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Design and Development of IoT Based Low Cost Syringe Pump

Dhuppe Pallavi[1], Tegampalle Anjana[2], Waghmare Shabhangi[3], Saurabh Kharjule[4], Ganesh Chaure[5]
Students, Department of Medical Electronics, Government Polytechnic, Nanded, Maharashtra, India[1,2,3]
Lecturer, Department of Instrumentation Engineering, Government Polytechnic Jintur, Parbhani, Maharashtra, India[4]
Lecturer, Department of Electrical Engineering, Government Polytechnic Jintur, Parbhani, Maharashtra, India[5]

Abstract: *Dispensing various drugs in small volume at different flow rate with high accuracy and precision is required to the critical patients for a long period of time. Continuous monitoring for such a long period is very hectic job for a staff working in Medical Industry. In current scenario various syringe pumps are available in medical industries with high cost and with complex operating mechanism. To overcome aforesaid constraints and to avail it in medical industries as per increased demand in COVID-19 situations a low cost syringe pump is designed. It consist of NEMA 17 stepper motor and Arduino Uno that operates at different flow rates and display the flow rate and volume of drug to be delivered on LCD panel as well as on the website using internet of thing (IoT) platform.*

Keywords: Syringe pump, lead screw, NEMA17 stepper motor, Arduino Uno, LCD display, internet of thing (IoT), ESP8266

I. INTRODUCTION

In the era of industry 4.0 all the industries are adopting IoT technology. It comprises of cloud based analysis and decision making of control elements. In IoT all the instruments are termed as things. All these things are connected with each other and with controller in the process using internet. In IoT all the devices or things are compatible to send data over internet. It reduces the data access time as well as operator presence time on the field.

In COVID-19 pandemic situation IoT was the need of time. In pandemic period there is vast requirement of remotely operated device. By considering the constraints of COVID-19 pandemic situation a low cost syringe pump using IoT technology is designed and developed in laboratory for final year student project work.

The section II represents the proposed methodology of design and development of syringe pump. Section III gives the brief about all the calculations behind the design and programming. Section IV deals with results obtained after implementation. Section V gives the brief about future scope related to this project.

II. METHODOLOGY

The traditional syringe pump needs mechanical components to provide mechanical strength to the system. It comprises of lead screw, which converts rotational motion of motor shaft into linear movement, connected to the plunger of syringe. Aluminium extrusion which provides base for the system. L-clamps to connect syringe with aluminium extrusion. To increase its accuracy some electronic components are added to the mechanical system. Sensors which are feedback elements are used to detect the current status of syringe parameters. NEMA-17 stepper motor is used to control the linear movement of syringe. A microcontroller Arduino-Uno is used to control stepper motor. The speed at which drug is to be delivered is used to calculate the required speed of stepper motor. All the parameters of syringe pump such as drug delivery rate, drug to be delivered are displayed locally on a LCD display and simultaneously on a web page using ESP-8266.

2.1 Mechanical Aspect

A. Lead Screw

Lead screws are threaded bars of metal and a threaded nut which is in direct contact with the screw; this generates sliding friction as opposed to rolling friction from other alternative devices (such as a ball screw). Rotational motion will turn the screw, causing the nut to move along in a linear motion. This, therefore, converts the motion from rotary to

