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## Refurbishment of Articulated Robot Through Plc For Pick And Place Operation

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### ABSTRACT :

This project presents the refurbishment of an articulated 6-axis robot through the integration of a Programmable Logic Controller (PLC) for executing pick-and-place operations using a teach pendant. The primary objective of this work is to extend the operational life of an existing Scorbot robotic arm by replacing its obsolete control system with a modern, PLC-based architecture.

The refurbished robot successfully performs pick-and-place tasks, making it suitable for educational training, research demonstrations, and small-scale industrial applications. The approach significantly reduces costs compared to procuring a new industrial robot, while also providing a valuable platform for skill development in robotics and automation.

The project demonstrates the advantages of cost-effectiveness, flexibility, and educational value, while acknowledging limitations such as reduced precision and reliance on relay-based control. Future enhancements include the integration of servo drives, closed-loop feedback, HMI/SCADA systems, and vision-based automation to expand the robot's applications.

**Keywords:** PLC, articulated robot, pick-and-place operation, refurbishment, industrial automation, relay control, limit switches, educational robotics

### 1. INTRODUCTION

In the era of rapid industrial automation, articulated robots play a crucial role in performing repetitive and precise tasks such as assembly, welding, painting, and material handling. Among these, pick and place operations are one of the most fundamental yet essential tasks in industries like manufacturing, packaging, and electronics. Traditionally, these robots are operated through dedicated controllers; however, the integration of Programmable Logic Controllers (PLCs) with articulated robots provides enhanced flexibility, reliability, and ease of programming through ladder logic.

The present project focuses on the refurbishment of an articulated robot and its control through a PLC using a teach pendant. The refurbishment ensures that the robot's mechanical and electrical subsystems are restored to working condition, while the integration of the PLC enables simplified automation and compatibility with industrial systems. The teach pendant acts as an interface that allows the operator to record and replay robot motions for pick and place operations. By combining these technologies, the project demonstrates how legacy robotic systems can be modernized for industrial applications at reduced cost.

### 2. LITERATURE SURVEY

1. Jovanović and D. Jovanović, "Integrating PLCs with robot motion control in engineering education," Departmental/Conference paper, Old Dominion University, 2012.

**Summary** — Reviews practical methods to teach robot motion control by integrating PLCs and robot systems in an educational lab. Useful for architecture decisions when you place PLC as the high-level coordinator for motion tasks, I/O handshaking, and safety interlocks. Discusses how to partition control tasks between PLC (sequencing, I/O, safety) and robot controller (trajectory/motion).

2. V. Vukomanović, M. R. B. Pantić et al., "PLC-based control of a robot manipulator with closed kinematic chain," in Proceedings of ICRA / related conference, 2009.

**Summary** — Demonstrates a PLC controlling a manipulator including kinematic considerations. Contains implementation details about encoding motion primitives in PLC logic, timing/scan constraints, and interfacing with low-level motor drivers — directly applicable when replacing or augmenting a SCORBOT controller using PLC outputs or when mapping joint commands into PLC tasks.

3. C. H. Lee, J. J. Chung et al., “A Novel Teaching System for Industrial Robots,” Sensors, vol. 14, no. 4, pp. 6012–6030, 2014.

**Summary** — Proposes a modern teach-pendant and teaching workflow for industrial arms that emphasizes usability and rapid teaching. Good source for teach-pendant UI design, safety features (dead-man switch, mode select), and how to capture & store poses for pick-and-place. Use this for designing the operator interface that sits on top of your PLC-based system.

4. Y. Gao, L. Zhang et al., “U-Pendant: A universal teach pendant for serial robots based on ROS,” Technical report / conference paper, 2015.

**Summary** — Presents an open, ROS-based universal teach pendant that works across serial manipulators. Helpful if you want a software teach-pendant (tablet/PC) that can run alongside PLC logic and either replace or augment the physical SCORBOT pendant for trajectory teach-in and pose capture. Shows API patterns for pose upload/download and remote jog control.

