PROJECT REPORT

ON

"Automated Coil Winding Machine"

Submitted to

R.T.M. Nagpur University, Nagpur

In partial fulfilment for the requirement of

Post Graduate Diploma in Industrial Robotics

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CERTIFICATE

This is to certify that the project titled "Automated Coil Winding Machine" has been submitted by _____________ in partial fulfilment for the requirement of the Post Graduate Diploma in Industrial Robotics. This is an original work carried out by him/her/them under the guidance of_____________ and has undergone the requisite hours of project work as specified by Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur.

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CHAPTER 1
INTRODUCTION

1.1 Problem Definition

A few years ago winding of the transform coil was done manually, by hand-driven machines, or using some motored machines for swift mechanism. In this modern era, industries still rely on hand-driven & manual winding machines which are used to wind not only in various types of transformers but also some other components and products such as AC/DC Motors, Inductors, and Generators. Some improvement can be seen in winding machines like Programmable transformer winding & automatic transformer winding machines using microcontrollers. Therefore, a further step towards advancement and latest technology in Automation Industry this work can now be completed using some automatic devices like Arduino, geared DC motors, Servo Motors, Motor Drivers, IR sensors which are easily available in the market as well as trouble-free to understand and program. IR sensor used for the detection of the number of winding which to be displayed on 16*2 LED display and push buttons also to be given to set the input and present the real-time status display for the number of windings for the transformer. By using this machine, the efforts for winding can be completed with precision & less human interference as compared to other machines. This machine is inexpensive and can be used for some small-scale production. It can also be helpful for university students to understand the process of winding miniature transformers.

1.2 Overview of Present Working System

1.2.1 Manual Operated Coil Winding Machine

- Manual Coil winding machine is a hand driven machine which is used to manufacture small transformer of 1A to 2A which are used for small scale projects, toys, and educational purpose. A Tight winding can be made using this type of manual machine.

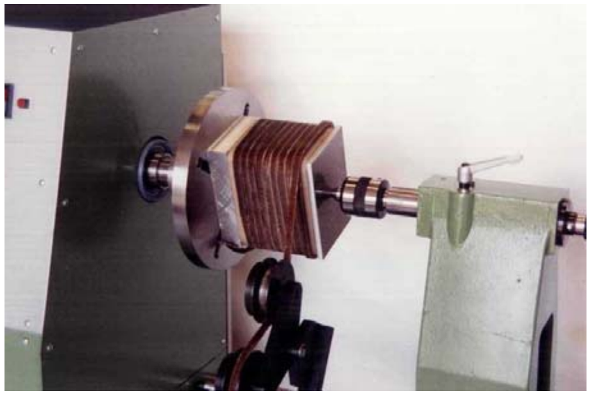
- Speed of this machine is dependent on the skill of labour used and cost required for maintenance of this machine is very low.

- Various hand driven manual machines are used for various coil winding like toroid winding, Transformer winding, motors winding, chokes, etc.

Handheld Coil Winding Machine

1.2.2 Recent Upgrades Made In Coil Winding Machine

- Due to advancement in technology and globalization the manual machines are now upgraded to semi-automated and automated coil winding machines which are purposely used by industries nowadays.
- A lot of skilled and technically sound labour is required to operate and handle the machine carefully.
- These machines uses some famous technologies like PLCs, Microcontrollers, HMIs, etc. which are commonly used these days.



CAW Heavy Duty Coil Machine

The above image shows a reference of semi-automated coil winding machine named as CAW heavy duty coil winding machine. The speed of this machine can be changed using a potentiometer given at the control panel, whereas we can also set speed limit according to diameter of the transformer coil.

- These machines may consist of single spindle or multi-spindle working for effective production, saves energy, time and reduces cost of the product.

1.2.2 Fully Automated Coil Winding Machine

- The automated coil winding machines are enormous in size as these are purposely used to produce big coil windings.
- Large transformer & 3-Phase motors coils can be easily wounded using this machine.
- The controllers used in these machines may vary from microcontrollers to PLCs and other new available technical controllers.
- Ace technicians are needed if any fault occurs as well as programming and hardware knowledge of controllers is a must requirement for the operator.
- These machines can vary in several types, which are given below:

1. Multi bobbin winding machine.
2. Armature winding machine.
3. Magneto winding machine
4. Flyer type winding machine
5. Bobbin less winding machine.

Fully Automated Coil Winding Machine

1.3 Drawbacks of the Present Working System

The recent upgrades regarding automated coil winding machines include many high-end fully automated transformer winding machines operating with very complex mechanisms. These high-end machines are generally used for many high powers and high-capacity transformers. The ones used to wind the small-scale 1 ampere or 2-ampere transformers used in the electronics field are still complex to use and are not suitable for undergraduates to fully work with them as it more often requires fine-tuning and therefore the problems here faced are shown in below points.

1. Excess or less number of coil windings on the product, that is while operating the machine sometimes this error happens
2. Low accuracy and precision as work is manually operated and human interference sometimes leads to error in the product.
3. Sometimes loose winding are there on the product which leads to deterioration of the product (it reduces the life of the product).
4. A routine maintenance is required to the manual operated machine.
5. Skilled labour is required to operate the machine carefully and properly to achieve a high end product.
6. The cost of automated coil winding machine in the market is too much expensive.

