Proc. Annual Symposium on Research & Industrial Training, 02(2015) 213-219
Department of Electronics – Wayamba University of Sri Lanka

LOW COST PUMP TO REGULATE DELIVERY OF DRUG INFUSION

D.P.L. Wijesinghe*, W.A.S. Wijesinghe

Department of Electronics, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka

*prabath89lk@gmail.com**

ABSTRACT

This paper describes the design of a low-cost drug delivery system to regulate the drug infusion. Drug delivery system is a small infusion pump used to gradually deliver drugs, at low doses and at a constant or controllable rate of drug to a patient who needs to take a drug-dose regularly in a specific period. Commercially available drug delivery systems imported from foreign countries and they are expensive. Moreover, repairing of these systems are difficult and general practice is to replace it with a new one. The. The designed system consists of a microcontroller to control the mechanical part, which applies pressure to the syringe pump. The rate of infusion of the drug can be set by the keypad, which will be used to calculate the RPM of the stepper motor attached to the shaft. The results show that the prototype design works well for controlling the infusion rate that can be used in medical service.

Keywords: Drug delivery system, Microcontroller, Stepper motor, LCD

1. Introduction

Programmable Drug Delivery Systems have been used to deliver very small quantities of drugs over long periods of time. They are also commonly called Syringe Pumps. Infusion is a method of delivering fluids, medication or nutrients into a patient's Circulatory system and it is generally used intravenously, although the subcutaneous, arterial and epidural infusions are occasionally used. Infusion pumps are typically found in hospitals and other point of care environments.[1]but commercially available syringe pumps are very expensive, unreliable and operating manually. They are not available commonly in some hospitals and unable to repair when it is damaged. This project was to implement a low cost drug delivery system using microcontroller technology. This system will deliver specific amount of medication dose gradually to the patient in regular periods of time. The design had been achieved by using microcontroller that drives a stepper motor in specified period of time proportional to the dose Rate required to be injected by syringe

pump system. The most popular use of my system is in palliative care to continuously administer drugs such as analgesics (painkillers), and in delivering of the insulin solution to patient who is suffering from the Diabetes disease, to deliver the desferrioxamie solution to patient having Thalassemia disease, antiemetic (medication to suppress nausea and vomiting), hormones, or other medicines, such as opiates.[2]

2. METHODOLOGY

2.1 System Overview

We have designed and implemented a prototype of basic drug delivery system whose functional block diagram is show in Figure 1.The keypad is used to enter the dose and the time period required and input values and the remaining time are displayed on the LCD. The Dipswitch is used to turn on the system. The main controlling part of the system is a microcontroller. We use Arduino Mega microcontroller since the board consists of required input/output connections. The microcontroller drives the stepper motor through the driver IC (L298) according the rate entered using the keypad. The stepper motor is connected to the mechanical shaft to apply pressure to the syringe.

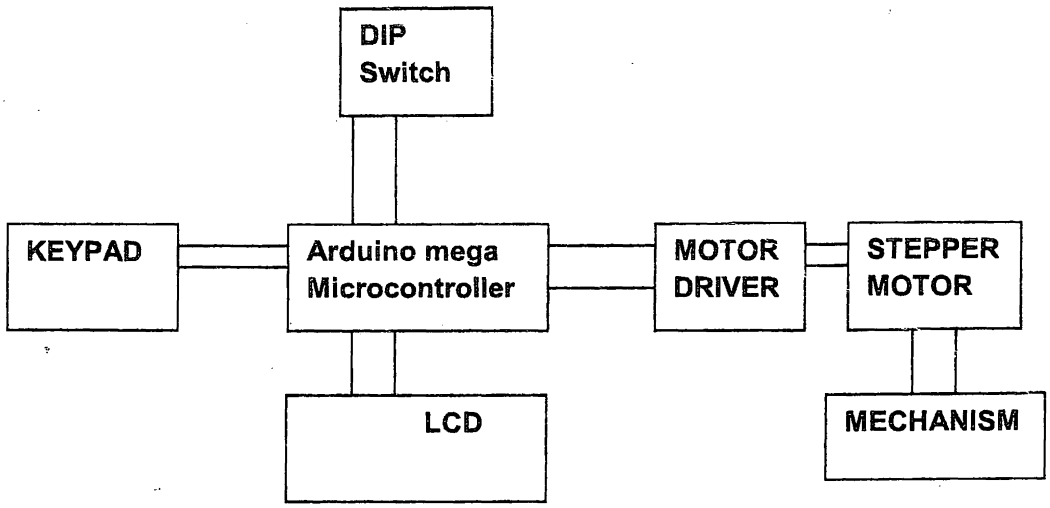

Figure 1: Block Diagram of the system

2.2 Mechanical part of the system

Linear actuator is used to move the piston of the stringer. It consists of screw rotation moving mechanism as shown in figure 2. Thread bar is directly connected to the stepper motor. The rate of movement of the actuator depends on the speed of stepper motor.

