Driving and Controlling Circuit of Insulin Pump

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Abstract. The main objective of this research is to preserve the life of the diabetic patient by designing a system that regulates insulin doses for the patient throughout the day, and that .By providing alerts, alerts and warning messages to the patient in the event of a drop in blood sugar or a severe increase, and they provide corrective doses in time ,it is appropriate to avoid dangerous and sudden cases that the patient may be exposed .Where it enables this system the patient to maintain normal levels of glucose by infusing an appropriate amount of insulin is the same as the normal pancreas does in the body of people without diabetes. Patients who used an insulin pump experienced a slight improvement in their blood sugar control, compared to patients who received injections of insulin.

Keywords: Insulin Pump, diabetes, glucose level, blood sugar, insulin injection, controller, simulates .

Introduction

An insulin pump is a small electronic device about the size of a mobile phone, which makes it easy to carry on a belt, in a pocket, or attached to a bra. An insulin pump helps you and your medical staff by simulating the function of a healthy pancreas and delivering basal insulin to the body by delivering small amounts of rapid-acting insulin throughout the day and night. Therefore, this device is invisible to others and provides you with invisible treatment.The pump performs a function similar to that of a healthy pancreas: By injecting insulin under the skin, the pump compensates for the need for frequent injections by giving precise doses of rapid-acting insulin 24 hours a day in an amount that approximates your body's needs..Diabetics have difficulty following some traditional methods of treatment and maintenance their level of blood sugar within the normal limits within the bloodstream. From this standpoint we directed to accomplish an action. It enables the patient to maintain normal levels of glucose by infusing an appropriate amount of insulin is the same as the normal pancreas does in the body of people without diabetes. A prototype of an insulin pump has been implemented and it is the latest technology to administer the quantity the right amount of insulin at the right time and with the least amount of intervention or help had been implemented .The pump model using modern electronic elements, the most important of which is the micro-control processor through which all parameters can be controlled in terms of pumping volume and time thoroughly treated [1-4].

2. Theoretical

We will learn about the pancreas, its location in the human body, its four main divisions, and its secretory ducts, some of which are main and others are sub-branches, through which it secretes its digestive juices, and the functions of the pancreas as it secretes two types of juices, each of which has a specific function. Pancreatic cells, most commonly islet cell, beta cell, produce insulin, the key hormone [8] in regulating carbohydrate, fat, and protein metabolism. Insulin is important in many metabolic processes: it promotes the uptake and metabolism of glucose by the body's cells; It prevents the liver from secreting glucose. makes muscle cells absorb amino acids, which are the building blocks of protein; It prevents the breakdown and release of fats. Insulin secretion from beta cells can be stimulated by growth hormone (somatotropin) or glucagon, but the most important trigger for insulin secretion is glucose. When the level of glucose in the blood rises, for example after eating a meal, insulin is released to counteract it. The inability of islet cells to produce insulin or the inability to produce sufficient amounts to control the level of glucose in the blood is one of the causes of diabetes.

3. Pancreas

The pancreas is a pear-shaped organ 6 to 10 inches long that extends horizontally behind the stomach in the upper left part of the human abdomen, and is surrounded by the small intestine, spleen, and liver. The pancreas acts as a ductal gland that secretes digestive juices and as an endocrine gland that regulates the level of sugar in the blood. This article aims to define the structure and functions of the pancreas and the most important diseases related to the pancreas.**3.1**

Functions of the pancreas:

The pancreas performs many vital functions in the human body, including: Secretion of digestive juices: The exocrine glands in the pancreas secrete a digestive juice that contains enzymes that break down food into small particles that can be easily absorbed. Among these enzymes: amylase enzyme that helps digest carbohydrates. Trypsin and chymotrypsin, which help digest proteins and convert them into amino acids. The

lipase enzyme that helps digest fats and convert them into fatty acids and cholesterol [5-7].

