BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 316

Power Electronics Laboratory

Final Project Report

Section: B1 Group: 06

Speed control of DC motor with feedback from digital tachometer

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Signature of Instructor: ______________________________

Academic Honesty Statement:

IMPORTANT! Please carefully read and sign the Academic Honesty Statement, below. <u>Type the student ID and name, and put your signature</u>. *You will not receive credit for this project experiment unless this statement is signed in the presence of your lab instructor.*

"In signing this statement, We hereby certify that the work on this project is our own and that we have not copied the work of any other students (past or present), and cited all relevant sources while completing this project. We understand that if we fail to honor this agreement, We will each receive a score of ZERO for this project and be subject to failure of this course."

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1 Abstract

In this control system, a battery serves as the power source, with a buck converter reducing its voltage to a suitable level for a motor. The motor's speed is adjusted via a potentiometer, while a tachometer measures the actual speed using infrared rays. A feedback loop constantly compares the desired motor speed, set by the potentiometer, with the actual speed detected by the tachometer. This comparison results in adjustments to the pulse width of the control signal using Pulse Width Modulation (PWM), which directly influences the motor's speed. If the actual speed deviates from the desired speed, the system dynamically alters the pulse width to maintain the motor's performance, making it a versatile control mechanism used in applications requiring precise speed regulation, such as robotics and industrial automation.

2 Introduction

This Project represents an innovative and practical application of control systems in the realm of electrical engineering. In this project, we explore the dynamic regulation of a DC motor's speed using a feedback mechanism provided by a digital tachometer. The ability to precisely control the speed of motors is crucial in numerous industrial and automation applications. By integrating a digital tachometer into the control system, we aim to achieve enhanced accuracy and efficiency in motor speed regulation. This project delves into the underlying principles of motor control, feedback systems, and digital sensors to design a robust and adaptable solution for achieving and maintaining the desired motor speeds. It is an exemplary showcase of how modern technology and control theory can be leveraged to optimize the performance of electromechanical systems in various practical scenarios.

3 Design

3.1 Necessary Equipment

- Arduino Uno
- Motor
- SG 3524
- LCD display
- Infrared sensor
- Potentiometer
- Bread board
- IRZ44, IRF250
- Connectors

3.2 Design Method

In this project, we embarked on the task of precisely controlling the speed of a DC motor, employing a sophisticated feedback system centered around an IR module designed to function as a Tachometer. Our journey commenced by harnessing input from a Potentiometer, which effectively acted as the means to set the desired speed for the motor.

With this desired speed in mind, we ventured further into the intricacies of our setup. We turned to the Tachometer, which played a pivotal role in measuring the current speed of the motor. Armed with this crucial data, we ventured into the realm of control.

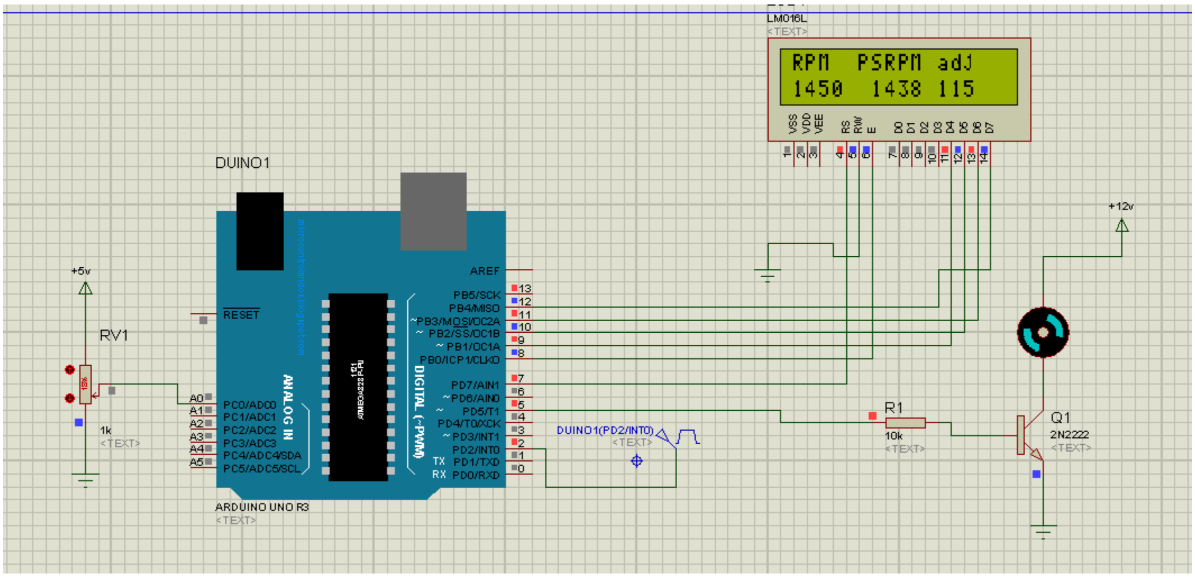
Our control strategy revolved around comparing the motor's real-time speed, as sensed by the Tachometer, with the desired speed preset using the Potentiometer. If the desired speed exceeded the current rate, our system ingeniously responded by widening the pulse width, thereby propelling the motor to accelerate. Conversely, if the motor's pace lagged behind the desired target, we adjusted the pulse width, skillfully decelerating the motor.

