Indicator of Digital RPM for Electrical Motor using Alarm Indicator with Over Speed

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Abstract

This work describes developing and implementing a system to display the torque and rotational speed (measured in revolutions per minute, or RPM) of electric motors using a digital system. The systemic breakdown of which the microcontroller is primarily the main component serves to increase operational efficiency and motor safety. The motor speed is measured with the use of sensors such as in the case of infrared technology or the Hall Effect. The falling edge from one channel is monitored by the ATmega16 microprocessor to process the data and shows the RPM number on a visual interface, like seven segment or an LCD interface. The system includes such a safety feature — an alarm — to reduce the chance of mechanical failure and increase in general dependability by sounding a buzzer or turning an LED on whenever the motor's speed is greater than some fixed threshold. Since this design is very suitable for incorporation into automotive applications, laboratory research settings, or industrial automation operations, this may be a better direction to choose ahead of time. Furthermore, the system is also scalable and economical and further inclusion of wireless monitoring capabilities is possible. Empirical testing of real time performance of the system's accuracy and efficacy is confirmed.

Keywords: AVR Microcontroller, RPM Monitoring, AT- mega32, Hall Effect Sensor, Over-speed Detection, Digital Tachometer, Alarm System, Motor Safety, IoT Integration, Real- time Monitoring.

INTRODUCTION

Recently these applications have become more and more important for accurate monitoring and control of electrical motor rotational speed. In all the way from robotics and industrial facilities to electric cars and smart home products, motor speed needs to be kept below the acceptable operating thresholds to promote efficiency, avoid mechanical failure and assure safety for the user. If ignored, conditions of overspeed can result in dangerous accidents, bigger wear and tear or irreparable system damage.

The usual approaches for measuring revolutions per minute (RPM) typically rely on expensive digital sensors, bulky me- chanical apparatuses or analog tachometers. Small, affordable and highly configurable digital RPM measurement and real time overspeed alert systems are offered by microcontrollers such as AVR series (e.g., ATMega328P) but this requires the rapid development of electronics. When interfaced with sen- sors like infrared or Hall effect module, these microcontrollers can precisely count the motor shaft revolutions, display RPM on the digital interface and sound an alarm on overspeed situation.

In this paper, we describe the design and building of a digital RPM monitoring system that continues to monitor the rotational speed of an electrical motor at all times using an AVR microcontroller. The integrated warning mechanism that interrupts operating at RPMs above a preset value is beneficial to the system's operational safety. In addition to the above, the suggested method ensures proactive fault prevention in both visual as well as auditory alarm along with real time speed visualization on a digital display.

The study focuses on system accuracy, cost effectiveness, and deployment simplicity, which makes it appropriate for academic settings, labs, and small-scale companies. In order to demonstrate the usefulness and dependability of the sug- gested design, this paper also examines comparable studies in microcontroller-based RPM monitoring and contrasts it with current approaches.

RELATED WORKED

Recent developments in microcontroller-based systems, with an emphasis on real-time RPM measurement and over- Motor speed, however, has greatly improved with speed alert mechanisms. monitoring and control. These advancements are essential for in a range of maintenance operational effective- ness and safety industrial applications. Cost-effective, real- time electric motor Recent has led to the development of mon- itoring solutions. sensor based motor diagnostics and embed
- ded systems. Numerous studies have used microcontroller- By way of investigation, based systems and Internet of Things platforms various facets of speed measurement, defect detec- tion, and remote condition monitoring.

Kumar et al. proposed such a digital tachometer using an in- frared sensor for a method of non-contact RPM measurement, utilizing an Arduino UNO in [1]. The configuration worked well for simple lab applications, but the configuration wasn't real time capable, or included overspeed alarms. Just as this, Yousuf et al. Study [2] indicates the use of Internet of Things to monitor the state of induction motors. They had addresses a solution with low quality of local alert systems and good quality RSS, based on temperature and vibration sensors with cloud connectivity.

