Belt Conveyor with Pick and Place Mechanism

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Abstract

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Belt conveyor is one such conveying system used in industries. A belt conveyor system consists of an endless belt of resilient material connected between two flat pulleys.

On analysing the conveyor systems used in industries, it was evident that the system is not widely used in Micro technology. In the existing belt conveyor system there is no option for picking and placing the materials automatically on the belt. For this purpose a pick and place mechanism was employed. The mechanism is electromagnet actuated. The motion of the arm was programmed using microcontroller along with the conveyor motions, thus synchronizing the sequence of operation.

1.Introduction

1.1 Automation in industry

Automation is the use of machines, control systems and information systems to optimize productivity in the production of goods and delivery of services. The correct incentive for applying automation is to increase productivity, and/or quality beyond that possible with current human labour levels so as to realize economies of scale, and/or realize predictable quality levels. In the scope of industrialisation, automation is a step beyond mechanization. Whereas mechanization provides human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements while increasing load capacity, speed, and repeatability.

One such advancement made in industries was the introduction of conveyor systems. A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials [1]. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries.

Automatic picking of parts is an important challenge to solve within factory automation, because it can remove tedious manual work and save labour costs. One such application involves parts that arrive with random position and orientation on a conveyor belt. The parts should be picked off the conveyor belt and placed systematically into bins.

Conveyor systems are used widespread across a range of industries due to the numerous benefits they provide.

- Conveyors are able to safely transport materials from one level to another, which when done by human labour would be strenuous and expensive.
- They can be installed almost anywhere, and are much safer than using a forklift or other machine to move materials.
- They can move loads of all shapes, sizes and weights. Also, many have advanced safety features that help prevent accidents.
- There are a variety of options available for running conveying systems, including the hydraulic, mechanical and fully automated systems, which are equipped to fit individual needs.

1.2 Objective of project

This project deals with the introduction of pick and place mechanism in accordance with conveyor. Production processes involve intermediate conveying of produced parts. These parts need to be picked off the conveyor and inserted either into containers for later shipping or into further production processes. Manual picking of conveyed parts is a dull and tiresome job that also exposes people to the risk of physical strain. Naturally, automation of the task is highly desirable.

2. Literature Review

2.1 Automation

Automation has had a notable impact in a wide range of industries such as manufacturing and beyond. Automation is the use of machines, control systems and information technologies to optimize productivity in the production of goods and delivery of services. Automation is applied to increase productivity, and/or quality beyond that possible with current human labour levels so as to realize economies of scale, and/or realize predictable quality levels. In the scope of industrialisation, automation is a step beyond mechanization [2]. Whereas mechanization provides human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements while increasing load capacity, speed, and repeatability.

2.2 Need of Automation

Time is the commodity that needs to be managed effectively and effectively in order to maximize productivity. As the process of doing business more and gets more complex and cumbersome, technology and automation becomes vital resources for success and continued growth of an organisation. Through the strategic use of automation and technology, an organisation can increase productivity and efficiency.

The old focus on using automation simply to increase productivity and reduce costs was seen to be short-sighted, because it is also necessary to provide a skilled workforce who can make repairs and manage the machinery.

2.2.1 Advantages and disadvantages of Automation

The main advantages of automation are:

- Increased throughput or productivity.
- Increased predictability of quality.
- Improved robustnessof processes or product.
- Increased consistency of output.
- Reduced direct human labour costs and expenses.

The main disadvantages of automation are:

- Security Threats/Vulnerability: An automated system may have a limited level of intelligence, and is therefore more susceptible to committing errors outside of its immediate scope of knowledge (e.g., it is typically unable to apply the rules of simple logic to general propositions).
- Unpredictable/excessive development costs: The research and development cost of automating a process may exceed the cost saved by the automation itself.
- High initial cost: The automation of a new product or plant typically requires a very large initial investment in comparison with the unit cost of the product, although the cost of automation may be spread among many products and over time.
- In manufacturing, the purpose of automation has shifted to issues broader than productivity, cost, and time.