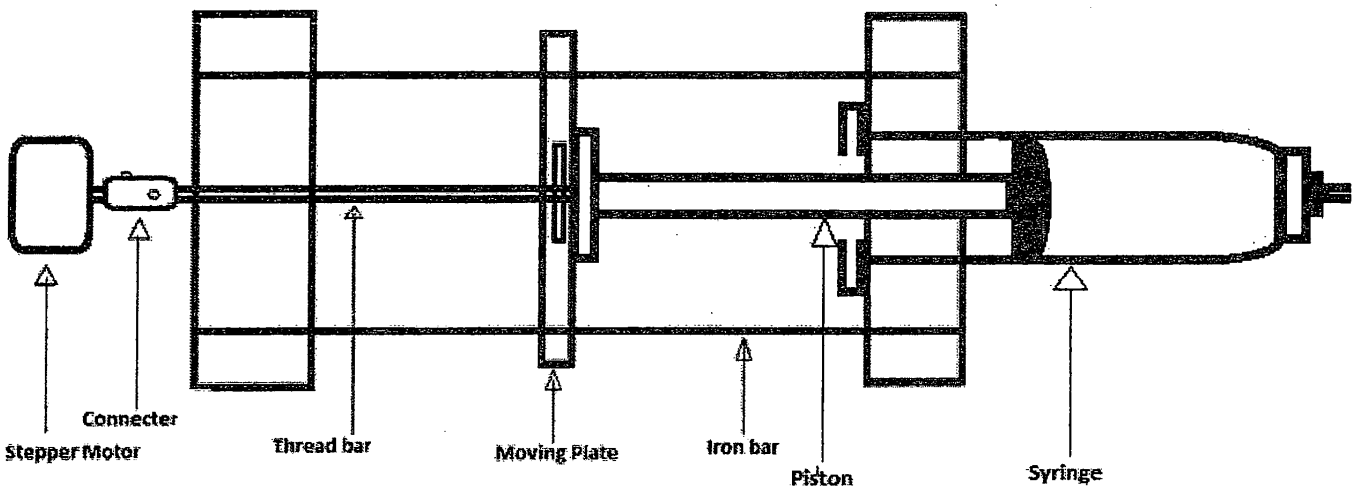

Figure 2: Mechanical part of the system

2.3 Circuit Diagram

The circuit consists of data input (keypad), display (LCD), and stepper motor driver parts as shown in the Figure 3.All the processes is done by Atmega 2560 microcontroller[4]. Keypad is connected to digital input pins and LCD is connected to digital output pins of the Arduino board. Bipolar stepper motor needs 4 input signals with different sequence of data to generate its rotation. We use L298 Motor Driver IC to drive the stepper motor which provide the required power requirements to the stepper motor.

