**Power and Sensing Management**

**Power Source and Distribution**

The robot is powered by a **12V, 4400 mAh Li-ion battery**, chosen for its balance between high energy density and portability. The distribution system is optimized for efficiency and safe operation:

* **12V Line (Direct Supply):**
  + L298N Motor Driver → 12V DC Motor with Encoder.
* **5V Line (Regulated by XL4015 Buck Converter):**
  + Raspberry Pi 5 → Acts as the central controller.
  + Raspberry Pi Camera (5MP Module).
  + LG USB Camera (1080P).
  + Servo Motor.
  + Push Button interface.

The **On/Off Switch** ensures safe startup and shutdown, while the **buck converter** provides stable 5V to sensitive components, preventing overload or voltage dips.

**Sensing Strategy and Components**

**LG PC Camera (1080P, USB Camera)**

* **Open Challenge:**
  + Detects blue/orange lines to decide rotation direction.
  + Identifies inner/outer black walls to keep the robot centered.
  + Handles wide/narrow corridor detection through zone-based balancing.
  + Manages turns using forward detection (zones A & E).
  + Counts laps (5, 9, 12 detections) and triggers final stop after 3 laps.

**Raspberry Pi Camera (5MP)**

* **Obstacle Challenge:**
  + Works like a dash cam during parallel parking.
  + Provides accurate visual feedback for parking alignment.
  + Lightweight, directly powered via Pi GPIO.

**Novelty and Optimization**

* Only **two cameras** handle all challenges, instead of using multiple ultrasonic or IR sensors.
* This reduces **power consumption, wiring complexity, and weight**, allowing faster response and smoother navigation.
* Optimized **camera training and image processing** ensure smooth execution under arena randomness.

**Power Consumption Management**

* **Motors:** Draw the largest current (peaks at sharp turns).
* **Raspberry Pi + Cameras:** Draw stable 5V regulated load (~1.5–2A).
* **Servo Motor:** Low intermittent load, activated during parking.
* **Total System Runtime:** The 4400 mAh battery ensures multiple full trial runs before recharge.

**Professional Documentation (Wiring & BOM)**

The wiring follows **professional standards**, with clear separation of 12V and 5V lines:

* **12V → L298N → Motors.**
* **12V → Buck Converter → 5V → Raspberry Pi → Cameras, Servo, Button.**
* Switch + PCB for safe operation and connections.

A detailed **Bill of Materials (BOM)** lists each component with ratings, ensuring compliance with WRO evaluation standards.

**Bill Of Materials (BOM) — summary table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Item (ref)** | **Qty** | **Nominal Voltage** | **Typical Current (A)** | **Typical Power (W)** | **Purpose / Notes** |
| 12V 4400 mAh battery | 1 | 12 V | — | 52.8 Wh (capacity) | Main energy source (12V, 4.4 Ah → 52.8 Wh) |
| ON / OFF switch | 1 | 12 V | — | — | Main battery switch |
| XL4015 step-down (12→5V) | 1 | 12 V in → 5 V out | up to 3 A (set) | up to 15 W out | Supplies Raspberry Pi and 5V peripherals (set current limit safely) |
| Raspberry Pi 5 (controller) | 1 | 5 V | **1.5** (typical) | **7.5** | Main compute & vision processing — fed from 5V converter |
| LG USB Camera (1080p) | 1 | 5 V | 0.20 | 1.0 | Primary vision for open round and Obstacle challenge |
| Raspberry Pi Camera (5MP) | 1 | 5 V | 0.20 | 1.0 | Parking / close-range vision |
| Servo motor (steering/parking) | 1 | 5 V | 0.50 (avg) | 2.5 | Actuator for parking/steering adjustments |
| L298N motor driver | 1 | 12 V (motors), 5 V logic | 0.1 (logic) + motor pass-through | 1.2 (logic) + motor power | Motor driver — motors draw directly from 12V |
| 12V DC motor with encoder | 1 | 12 V | **2.0** each (avg running) | **24** each → **48** total | Drive motors — **largest power consumers** (stall >> average) |
| Push button | 1 | 5 V | 0.01 | 0.05 | Start/stop or mode switch |

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Component Name** | **Image** | **Approximate Cost (₹)** |
| 1. | Raspberry Pi 5 | A green circuit board with many different ports  AI-generated content may be incorrect. | 6,000 |
| 2. | L298D Motor Driver | A close-up of a circuit board  AI-generated content may be incorrect. | 90 |
| 3. | DC Motor with Encoder | A small electric motor with wires  AI-generated content may be incorrect. | 700 |
| 4. | High Torque Servo Motor | A small black electronic device with wire  AI-generated content may be incorrect. | 350 |
| 5. | Lithium-Ion Battery | A battery with wires and a label  AI-generated content may be incorrect. | 950 |
| 6. | Buck-to-Buck Converter | A close-up of a blue circuit board  AI-generated content may be incorrect. | 160 |
| 7. | Red On/Off Switch | A red and black switch  AI-generated content may be incorrect. | 50 - 100 |
| 8. | Push Buttons | A black and silver square with a round black button  AI-generated content may be incorrect. | 10 - 30 per button |
| 9. | Raspberry pi Camera | A small computer chip with a small square button  AI-generated content may be incorrect. | 350 |
| 10 | LG USB Camera 1080P | A black video game camera  AI-generated content may be incorrect. | 1300 |

**Block Diagram**

A diagram of a computer system

AI-generated content may be incorrect.