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Joystick-Controlled Car Using PIC16F877A Microcontroller

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Abstract

This report presents an embedded system project designed to control a car using a wired joystick module with three levels of speed. The project utilizes the PIC16F877A microcontroller as the core component to interface between the joystick module and the car's control system. The report outlines the system's architecture, hardware, and software components, as well as the implementation details and testing results.

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1 INTRODUCTION

This report provides a comprehensive overview of an embedded system project utilizing the PIC 16F877A microcontroller. The project focuses on designing and implementing a wired joystick module-controlled car capable of movement in four directions (forward, backward, left, and right) with three levels of speed control. Additionally, an ultrasonic sensor is incorporated to detect nearby objects, interrupt the system, and activate LEDs as a visual indication.

1.1 OBJECTIVES

The objective of this embedded system project is to develop a wired joystick module-controlled car with advanced functionalities. The system allows users to control the car's movement using a joystick module, with options for adjusting the speed level. To enhance safety and awareness, an ultrasonic sensor is utilized to detect nearby objects. When an object is detected within a specified range, the system interrupts the car's operation and activates LEDs to indicate the user.

1.2 THEORY

The car control project uses the PIC16F877A microcontroller and a wired joystick module to control the car's movement and speed using the PWM technique. Analog-to-digital conversion is used to convert analog signals into digital values, which are then sent to the car's control system. Testing and debugging procedures are essential to ensure the system's functionality and reliability. The theoretical understanding of the microcontroller, analog-to-digital conversion, digital signal processing, control signal generation, and motor control is essential for successful implementation.

List of components and how they work:

1. Pic (16F877A): The PIC16F877A is a microcontroller developed by Microchip Technology. It is based on the PIC architecture and is commonly used in embedded systems and other control applications. The PIC16F877A has a wide range of features including: -An 8-bit CPU -35 I/O pins - 8K bytes of Flash program memory -368 bytes of RAM -A variety of peripheral modules such as timers, A/D converters, and communication interfaces.

The PIC16F877A is programmed using a specialized programming language called assembly, or using a high-level language such as C or Basic with the help of a compiler. Once programmed, the PIC16F877A can be used to control various devices and systems by processing inputs and outputs, performing calculations, and making decisions based on the program code.

2. DC Motors: DC (Direct Current) motors are commonly used in car control systems. These motors convert electrical energy into mechanical motion. By varying the voltage and polarity applied to the motor terminals, the speed and direction of the motor can be controlled. DC motors are suitable for controlling the car's wheels, as their speed can be adjusted to achieve different levels of motion.

3. **H-Bridge:** an electronic circuit that allows for controlling the direction and speed of a motor. It typically consists of four switches (transistors or MOSFETs) arranged in an H shape. By selectively turning on and off the switches, the motor's polarity can be reversed, enabling forward and backward motion. The H-bridge is an essential component in controlling the DC motors used in the car, as it provides bidirectional control.

4. **Joystick Module:** The joystick is an input device that enables users to control the car's movement and speed. It typically consists of one or more potentiometers that generate analog voltage signals proportional to the position of the joystick in different directions. The analog signals from the joystick are converted into digital values using the microcontroller's analog-to-digital converter (ADC) for further processing.

5. **The Chassis:** The chassis refers to the structural framework of the car, providing support and housing for various components. It typically includes the main body, wheels, and mounting points for the motors, microcontroller, and other electronic components. The chassis should be sturdy and durable to ensure the stability and safety of the car.

6. **Ultrasonic Sensor:** ultrasonic sensor is a device that uses high-frequency sound waves to detect objects or measure distances. It emits ultrasonic waves and measures the time it takes for them to bounce back after hitting an object, allowing it to calculate the distance. These sensors are commonly used in various applications, such as proximity detection, distance measurement, and collision avoidance systems. They offer non-contact operation, a wide detection range, and good accuracy, making them valuable in industries like robotics, automation, and security.

Other Components:

Oscillator – 1

Wheels – 2

Lithium-Ion Battery - 3

Breadboard – 1

LEDs

Wires (male-male, female-male)

2 PROCEDURE AND METHODS

Procedure:

- a) **Hardware setup:** Begin by setting up the hardware components, including the PIC16F877A microcontroller, wired joystick module, H-bridge, DC motors, and chassis. Connect the necessary wires and ensure proper power supply arrangements.
- b) **Software development:** Develop the firmware for the PIC16F877A microcontroller using a suitable programming language such as C. Implement the necessary code to read analog inputs from the

joystick module, process the data, and generate appropriate control signals for the H-bridge and DC motors.

