Sparks Academy

TNPSC CTSE - 2025

DIPLOMA LEVEL

INDUSTRIAL ROBOTICS AND DIGITAL MANUFACTURING TECHNICIAN

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SUBJECT CODE: 538

81908 79379

INDUSTRIAL ROBOT

- Industrial robots are automated, programmable machines capable of movement on three or more axes, used to perform tasks in manufacturing and production environments.

Applications

- Welding
- Material Handling
- Machine Tending
- Assembly
- Painting and Coating
- Inspection and Quality Control
- Cutting, Grinding, and Deburring
- Additive Manufacturing (3D Printing)

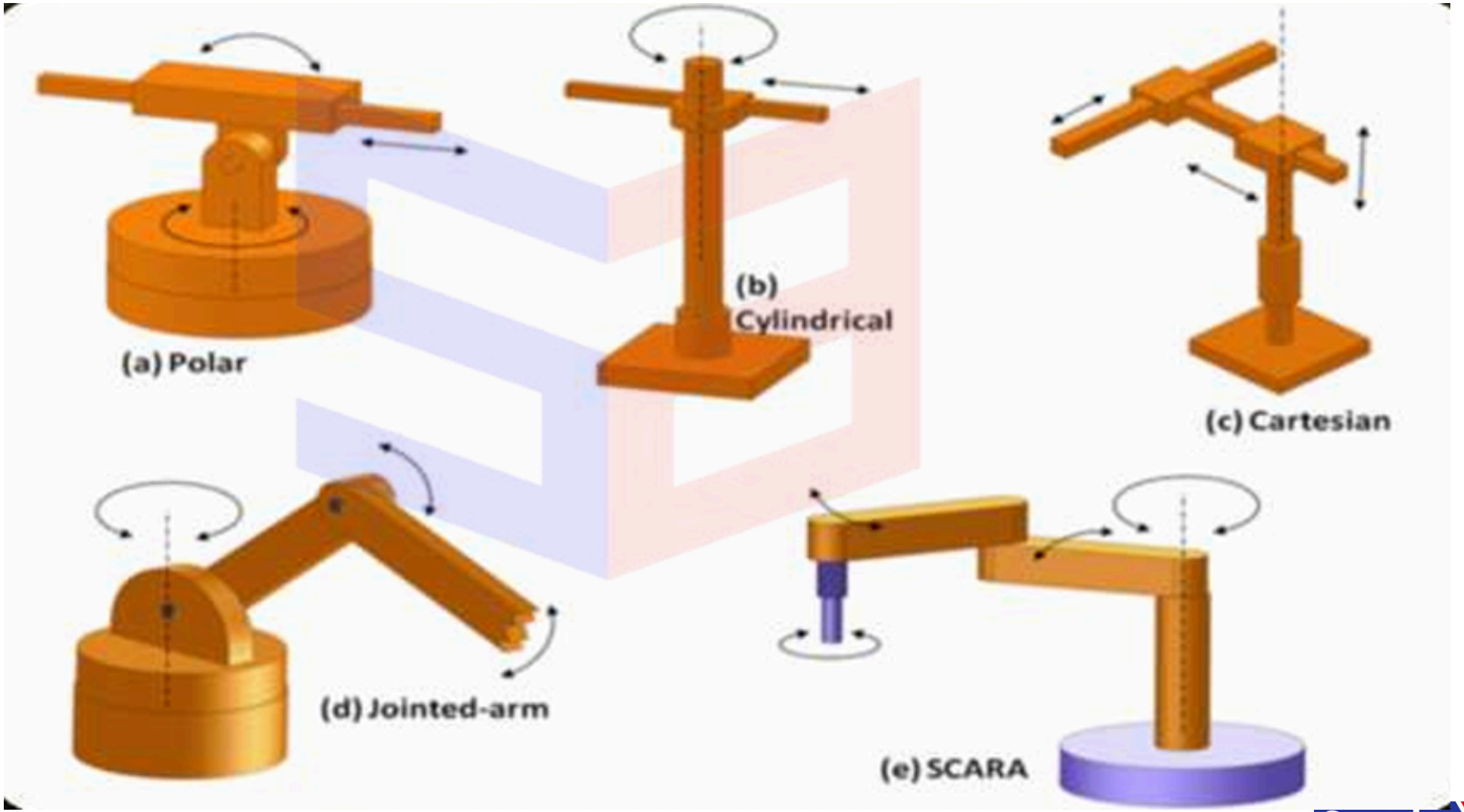
ROBOT TYPES

Type	Axes	Speed	Payload	Applications
Articulated	4–6	Medium	Medium–High	Welding, Assembly
SCARA	4	Very High	Low–Medium	Electronics, Assembly
Cartesian	3+	Medium	High	CNC, Large Parts
Delta	3–4	Very High	Low	Packaging, Sorting
Cylindrical	3	Medium	Medium	Machine Loading