1.4 Overview of Proposed System

Industries always need these three parameters they are cheap cost, precise task, and long life of the product for the machines they are using so that the production will be more appreciative and effortless. Mainer times the windings done by manual machines are loose due to which problems occur and customers are also unsatisfied with the product. Apart from this manual machine & programmable machines consumes much amount of time, labour work and power consumption. Therefore, to overcome the standard problems that occurred during the production of the transformer using manual machines, the automated winding machine can be proven as the best performers as well as satisfactory results are obtained. Here we are using the latest and cheapest technology that is Arduino Nano, IR sensor DC motors & servo motors. By using these tools, the servo motors are programmed such that it not only possesses the automatic rotational movement but also a lateral movement which helps to readily wind the coils of the transformer.

The Objective of the development of this model is

- To reduce human interference.
- Accurate & Precise work for the last product.
- Manufacture a cost-effective machine.
- Study of automatic transformer winding for students.

1.5 Advantages of the Proposed System

The proposed system has following advantages

- Cost effective.
- Easy to understand and operate.
- Light weight.
- Highly suitable for light weight transformer.
- Compact design.
- Fast operation.

1.6 Scope of Proposed System

The proposed system is ideal for the beginners so that they can familiarise with the working of transformer. As it is easy to understand one has to simply input the number of coils in the machine and it will do the rest of the work. However for its industrial application, some more modifications will be needed in order to meet the industrial standards.

1.7 Role of intern

The intern has the following roles:

- To understand the basics of transformer.
- To familiarise with the designing software like AutoCAD.
- To understand the working of Arduino programming.
- To be able to make the circuit required circuit for the system.

CHAPTER 2
SYSTEM ANALYSIS

2.1 System Requirements

2.1.1 Hardware Setup

Tools

Electric Cutter (Cold Saw):

A circular saw is a tool for cutting many materials such as wood, masonry, plastic, or metal and may be hand-held or mounted to a machine. Circular saw blades are specially designed for each particular material they are intended to cut.

Drilling machine:

A drill or drilling machine is a tool primarily used for making round holes or driving fasteners. It is fitted with a bit, either a drill or driver, depending on application, secured by a chuck. Some powered drills also include a hammer function. Drills vary widely in speed, power, and size. They are characteristically corded electrically driven devices, with hand-operated types dramatically decreasing in popularity and cordless battery-powered ones proliferating.

Digital Multi meter:

A multimeter also known as a VOM (volt-ohm-milliammeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance. Digital multimeters (DMM, DVOM) have a numeric display, and may also show a graphical bar representing the measured value. Multimeter was used to calculate parameters like current, voltage, resistance, power etc.

General Tool Box:

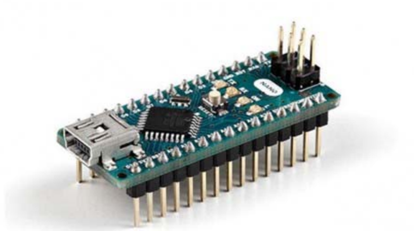
A general tool box contains all the necessary tools to work on a project. The tools we used in this project are:

- Screwdriver set
- Wire cutter
- Wire stripper
- Soldering iron
- Hot Glue gun

Hardware Components

1) **Arduino Nano:**
It is a complete, breadboard-friendly, and small board based on ATmega328 (i.e., Arduino Nano 3.x), which has moreover the same functionality of Arduino Duemilanove without a DC power jack and connects to the computer using a Mini-B USB cable rather than the standard one.

Arduino Nano comes with an ATmega328 microcontroller based on AVR architecture which operates on 5 Volts (DC). Its peripherals include the flash memory of 32KB out of which 2 KB is used by bootloader, an SRAM of 2KB, the clock frequency of 16MHz, and an EEPROM of 1KB. Nano has 8 analog input pins and 22 digital input/output pins out of which 6 are PWM (Pulse Width Modulation) pins. Arduino Nano working -with an input voltage of 7-12V, gives 40mA of current through its input/output pins.



Arduino Nano

Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash Memory	32 KB of which 2 KB used by bootloader
SRAM	2 KB
Clock Speed	16 MHz
Analog IN Pins	8
EEPROM	1 KB
DC Current per I/O Pins	40 mA (I/O Pins)
Input Voltage	7-12 V
Digital I/O Pins	22 (6 of which are PWM)
PWM Output	6
Power Consumption	19 mA
PCB Size	18 x 45 mm
Weight	7 g

2) Servo Motor:

The Tower Pro SG-90 operates at a typical 5V producing a torque of 2.5kg/cm with an operating speed of 0.1s/60º. Servo motor uses plastic gears, provides the rotation of 0º-180º, weighs approximately 9gm, and comes with additional gear horns and screws.

The servo motor has three wires priory connected to it which helps with interfacing with different microcontrollers. Usually, the colour pattern of these wires is the same, Brown is the ground wire connected to the ground of the system, Red powers the motor and needs typical +5V, Orange is the PWM signal is given through this wire to drive the motor.

Servo Motor

3) The Relay Module:

The single channel relay module is an electromechanical device that uses current to open or close the common terminal of a switch, it also includes the components that acts as indicators to show status of the module.

