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Design and Analysis of Automatic Insulin Delivery System Using Pic Microcontroller

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Abstract

In our country millions of peoples are affected by diabetes. In future, this range will get increased as said by the World Health Organization (WHO). Diabetes is a chronic disease and has the high risk of heart attack, stroke and in later stages cause blindness, kidney failure. This is mainly associated with insulin production and its action. Hence to recover the diabetic patients from these risks, insulin must be given periodically to the persons. Nowadays insulin is given to the diabetic patients by injector, inhaler or by syringes. This is not a precise method to sustain our blood glucose level. So to manage the problems related with this complex disease, automatic insulin pump provides the better blood glucose level maintained by injecting the insulin at regular intervals. This insulin pump supply distinctly limited dosage of insulin to diabetic persons who require multiple injections daily to maintain their glucose level in blood. This system automatically provides insulin at predefined times regularly, so that they keep control of blood glucose level.

Keywords*: Diabetes, Blood glucose, Insulin pump, Automation, Microcontroller.*

1. Introduction

Insulin is one of the important hormone produce in our body. This is made by the pancreas that allows human body to use sugar (Glucose) from carbohydrates in the food that humans eat for energy. Insulin helps to keep blood sugar level in human from getting too high (Hyperglycemia) or too low (Hypoglycemia) [1].Abnormal insulin production in human body will lead to diabetes mellitus. This is a chronic disease and has the high risk of heart attack, stroke, kidney failure and blindness. Hence to avoid these high risks of this disease insulin must be given to the patients artificially. Now a day's insulin is given through injections, inhalers and syringes. But injection method is not a finest method for persons who are affected severely by diabetes. Because if they forget one time to take this injection, then it will lead to many problems for them. In order to avoid these issues, automatic insulin delivery system will exhibit better performance over traditional method. It automatically delivers predefined insulin dosage at predefined time [2]. Hence it reduces the high risk of diabetes.

Automation

Automation plays a major role in this insulin pump. This pump is designed mainly based upon the automation concept. Automation is nothing but a technology which reduces the human efforts and human errors to give better accuracy. Automation is mainly done in the control system of a unit. The control system is automated by many ways but here microcontroller is used because this automatic insulin pump is a compact unit, i.e.

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size of the system plays a important role. This must be portable and it comes under the embedded system. Embedded system is a system which is mainly designed for a specific task or work [3]. So Microcontroller will be the best solution for this unit. Automation in these types of medical devices will help us to make a better improvement in treatment of these types of chronic diseases.

Insulin pump

Insulin pump is a small, computerized device that delivers insulin continuously throughout the day. It attempts to mimic the normal pancreas release of insulin, but we must tell the pump how much insulin to inject. This is an automated device which can be able to deliver limited dosage of insulin at defined times. It is like a pager, patients can carry and wear it under the abdomen throughout the day and insulin is injected to the body by a small needle [4]. There are two types of Insulin based on the amount it comes out such as Basal insulin and Bolus insulin. Basal insulin is referred to as "Background insulin". Basal means Base i.e. it is produced in continuous and tiny amount. It is produced between meals and during the sleep and keeps the body stable between the meals and night. Bolus means large amount. A person needs large tracks of insulin whenever he goes to eat because human body needs this large amount of insulin to match the glucose level during their food time [5]. This insulin pump is mainly designed to deliver the bolus ratings of insulin i.e. before their meals.

Objectives

The main objectives of this insulin pump are to provide multiple injections everyday automatically to the patients and to maintain better glucose level in blood, recover the diabetic patients from complex issues, to avoid high risks of diabetes and to avoid injuries or marks in diabetic patients by taking multiple injections daily.

2. Problem Identification

Nowadays, persons with diabetes are taking insulin through injections, inhalers, infusers, etc., this type of insulin consumption will make marks, injuries, scars in the patients skin so aged persons will get greatly affected by this process. These Injectors can also cause bruising. They are more painful than injections and also expensive [6]. Implantable insulin pump requires surgery to implant it and Insulin patch does not pass through the skin easily. Then, today peoples are living in a hurry burry life so it is possible to forget to take insulin once a day. If peoples affected severely by diabetes and are in matured stages it will lead to severe complications such as giddiness, low blood sugar level, shivering etc. To overcome these types of issues, automatic insulin delivery system (Insulin pump) will provide a better solution because it will spontaneously deliver the insulin to the patients once they set [7].

3. Description of Proposed System

Automatic insulin delivery system is proposed to overcome the above issues in the traditional devices. This insulin pump is a device looks like pager and it can be fixed at the lower abdomen i.e. waist where the people wears belt. It is a portable device so everyone can easily carry this device. This system automatically delivers the limited dosage of insulin at appropriate time regularly for those taking multiple injections daily. A view of the device is created and shown below.

