# Red Torque – Detailed Major Component Study

1. Raspberry Pi 5

The Raspberry Pi 5 is the latest and most powerful version of the Raspberry Pi computer series. It looks like a small board but has the power of a full desktop. It is made for DIY and educational projects, especially robotics.

In our robot project, it will be the main brain handling image processing, decision-making, and controlling other components.

- Quad-core 64-bit ARM Cortex-A76 CPU running at 2.4GHz – faster than Pi 4.
- Dual camera ports – supports two camera modules at the same time.
- PCIe 2.0 interface – allows fast SSD storage or expansion cards.
- Real-time clock – keeps track of time even without power.
- Improved GPIO performance – faster and better I/O for sensors.
- Supports active cooling via fan connector directly on board.
- USB 3.0 ports – faster data transfer from external devices.
- Used as the main controller to run Linux (Raspberry Pi OS).

The Raspberry Pi 5 acts as the main brain of the robot, handling tasks like image processing, sensor integration, and decision-making. It runs the software that controls movement, processes camera input, and communicates with other modules like the ESP32.
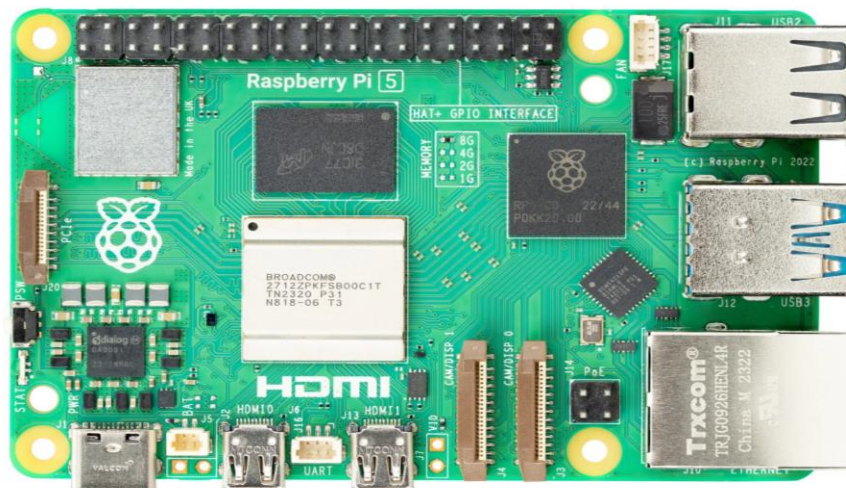
2. Microsoft USB webcam

The Microsoft USB Webcam is a plug-and-play camera that connects via USB, compatible with the Raspberry Pi and other computers.

- Provides video resolution up to 720p at 30–60fps (depending on model).

- Captures images and videos with low latency, suitable for real-time detection.

- Compatible with Python libraries like OpenCV (cv2.VideoCapture).

- Used in our robot to detect red and green cubes and perform line following.

This webcam helps the Raspberry Pi perform computer vision tasks such as object detection, colour recognition, and motion tracking, allowing the robot to understand and respond to its surroundings in real time.

Microsoft USB webcam

3. ESP32 Microcontroller

The ESP32 is a low-cost, low-power microcontroller board that includes built-in Wi-Fi and Bluetooth. It is popular in IoT and robotics projects.

- Dual-core processor with speeds up to 240 MHz.
- Wi-Fi and Bluetooth capabilities make it suitable for wireless communication.
- Can be programmed using Arduino IDE or MicroPython.
- Multiple GPIO pins to connect sensors and control motors.
- I2C, SPI, UART interfaces for communication with other boards and modules.
- In our project, used as a helper board to offload simple sensor readings or Bluetooth tasks.