The relay module works on the supply voltage of .375V to 6V, while in active state the relay works on 70mA. The relay can handle maximum contact voltage of 250VAC or 30VDC.The Relay Module includes the components, 5V relay, Transistor, Diode, LEDs, Resistors, etc. For this project, the Relay as a switch to control the dc motor in normally open configuration.

The Relay Module

Pin Number	Pin Name	Description
1	Relay Trigger	Input to activate the relay
2	Ground	0V reference
3	VCC	Supply input for powering the relay coil
4	Normally Open	Normally open terminal of the relay
5	Common	Common terminal of the relay
6	Normally Closed	Normally closed contact of the relay

Single-Channel Relay Module Specifications

- Supply voltage – 3.75V to 6V
- Quiescent current: 2mA
- Current when the relay is active: ~70mA
- Relay maximum contact voltage – 250VAC or 30VDC
- Relay maximum current – 10A

4) LCD 16*2:

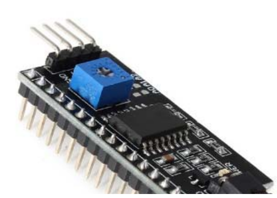
A liquid-crystal display (LCD) is a flat-panel display or another electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead of using a backlight or reflector to produce images in colour or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as pre-set words, digits, and 7-segment displays, as in a digital clock

LCD Display 16*2

LCD 16*2 works with an operating voltage of 4.7V to 5.3V and consumes 1mA without a backlight. Here each character is built by a 5* 8-pixel box, LCD can work on both 8-bit and 4-bit mode also, it is capable of displaying any custom generated characters and is available in green and blue backlight.

5) I2C adapter:

I2C module is used to convert parallel data from LCD to serial form so that less number of pins would be needed to interface the LCD. The module also includes the contrast adjustment potentiometer to control contrast of the LCD display. The operating voltage for I2C module is 5V, it provides the Serial I2C control of LCD display via PCF8574, the I2C module is compatible for 16*2 LCD, and the data realization only 2 data pins would be used.



I2C Adapter for LCD

6) **IR Module (object detector):**

IR module includes an IR transmitter and a photodiode receiver. IR light has a wavelength of 700nm-1mm which is much higher than the visible light range. IR LEDs emits light at an angle of approx. 20-60 degree and ranges from few centimetres to several feet, depending on the manufacturer. The IR module also includes on board LM358 OP-Amp which is used as a voltage comparator and the output of the comparator is sent to the output terminal. The module operates at 5V dc and input/output pins are compliant with 3.3V and 5V, it has a range of up to 20cm including an adjustable sensing range that works on a 20mA supply current.

IR Module (object detector)

7) **Geared DC motor:**

Gear motors are a mix of a regular dc motor and a servo motor and they can be moved bidirectional (one step at a time), positioned accurately, but can also provide continuous rotation. As the aim of our project is to minimize the scale and cost of the system, the dc motor is advantageous over the stepper motor as it's easy to control, program, and also cost-effective.

Geared DC Motor

8) **Button switch for keypad:**

Instead of using the ready-made keypad from the market, we chose to use our keypad made from these push-button switches which work on tactile feedback with a power rating of a maximum 50A 24V dc. It has an operating force of 2.55 N (0.69 variable), contact resistance of 100mOhms, and an operating temperature range of -20^{o}C to +70^{o}C.

Pushbutton Switch

9) **Potentiometer:**

The potentiometer is a 3 terminal variable resistor where the resistance is manually varied to control current. The two types of general potentiometers are rotary potentiometer and linear potentiometer. Potentiometer shown above has uniform resistance placed in semi-circular pattern placed between two terminals. The middle terminal is connected to rotary knob via sliding contact. Rotating the knob results in movement of sliding contact on resistance.

Potentiometer

2.1.2 Software Setup

AUTODESK AUTOCAD:

AutoCAD is a computer-aided tool that allows many different types of designers to create diverse kinds of drawings and designs. This program helps designers create their designs much more quickly than by hand and offers many quick, easy, and useful features, such as copy and paste. AutoCAD can create any 2D drawing and 3D model or construction that can be 29 drawn by hand. The program also allows the user to group or layer objects, keep objects in a database for future use, and manipulate properties of objects, such as size, shape, and location.

TINKERCAD:

TinkerCAD is a free, online 3D modelling program that runs in a web browser, known for its simplicity and ease of use. Since it became available in 2011 it has become a popular platform for creating models for 3D printing as well as an entry-level introduction to constructive solid geometry in schools.

ARDUINO IDE:

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. By default, avrdude is used as the uploading tool to flash the user code onto official Arduino boards.