Polar	3	Medium	Medium	Arc Welding, Handling
Collaborative	4–6	Low–Medium	Low	Co-working with Humans

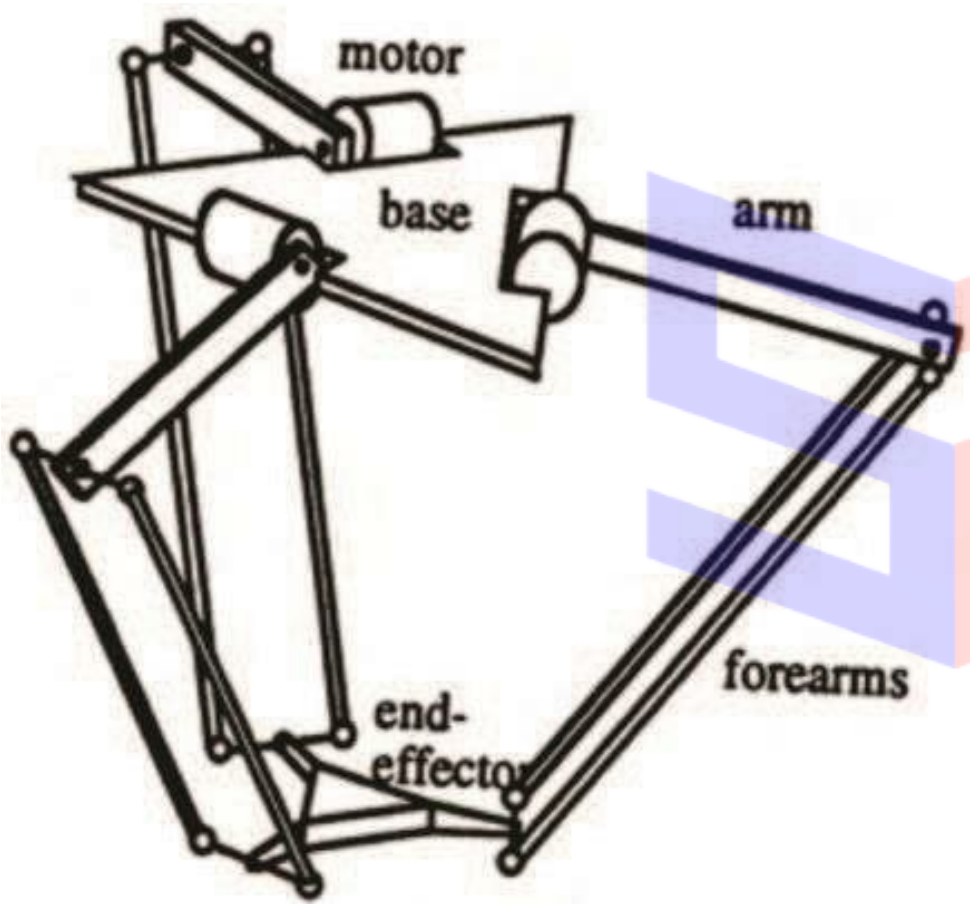
ROBOT CONFIGURATIONS

Configuration	Main Feature	Work Envelope	Typical Use
Cartesian	Linear motion (XYZ)	Box-shaped	CNC, 3D Printing
Cylindrical	Vertical and rotary	Cylinder	Assembly, Coating
Spherical (Polar)	Arm extends & rotates	Spherical	Welding, Die-casting
Articulated	Human-like flexibility	Irregular	Welding, Painting, Assembly
SCARA	Horizontal compliance	Cylindrical	Electronics assembly
Delta	High-speed, parallel	Dome-shaped	Packaging, Pick-and-place
Parallel/Hybrid	Precision & stiffness	3D (custom)	Simulation, Machining, Medical

ROBOT CONFIGURATIONS



ROBOT CONFIGURATIONS



Delta

Parallel/Hybrid

ROBOTIC CELL

- A robotic cell is a complete setup of hardware and software that enables a robot to perform its task safely and efficiently.

