

Real Time Rollover Safety System for Heavy Duty Vehicle

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Abstract - Heavy-duty vehicles, such as trucks and buses, play a crucial role in transportation and commerce, facilitating the movement of goods and people across vast distances. However, these vehicles are also susceptible to rollover accidents, which can have devastating consequences in terms of loss of life, property damage, and economic impact. According to statistics from the National Highway Traffic Safety Administration (NHTSA), rollover accidents involving heavy-duty vehicles are among the most severe and deadliest types of crashes on our roads.. In this paper, we propose a Real-Time Rollover Safety System designed specifically for heavy-duty vehicles. Our system leverages advanced technologies, including the STM32F407 microcontroller, servo valve, and hydraulic system, to effectively monitor and control the vehicle's tilt angle in real-time.

Keywords: Safety System, Heavy Duty Vehicles, NHTSA, Trucks, Buses, Rollover Safety System, Hydraulic system.

I. INTRODUCTION

In today's world, Automation is a very important part of the invention. This Project focuses on safety of loaded vehicles from the rollover, side wind, overturn etc. These technologies have some limitations and are overcomes by using stm32f407 microcontroller, servo valve &hydraulic system and it gives better performance and reliability.

The STM32F407 microcontroller serves as the brain of our safety system, providing the processing power and flexibility needed to execute complex control algorithms and interface with various sensors and actuators. By harnessing the computational capabilities of the STM32F407, we can achieve precise and responsive control of the vehicle's hydraulic system, enabling rapid adjustments to prevent potential rollover situations.

Central to our safety system is the integration of a servo valve and hydraulic system, which allows for dynamic adjustment of the vehicle's tilt angle in response to changing driving conditions. The servo valve acts as the actuator,

receiving commands from the microcontroller and modulating the flow of hydraulic fluid to the vehicle's suspension system.

By fine-tuning the hydraulic pressure applied to each suspension component, our system can effectively stabilize the vehicle and counteract forces that may lead to rollover. Key to the effectiveness of our rollover safety system is the ability to accurately monitor the vehicle's tilt angle in real-time. Through the use of advanced sensors, such as gyroscopes and accelerometers, coupled with sophisticated algorithms, we can precisely measure the vehicle's orientation and detect potential rollover scenarios before they escalate. This real-time monitoring capability enables our system to proactively intervene and apply corrective measures to maintain vehicle stability and prevent rollover accidents.

The existing load on trailer get display on LCD screen displaying an overload message on an LCD screen in a truck trolley is a useful safety feature to alert operators and prevent potential issues related to excessive load Integrate an LCD screen into the truck trolley's control panel or dashboard[3]. This screen will display relevant information, including the overload message. If an overload condition is observed, a visual and audible alarm will continuously beep. Overload message will be displayed on load screen.

In the subsequent sections of this paper, we will delve into the technical details of our Real-Time Rollover Safety System, including the design and implementation of the control algorithms, the integration of the STM32F407 microcontroller [1] and servo valve, and the validation of our system through simulation and experimental testing.

Through our research and development efforts, we aim to contribute to the advancement of rollover prevention technologies and enhance the safety of heavy-duty vehicles on our road.