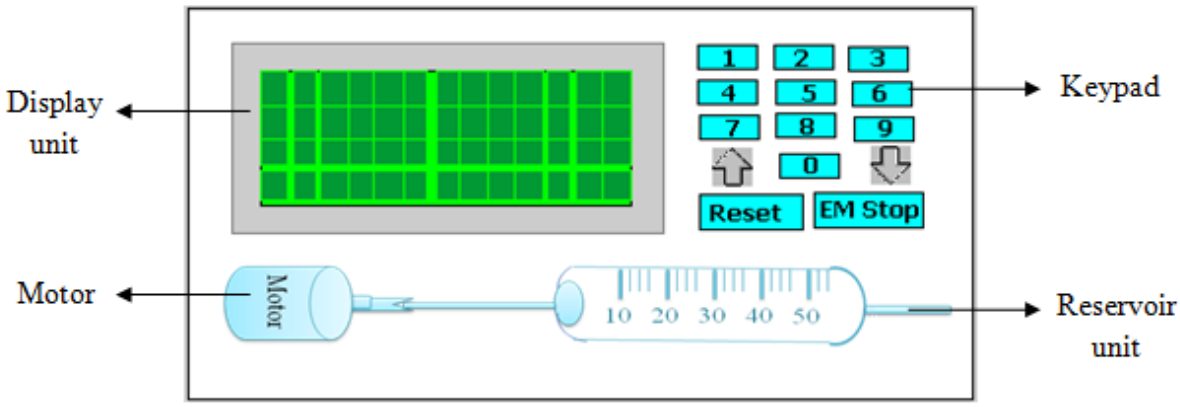


Figure 1. View of the Proposed System

4. Block Diagram of Proposed System

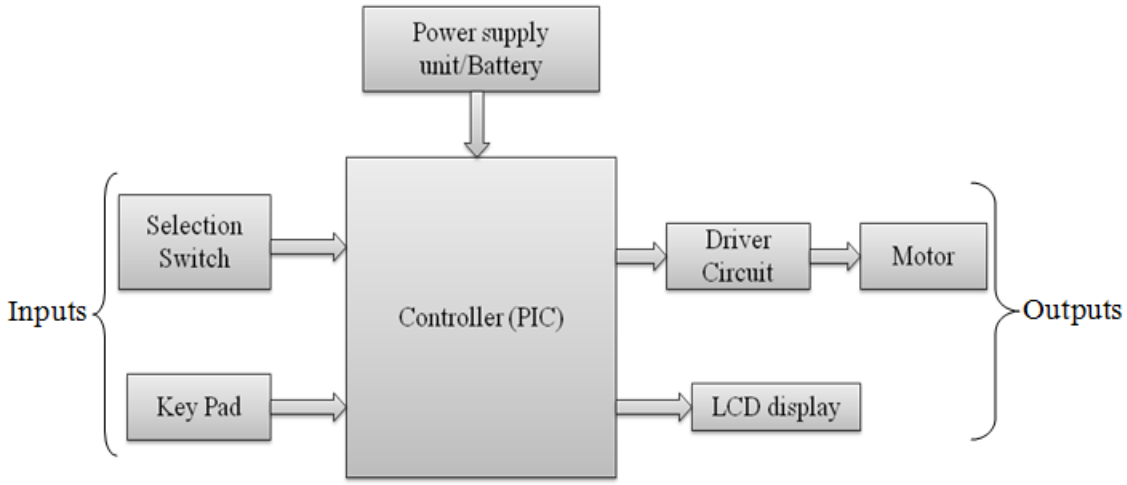


Figure 2. Block Diagram of Proposed System

The above diagram shows the block diagram of the proposed system. It consists of both hardware and software components. Hardware components comprises of Power supply unit (Battery), Input and Output unit. Selection switches, keypads comprising the Input unit. Microcontroller acts as the brain and controls the overall system. Output unit consists of Motor and LCD display. RTC (Real Time Clock) will provide the time to the controller and required timings can be set in the RTC, controller will send signals to the motor at that time only to infuse insulin. Time and dosage level can also be adjusted through this system.

5. Description of Hardware Components

Power supply unit is used to give power to the entire system. Here 9volt battery is used. Selection switch is used for on/off the overall system and it is used to select the time and dosage level. Keypads are used to enter the required values and timings. These are input devices and hence used to give input signals.