Components

- Industrial Robot Arm
  - The core of the cell.
  - Types: Articulated, SCARA, Delta, Cartesian.
  - Controlled by servo motors and encoders.
- End Effectors (EOAT - End of Arm Tooling)
  - Grippers (mechanical, vacuum, magnetic)
  - Welding torches, paint sprayers
  - Sensors or cameras

ROBOTIC CELL

Components

- Robot Controller
  - Brain of the robot; contains software and hardware to control motion, speed, path.
  - Interface for programming (e.g., teach pendant or PC interface).
- Safety Systems
  - Fencing, light curtains, emergency stops, safety scanners.
  - Ensures compliance with ISO 10218 and other safety norms.
- Workholding Fixtures
  - Holds the part in place for operations like welding, machining.
  - Can be manual, pneumatic, or robotic.

ROBOTIC CELL

Components

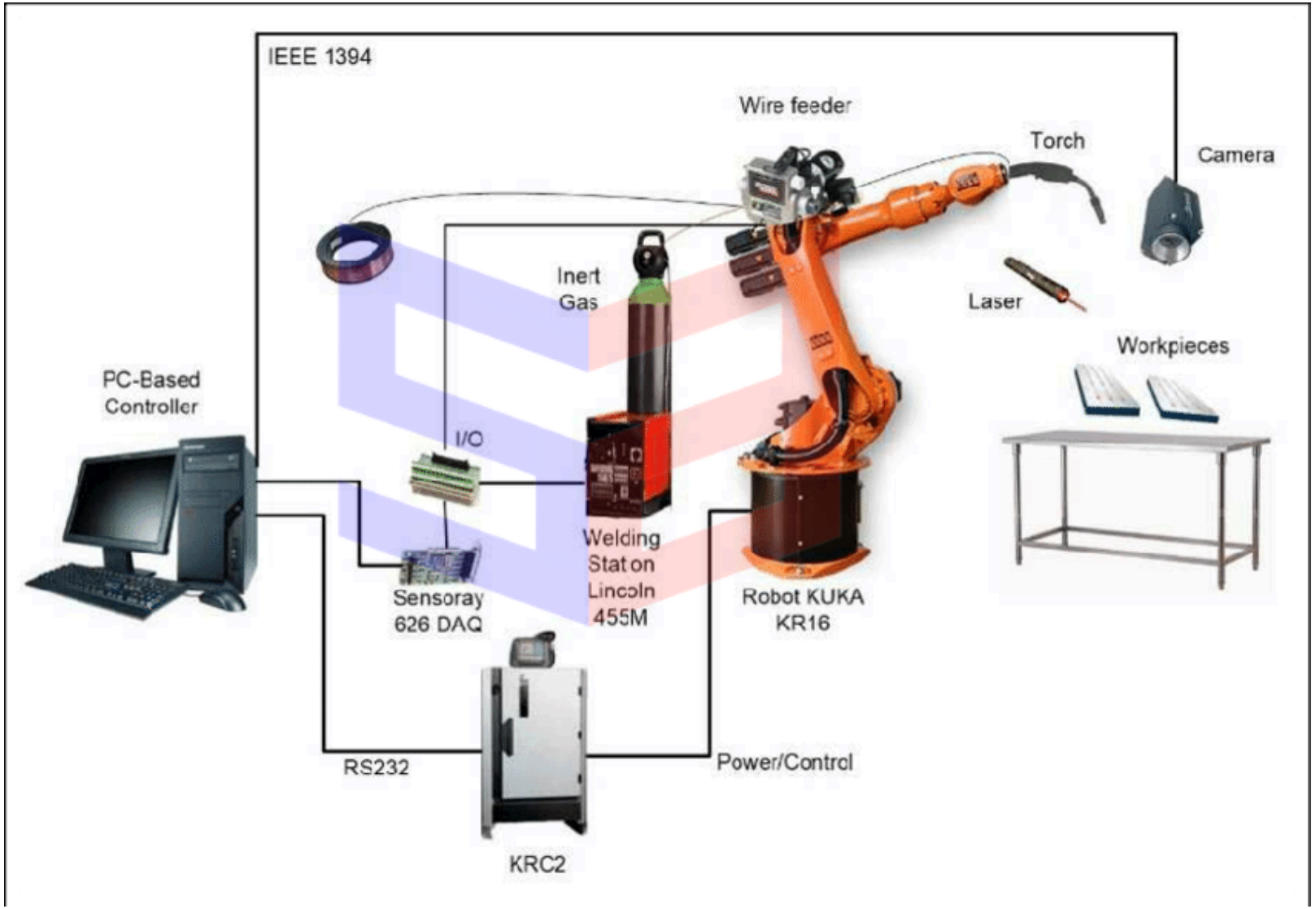
- Vision Systems
  - Cameras and software for:
  - Object recognition
  - Inspection
  - Robot guidance
- Conveyors and Feeders
  - Moves materials into and out of the robotic cell.
  - Often integrated with sensors for part detection and alignment.