The mastermind behind this intricate dance of precision was none other than an Arduino, orchestrating every move with finesse. To provide users with tangible feedback on the speed dynamics, we harnessed a 16x2 LCD display, which elegantly showcased both the desired and real-time motor speeds.

As with any complex system, the power requirements posed their own challenges. Multiple voltage sources were necessitated, and to seamlessly regulate these voltages for precise motor control, we harnessed the capabilities of a buck converter, ensuring a stable and reliable power supply.

For the critical task of driving the motor, we entrusted a MOSFET, recognizing that the microcontroller alone couldn't deliver the requisite current. This approach ensured that our project operated flawlessly, bringing together engineering, electronics, and software in perfect harmony to achieve our goal of precise DC motor speed control.

3.3 Simulation Model



4 Implementation

This project was implemented by Arduino Uno. Arduino calculates the current speed and works with the feedback system to control the speed. Infrared ray was used to find the speed using the law of reflection. One of the wings of the fan is white in color and from there IR was reflected. By counting the number of reflections per second, we find the rotation per minute.

4.1 Via Arduino Code:

Several variables are initialized at the very beginning.
Isr() function increases the rev variable each time it is called.
Pin modes are set for ‘sense pin’ as input and ‘motorpin’ as output.

Project__EEE316.ino

```
float value = 0;
float rev = 0;
int rpm;
int oldtime = 0;
int time;
int sensePin = A0;          // this pin will be used to set the frequency by changing the varible resistor.
int motorPin = 5;          // Motor is connected here
int incmspeed = 50;
void isr()                 //interrupt service routine, only in pin number 2 or pin number 3
{
  rev++;
}

void setup() {
  Serial.begin(9600);
  pinMode(sensePin, INPUT);
  pinMode(motorPin, OUTPUT);
  attachInterrupt(0, isr, RISING);  //attaching the interrupt
}
```

The loop() function is where the main code execution occurs.
The RPM is measured with the help of formula.
The speed (‘incmspeed’) is adjusted based on the current value and preset value.

Project__EEE316.ino

```
void loop() {
  int val = analogRead(sensePin);  //val stores the frequency value this value will be compared with the rpmcount which is the frequency of the motor.
  val = map(val, 0, 1023, 0, 8000);
  Serial.println("PRESET VALUE:");
  Serial.println(val);
  delay(1000);
  detachInterrupt(0);
  time = millis() - oldtime;  //finding total time for one rev
  rpm = (rev / time) * 60000;  //calculating the rpm
  oldtime = millis();
  rev = 0;
  Serial.println("Current RPM:");
  Serial.println(rpm);
  attachInterrupt(0, isr, RISING);

  if (rpm < val) {
    incmspeed = incmspeed + 10;
  }
  if (rpm > val) {
    incmspeed = incmspeed - 10;
  }
  if (incmspeed < 1) {
    incmspeed = 0;
  }
  if (incmspeed > 254) {
    incmspeed = 255;
  }
  Serial.println("SPEED VALUE:");
  Serial.println(incmspeed);
  analogWrite(motorPin, incmspeed);
}
```

