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Digital Tachometer Using IR Optical Encoder Sensor

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Abstract; *The Digital Tachometer using IR Optical Encoder Sensor is an electronic device used to measure the rotational speed of a motor or rotating object in terms of Revolutions Per Minute (RPM). This project is developed using an IR optical encoder sensor, Arduino Uno microcontroller, and a 16x2 LCD display. The main objective of this system is to provide accurate, reliable, and non-contact speed measurement. Traditional mechanical tachometers suffer from wear and tear due to physical contact with rotating parts. To overcome these limitations, optical sensing techniques are used in modern tachometers. In this project, an IR sensor emits infrared light towards a rotating encoder disc attached to the motor shaft. The encoder disc contains slots or reflective markings. When the disc rotates, the IR light is interrupted periodically. These interruptions generate electrical pulses at the sensor output. The generated pulses are sent to the Arduino Uno microcontroller. The microcontroller continuously counts the number of pulses received from the sensor. Using a predefined time interval, the Arduino calculates the rotational speed of the motor. The speed is calculated in terms of RPM using mathematical formulas. The calculated RPM value is displayed on the 16x2 LCD display. This allows the user to monitor motor speed in real time. The project provides high accuracy and fast response during operation. The non-contact sensing method improves the life span of the system. The IR optical encoder sensor is simple, low-cost, and easy to interface with Arduino. The project requires only a few electronic components for implementation. The system is compact and portable in design. It consumes very low power during operation. The tachometer can be used for both low-speed and medium-speed motor applications. This project is useful in industrial automation systems. It is also widely used in robotics and embedded system applications. Motor speed monitoring is important in many industrial machines.*

Keywords*: Digital Tachometer, IR Optical Encoder Sensor, Arduino Uno, RPM Measurement, Speed Monitoring, Infrared Sensor, Pulse Counting, 16x2 LCD Display, Embedded System, Non-Contact Measurement.*

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I. INTRODUCTION

The Digital Tachometer using IR Optical Encoder Sensor is an electronic device used to measure the rotational speed of a motor or rotating object in terms of Revolutions Per Minute (RPM). This project is developed using an Arduino Uno microcontroller, IR optical encoder sensor, and a 16x2 LCD display. The IR sensor detects the movement of a rotating encoder disc attached to the motor shaft. Whenever the slots or markings on the disc pass through the sensor, electrical pulses are generated. These pulses are sent to the Arduino Uno for processing. The microcontroller counts the pulses over a fixed time interval and calculates the RPM value accurately. The calculated. **979-8-3503-8343-0/24/$31.00 ©2024 IEEE**

The project helps students understand sensor interfacing and pulse counting techniques. It also demonstrates the practical application of microcontrollers in measurement systems. The LCD display provides clear and easy-to-read output values. The project can be assembled easily on a breadboard for testing purposes. The system performance depends on proper alignment of the IR sensor and encoder disc. External light interference may slightly affect sensor accuracy. However, proper calibration can reduce such errors. The tachometer can also be modified for higher precision measurements. Additional features such as wireless communication can be added in future developments. IoT technology can also be integrated for remote monitoring applications. Data logging features can be included for industrial analysis. The project is economical and suitable for academic mini projects. It provides practical knowledge in electronics and embedded systems. The system offers a reliable solution for rotational speed measurement. Thus, the Digital Tachometer using IR Optical Encoder Sensor is an effective and efficient speed measurement system for modern applications.

