Highly Precise Wire Feeder & Cutter Machine with Stepper Motor Using Atmega32 Microcontroller

Rimpi Datta, Mohit Sharma, Puspak Pain, Arnima Das, Saradindu Panda

Department of Electronics and Communication Engineering, Narula Institute of Technology, Kolkata, India

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Abstract

This article aims to improve the wire feeding technique and as well as the cutting process of wires. Generally, in industries the machines which they use is of low quality and less accuracy due to which industries are facing uncalculated losses either due to extra wire feeding, which causes wastage of material and on the other hand if less amount of material is feed then that piece is rejected and in this way industries are unknowingly facing huge losses at every piece of wire. So as to solve this problem, this proposed design focuses on to use less expensive sensors and implementing the advanced algorithm to achieve the precision and accuracy which helps the industries to attain that amount of production. In this design stepper motor is used for feeding the wire along with three less expensive sensors are used to give feedback to the controller while feeding the wire. During which the controller gives this data from the sensors to the PID control program which manipulates and control the entire precision feeding of wire. Cutting mechanism uses servo motor for cutting the wire.

1. Introduction

In Industry wire feeding and cutting process are performed by automatic controllers, in industry generally stepper or AC servo motors are used for wire feeding process. AC Servo motors are quite expensive than stepper motor, so for cost effective solution stepper motors are widely used in industry for wire feeding process.AC Servo motors are costly because it contains various features in it, such as current and voltage rating at that instant of driving and a feedback system generally comprises of encoder fitted with the spindle of the motor shaft so that when spindle rotates then along with that encoder shaft will also rotate to count the number of pulses it is lapsing, and this features made AC servo motor precise and prudent for the use of industry. Whereas in stepper motor, there are two type of stepper open loop and closed loop stepper motor, as the name follows the open loop stepper do not have any kind of feedback or voltage or current rating data so as to configure it according to our needs. Whereas in closed loop stepper motor there is a feedback system is attached with the closed loop stepper motor, such as encoder. The closed loop stepper motor still cannot match the precision level with the servo motor because in servo motor the drive is programmable as well, so by connecting the drive with the computer a detailed current and voltage rating and elapsed pulses with calculated distance, speed and angle can be determined and by this features it enables the user to perform his or her task up to the mark, because to perform such high precision and productive task a detailed analysis to be perform and for that the mathematical calculations require few quantized data by which controller can determine the desired output as per the user requirement. Whereas in stepper motor drives does not have those programmable options for precision driving of stepper motor. In spite of all this engineering there is an error of 10mm to 20mm extra wire feeding, which can be either by mechanically or lagging pulses from the driving motor. The main reason behind this problem is due to not having appropriate feedback sensors with the feeder mechanism or the system. According to the calculation, if a particular industry who are specialised in producing huge number of cut wires or any strip or thread like material and if due to this percentage error of feeding and cutting that particular company is suffering a huge loss, which are being neglected because co-workers or labourers are not caring about the feeding and cutting of extra 10mm to 20mm. This proposed design focuses on those problems and gave a detailed analysis on how to overcome this improper wire feeding and cutting problem. In this proposed design, mechanical error sensing to stepper motor pulses feedback sensing and most importantly the slippage of wire out of the feeder is look to it. For slippage of wire a specially designed sensor is used to monitor the feeding of wire millimetre by millimetre. In this design three basic sensors are used Pulse counter encoder (250 PPR), proximity sensor and Passive infrared sensor. The controller receiving the sensor signals in parallel manner and each sensor signal is decoded by a definite algorithm which sampled the sensors data and fed to the different blocks of the code of the algorithm. Basically, there are lots of wire feeder are available in the market but majority of them have 10 to 20% of error percentage of extra feeding of wire which tends to wastage and incur a loss in the company. Firstly, when the operation of wire feeding begins the controller start giving pulses to the stepper motor driver IC then stepper driver IC drive the stepper at specified RPM (Revolution Per Minute) and speed, as soon as the wire feeds the encoder starts rotating along with the stepper motor and so the encoder generates pulses and fed it to the controller. The controller then start taking the encoder pulses, after that comes the proximity sensor the proximity sensor here works as a mechanical encoder which is counting the each teeth of the rotor of the stepper motor so as to monitor the slippage of the wire. By following this technique this proposed design aims solve this problem.

The circuit topology of the proposed Automatic Wire Feeder and Cutter Machine Using ATmega32 Microcontroller is shown in Fig -1.