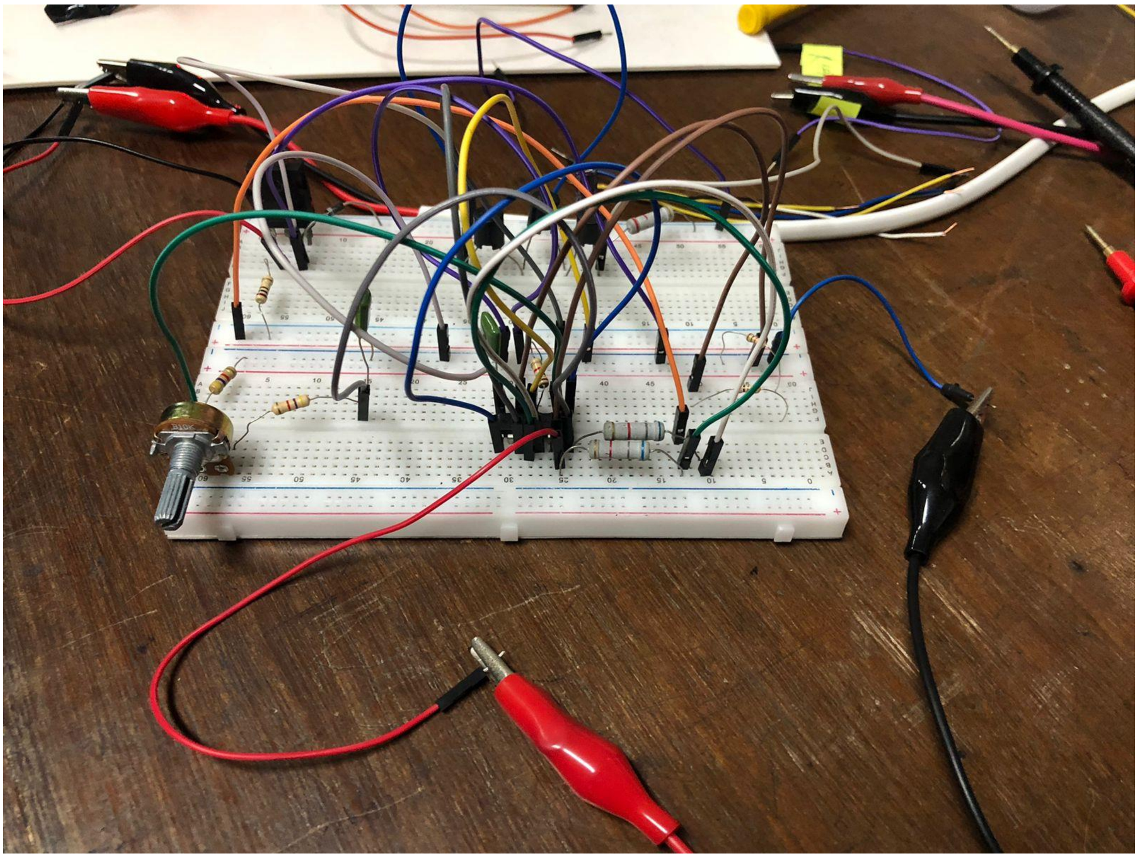

- This code is designed to control sensor first.