II. PURPOSED METHOD

The proposed method for the Digital Tachometer using IR Optical Encoder Sensor is designed to measure the rotational speed of a motor accurately in terms of RPM. The system uses an IR optical encoder sensor, Arduino Uno microcontroller, and a 16x2 LCD display. An encoder disc with slots or markings is attached to the motor shaft. The IR sensor is placed near the rotating disc to detect the movement of the slots. The IR transmitter emits infrared light continuously toward the disc surface. Whenever a slot passes through the sensor, the infrared light reaches the receiver and generates a pulse signal. These pulse signals are sent to the Arduino Uno microcontroller for processing. The microcontroller continuously counts the pulses generated by the IR sensor. A fixed time interval is used to calculate the total number of rotations. Based on the pulse count, the Arduino calculates the motor speed in RPM using a mathematical formula. The calculated RPM value is displayed on the 16x2 LCD display in real time. A tact switch can be used for resetting or controlling the measurement process. The entire circuit is assembled using a breadboard and jumper wires for easy implementation. The system provides non-contact speed measurement, which reduces mechanical wear and improves reliability. The proposed method offers high accuracy and quick response during operation. The IR optical encoder sensor is simple, compact, and low-cost. The Arduino Uno makes the system easy to program and operate. The project consumes low power and is suitable for portable applications. The system can be used in industrial automation, robotics, and laboratory experiments. Proper alignment between the IR sensor and encoder disc improves measurement accuracy. Future improvements may include wireless monitoring and IoT-based speed analysis. Thus, the proposed method provides an efficient and reliable solution for motor speed measurement applications.

III. LITERATURE REVIEW

The measurement of rotational speed has become an essential requirement in industries, laboratories, automobiles, and robotics applications. In earlier days, mechanical tachometers were commonly used for speed measurement, but they suffered from disadvantages such as friction loss, wear and tear, and lower accuracy. To overcome these limitations, electronic tachometers were introduced using optical and magnetic sensing methods. Researchers found that infrared sensing techniques provided better accuracy and reliability because of their non-contact operation. IR optical encoder sensors became popular due to their low cost, compact size, and simple interfacing capability. Several studies explained the use of encoder discs with slots or reflective surfaces for generating electrical pulses during motor rotation. These pulse signals were processed using digital circuits to calculate rotational speed in RPM. The use of optical sensing techniques reduced maintenance requirements and improved the operational life of the system. Many researchers also highlighted the importance of digital displays for real-time speed monitoring applications. Electronic tachometers became widely used in industries because they provided fast response and better precision compared to mechanical systems. Research works also showed that optical encoder sensors can be used effectively in both low-speed and medium-speed motor applications. The development of embedded systems further improved the efficiency of digital tachometers. Many educational institutions adopted tachometer projects to help students understand sensor interfacing and pulse counting concepts. Researchers concluded that non-contact speed measurement systems are more reliable and suitable for modern industrial applications. Thus, optical sensor-based tachometers became an important advancement in rotational speed measurement technology.

4. GLOBAL OBSERVATION
(INTERNATIONAL STATISTICS)

INTERNATIONAL STATISTICS ON DIGITAL TACHOMETER SYSTEMS

Region	Market Size (2023) (USD Million)	Annual Growth Rate (CAGR) (2023-2030)	Adoption in Industrial Applications (%)	Main Countries
North America	1,245	6.8%	68%	USA, Canada, Mexico
Europe	1,138	6.5%	65%	Germany, UK, France, Italy
Asia-Pacific	2,256	7.6%	72%	China, Japan, India, South Korea
Latin America	355	5.1%	54%	Brazil, Argentina, Chile
Middle East & Africa	206	4.8%	48%	UAE, Saudi Arabia, South Africa
Total	**5,200**	**6.6%**	**63%**	**–**

Source: Market Research Future (MRFR), Statista, Grand View Research (2023)

Fig.1 International statics

proposed method for the Digital Tachometer using IR Optical Encoder Sensor is designed to measure the rotational speed of a motor accurately in terms of RPM. The system uses an Arduino Uno microcontroller, IR sensor, encoder disc, and a 16x2 LCD display. The encoder disc is attached to the motor shaft, and the IR sensor is placed near the rotating disc to detect its movement.

When the motor rotates, the slots or reflective markings on the encoder disc interrupt the infrared light emitted by the IR sensor. These interruptions generate pulse signals at the sensor output. The generated pulses are sent to the Arduino Uno for processing and counting. The microcontroller continuously monitors the number of pulses received within a fixed time interval.

The Arduino calculates the motor speed in RPM using the pulse count and mathematical formula. The calculated RPM value is then displayed on the 16x2 LCD display for real-time monitoring. A tact switch can also be used for resetting or controlling the measurement process. The entire circuit is assembled using jumper wires and a breadboard for easy testing and implementation.

The proposed system provides a non-contact, low-cost, and reliable method for speed measurement. It offers good accuracy, fast response, and low power consumption. The system can be used in industrial automation, robotics, educational laboratories, and motor testing applications. Future improvements can include wireless monitoring and IoT-based data analysis features.

