ESP32 X-Drive Omnidirectional Robot

Block Diagram and System Description

1. Introduction

This project presents the design and implementation of an ESP32-based X-drive omnidirectional mobile robot controlled using a PS5 Bluetooth controller. The system enables smooth multi-directional motion by converting user joystick inputs into individual wheel velocities using inverse kinematic equations. The block diagram represents the logical flow of signals and power within the system.

2. System Overview

The system is divided into five major functional blocks: User Input, Control Unit, Motor Drive Unit, Actuation Unit, and Power Supply. Each block plays a crucial role in achieving accurate and responsive omnidirectional motion.

3. Functional Block Description

PS5 Controller (User Input Unit)
The PS5 wireless controller acts as the human–machine interface. Joystick movements are transmitted to the ESP32 via Bluetooth. The left joystick controls linear motion (forward/backward and lateral movement), while the right joystick controls rotational motion.

ESP32 Microcontroller (Control Unit)
The ESP32 serves as the central processing unit. It receives Bluetooth data from the PS5 controller, applies dead-zone filtering, computes velocity components (vx, vy, ω), and executes X-drive inverse kinematic equations to calculate individual motor speeds. The ESP32 generates PWM and direction signals required for motor control.

Motor Driver Module (Power Interface Unit)
The motor driver acts as a power amplification stage. Since the ESP32 cannot supply sufficient current to drive motors directly, the motor driver boosts the PWM and direction signals to appropriate voltage and current levels required by the DC motors.

DC Motors with Omni Wheels (Actuation Unit)
Four DC geared motors equipped with omni wheels are arranged in an X-drive configuration at 45 degrees. This arrangement allows the robot to move in any direction without changing its orientation.

Power Supply Unit
A dedicated battery pack supplies power to the motor driver and motors, while a regulated supply powers the ESP32. A common ground is maintained to ensure reliable signal reference and system stability.

4. X-Drive Kinematic Principle

X-drive kinematics is based on resolving the desired robot motion into individual wheel velocities. The ESP32 computes motor speeds using inverse kinematic equations, ensuring coordinated motion of all wheels. Normalization is applied to keep PWM values within safe operating limits.

5. Advantages of the Proposed System

- Enables true omnidirectional movement
- Smooth and responsive control using PS5 controller
- Wireless operation using built-in ESP32 Bluetooth

- Modular design suitable for upgrades such as encoders and PID control

6. Applications

- Robotics competitions and technical exhibitions
- Automated Guided Vehicle (AGV) prototypes
- Research and educational robotics platforms

7. Conclusion

The ESP32-based X-drive robot demonstrates an efficient and flexible approach to omnidirectional mobility. By integrating Bluetooth-based user input, real-time kinematic computation, and PWM motor control, the system achieves reliable and precise motion control. The modular architecture allows easy future enhancements such as encoder feedback, PID control, and autonomous navigation.