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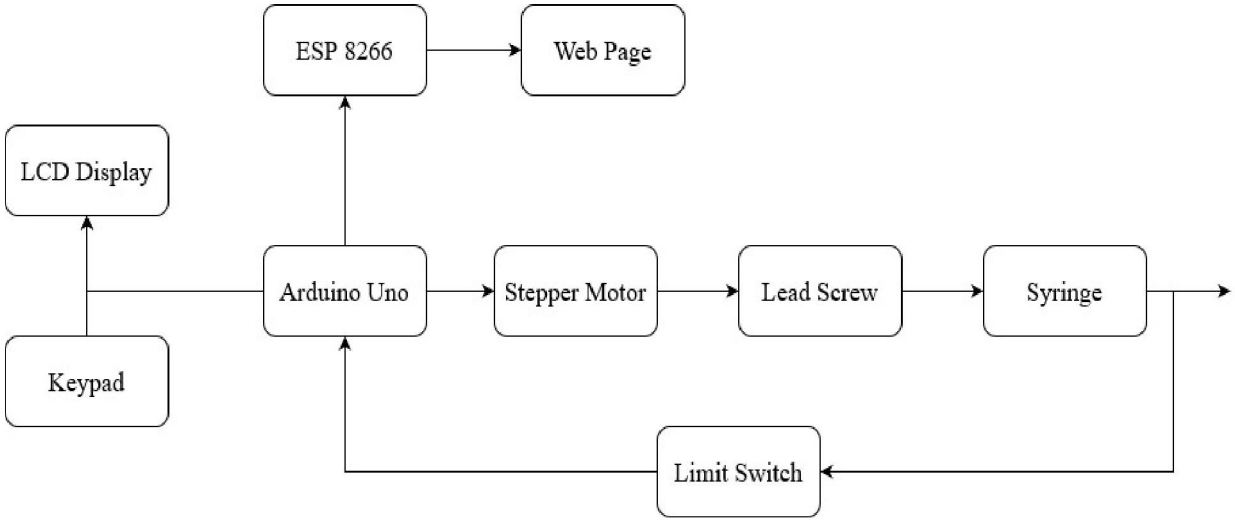
linear. They can be used for either vertical or horizontal movements and can use linear glides for support where necessary.



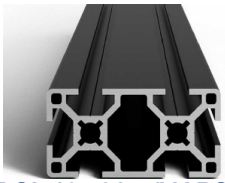
They can be operated either manually or mortised depending on the application in hand.Where the screw itself is generally constructed of stainless steel, the nut can be various materials depending on what is better suited for the application. Heavy-duty applications will require a metal nut whereas other applications may require a plastic one.

B. Syringe

Syringe is a device used to infuse drug into patient body. To deliver the drug into patient body plunger of syringe is moved linearly. Volume of drug to be delivered in speculative time is depend on the linear velocity of plunger. This linear motion of plunger is controlled by stepper motor. The lead screw connected to stepper motor is attached to syringe plunger which results in the automated syringe pump system.

C. Aluminium Extrusion

All the components used to build a syringe pump are placed on a rugged aluminium extrusion. The used material provide base as well as strength to the system with lo weight.



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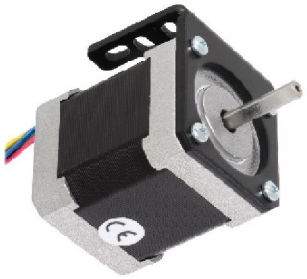
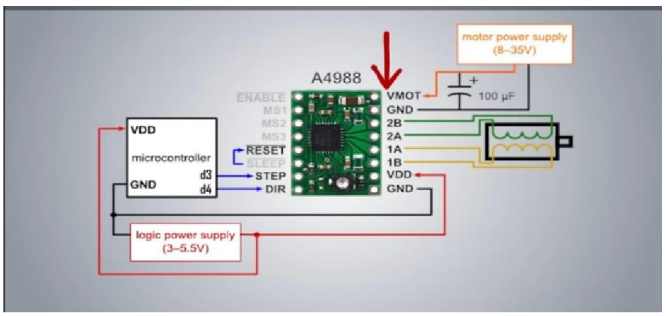
2.2 Electronic Aspect

A. NEMA-17 Stepper Motor

The stepper motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation. There are two types of stepper motors *Bipolar and Unipolar*. Bipolar stepper motors are a type of stepper motor with a single winding per phase and no centre tap (unlike a unipolar stepper motor). The DC current in a winding needs to be reversed to reverse a magnetic pole and allow the motor to function. Advantages of step motors are Low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment.