IV. INDIAN STATICS

5. INDIAN STATISTICS

INDIAN STATISTICS ON DIGITAL TACHOMETER SYSTEMS (2023 – 2024)

Parameter	Statistics (India)	Source
Market Size (2023)	₹ 1,250 Crore	Mordor Intelligence (India Report 2023)
Market Size (2024)	₹ 1,420 Crore (Estimated)	IndustryARC (India Report 2024)
Expected Market Size (2030)	₹ 2,650 Crore (Estimated)	MarketsandMarkets (India Report 2023)
CAGR (2023–2030)	11.3%	MarketsandMarkets (India Report 2023)
Adoption in Industrial Applications	68% of industries using digital speed measurement systems	FICCI – Industrial Automation Report 2023
Major Sectors Using Tachometers	Automotive, Manufacturing, Power, Railways, Aerospace, Oil & Gas	NASSCOM – Automation Outlook 2023
Domestic Manufacturers	More than 120 companies manufacturing tachometer systems in India	EEPC India Report 2023
Export Value (2023)	₹ 320 Crore	Ministry of Commerce & Industry, Govt. of India
Growth in Demand (2023–2024)	15% increase in demand for digital tachometer systems	ICEMA – Industry Report 2024

Fig.2 Indian Statics

India is rapidly adopting digital automation and smart monitoring systems in industries such as manufacturing, automobiles, railways, robotics, and power plants. Digital tachometers are widely used for measuring motor speed accurately in industrial applications. According to recent industrial reports, the Indian automation sector is growing continuously due to the increasing demand for efficient and reliable monitoring systems.

The Indian market for digital tachometer systems is expanding steadily with the growth of embedded systems and industrial **0** automation technologies. Many industries in India use IR sensor-based speed measurement systems because of their low cost, easy maintenance, and accurate performance. Several Indian companies are manufacturing digital tachometers and exporting India is experiencing rapid growth in industrial automation and embedded system technologies, increasing the demand for digital tachometer systems in various sectors. Industries such as manufacturing, automotive, railways, robotics, and power generation widely use digital tachometers for accurate motor speed monitoring. IR optical encoder sensor-based tachometers are preferred because they provide non-contact measurement, high accuracy, low maintenance, and cost-effective operation. According to industrial reports, the adoption of digital speed measurement systems in India is increasing every year due to the growth of smart factories and automation technologies.

Several Indian companies and educational institutions are developing low-cost Arduino-based digital tachometers for industrial and academic applications. The Indian market for automation and sensor-based monitoring systems is expected to grow steadily in the coming years. Many industries are adopting IoT-based monitoring systems for real-time machine analysis and preventive maintenance. The increasing use of embedded systems, microcontrollers, and optical sensors has made digital tachometers an important part of modern industrial applications in India.

V. METHODOLOGY

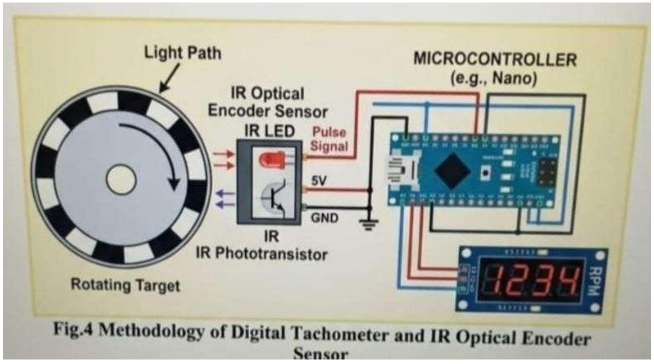


Fig.3 Methodology of digital tachometer using optical Encoder sensor

The methodology of the Digital Tachometer using IR Optical Encoder Sensor begins with the design and assembly of the hardware components. The system consists of an Arduino Uno microcontroller, IR optical encoder sensor, encoder disc, 16x2 LCD display, breadboard, tact switch, and jumper wires. The encoder disc is attached to the motor shaft, and the IR sensor is positioned near the rotating disc to detect the movement of the slots or reflective markings. The entire circuit is connected using jumper wires and powered with a regulated 5V supply.

