Introduction

Engineering Technology

Obstacles in Traditional Parking

- Limited space in high-density urban areas.
- Time wasted searching for available spots.
- Increased traffic congestion around parking zones.
- Poor user experience and security.
- Manual systems prone to errors and inefficiency.

Importance of Smart Parking

- Efficient use of vertical and horizontal space.
- Reduces human error and traffic congestion.
- Enhances user convenience and speed.
- Enables data-driven decisions (e.g., peak hours, demand).

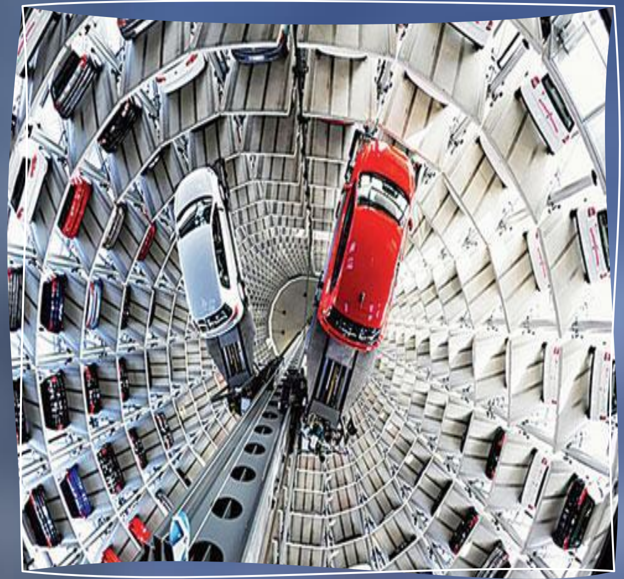
Common Types of Smart Parking

- Shifting platforms in a matrix layout

Puzzle Automated Parking

- Horizontal shuttle + vertical lift (our project).

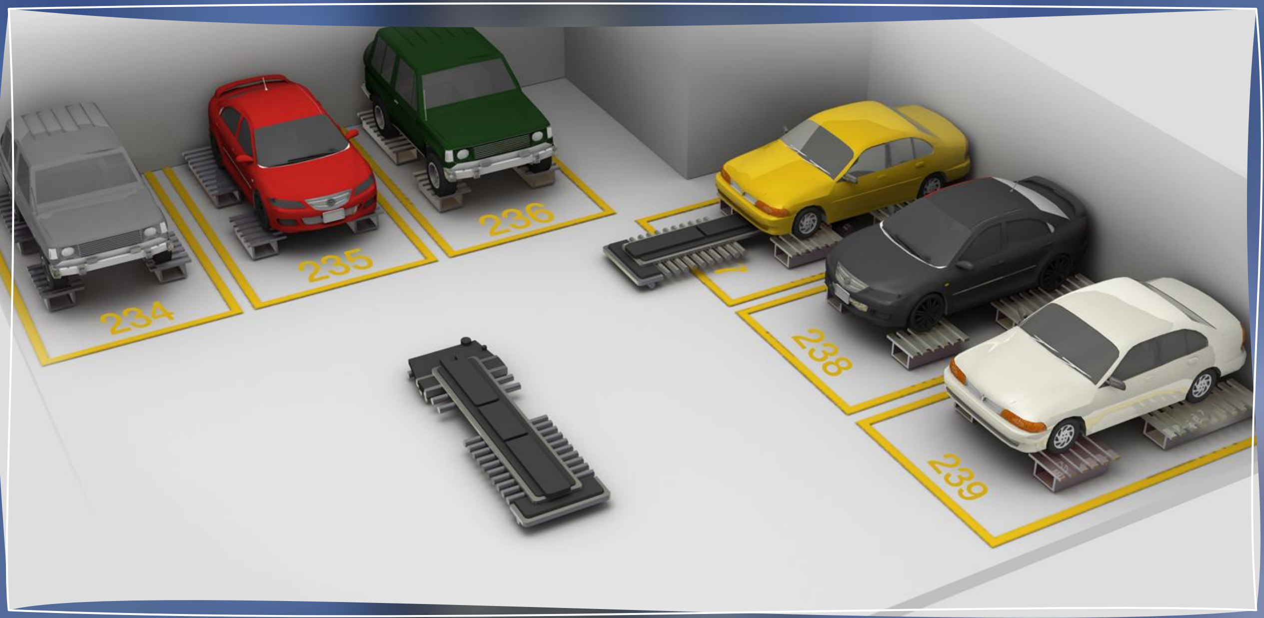
Shuttle Automated Parking



- Vertical carousels.

