end. The final component of the connection between the circuit and the monitor is the serial port emulator VSPE program, when a connection occurred it will display as shown in Fig. 8.

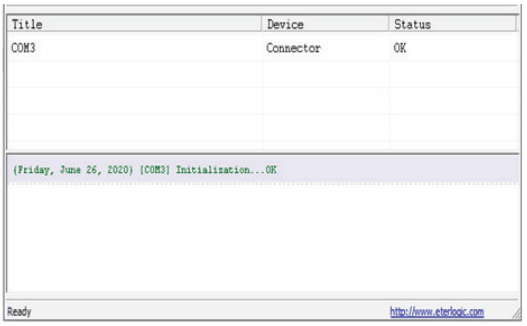

Fig.8. Serial connection

IV. Results and Discussions

Computer aided tool used to simulate and test the proposed design. The system was tested in different operating cases to ensure that it provides efficient service. The results include the indicator status and the received data in the monitoring page the first case as shown in Fig. 9 is the normal case in which the glucose level was within the normal range.

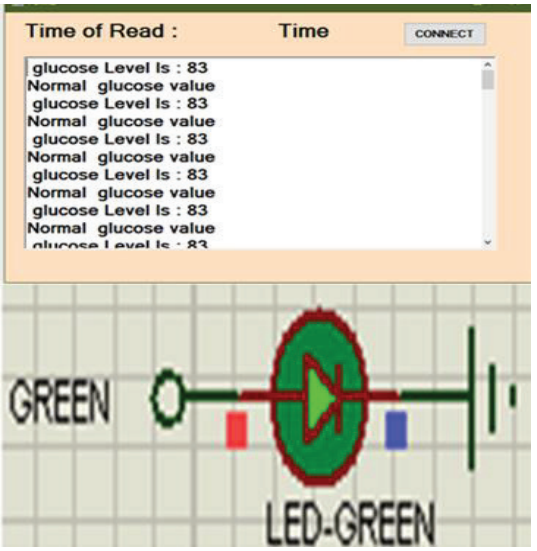

Fig.9. Low case

As shown in the simulation results of the normal case the green indicator was turn on and the monitoring page displayed the level and the status. In the normal case there is not an injection of insulin. The second test is shown in Fig. 10. In this case the glucose level is under the normal range and the specific color of the indicator in this case is red.

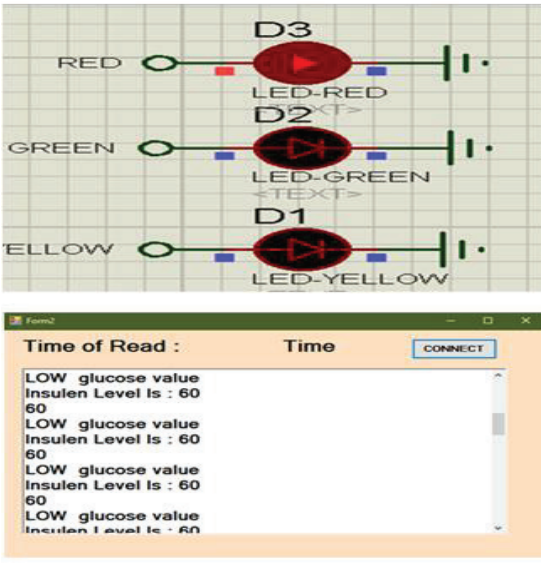

Fig.10. Low level

The third case as shown Fig. 11 is the high level of glucose and the pump provides two unit of insulin.

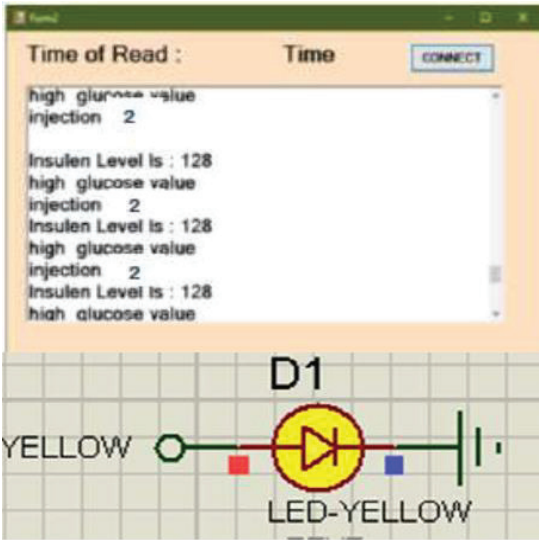

Fig.11. High Level

Similarly, the very high level of glucose is shown in Fig. 12. The pump in this case operates to provide four units.

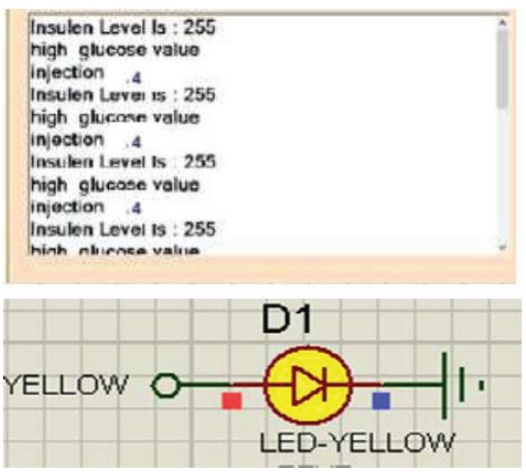

Fig.12.Very high level

V. Conclusion

This paper presented closed loop insulin pump using wireless monitoring system. The system was simulated using computer aided tool and the results were analyzed and discussed. Three operation cases were considered, the low level of glucose, the normal and the high level of glucose. Each operating case specified by using different LED color. The overall results proved that the system works correctly and provides excellent service.

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