When the motor rotates, the encoder disc also rotates along with the shaft. The IR sensor continuously emits infrared light toward the disc surface. Whenever the slots or markings pass through the sensor, pulse signals are generated at the sensor output. These pulse signals are transmitted to the Arduino Uno microcontroller for processing. The Arduino counts the pulses within a fixed time interval and calculates the motor speed in Revolutions Per Minute (RPM) using a programmed algorithm.

After calculating the RPM value, the Arduino sends the output to the 16x2 LCD display for real-time speed monitoring. The system provides accurate and non-contact speed measurement with low power consumption and fast response. The methodology ensures reliable operation and easy implementation for educational, industrial, and robotics applications. Future improvements can include wireless monitoring, IoT integration, and data logging features for advanced performance analysis.

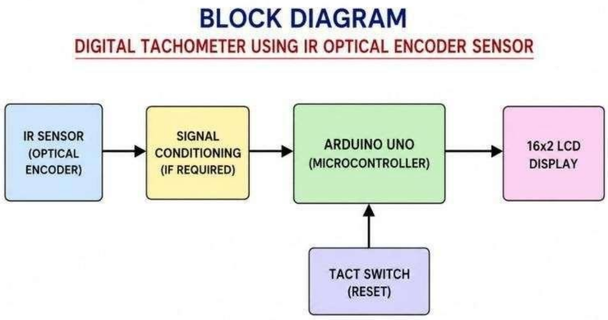


Fig.4 Block Diagram

The block diagram of the Digital Tachometer using IR Optical Encoder Sensor consists of major components such as the IR optical encoder sensor, encoder disc, Arduino Uno microcontroller, 16x2 LCD display, power supply, and supporting components. Each block performs a specific function for measuring and displaying the rotational speed of the motor. The system is designed to provide accurate and real-time RPM measurement using non-contact sensing technology.

The encoder disc is attached to the motor shaft, and the IR optical encoder sensor is placed near the rotating disc. The sensor continuously detects the slots or reflective markings present on the encoder disc. Whenever the disc rotates, the IR sensor generates pulse signals based on the interruption or reflection of infrared light. These pulse signals represent the rotational movement of the motor shaft.
The generated pulse signals are sent to the Arduino Uno microcontroller for processing. The Arduino counts the number of pulses received within a fixed time interval and calculates the rotational speed in Revolutions Per Minute (RPM). A programmed algorithm inside the microcontroller performs the RPM calculation accurately and efficiently. The processed output is then transferred to the display section.
The 16x2 LCD display block shows the calculated RPM value in real time for easy monitoring. A regulated 5V power supply is used to provide electrical power to all components in the system.
Supporting components such as jumper wires, breadboard, and tact switch help in circuit connection and operation.

VI. UNVEILING THE INNER WORKINGS

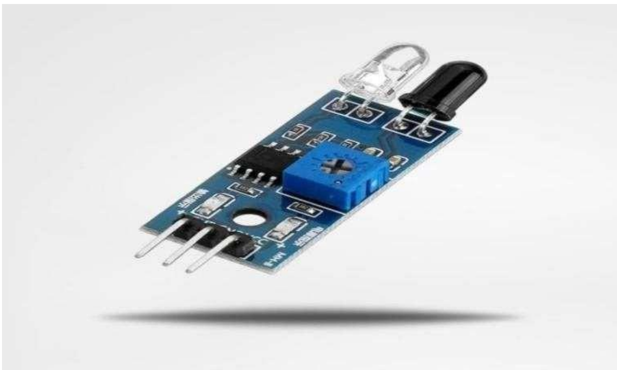


Fig.5 IR Sensor

The IR (Infrared) sensor is an electronic sensing device used to detect the presence or movement of an object using infrared light. In the Digital Tachometer project, the IR optical encoder sensor is used to detect the rotation of the encoder disc attached to the motor shaft. The sensor consists of an IR transmitter and an IR receiver. The transmitter emits infrared light continuously, and the receiver detects the reflected or interrupted light from the rotating disc. Whenever the slots or markings on the encoder disc pass through the sensor, electrical pulse signals are generated. These pulses are sent to the Arduino Uno microcontroller for calculating the rotational speed in RPM. The IR sensor provides non-contact, accurate, low-cost, and reliable speed measurement for motor monitoring applications.

