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DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

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Power Electronics Laboratory

Final Project Report

Section: B1 Group: 05

Sensorless BLDC Motor Control with Arduino

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1 Abstract

Sensorless BLDC motor control sometimes called sensorless trapezoidal control of BLDC motors uses back EMF (BEMF) for determining the location of the motor's rotor with respect to the motor's stator. A voltage applied across a motor's winding forces the motor's rotor to turn. But motor also generates its own voltage. This voltage is referred to as back electromotive force which is proportional to the motor's rotational speed. Back EMF can be used to determine a motor's rotor speed and position—no sensors are required. This will make controlling the motor easier with less wire. Though, controlling a motor by means of back EMF is not a simple task. Our sensorless BLDC motor is operated by the help of a dedicated MOSFET driver IC**.**

2 Introduction

Driving a brushless motor requires control electronics for precise commutation. However, this is possible only if the control electronics "know" the exact position of the rotor at all times. Traditionally, this information was provided by sensors, i.e., Hall sensors, installed inside the motor. But it can be done differently. Sensorless control methods use current and voltage information from the motor to determine the rotor position. The motor speed can then be derived from changes in the rotor position, and this information can be used for speed control. More advanced sensorless control methods can even control the current (torque) and the position. Leaving out the sensors has a range of benefits, such as lower cost and space savings, because cables, connectors, and sensitive electronic circuits become unnecessary.

3 Design

The objective of this designed system is to make a precise speed control circuit for a brushless DC motor which can be implemented with some simple IC's . Throughout the design process simplicity along with lost cost is prioritized. A microcontroller will be used as the heart of the system which will do the mathematical calculations along with generating the gate pulse required for the MOSFET network. MOSFET driver will provide isolation with the main circuit from the microcontroller and provide extra power when needed. MOSFET will do the switching for the required waves for driving the motor and supply motor's required current when needed.

3.1 Problem Formulation:

DC motos can be a good alternative to our daily operated other types of motors. The problem that comes with this advantage is that DC motors brush isn't life lasting element. The solution comes from the problem itself; brushless DC motor is widely used now. Although its wide usability controlling speed of a DC motor is always more complex than controlling the speed of normal induction motor or any other ac motor. But by having the ability to control speed of a DC motor we have precision in the step size. The speed controlling method of a DC motor also unlocks some feature like an increment/decrement of 5 to 10 rpm accurately where AC motors cannot provide us with this much accuracy.

3.1.1 Identification of Scope

We have a large number of ways available when it comes to the purpose of speed controlling of a DC motor. Some comes with a precise control with a low power handling capability , whereas others come with high power handling capacity but with lower accuracy. We can tune these features more or less in our designed circuit. We can easily swap out the power MOSFET's with a low power one for very high accuracy or keep the current one for moderate accuracy.

3.1.2 Literature Review

In recent years, the speed control of DC motor is not the latest technique, and several different working models are intended to control speed with specific working techniques.

Many studies have been done in this area. This involves (2018) state-of-art ZCD detection method that enables high performance specially for high-speed range because relationship between magnitude of Back-EMF and rotor speed is directly proportional. This method of speed control using zero crossing was able to generate the results of this paper.*(S. M. Awchar et al,2018)*[1]. This research work proposes a new solution for determination of rotor position by implementing Back-EMF observer over wide speed range. In this case the observer is designed using motor basic equations which results in high performance at near zero speed as well as on full speed range. Also, the rotor position identified is found to be independent of rotor speed. Moreover, the solution does require any additional circuitry in comparison to ZCD detection method. Additionally, this technique is executed using MATLAB for three/four-wheeler based electric vehicles (48V).

Ajay al.(2018)[2] compared the performance of the back emf based system with a hall effect sensor-based motor and got almost equal results. They also proposed a wide range of controlling methods which all depends on the back emf detection, but their calculation process makes them different from each other, i.e.

1) **Direct Back Emf sensing Methods:**

    A) Back-emf zero crossing detection or terminal voltage sensing.

    B) PWM strategies.

2) **Indirect Back Emf sensing Methods:**

    A) Back-emf integration.

    B) Third harmonic voltage integration.

    C) Free wheeling diode conduction or terminal current sensing.

The major issues with these implementation process is that it requires a high computational power and a very high-quality power supply, which might not be available all the time.