II. FLOW CHART

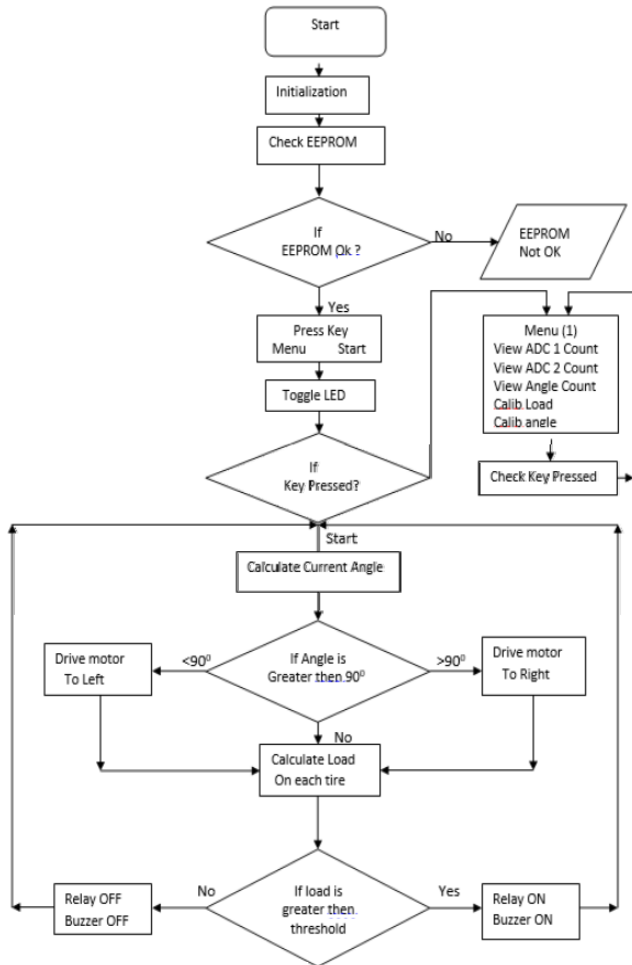


Figure 1: Flow chart

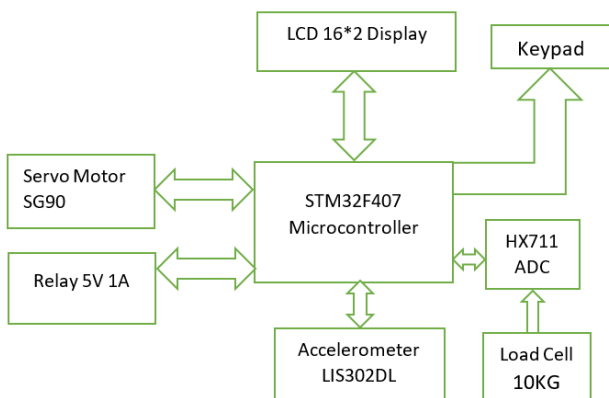


Figure 2: Block Diagram

III. SYSTEM DESIGN

3.1 Servo motor SG90

The SG90 servo motor typically has dimensions of approximately 23mm x 12.2mm x 29mm (L x W x H) and

weighs around 9 grams. The operating voltage range for the SG90 servo motor is commonly between 4.8V to 6V DC. The SG90 servo motor typically provides a torque of around 1.8 kg/cm (4.8V) to 2.2 kg/cm (6V). The speed of the SG90 servo motor varies depending on the load and voltage applied, but it typically ranges from 0.1 sec/60° (4.8V) to 0.08 sec/60° (6V).[4]

3.2 microcontroller STM32F4

ARM Cortex-M4 core running at up to 168 MHz with FPU (Floating Point Unit) and DSP (Digital Signal Processing) instructions. Up to 1 MB of Flash memory for program.[2] Up to 192 KB of SRAM (Static Random Access Memory) for data storage. Up to 192 KB of SRAM (Static Random Access Memory) for data storage. 12-bit ADC with multiple channels. 12-bit DAC for analog output. -40°C to +85°C (Industrial grade) or -40°C to +125°C (Extended industrial grade). Typically operates at 3.3V, but some pins are 5V tolerant. [1]

3.3 Accelerometer LIS302DL

The LIS302DL accelerometer is designed to measure acceleration along three perpendicular axes: X, Y, and Z. It detect both static (e.g., gravity) and dynamic (e.g., motion or vibration) acceleration. The LIS302DL typically has selectable measurement ranges.[5]

3.4 Load Cell

The Sensotec Model 31 load cell is a high-precision force sensor designed for applications requiring accurate and reliable force measurement up to 10 kg. The load cell provides a low-voltage output signal of 0-20 mV, which can be amplified and conditioned for further processing by signal conditioning equipment or data acquisition systems. Capacity: 10 kg (22 lbs) Sensitivity: 2.0 mV/V Excitation Voltage: 10 VDC (Nominal) Output: 0-20 mV (Nominal) Accuracy: ±0.02% Full Scale Operating Temperature Range: -10°C to +40°C.

3.5 ADC HX711

Resolution The HX711 has a resolution of up to 24 bits, which allows for highly accurate measurements. Input Voltage Range Typically, the HX711 operates with an input voltage range of 2.6V to 5.5V, making it compatible with a wide range of microcontrollers and other digital systems Selectable Gain: The HX711 offers selectable gain settings of 32, 64, and 128, allowing users to adjust the amplification factor based on the specific requirements of their application. Data Rate It supports selectable data rates, typically ranging from 10 to 80

samples per second (SPS), allowing users to balance between speed and resolution according to their needs.

3.6 Keypad

A keypad is a user interface device consisting of a set of buttons arranged in a grid or matrix. It allows users to input alphanumeric characters, numeric digits, or control commands by pressing the buttons. Keyboards typically consist of individual keys arranged in a grid layout, with each key representing a specific character, digit, or function. The keys are usually made of plastic or rubber and contain a conductive material that forms an electrical contact when pressed.

IV. SIMULATION

Pulse Width Modulation (PWM) is commonly used to control servo motors. Servo motors are controlled by sending them a series of pulses whose duration determines the position of the servo's shaft. In the main function, we define the PWM period (period) and the duty cycle (duty_cycle). Then, we create a PWM signal generator `pwm_signal` using the `generate_pwm` function. We simulate the movement of the servo motor from 0 to 180 degrees in steps of 10 degrees by calling the `move_servo` [4] function for each angle. After moving the servo to the desired angle, we print the current angle and pause for 1 second before proceeding to the next angle.