ROBOTIC CELL

Components

- Sensors
  - Proximity sensors, force-torque sensors, temperature sensors, pressure sensors
  - Provides real-time data for robot decision-making.
- Communication Interfaces
  - Connects robot to PLCs, HMIs, MES systems, or IoT platforms.
  - Uses protocols like Ethernet/IP, PROFINET, Modbus.
- Power Supply and Control Panel
  - Supplies and manages power to all components.
  - Contains relays, circuit breakers, and monitoring equipment.

ROBOTIC CELL



SENSORS USED IN INDUSTRIAL ROBOT

🔍 1. Position and Displacement Sensors

These sensors help in determining the **location and movement** of robot joints or end-effectors.

📌 Types:

- **Potentiometers**: Measure angular or linear position via resistance changes.
- **Encoders**:
  - **Incremental Encoder**: Measures relative motion (steps or pulses).
  - **Absolute Encoder**: Measures exact position even after power loss.
- **Linear Variable Differential Transformer (LVDT)**: Measures linear displacement accurately.

📌 Used for:

- Joint angle feedback
- Arm movement control
- Path correction

SENSORS USED IN INDUSTRIAL ROBOT

💪 2. Force and Torque Sensors

Used to measure the **interaction force** between the robot and its environment.

📌 Types:

- Strain Gauge Sensors
- Piezoelectric Sensors
- Multi-Axis Force/Torque Sensors

📌 Used for:

- Assembly tasks with precise force control
- Surface finishing (grinding, polishing)
- Collision detection and compliance

SENSORS USED IN INDUSTRIAL ROBOT

👀 3. Vision Sensors / Cameras

Used for capturing images for processing and decision-making.

📌 Types:

- **2D Vision Systems**: Flat object detection and recognition
- **3D Vision Systems**: Depth and spatial recognition (via stereo cameras, LIDAR, structured light)
- **Smart Cameras**: With built-in processing

📌 Used for:

- Object identification and sorting
- Quality inspection
- Robot guidance and part alignment

SENSORS USED IN INDUSTRIAL ROBOT

🌡️ 4. Proximity and Presence Sensors

Detect the **presence, absence, or distance** of nearby objects without physical contact.

📌 Types:

- **Inductive Sensors** (metal objects)
- **Capacitive Sensors** (non-metallic and metallic)
- **Ultrasonic Sensors**
- **Infrared (IR) Sensors**

📌 Used for:

- Part detection
- Safety interlocks
- Object approach warning

SENSORS USED IN INDUSTRIAL ROBOT

🔥 5. Tactile Sensors (Touch Sensors)

Provide information about **physical contact**, surface texture, and pressure.

📌 Types:

- Conductive Rubber Pads
- Piezoelectric Films
- Resistive Touch Grids

📌 Used for:

- Grasp detection
- Part slippage feedback
- Surface inspection

SENSORS USED IN INDUSTRIAL ROBOT

🔄 6. Speed and Acceleration Sensors

Measure the **velocity or acceleration** of robot arms or tools.

📌 Types:

- Gyroscopes
- Accelerometers
- Tachometers

📌 Used for:

- Motion control
- Path stability
- Dynamic compensation

SENSORS USED IN INDUSTRIAL ROBOT

7. Environmental Sensors

Monitor **external environmental conditions** that may affect the robot's operation.

Types:

- Temperature Sensors
- Humidity Sensors
- Gas/Smoke Sensors

Used for:

- Cleanroom operation
- Hazard detection
- Process safety monitoring

SENSORS USED IN INDUSTRIAL ROBOT

🧠 8. Safety Sensors

Ensure safe interaction between robots, humans, and other machinery.