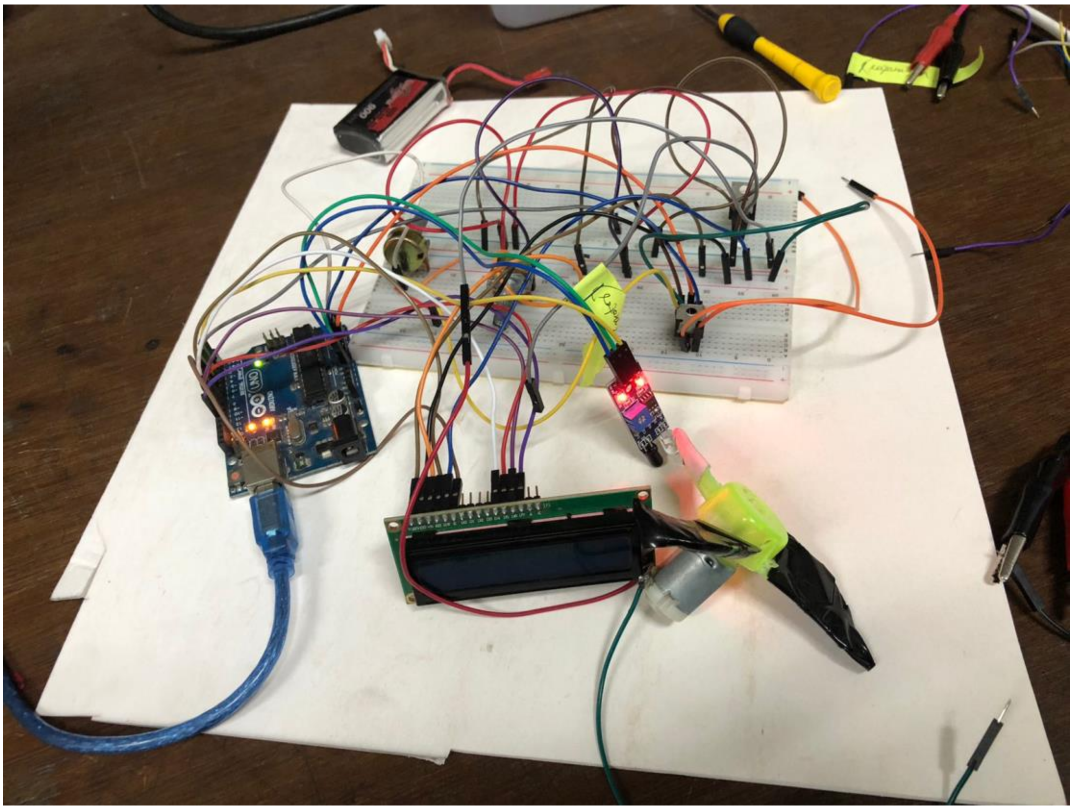
- The motor's speed is adjusted to match the desired RPM.

- If the RPM is below the desired value, the motor speed increases, and if it's above, the motor speed decreases.

- The code continuously loops through this process to maintain the motor at the desired RPM.