3. Description of Components

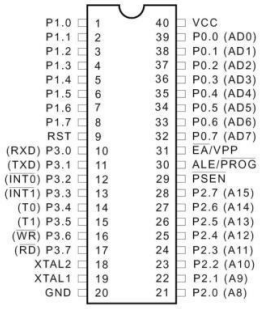
3.1Microcontroller

The microcontroller is the heart of this project. A microcontroller (sometimes abbreviated µC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals [3].

3.1.1 Features

- 8 bit microcontroller
- 4K bytes of in system reprogrammable flash memory
- 128*8 bit internal RAM
- Two 16 bit timers/counters
- 32 programmable I/O line
- Fully static operation: 0 Hz to 24 MHz
- 3 internal and 2 external interrupts
- 16 bit address bus
- 16-bit program counter and data pointer
- 32 general purpose registers each of 8 bits

3.1.2PIN Details of 8051



Pin Layout of 8051

Pin Description

- VCC Supply voltage
- GND ground
- Pin 40- VCC Supply voltage: This pin is connected to the power supply or the +ve end of the battery [4].

- Pin 20- Ground: This pin is connected to the ground of the power source.
- Pin 32 to Pin 39 (Port 0) - Pin 32 to Pin 39 are the reserved for Port 0 operations. Port 0 is an 8-bit open-drain bi-directional I/O port. When 1′s are written to port 0 pins, the pins can be used as high impedance inputs. In this mode P0 has internal pull-ups. External pull-ups are required for using this port.
- Pin 1 to Pin 8 (Port 1) - Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. Port 1 also receives the low-order address bytes during Flash programming and verification. Port 1 does not need any external pull-up resistors.
- Pin 10 to Pin 17 (Port 3): Port 3 is an 8-bit bi-directional I/O port with internal pull-ups.
- P3.0- RXD- 8051 comes with UART. i.e. Universal Asynchronous Receiver and Transmitter. This pin is Serial Receiver Pin / Serial Input Pin. Here the UART serial communication is carried out. This pin is connected as an input pin to receive serial data.
- P3.1- TXD- This is the UART Serial Transmitter Pin. This pin is used as serial output pin. This pin acts as serial transmitter.
- P3.2- INT0-(External Interrupt 0) - This is an external interrupt. It is a hardware interrupt and if any device wants to use services of microcontroller, it can temporarily interrupt microcontroller working get microcontroller services.
- P3.3- INT1-(External Interrupt 1) - This is another external interrupt. Both these interrupts are active low. This means that the interrupt will be active when logic 0 is given to these pins.
- P3.4- T0 (Timer/ Counter external input 0) - This is an external timer/ counter input. This pin can be used for counting external pulses. For example- you want to count number of vehicles passing through a toll plaza. So you can connect this pin to the sensor and then you can program the microcontroller for further operations.
- P3.5- T1 (Timer/ Counter 1) - Same operation as Timer 0. There are two timer/counters in 8051 microcontroller.
- P3.6- WR- (External Data memory write) - This pin is the external memory write strobe. This pin is used to interface external memory with microcontroller. This pin is active low pin. When low, microcontroller writes to the external memory through its address pins.
- P3.7- RD- (External Data Read Chip) - This pin is for reading from external memory. Again this pin is active low.
- Pin 21 to Pin 28- (Port 2) - This is also an 8 bit bi-directional I/O Port with internal pull-ups. Pull-ups mean resistors.
- Pin 9- (RST) - This is Reset pin. It is an external interrupt. This pin is given the trigger for performing Reset operation. When triggered, it resets the compiler to the starting address from where the program is written in the 8051 memory.
- Pin 31- (EA/ VPP) - External Access Enable. EA should be strapped to VCC for internal program executions. EA must be connected to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH.
- Pin 30-(ALE/PROG) - Address Latch Enable output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming.
- Pin 29-(PSEN) - Program Store Enable is the read strobe to external program memory.
- Pin 18 and Pin 19 (XTAL 1 and XTAL 2) - These are the pins for external oscillator connections. A crystal oscillator of frequency 11.0592 MHz is connected with these two pins. Two Ceramic 33 pf capacitors are connected with the oscillator and one pin of both the capacitors are connected with ground. These capacitors perform DC ground operations. These block any low frequency below 11.0592 MHz.