3.1.3 Formulation of Problem

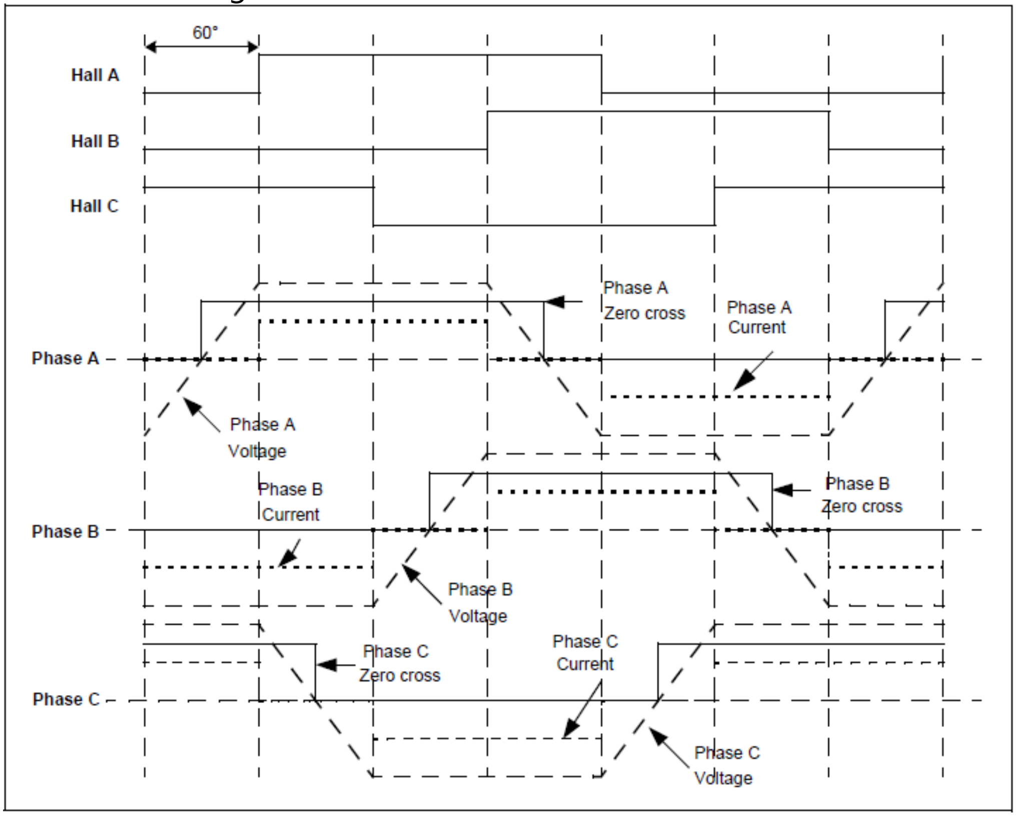
First process is generating a suitable gate pulse for the motor circuit to drive. These pulses are generated from the digital pin of a microcontroller which can produce up to 5V volts but can support only a few milliwatts. So, we need a buffer circuit that will follow the gate pulses generated from the microcontroller and boost the power of the signals. Then these signals will be going to the switching MOSFETS which will be the final step before the motor itself. These switching MOSFET's will be generating the required signals for the motor and supplying the power to the motor.

3.1.4 Analysis

The purpose is to design a circuit that can drive a DC motor and control its speed without any additional wiring or any other components. To prevent the motor from shaking and creating some unwanted vibrations there will be a minimum limit to the speed. Our designed circuit will provide a very accurate speed control over just increasing or decreasing it with a specific information of rpm thus helping in some areas where these few rpms can save a huge.

3.2 Design Method:

When the BLDC motor rotates, each winding (3 windings) generates BEMF opposes the main voltage. The 3 generated BEMF signals are 120° out of phase which is the same as the hall effect sensor signals. The figure below shows the relationship between the hall effect signals and the BEMF signals:

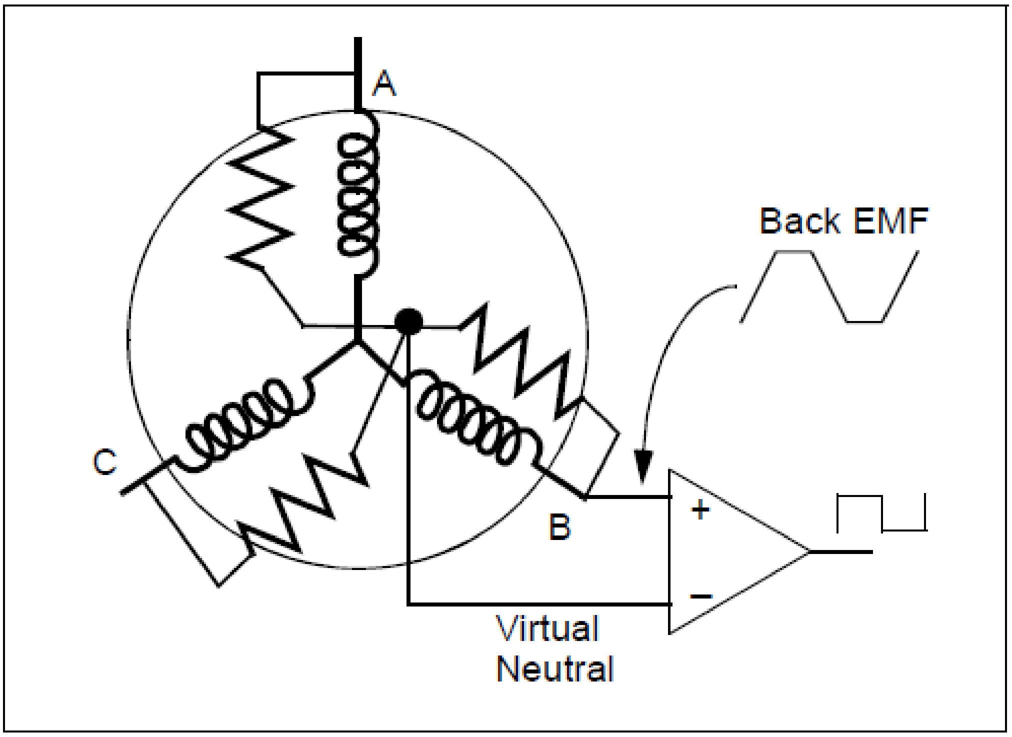


As shown in the figure above, the BEMF signals are not synchronized with the hall effect sensor signals (phase shift of 30°). In every energizing sequence, two windings are energized (one connected to positive and the other to negative) and the third winding is left open (floating). The floating winding is used to detect the zero crossing, thus, the combination of all 3 zero cross over point are used to generate the energizing sequence. Totally we've 6 events:
Phase A zero crossing: from high to low and from low to high
Phase B zero crossing: from high to low and from low to high
Phase C zero crossing: from high to low and from low to high.

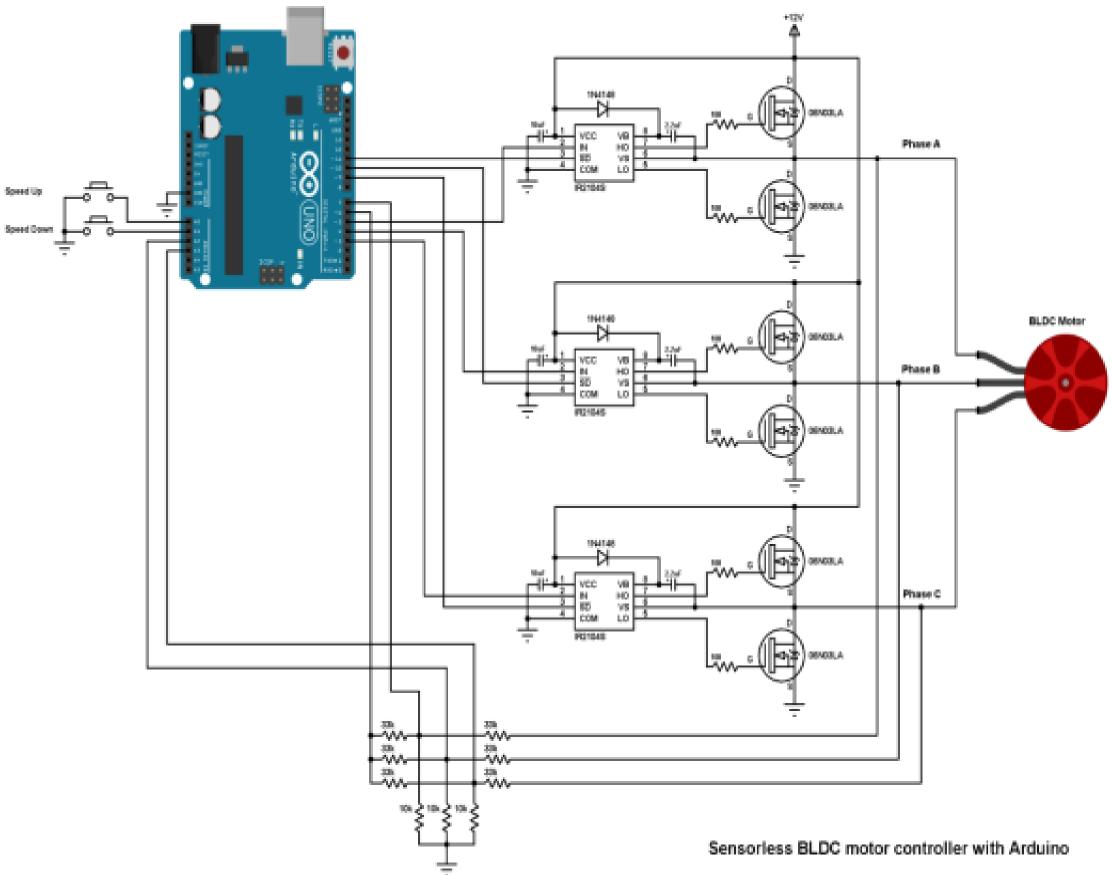
How to detect the zero-crossing event:

The easiest way to detect the zero crossing events is by using comparators. The comparator has 3 main terminals: 2 inputs (positive and negative) and an output. Comparator output is logic high if the positive voltage is greater than the negative voltage, and logic low if the positive voltage is lower than the negative voltage.

Basically 3 comparators are needed for this project, connections are done as shown in the figure below (example for phase B). Each phase requires a similar circuit.



