CSE411: Real-Time and Embedded Systems Design

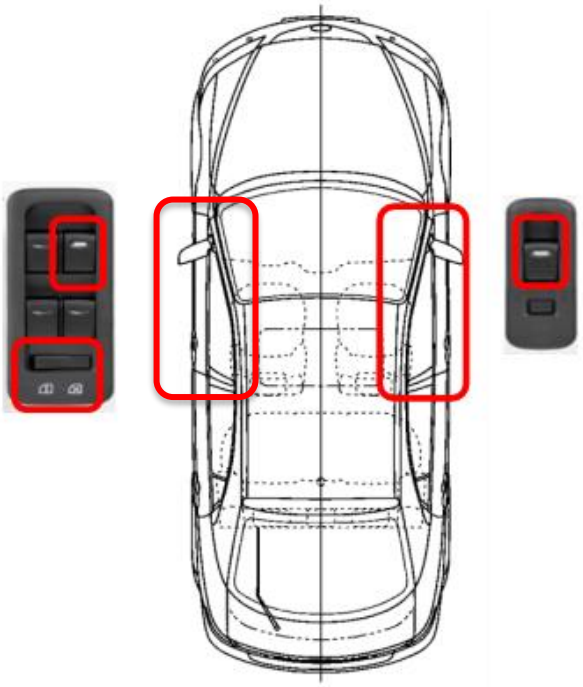
Spring 2025

Project Description – Idea 1

Advanced Power Window Control System

Project Overview

This project aims to develop an advanced power window control system using the Tiva C Series TM4C123GH6PM microcontroller and FreeRTOS for real-time task management. The system will control a front passenger door window, featuring manual and automatic operation, obstacle detection, window lock functionality, and precise position tracking. The implementation emphasizes safety, reliability, and efficient resource utilization.



Key Features

1. **Manual and Automatic Window Operation**
   - Manual Mode: The window moves up or down while the respective switch is held.
   - One-Touch Auto Mode: A short press fully opens or closes the window without requiring continuous input.
2. **Obstacle Detection and Safety Measures**
   - IR sensors detect obstacles during auto-close operation.
   - If an obstacle is detected, the window immediately stops and reverses downward for 0.5 seconds to prevent injury or damage.
   - Upper and lower limit switches ensure safe operation by preventing over-travel.
3. **Position Control with Encoder Feedback**
   - An incremental encoder provides precise window position feedback.
   - Position tracking enables additional features like partial window opening.
4. **Window Lock Functionality**
   - A window lock switch allows the driver to disable passenger-side controls.
   - When activated, only the driver can operate the passenger window.
   - Status is displayed on an LCD screen
5. **Power Management**
   - The system enters low-power mode when idle, reducing energy consumption and improving efficiency
6. **Real-Time Task Scheduling with FreeRTOS**
   - The system is structured into independent FreeRTOS tasks for:
     - Manual and automatic window control
     - Obstacle detection and response
     - Position tracking and safety monitoring
     - System status updates (LCD, LED, buzzer alerts)
   - Synchronization is handled using semaphores and message queues to ensure reliable task execution.

Hardware Components

- Microcontroller: TM4C123GH6PM (Tiva C Series)
- Motor and Driver: DC motor with an H-bridge motor driver
- Sensors:
  - IR Sensor for obstacle detection
  - Incremental encoder for position tracking
  - Limit switches for limits of window
- User Interface:
  - Push buttons for window control
  - ON/OFF switch for window lock
  - LCD display for status updates
  - Buzzer and RGB LED for audible/visual alerts

Project Deliverables

1. Hardware Setup: A fully functional prototype with all components integrated.
2. Software Implementation: Well-structured, modular FreeRTOS-based firmware.
3. Live Demonstration: Showcasing all features in real-time operation.
4. Project Report including but not limited to:
   - System design and architecture
   - FreeRTOS implementation details
   - Challenges and solutions
   - Future improvements

Project CHECKLIST

MARKS	ACTIVITIES
2	Manual Mode from both sides
2	Automatic Mode from both sides
2	Obstacle Detection and Jam Protection
2	Encoder feedback
2	Upper/lower limit switches
1	LCD displays window's position accurately
1	Lock switch disables passenger-side control properly
1	Driver retains full control when lock is enabled
1	Sleep mode when idle
1	Tasks are created and scheduled correctly
1	Tasks priorities are assigned properly
1	Semaphores/mutexes for resource management
1	Queues for passing data between tasks
2	Full Technical Report
5	Individual Assessment
25	Total Project