In using current signals, Pietrzak and Wolkiewicz [3] had tried to use AI models to find issues in permanent magnet synchronous motors (PMSMs). The results of their work, however, have high diagnostic accuracy but are too costly in terms of hardware expense and implementation complexity to be used in settings with low budgets or for education purposes. [4] developed a simple tachometer using the 8051 microcontroller and infrared sensing. Though they did not handle buzzer alert or threshold control, their work gave fundamental insight into an embedded RPM tracking.

With an emphasis on road safety, Adebisi et al. [5]used a microcontroller to integrate speed-limiting systems in cars. Their technology, however, was designed specifically for au- tomobiles and was not meant for general-purpose motor speed monitoring. ESP32-based IoT monitoring for industrial motors was demonstrated by Navina and Priyadharshini [6]. Although their technology holds potential for wireless monitoring, the system did not prioritize real-time user interaction and was designed for high-power applications.

Embedded methods for induction motor monitoring with both voltage and RPM detection were investigated by Patil et al. [7]. However, the measurement accuracy was limited due to the usage of analog sensors. GSM and GPS modules were used by Chekuri [8] to install a vehicle control system that tracked speed and sent out emergency alerts. The system was primarily concerned with location-based monitoring, even though it was pertinent to RPM applications.

A microcontroller-based tachometer designed for vibrating motors was introduced by Mehta and Arora [9]. Although their study presented an effective measurement method, it lacked real-time alarms and user-set threshold settings. For mobile motor setups, Kumar et al. demonstrated an embedded digital tachometer with a Hall Effect sensor in [10]. Although their system lacks modular expansion for future IoT connec- tion, it closely resembles our methodology.

Using RPM data, Yamamoto and Miyake [11] employed deep learning models to forecast industrial motor failures. De- spite being useful for predictive maintenance, its applicability for small-scale use was diminished by its need on massive datasets and computational power. Using Bluetooth modules, Jadhav and Pawar [12] created a mobile app-based RPM monitoring solution for farm motors. Although it was easy to use, it had limited hardware-side alarm methods and required continuous smartphone connectivity.

Other noteworthy studies include those by Jain et al. [13], who suggested a hybrid microcontroller-IoT system for real- time fault diagnosis; S. Kumar et al. [14], who used RPM- based telemetry to focus on predictive maintenance in man- ufacturing plants; and R. Bose et al. [15], who created an inexpensive, cloud-connected tachometer for motorcycle engines. Despite being creative, these studies frequently focus on particular domains or lack integrated alert mechanisms.

Recent developments in embedded systems and Internet of Things (IoT) technologies have significantly advanced motor speed tracking and fault prediction. Kirana [16] introduced a tachometer model utilizing both contact and non-contact mechanisms controlled by a microcontroller, demonstrating versatility for various industrial applications. In the field of automotive technology, Kolhe and Taru [17] designed a digital speedometer system with Arduino integration, specifially targeting Formula Student vehicles to enhance telemetry capabilities.

Navina and Priyadharshini [18] proposed a real-time motor monitoring framework using the ESP32 microcontroller, facil- itating seamless cloud communication for industrial automa- tion. Similarly, Yamamoto and Miyake [19] leveraged deep learning to perform predictive maintenance using RPM data, resulting in improved fault anticipation and reduced system failures.

In the agriculture sector, Jadhav and Pawar [20] developed a system capable of monitoring motor RPM via mobile in- terfaces, thus contributing to the efficiency of smart farming systems. A real-time fault diagnosis approach was introduced by Jain et al. [21], combining IoT and microcontroller platforms to support dynamic health checks of motors.

Kumar et al. [22] focused on integrating RPM and thermal sensors to enable predictive maintenance using embedded logic and sensor data. A low-cost tachometer with cloud support for motorcycle engines was proposed by Bose et al. [23], contributing to economical yet scalable monitoring solutions. Mehta and Arora [24] emphasized foundational design through a simple microcontroller-based tachometer to measure rotational speed effectively.