2.2 Feasibility Study

2.2.1 Economic Feasibility

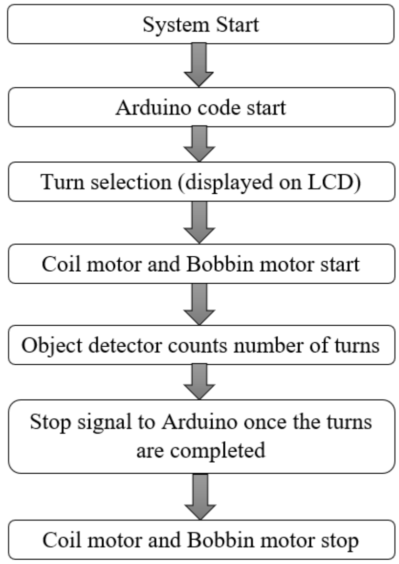
In order for the system to be economically feasible, it is essential that it should be cost effective and the components should be easily available. Below are the list of components with their price and status of availability

Component Name	Price	Availability
Arduino Nano	250/-	Easy
Servo Motor	120/-	Easy
Relay Module	70/-	Easy
LCD 16*2	180/-	Easy
I2C Adaptor	40/-	Easy
IR Module	120/-	Easy
Geared DC Motor	200/-	Easy
Button Switch	2/-	Easy
Potentiometer	10/-	Easy
Buzzer	5/-	Easy
Connecting Wires	50/-	Easy

The total cost of all components was around 1500/- (including spares for the backup stationary) and were easily available in the market. Therefore it can be said that the proposed system can easily be manufactured.

2.2.2 Operational Feasibility

The system works on different power modes. Servo motor, LCD display, push button and buzzer receive power from Arduino Nano which operates on 5V DC. The geared servo motor operates on 12V DC. The operation of the system is simple and explained in flowchart below:



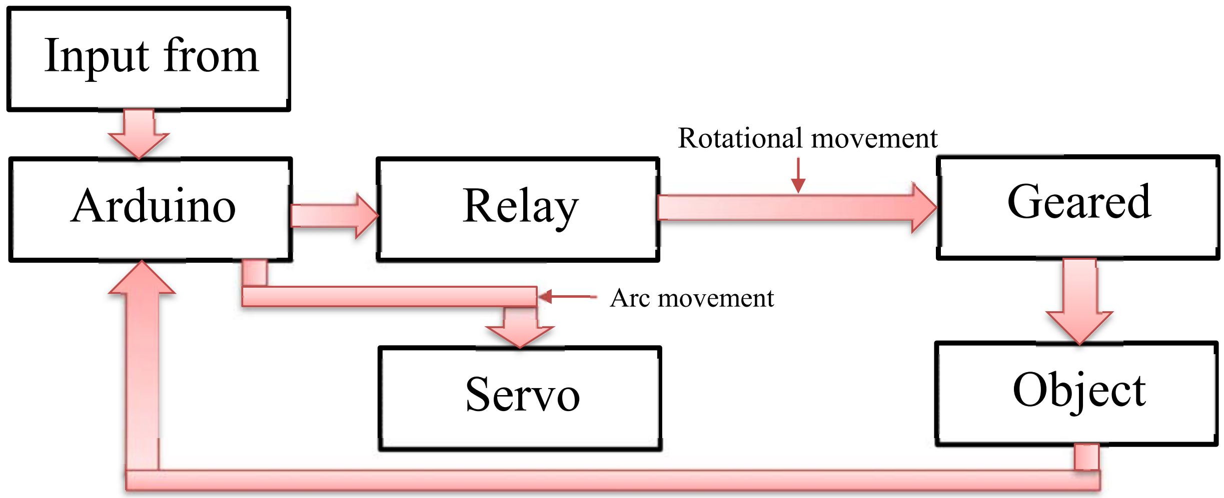
As seen in the flow chart from flowchart the user provides the input (i.e., the numbers of turns to wound on the bobbin) to the Arduino then, the selected number of turns as well as relative information will be displayed on the LCD display. According to the input from keyboard, the Arduino will activate the dc motor for rotational movement via 5V relay module, and drive the servo in arc fashion to provide a sort of lateral movement which will allow wire to spread uniformly over the bobbin.

2.2.3 Technical Feasibility

The proposed system is working on Arduino Nano which is very easy to program. Anyone with basic programming syntax knowledge is able to code the Arduino. The Arduino itself contains various libraries in which the library of servo motor is present. So there is no need for other software to program the servo motor separately. In the same way the LCD display can also be programmed for user interface. The circuit diagram of the system is not too complex to understand and it can be easily made and easy to assemble. Therefore the technicality of the system is not hard.