Fig.1 anatomical structure of the pancreas

3.1 Location of the pancreas:

located in the abdominal cavity at the level of the first or second lumbar vertebra, and it is in a position deeper than the stomach, so it is located behind it, its length is about 15 cm, and its weight is about 70 grams. Its outer surface appears to be divided into small parts,

3.2 Insulin Pump

Insulin pump is the latest in modern technology for insulin injection. It helps diabetics to take the necessary amount of insulin, at the right time and with the least amount of intervention or anyone else's help

Insulin pump consists of following main sections:

- A reservoir is similar to an insulin tank.
- Battery powered pump.
- A small computer device enables the user to give the real amount of insulin figure.2 shows an insulin pump).

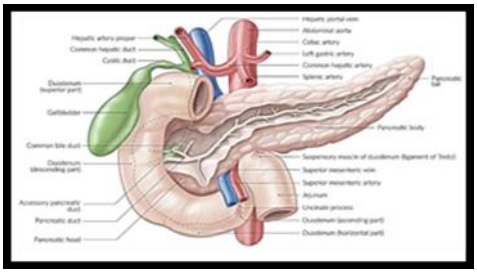

Fig.2 insulin pump.

3.3 Mechanism of action:

The pump is usually placed from the outside. It is connected to a thin plastic tube at the end of which there is a soft cannula through which insulin passes through. The soft tube is implanted through a needle under the skin or in the fatty part of the abdomen, where the location of the needle's stitches must be changed constantly. Instructions for insulin doses are entered through the pump's computer to give insulin in a stable calculation. The tube is changed every two days and can be detached from the pump when you are showering or swimming. With the simple press of a button, you can deliver the required amount of insulin anytime and anywhere. The pump produces a substantial amount of insulin during the day, and allows the user to program or manually control it to inject a dose of insulin at mealtimes or when needed. The pump reduces the fluctuation of the blood sugar level with the various daily conditions that the patient may go through [8].

4. working insulin pump patterns:

Pump acting on pumping specific insulin quantities for diabetics. However, this quantity varies according to the operating mode of the pump that has been chosen, as the user can choose between two working modes of the pump, according to it own condition, and according to metabolic activity. Basically, most insulin pumps operate according to two basic modes:

- Basic mode.
- Dietary dependent mode

4.1 Basic mode of insulin pump therapy

According to the basic working pattern, a constant rate of insulin will be pumped throughout the twenty-four hours of the day. So that these quantities of insulin pumped cover the patient's requirements in order to ensure continuous control of the level of sugar in the blood, so that it is kept within the normal range when choosing the patient to work according to the basic pattern, it first must that choose a very important parameter, which is the amount of the required daily dose of insulin Or, what is known as Total Daily Dose (TDD), in order to enter it, calculations are made. To assume that the patient weighs 60 kg,

We divide this amount by 24 hours to get the required amount of insulin per hour, i.e. the pump output flow rate. In our case, it is (24/30) = 1. 25 units of insulin every hour The amount of basic type insulin is equal to 50% of the total daily dose required for diabetic patients. There are many types of background insulin (ie, the insulin used in the basic form), the most common and used are medium or long term insulin.

4.2 features of the insulin pump:

- It provides the user with a better lifestyle compared to the use of other devices to control insulin. Improvement in the pump-based lifestyle is for patients with diabetes type 1 and type 2.
- Using rapid-acting insulin requires regular meals, and exercise regimen pre-needs to control blood sugar levels with slow-acting insulin.
- The programmed baseline level allows a specific insulin to be delivered in varying amounts at different times of the day.
- The use of dietary insulin from the pump is appropriate and better compared to injections.
- Insulin pumps make it possible to deliver adequate amounts of insulin compared to using of syringes. This supports a more accurate

control of blood sugar and hemoglobin levels, reduces the chances of long-term complications associated with diabetes, and saves money in the long term compared with the use of multiple daily injections.

5. Experimental Work

we will talk about the steps of the project, an explanation of the components of the main circuit of the Atmega16L microcontroller, the DC motor, the keypad, the LCD display and transistors, the feeding circuit, the mechanism of the circuit, the application of the circuit to Test board, circuit diagram plus microcontroller software.

5.1 work steps:

First: Conducting a theoretical study on the insulin pump and collecting information on the idea of the device's work.

Second: An adequate studying the electronic circuit and collecting information about electronic parts and datasheets.

