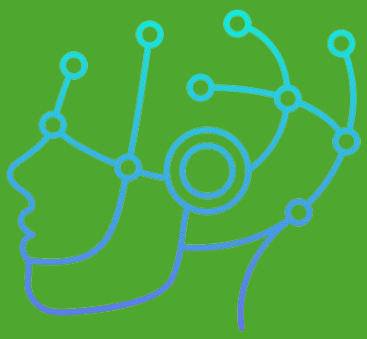

ZAS ROBOTICS

BUILD THE FUTURE

Navigational Robotics Series

Robot Car-2 (Communicaation)

Documentation (V1.0)

Contents

1. Robot Car-2 (communication Edition)- Product Overview & Hardware Documentation.

The **ZAS Robotics Navigational Robot Car-2 (Communications Edition)** is a programmable, wireless-controlled educational robot designed to help students master real-world concepts in **embedded systems, wireless communication, motor control, and human-to-robot interaction**.

Built on the same **Creative Controller + Arduino platform** used in Car-1, the Car-2 replaces autonomous sensor-based navigation with a complete **transmitter–receiver communication system** powered by the following modules:

- **NRF24L01 wireless transceiver** (primary communication)
- **Joystick** for smooth directional control
- **MPU6050** for tilt-based gesture control
- **Button-based directional commands**
- **OLED display** for visual feedback (mode & current action)

This communication-driven design makes Car-2 an ideal learning platform for modern robotics applications such as:

- Wireless remote-controlled robots
- Communication architecture in robotics
- Embedded I/O mapping and data flow
- Real-time command processing
- Control engineering fundamentals
- RC car, drone, and robot-arm remote control
- Data generation for **Imitation Learning & Reinforcement Learning**

Who Can Use This Kit?

- Schools & **STEM education programs**
- **Engineering colleges** and polytechnics
- Robotics & **innovation labs**
- **Maker spaces** and workshops
- IoT & embedded learning centers
- Students entering wireless or communication-based robotics

Car-2 functions as a **complete standalone product**, requiring no sensors or autonomous modes.

However, **when paired with Car-1**, learners experience the full robotics journey:

- **Car-1 → Robot Intelligence (Sensors + Navigation)**
- **Car-2 → Wireless Control (Remote Command Architecture)**

Together, they form a powerful two-step learning path that mirrors modern robotic systems used in industry, research, drones, AGVs, and IoT robotics.

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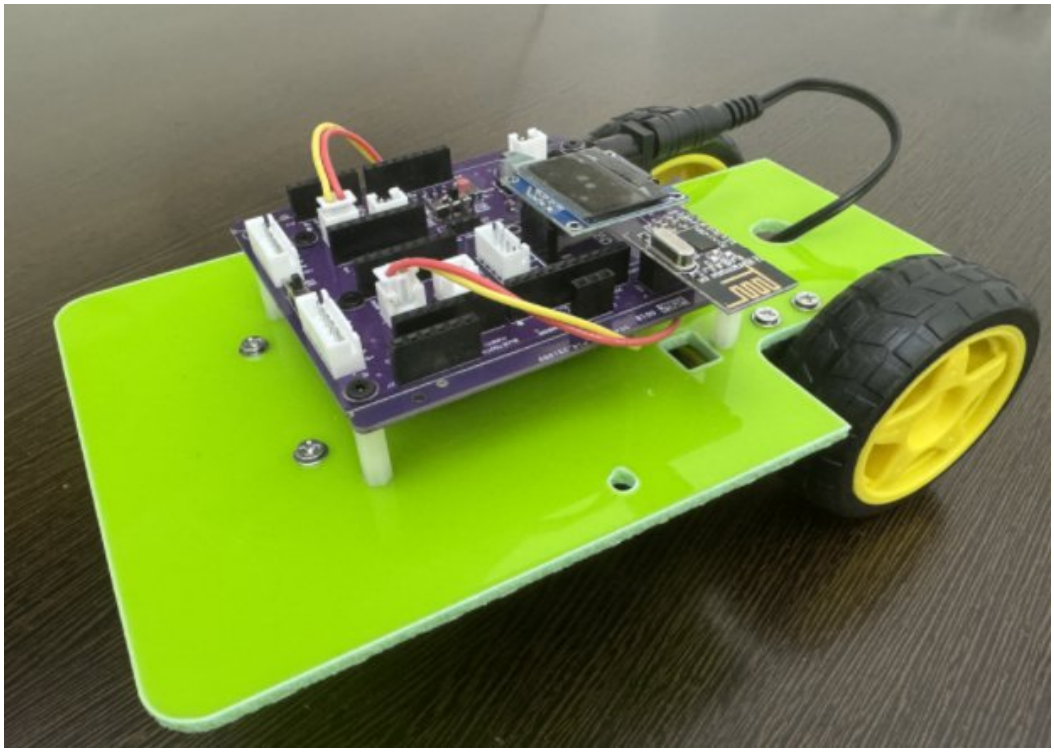