Further embedded enhancements were explored by Kumar et al. [25], who implemented a vibration-sensitive tachometer for accurate motor speed monitoring in precision environ- ments. A similar effort was seen by Kumar, Sharma, and Mehra [26], who created a user-friendly and affordable digital tachometer using Arduino UNO.

Yousuf et al. [27] applied IoT to enable remote condition monitoring of induction motors, offering real-time diagnostics. AI was introduced into motor health analysis by Pietrzak and Wolkiewicz [28], who built a system to detect faults in permanent magnet synchronous motors using current signal analysis.

A basic but functional tachometer using an 8051 micro- controller was developed by Ehikhamenle and Omijeh [29], primarily serving educational and training purposes. Adebisi et al. [30] contributed an automotive safety enhancement system featuring microcontroller-based speed regulation and alert capabilities.

In another application, Patil et al. [31] presented an embedded monitoring and control unit for induction motors, offering real-time tracking and system feedback. IoT-based vehicular monitoring was further explored by Chekuri [32], who demonstrated improved operational control through a connected ecosystem.

The scalability of IoT-based monitoring systems was rein- forced by Navina and Priyadharshini [33], highlighting its adaptability across diverse industrial setups. A reiteration of the low-cost cloud-connected tachometer was presented by Bose et al. [34], tailored for broader deployment across different vehicle engines. Lastly, Kumar, Tiwari, and Pandey [35]demonstrated a comprehensive approach to predictive maintenance using combined RPM and temperature data, offering robust analytics for condition-based management.

In contrast, the proposed system uniquely combines accu- racy, real-time threshold control, cost-efficiency, and modular expandability. It is particularly suitable for educational insti- tutions, small-scale industries, and prototyping environments where resource constraints exist but precision and adaptability are still required.

METHODOLOGY

A system is suggested for tracking DC motor rotational speed in real time and providing alert when the motor ro- tational speed exceeds a pre determined threshold. To do this, alarms indicator, display unit, AVR microcontroller (AT- mega32) and Hall Effect sensor are used.

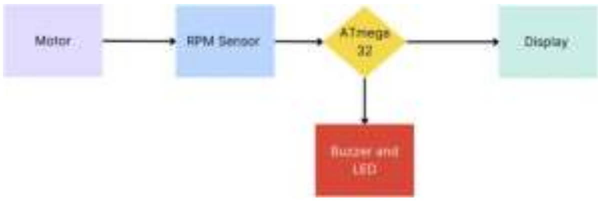

Fig. 1. Block diagram of the proposed RPM and torque monitoring system.

A standard electronic components such as an ATmega32A microcontroller, voltage regulator and sensor modules were used to design the proposed hardware system. Thus, circuit schematic was simulated and verified before PCB design.

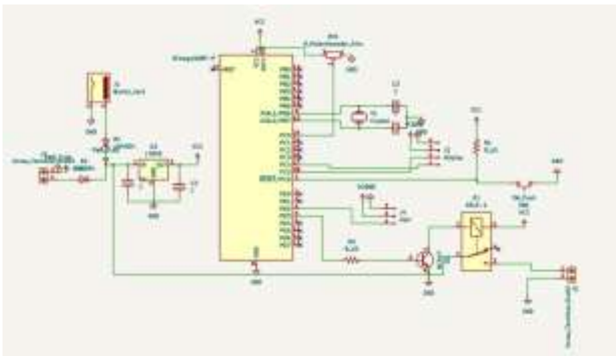

Fig. 2. Circuit schematic of the proposed system

Following this, the PCB was designed based on the verified schematic to accommodate all the components in a compact layout.