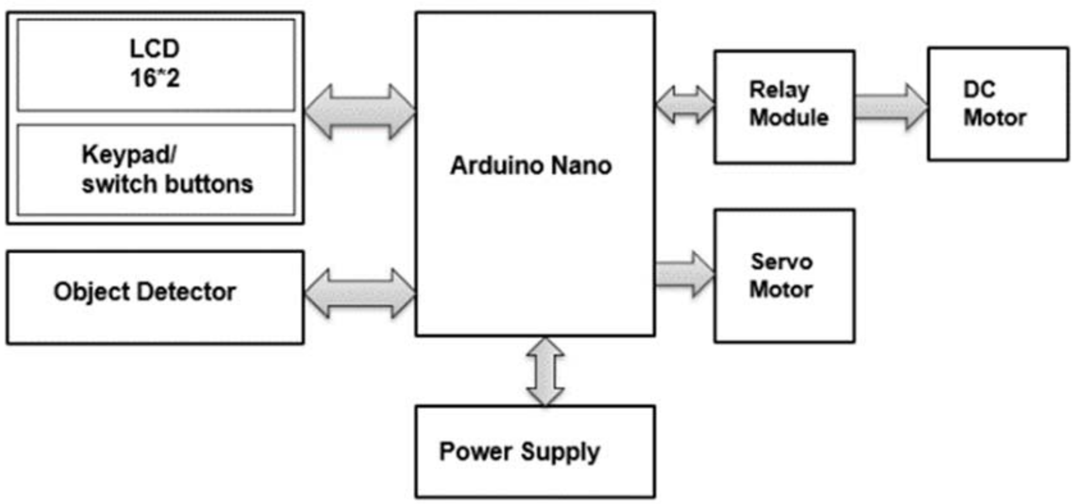
CHAPTER 3
SYSTEM DESIGN

3.1 Data Flow Diagram



Block diagram for the working mechanism of the model

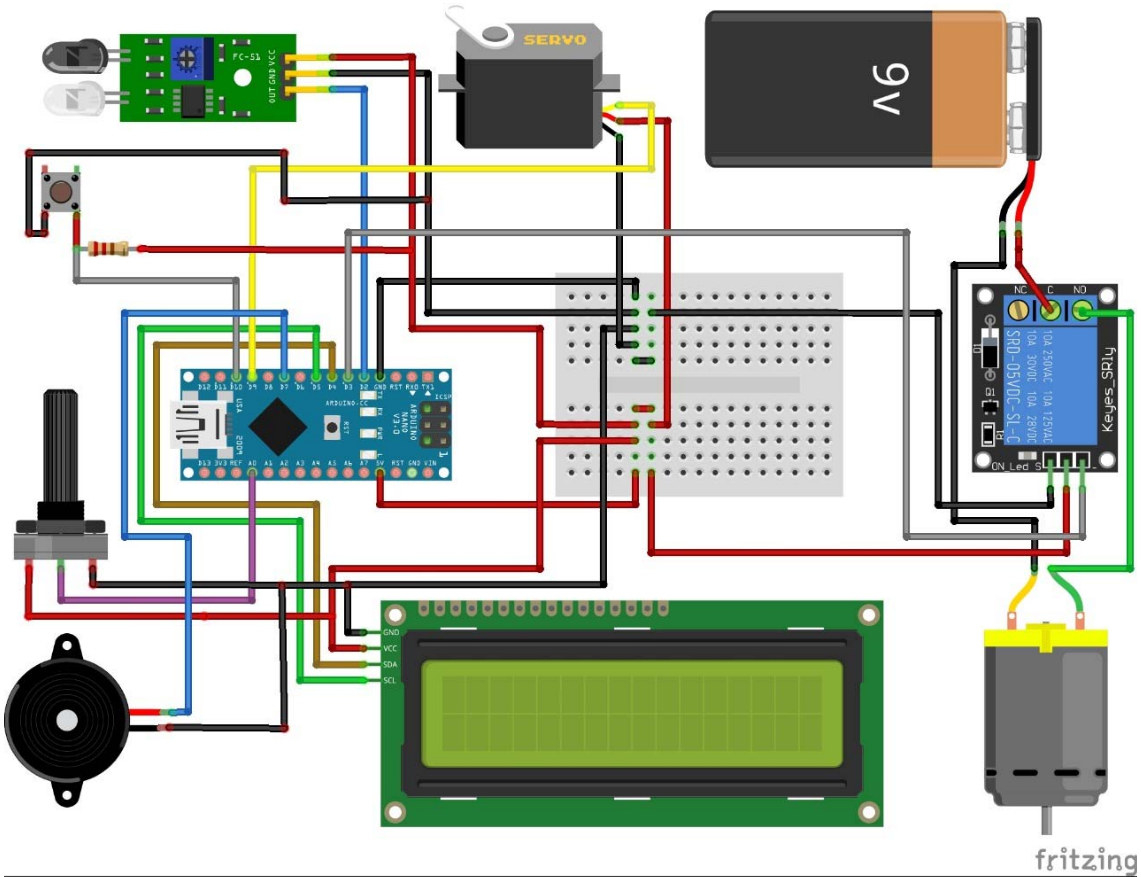
3.2 System Flowchart



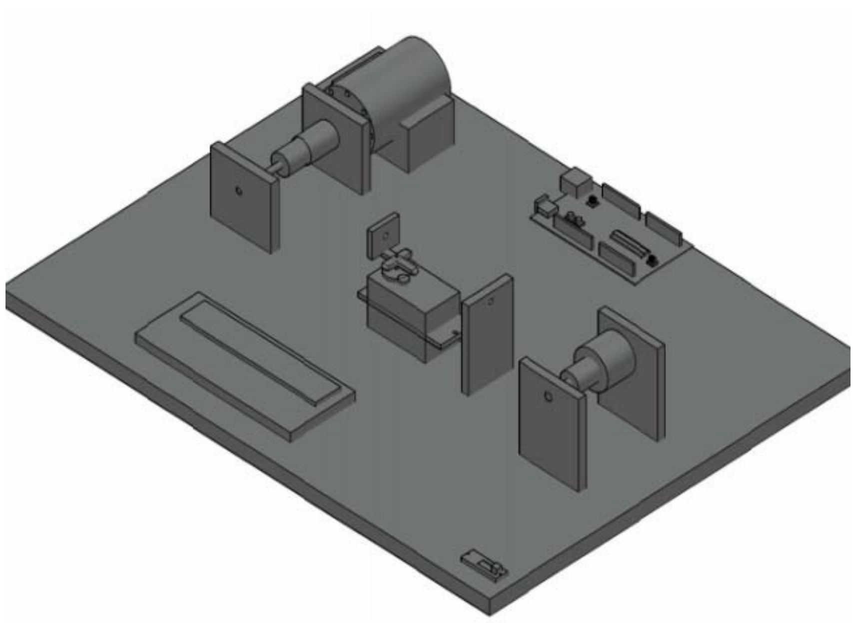
Above is the block diagram of the model to be made. In this all the components are connected directly or indirectly to the Arduino Nano board. In the Block diagram given above, the liquid crystal display with 16*2 pixels i.e., 16 columns and 2 rows of pixels. The LCD is used to display the real-time status of the number of turns made on the bobbin will be displayed on the LCD. The inputs from the keypad or switch buttons while selecting the number of turns to be wound are also displayed.

The object detector is used here to count the number of turns made by the dc motor. Here, the object detector includes an IR led and a photodiode so that it will measure the number of turns made by the shaft of the dc motor. The 5V relay module is used to control the dc motor via Arduino, another motor is the servo motor which is directly connected with the Arduino Nano.

Two types of movements are required to wound the wires to the bobbin, first rotational movement, and second lateral movement. The rotational movement controls the number of turns to be wound and the lateral movement is used to cover the overall woundable size of the bobbin. Here, instead of using the threaded shaft, we have used the servo motor to control the area covered in the winding process. So, the servo motor is used within the previously decided range which is finalized using trial and error.



Complete Circuit Diagram of the System



CAD design of the System

CHAPTER 4

CODING: SOURCE CODE

```
#include <LiquidCrystal_I2C.h>
#include <Servo.h>

int buzzPin =7;
Servo myServo;
int ServoPin = 9;
int ServoPos = 90;
int ServoAdd = 1;

int IRPin = 2;
int IRState;

int okButton = 10;
int okButtonState;

int potPin = A0;
int potState;

int motorPin = 3;

int totalWinding;
int windCount = 0;
int mappedPotState;

LiquidCrystal_I2C lcd (0x27, 16, 2);



void setup() {
  // put your setup code here, to run once:
  pinMode (okButton, INPUT);
  pinMode (IRPin, INPUT);
  pinMode (buzzPin, OUTPUT);
  pinMode (motorPin, OUTPUT);
  myServo.attach(ServoPin);
  digitalWrite (motorPin, LOW);
  okButtonState = digitalRead (okButton);

  //lcd related stuff
  lcd.init();
  lcd.backlight();
```

```
lcd.setCursor (0,0);
lcd.print("Coil Winder");
lcd.setCursor (0,1);
lcd.print ("PGDIR RTMNU");
