Sumo Bot Documentation

# 2. Components Used

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| Component | Quantity | Description |
| Aluminium Rod | 7 | Used for chassis frame construction, welded into 10" × 12" box |
| Stainless Steel Metal Sheet | 1 | Used for wedge to slide under opponents |
| Li-Po Battery Pack (4S6P) | 1 | 12V–14.8V nominal, 15Ah, 30A max continuous current |
| Window Motor | 4 | High torque DC motors mounted at corners for drive |
| Rubber Tyres | 4 | Provide traction and stability |
| ESP32 | 1 | Microcontroller for Bluetooth-based remote control |
| Relay Module | 2 | Two-channel relay modules for left and right wheel H-bridge control |
| Push Buttons (6x6x6 mm) | 2 | Control input buttons (reset and emergency stop) |
| Voltage Regulator (Buck/Boost) | 1 | Regulates battery voltage for electronics |

# 3. Mechanical Assembly

## 3.1 Chassis Design

The chassis was constructed by welding seven aluminium rods into a rectangular box measuring 10 inches by 12 inches. This provided a rigid framework for mounting motors and other components. Once the motors were attached at each corner with tyres, the final overall dimensions of the robot became 12 inches by 12 inches, perfectly within the allowed competition limits.

## 3.2 Motor and Wheel Placement

Each of the four window motors was mounted at the four corners of the chassis. The placement of the motors provides a tank-drive configuration, where the left pair of wheels is controlled together and the right pair together. This allows for differential steering, high maneuverability, and stable pushing power.

## 3.3 Wedge Attachment

A stainless steel sheet was fabricated and welded onto the front of the chassis to serve as a wedge. This design element helps the robot slide under its opponent, lift slightly, and push it out of the ring. The wedge is angled to reduce resistance and maximize effectiveness.

# 4. Electronics Assembly

The electronics system is based on a Li-Po battery pack configured as 4 cells in series and 6 in parallel (4S6P). This provides a nominal voltage of ~14.8 V, a total capacity of 15 Ah, and a maximum continuous current draw of 30 A. The system is protected with a 40 A main fuse and a manual E-stop switch for safety.

Power is distributed through a central power bus. From the bus, one branch feeds a buck converter to power the ESP32 and relay coils, while other branches (protected by 30 A fuses) feed the relay modules for motor control.

# 5. Programming / Control Logic

The ESP32 microcontroller is programmed to receive commands via Bluetooth from a smartphone-based remote control application. Four GPIO pins are assigned to control the relay module inputs, forming a relay-based H-bridge for each side of the robot. This allows forward and reverse motion for both left and right wheels independently.

Due to the limitations of relays, PWM speed control is not feasible. The control logic is therefore restricted to forward, reverse, and stop commands. A software interlock ensures that forward and reverse relays on the same side are never activated simultaneously to prevent short circuits.

# 6. Circuit Design (Relay-Based H-Bridge)

Each side of the robot is controlled by a pair of relays configured as an H-bridge. In this design, energizing the 'Forward' relay applies battery + to one motor terminal and - to the other, causing forward motion. Energizing the 'Reverse' relay swaps the polarity, reversing the motor direction. When both relays are off, the motors are in a neutral/braking state.

The wiring is arranged such that two window motors per side are connected in parallel. This ensures synchronized motion and balanced torque output. A truth table describing the relay control logic is shown below:

Left/Right FWD = 1, REV = 0 → Forward
Left/Right FWD = 0, REV = 1 → Reverse
Left/Right FWD = 0, REV = 0 → Neutral/Brake
Left/Right FWD = 1, REV = 1 → Invalid (blocked by code)

# 7. Competition Strategy

The robot is designed for high torque pushing power and low-ground clearance wedge attacks. Its strategy relies on quickly engaging opponents, sliding under them, and pushing them out of the ring. The differential drive allows precise turning maneuvers, letting the robot re-engage opponents effectively.

The focus is on durability, torque, and reliability rather than high speed. By optimizing traction and center of gravity, the bot resists being pushed aside and maximizes grip.

# 8. Testing and Results

Initial testing verified the correct functioning of the relay-based control system and the Bluetooth connection. The motors provided significant pushing force, confirming the suitability of window motors for torque-heavy tasks. The runtime at moderate load was estimated at ~2 hours, sufficient for competition matches.

During testing, it was confirmed that the wedge successfully allowed the robot to lift and destabilize lighter opponents. The differential steering allowed smooth maneuverability within the confined competition area.

# 9. Safety Considerations

Several safety measures were implemented to ensure reliability during operation:
• Main 40 A fuse to protect against overcurrent
• 30 A branch fuses for each side drive system
• Emergency stop switch for quick shutdown
• Relay interlock in software to prevent shorting
• Proper insulation and crimping of high-current connections
• TVS diodes and capacitors across motors to suppress voltage spikes