A. System Architecture Overview

A real time RPM monitoring of DC motor as well as trig- gering an alert if the motor, RPM is more than the predefined threshold has been designed to be an aspect of the proposed system. It bases the functionality of this on an integration of an AVR microcontroller (ATmega32), a Hall Effect sensor, an LCD display, an audible alarm. Fig. 1 The overall block diagram of the system is presented including the interaction between the principal components. The central processing unit of the system is the ATmega32 microcontroller (U1). Input to

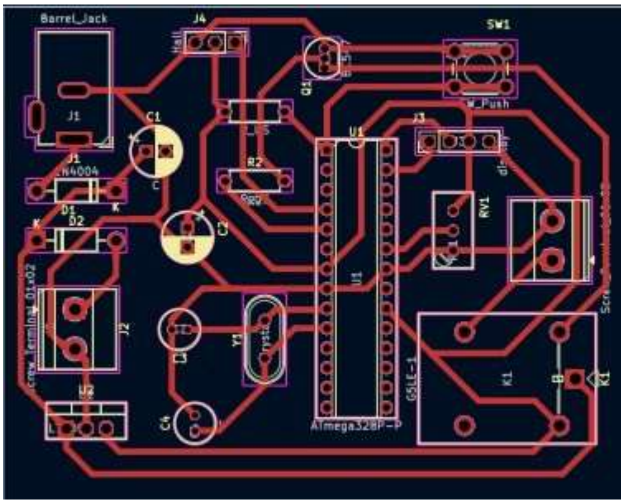

Fig. 3. PCB layout for component placement and routing

it is provided from a Hall Effect sensor (MAG1) that senses magnetic pulse generated by the rotation of the motor shaft. The microcontroller counts how many of these pulses occur over a period of time to determine the RPM.

The motor speed can be monitored real time by users from the 16x2 LCD screen (LCD1), which displays the calculated RPM value. The system itself also includes an alert mechanism herein, through the use of g the BUZ1 buzzer, which is activated should the RPM exceed the preprogrammed safety limit.

The whole thing is running off a regulated 5V supply, the 5V (including all necessary overvoltage protection and regulation) provided by a 7805 voltage regulator (U2). A crystal oscillator (X1) is used to maintain timing accuracy of the microcontroller. For voltage stabilization, reset control and user input, additional components, including resistors, capacitors, and push button switches, are used.

The detailed schematic of the system circuit is shown in Fig. 2, which was first simulated and verified prior to the PCB layout design. This ensures accurate signal routing and compact component placement. The finalized PCB layout is depicted in Fig. 3, which supports efficient and reliable implementation of the hardware system.

B. Sensor Interface and Signal Processing

A Hall Effect sensor is put near the motor shaft. The sensor is affixed to a small magnet that is fixed onto the rotating shaft so that it records a digital pulse with every rotation. These pulses are given to micro controller external interrupt or timer pin.

In a one second interval, the first pulse is assigned to the first revolution (or first fraction thereof), the second pulse to the second revolution (or another first fraction thereof), etc., and the total number of times all pulses are recorded. Since the signal is already digital form, therefore no other conditioning is required.

C. RPM Calculation using ATmega32

The ATmega32 microcontroller is programmed using em- bedded C to perform pulse counting within a defined time window (typically one second). The RPM is calculated using the following equation:

$$\text{RPM} = \frac{N \times 60}{P} \qquad (1)$$

Where

- N = Number of pulses counted in one second
- P = Pulses per revolution (depends on the number of magnets or sensor placement)

The calculated RPM value is then displayed and compared against a predefined threshold.

D. Display Unit

To get users to realize motor speed in real time, a microcon- troller is interfaced with a display unit like 16x2 lcd or OLED. For hardware they use, the display connection is established with an I2C interface or a parallel data bus. The RPM reading that is displayed is constantly being updated and the user is able to discuss the motor's speed performance.

E. Alarm System Implementation

The alarm system is triggered if the rpm goes above the predefined threshold. This system comprises: A device which generates an audible tone or a tone audible to people so that they may notice it or turn to see the cause of the noise. A visual indication of the overspeed condition provided by an LED.

These indicators are wired to the output pins of the mi- crocontroller, and connected to. The indicators and the mi- crocontroller are protected with transistors or current limiting resistors that switch them via.

F. Threshold Control Mechanism

A set of push buttons are incorporated so that the user is allowed to define the RPM threshold.