3.3Circuit Diagram



Sensorless BLDC motor controller with Arduino

3.4Full Source Code of Firmware

```
float rpm;

#define SPEED_UP          A0
#define SPEED_DOWN        A1
#define PWM_MAX_DUTY      255
#define PWM_MIN_DUTY      130
#define PWM_START_DUTY    200

byte bldc_step = 0, motor_speed;
unsigned int i;
void setup() {
  Serial.begin(9600);
  DDRD  |= 0x38;           // Configure pins
3, 4 and 5 as outputs
  PORTD  = 0x00;
  DDRB  |= 0x0E;           // Configure pins
9, 10 and 11 as outputs
  PORTB  = 0x31;
  // Timer1 module setting: set clock source
to clkI/O / 1 (no prescaling)
  TCCR1A = 0;
  TCCR1B = 0x01;
  // Timer2 module setting: set clock source
to clkI/O / 1 (no prescaling)
  TCCR2A = 0;
  TCCR2B = 0x01;
  // Analog comparator setting
  ACSR   = 0x10;           // Disable and
clear (flag bit) analog comparator interrupt
  pinMode(SPEED_UP,   INPUT_PULLUP);
  pinMode(SPEED_DOWN, INPUT_PULLUP);


}


// Analog comparator ISR
ISR (ANALOG_COMP_vect) {
  // BEMF debounce
  for(i = 0; i < 10; i++) {
    if(bldc_step & 1){
      if(!(ACSR & 0x20)) i -= 1;
    }
    else {
      if((ACSR & 0x20))  i -= 1;
    }
  }
  bldc_move();
  bldc_step++;
  bldc_step %= 3;
}
void bldc_move(){        // BLDC motor
commutation function
  switch(bldc_step){
    case 0:
      AH_BL();
      BEMF_C_RISING();
      break;
    case 1:
      AH_CL();
      BEMF_B_FALLING();
      break;
    case 2:
      BH_CL();
      BEMF_A_RISING();
      break;
    case 3:
      BH_AL();
      BEMF_C_FALLING();
      break;
    case 4:
      CH_AL();
      BEMF_B_RISING();
      break;
    case 5:
      CH_BL();
      BEMF_A_FALLING();
      break;
  }
}
void loop() {
    while(!(digitalRead(SPEED_DOWN)) &&
motor_speed > PWM_MIN_DUTY){
      motor_speed--;
      SET_PWM_DUTY(motor_speed);
      rpm = (motor_speed/255.0) * 1100;
      Serial.print("Current speed is ");
      Serial.print(rpm);
      Serial.print(" rpm");
      Serial.print("\n");
      delay(100);
    }
  }

}

void BEMF_A_RISING(){
  ADCSRB = (0 << ACME);    // Select AIN1 as
comparator negative input
  ACSR |= 0x03;            // Set interrupt on
rising edge
}
void BEMF_A_FALLING(){
  ADCSRB = (0 << ACME);    // Select AIN1 as
comparator negative input
  ACSR &= ~0x01;           // Set interrupt on
falling edge
}
void BEMF_B_RISING(){
  ADCSRA = (0 << ADEN);   // Disable the ADC
module
  ADCSRB = (1 << ACME);
  ADMUX = 2;              // Select analog
channel 2 as comparator negative input
  ACSR |= 0x03;
}
void BEMF_B_FALLING(){
  ADCSRA = (0 << ADEN);   // Disable the ADC
module
  ADCSRB = (1 << ACME);
  ADMUX = 2;              // Select analog
channel 2 as comparator negative input
  ACSR &= ~0x01;
}
void BEMF_C_RISING(){
  ADCSRA = (0 << ADEN);   // Disable the ADC
module
  ADCSRB = (1 << ACME);
  ADMUX = 3;              // Select analog
channel 3 as comparator negative input
  ACSR |= 0x03;
}
void BEMF_C_FALLING(){
  ADCSRA = (0 << ADEN);   // Disable the ADC
module
  ADCSRB = (1 << ACME);
  ADMUX = 3;              // Select analog
channel 3 as comparator negative input
  ACSR &= ~0x01;
}

void AH_BL(){
  PORTB  =  0x04;
  PORTD &= ~0x18;
  PORTD |=  0x20;
  TCCR1A =  0;            // Turn pin 11
(OC2A) PWM ON (pin 9 & pin 10 OFF)
  TCCR2A =  0x81;         //
}
void AH_CL(){
  PORTB  =  0x02;
  PORTD &= ~0x18;
  PORTD |=  0x20;
  TCCR1A =  0;            // Turn pin 11
(OC2A) PWM ON (pin 9 & pin 10 OFF)
  TCCR2A =  0x81;         //
}
void BH_CL(){
  PORTB  =  0x02;
  PORTD &= ~0x28;
  PORTD |=  0x10;
```

```
  rpm = (PWM_START_DUTY/255.0) * 1100;
  Serial.print("Current speed is ");
  Serial.print(rpm);
  Serial.print(" rpm");
  Serial.print("\n");

  SET_PWM_DUTY(PWM_START_DUTY);    // Setup
starting PWM with duty cycle = PWM_START_DUTY
  i = 5000;
  // Motor start
  while(i > 100) {
    delayMicroseconds(i);
    bldc_move();
    bldc_step++;
    bldc_step %= 6;
    i = i - 20;
  }
  motor_speed = PWM_START_DUTY;
  ACSR |= 0x08;                    // Enable
analog comparator interrupt
  while(1) {
    while(!(digitalRead(SPEED_UP)) &&
motor_speed < PWM_MAX_DUTY){
      motor_speed++;
      SET_PWM_DUTY(motor_speed);
      rpm = (motor_speed/255.0) * 1100;
      Serial.print("Current speed is ");
      Serial.print(rpm);
      Serial.print("rpm");
      Serial.print("\n");
      delay(100);
    }
```