Figure 1. Robot Car-2 (Communication Edition)

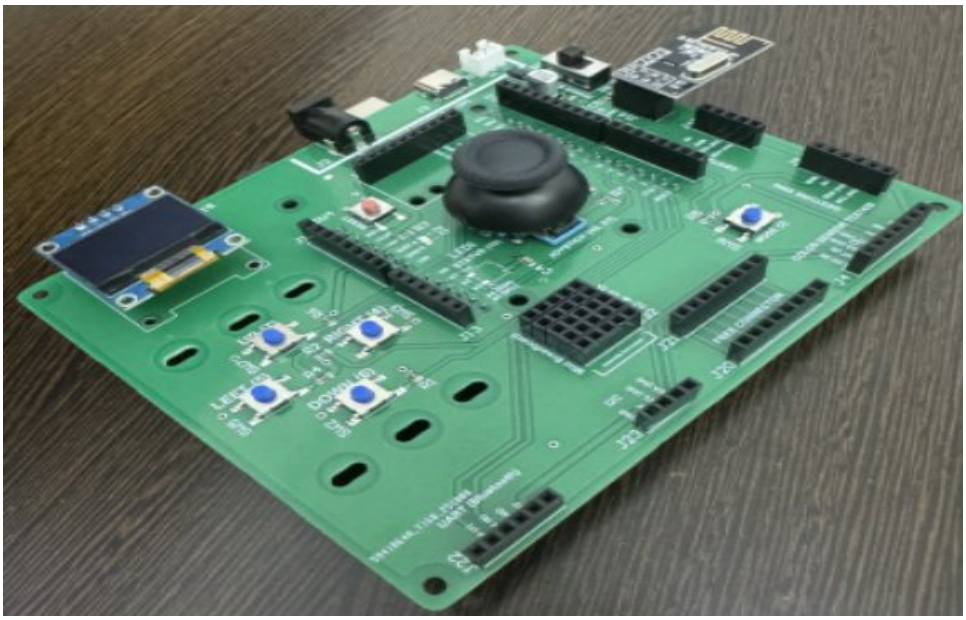

Figure 2. Robot Car-2 (Communication Edition) - Handheld Controller (Transmitter)

2. Hardware System Architecture

The ZAS Robotics Navigational Robot Car-2 (Communication Edition) is designed with the same structured, classroom-friendly modular architecture used in Car-1 but optimized for **wireless communication**, **remote command execution**, and **real-time motor control**.
Instead of autonomous sensor navigation (Car-1), Car-2 is engineered around a **Transmitter–Receiver Architecture** using the NRF24L01 module, Joystick/MPU/Button inputs, and a dedicated Creative Controller Board.

Car-2 consists of three primary hardware layers:

A. Base Chassis (3-Wheel Drive System)

This is the mechanical foundation of the robot, shared with Car-1 for standardization and teaching continuity.

Key Features

Two DC Gear Motors (Left & Right)
• Enable forward, reverse, turning, and pivot rotations.
• Controlled by TB6612 dual motor driver.

Front Caster Wheel
• Acts as the third support point, allowing smooth rotation and maneuvering.

Rear-Mounted Battery Pack
• Maintains center of gravity and prevents front tilt.

B. Car-2 Creative Controller Board (Communication Edition)

This is a dedicated PCB designed specifically for remote-controlled robotics.
It replaces Car-1's sensor interfaces with **communication interfaces**, **input devices**, and **status display modules**.