Silo/Rotary Parking

Common Types of Smart Parking



- Robotic arm moves cars into slots.

- Mobile robots park the car autonomously

Crane Parking System

Valet Robots (AGVs)

Pros of Shuttle Systems

- Fast and efficient retrieval time
- Modular and scalable design
- Ideal for medium to large parking facilities
- Reduced human involvement
- Suitable for integration with AI , IoT, and SCADA

Cons of Shuttle Systems

- High initial cost
- Maintenance of shuttle rails and elevator
- More complex control systems

Future Challenges in Smart Parking Systems

Scalability in Dense Urban Areas

- Adapting smart parking solutions to old, crowded cities with limited retrofitting options.
- Difficulties integrating with existing infrastructure (utilities, roads, etc.).

High Initial Investment

- Automation, sensors, PLCs, and software platforms are costly upfront.
- ROI (return on investment) may take time, especially in public projects.

System Integration

- Integrating various technologies: PLCs, HMI, SCADA, databases, sensors, and mobile apps.
- Ensuring real-time communication between all systems (e.g., with OPC UA, MQTT, or Modbus).

Cybersecurity Risks

- Smart systems connected to the internet are vulnerable to hacking or data theft.
- Requires secure protocols and encrypted communication to protect user and system data.

Future Challenges in Smart Parking Systems

Maintenance Complexity

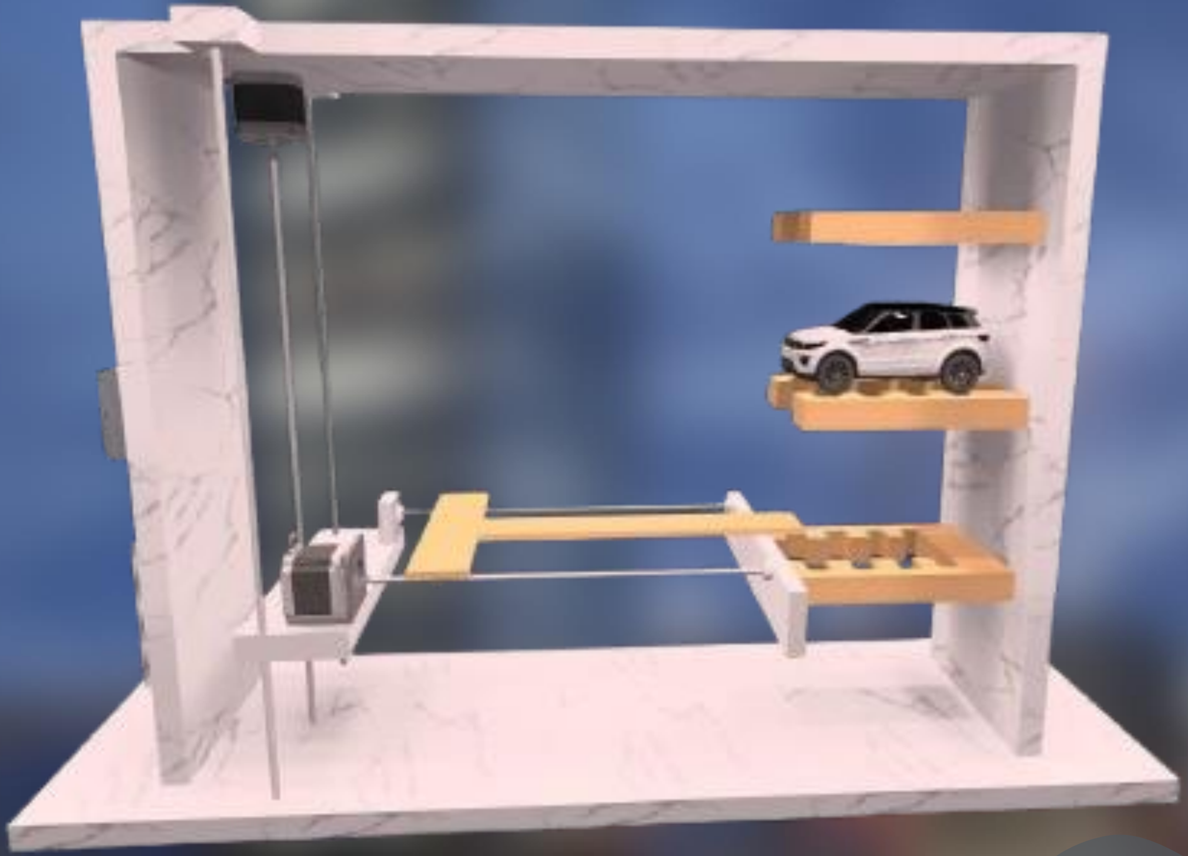
- More sensors and moving parts (e.g., shuttle systems) require specialized and regular maintenance.
- Downtime can affect service reliability.