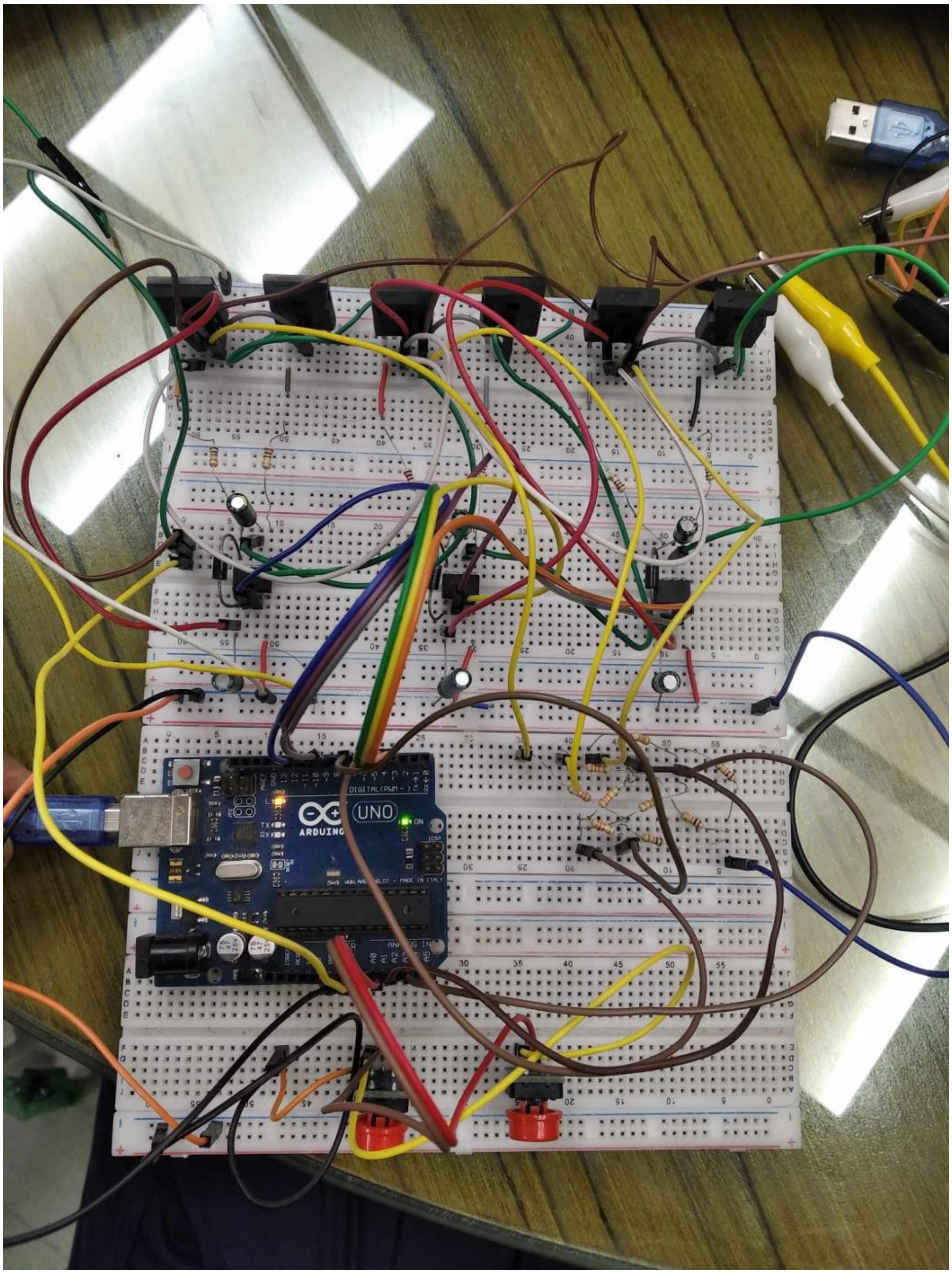
```
  TCCR2A =  0;            // Turn pin 10
(OC1B) PWM ON (pin 9 & pin 11 OFF)
  TCCR1A =  0x21;         //
}
void BH_AL(){
  PORTB  =  0x08;
  PORTD &= ~0x28;
  PORTD |=  0x10;
  TCCR2A =  0;            // Turn pin 10
(OC1B) PWM ON (pin 9 & pin 11 OFF)
  TCCR1A =  0x21;         //
}
void CH_AL(){
  PORTB  =  0x08;
  PORTD &= ~0x30;
  PORTD |=  0x08;
  TCCR2A =  0;            // Turn pin 9 (OC1A)
PWM ON (pin 10 & pin 11 OFF)
  TCCR1A =  0x81;         //
}
void CH_BL(){
  PORTB  =  0x04;
  PORTD &= ~0x30;
  PORTD |=  0x08;
  TCCR2A =  0;            // Turn pin 9 (OC1A)
PWM ON (pin 10 & pin 11 OFF)
  TCCR1A =  0x81;         //
}

void SET_PWM_DUTY(byte duty){
  if(duty < PWM_MIN_DUTY)
    duty  = PWM_MIN_DUTY;
  if(duty > PWM_MAX_DUTY)
    duty  = PWM_MAX_DUTY;
  OCR1A  = duty;                   // Set pin
9  PWM duty cycle
  OCR1B  = duty;                   // Set pin
10 PWM duty cycle
  OCR2A  = duty;                   // Set pin
11 PWM duty cycle
}
```