The ESP32 is used for handling low-level tasks like motor control, reading sensor data, and wireless communication (Bluetooth or Wi-Fi). It works alongside the Raspberry Pi to offload real-time processing and ensures smooth coordination between hardware components in the robot.
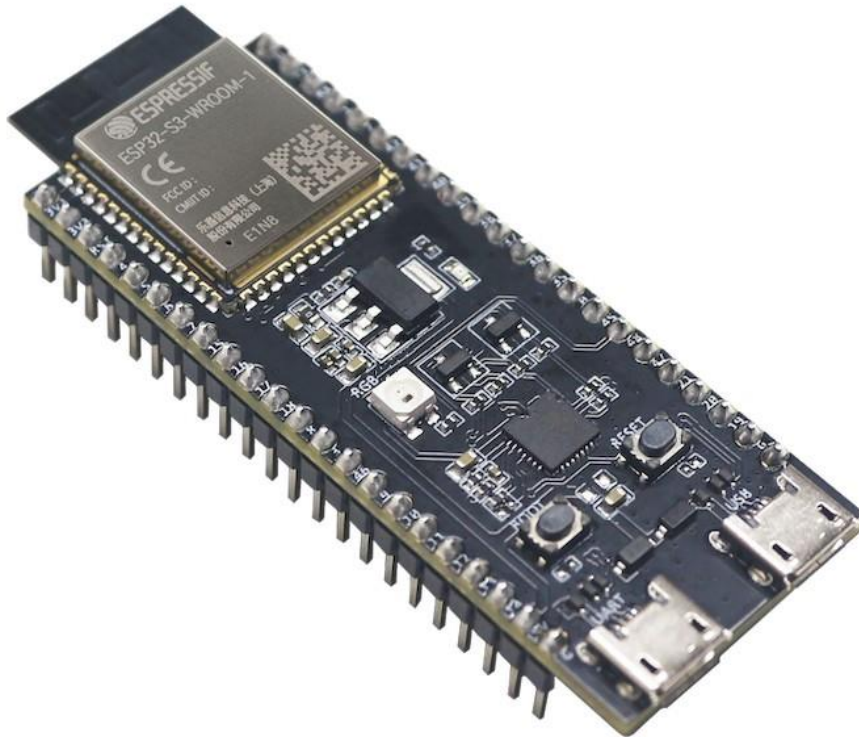
ESP-32

5. Buck Converter & USB Buck

A buck converter is a voltage step-down converter that changes a high input voltage to a lower output voltage. It is crucial for safely powering electronics from batteries.

- Converts 11.1V from battery to 5V or 3.3V for Raspberry Pi and ESP32.
- Some models come with USB output for easy powering of USB devices.
- Adjustable voltage using a screw trimmer.
- Ensures consistent and safe voltage levels to prevent board damage.
- Two types used: standard screw terminal buck and USB buck module.

The buck converter steps down the high voltage from the battery (like 12V) to a lower voltage (like 5V) needed by the Raspberry Pi and other components. The USB buck converter does the same but gives output through a USB port, making it easier to power boards like the Pi or ESP32 directly.

USB BUCK CONVERTER   **DC-DC BUCK CONVERTER**

6. Bonka 11.1v LiPo Battery

This is a high-performance LiPo battery often used in drones and RC cars. It provides 11.1V output and has a discharge capacity suited for robotics.

- 3-cell LiPo battery giving a total of 11.1V.
- 2200mAh capacity – can power the robot for a decent amount of time.
- XT-60 connector for strong, secure connection.
- Used with a buck converter to deliver 5V to our components.
- Must be handled with care – requires balanced charging.
- Compact size – easy to mount on the chassis.

The 2200mAh LiPo battery provides portable, high-current power for the entire robot system. It supplies energy to the Raspberry Pi, motors, sensors, and other modules. Its high discharge rate and lightweight design make it ideal for mobile robotic applications where stable power is essential.

Bonka 11.1V 2200 Mah Battery

Summary

The core components explored include the Raspberry Pi 5, which functions as the main processor responsible for handling computation and data processing. The Microsoft USB Webcam is used for capturing images and video, making it suitable for vision-based tasks. The ESP32 microcontroller provides wireless connectivity through Wi-Fi and Bluetooth and supports multiple I/O functions for flexible hardware interfacing. A 2200mAh LiPo battery serves as the main power source, supplying energy to all components. Voltage regulation is managed through a buck converter and a USB buck converter, which safely step down higher voltage to levels required by sensitive electronics.

Each component plays a vital role in building a stable and efficient electronic system. Their individual functions and purposes are clearly identified and will be used collectively in the system's design and integration.