Front-Side Features

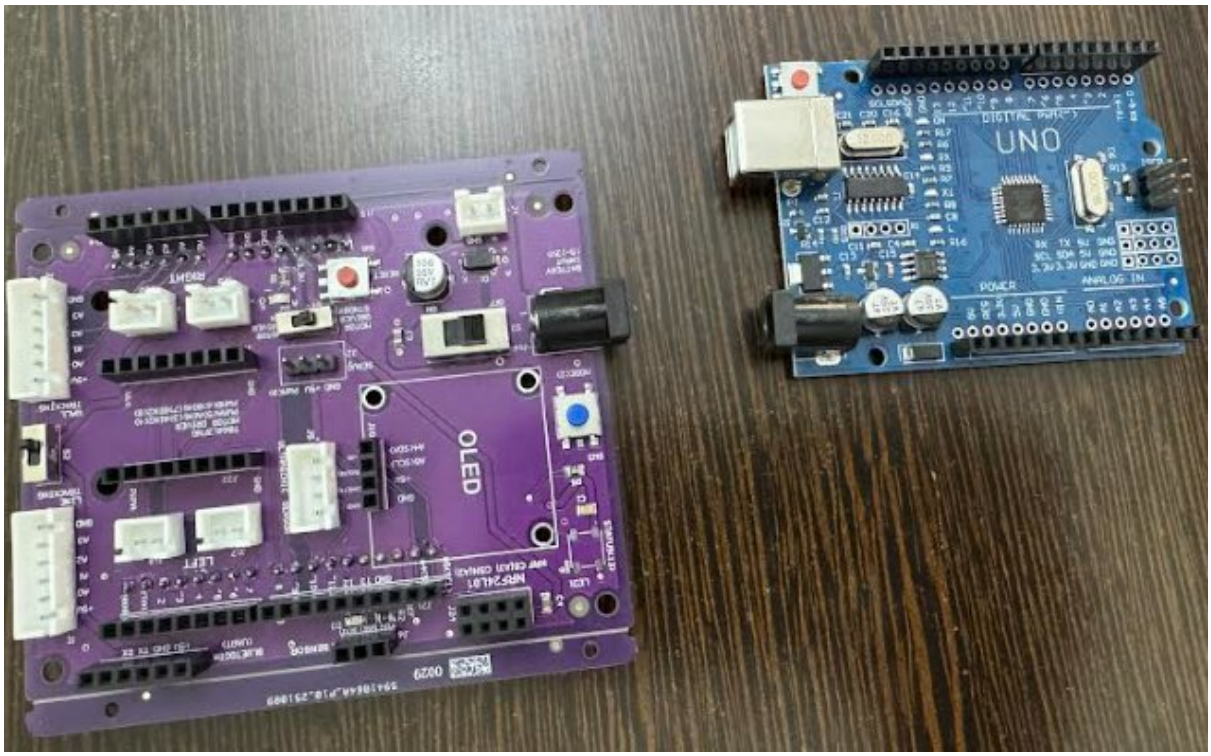

Figure 3. Robot Car-2 (Communication edition) - Front-Side View of car-2 Sensor creative board and Arduino

• Arduino Uno for program execution
• NRF24L01 wireless module slot (CE → A3, CSN → A2)
• OLED display (I2C – address 0x3C) for mode & feedback
• Joystick interface (X & Y analog pins)
• MPU6050 connector (I2C)
• Button inputs (Up, Down, Left, Right + Mode switch)
• TB6612 motor driver interface
• Clear JST plug-and-play connectors
• Power input, 5V regulator, protective circuitry
• Onboard LEDs for diagnostic status