Third: Implementing and testing the circuit on the Test board.

Fourth: Install the electronic elements on the fiber and test the circuit permanently.

5.2 Main circuit components:

- **Atmega16L microcontroller:**

In order to ensure continuous control of the pump operation and the other parts of the circuit, the Atmega16 L microcontroller will be used from the AVR family produced by Atmel . The AVR controllers are from the RISK architecture controllers. The Atmel family is based on Harvard architecture with separate data and software storage.

Programs are stored in fixed memory (in Harvard architecture) and non-fixed memory data for the data. As this feature produces a greater possibility for use in application systems under high electrical pulses etc. This leads only to restarting the program without losing the important transformers stored in the EEPROM memories of the controller.

Atmega16 L controller it often comes with 40-DIL packaging, which is characterized by the presence of 4 Input / output gates, each gate includes 8 pins, through which control commands can be sent, and various information to be received, as well as a pin for the controller resetting , which operates with zero logic, and can be activated externally. Fig.5 shows the electrode distribution of the controller.

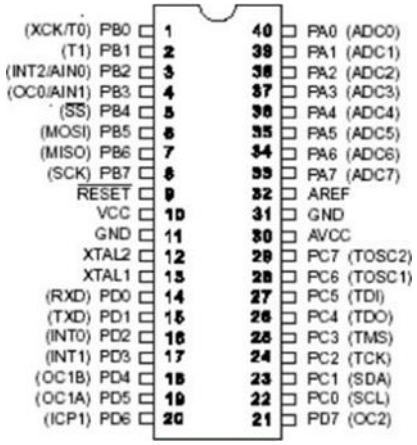

Fig.3 Distribution of controller poles.

5.3 Explanation of some controller poles:

- Poles PA0 - PA7: used as input and output gates as well as analog –digital switches .
- Poles PB0 - PB7: They can be used as input / output gates, and some of it poles are for controller programming, and in serial communications.
- Poles PD0 - PD7: They can be used as input / output gates,some poles like . RXD, TXD, INTO, INT1, ICP, OCIB which worked as interrupts.
- Poles : XTAL1, XTAL2 are the pins to which an external crystal is attached , according to a frequency desired by the programmer.
- The electrodes: MOSI, MISO, SCK, Reset, GND are the pins that used in programming the controller, and they can be connected to the computer via the RS-232 or via the USB or via the COM connection.

5.4 Interrupts:

The program usually runs in succession of instructions, except that an external event called "interrupt" can be entered which interrupts the operation of the program and starts the ISR routine interrupt service, and after the ISR service is finished, The program will return to work on the next instructions before the interrupt . System is able to call an ISR if the following conditions must be true

1) Interruptions should be generally enabled

2) The Interrupt mask must be enabled.

5.5 Timers / Counters:

A timer counter is a piece of hardware integrated with a microcontroller and is like a clock that is used to set a timer to trigger an interrupt at a certain point in the future.

When a certain point is reached, the interrupt can be used as an alert, triggering a different code, or changing the Pin output like an alarm for the processor. The importance of timers is that external

interrupts run asynchronously, or independently of the main program, instead of running a recurring loop called (millis), in which the timer can do its own work while the code does other things. Timers work by increasing the counter also known as the counter register as the counter register can count to a certain value, depending on their size [9-13].

The timer increases the counter one step at a time until it reaches the maximum value, after this, value the counter has reached overflows, and then returns to zero point.

Usually the timer gives signal in the event of overflows, and this signal can be verified manually as we can have an operator option to interrupt the timer, just like the interrupt instruction where we can specify the ISR system to run specific code when the counter reaches the overflow state. Over flows. Where (ISR) resets the overflows flag without us even seeing it. So using interrupts is usually the best option for simplicity and speed.

In order to increase the counter value at regular intervals, the timer must be able to reach the clock generator. The clock generator generates a regular repeat signal. In each time, the timer detects this signal, it increases the counter one time. The timers depend on the clock generator, and the smallest time unit must be a period of this clock.