### III.METHODOLOGY

The working methodology of refurbishing an articulated robot through PLC involves interfacing manual switches and limit switches as PLC inputs and controlling DC motors through relay outputs. Each motor requires two relays to determine its direction of rotation (forward/reverse or clockwise/counterclockwise). The PLC executes ladder logic instructions that drive the relays based on operator commands and safety interlocks. The system is built around the Bosch Rexroth L10 Trainer Kit, IndraLogic software for programming, and the SCORBOT articulated robot with DC motors and a mechanical gripper.

#### Work Outline details

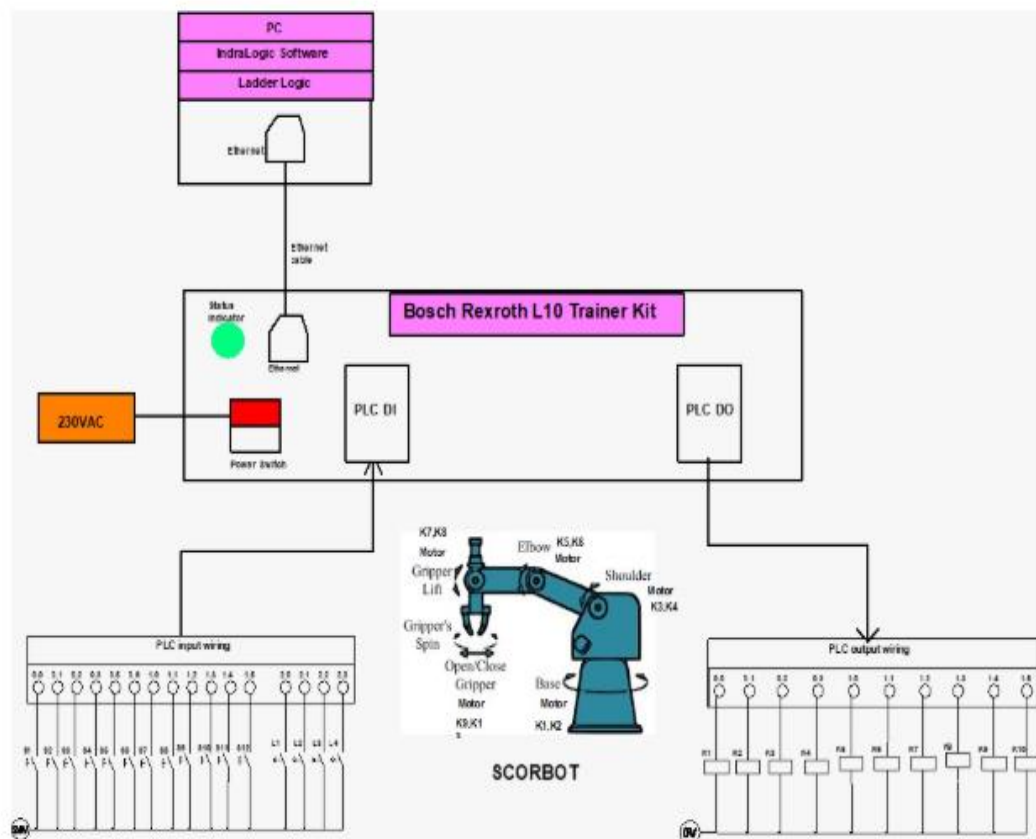


Figure1: SIX – Axis Articulated robot

#### 3.1 PLC Input and Output Wiring

##### Inputs (Switches and Limit Switches):

- Push buttons (PB) act as manual commands for robot movement.
- Limit switches (LS) prevent over-travel of each joint, ensuring safety and protecting motors.
- Start/Stop push buttons control overall robot operation.