The proposed automatic wire feeder and cutter machine consists of two main mechanism, the feeder of the wire driven by steeper motor and the cutter part which is driven by servo motor to cut the wire feed by the feeder. On the other hand it consist a 4x4 keypad to enter the length of the wire and the number of wires as well. In the below circuit diagram a 16x2 LCD Display is attached with the microcontroller for showing the output of the processing. A L298N H-bridge stepper driver module is used to drive the stepper motor at a specified number of turns so as to drive the feeder for the specified length of wire to feed. Lastly, a PWM pin is assigned for the ed he of

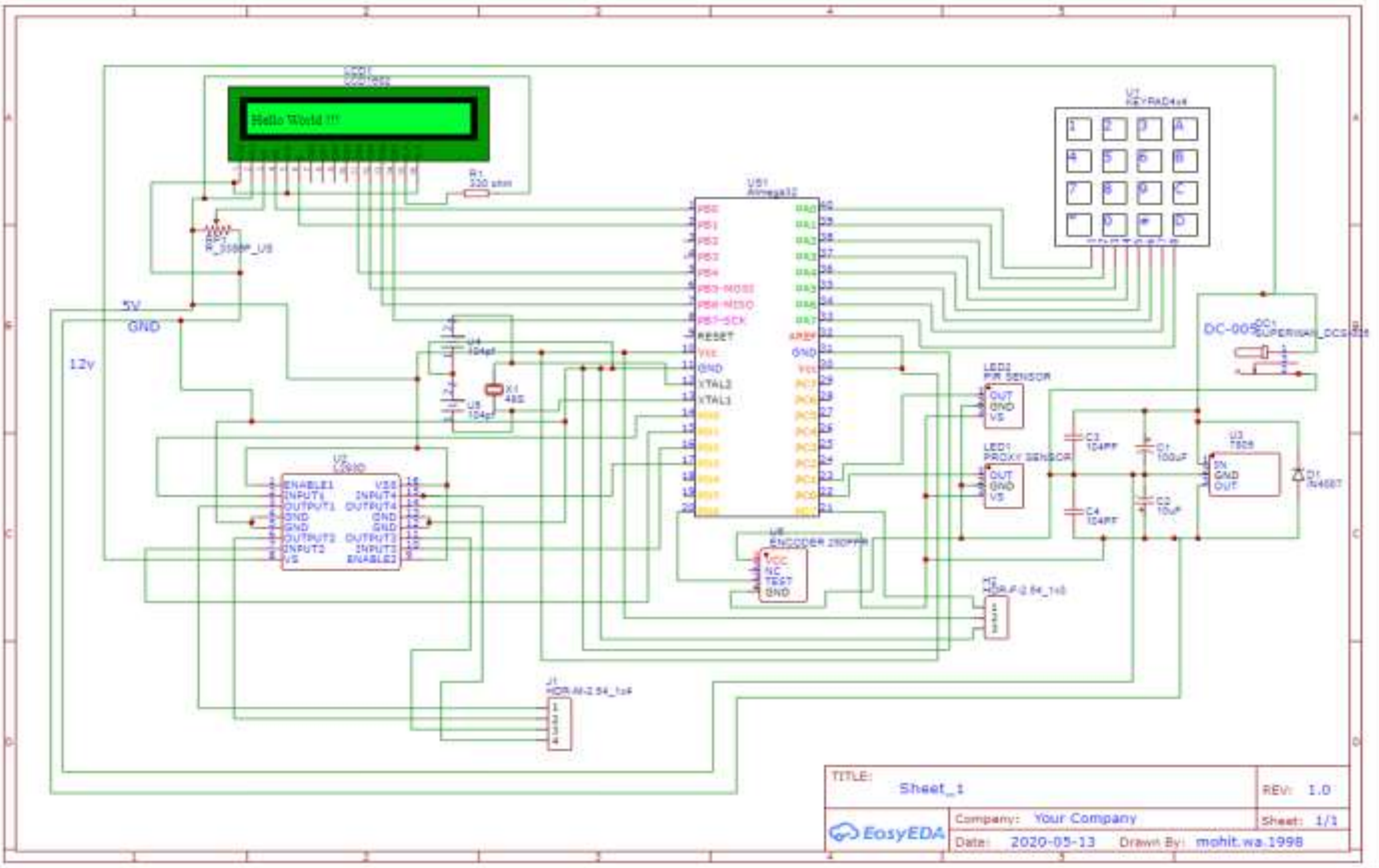

Fig-1 Proposed automatic wire feeder and cutter circuit diagram

2.2 *Working Principle*

The proposed design has two main parts the wire feeder mechanism and on the other hand the wire cutter mechanism.