Back-Side Engineering

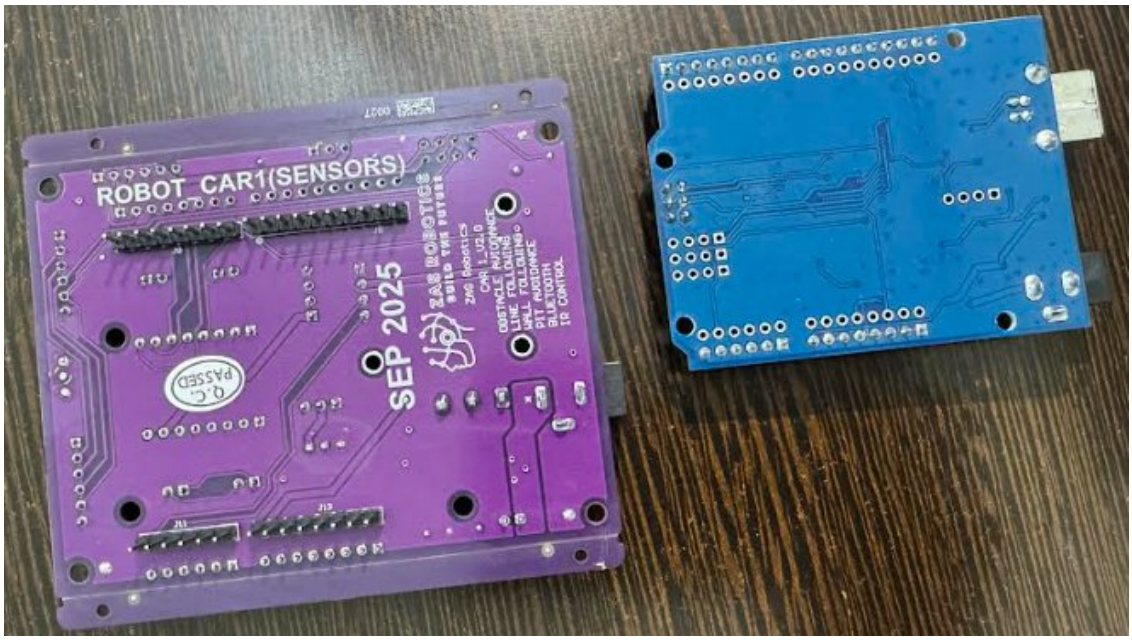

Figure 4. Robot Car-2 (Communication edition) - Back-Side View of car-2 Sensor creative board and Arduino

• Cleanly routed signal traces for communication stability
• Reinforced motor driver power lines
• Noise-isolated I²C & NRF24L01 signals
• Mechanical strengthening for repeated classroom usage

Mounted Assembly

Figure 5. Robot Car-2 (Communication edition) - Mounted car-2 Sensor creative board and Arduino Mounted

• Arduino Uno fits directly on top of the controller board
• All connections routed internally → **no messy jumper wires**
• Strong screw-mounted platform for durability
• Professional finish suitable for labs, universities, and competitions

C. Remote Controller Board (Handheld Transmitter)

Car-2 includes a dedicated transmitter board to send commands to the robot via NRF24L01.

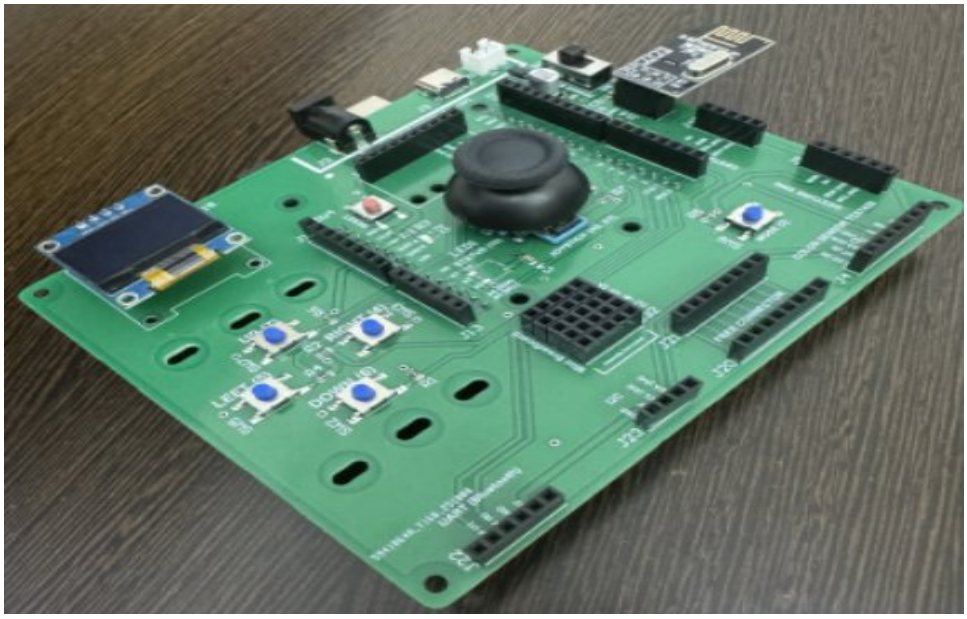

Figure 6. Robot Car-2 (Communication Edition) - Handheld Controller (Transmitter)

Key Modules on the Transmitter

• NRF24L01 wireless module
• Joystick module (analog)
• MPU6050 (tilt-based robot movement)
• Four directional buttons
• Mode-change button (Buttons → MPU → Joystick)
• Status LED
• OLED screen showing current mode + transmitted command

This transmitter allows **three types of control modes**:

Button Mode – Simple directional control

MPU Mode – Tilt the remote and the car moves

Joystick Mode – Smooth analog motion control

3. Component List & Function

The robot's behaviour in Car-2 is achieved through the coordinated interaction of wireless communication modules, input devices, motor-control electronics, and a receiver microcontroller.