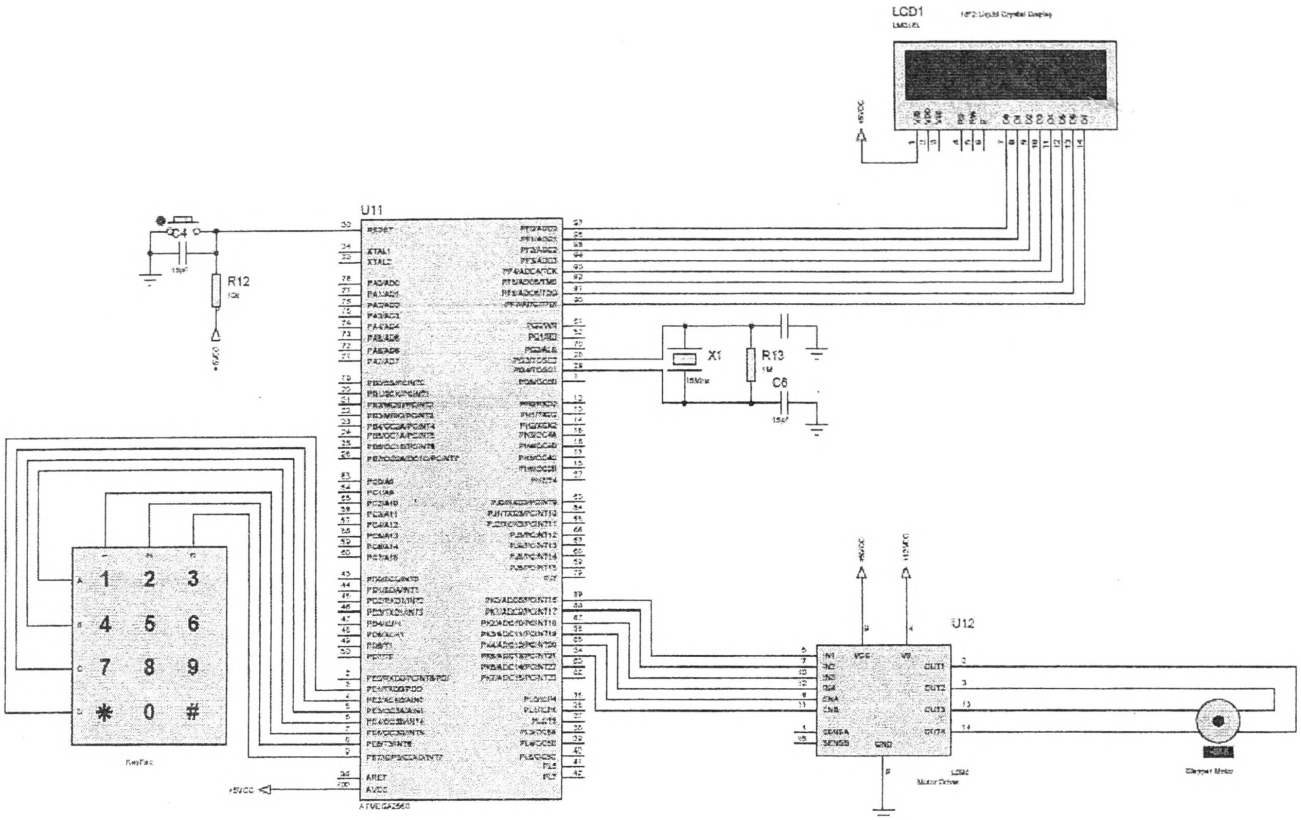

Figure 3: Circuit diagram

A -Atmega 2560 Microcontroller

B -Dial Pad

C -L298 driver IC

D -Stepper Motor

E -Liquid Crystal Display

X1 -Crystal Oscillator

R12 -10k Resistor

R13 -1k Resistor

S1 -Dip Switch

C1,C2,C3 – 10nF Capacitor

The Figure 4 shows the part of the prototype design. It contains 16 inputs keypad and 16*2 LCD for value input and display, motor drive circuit and stepper motor for mechanical part and Atmega microcontroller for processing part. The stepper motor directly connected to the mechanical part.