delay (3000);
lcd.clear();
lcd.setCursor (0,0);
lcd.print ("  Developed by  ");
lcd.setCursor(0,1);
lcd.print ("BunyVivekPratik");
delay(2000);
lcd.clear();

lcd.setCursor(0,0);
lcd.print ("Enter Weight: ");
lcd.setCursor(0,1);
lcd.print ("Ok to confirm");
delay (1000);

while (okButtonState == HIGH)
{
  potState = analogRead (potPin);
  mappedPotState = map(potState, 0, 1023, 0, 50);
  lcd.setCursor(14,0);
  lcd.print (mappedPotState);
  delay(500);
  if (digitalRead(okButton) == LOW)
  {
    break;
  }
}

lcd.clear();
//windCalc()
lcd.setCursor(0,0);
lcd.print ("Chosen wght=");
lcd.print (mappedPotState);
lcd.print ("g");
totalWinding = mappedPotState * 3;
```

```
  lcd.setCursor (0,1);
  lcd.print ("Windings:");
  lcd.print (totalWinding);
  delay(3000);

  lcd.clear();
  //countDown()
  lcd.print ("Starting in ");
  lcd.setCursor (0,0);
  lcd.setCursor (0,1);
  lcd.print("Reset -> Cancel");
  for (int i = 9; i>=0; i--)
   {
    lcd.setCursor(13,0);
    lcd.print (i);
    delay (1000);
   }
}

void loop() {
  // put your main code here, to run repeatedly:

  for(windCount; windCount < totalWinding; windCount++)
  {
//while(windCount < totalWinding)
  //{
   digitalWrite(motorPin, HIGH);
   IRState = digitalRead(IRPin);
   Serial.println (IRState);
   //lcd.clear();
   lcd.setCursor(0,0);
   lcd.print ("Windings: ");
   lcd.print (windCount);
   //digitalWrite(motorPin, HIGH);
   for (int pos = 0; pos <= 180; pos += 1)
    { // goes from 0 degrees to 180 degrees
     // in steps of 1 degree
     myServo.write(pos);              // tell servo to go to position in variable 'pos'
     delay(15);                       // waits 15ms for the servo to reach the position
    }
```

```
  for (int pos = 180; pos >= 0; pos -= 1)
    { // goes from 180 degrees to 0 degrees
      myServo.write(pos);              // tell servo to go to position in variable 'pos'
      delay(15);                       // waits 15ms for the servo to reach the position
    }
  }



/*
if (ServoPos==135 || ServoPos==40){
 ServoAdd = -ServoAdd;
}
ServoPos = ServoPos + ServoAdd;
myServo.write (ServoPos);
*/

 while(windCount >= totalWinding)
 {
  digitalWrite (motorPin,LOW);
  digitalWrite(buzzPin, HIGH);
  delay (500);
  digitalWrite(buzzPin, LOW);
  delay (500);
 //switchOnFunction();
 //myServo.write(150);
 //delay(1000);
 //myServo.write(90);

  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print ("Winding Complete");
  lcd.setCursor(0,1);
  lcd.print ("Reset -> restart");
  delay (1000);
 }
}
```