4.2 Hardware Implementation:





4.3 Output Waveform of SG 3524:

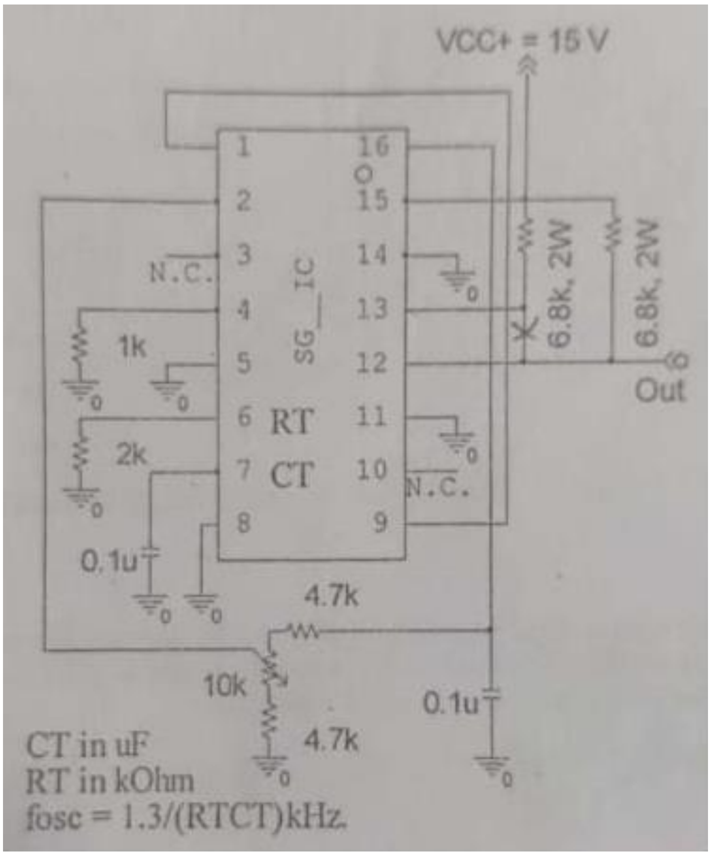


Fig: Circuit Diagram of Buck Converter

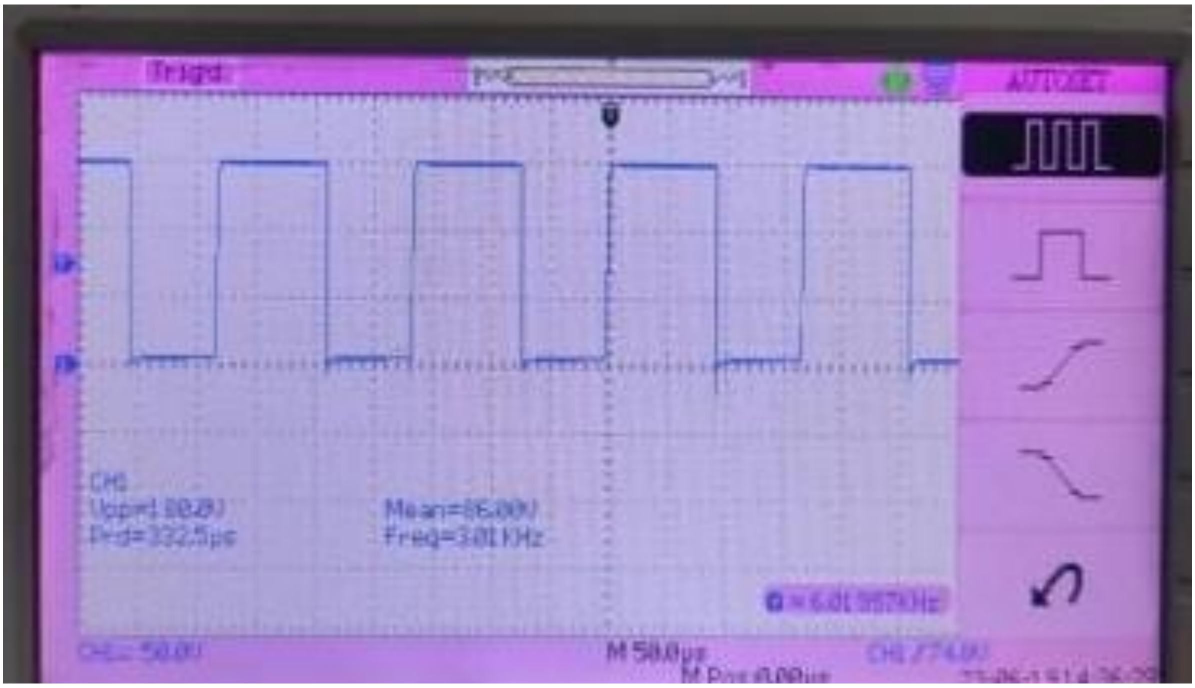


Fig: Output

5 Design Analysis and Evaluation

- The code and circuit worked successfully.

- Yet there is a small margin of error occurred due to the controller circuit.

- The output becomes slightly inconsistent due to the variation of amplitude and duty cycle of the pulse signal extracted from buck converter.

- To solve this problem, we had to crosscheck the appropriate amplitude and duty cycle of the converter time and again.

- Through proper circuit modelling and sincere hard work, the project is completed successfully

5.1 Novelty

- We have used Infrared Ray to calculate speed using its reflection. This method is unique and we manipulated the law of reflection in our project.

- We have used buck converter for stepping down our voltage.

- ➢ In order to get a voltage range of 5V-6V, we had to use inductor of inductance 9mH.

- ➢ The feedback system tries to catch the preset speed by changing the pulse width of the voltage.

5.2 Design Considerations

5.2.1 Considerations to public health and safety

- ✓ Electrical Safety: Small amount of voltage is required for this circuit which prevents electric shock. Moreover, we have designed the circuit considering proper grounding, insulation and so on.
- ✓ Mechanical Safety: For applications involving moving parts, such as conveyor belts or robotic arms, we will install safety features like emergency stop buttons, protective barriers, and fail-safe mechanisms to halt operations in case of a malfunction or personnel entering a hazardous zone.