Considering that we provided a 4MHz clock signal on the clock to the timer, we can calculate a period Timer according to the following equation:

T = 1 / f

T = 1/4 MHz = 1/4 * 10 + 6) Hz T = (0.00000025) s

T = timer period

f = clock frequency

5.6 DC Motor:

A direct current motor (DC motor) is a motor that converts electrical energy into kinetic energy only on DC systems. DC motors are divided into two different types of current:**The first**: is a symmetric motor.

The second: it is the drive of the bearing seat or the motor of the ball bearing.

- DC motors provide possibility speed control inflexible and dynamic more than AC motors by change the speed , torque and even rotation direction of engine according changes in laod and labor requirements within easy and simple mechanisms.
- DC motors are commonly used , especially small ones that works on low volts ((12 volts, for example) where using simple and low cost control system .

5.7 General structure of the DC motor:

In general, the electric motor consists of the following parts:

The rotor: It is the rotating part of the motor and is tightly balanced against vibrations and coated with materials especially for protecting files, called armature.

The stator: It is the stable part of the motor. It can be either the stator or the rotor were permanent magnets or electrical coils.

The structure: it is the metal body that surrounds the stator coils and protects the motor from external factors.

The axis: the part that transmits the mechanical movement to the load.

Collector: a split ring fixed on the axis of rotation that rotates with it, and its task is to change the direction of the current passing through the armature windings, that is, converting the current from continuous to alternating .

the coils: An electrical conductors to the collector and they are either copper or carbon fixed with springs to press the collector. The collector and motors are only found in DC motors.

Electrical conductors: used to conduct electrical current to the motor, as Fig.4 shows the general parts of a DC motor.

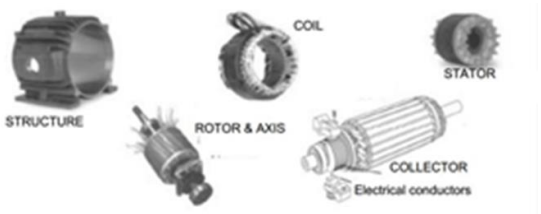

Fig .4 General parts of a DC motor

5.8 Keypad 4x4:

The keyboard matrix is a key configuration used as an input tool by defining and decoding the key that was pressed when there are more than eight keys necessary for use, and it also reduces the number of connections; The 16-key keyboard is arranged in a matrix of four columns and four lines (4X4) and thus it needs eight lines of the processor to achieve all connections instead of 16 lines when connected in a linear connection. The benefit of this method appears in short the gates entrances, and the greater the number of keys, the more evident the effect and usefulness of this method.

Fig,5 shows the keyboard used in our project.

The lines and columns of the input panel are known by the datasheet, as it can be done by experimenting with a voltmelemeter. Where we put one of the poles of the potentiometer on one of the wires and pass the other pole over the rest of the wires, knowing that the potentiometer is placed on the option of short.

5.9 LCD display screen:

It is an optical device consisting of crystals arranged on a thin surface divided into severalelements supported by a backlight, the crystal converts polarized light to display an image, symbol or sign. A screen consists of elements that represent points of color or light. Using the electric field we control the direction of the light and with the help of a polarizing filter and backlight the image we are using in our project shows a 16 x 2 LCD display to make the results easier for the user to read.

This screen has 16 pins, where **Table 1** shows the name and function of each bolt

Table 1 LCD poles

ITEM	SYMBOL	LEVEL	DESCREPTION
1	V_{SS}	L	Power GND
2	V_{DD}	H	Power Positive
3	V_{EE}	L	Voltage for LCD PANEL Drive
4	RS	H/L	Register Select
5	R/W	H/L	Read/Write Select
6	E	H/L	Read/Write Enable
7	DB_0	H/L	Data Bus
8	DB_1	H/L	
9	DB_2	H/L	
10	DB_3	H/L	
11	DB_4	H/L	
12	DB_5	H/L	
13	DB_6	H/L	
14	DB_7	H/L	
15	K	L	LED BACKLIGHT -
16	A	H	LED BACKLIGHT +

5.10 Capacitor:

Component of an electrical circuit, device that stores electrical energy or electrical charge for a period of time in the form of an electrical field, formed between two conductors, each of which carries an electrical charge of equal magnitude and opposite sign. The electrical charge is then depleted or dissipated over time (the two plates are separated by an insulating material).

