Mechatronics

Introduction to Robotics

Courseware Sample

39411-F0
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## Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="DANGER" /></td>
<td><strong>DANGER</strong> indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.</td>
</tr>
<tr>
<td><img src="image" alt="WARNING" /></td>
<td><strong>WARNING</strong> indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.</td>
</tr>
<tr>
<td><img src="image" alt="CAUTION" /></td>
<td><strong>CAUTION</strong> indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.</td>
</tr>
<tr>
<td><img src="image" alt="CAUTION" /></td>
<td><strong>CAUTION</strong> used without the <em>Caution, risk of danger</em> sign, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.</td>
</tr>
<tr>
<td><img src="image" alt="Caution, risk of electric shock" /></td>
<td>Caution, risk of electric shock</td>
</tr>
<tr>
<td><img src="image" alt="Caution, hot surface" /></td>
<td>Caution, hot surface</td>
</tr>
<tr>
<td><img src="image" alt="Caution, risk of danger" /></td>
<td>Caution, risk of danger</td>
</tr>
<tr>
<td><img src="image" alt="Caution, lifting hazard" /></td>
<td>Caution, lifting hazard</td>
</tr>
<tr>
<td><img src="image" alt="Caution, hand entanglement hazard" /></td>
<td>Caution, hand entanglement hazard</td>
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<tr>
<td><img src="image" alt="Notice, non-ionizing radiation" /></td>
<td>Notice, non-ionizing radiation</td>
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<tr>
<td><img src="image" alt="Direct current" /></td>
<td>Direct current</td>
</tr>
<tr>
<td><img src="image" alt="Alternating current" /></td>
<td>Alternating current</td>
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<tr>
<td><img src="image" alt="Both direct and alternating current" /></td>
<td>Both direct and alternating current</td>
</tr>
<tr>
<td><img src="image" alt="Three-phase alternating current" /></td>
<td>Three-phase alternating current</td>
</tr>
<tr>
<td><img src="image" alt="Earth (ground) terminal" /></td>
<td>Earth (ground) terminal</td>
</tr>
</tbody>
</table>
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<tr>
<td><img src="image" alt="Symbol" /></td>
<td>Protective conductor terminal</td>
</tr>
<tr>
<td><img src="image" alt="Symbol" /></td>
<td>Frame or chassis terminal</td>
</tr>
<tr>
<td><img src="image" alt="Symbol" /></td>
<td>Equipotentiality</td>
</tr>
<tr>
<td><img src="image" alt="Symbol" /></td>
<td>On (supply)</td>
</tr>
<tr>
<td><img src="image" alt="Symbol" /></td>
<td>Off (supply)</td>
</tr>
<tr>
<td><img src="image" alt="Symbol" /></td>
<td>Equipment protected throughout by double insulation or reinforced insulation</td>
</tr>
<tr>
<td><img src="image" alt="Symbol" /></td>
<td>In position of a bi-stable push control</td>
</tr>
<tr>
<td><img src="image" alt="Symbol" /></td>
<td>Out position of a bi-stable push control</td>
</tr>
</tbody>
</table>

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.
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Unit 2   Programming
Introduction

The Lab-Volt Robot System, Models 5150, provides complete and affordable training in the programming and operation of industrial style robots. Through the curriculum and hands-on experience gained in working with the Robot System, students learn to create automated work cells.

The precision-built articulated-arm robot of the Robot System represents an important step forward in automation and handling. A stepper motor in the base of the unit provides horizontal rotation, while additional stepper motors in the shoulder provide precision movements of specialized components.

The articulated-arm robot has five axes of rotation plus a gripper. Each articulation can be controlled and moved independently. Movements of the joints are accomplished by belts through a series of gears, while the gripper mechanism is activated by cables and belt driven pulleys.