3.1.3 Criteria for Choosing a Microcontroller

The basic criteria for choosing a microcontroller suitable for the application are:

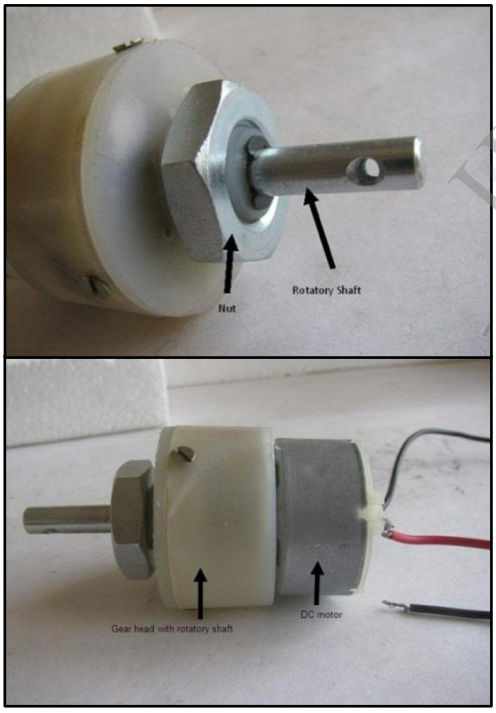
- The first and foremost criterion is that it must meet the task at hand efficiently and cost-effectively. In analysing the needs of a microcontroller-based project, it is seen whether an 8- bit, 16-bit or 32-bit microcontroller can best handle the computing needs of the task most effectively [5]. Among the other considerations in this category are:
  1. Speed
  2. Packaging:It may be a 40-pin DIP (dual inline package) or a QFP (quad flat package), or some other packaging format. This is important in terms of space, assembling, and prototyping the end product.
  3. Power consumption:This is especially critical for battery-powered products.
  4. The number of I/O pins and the timer on the chip.
- Key considerations include the availability of an assembler, debugger, compiler, technical support.

3.2 DC Motor

An electric motor uses electrical energy to produce mechanical energy, very typically through the interaction of magnetic fields and current-carrying conductors. The reverse process, producing electrical energy from mechanical energy, is accomplished by a generator or dynamo. Traction motors used on vehicles often perform both tasks. Many types of electric motors can be run as generators, and vice versa.

3.2.1 Geared DC Motor

Working - Geared DC motors can be defined as an extension of DC motor which already had its Insight details demystified here. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM [6] .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This Insight will explore all the minor and major details that make the gear head and hence the working of geared DC motor.



Geared D.C motor

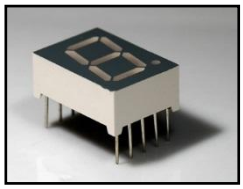
External Structure- At the first sight, the external structure of a DC geared motor looks as a straight expansion over the simple DC ones. The lateral view of the motor shows the outer protrudes of the gear head [7]. A nut is placed near the shaft which helps in mounting the motor to the other parts of the assembly. Also, an internally threaded hole is there on the shaft to allow attachments or extensions such as wheel to be attached to the motor.

3.2.2 Specification

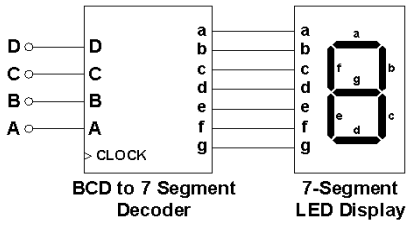
Rating	12V DC motors with Gearbox
RPM(base motor)	3000
RPM(geared)	30
Torque	1.2kgcm
No-load current	60 mA (Max)
Load current	300 mA (Max)

3.3 Seven Counter- Seven Segment display

A seven-segment display (SSD), or seven-segment indicator, is a form of electronic display device for displaying decimal numerals that is an alternative to the more complex dot-matrix displays. Seven-segment displays are widely used in digital clocks, electronic meters, and other electronic devices for displaying numerical information.