In this design, a highly precise driving motor is used (Stepper Motor) it is not an ordinary motor. [1]Stepper Motor requires a routine of four switching pins from the microcontroller at a specific switching speed of the timer hardware in the microcontroller, this switching speed and the number of pulses decides the speed of rotation and the number of revolution.

[2]Whereas in cutter mechanism, Servo Motor is used which is rotated at a specific angles. Here in this design Servo Motor is driven at specific angle so that the cutter cut the wire

properly. Unlike, Stepper Motor Servo Motor is not driven by four high speed switching pins from the microcontroller. In Servo Motor a PWM signal is required to drive the Servo Motor of different duty-cycle for varying angles and at a fixed frequency. Generally, the proposed design uses a metal geared 125Hz Servo Motor to deliver the purpose.

Proximity sensor, Pulse Encoder and PIR sensor this three play an important role to achieve the purpose of research. Proximity sensor is attached [Fig-2] with the mechanical gear connected with the shaft of the stepper motor, which is working as a mechanical encoder while feeding the wire. On the other end of the stepper motor pulse encoder is connected which gives the corresponding pulses when stepper motor rotates. The mechanical pulse generated by the mechanical encoder and by pulses encoder, it creates a feedback system for both the mechanical feedback and for the program pulse feedback. In order to maintain the proper feeding of wire a specified feedback system is required, generally in industries pulse encoder are being used to keep a track of missing pulses feeding to the motor, if motor misses any pulse while driving, then pulse encoder gives a feedback to the controller and then the controller feeds more amount of required pulses to complete the task. In this approach mechanical encoder is also used, because comparison of the pulses of both the encoders is perform by which controller can estimate that mechanically and programmatically driving of motor is working properly.

Secondly, in this approach slippage of wire is also monitored by PIR sensor. PIR Sensor has a wide range of sensing, so in order to measure the point of focus of motion a special arrangement of lenses is designed so that while feeding the wire, with every 1mm of feeding of wire PIR sensor monitor the movement of wire and compare it with pulses of other two encoder sensors, simultaneously three sensors gives feedback to controller and depending upon the feedback the PID (Proportional-Integral-Derivative) control program in the controller drives the motor and feed wire precisely. This design is approach for feeding wires of thickness ranges from 0.6 to 1.5mm. Different thickness of wire can be feed by changing the roller of desired thickness.

2.3 *Calculation of operation*

As we know wire is feeding by stepper motor so pulses are calculated corresponding to the wire feeding by the stepper motor. With one rotation of stepper motor, it is feeding 4cm of wire, so according to it

1cm =100 pulses.

When user put the value from the keypad for example 10cm then to generate the corresponding pulses this formula follows.

10cm (input) * 100pulses = 1000 pulses (to stepper motor)

Metal gear 125Hz Servo Motor is used in this design, to move the cutting mechanism at specified angle the particular formula follows.

1. -90° at 0.52ms duty cycle Period of 125Hz PWM.
2. 0° at 1.4ms duty cycle Period of 125Hz PWM.
3. +90° at 2.4ms duty cycle Period of 125Hz PWM.

In this design -90° to +90° is used, corresponding to the degrees 0.52 and 2.4ms duty-cycle is used in the program.

Fig-2 in below diagram the arrangement of Mechanical Encoder is shown, in the diagram there are two pinion the smaller diameter pinion is connected to the spindle of the stepper motor so that when stepper motor rotates along with that the pinion also rotate and along with that it rotates the mechanical encoder pinion and a proximity is attached at the edge of each and every teeth of pinion.

[8]On the other hand Fig-3 in below diagram shows the innovative design to concentrate the sensing range of PIR sensor at a fixed focal point so that movement of wire feeding can be measure, whereas in the diagram the labelled part "Black Body" is essential in this proposed design because PIR sensor is highly sensitive so even any kind of outside may can give noise signal from our desired output of the sensor. Lens is used to concentrate the rays at a focal point to monitor the movement of the wire millimetre by millimetre.