The articulations can be controlled and programmed by using either the optional Teach Pendant, Model 5106, or the provided RoboCIM 5150 Software. This software, a powerful learning tool, allows students to create programs, perform tests in the Simulation mode, and then test the operation of the real system in the Control mode. The software provides a three-dimensional virtual environment and an easy-to-use interface allowing students to easily learn the fundamentals of robotics. Two programming modes are available: an intuitive icon programming mode and a text programming mode to create more complex tasks.

Optional devices can be added to the system to perform more complex tasks. The optional devices include a Rotary Carousel, Belt Conveyors, Gravity Feeders, Pneumatic Feeders, and a Signal Tower.
INTRODUCTION TO ROBOTICS

Unit 1 Introduction and Familiarization


Ex. 1-1 Control of the Robot, Using RoboCIM

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Ex. 1-2 Control of the Robot, Using the Teach Pendant

Setting up the system. Control of the robot’s articulations, using the Teach Pendant. Control of the robot’s articulations to grip, move, and rotate objects. Shutdown procedure.

Unit 2 Programming


Ex. 2-1 Programming, Using RoboCIM

Creating a new workspace, adjusting the work area, and positioning objects in the view display area. Recording the points to be used for program editing. Program editing. Testing the program in the Simulation mode. Testing the program in the Control mode.

Ex. 2-2 Programming, Using the Teach Pendant

Setting up the system. Recording points. Testing the recorded points. Executing the program.

Unit 3 Program Editing

Ex. 3-1 Program Editing, Using RoboCIM

Editing a program to take account of a change in object positioning. Editing a program in order to insert a delay. Modifying the speed associated with a recorded programmed point.

Ex. 3-2 Program Editing, Using the Teach Pendant

Editing a program to take account of a change in object positioning. Editing a program in order to insert a delay. Modifying the speed associated with a recorded programmed point.
INTRODUCTION TO ROBOTICS (cont’d)

Unit 4  Industrial Application 1

Creating a program that simulates the spot welding of a metallic can. Editing the program in order to insert extra welding points. Creating a program that simulates the continuous welding of a steel plate.

Unit 5  Industrial Application 2

Creating a program that simulates the automated painting of a surface with a spray gun. Editing the program to modify the spraying speed. Editing the program to keep a constant angle between the nozzle of the spray gun and the surface being painted.

Unit 6  Industrial Application 3

Experimenting with the rotation of the Lab-Volt Rotary Carousel. Creating a program that simulates a galvanizing process by which parts are dipped into a bath of molten zinc and then moved to a carousel workstation.

Unit 7  Industrial Application 4

Creating a program where the robot pick up parts from one of the Lab-Volt Gravity or Pneumatic Feeders and drop them into a metallic can. When the feeder becomes empty, the robot stays at the home position until parts are placed in the feeder.

Unit 8  Industrial Application 5

Creating a program where the robot picks up parts from one of the Lab-Volt feeders and places them on the Lab-Volt Belt Conveyor. The parts are then moved along the conveyor belt in a continuous way.

Unit 9  Industrial Application 6

Creating a program where the robot picks up part from one of the Lab-Volt feeders and places them on the Lab-Volt Belt Conveyor. The parts are then moved a certain distance along the conveyor belt, the conveyor motor being alternately started and stopped by using TTL control signals.

Appendices
A  Equipment Utilization Chart
B  Connecting the Equipment
C  Teach Pendant Commands
Sample Exercise

Extracted from

Introduction to Robotics
UNIT OBJECTIVE

In this unit, you will create a program where the robot picks up parts from a feeder and places them on a conveyor belt.

DISCUSSION OF FUNDAMENTALS

A conveyor is an endless belt or rolling chain used to carry parts or materials from one point to another, such as from one workcell to another. The parts or materials are moved, over a horizontal or inclined plane, usually with continuous motion.

Figure 8-1 shows the Lab-Volt Belt Conveyor, Model 5118. The conveyor is operated by using microswitches mounted on the conveyor control panel, or by using control signals provided at the TTL output terminals of the robot base.