User Adoption & Behavior

- Older users or those unfamiliar with automation may find systems confusing.
- Adoption may require public education or easy-to-use interfaces.

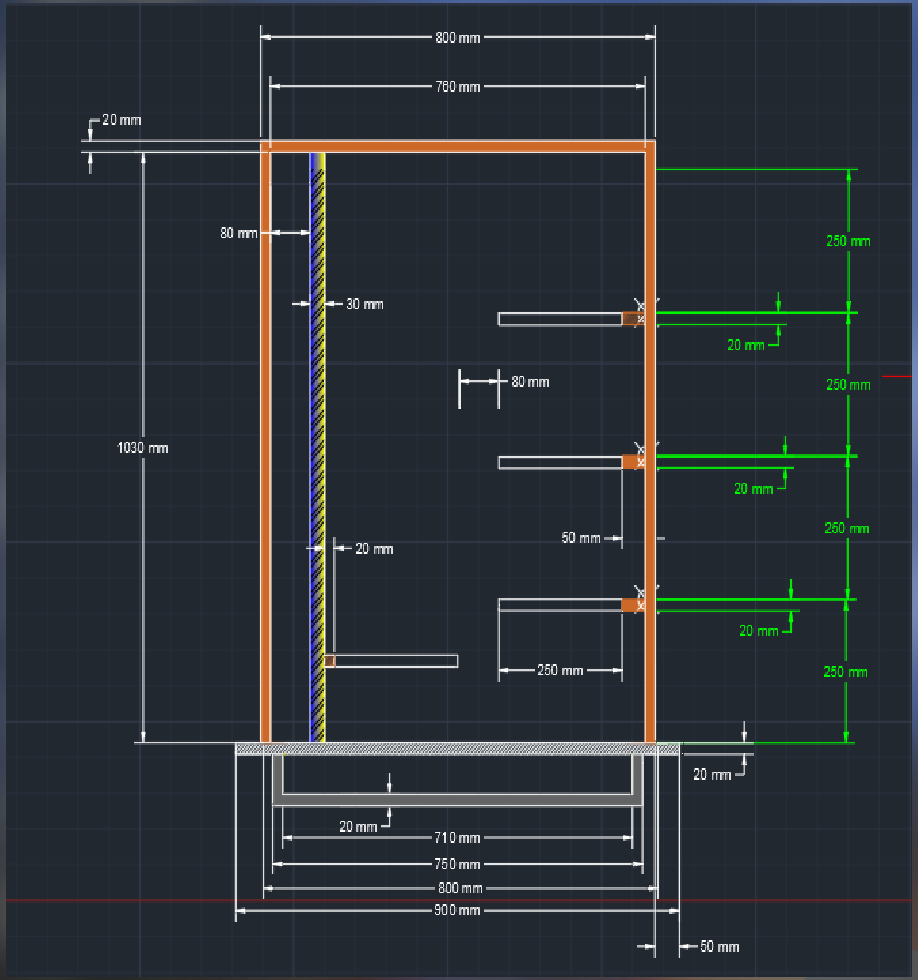
System Structure

Our project focuses on utilizing vertical space for parking cars by designing the structure to consist of three vertical floors.



