

Design and Implementation of a Contactless Digital Tachometer

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1. Introduction

Accurate measurement of rotational speed is essential for ensuring optimal performance and safety in industrial applications. Traditional contact tachometers can pose safety hazards due to their direct interaction with moving parts, which increases the risk of accidents and equipment damage. In contrast, contactless tachometers utilise sensors to measure speed without physical contact, significantly reducing safety risks.

The goal of this project is to design and implement a contactless tachometer that employs infrared technology. This approach aims to eliminate health and safety concerns while maintaining a high level of accuracy across a wide operating range.

2. Infrared Overview

Infrared (IR) tachometers measure rotational speed using an IR light source and receiver. An IR beam is emitted onto the rotating object which reflects it back towards the receiver. This generates signals corresponding to revolutions, allowing RPM calculation.

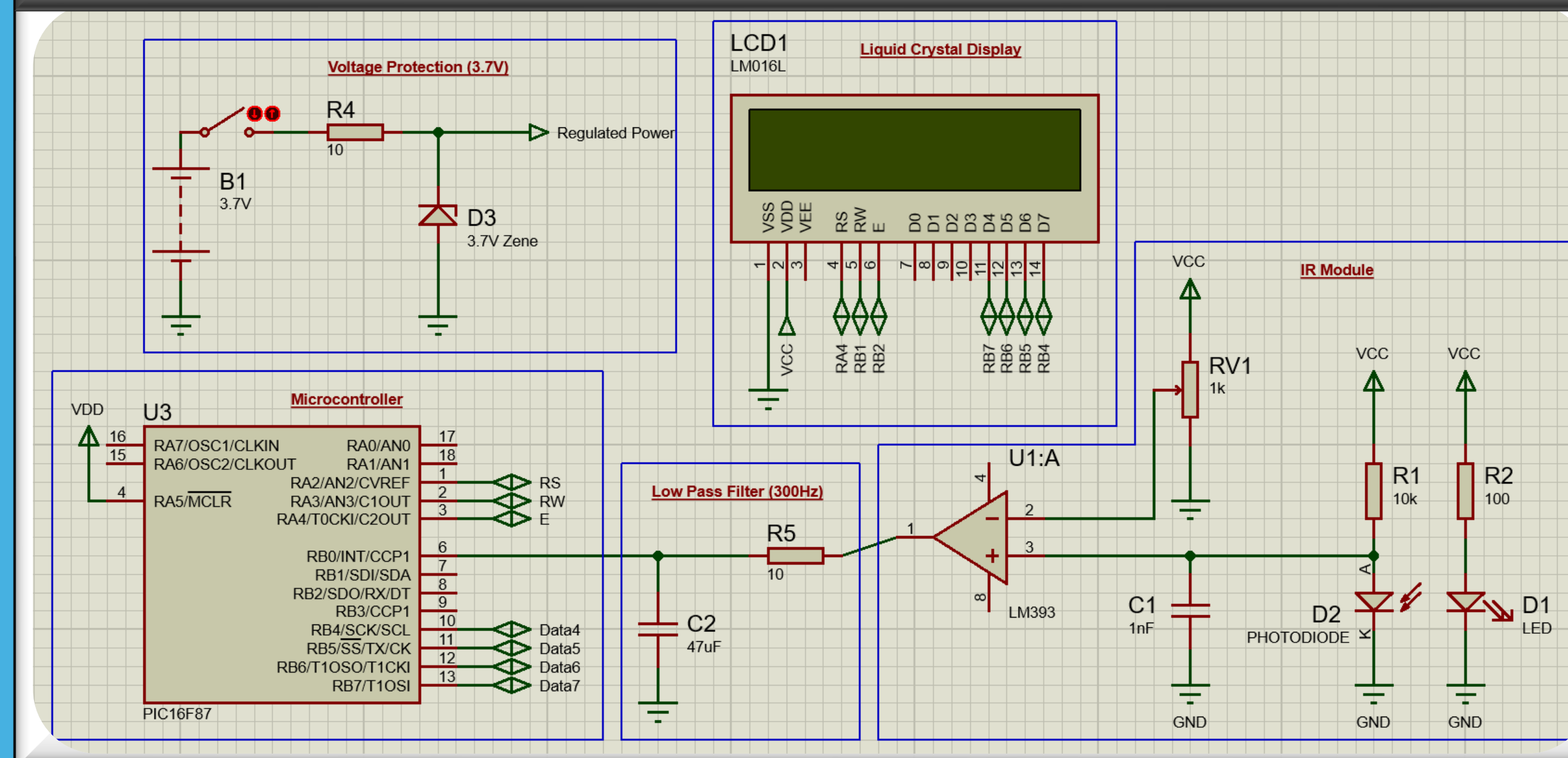
Advantages of IR Tachometers

- **Contactless Measurement:** Reduces health and safety risks by eliminating physical contact with moving parts.
- **High Accuracy:** Provides precise measurements under optimal conditions.
- **Cost-Effective:** Constructed with simple electronic components, making them inexpensive.

Disadvantages of IR Tachometers

- **Environmental Sensitivity:** Performance is heavily diminished by sunlight, dust, and water vapor.
- **Limited Range:** Typically has a shorter operational range due to interference sensitivity and wavelength.

3. Tachometer Circuit Design



4. Tachometer Design



The PIC16F87 serves as the central processing unit of this device. It connects all components, processes all information, and outputs instructions to the display. Key features include a 20 MHz clock frequency, a CCP module for real-time signal analysis, a 16-bit timer, and 7KB of programmable memory.

The tachometer is housed in an IP65-rated enclosure that contains all the circuitry and components. It features a 16x2 LCD for displaying RPM data, with an IR sensor module to detect motor speed. All components are interconnected via a dedicated PCB, with modulated connections via Molex connectors. The device is powered by a rechargeable 3.7V Li-ion battery, which can be recharged conveniently through a USB-C charging module.



5. Simulation Evaluation

Accuracy:

- Average accuracy of **99.43%** across the tested range.
- Achieved **100% accuracy** at lower frequencies (5Hz to 15Hz).
- Maintained **above 99.50% accuracy** up to 5400 RPM.
- Decline in accuracy observed at higher frequencies, dropping to **98.90%** at 12000 RPM.

Precision:

- High precision was demonstrated with no deviation across multiple tests, indicating reliable measurement consistency.

Resolution:

- The software utilises a CCP module to achieve a resolution of **1 RPM**.

Operational Range:

- Effective range identified from **240 RPM to 10800 RPM**.
- Lower limit exceeds project specifications; upper limit narrowly misses the accuracy target by **0.1%**.

6. Summary & Future Work

This tachometer demonstrated high accuracy, precision, and a wide operating range throughout software evaluation. However, an LCD driver issue prevented practical testing within the project timeframe. Nonetheless, thorough research and hardware analysis strongly suggests minor software modifications will enable the tachometer to perform well in its intended application.

Moving forward, efforts will focus on modifying the LCD driver file to address the current issues. Alternatively, the use of a different compiler program may be considered to generate a compatible driver file.

An optical lens may also be examined to try and reduce some of the environmental interferences present within optical devices and increase the measurement distance of the tachometer.