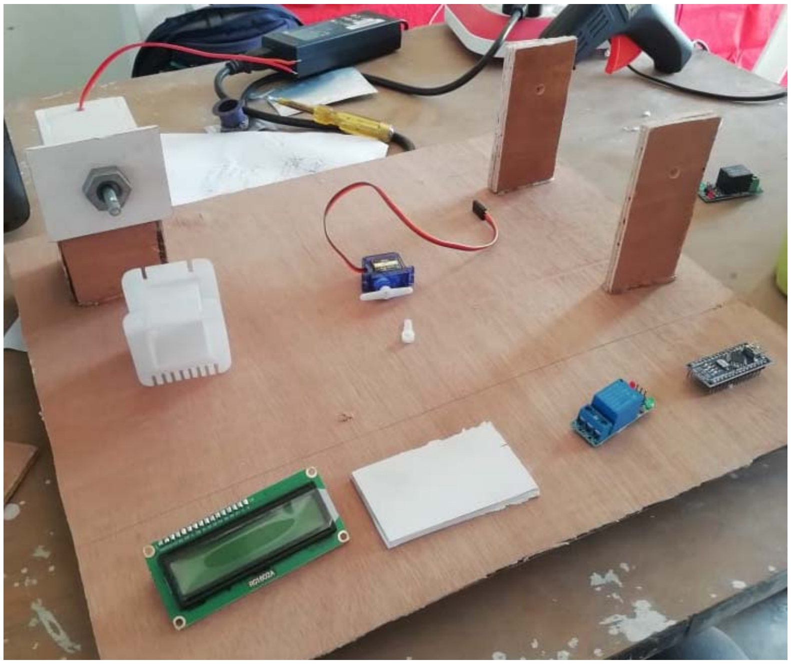
CHAPTER 5
SYSTEM TESTING

5.1 Program Testing

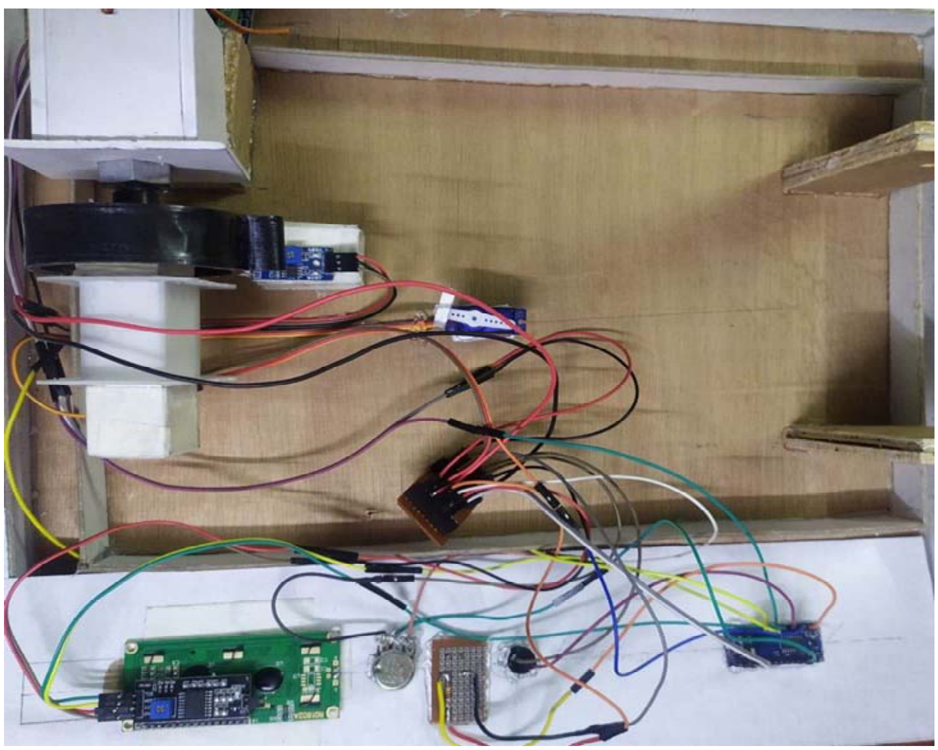
Successful execution of the Arduino program