System Structure

In the 2D design, the focus was on clearly illustrating all the dimensions of the project.

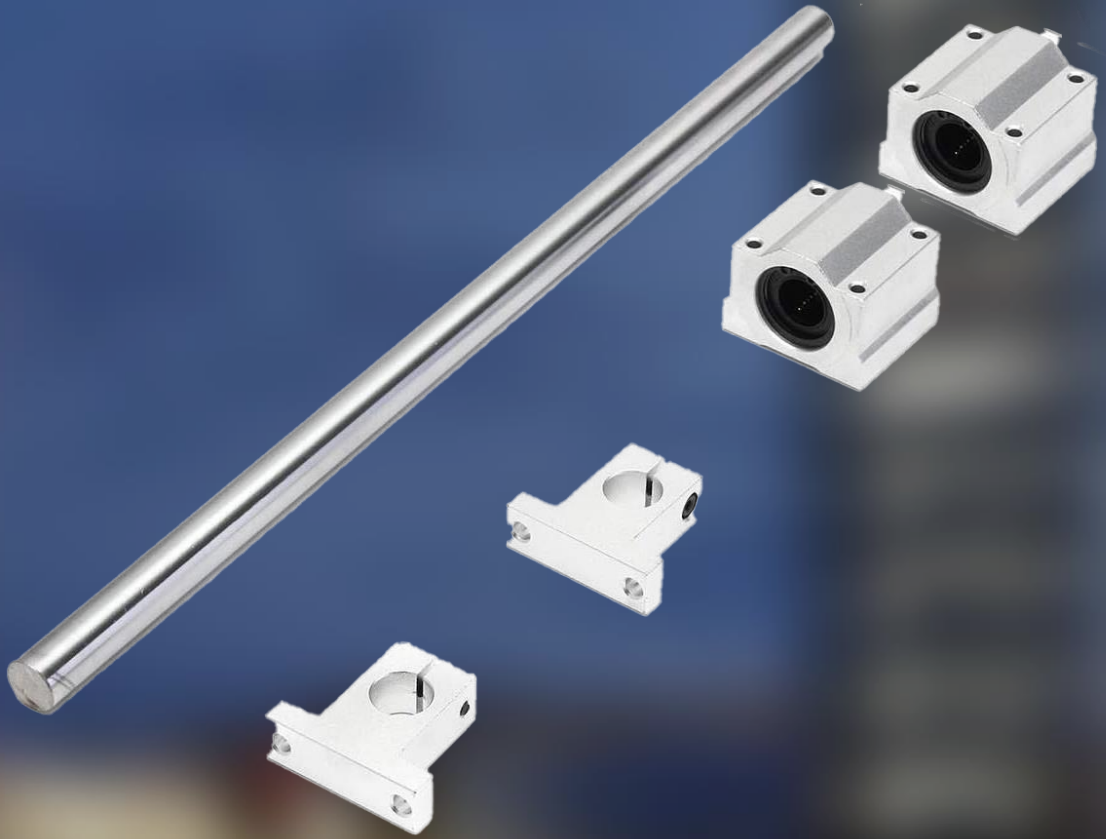


Mechanical Parts

Lead Screw

Mechanical Parts

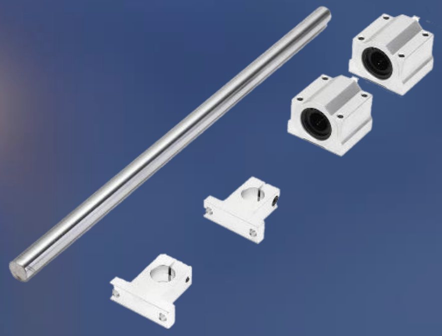
Lead Screw



Liner Guid