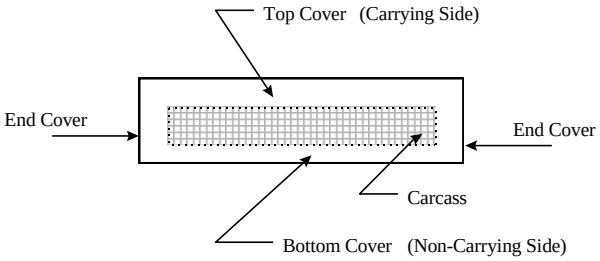


Seven segment display



3.4Belt

The belt consists of a carcass covered from all sides with a filler material like PVC and neoprene.



3.4.1 Essential Properties

The belt works as a tractive element as well as load-carrying element. It may be used for different kind of material transportation at a higher speed (6-8 m/s).
For this purpose the belt need to have the following essential properties:

- Flexibility
- Transverse rigidity
- Low mass per unit length
- High strength
- Simplicity and inexpensive
- Longer life
- Should not stretch under normal working stresses, i.e., low relative elongation.
- Wear resistant
- Fire resistant

3.4.2Specification

Belt dimensions	Belt material
Length-1200mm Width-380mm	Leather

3.5Stepper Motor

A stepper motor (or step motor) is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application

3.5.1 Fundamentals of Operation

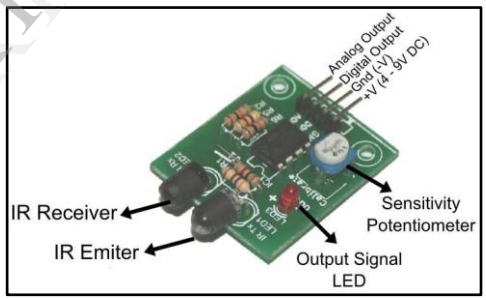
DC brush motors rotate continuously when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron [8]. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first, one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From this point the process is repeated. Each of those rotations is called a "step", with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle.

3.5.2 Specification

No. Of steps per rotation	48(7.5° / step)
Drive method	2-2 phase
Drive circuit	Unipolar stepper motor
Drive voltage	12 Volts
Drive method	400mA
Coil resistance/Phase	50ohms
Dimension – Diameter	35mm
Operating temperature	-10°C ~ 50°C

3.6IR Sensors

An infrared sensor is a type of photoelectric beam system used as an electronic alarm. It is designed to alert the user to an intruder's presence by transmitting infrared light beams across an area, where these beams may be obstructed. They are often used in military installations and other facilities of restricted access [9].



IR sensor terminology

3.6.1 Specification

Maximum range	40-50 cm (indoors) 15-20 cm (outdoors)
Operating voltage	3 to 9V

3.7Idlers

In a conveyor belt installation different types of idlers or roller supports are used. The idlers are required for proper support and protection of the belt and proper support of the load being conveyed. Idlers are designed with different diameters and are provided with antifriction bearings and seals, and are mounted on

shafts. Frictional resistance of idlers influences the belt tension and consequently the power requirement.

Idlers are mounted on a support frame, which can be shiftable or permanent. The carrying side of the belt is supported on the carrier rollers sets. A set of three rollers are arranged to form a trough for the troughed belt conveyor. The return side of the belt is supported on straight return idlers. The spacing of the idlers is determined based on the belt sag between the idlers. The sag depends on the belt tension, belt width, belt properties and the pay-load per meter of the belt. The idlers are specified by its length and diameter.

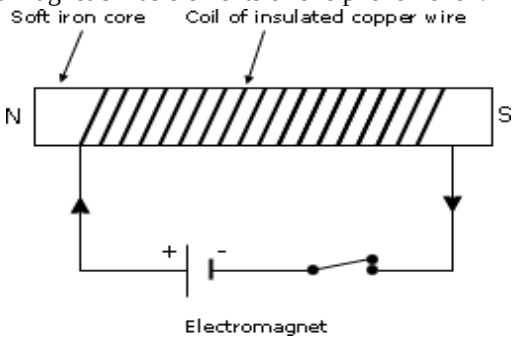
In this project, as idlers PVC pipe along with roller grippers are used. Roller grippers are inserted into PVC pipes, which are connected to DC motor. DC motor drives the idlers on which the belt runs.