| Sl. No | Input Device                | PLC Address | Description                   |
|--------|-----------------------------|-------------|-------------------------------|
| 1      | Base CW Push Button (S1)    | %IX0.0      | Rotate base clockwise         |
| 2      | Base CCW Push Button (S2)   | %IX0.1      | Rotate base counterclockwise  |
| 3      | Shoulder FWD PB (S3)        | %IX0.2      | Move shoulder forward (up)    |
| 4      | Shoulder REV PB (S4)        | %IX0.3      | Move shoulder backward (down) |
| 5      | Elbow UP PB (S5)            | %IX0.5      | Raise elbow                   |
| 6      | Elbow DOWN PB (S6)          | %IX0.6      | Lower elbow                   |
| 7      | Wrist UP PB (S7)            | %IX1.0      | Tilt wrist upward             |
| 8      | Wrist DOWN PB (S8)          | %IX1.1      | Tilt wrist downward           |
| 9      | Gripper Open PB (S9)        | %IX1.2      | Open gripper                  |
| 10     | Gripper Close PB (S10)      | %IX1.3      | Close gripper                 |
| 11     | Start PB (S11)              | %IX1.4      | System ON                     |
| 12     | Stop PB (S12)               | %IX1.5      | System OFF                    |
| 13     | Base Limit Switch (S13)     | %IX2.0      | Base axis end-stop            |
| 14     | Elbow Limit Switch (S14)    | %IX2.1      | Elbow axis end-stop           |
| 15     | Shoulder Limit Switch (S15) | %IX2.2      | Shoulder axis end-stop        |
| 16     | Wrist Limit Switch (S16)    | %IX2.3      | Wrist axis end-stop           |

Table.1: PLC input and output wiring for inputs

**Outputs (Relay Control for Motors):**

- Each motor requires **two relays (K1/K2, K3/K4, etc.)** for bi-directional control.
- The PLC energizes relays, which in turn supply power to the DC motors.

Outputs are mapped as follows:

| Sl. No | Output Device       | PLC Address | Function                       |
|--------|---------------------|-------------|--------------------------------|
| 1      | Base CW Relay (K1)  | %QX0.0      | Base rotation clockwise        |
| 2      | Base CCW Relay (K2) | %QX0.1      | Base rotation counterclockwise |
| 3      | Shoulder FWD (K3)   | %QX0.2      | Shoulder forward motion        |
| 4      | Shoulder REV (K4)   | %QX0.3      | Shoulder backward motion       |
| 5      | Elbow UP (K5)       | %QX1.0      | Raise elbow                    |
| 6      | Elbow DOWN (K6)     | %QX1.1      | Lower elbow                    |
| 7      | Wrist UP (K7)       | %QX1.2      | Tilt wrist upward              |
| 8      | Wrist DOWN (K8)     | %QX1.3      | Tilt wrist downward            |
| 9      | Gripper Open (K9)   | %QX1.4      | Open mechanical gripper        |
| 10     | Gripper Close (K10) | %QX1.5      | Close mechanical gripper       |

Table.2: PLC input and output wiring for outputs

**3.2 Relay Logic for Motor Direction**

Each DC motor has two relays that determine direction:

- Relay 1 ON + Relay 2 OFF → Forward/Clockwise rotation**
- Relay 1 OFF + Relay 2 ON → Reverse/Counterclockwise rotation**
- Both OFF → Motor Stop**
- Both ON → Invalid state (prevented by interlock logic in PLC program)**

This arrangement is similar to an H-Bridge concept, implemented using relays.

### 3.3 Summary of Working

- The operator gives input via push buttons or teach pendant.
- The PLC processes inputs and generates output signals.
- Relays act as drivers, directing DC motor rotation.
- Limit switches safeguard against over-travel.
- The robot executes pick and place operations reliably with PLC coordination.

This methodology ensures a robust and practical refurbishment, making the SCORBOT robot suitable for industrial training and academic demonstration.

## RESULTS AND DISCUSSION

### Primary Results

#### 1. Manual operation results

**Description:** In manual mode, the robot was operated using basic switches, buttons or HMI jog interface, without automated sequencing. Each movement (joint or axis) was controlled by step by step by human operator.

##### Observations:

| Parameter         | observation                                   |
|-------------------|-----------------------------------------------|
| Control type      | Manual via HMI buttons or physical switches   |
| Average peak time | 20- 30 seconds (operator dependent)           |
| Accuracy          | Moderate( varied due to manual control)       |
| Repeatability     | Low (affected by human error)                 |
| Operator fatigue  | High for long durations                       |
| Safety            | Need constant attention to prevent collisions |
| Ease of use       | Simple, but not efficient                     |

##### Challenges:

- Operator dependent delays.
- Inconsistent placement accuracy.
- Fatigue during prolonged operation

### Secondary Results

#### 2. Automatic Operation Results (Plc –Controlled)

**Description:** In automatic mode, the robots follows a plc programmed sequence for pick and place tasks. All movements were synchronized, timed, and executed based sensor input and motion commands.