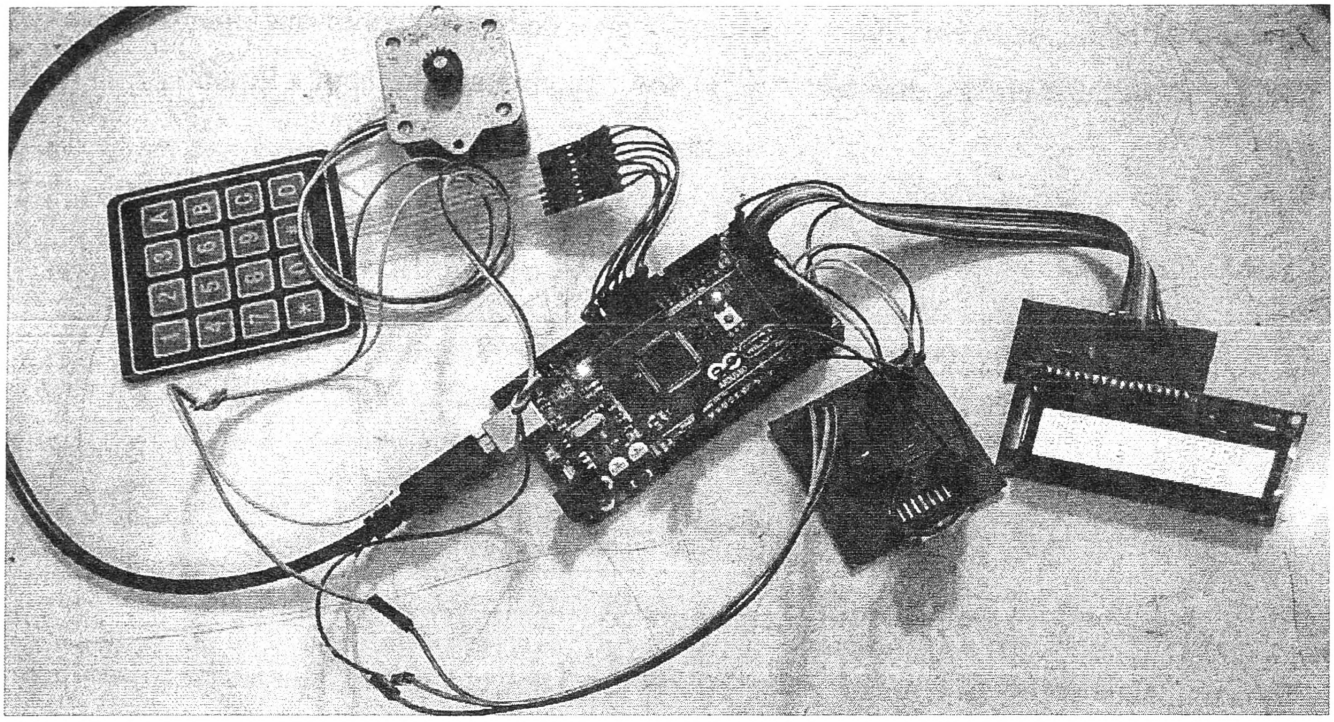

Figure 4: Electronics of the prototype design of the drug delivery system

2.4 Microcontroller Programming

Microcontroller is programmed to determine the rotation speed of the stepper motor based on the given volume and time period using the keypad. The following simple formula is used to determine the rotation speed of the stepper motor.

Volume in milileter (V) and Time in minutes (T) taken as the user inputs

Stepper motor run time = T*60*1000 (micro seconds)

$1ml = 1cm^3$

Cross sectional area (A) is constant in a given Syringe

Total Volume of the syringe = A*D, where D is the length of the syringe

Length is propotional to the volume $D \sim V$

Stepper motor speed(s) = D/T

3. Results and Discussion

The results show that the microcontroller system controls the stepper motor rotation speed to move the shaft so that the syringe releases liquid according to the required rate. A sample set of calculated rotation speeds of the stepper motor is given in the Table 1. The first two columns

show the RPM for different volumes of liquid to be delivered within one hour and the last two columns show the RPM for different time period of constant volume of a liquid.

Table 1: RPM calculation of stepper motor

Constant time 1 hour		Constant volume 50 millileters	
Volume	RPM of Stepper	Time	RPM of Stepper
10ml	0.0167	60 min	0.833
20ml	0.0333	50min	1
30ml	0.05	40min	1.25
40ml	0.0667	30min	1.667
50ml	0.0833	20min	2.5

The cost for the entire system was about 8000/= Sri Lankan Rupees. This value is very low compared to the similar systems imported for the use in Sri Lankan hospitals.

The main advantage of the system is that it can be programmed to deliver the required rate very easily. After all it consists of a microcontroller, which can be programmed using a personal computer to change the firmware as required. So the modifications can be done very easily.

The prototype works with an uninterrupted power supply. Any power failure causes the system to lose current data and needs the system to restart. It does not continue from the point where it stopped. This weakness could be removed with the use of FLASH memory or an SD Card to store the data.

4. CONCLUSION

We described the design of a prototype system to regulate the delivery of drug infusion as required for a given situation. The system consisted aArduino microcontroller board as the main processor which controls the pressure applied to the syringe to regulate the rate of liquid flow. The results show that the system can be further improved to use in hospitals. The total cost for the prototype system is about 8000/= Sri Lankan Rupees which is very lower than the systems available in the market.

REFFERENCES

[1]. Margaret LaFond,*Multiple syringe pump*,US 4563175A ,JAN 7 1986,1-7

[2]. George G. Siposs, Jerry B. Christian,*Variable rate syringe pump for insulin delivery,* US4435173 A, Mar 6, 1984,1-4

[3]. http://www.st.com/web/en/resource/technical/document/datasheet/CD00000240L298.pdf (Referred on 17.6.2014)

[4]. http://www.atmel.com/Images/Atmel-2549-8-bit-AVR-Microcontroller-ATmega640-1280-1281-2560-2561_datasheet.pdf(Referred on 02.7.2014)

[5]. http://www.arduino.cc/em/main/ArduinoBoardMega2560 (Referred on 02.7.2014)