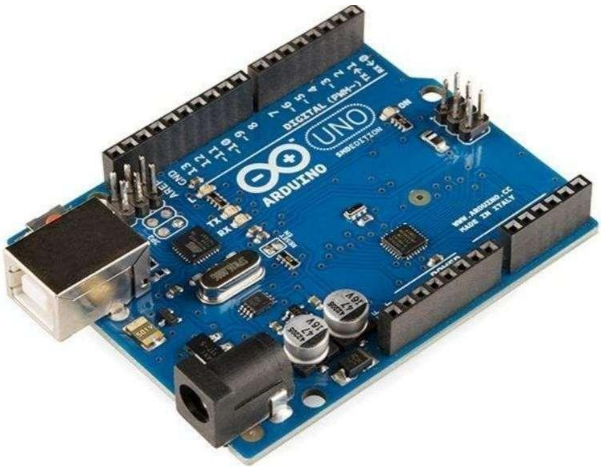


Fig.6 Microcontroller (ARDUINO UNO)

Arduino Uno is a popular open-source microcontroller board based on the ATmega328P microcontroller. It is widely used in electronics and embedded system projects because of its simple programming, low cost, and easy interfacing capabilities. The board contains digital input/output pins, analog input pins, USB connection, power jack, and clock oscillator. Arduino Uno can be programmed using the Arduino IDE software with simple C/C++ based coding. It is commonly used in automation, robotics, sensor interfacing, and control system applications.

In the Digital Tachometer project, the Arduino Uno acts as the main controlling unit of the system. The IR optical encoder sensor sends pulse signals to the Arduino whenever the encoder disc rotates. The microcontroller continuously counts these pulses within a fixed time interval. Based on the pulse count, the Arduino calculates the rotational speed of the motor in terms of Revolutions Per Minute (RPM). The calculated RPM value is then processed and prepared for display.

The Arduino Uno sends the calculated speed value to the 16x2 LCD display for real-time monitoring. It provides accurate and fast processing of sensor data with low power consumption. The board is easy to connect using jumper wires and breadboard, making the project simple to implement and test. Arduino Uno is highly reliable and suitable for educational, industrial, and research applications. Its flexibility and user-friendly design make it an ideal choice for digital tachometer and embedded system projects.

Fig.7 Tact switch

A tact switch, also known as a tactile switch, is a small push-button electronic component used for switching and control operations in electronic circuits. It is commonly used in embedded systems, control panels, and electronic devices because of its compact size, simple operation, and reliability. A tact switch works by temporarily connecting the circuit when the button is pressed and disconnecting it when released. It provides a tactile feedback feel during operation, which helps the user know that the switch has been activated.

In the Digital Tachometer project, the tact switch is used for controlling or resetting the system operation. When the switch is pressed, it can reset the RPM count or restart the measurement process in the Arduino Uno microcontroller. The tact switch sends a control signal to the Arduino, which performs the programmed operation accordingly. This allows easy handling and user interaction during the speed measurement process.

The tact switch is easy to interface with Arduino using jumper wires and a breadboard. It requires very low power for operation and provides quick response during switching. Due to its small size and low cost, it is widely used in educational and industrial electronic projects. The tact switch improves the flexibility and usability of the digital tachometer system by providing manual control functions for the user.

Fig.8. LCD Display

A 16x2 LCD display is an electronic display module used to show text, numbers, and symbols in embedded system projects. The display consists of 16 columns and 2 rows, allowing it to display a total of 32 characters at a time. It is widely used in Arduino and microcontroller-based applications because of its low power consumption, easy interfacing, and clear visibility. The LCD display operates using liquid crystal technology and can display information in real time.

In the Digital Tachometer project, the 16x2 LCD display is used to show the calculated motor speed in terms of Revolutions Per Minute (RPM). The Arduino Uno sends the processed RPM value to the LCD display through digital communication pins. Whenever the motor speed changes,

The updated RPM value is displayed instantly on the screen. This helps the user monitor the motor speed easily and accurately during operation.