An increase the threshold button.

A threshold lowering button is provided.

A button that will reset default settings or mute the alarm. Finally, these buttons are connected to digital input pins and they are monitored by the microcontroller with polling or with interrupt based soffit. To avoid the false input due to contact

bounce a debouncing logic is executed in software.

G. Power Supply and PCB Layout

The system is powered through a regulated 5V DC supply, suitable for both the ATmega32 microcontroller and other logic-level components. A voltage regulator, such as the 7805 or a buck converter, is employed to ensure stable voltage supply regardless of the input fluctuations.

The entire circuit is designed on a compact printed circuit board (PCB) using electronic design automation (EDA) tools. The PCB layout (shown in Fig. 2) optimizes component placement and minimizes noise, ensuring reliable performance and ease of assembly.

Figure 2 presents the detailed circuit diagram, which highlights the interconnections of all components such as the Atmega32 microcontroller, voltage regulator, capacitors, push buttons, display unit, buzzer, and sensor module. This schematic was designed using Proteus software.

Figure 3 shows the PCB layout of the system. The layout was generated using PCB design software to ensure compact- ness, reduced noise, and optimal component placement for efficient signal flow.

Figure 4 provides a 3D model of the fully assembled PCB, visually confirming the physical placement of key components including the microcontroller, diodes, capacitors, connectors, and voltage regulator. This model was generated to verify practical feasibility before fabrication.

Table I lists the core system components along with their specifications and functional roles. This tabular representation summarizes key hardware elements like the microcontroller, Hall sensor, crystal oscillator, and other peripherals used in the implementation.

TABLE I SYSTEM COMPONENTS AND SPECIFICATIONS

Component	**Specification**	**Function**

AVR Microcontroller	ATmega16/ATmega32	Core processing unit
Hall Effect Sensor	A3144	Detects rotation
LCD Display	16x2 Alphanumeric	Displays real-time RPM
Alarm Indicators	Buzzer and LED	Indicates overspeed
Push Buttons	Tactile Switches	User input
Motor (Test Object)	DC/AC Motor	Test Object
Crystal Oscillator	16 MHz	Timing accuracy

RESULTS AND DISCUSSION

The PCB was designed and routed, and then a 3D visu- alization was created in order to evaluate design aesthetics and placement of components. Components such as micro controller, capacitors, voltage regulator and others are all confirmed to be properly aligned in the 3D view.

A. Experimental Setup

In order to confirm the functionality of the suggested RPM monitoring and alert system, a prototype of said system was created and tested in a controlled laboratory setting. Hardware components included: ATmega32 microprocessor, a 16x2 LCD, A3144 Hall Effect sensor, tactile push buttons and conventional DC motors. It was being powered by a DC source controlled at 5V. The rotating portion of the DC motor was fastened to a tiny magnet, and the Hall Effect sensor

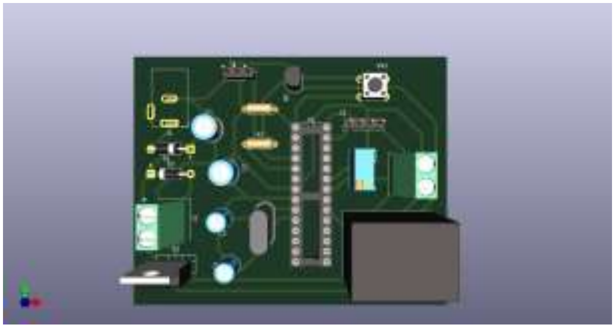

Fig. 4. 3D model of the assembled PCB

was placed close to the shaft. Interacting between magnet and sensor helped the microcontroller identify rotational pulses.