3.7.1 Specification

PVC pipe dimensions	Length = 380mm Thickness = 2mm Radius = 35mm
Roller gripper dimensions	Length = 60mm Thickness = 4mm Radius = 33mm

3.8Pick and place mechanism

Pick and place is a newly introduced mechanism which works on the principle of electromagnetism [10]. The setup consists of a metal rod wounded by copper wire which is connected to electricity. Electromagnetism is the interaction of uncharged magnetic force fields with electrical conductors. Electromagnetic force is also called Lorentz force, which includes both electricity and magnetism as elements of one phenomenon.



Stepper motor is used to control the direction of picking device. The setup is mounted on PVC pipe.

3.8.1 Specification

PCV pipe dimensions	Length – 50mm Diameter – 3.5mm
Rod	Ferrous material
Winding	Copper wire

3.9Base and frame

Base houses the whole setup and frame is the supporting structure which houses the drives. Base is made of plywood and frame made of sheet metal.

3.9.1 Specification

Component	Dimension	Materials
Base	Length – 190mm Width – 615mm Thickness – 20mm	Plywood
L – Frame	Length – 275mm Width – 100mm Thickness – 2mm	Sheet metal

3.10Adapters

Adapters are used to convert alternate current to direct current.

3.10.1 Specification

Model number	1201000w1eu
Input	100-240V
Frequency	50/60 Hz
Current	0.3A
Output	12V=1.0A
Output Power	12.0W Max

4. Sequence of operation

The controller board which consists of microcontroller, IR sensor, counter etc are connected to power supply. A DC adapter is used to supply power, which converts AC to DC.

Two DC adapters are used of which one is connected with the main controller board and the other with DC motors.

- Firstly the power supply is switched ON; the DC motor starts to run.
- When DC motor starts, the belt starts rolling, resembling the working of a belt conveyor.
- The stepper motor starts running, picking the object (ferrous material) and places it on the belt conveyor.
- As the power is switched ON, IR sensor gets actuated. When an object comes in between the sensors and cuts the beam, the counter starts counting.

Therefore the introduction of automatic pick and place mechanism reduces human effort and counter system helps in keeping the number of components passed in check.

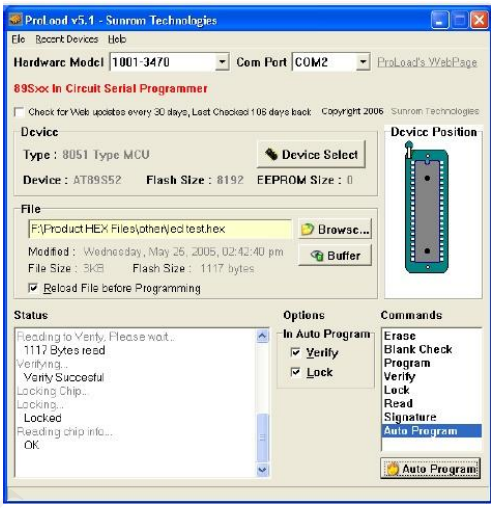
5. Software development and fabrication

5.1 Proload

5.1.1 Creating a Program using Proload

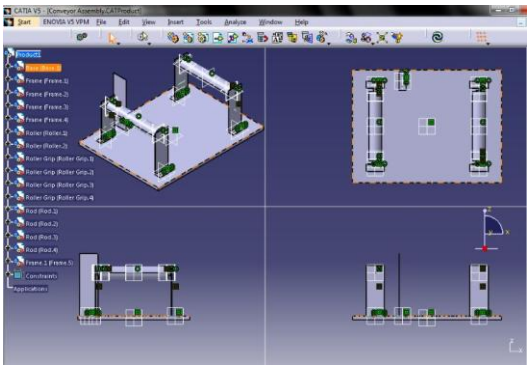
Proload is software which accepts only hex files. Once the machine code is converted into hex code, that hex code has to be dumped into the microcontroller placed in the programmer kit and this is done by the Proload. Programmer kit contains a microcontroller on it other than the one which is to be programmed. This microcontroller has a program in it written in such a way that it accepts the hex file from the keil compiler and dumps this hex file into the microcontroller which is to be programmed. As this programmer kit requires power supply to be operated, this power supply is given from the power supply circuit designed above. It should be noted that this programmer kit contains a power supply section in the board itself but in order to switch on that power supply, a source is required. Thus this is accomplished from the power supply board with an output of 12volts or from an adapter connected to 230 V AC.