- c) **Testing and debugging:** Conduct comprehensive testing and debugging procedures to ensure the functionality and reliability of the system. Verify the accuracy of joystick inputs, test speed control at different levels, and validate the precision of direct control. Make necessary adjustments and corrections as required.

Methods:

- i. **Analog-to-digital conversion:** Utilize the built-in ADC modules of the PIC16F877A microcontroller to convert the analog signals from the joystick module into digital values. Set appropriate resolution and sampling rates to ensure accurate conversion.
- ii. **Digital signal processing:** Process the digital values obtained from the ADC to determine the desired speed and direction for the car. This may involve mapping the digital values to different speed levels using the PWM technique and defining thresholds for determining the direction (e.g., forward, backward, left, right).
- iii. **Control signal generation:** Based on the processed digital values, generate control signals for the H-bridge to adjust the speed and direction of the DC motors. Use suitable techniques such as digital pulses or Pulse Width Modulation (PWM) signals to achieve smooth and precise control.
- iv. **Motor Control using H-Bridge:** The H-Bridge circuit, connected to the PIC microcontroller, controls the DC motors' rotation and speed. The microcontroller generates the necessary control signals (PWM) to activate the motors and adjust their speed based on the joystick inputs.
- v. **Ultrasonic Proximity Detection and LED Activation:** The ultrasonic sensor continuously measures the distance between the car and nearby objects. The microcontroller triggers the ultrasonic sensor to emit ultrasonic waves and measures the time taken for the waves to return. Based on this data, the microcontroller calculates the distance and determines if an object is within the predefined range. When an object is detected within the specified range, the microcontroller activates the corresponding LEDs to indicate the proximity.

3 DESIGN

Software Design (Flow Chart):