B. RPM Measurement Accuracy

The accuracy of the RPM measurements was confirmed by contrasting values obtained from the suggested method against those from a high precision digital thermometer which is sold commercially. The tests were performed over a broad range of motor speeds namely from 100 RPM to 3000 RPM. It had less than ±2.5

C. Alarm Triggering and Threshold Control

The integrated alarm system was used to evaluate different RPM situations. The system that was created was able to successfully activate visual (LED) as well as audio (buzzer) notification when the motor's rotational speed exceeded the user specified threshold. The user interface's haptic pushbut- tons also enable the low level digital RPM threshold to be easily adjusted throughout operation. The ability to get rid of the necessity to restart or change the configuration of the device improved user comfort and control.

D. Power and Stability Analysis

The 16 MHz crystal oscillator provided the precise clock signals needed for timing of the pulses and calculation of RPM. During the experiment course, the use of the 7805 voltage regulator made it sure that a constant 5V power supply would be ensured throughout the testing procedure. Even in the sense of varying input voltage circumstances, the system would perform consistently without unexpected oscillations or resets. This demonstrates the circuit design's stability and resistance.

E. Scalability and Cost Efficiency

The low cost is one of the strength of the system. All of the prototype, without the motor, cost under $20 USD. The scalability of this design is achieved due to the modular design; the components like Wi-Fi (ESP8266) or Bluetooth (HC-05) modules can be added to add remote monitoring and control, making the system future ready for Internet of Things (IoT) applications.

Conclusion

As presented in this work, such a digital RPM monitoring and over-speed alarm system does not require much in terms of cost and reliability, using the ATmega32 microcontroller and the A3144 Hall Effect sensor as the components of choice. The error margin of system on the detection of real time speed was ±2.5%, and effectively triggered alarm beyond user defined values. Being a low cost, modular design, it allows for adaption in many industrial and research applications. The prototype provides a scalable base that can be used for future development in wireless connectivity and multiple motor monitoring to safer and smarter motor control systems.

Future Work

Based on this, the proposed system can serve as the basis for a number of advanced features and functional extensions that can have a great impact on the applicability as well as the value of the system in real world environments. As a part of the future scope, several potential enhancements are envisioned.

Wireless Monitoring and Control: The integration of wireless communication modules such as **ESP8266**, **ESP32**, or **GSM/GPRS modules** will allow the sys- tem to transmit real-time motor RPM data to remote servers or cloud dashboards. This will enable operators to monitor motor performance and receive alerts via web- based platforms or mobile applications, ensuring remote accessibility and control in critical scenarios.

Torque and Load Monitoring: Incorporating **torque sensors** or **current-sensing modules** like ACS712 or INA219 can provide valuable insights into the mechanical load and operational stress on the motor. This feature would allow for the real-time estimation of torque, fa- cilitating more accurate diagnostics and improving the system's ability to predict mechanical overloads or im- balances.

Cloud-Based Data Logging and Visualization: By connecting the system to cloud platforms such as **ThingS- peak**, **Firebase**, or **AWS IoT Core**, users can store his- torical RPM and alarm data securely. The cloud interface can be used to visualize trends, generate reports, and apply statistical analysis for predictive maintenance and decision-making.

Mobile and Desktop Applications: Development of cross-platform applications for **Android**, **iOS**, and **Win- dows** can enhance user interaction. These apps could al- low dynamic configuration of over-speed thresholds, real- time visualization of motor data, alarm acknowledgment, and access to system logs—all from an intuitive graphical interface.

AI-Based Predictive Maintenance: Integration of **ma- chine learning algorithms** can enable the system to detect abnormal patterns in RPM fluctuations, torque, or vibration. Over time, these algorithms can learn to forecast potential failures or maintenance needs, reduc- ing unexpected downtimes and improving equipment longevity.

Multi-Motor Monitoring and Control: The architecture can be extended to monitor and control **multiple motors simultaneously**, each with its own RPM sensor and alarm module. A central microcontroller or embedded system could manage and coordinate the data, supporting load balancing and efficient resource utilization in industrial applications.

In conclusion, these future enhancements are not only raising the technical sophistication of the proposed RPM monitoring system, but also making it applicable to various fields of application ranging from small laboratories to smart factories.

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