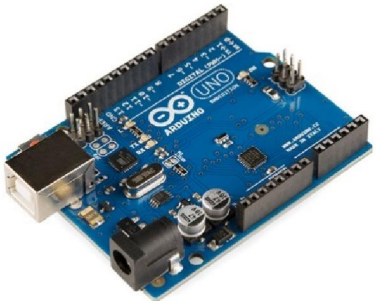


NEMA 17 is a hybrid stepping motor with a 1.8° step angle (200 steps/revolution). This stepper motor is operated using A4899 motor driver IC.The A4899 driver allows micro stepping by allowing intermediate step locations. This is achieved by energizing the coils with intermediate current levels.The motor power supply is connected to GND and VMOT (top right). The two coils of the stepper motor are connected to 1A, 1B and 2A, 2B as shown in figure. The GND pin is connected to the ground pin of the microcontroller and VDD is connected to 5V.



B. Arduino Uno

Arduino UNO is a microcontroller board based on the **ATmega328P**. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.



C. ESP8266 Node-MCU

Node MCU is an open source Lua based firmware and development board specially targeted for IOT based applications. It includes firmware that run on the ESP8266 Wi-Fi SoC from espressif system and hardware which is based on the ESP-12 module.

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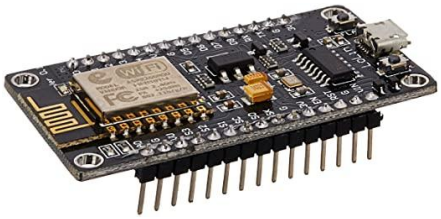


D. Limit Switch

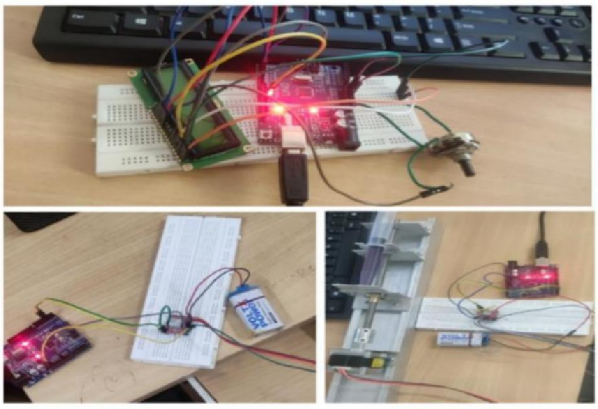
Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation. They can determine the presence, passing, positioning, and end of travel of an object.

E. LCD

A 16*2 LCD is used to display all the parameters and message locally. A 16x2 LCD means it can display 16 Characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix.The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. This LCD has two registers, namely, Command and Data.

III. Result And Discussion

As discussed in earlier section all the mechanical components of the system are attached to electronic components to automate the process for improvement of accuracy. To operate all the system as per required conditions a microcontroller is used. All the components are connected to the microcontroller Arduino Uno. LCD, stepper motor, keypad, limit switch are connected to Arduino Uno digital IO pins.



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The connection diagram is shown in fig. The result is displayed locally on LCD screen. To display the real time value of remaining drug ESP8266 NodeMCU is connected with Arduino Uno. NodeMCU connects with cloud and sent the data on cloud. To display these values on cloud ThingSpeak platform is used. A dashboard is created to display all the real time values of drug delivery graphically on webpage. Anyone can access this webpage using the url link generated by ThingSpeak. Also IFTTT platform is used to interact with concern person when alarm is generated, It sends the message to concerned person as soon as syringe is near to empty.

IV. CONCLUSION

The designed syringe pump is more accurate than physically available pumps in the market. It is easy to monitor drug delivery rate and the volume delivered during the time remotely by using the web page. The graphical representation of real time parameter values leads to easy analysis of drug delivery rate and current status of drug. ThingSpeak and IFTTT platform helps the doctors to access current status of the system online. Hence accessibility is improved.

ACKNOWLEDGMENT

The heading of the Acknowledgment section and the References section must not be numbered.Causal Productions wishes to acknowledge Michael Shell and other contributors for developing and maintaining the IEEE LaTeX style files which have been used in the preparation of this template.

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