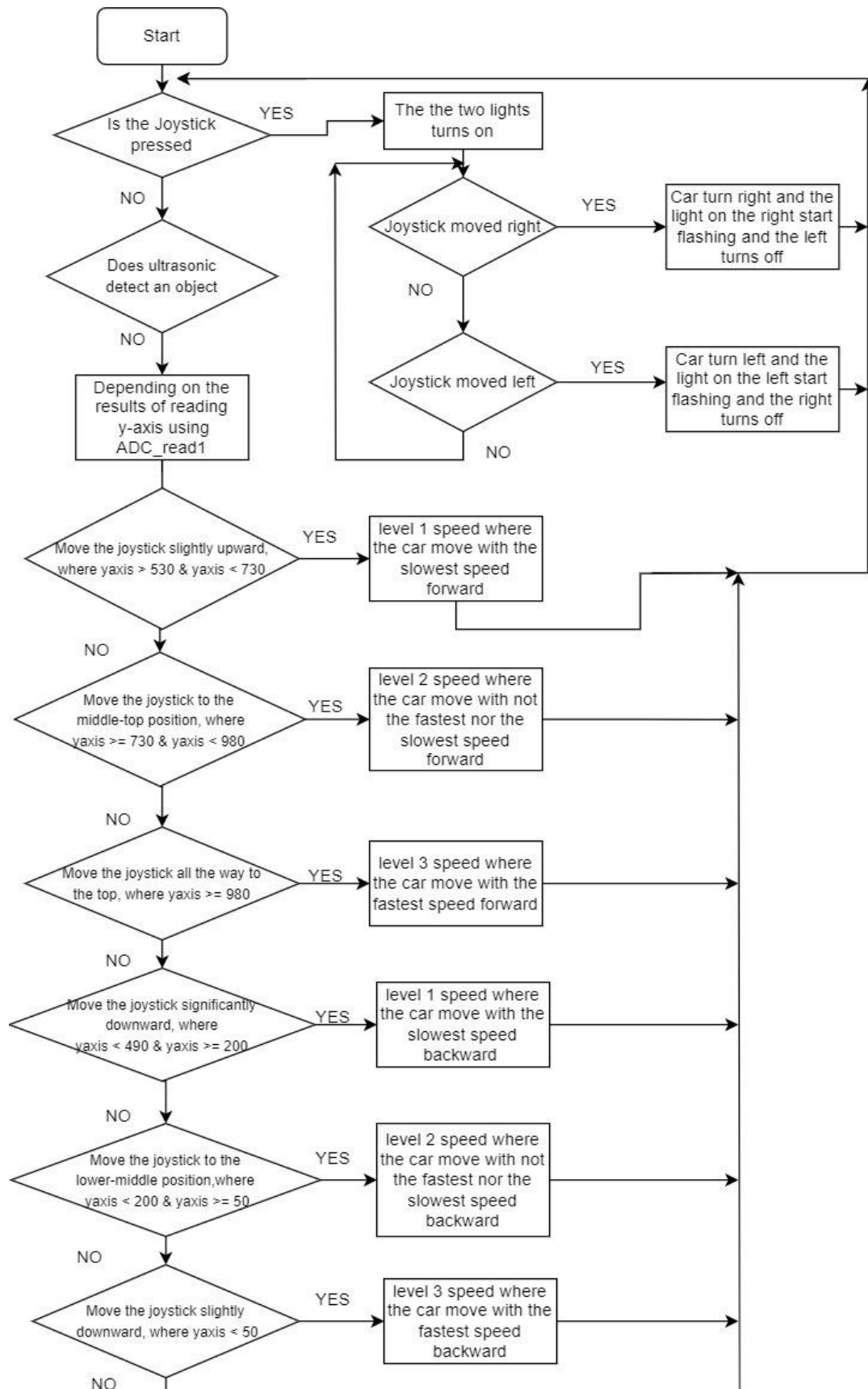


Figure 1: Flow Chart

Electrical Design:

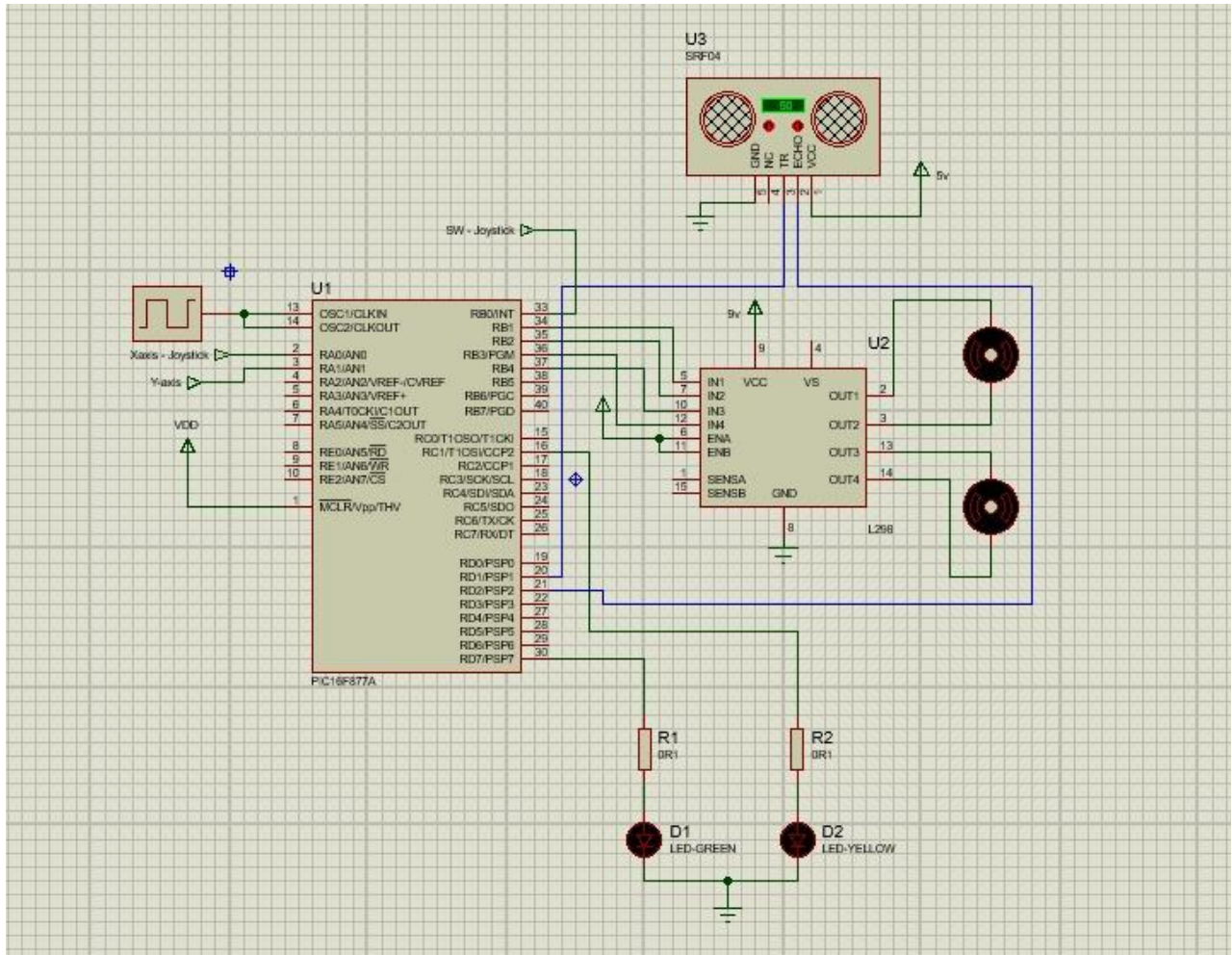


Figure 2: Electrical Design

Hardware Design:

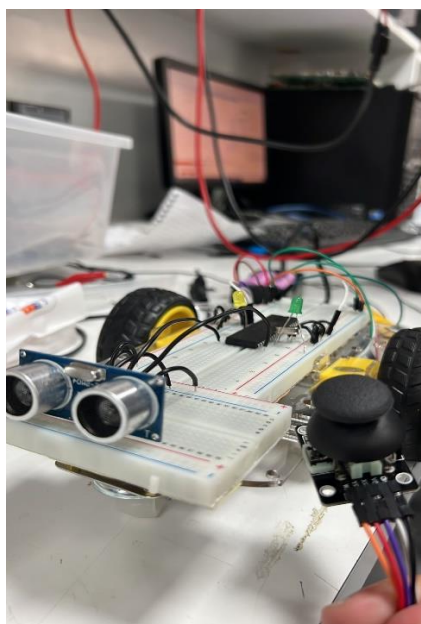
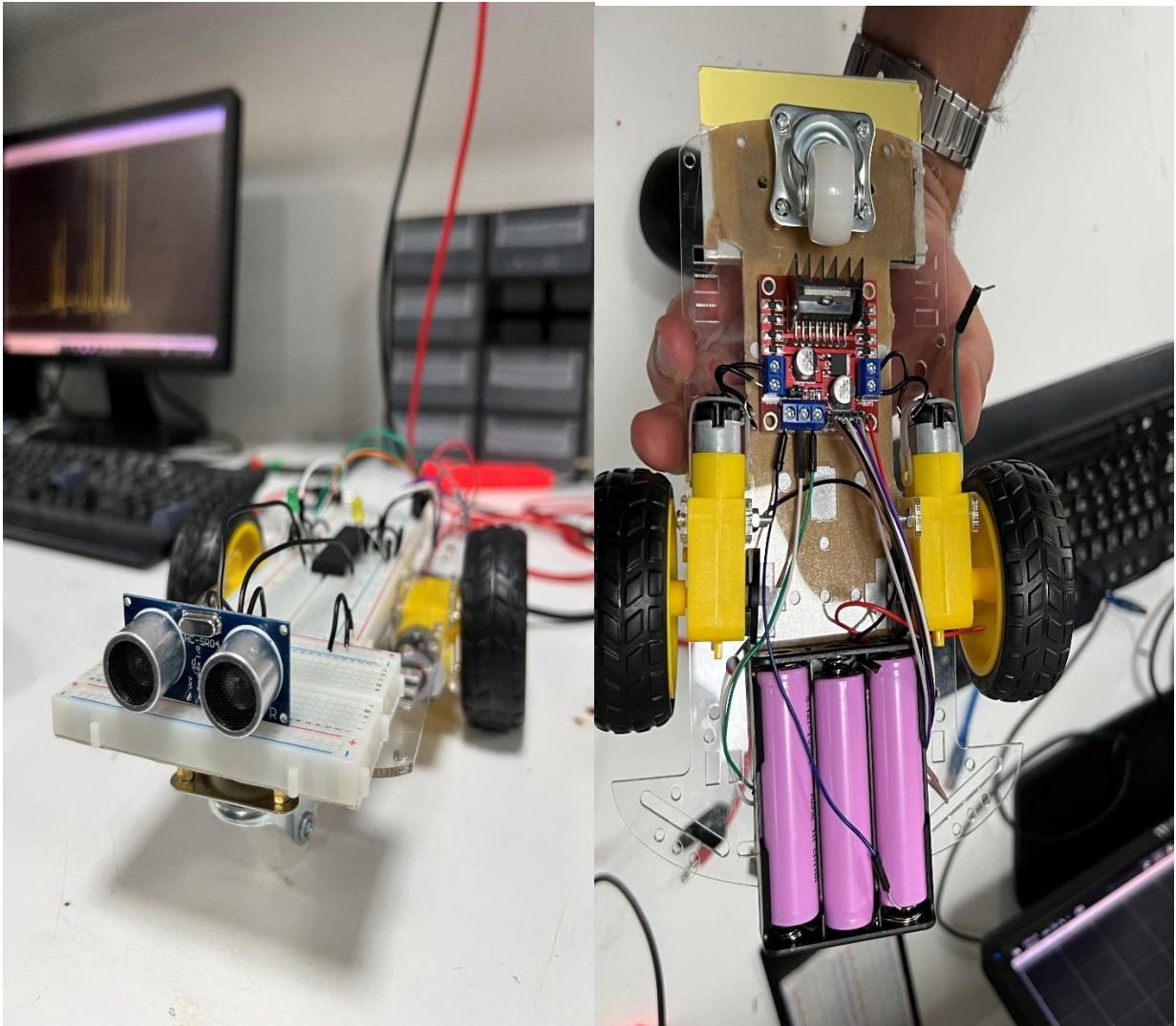