Fig-4 shows the block diagram of working proposed model, the heart of the proposed design is the Atmega32 microcontroller, in the diagram LCD display , stepper motor and servo motor are the output devices whereas keypad is the input device by which user can select the number of wires to be cut and the length of the wire.

Fig-5 shows [1],[2]the flow chart of the program code operation of the proposed design from input end to the output end.

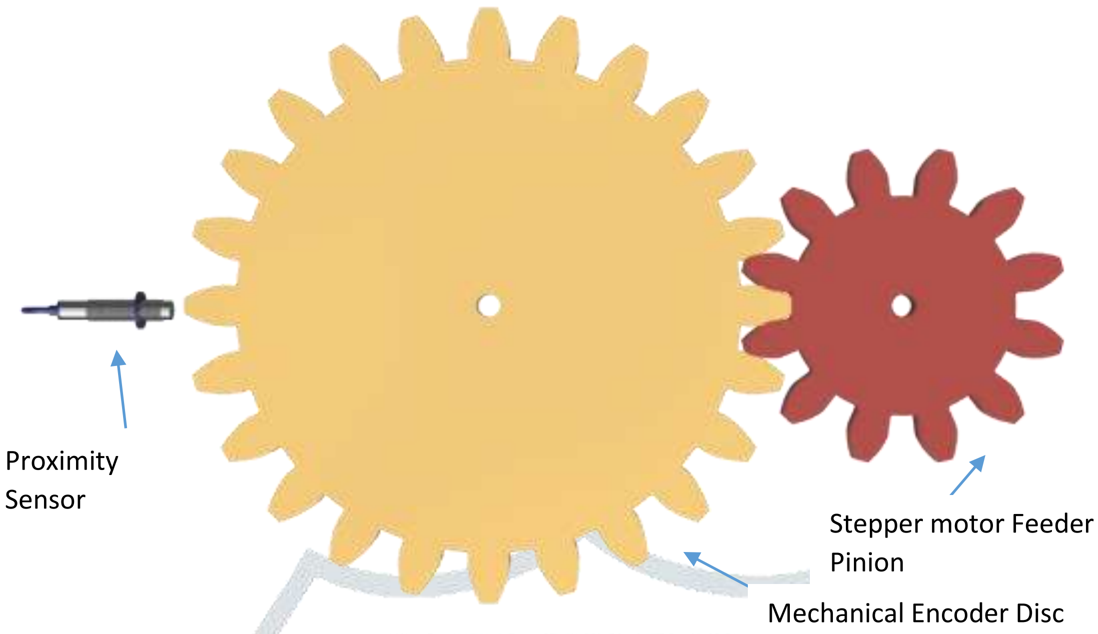

Fig-2 Proposed design Mechanical Encoder

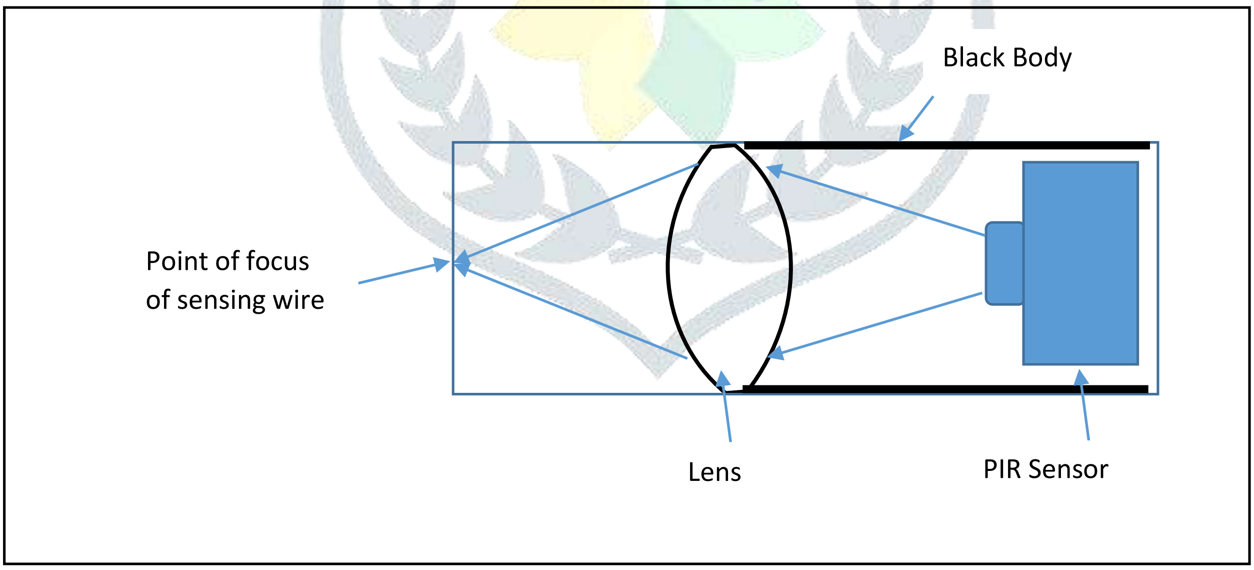

Fig-3 Proposed design Special arrangement PIR Sensor