Mechanical Parts

Lead Screw

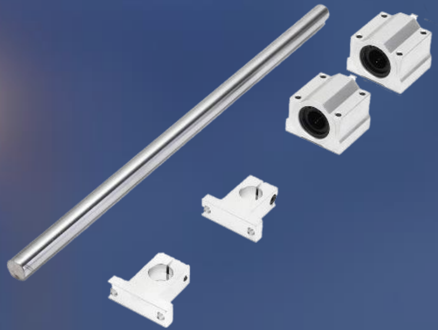


Liner Guide

Bearing

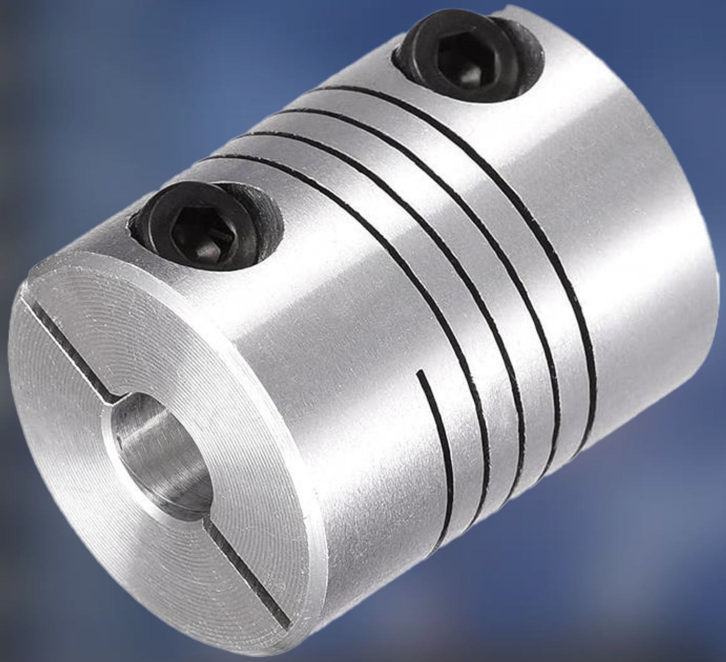
Mechanical Parts

Lead Screw



Liner Guide

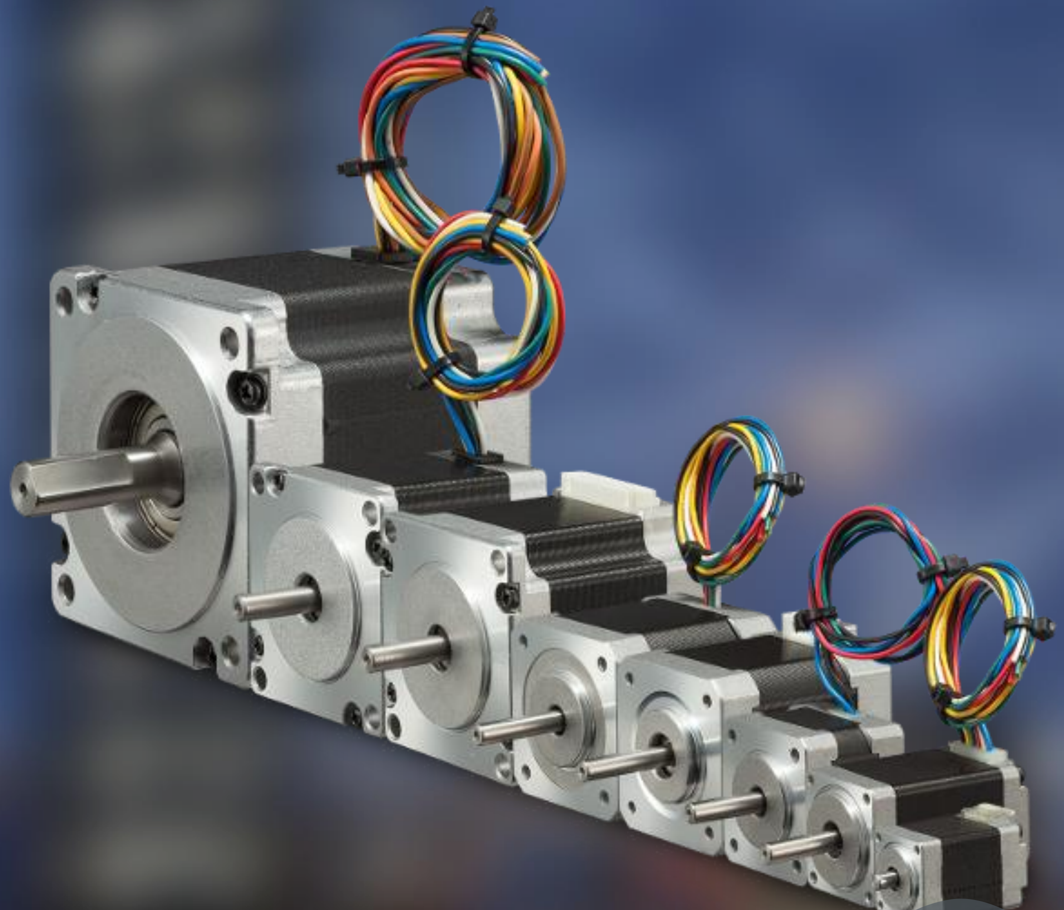
Bearing



Coupling

Electrical Parts

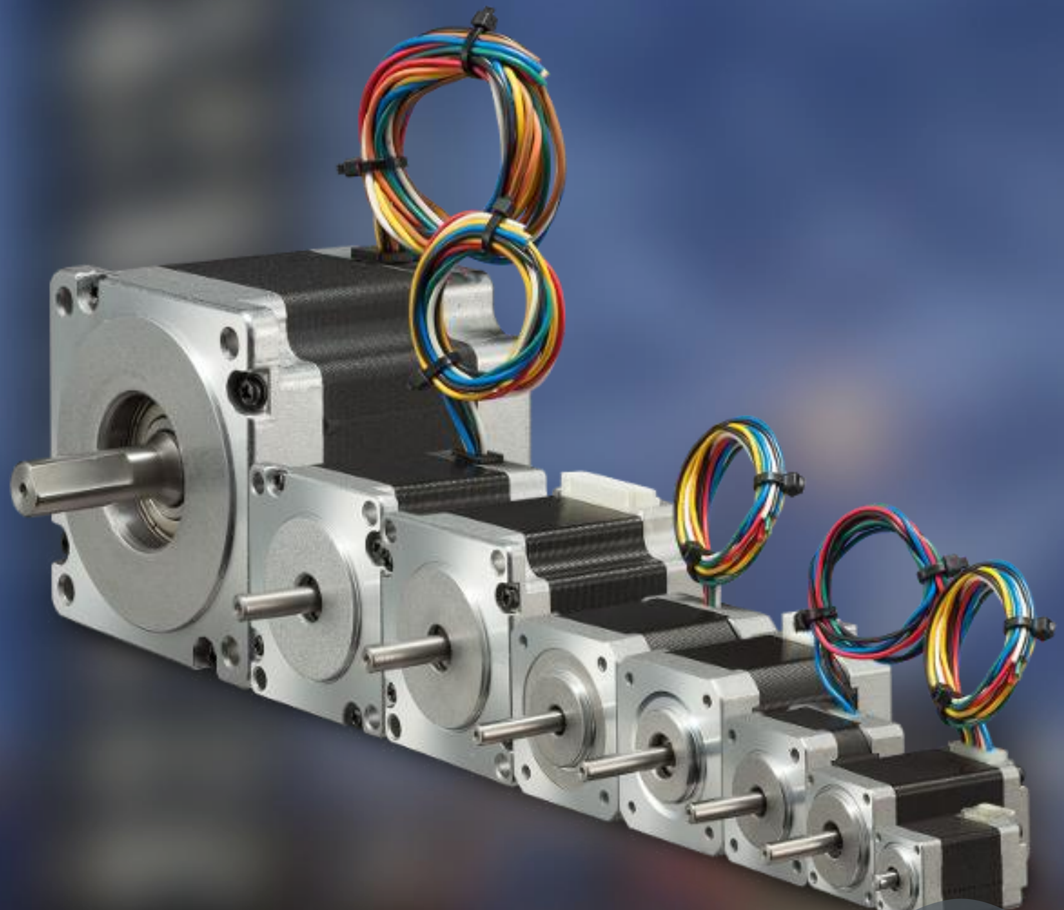
- For the vertical movement, we needed a motor with high torque to lift the load safely and precisely.
- We selected a NEMA 17 stepper motor because it provides:
    1. Torque range: 0.4 – 0.5 N·m
    2. Voltage: 12 – 24V
    3. DCCurrent: 1.5 – 2.0 A