##### Observations:

| Parameter            | observation                             |
|----------------------|-----------------------------------------|
| Control type         | PLC based automatic sequence            |
| Average peak time    | 5-8 seconds per cycle                   |
| Accuracy             | High (repeatable path defined in logic) |
| Repeatability        | Very high(consistent each cycle)        |
| Operator involvement | Minimal (supervisory only)              |
| Safety               | Interlocks and limit switches active    |

##### Benefits:

- Faster and repeatable operation.
- Reduced operator work load.
- Better integration with sensor for object detection.
- Safe and efficient for contineous use.

### 3. Comparative analysis:

| Metric                   | Manual mode             | Automatic (plc) mode      |
|--------------------------|-------------------------|---------------------------|
| Avg. pick and place time | 20-30 sec (varies)      | 5-8 sec( fixed)           |
| Accuracy                 | Low                     | High                      |
| Repeatability            | Moderate                | High                      |
| Operator fatigue         | High                    | Very low                  |
| Safety measures          | Manual attention needed | Automated interlocks used |

### Conclusion from Results

- The refurbishment successfully restored and enhanced the robot's operational capability.
- PLC integration improved accuracy, speed, and reliability.
- The system can now be effectively used for industrial pick-and-place tasks with minimal maintenance requirements.

## CONCLUSION

The refurbishment of the articulated 6-axis robot using a PLC-based control system has successfully demonstrated the feasibility of integrating industrial automation principles into an existing robotic platform. By employing ladder logic programming, relay-based motor direction control, and limit switch feedback, the robot was made capable of executing pick-and-place operations effectively.

This setup not only enhances the functional life of the existing robot but also provides a low-cost, educationally valuable system for training in robotics and automation. The project highlights the importance of combining mechanical systems with PLC-based control to achieve both industrial and academic objectives.

## REFERENCES

- [1] Dzedzickis, A.; Subačiūtė-Žemaitienė, J.; Šutinys, E.; Samukaitė-Bubnienė, U.; Bučinskas, V. "Advanced Applications of Industrial Robotics: New Trends and Possibilities", *Appl. Sci.* 2022, 12, 135. <https://doi.org/10.3390/app12010135>
- [2] S Chitikeshi, [S Dhali](#), [V Jovanovic](#) "Integrating PLCs with Robot Motion Control in Engineering Capstone Courses", 2022 ASEE Annual Conference & Exposition, 2022
- [3] L. Maha. "Different Applications of Programmable Logic Control (PLC)," *International Journal of Computer Science, Engineering and Information Technology (IJCEIT)*, vol. 4,no.1.,2014, doi : 10.5121/ijceit.2014.4103.
- [4] S. Vosough and A. Vosough "PLC & its Applications" *International Journal of Multidisciplinary Sciences and Engineering*, Vol.-2, Issue-8. November 2011.
- [5] S. Gupta & S. C. Sharma, "Selection and Application of advance control System: PLC, DCS & PC Based System" *Journal of Scientific & Industrial research*, Vol.-64, pp-249 -225. 2005.
- [6] Alvares, A. J., Toquica, J. S., Lima, E. J., & Bomfim, M. H. Retrofitting of the IRB6-S2 robotic manipulator using Computer Numerical Control-based controllers. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, 40(3), pp149, March 2018.
- [7] Bonfe, Marcello, Matteo Vignali, and Mario Fiorini. "PLC-based control of a robot manipulator with closed kinematic chain." *2009 IEEE International Conference on Robotics and Automation*. IEEE, pp 1262-1267 2009.
- [8] C. A. Chung, "A cost-effective approach for the development of an integrated PC-PLC robot system for industrial engineering education," in *IEEE Transactions on Education*, vol. 41, no. 4, pp. 306-310, Nov. 1998, doi: 10.1109/13.728266.