Each component plays a specific role in transmitting commands, receiving data, or producing movement, as described in the table below.

Component / Module	Purpose / Role
Arduino Board (Receiver – on Car)	Core microcontroller that receives wireless commands from the transmitter and converts them into motor actions (forward, reverse, left, right, stop).
TB6612 Motor Driver	Drives both DC motors using PWM speed control and direction signals. Ensures smooth, stable, and efficient motor operation.
2× DC Gear Motors	Provide all physical motion of the robot—forward, backward, turning, and pivoting—based on received commands.
NRF24L01 Wireless Module (Car Receiver)	Receives string-based commands ("up", "down", "left", "right") from the transmitter over 2.4 GHz wireless communication.
OLED Display (on Remote)	Shows mode selection (Buttons / MPU / Joystick), transmitted commands, and real-time feedback for the user.
Joystick Module (Remote)	Allows smooth analog control of robot movement. Tilt direction maps to robot motion (forward/back/left/right).
MPU6050 IMU (Remote)	Enables tilt-based gesture control. The robot moves based on physical tilting of the handheld remote.
Push Buttons (Remote)	Directional buttons (Up, Down, Left, Right) for precise step-based control of the robot.
Mode-Selection Button (Remote)	Switches between the three control modes: Button Mode → MPU Mode → Joystick Mode.
Status LED (Remote)	Provides visual confirmation when switching modes or sending commands.
NRF24L01 Wireless Module (Remote Transmitter)	Sends encoded directional commands to the robot's receiver using the same communication pipe address.
Battery Pack	Supplies stable power to both the car receiver system and the remote controller (depending on power design).

5.Two Rear Wheels (Drive Wheels)

The robot uses **two large rear wheels**, each connected to a **DC gear motor**, forming a **differential drive system**.

Figure 7. Robot Car-1 (Sensors edition) - Rear Wheels

How It Works

- Both motors forward → robot moves straight
- Left motor only → robot turns right
- Right motor only → robot turns left
- Motors in opposite directions → robot rotates in place

Advantages

- Excellent turning capability
- Simple motor control using PWM + direction signals
- Smooth forward and curved path navigation
- Suitable for obstacle avoidance & line/path following

6. Front Caster Wheel (Support Wheel)

The front of the robot uses a **metal ball caster wheel**, also called a free-rolling support wheel.

Figure 8. Robot Car-1 (Sensors edition) – Front caster Wheel

Purpose

- Supports the robot's weight at the front
- Allows friction-free movement in any direction
- Follows the steering generated by the rear wheels
- Ensures stability during rotation and turns

Advantages

- Zero steering mechanism needed
- Low friction on most surfaces
- Smooth motion even on curves

7. Dual DC Motors (Main Power for Movement)

The robot is powered by **two TT DC gear motors** with ~130 RPM speed.

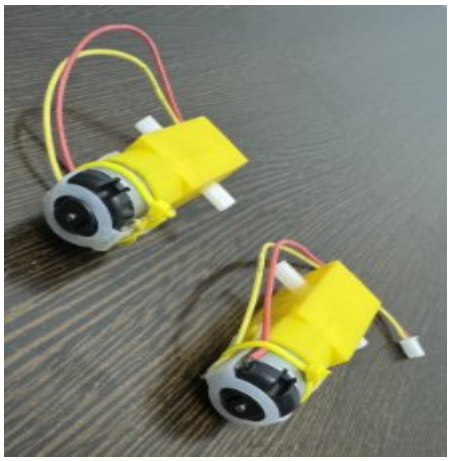

Figure 9. Robot Car-1 (Sensors edition) – Dual DC motor for rear left and right wheels

These motors provide all the motion:

- Forward movement
- Reverse movement
- Turning left / right
- Rotating on the spot

The motors are controlled using the **TB6612 motor driver**, which provides:

- High-efficiency PWM speed control
- Reliable direction control
- Enough current to drive both motors simultaneously

8. Motor Driver Pin Configuration (TB6612 + Motors)

Left Motor

- A-IN1 → Arduino Nano Pin **3**
- A-IN2 → Arduino Nano Pin **4**
- PWMA → Arduino Nano Pin **5**

Right Motor

- B-IN1 → Arduino Nano Pin **8**
- B-IN2 → Arduino Nano Pin **7**
- PWMB → Arduino Nano Pin **6**

Motor Specifications

- TT Motor (Yellow Gear Motor)
- **Speed:** 130 RPM
- **Operating Voltage:** 6V

9. Robot Operating Modes & Algorithms (Car-2 Edition)

Car-2 uses **wireless command-based operation** rather than sensors.

Car-2 supports **three wireless control modes** through the handheld transmitter:

Mode 1: Button Control Mode (Simple RC Mode)

The transmitter has four directional buttons:

- **Up → Forward**
- **Down → Reverse**
- **Left → Turn Left**
- **Right → Turn Right**

The transmitter sends short wireless commands such as:

```
"up", "down", "left", "right"
```

The receiver interprets these commands and runs the corresponding motor action.

Mode 2: MPU6050 Tilt Control Mode (Motion-Controlled Robot)

The transmitter includes a **gyro + accelerometer (MPU6050)**.

How It Works

Tilt forward → robot moves forward
Tilt backward → robot reverses
Tilt left → robot turns left
Tilt right → robot turns right

This mode teaches:

- IMU processing
- Gesture-based robot control
- Sensor-to-action mapping via wireless communication

Mode 3: Joystick Control Mode (Analog RC Mode)

The remote has a **2-axis joystick**.

Joystick axis reading → maps to directional movement:

- Push up → forward
- Push down → backward
- Push left → left
- Push right → right

The joystick values are filtered and mapped to commands:

```
"up", "down", "left", "right"
```

10. Learning Outcomes for Students (Car-2 Edition)

By working with Robot Car-2 (Communication Edition), students will learn:

Wireless Communication

- NRF24L01 radio communication
- Pairing transmitter & receiver addresses
- Sending/receiving structured wireless commands

Embedded System Programming

- Managing multiple control modes (buttons, IMU, joystick)
- Displaying system status on OLED
- Writing modular and interrupt-safe code

Motor Control Engineering

- Differential drive motion
- H-bridge motor control
- PWM speed regulation

User Interface & Control Logic

- Designing human-controlled robot systems
- Real-time command processing
- Error handling (e.g., no signal → stop motors)

AI/Robotics Applications

- Generating datasets for Imitation Learning
- Remote teleoperation during early Reinforcement Learning experiments
- Understanding RC robotics architecture (core of drones, RC cars, robots)

11. Safety Guidelines

- Double-check all power wiring
- Use correct battery input (5V–12V)
- Test on a safe indoor surface
- Do not leave powered robot unattended
- Verify NRF24 module connections carefully
- Keep transmitter and receiver address identical
- Stop motors before changing wiring

12. Learning Outcomes for Students

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13. Additional Mechanical Notes

Car-2 retains the same robust mechanical design as Car-1 but removes the sensor front board:

- Uses 3-wheel differential drive
- Rear-mounted battery pack for balance
- Clean top plate for mounting communication board
- No IR or ultrasonic bracket needed
- Remote-control logic ensures responsive manoeuvring

14. Summary (Car-2 Edition)

The ZAS Robotics Navigational Robot Car-2 (Communication Edition) is a hands-on, wireless-controlled robotics platform designed to teach students real-world concepts in **communication systems, embedded control, motor driving, remote operation, and human-robot interaction**.

Built on the same solid hardware foundation as Car-1, Car-2 replaces autonomous navigation with a powerful **transmitter–receiver architecture** featuring button control, joystick control, and motion-based control using an IMU.

It is ideal for:

- STEM labs
- College engineering courses
- Robotics clubs
- Communication-based robotics projects
- Early-stage datasets for AI/ML

With Car-2, students gain a clear understanding of how **wireless commands translate into real robot actions**, making it a perfect stepping stone toward advanced robotics, IoT systems, and RC-based engineering applications.