📌 Types:

- Light Curtains
- Laser Scanners (LIDAR)
- Emergency Stop Buttons
- Safety Mats

📌 Used for:

- Area monitoring
- Human-robot collaboration
- Emergency halts

SENSORS USED IN INDUSTRIAL ROBOT

Sensor Type	Primary Function	Common Application
Position Sensors	Joint/arm position feedback	Arm control, repeatability
Force/Torque	Detect forces/moments	Assembly, deburring
Vision Sensors	Image capture and analysis	Inspection, part recognition
Proximity Sensors	Detect object approach	Pick-and-place, collision avoidance
Tactile Sensors	Detect contact/pressure	Gripping, surface detection
Speed Sensors	Motion feedback	Smooth control, compensation
Environmental	Monitor surroundings	Hazard detection, temperature control
Safety Sensors	Human/area safety	Collaborative robots, emergency stop

INSTALL MECHANICAL CONNECTIONS

✅ 1. Preparation

- **Review assembly drawings and manuals**
- **Gather tools**: torque wrenches, screwdrivers, pliers, alignment pins
- **Inspect parts**: Check for deformation, dirt, rust, or wear

✅ 2. Mounting the Robot Base

- Ensure **flatness and level** of the mounting surface
- Use **anchor bolts or leveling feet**
- Apply **torque to specification** using a calibrated torque wrench
- Check for **rigid and vibration-free** installation

INSTALL MECHANICAL CONNECTIONS

✅ 3. Connecting the Arm and Joints

- Align mechanical joints (use dowel pins if needed)
- Install bearings, seals, and locking rings as required
- Apply **lubrication** to moving parts (follow manufacturer's recommendation)

✅ 4. Installing End Effectors (Grippers, Welders, etc.)

- Mount securely on the flange or wrist
- Use proper spacers and fasteners
- Route pneumatic or electrical lines neatly to prevent entanglement

INSTALL MECHANICAL CONNECTIONS

✅ 5. Cable and Hose Management

- Use **flexible conduit** or **cable chains**
- Ensure **no excessive bending or pulling**
- Provide **strain relief** at both ends

✅ 6. Alignment Check

- Verify axis alignment using alignment tools or laser systems
- Ensure end-effector aligns with fixtures and work area

INSTALL ELECTRICAL CONNECTIONS

✅ 1. Safety First

- Power off all systems
- Lockout/tagout (LOTO) as per safety procedures
- Use insulated tools and PPE

✅ 2. Power Supply Wiring

- Connect power cables from main panel to robot controller
- Ensure proper **grounding and bonding**
- Match voltage and phase requirements (e.g., 230V, 3-phase)

INSTALL ELECTRICAL CONNECTIONS

✅ 3. Motor and Encoder Connections

- Connect each motor and encoder cable to the correct axis port
- Check connector locking mechanisms and labels
- Avoid EMI (electromagnetic interference) by **separating power and signal cables**

✅ 4. I/O Wiring

- Connect limit switches, sensors, actuators to I/O terminals
- Use proper cable numbering and color coding
- Shield signal wires if required (to prevent noise)

INSTALL ELECTRICAL CONNECTIONS

✅ 5. Network and Communication

- Ethernet, PROFINET, EtherCAT, Modbus connections to:
  - PLC
  - HMI
  - Safety controllers
- Test network connectivity and address settings

INSPECT MECHANICAL AND ELECTRICAL CONNECTIONS

A. Mechanical Inspection

- Check for:
  - Loose bolts or fasteners
  - Misalignment in joints or fixtures
  - Proper lubrication
  - Signs of wear or mechanical interference
- Use feeler gauges, torque wrenches, and alignment tools

INSPECT MECHANICAL AND ELECTRICAL CONNECTIONS

🔌 B. Electrical Inspection

- Check:
  - Continuity of wires (using multimeter)
  - Insulation resistance
  - Proper terminal tightening (torque rating)
  - Cable strain relief and routing
  - EMI protection and shielding
- Look for:
  - Burn marks, damaged insulation
  - Loose connections or open wires

🧪 C. Functional Testing

- Power on system gradually (dry run)
- Run basic motion tests of robot axes
- Verify sensor signals on controller interface
- Ensure emergency stops and safety systems work correctly