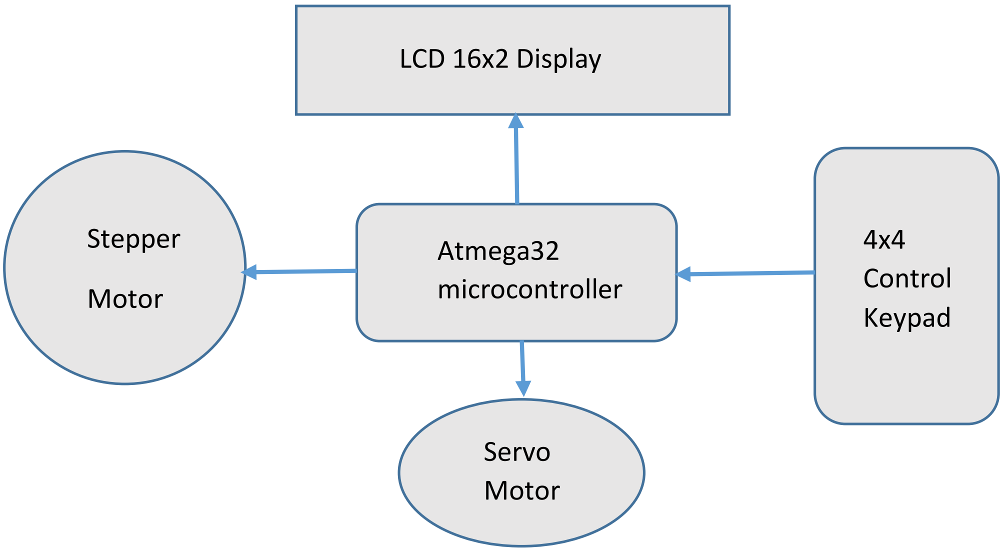

Fig-4 Proposed block diagram of working design

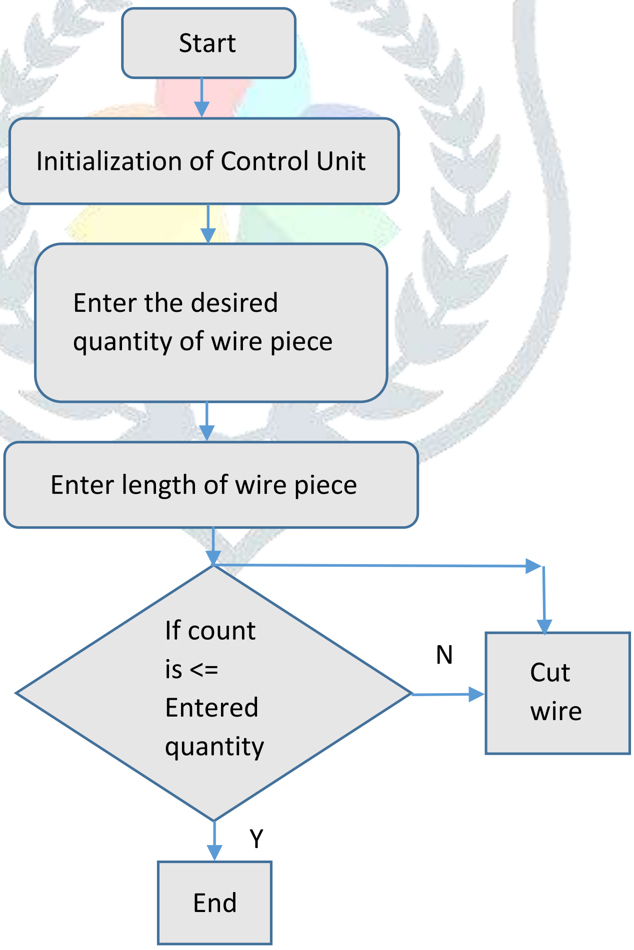

Fig-5 Flow Chart of basic working principle of wire feeding

3. Experimental Results

3.1 *Results*

This proposed design approach is to feed wire precisely and to achieve that accuracy and precision, one [8] PID control program monitors and take the reading of individual sensor at specified interval and sample the data of sensor to deliver accurate pulses to the stepper motor so that there may not be any kind of slippage and missing pulses due to which less or extra material is feed at every piece.