When installed in an electrical circuit, it can discharge the stored charge instantaneously, and it can also be recharged. The type of capacitor is determined according to the insulating material used in its manufacture, if it is from air, the name is called an air condenser, or plastic if it is plastic, or mica capacitor, or ceramic capacitor and so on according to the type of its material. If use chemical solution as buffer chemical condenser. In the feeding circuit, several chemical capacitors were used in the following locations:

1- On both ends of the battery, to erase the noise resulting from the operation of the engine.

2- On the output of the regulator, because the resulting voltage may be unstable at the value of 5V instantaneously (which is not desirable for the processor), either in excess or less than that, so the capacitor stores the charge if the voltage is greater than 5v and discharges the charge if the voltage is Less than 5v, and thus we have maintained a constant input voltage for the processor and protected it from any unwanted frequencies that may affect itsoperation

6. Mechanism of circuit work:

- Income: a section which consists of feeding circuit, keyboard, which provides data entered.
- Processing unit: It is the At mega 16L processor that processes the input data,controls it and transforms it into information that can be understood by the output units.
- Output: represented by the LCD screen and the motor, which shows the processing operations in writing or mechanically, such as the pumping process of the engine, and there is the drive unit that drives and controls the engine's work.

6.1 Mechanism of action:

1. The insulin pump works with two basic patterns, "dietary pattern, basic pattern" and it is possible for each pattern to work separately or for the two types to be combined into one type.
2. The basic pattern was chosen because it enables us to implement all the basic pump functions without entering into the complexities of calculating examples of the dietary pattern, which follows according to the medical condition.
3. In this project, we will replace insulin with water for easy handling, add the possibility to experiment and show the result. For the speed in showing the result, every hour will be considered a real 10 seconds, and we have thus simulated the normal time.

4. To pump a certain amount of insulin every hour (10 seconds) without the presence of a sensor to indicate the amount of insulin entering the blood (so we need to model the pump and transmission tools). Either we constant the pumping time and change the pumping speed, or we constant the pumping speed and change the time.

5. In this project we chose to fix the pumping time and change the pumping speed, according to the patient's weight in order to deal with the timer and with the PWM signal that will change the pumping speed according to the patient's weight being entered

6. Power circuit: We need a Power component to transfer the signal to the PWM to the motor. And the same frequency and same values because the processor cannot give the right voltage and current to drive the motor. So we chose a combination of two transistors, the first NPN transistors BD243, which transmits the signal inverted to the MOSFET IRF520 transistor, which is driven by the inverted voltage because it is of p-type and thus the signal arrives at the PWM in the correct form while allowing the motor to draw the required current.

7. Results and Discussion

We found that high blood glucose negatively affects human health.Therefore, we implemented this project to control the blood sugar level through the (income) monitoring unit.Simulated by keyboard instead of a blood sugar sensor and with pumping dosed insulin specified by a pumping unit simulated by a simple DC motor.

Thus, in this project, we obtained a model that simulates the functioning of the insulin pump present in the market is only one (basic) pattern due to the complexity of the calculations of the dietary pattern examples that follow medical condition by applying a series of electronic circuits after replacement The real thing in the pump, with simple circuits and mechanisms, through which we were able to obtain an acceptable results close to the actual results of a regular pump [14-16].

Conclusion

The field of medical engineering is witnessing a continuous and remarkable development in conjunction with the development of science and technology which enriches the medical field with diverse and innovative ideas for developing advanced medical devices that contribute to better diagnose and treat chronic diseases, including diabetes, which revolves around an idea of our project.

There are a lot of ideas that could be applied to the insulin pump circuit system of the near future, among these ideas:

- Work on developing pumps of smaller size so that they perform their task more precisely.
- Designing a servo-motor insulin pump that delivers high-precision and better results DC motors and stepper motors.In conclusion, we hope that we have succeeded in understanding the various aspects of the project and explaining all ideas

We also hope that the completed circuit will achieve scientific benefit in treating diabetic patients and be

A base upon which to build larger projects with more varied and accurate tasks that can be implemented soon.

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