Control Unit

Microcontroller acts as the brain of the system and it controls the entire unit. It gives commands to the output units based on the signal from the input devices. PIC16F877A series is used here with PIC16f &18f microcontroller board. It is 8 bit, 28 pin microcontroller and is one of the latest products of Microchip. It has many advantages such as low cost, wide range of applications, easy availability so it is used in control of different process. RTC (Real Time Clock) is used to set time for user [8].

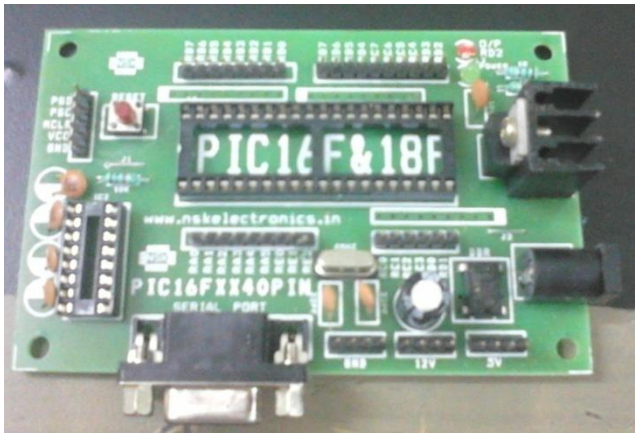


Figure 3. PIC 16f Microcontroller Board

Figure 4. PIC 16F877A

Output Unit

The output devices used in this system are motor, LCD display. Servo motor with 4.8-6.0 VDC operating voltage is used in this system. Driver IC is used to drive the motor, it is used here because it will provide higher current signal by taking low current controlled signal. To display timings, values entered, messages LCD display is used at the top of the system [9].

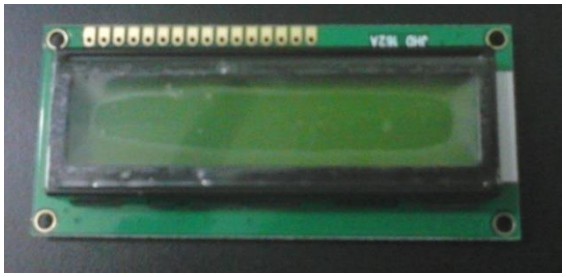


Figure 5. LCD Display

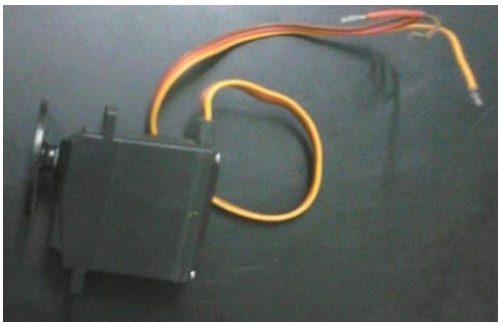


Figure 6. Servo Motor

Software Description

Software used for programming the entire system is mikroc pro for PIC controllers. It is a full-featured ANSI C compiler for PIC devices from Microchip. It is one of the finest solution and prime software to develop coding and program for PIC microcontrollers. It provides Integrated Development Environment (IDE) and hardware, software libraries. It has complied with advanced optimization [10].

6. Working of the System

This system has start and stop (On/Off) switches. Entire system is start and stop by these switches and it has one menu switch. Using this user can select timing and dosage level for them and also they can change their previous settings. Then it has one up and down switches for scrolling. Each and every instruction will display in LCD. It acts as the interface between the user and controller. When the user ON the system, RTC gets on and they can enter their values. The motor starts rotating when the defined time reaches. Whenever motor got signal pulses it actuates the screw rod to rotate clockwise, at that time syringe unit attached at one part of the screw rod moves in the forward direction and delivers insulin through the tube which is at the end of the syringe unit. The below flow diagram will show the working of the system.