This is achieved by completing the following steps:
• Install the Proload Software in the PC.
• Now connect the Programmer kit to the PC (CPU) through serial cable. Power up the kit from AC Adaptor.
• Now place the microcontroller in the GIF socket provided in the programmer kit.
• Click on the Proload icon in the PC. A window appears providing the information like Hardware model, com port, device type, Flash size etc. Click on browse option to select the hex file to be dumped into the microcontroller and then click on “Auto program” to program the microcontroller with that particular hex file.
• The status of the microcontroller can be seen in the small status window in the bottom of the page.
• After this process is completed, remove the microcontroller from the programmer kit and place it in your system board. Now the system board behaves according to the program written in the microcontroller.



5.2 Fabrication setup

The components are modelled in CatiaV5software package; the drafted copies of all the parts used for assembly purpose are as shown below.



Model Final Assembly

The microcontroller program composed that is used to operate IR sensor and stepper motor are as follows:

```
#include<reg52.h>
sfr stepper=0xA0;
sbit relay=P1^4;
//sbit ir=P1^5;
```

```
char
num[]={0x40,0xF9,0x24,0x30,0x19,0x12,0x02,0xF8,0
x00,0x10};                    // Hex values corresponding
to digits 0 to 9
int i;


void delay_ms(int time)              // Time delay
function
{
int i,j;
for(i=0;i<time;i++)
for(j=0;j<1275;j++);
}
void display() interrupt 0  // Function to display the
digits on seven segment. For more details refer seven
segment multiplexing.
{
counter++;
if(counter>9)
{
counter=0;
    }
switch(counter)
{
case 0:
          P0=num[counter];
break;
case 1:
          P0=num[counter];
break;
case 2:
          P0=num[counter];
break;
case 3:
          P0=num[counter];
break;
case 4:
          P0=num[counter];
break;
case 5:
          P0=num[counter];
break;
case 6:
          P0=num[counter];
break;
case 7:
          P0=num[counter];
break;
case 8:
          P0=num[counter];
break;
case 9:
          P0=num[counter];
break;
}
delay_ms(100);
return;
}
void delay()
{
int j;
for(j=0;j<9000;j++);
}
void stepperclock(int x)
{
for(i=0;i<x;i++)
{
stepper=0x01;
delay();
stepper=0x03;
delay();
stepper=0x02;
delay();
stepper=0x06;
delay();
stepper=0x04;
delay();
stepper=0x0C;
delay();
stepper=0x08;
delay();
stepper=0x09;
delay();
    }
delay();
}
void stepperanticlock(int y)
{
for(i=0;i<y;i++)
{
stepper=0x09;
delay();
stepper=0x08;
delay();
stepper=0x0C;
delay();
stepper=0x04;
delay();
stepper=0x06;
delay();
stepper=0x02;
delay();
stepper=0x03;
delay();
stepper=0x01;
      delay();
}
  delay();
}
void main()
{
```

```
while(1)
{
        motor();
        relay=1;
        delay_ms(200);
        stepperclock(9);
        delay_ms(100);
        relay=0;
        delay_ms(100);
        stepperanticlock(9);
        delay_ms(100);
        display();
  }
}
```

6. Conclusion

- With reference to observation made in this project I can conclude that employing the pick and place mechanism will bring accuracy and efficiency to the production system. Automation was the way to bring these changes.
- This project is an integration of mechanical and electrical systems commonly known as mechatronics.
- The system will reduce human effort considerably, thus reducing the cost incurred by human errors.
- The project can be put use to a variety of industries such as micro technology, manufacturing, packaging, canned food industry for inter transportation.
- The project will reduce the need for presence of humans in hazardous environments in industries.

7. Scope for future work

- Due to limited availability of powerful electromagnets, it is not possible to efficiently use the pick and place mechanism which is actuated using an electromagnet.
- In current experimental setup, replacing current motor by ones with more torque could carry heavy objects.
- The pulley distance could be adjusted so that belt tension is maintained.
- The pick and place mechanism could be replaced with a more advance system.
- Several developments in picking mechanism could make it more flexible and capable.

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