Fig-8 Software simulation is also perform to observe the proper functioning of the programming, it is convenient to test the prototype of program in simulation software which gives the confidence to explore with hardware and tally every possible output corresponding to the software generated data.

Fig-6 shows the block diagram of PID Control, initially the controller giving pulses to stepper depend on the calculated pulses from the user, during that all the three sensors collect their reading of data and gives feedback to the controller which ultimately goes to the PID control program and then the algorithm manipulate the data from the sensors and gives a desired output by which feeding of can be done precisely and accurately.

Fig-7 shows the pulses given to the stepper motor after performing the PID Control algorithm manipulations, a detailed pulse to wire feed length data is shown in Table-1.

Sl no.	Length of wire entered by user	Design Output	Pulses by controller	% of Error
1	10cm	10.2cm	1000	2%
2	15cm	15.1cm	1500	1%
3	20cm	20.3cm	2000	3%
4	25cm	25.1cm	2500	1%
5	30cm	30.2cm	3000	2%
6	35cm	35.2cm	3500	2%

After observing the table it is evident that percentage of error is way more negligible but in case of other industrial system, it has 2 to 3 cm of error which is the only reason this design is proposed to solve is problem. In Fig-7 it shows the pulses generated by the controller after analysing the error by the PID control and corresponding pulses are given by the controller to achieve maximum accuracy.