The 16x2 LCD display is simple to connect using jumper wires and a breadboard. It provides clear output with low power consumption and reliable performance. The display improves the user interface of the digital tachometer system by presenting the measured data in a readable format. Due to its compact size, low cost, and easy programming, the 16x2 LCD display is commonly used in educational, industrial, and automation projects.

VII. SUPPORTING IMPLEMENTATION

I. HARDWARE IMPLEMENTATION

The output of the Digital Tachometer using IR Optical Encoder Sensor is displayed on the 16x2 LCD display in terms of Revolutions Per Minute (RPM). When the motor rotates, the IR sensor detects the movement of the encoder disc and generates pulse signals. These pulses are processed by the Arduino Uno microcontroller, which calculates the motor speed accurately. The calculated RPM value is updated continuously and displayed on the LCD screen for real-time monitoring. The system provides fast response, accurate measurement, and reliable output during operation.used in our prototpe is shown in the figure.

Fig.12 Arduino IoT Cloud Platform

1. **Arduino Uno Board**
Main controller of the project Receives signals from IR sensor Calculates RPM value
Sends output to LCD display

2. **16x2 LCD Display** Displays RPM value Provides real-time output Easy to interface with Arduino
Low power consumption

3. **IR Sensor Module**
Detects rotation of encoder disc Generates pulse signals

Provides non-contact sensing Sends signals to Arduino

4. **Tact Switch (Reset Switch)** Used for reset operation Controls system function Provides quick response
Easy to operate

5. **Breadboard**
Used for circuit connections No soldering required Easy for testing circuits Reusable component

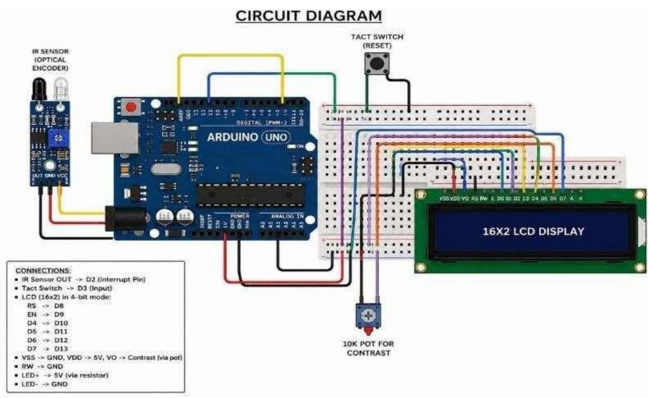
6. **Jumper Wires**
Connect electronic components Transfer signals and power Flexible and easy to use Supports temporary connections
The Digital Tachometer project is implemented using the Arduino Uno microcontroller. In this system, the IR sensor module detects the rotation of the encoder disc attached to the motor shaft and generates pulse signals. These pulse signals are received by the Arduino Uno, which counts the pulses within a fixed time interval and calculates the rotational speed in RPM. The calculated RPM value is then displayed on the 16x2 LCD display for real-time monitoring. Arduino Uno acts as the main control unit of the project and performs all processing, calculation, and display operations efficiently.