Program Execution Underway

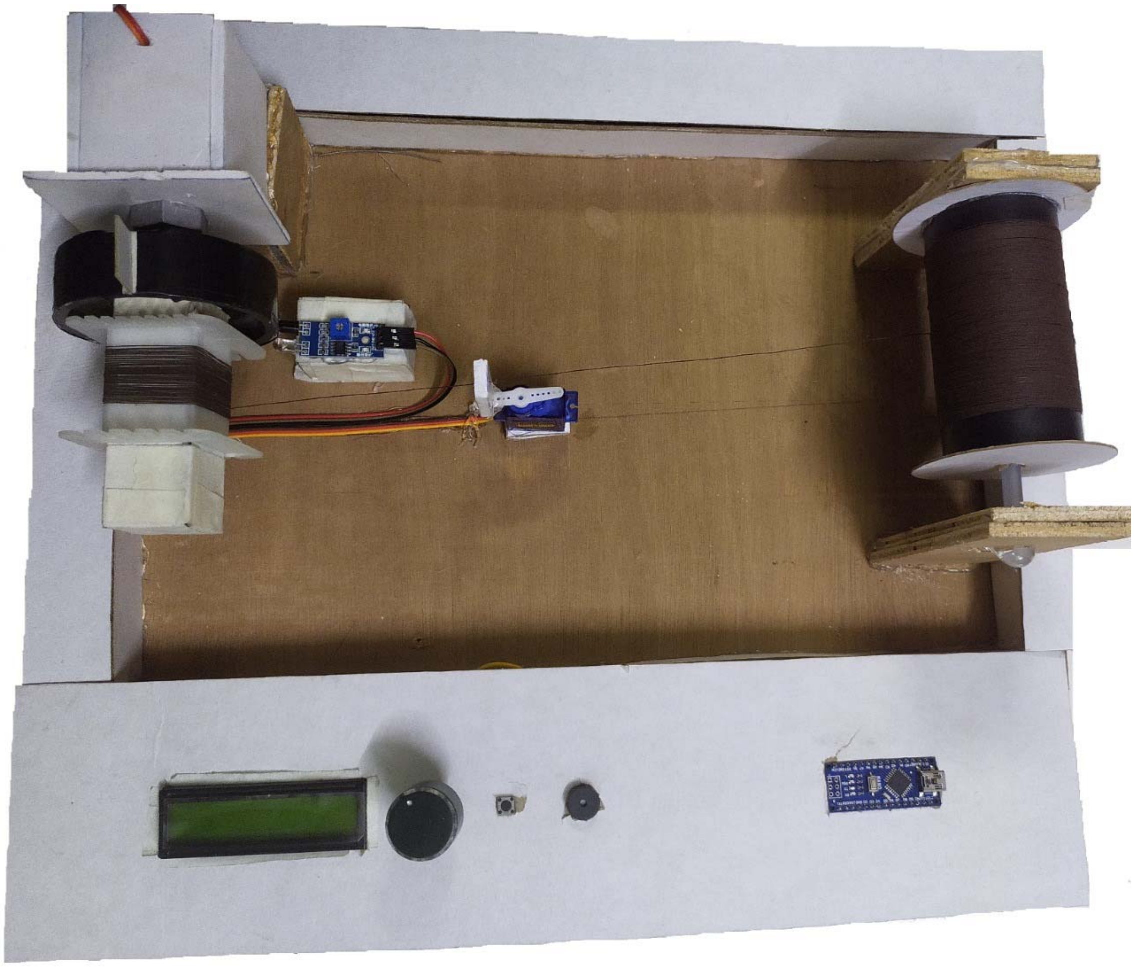
5.2 System Testing



Initial System Setup Layout



Complete Wiring of System



Final Assembly of System

CHAPTER 6
LIMITATIONS AND FUTURE SCOPE

6.1 Limitations of the System

Despite being advanced from the previous versions, the system has its limitations:

- The current system can only be used for lightweight transformers only.
- There is a risk of failure in servomotor.
- The material used for making the body of system is not durable.
- The current system can only be used for educational purpose.
- There is no backup for power loss situation.

6.2 Future Scope of the System

The system with few changes can be very advantageous in the industry:

- With change in the construction material, the system can be made strong and sturdy for industrial environment.
- With modifications in the code, customised windings can be obtained.
- Servomotor can be fine-tuned for more precision winding.
- DC motor can be modified in such a way that it can hold bobbins of different size and weight.

CHAPTER 7
CONCLUSION

Having examined the previous coil winding models a conclusion can be sorted that the preceding machines do not have such quality precision, had high maintenance, and extreme human interference. To overcome these problems, some upgrade versions were also made so that the parameters such as cost and human interference to be reduced to make it automatic but did not have the perfect precision for the number of coils and tightness during the procedure.

Therefore, for such precision and equal distribution over the area of the bobbin with thickness and tightness of wire Programmable Coil winding machines are used. But the only drawback we found here is the size of the machine is from medium to a large scale (which consumes a lot of areas), expensive controllers, parts, and components, as well as more power consumption, is found. Skilled men are also required to handle the device with care

To resolve all these problems a compact-sized, well designed, accurate & precise transformer winding machine is made. The only problem that may occur is the speed of winding the coils. If the speed is nominal the machine works great with the precision point of view, but if speed increases then there may be chances that winding may get spilled and crumble over the area of the bobbin.

CHAPTER 8
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