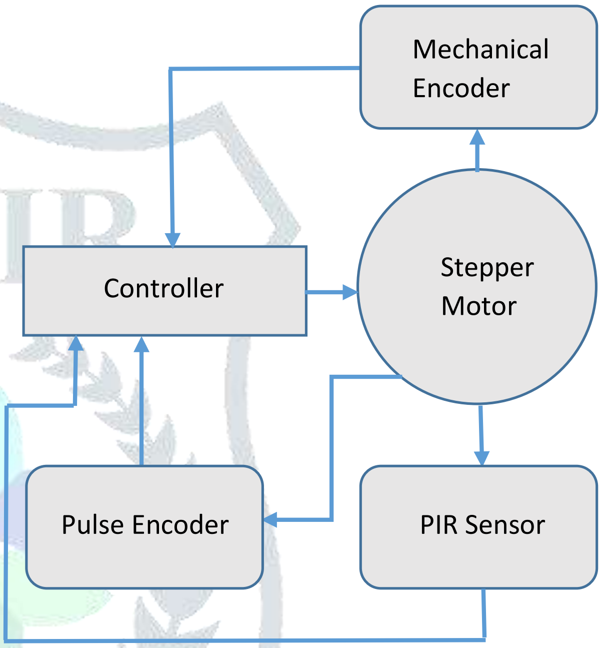

Fig-6 PID Control algorithm

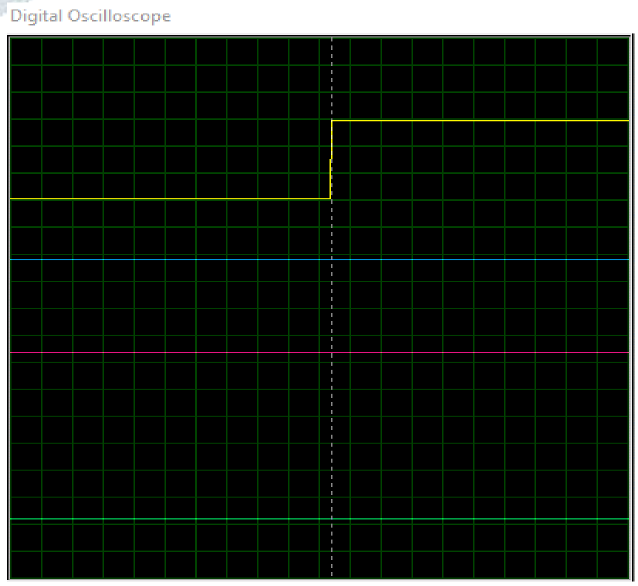

Fig-7 Stepper motor Pulses

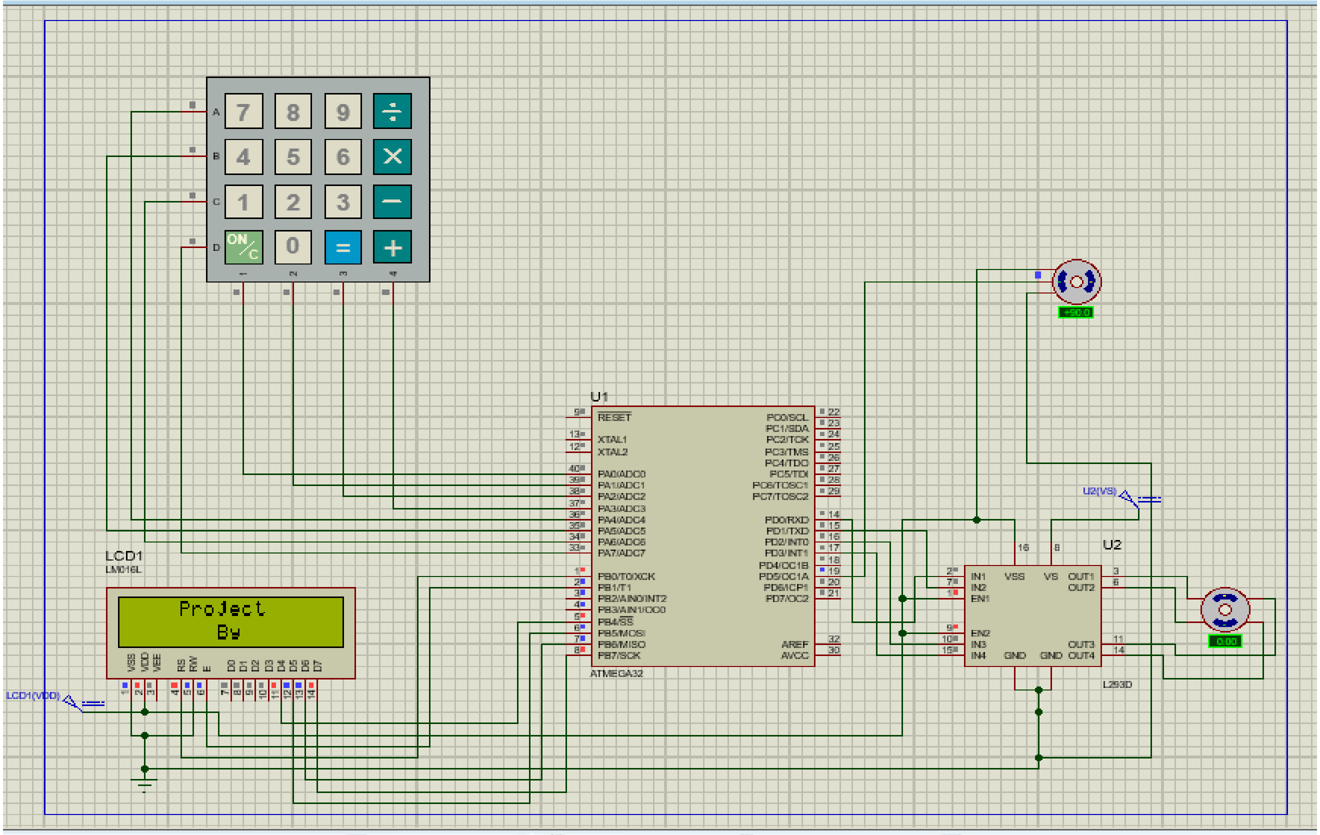

Fig-8 Proposed design simulation design in Proteus Software

Fig-9 Proposed design hardware

4. Conclusion

One of the major aspects of this proposed design is to provide accurate and precise feeding of wire and cutting, whereas it has one more important aspect which is really helpful for the production industry. In production industry where they have to produce millions of cut wire in day and along with that by keeping in mind that there should not be any wastage or rejected pieces are made due to short length of wire. So in order to solve all those problems, this proposed design is made, with help of less expensive sensors this proposed can achieve the desired accuracy which enables production industries to produce maximum number cut wires with less amount of wastage and rejected pieces.

5. References

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