Table: Source Code for the main program

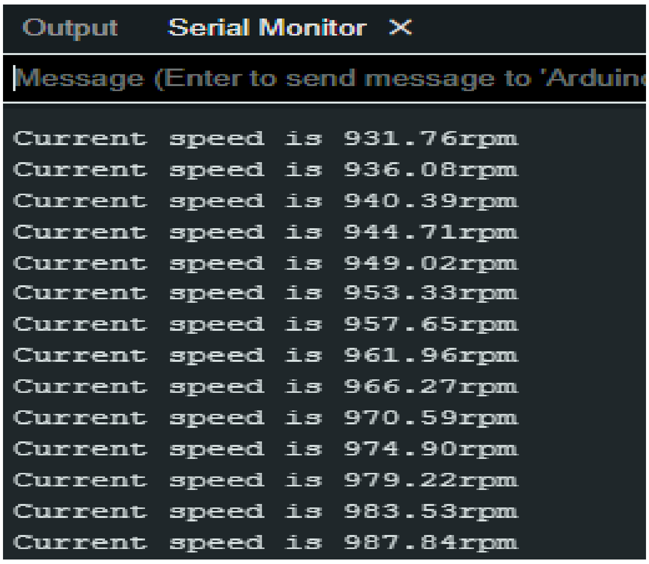
4 Implementation

We have implemented the circuit in the breadboard for better understanding and ability to debug . Following is a picture of the project:



4.1 Experiment and Data Collection

We have uploaded the microcontroller code by connecting it with a laptop and observed the following output in the serial monitor for increment of speed:



5 Design Analysis and Evaluation

After the continuous work of the couple of weeks and few months now we are able to write and calculate that what we get in the form of results from this hardware and the presentation of findings of that result in this chapter we will also discuss the limitations of the hardware and also the solution of these limitations and recommendations for the future work in detail.

5.1 Novelty

Sensorless speed control of BLDC (Brushless Direct Current) motors is an innovative and exciting project that offers several novel aspects and advantages compared to traditional sensor-based control methods. Here are some points highlighting the novelty of such a project:

1. **Cost Reduction**: Sensorless control eliminates the need for expensive Hall-effect sensors or encoders, significantly reducing the overall cost of the motor control system.

2. **Increased Reliability**: Without sensors, there are no components that can wear out or become damaged, leading to increased long-term reliability and reduced maintenance requirements.

3. **Simplified Hardware**: Sensorless control simplifies the hardware setup by eliminating the need for sensor wiring and alignment, making it more straightforward and less prone to errors during installation.

4. **Enhanced Robustness**: Sensorless control can adapt to various environmental conditions and motor variations, making it more robust in real-world applications where sensors may struggle with factors like temperature variations or external interferences.

5. **Improved Efficiency**: Sensorless control can dynamically adjust the motor's operation to maximize efficiency, especially in partial load conditions, which is crucial for applications requiring energy savings.

6. **Reduced Size and Weight**: Eliminating sensors allows for a more compact and lightweight motor design, making it suitable for applications with strict size and weight constraints, such as drones and electric vehicles.

7. **Dynamic Performance Optimization**: Sensorless algorithms can continuously optimize motor performance by adjusting parameters like timing and current in real-time, resulting in improved speed and torque control.

8. **Adaptive Control**: Sensorless control can adapt to changes in motor characteristics over time, ensuring consistent performance even as the motor ages or experiences wear and tear.

9. **Noise Reduction**: By eliminating sensor-related noise and potential glitches, sensorless control can lead to quieter motor operation, which is crucial in noise-sensitive applications.

10. **Ease of Integration**: Sensorless control can be integrated with microcontrollers and digital signal processors (DSPs) to create smart motor control systems, enabling features like remote monitoring, diagnostics, and control through IoT platforms.

11. **Advanced Control Strategies**: Sensorless control opens the door to advanced control strategies like field-oriented control (FOC) and direct torque control (DTC), which can provide precise and rapid motor response.

12. **Potential for AI Integration**: Sensorless control can be combined with artificial intelligence (AI) and machine learning algorithms to create self-learning motor control systems that adapt to changing operating conditions and optimize performance autonomously.

13. **Environmental Benefits**: The efficiency improvements associated with sensorless control can contribute to energy savings and reduced greenhouse gas emissions, making it environmentally friendly.

14. **Research and Development Opportunities**: Developing sensorless control algorithms presents opportunities for research and innovation in the field of motor control, with applications spanning from industrial automation to electric mobility.

15. **Market Demand**: As sensorless control becomes more prevalent in various industries, it opens up opportunities for market growth and product differentiation.

5.2 Design Considerations

For designing the system, we have several ways to go forward. We could build the circuit from scratch or could use some prebuilt modules too. We have taken consideration of effectiveness, efficiency a practicality while designing the project. Here are the key design considerations for this project:

Using Microcontroller:

We used microcontroller for generation of gate pulses over any 555-timer based oscillatory circuits. The reason behind this is if we used an oscillatory circuit our further calculations would require a microcontroller which was a waste of capacity. That's why we used a microcontroller which can generate the gate pulse and do calculation of speed simultaneously.