Stepper Motors (NEMA)

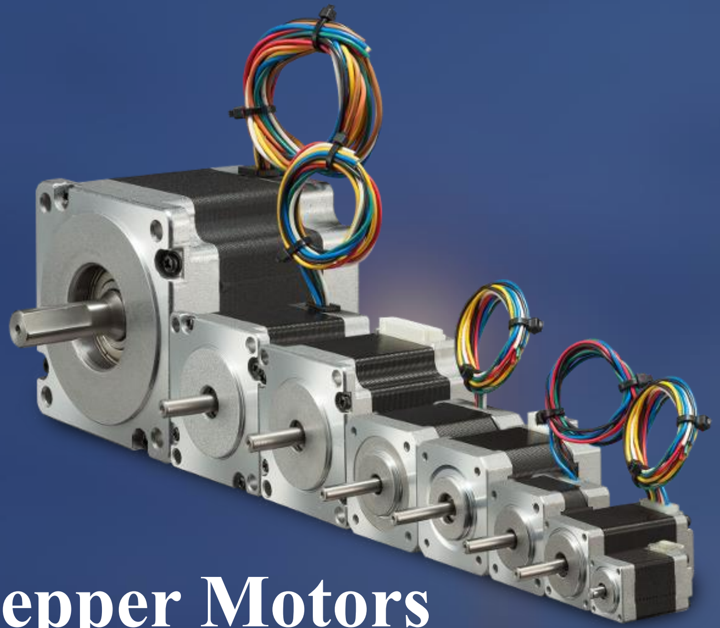
Electrical Parts

- For the horizontal movement, the load is lighter and doesn't require much torque.
- We selected a NEMA 14 stepper motor because it is:
  1. More compact: 35 × 35 mm
  2. Torque: 0.1 – 0.2 N·m
  3. Voltage: 12 – 24V
  4. DC Current: 0.8 – 1.2 A