Figure 8-1. The Lab-Volt Belt Conveyor, Model 5118.

Note: For detailed information on the connection, operation, and control of the Lab-Volt Belt Conveyor, Model 5118, refer to Appendix D of the Lab-Volt User Guide "Robot System Model 5150".
EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart, in Appendix A of this manual, to obtain the list of equipment required to perform this exercise.

Procedure Summary

In this exercise, you will create a program that makes the robot pick up parts from a feeder and place them on a conveyor. The object positioning and the created program will resemble those previously used for Unit 7, except that this time, a belt conveyor will be used instead of a metallic can.

Note: This unit can be performed by using either the RoboCIM software or the optional Teach Pendant.

PROCEDURE

CAUTION!

When you are working with moving equipment, make sure you are not wearing anything that might get caught in the equipment, such as a tie or jewelry. If your hair is long, tie it out of the way. Pay particular attention to keeping your hands, other body parts, or anything attached to your body out of the mechanisms of the robot while the robot is moving.

Transferring Parts from a Feeder to a Conveyor

1. On the Work Surface, position the objects as shown in Figure 8-2 or 8-3, depending upon whether you are using a gravity feeder or a pneumatic feeder.

As the figures show, the reference point of the Belt Conveyor is the left-hand location pin of its location guide (when viewing the front panel of the Conveyor control box).

Note: If you are using RoboCIM, display the Object window for the feeder. In the field "Number of Parts", enter the number of parts you have placed in the storage section of the feeder; also, set the field "NO (Yellow) Terminal Connections" to "TTL 1".

Then, display the Object window for the conveyor. Set the field "On Work Surfaces" to "Yes", and the field "Conveyor Motion" to "Forward".
Figure 8-2. Object positioning with a gravity feeder (Model 5119 or 5121).
2. Connect the normally-open contact (yellow and black jacks) of the feeder microswitch to TTL input 1 of the robot base. The microswitch will prevent the robot from trying to grasp a part when the feeder becomes empty.
Industrial Application 5

☐ 3. On the control panel of the Belt Conveyor, make the following settings:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLOCK</td>
<td>DISABLE</td>
</tr>
<tr>
<td>SPEED</td>
<td>LOW</td>
</tr>
<tr>
<td>MOTOR</td>
<td>ENGAGE</td>
</tr>
<tr>
<td>DIRECTION</td>
<td>FORWARD</td>
</tr>
</tbody>
</table>

☐ 4. Turn on the conveyor, using the power switch on the left-hand side of its control panel.

Then, set the CLOCK switch to ENABLE the start of the conveyor motor. Place a square part on the conveyor belt and observe it as it is moved from right to left along the conveyor belt, until it falls on the Work Surface.

☐ 5. Create a program that will make the robot perform the following tasks in sequence:

a. Check the status of TTL input 1 to see if a part is available in the feeder.

b. If a part is available in the feeder, lower and position the open gripper near this part.

c. Close the gripper to grasp the part.

d. Slowly withdraw the part from the feeder, taking care that the part does not rub against or collide with the feeder.

e. Place the part on the right-hand extremity of the conveyor belt (initial location as identified on Figures 8-2 and 8-3). Since the conveyor is running continuously, the part is moved along the conveyor belt.

   **Note:** When defining the point where the part is placed on the conveyor belt, be sure that the part does not touch the conveyor belt so that, when released by the gripper, it will be clear of the gripper fingers, and will be allowed to move freely along the belt.

f. Return the end effector to the home position.

g. Restart from the beginning and run the program until the feeder becomes empty.

☐ 6. Once the program is completed, tested, and debugged, save it.

   **Note:** If, during program testing, you find that the pin of the conveyor microswitch impedes the motion of the parts on the conveyor belt, remove the microswitch from the conveyor.

Show your program to your instructor for approval.
If time permits, experiment further with the operation of the conveyor: set its SPEED switch to MEDIUM or HIGH and then execute your program again.