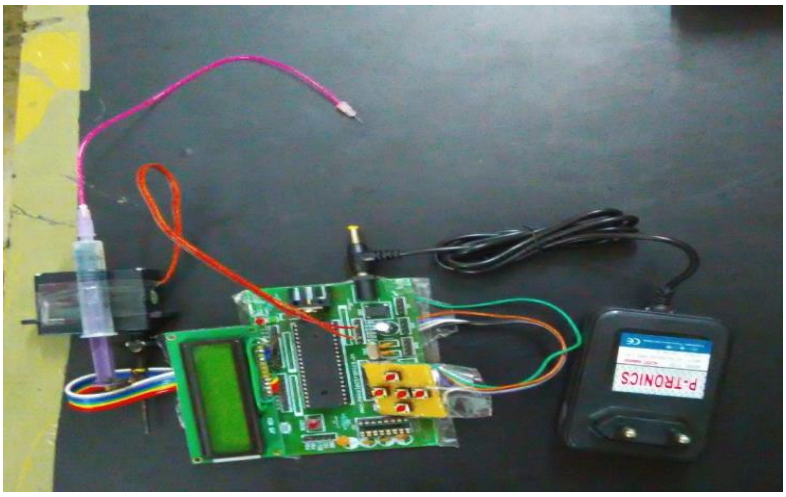
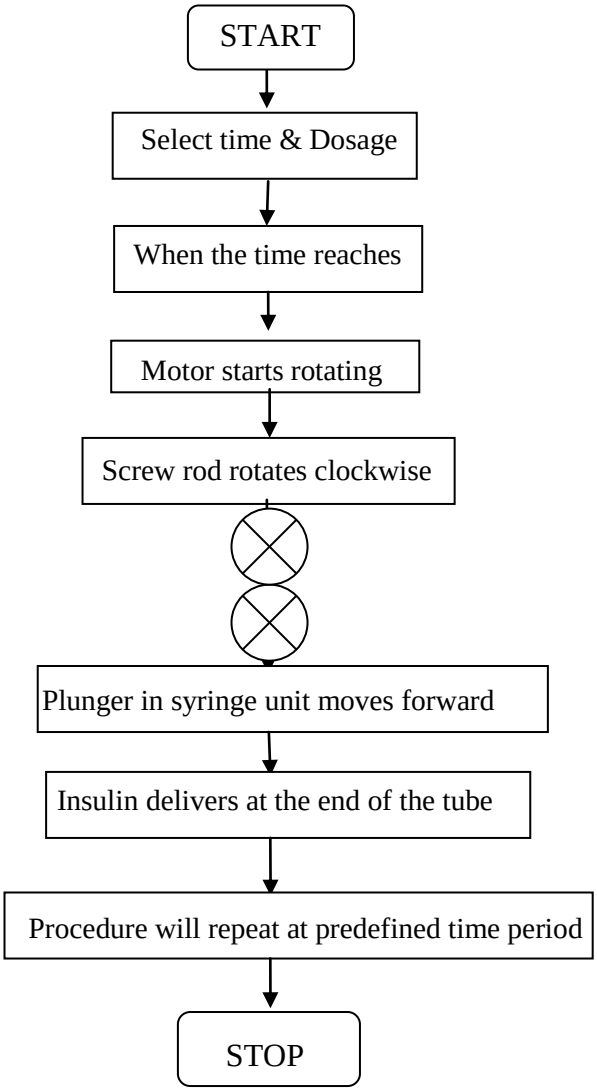


Figure 7. Internal View of the System

Figure 8. Prototype of the Proposed System

Flow chart



7. Advantages

This type of automatic insulin pump will offer numerous advantages. They are insulin delivery will be precise, it reduce the risk of blood glucose level so tighter blood control, reduces the risk of side effects such as heart attack, hypoglycemia, blindness etc, it offers greater flexibility [11].

8. Results and Discussion

In this section, automatic insulin delivery system for diabetic patients with low cost was discussed. To make this system automatic, PIC microcontroller was used and mikroc pro for PIC software was used for programming the PIC microcontroller. This system gives more advantages such as more flexibility, easy to use, simple mechanism, etc,. The insulin delivery of the system was appropriate and it gives nearly 0.20 – 0.30 ml of insulin. Screw rod is attached between the motor and the syringe unit. One tube with small needle is attached at the end, so that insulin will be given to the patients through this needle.

UNITS	Actual Volume get by U-40 Insulin syringe	Volume get by Automatic insulin system
1	0.025 ml	0.022 – 0.027ml
2	0.05 ml	0.047 – 0.052 ml
3	0.075 ml	0.073 – 0.077 ml
4	0.1 ml	0.097 – 0.012 ml

In U-40 insulin 10 units is 0.25ml but this system gives nearly 0.22 – 0.28 ml. Future work of this project will be increasing the accuracy of the insulin delivery system.

Volume of insulin get in different trials of different units is shown in the above table.

9. Conclusion

In this paper, a prototype of automated insulin pump by a PIC microcontroller with low cost has been designed and model was created. The accuracy of this system also checked. It has been tested for its functioning of delivering insulin to the required accuracy level. It delivers insulin nearly to the accurate value. This type of automatic insulin pump will be very helpful to the severely affected diabetic peoples. This insulin pump is used to maintain the blood glucose level of patients so that they can avoid high risks of diabetes mellitus and will lead a better life. It is easy to use so everyone can use this pump and it has simple mechanism. The cost of this pump also is very low so every person can able to buy this.

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