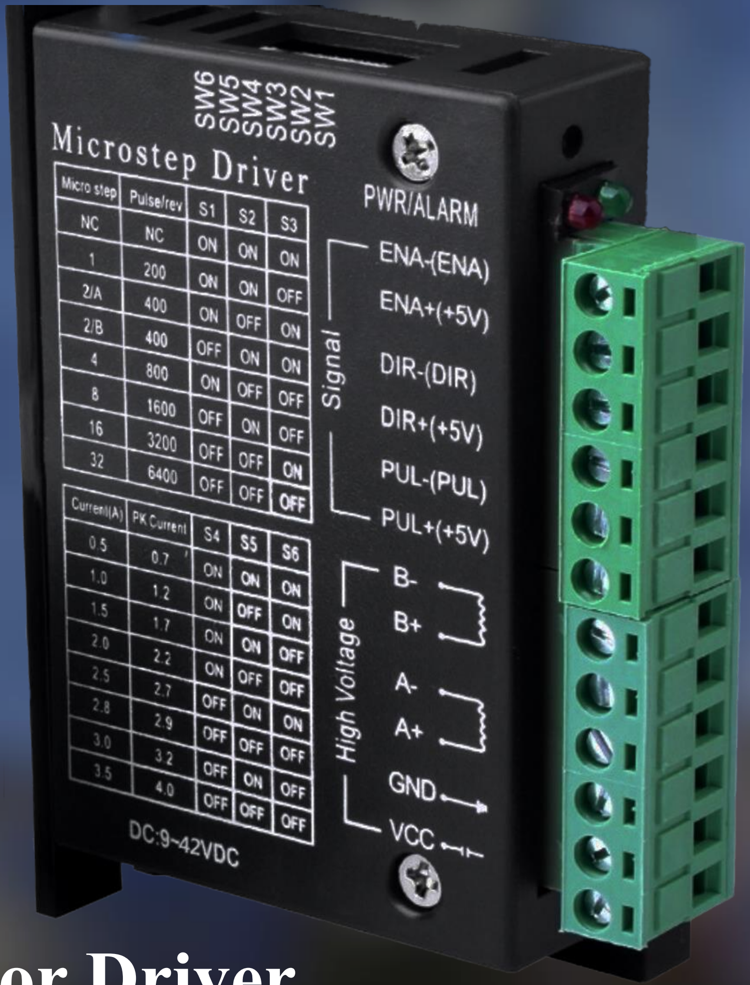


Stepper Motors (NEMA)

Electrical Parts



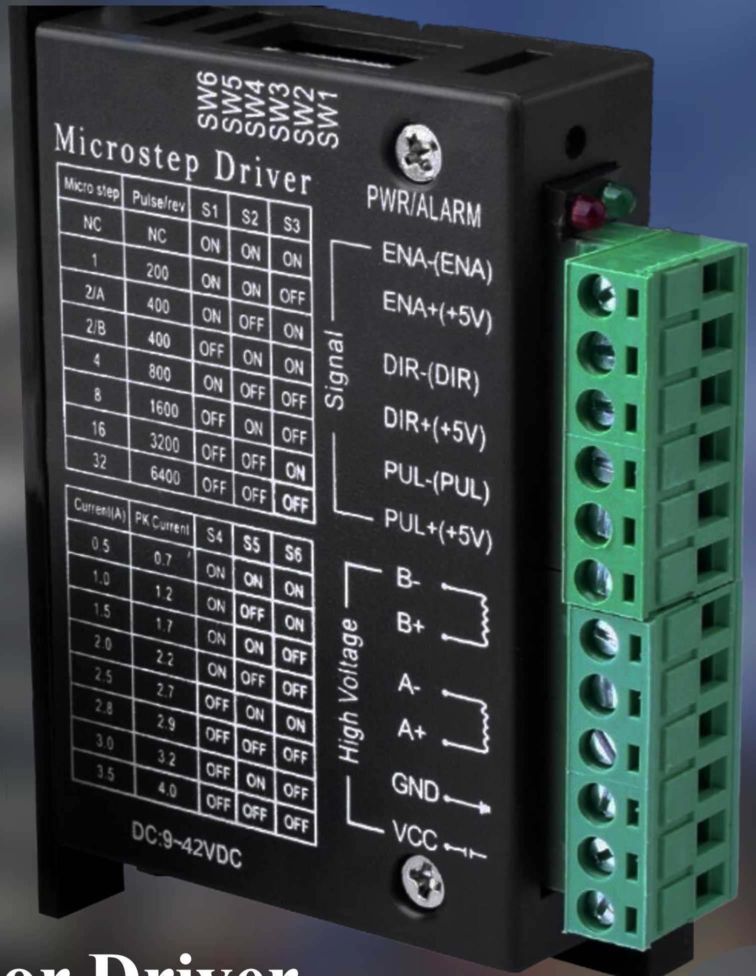
Stepper Motors (NEMA)



Motor Driver

Electrical Parts

- We chose the TB6600 driver because it fully supports our motors' voltage and current ratings.
- It also gave us the flexibility to set the microstepping for smoother motion, and its interface with the PLC is simple and reliable.



Motor Driver

Electrical Parts

We chose a 24V DC power supply as it suits all system components and ensures better protection
since 24V is a safe and low-risk voltage for users and technicians

Power supply

Electrical Parts

We selected the Siemens
S7-1212C DC/DC/DC PLC

plc