CONCLUSION

In this exercise, you created a program that made the robot pick up parts from a feeder and place them on a belt conveyor. The parts were moved along the conveyor belt until they fell on the Work Surface.

REVIEW QUESTIONS

1. What is a conveyor? What is it used for? Explain.

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Instructor Guide Sample

Extracted from

Introduction to Robotics
UNIT 2 PROGRAMMING

EX. 2-1 PROGRAMMING, USING ROBOCIM

ANSWERS TO REVIEW QUESTIONS

1. The work cell of a robot is the environment in which the robot must perform its task. When working with the Lab-Volt Robot System, the work cell consists of the following elements: the robot, the controller (that is, the computer that runs the RoboCIM software or the optional Teach Pendant), the Work Surface, and the various objects used (e.g. the film canister, the metallic can, the conveyor, the gravity feeder, etc.)

2. The work envelope of a robot is the area within which the robot motions can take place. In other words, the work envelope contains all the points that can be reached by the robot.

3. The end effector of a robot is that part attached to the arm by which objects can be grasped or worked upon. For example, the end effector can be a grinder, a welding torch, a paint nozzle, a vacuum pump, tweezers, a scalpel, a blowtorch, etc.

4. Four methods are: manual, walk-through, lead-through programming, and software programming.
   a. The manual method is achieved by an operator who physically sets the necessary end stops, switches, cams, electric wires, or hoses to complete a sequence of steps. This type of programming is characteristic of the less sophisticated robots.
   b. The walk-through method requires that an operator, experienced in performing the tasks to be performed by the robot, physically guides the end effector through the path required to perform this task. The defined path is recorded to memory through the sampling and recording of many points. This method requires that the robot arm be accurately and effortlessly guidable by the operator. Examples of applications for walk-through programming are robots used for painting with a spray gun or for arc welding.
   c. With the lead-through programming method, the operator uses a teach pendant to lead the robot through the desired positions. As the robot end effector reaches each desired point in the sequence of motion, the point is recorded into memory. The points recorded into memory are used to generate the path that the robot will follow during operation. This method corresponds to the programming method used with the Teach Pendant (Model 5106), or with the RoboCIM software placed in the Control mode (on-line).
d. With the software programming method, the robot is programmed by means of a computer. This method of programming is also known as off-line programming since the programming generally occurs away from the robot. This method corresponds to the programming method used with the RoboCIM software placed in the Simulation mode (off-line).

5. To permit repeated and continuous execution of the program, as a program is usually intended to be used for more and once.

**EX. 2-2 PROGRAMMING, USING THE TEACH PENDANT**

**ANSWERS TO REVIEW QUESTIONS**

1. The work cell of a robot is the environment in which the robot must perform its task. When working with the Lab-Volt Robot System, the work cell consists of the following elements: the robot, the controller (that is, the computer that runs the RoboCIM software or the optional Teach Pendant), the Work Surface, and the various objects used (e.g. the film canister, the metallic can, the conveyor, the gravity feeder, etc.)

2. The work envelope of a robot is the area within which the robot motions can take place. In other words, the work envelope contains all the points that can be reached by the robot.

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c. With the **lead-through programming** method, the operator uses a teach pendant to lead the robot through the desired positions. As the robot end effector reaches each desired point in the sequence of motion, the point is recorded into memory. The points recorded into memory are used to generate the path that the robot will follow during operation. This method corresponds to the programming method used with the Teach Pendant (Model 5106), or with the RoboCIM software placed in the Control mode (on-line).

d. With the **software programming** method, the robot is programmed by means of a computer. This method of programming is also known as off-line programming since the programming generally occurs away from the robot. This method corresponds to the programming method used with the RoboCIM software placed in the Simulation mode (off-line).

5. To permit repeated and continuous execution of the program, as a program is usually intended to be used for more than once.