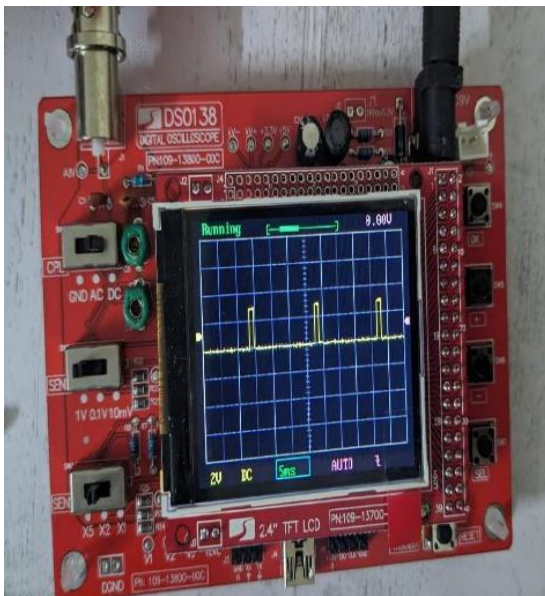


Figure 3: PWM simulation servo motor

To simulate controlling a servo motor, we can generate a PWM signal with a specific frequency and duty cycle. The duty cycle represents the proportion of time that the signal is in the "on" state compared to the total period of the signal. By varying the duty cycle, we can control the position of the

servo motor. In the simulation, we can vary the duty cycle of the PWM signal to simulate moving the servo motor to different positions. A lower duty cycle corresponds to a smaller angle, while a higher duty cycle corresponds to a larger angle. By adjusting the duty cycle over time, we can mimic the movement of the servo motor through its range of motion. In a simulation, we might visualize the movement of the servo motor [4] by observing changes in the duty cycle of the PWM signal and correlating them with changes in the position of the simulated servo update the LCD display with the latest weight and load angle data.

V. FINAL PROJECT VIEW

Creating a final view of a project involving an LCD displaying weight and load angle would typically involve integrating hardware components such as sensors, a microcontroller, and an LCD [2] display, as well as writing code to gather data from the sensors and update the LCD accordingly.

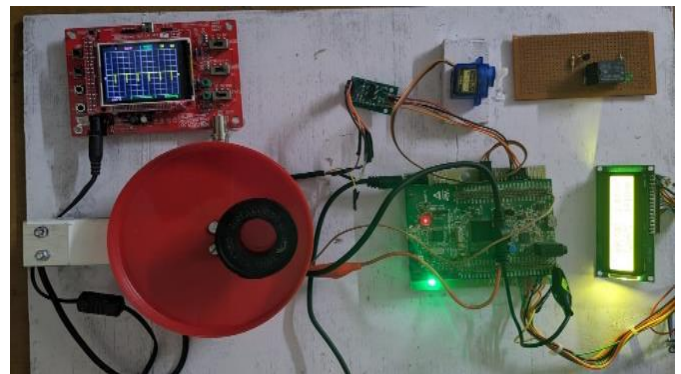


Figure 4: Hardware setup

However, since we're not actually building the physical project here, I'll provide a conceptual representation. **STM32F407 microcontroller:** Controls the overall operation and interfaces with other hardware components. **Servo motor:** Used for controlling the roller's movement or positioning. **Accelerometer:** Detects vehicle acceleration and deceleration to adjust roller speed accordingly. **LCD display:** Provides real-time feedback and status information to the user. **Keypad:** Allows user input for system configuration or control. **ADC (Analog-to-Digital Converter):** Converts analog signals from sensors like the accelerometer and load cell into digital values for processing by the microcontroller. **Load cell (up to 10 kg):** Measures the weight or force applied to the roller. **Relay:** Used for controlling external devices or systems based on input from the microcontroller. Additionally, you would need power supplies, wiring, connectors, and possibly enclosures for protection against environmental factors. Software-wise, you'd need firmware for the microcontroller to manage inputs, process data, and control outputs effectively.

VI. RESULT

An LCD displaying weight and load angle [3], we'll create a hypothetical scenario where we have weight and load angle data available. Then, we'll depict how this information could be displayed on an LCD screen. Load angle refers to the angle at which a load is positioned relative to a reference point.



Figure 5: Load angle & load in gram display

For simplicity, we'll assume load angle data is measured in degrees. We'll simulate a typical LCD [2] display with two sections: one for displaying weight and the other for displaying load angle.

VII. CONCLUSION

Users can continuously monitor the weight being lifted or supported and the angle at which the load is positioned relative to a reference point. The LCD display provides instant updates, allowing users to stay informed about changes in weight and load angle without the need for manual measurements. The project's versatility makes it suitable for various applications, including industrial automation, robotics, structural health monitoring, and load-bearing equipment.

ACKNOWLEDGEMENT

We would also like to show our gratitude to Prof. Dr. S. G. Kanade and Prof. A. P. Kinge (Professor, Department of

Electrical Engineering, TSSM's BSCOER, Pune, Maharashtra, India.) for sharing their pearls of wisdom with us during the course of this research. We are also immensely grateful to him for his comments on an earlier version of the manuscript, although any errors are our own and should not tarnish the reputations of these esteemed persons.

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Citation of this Article:

Shahanediwan Tanjil, Prof. Dr. S. G. Kanade, Prof. A. P. Kinge, "Real Time Rollover Safety System for Heavy Duty Vehicle", Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 3, pp 354-357, March 2024. Article DOI <https://doi.org/10.47001/IRJIET/2024.803054>