MOSFET Driver IC:

We have used a BJT based MOSFET driving circuit that does the same work as the MOSFET driver IC. But when we didn't got satisfactory result from it we started to debug the problem and found that,

When we just started the circuit BLDC motor pushed a very high amount of current that flows through the BJT's base. That base was connected with the microcontroller and that's why that high current draw was resetting the controller itself every time. As a result we got just some initial rotations from the motor and then the motor couldn't follow the switching frequency. MOSFET driver IC provides isolation from the input circuit to the output far better than the previous circuit.

Safety Features:

This circuit has an auto cutoff feature if the speed of the motor goes above a specific limit by cutting of power to the motor. Safety of the circuit can be enhanced by heat management.

Energy Management:

Design an efficient power supply and management system to optimize the operation loss. We need to Consider the use of rechargeable batteries and a charging mechanism.

User Interface:

Create a user-friendly interface for monitoring the motors speed, controlling its speed, and receiving alerts. We have implemented a simple push button for increment and decrement of speed.

Environmental Adaptability:

Ensure the system can work with regenerative braking systems in electric vehicles by reducing heat generated from the break and also reducing carbon elements to the environment.

Scalability:

Design the system in a way that allows for future upgrades and enhancements, such as adding more features ,machine learning algorithm implementation for sensing any unstable condition during operation.

5.2.1 Considerations to public health and safety

Sensorless speed control of BLDC (Brushless Direct Current) motors, like any technological advancement, comes with its own set of considerations related to public health and safety. Implementing such systems requires careful planning and adherence to safety standards to mitigate potential risks. Here are some key considerations to ensure public health and safety when working on sensorless speed control of BLDC motors:

1. Electrical Safety:

- Ensure proper grounding and insulation to prevent electrical shocks.
- Use appropriate voltage levels and protection devices (fuses, circuit breakers) to prevent overcurrent situations.
- Comply with electrical codes and standards relevant to your jurisdiction.

2. Fire Safety:

- Implement safeguards against overheating, short circuits, and electrical fires.
- Use flame-resistant materials in motor components and enclosures.

3. EMI/RFI Compliance:

- Address electromagnetic interference (EMI) and radio-frequency interference (RFI) issues to prevent interference with other electronic devices and radio communication systems.

4. Motor Overheating Prevention:

- Employ temperature sensors and thermal protection mechanisms to prevent the motor from overheating during prolonged use.
- Ensure proper ventilation and cooling for motors that operate in high-temperature environments.

5. Noise Reduction:

- Implement noise-reduction measures to minimize sound emissions from the motor, especially in residential and noise-sensitive areas.

6. Environmental Impact:

- Assess the environmental impact of the BLDC motor system, including materials used in manufacturing and end-of-life disposal or recycling.

7. Mechanical Safety:

- Ensure that there are safety mechanisms to stop the motor in case of mechanical failures, such as a blocked rotor or mechanical overloads.
- Use appropriate mechanical enclosures and protective covers to prevent contact with moving parts.

8. Cybersecurity:

- Secure communication interfaces and control systems to prevent unauthorized access, which could pose safety risks if the motor control is compromised.

9. Training and Education:

- Train operators and maintenance personnel on safe operation, troubleshooting, and emergency response procedures.
- Provide clear user manuals and safety instructions.

10. Regulatory Compliance:

- Comply with relevant safety standards, such as UL (Underwriters Laboratories) or CE (Conformité Européenne), depending on the market and jurisdiction in which the system will be used.

11. Maintenance and Inspection:

- Establish a regular maintenance schedule for the BLDC motor system to detect and address potential safety issues proactively.
- Periodically inspect the motor and control system for signs of wear, damage, or degradation.

By carefully addressing these considerations, we can help ensure that the implementation of sensorless speed control of BLDC motors is done with the utmost concern for public health and safety, reducing the likelihood of accidents or adverse effects. Collaboration with relevant regulatory bodies and experts in the field can also provide valuable guidance in achieving safety compliance.

5.2.2 Considerations to environment:

1.Energy Efficiency:
Sensorless control allows for more precise control of the motor's speed and torque, which can lead to higher energy efficiency. By reducing energy consumption, the environmental impact in terms of reduced greenhouse gas emissions and resource consumption can be minimized.

2.Materials Selection:
Consider the materials used in the manufacture of BLDC motors and control systems. Opt for materials that are environmentally friendly, such as those with low toxicity and recyclability.

3.End-of-Life Disposal:
Evaluate the recyclability and proper disposal methods for the components of the BLDC motor system. Ensure that components can be easily disassembled and recycled or disposed of responsibly.

4.Longevity and Durability:
Design the motor system for longevity and durability to reduce the frequency of replacements and, consequently, the waste generated.

5.Reduced Noise Pollution:
Sensorless control can lead to quieter motor operation, which can benefit the environment by reducing noise pollution in residential and urban areas.

6.Supply Chain Sustainability:
Consider the sustainability of your supply chain. Work with suppliers who prioritize environmentally friendly practices and materials.