5.2.2 Considerations to environment

- ✓ The project doesn't involve any kind of emissions of Carbon and Greenhouse gases.
- ✓ Other than the battery, no other components are harmful for soil.
- ✓ This is energy efficient and reduce power consumption.

5.2.3 Considerations to cultural and societal needs

- ✓ Ours is a tropical, hot country with tropic of cancer passing over the country. So controlling the speed of cooling system and fans is important.
- ✓ This project has acceptance not only in our country but also all over the world.
- ✓ The countries with advanced technology can use our project to control arms of robot and speed of a conveyor belt.

5.3 Limitations of Tools

- ▪ According to our design, one blade out of three in a fan should be white and other two should be black. As black blades of the fan will absorb IR but white will reflect the ray.
- ▪ The feedback system has marginal steady state error. We needed to compensate the error.
- ▪ The circuit has high inductance which may consume additional power.

5.3 Impact Assessment

5.3.1 Assessment of Societal and Cultural Issues

- o Without any doubt, this project will have acceptance to each and every society.
- o The project is not for any particular culture and nation.
- o This can be used in diversified machine to control speed and position.

5.3.2 Assessment of Health and Safety Issues

- The project is harmless to living things.
- Blades of the fan was covered by a case to protect fingers.
- As the control system controls the machine, in no other way the motor will run away burning itself at higher potential.

6 Reflection on Individual and Team work

Our team has 6 members. And we divided ourselves in three subgroups. Each subgroups consist of two members. And we divided the job in three parts. Thus successful completion of tasks by each of the groups, made this project successful.

6.1 Individual Contribution of Each Member

Roll 98 and 1806068 designed the buck converter and calculated the required value of inductance theoretically.

Roll 96 and 95 designed the feedback system in Arduino.

Roll 97 and 73 implemented the whole circuit with digital tachometer.

6.2 Log Book of Project Implementation

Date	Milestone achieved
4th week	Submitted Project Proposal
5th week	Figured out the design method and divided the job among ourselves.
6th week	Purchased necessary equipment
8th week	Completed designing Buck converter.
9th week	Implemented tachometer and tested randomly to ensure it worked.
11th week	Implemented the feedback in Arduino.
12th week	Co-ordinating the whole circuit and testing in lab

7 Project Management and Cost Analysis

From our observation, this project is worth considering the amount of expense.

Components Used	Market price(Tk)
1. Arduino Uno	**1000**
2. DC Motor	**200**
3. LiPo Battery	**1100**
4. 16*2 LCD display	**250**
5. IR sensor	**50**
6. Breadboard (4)	**520**
7. Others	**200**
Total	**3320**

We require only Tk. 3320 to control the speed. Some other control systems were so expensive. Though our project had some limitations, the project was very cheap compared to the job it did.

8 Future Implementation:

- Advanced Control Algorithms: The project could explore the implementation of advanced control algorithms, such as model predictive control (MPC) or adaptive control, to achieve even more precise and responsive speed control. These algorithms can adapt to changing motor dynamics and optimize control parameters in real-time.

- Integration of Machine Learning: Machine learning techniques, such as neural networks or reinforcement learning, could be employed to optimize the control system parameters based on data-driven models. This could lead to improved efficiency, better disturbance rejection, and enhanced motor performance.

- Smart Sensor Integration: Integration of smart sensors, such as accelerometers or gyroscopes, along with the tachometer, could provide additional data for more accurate speed monitoring and feedback control. These sensors can help compensate for external disturbances and provide better motor performance.

- Energy Efficiency Optimization: The project could focus on optimizing the motor's energy efficiency by considering factors such as load demand, speed profiles, and power consumption. This could involve developing energy-efficient control strategies, incorporating regenerative braking, or integrating energy storage systems.

- Integration with IoT and Cloud Connectivity: Future implementations may leverage Internet of Things (IoT) technology and cloud connectivity to enable remote monitoring, data logging, and analysis. This would facilitate performance optimization, predictive maintenance, and integration with other smart systems.

9 References

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