Figure 3: Hardware Design

4 Problems and Recommendations

- **The joystick module can move freely at 360°, thus leading to errors in choosing the direction of the movement.**

Recommendation: We solved this problem by using interrupts. Whenever you want to move to the right or left, press on the gear of the joystick, and you will get into an interrupt (the LEDs will turn on). Then, move the joystick to the right or left, and the LED in the chosen direction will stay on; the other one will turn off, and the car will move in the chosen direction.

- **When the Ultrasonic always enters the interrupt directly in the default case.**

Recommendation: we found out the distance formula was wrong and after adding the right distance formula, the code entered the interrupt only when there is a reasonable distance.

- **Controlling the DC motors and managing the power supply for the system can be complex, especially when handling multiple motors and varying speed levels.**

Recommendation: Use an H-Bridge motor driver capable of handling the power requirements of the DC motors. Implement appropriate power management techniques, such as voltage regulation and current limiting, to protect the components and ensure stable operation.

5 RESULTS

-Developed an embedded system that allows users to control a car's movement and speed using a wired joystick module, Verify that the car responds accurately to each joystick input and moves in the desired direction.

-Interface the PIC16F877A microcontroller with the wired joystick module to read analog signals representing the desired speed and direction.

-Convert the analog signals from the joystick module into digital values for further processing.

- Process the digital values to determine the appropriate speed and direction for the car.

-Generate control signals based on the processed data to adjust the car's speed and direction using the car's control system, and Test the different speed levels and ensure the car adjusts its speed accordingly.

-Implement multiple speed levels for the car, allowing users to choose between different three-speed settings.

-Document the entire project, including the hardware design, software development, implementation details, and testing results, for future reference and replication.

-Place objects at various distances from the car and verify if the ultrasonic sensor accurately detects them. Check if the LEDs respond appropriately to indicate the proximity to the user.

6 CONCLUSIONS

The embedded system project successfully implements a wired joystick module-controlled car utilizing the PIC 16F877A microcontroller, H-Bridge motor control, and ultrasonic proximity detection. The project's architecture and implementation provide users with intuitive control over the car's movement while ensuring safety through object detection and LED indication. The system demonstrates the capabilities of the chosen microcontroller and serves as a foundation for further enhancements and applications in the field of robotics and automation.

7 REFERENCES

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