7.Life Cycle Assessment (LCA):
Conduct a life cycle assessment to evaluate the environmental impact of the BLDC motor system from raw material extraction to manufacturing, usage, and disposal. This assessment can help identify areas for improvement.

8.Energy Source:
Depending on the application, consider the source of energy used

to power the BLDC motor system. Using renewable energy sources can significantly reduce the carbon footprint of the system.

9.Regulatory Compliance:
Ensure that the BLDC motor system complies with environmental regulations and standards, such as RoHS (Restriction of Hazardous Substances) and REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals).

10.Efficient Manufacturing:
Optimize the manufacturing process to reduce waste, energy consumption, and emissions. Implement lean manufacturing principles to minimize environmental impact.

11.Packaging:
Consider eco-friendly packaging options that reduce waste and are easily recyclable or biodegradable.

12.Minimize Hazardous Materials:
Avoid the use of hazardous materials or substances in the motor and control system, which can be harmful to the environment during production and disposal.

14. Transportation Efficiency:
If the BLDC motor systems are shipped or transported, optimize transportation routes and methods to reduce fuel consumption and emissions.

5.3Limitations of Tools :

The project involves elements like BJT,MOSFET,IC's and microcontrollers, capacitors ,diodes. As in this project its just a initial design there can be more than one component which can cause a failure. Though the rates are low but as we are considering a high current it can happen. By improving the power handling capacity we can easily overcome some of the issues.

6 Communication :

7.1 Executive Summary:

FOR IMMEDIATE PRESS RELEASE

Introducing the Electric Motors : A Motor Controlling Circuit without sensors

Imagine a sensorless BLDC motor as a "smart" motor that can keep itself running smoothly without needing extra sensors or detectors.

Typically, when we use a motor, like the one in a fan or a toy car, there are sensors in place to tell it how fast to spin or where to stop. These sensors act like our eyes, helping the motor know what's going on around it.

But in some cases, we want to make things simpler and more reliable. That's where the sensorless BLDC motor comes in. It's like a motor with a built-in sense of direction.

Here's how it works:

Listening to Its Surroundings: As the motor spins, it makes a sort of "whisper" that only it can hear. This whisper is a special signal called "back EMF." It's like the motor talking to itself.

Understanding the Whisper: The motor is really good at listening to its own whisper. It can tell from the whisper how fast it's spinning and where it is in its rotation.

Adjusting on the Fly: Based on what it hears from the whisper, the motor makes quick decisions to keep itself running smoothly. It knows when to speed up, slow down, or even stop if needed.

So, you can think of a sensorless BLDC motor as a motor with a built-in sixth sense. It doesn't need extra "eyes" (sensors) to see what's happening around it. Instead, it relies on its own special sense (the back EMF whisper) to do its job.

This makes sensorless BLDC motors great for all sorts of gadgets and machines where simplicity and reliability are important. They're like the smart, self-driving cars of the motor world, and they help things run smoothly without the need for extra sensors or detectors.

7 Project Management and Cost Analysis

7.1 Bill of Materials

COMPONENT	PRICE(Taka)
Capacitor,Diode,Resistor,Connectors	100
Push Button & Switches	20
Arduino Uno (2)	2*1000=2000
LCD Display With I2C Module	385
IR Sensor	80
BLDC Motor	550
MOSFET(6)	6*150=900
MOSFET Driver(3)	3*150=550
LiPO Battery	1650
TOTAL	6235

8 Future Work

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There are still some areas where future improvements can be made. Here are some potential areas of improvement:

Performance:
Improving the overall performance of sensorless BLDC motor control systems can help enhance their efficiency and reliability. For example, improving the accuracy of the rotor position estimation algorithm can lead to better torque control and smoother operation.

Robustness:
Sensorless BLDC motor control systems can be sensitive to various disturbances, such as noise, voltage fluctuations, and temperature changes. Enhancing the robustness of these systems

can make them more resilient to these
disturbances, ensuring reliable operation in harsh environments.

Power density:
Increasing the power density of the motor control system can help reduce the size and weight of the system, making it more compact and portable. This can be achieved by improving the efficiency of the power electronics and reducing the heat dissipation requirements.

Integration:
Integrating the sensorless BLDC motor control system with other systems, such as battery management and power electronics, can help improve the overall system efficiency and reduce system complexity.

Cost:
Reducing the cost of sensorless BLDC motor control systems can make them more affordable and accessible to a wider range of applications. This can be achieved through advancements in manufacturing, design, and materials.

9 References

1.S. M. Awchar, S. P. Diwan and P. Arlikar, "Advanced Technique for Speed Control Of Sensor-Less BLDC Motor," 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), Pune, India, 2018, pp. 1-5, doi: 10.1109/ICCUBEA.2018.8697796.

2.Ajay, & Venugopal, Pranav & S, Chaithanya & Chandran, Lekshmi & Krishna, V. (2018). Sensor less Speed Control Method for Brushless DC Motors Using Back EMF Method. 1525-1530. 10.1109/RTEICT42901.2018.9012317.

3.https://www.allaboutcircuits.com/technical-articles/sensorless-brushless-dc-bldc-motor-control/