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(7, 6, 5, 4, 3,
#define sensor 9
#define start 12
int delay1()
{
//unsigned int long k;
int i,j;
unsigned int count=0;
for(i=0;i<1000;i++)
{
for(j=0;j<1000;j++)
{
if(digitalRead(sensor))
{
count++;
while(digitalRead(sensor));
}
}
}
return count;
}
void setup()
{
pinMode(sensor, INPUT);
pinMode(start, INPUT);
pinMode(2, OUTPUT);
lcd.begin(16, 2);
lcd.print(" Tachometer");
delay(2000);
digitalWrite(start, HIGH);
}
void loop()
{
unsigned int time=0,RPM=0;
lcd.clear();
lcd.print(" Please Press ");
lcd.setCursor(0,1);
lcd.print("Button to Start ");
while(digitalRead(start));
lcd.clear();
lcd.print("Reading RPM....");
time=delay1();
lcd.clear();
lcd.print("Please Wait....");
RPM=(time*12)/3;
delay(2000);
lcd.clear();
lcd.print("RPM=");
lcd.print(RPM);
delay(5000);
}
```

Fig. Software coding

This Arduino program is used to measure the rotational speed of a motor using an IR sensor and display the RPM value on a 16x2 LCD display. The program starts by including the LiquidCrystal library for LCD interfacing and defining the sensor and start switch pins. The delay1() function counts the pulses generated by the IR sensor whenever the encoder disc rotates. In the setup() function, the sensor pin is configured as input, the LCD is initialized, and a welcome message is displayed. In the loop() function, the LCD first asks the user to press the start button. After pressing the button, the Arduino reads the pulse count from the IR sensor, calculates the RPM value using the formula RPM = (time × 12) / 3, and displays the calculated RPM on the LCD screen. The process repeats continuously to provide real-time motor speed measurement.

5. Digital Tachometer Using IR Optical Encoder Sensor Working Process And Circuit Connection



The circuit diagram of the digital tachometer consists of an Arduino Uno, IR optical encoder sensor, 16x2 LCD display, tact switch, breadboard, and jumper wires. The Arduino Uno acts as the main controller of the system. The IR sensor module is connected to the Arduino and is used to detect the rotation of the encoder disc attached to the motor shaft. The sensor contains an IR LED and photodiode arrangement that generates pulses whenever the slot or reflective mark passes in front of it. The output pin of the IR sensor is connected to the digital interrupt pin of the Arduino for accurate pulse counting. The Arduino counts the number of pulses generated within a fixed time interval and calculates the RPM value. A 16x2 LCD display is interfaced with the Arduino in 4-bit mode to display the measured RPM continuously. The LCD receives control and data signals from the Arduino digital pins. A tact switch is connected as a reset button to restart or reset the reading whenever required. The breadboard is used to make temporary electrical connections without soldering. Jumper wires provide proper connections between all components. The entire circuit operates using a 5V power supply provided by the Arduino board. The system works as a non-contact speed measuring device. It provides accurate and reliable RPM measurement for rotating motors and mechanical systems.

VIII. RESULT AND DISCUSSION

The digital tachometer using an IR optical encoder sensor was successfully designed and implemented using an Arduino Uno, IR sensor, and 16x2 LCD display. The system was able to detect the rotation of the motor shaft accurately by sensing the pulses generated from the encoder disc.

The calculated RPM value was displayed clearly on the LCD display in real time. The circuit operated properly with a stable 5V power supply and produced consistent readings during testing.

During experimentation, the IR sensor showed good sensitivity in detecting the slots of the rotating disc without physical contact. The Arduino counted the pulses efficiently and converted them into RPM values with minimal delay.

The tact switch successfully reset the readings whenever required. The use of a digital display improved readability and accuracy compared to analog measurement methods. The project demonstrated reliable performance for both low-speed and medium-speed motor applications.

The developed system proved to be a low-cost, compact, and efficient method for speed measurement. The non-contact sensing technique reduced mechanical wear and improved durability.

The project can be further enhanced by adding wireless monitoring, data logging, or higher precision sensors for industrial applications. Overall, the digital tachometer provided accurate RPM measurement and fulfilled the objectives of the project successfully.

IX. CONCLUSION

The digital tachometer using an optical encoder sensor was successfully designed and implemented to measure the rotational speed of a motor shaft accurately and efficiently. The optical encoder sensor detected the rotation of the shaft by generating pulse signals, which were processed by the Arduino microcontroller to calculate the RPM value. The calculated speed was displayed on the 16×2 LCD display in real time, providing clear and continuous monitoring of motor speed.

This project demonstrated the effective use of embedded systems and sensor interfacing techniques in practical engineering applications. The non-contact method of speed measurement improved the accuracy and reliability of the system when compared to conventional mechanical tachometers. The use of an optical encoder sensor also reduced mechanical wear and ensured smooth operation during continuous monitoring.

The developed tachometer system proved to be simple, economical, and easy to construct using readily available electronic components. The Arduino platform made the programming and interfacing process flexible and user-friendly. The project enhanced understanding of pulse counting, RPM calculation, LCD interfacing, and real-time data processing in microcontroller-based systems.

Overall, the project achieved its objective of creating a reliable digital speed measurement system suitable for industrial, automotive, robotics, and laboratory applications. Future improvements can include wireless data transmission, IoT-based monitoring, data logging, and higher precision sensors for advanced industrial automation systems.

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