Robotics, Integration, and Automation

BUILDING ROBOT JOBS

Name	Class/Period	Date

1. Overview

In this lab activity, you will use the position variables that you registered in the previous lab activity to create pick-and-place jobs. You will also create jobs that activate and deactivate digital output devices such as the gripper jaws and the conveyor motor.

2. Performance Objectives

After completing this lab activity, you will be able to:

- Create robot pick-and-place jobs for your project application.
- Create jobs that activate digital outputs.
- Play robot jobs.

3. Required Materials

You need the following materials to complete the lab activity:

- SmartCart 4.0
- Computer
- Ethernet cables

4. Required Software

No special software is required for this lab activity.

5. Inventory and Safety

Before beginning the lab activity, review this checklist and mark off each item as you complete it.

- ☐ All hardware components are available for this lab activity.
- ☐ Hands, hair, and clothing are securely away from the work area.
- ☐ The work area is clean and devoid of food or drink.
- ☐ Review the SmartCart safety guidelines.
- ☐ Read through the entirety of this lab activity to familiarize yourself with the requirements.

6. Lab Activity

6.1. Preliminary Steps

Robot Setup

Before starting this lab activity in earnest, ensure that your robotic system has the two tools and the position variables for the project application registered on the controller. Refer to the previous lab activity for instructions on how to register tools and position variables.

SmartCart Setup

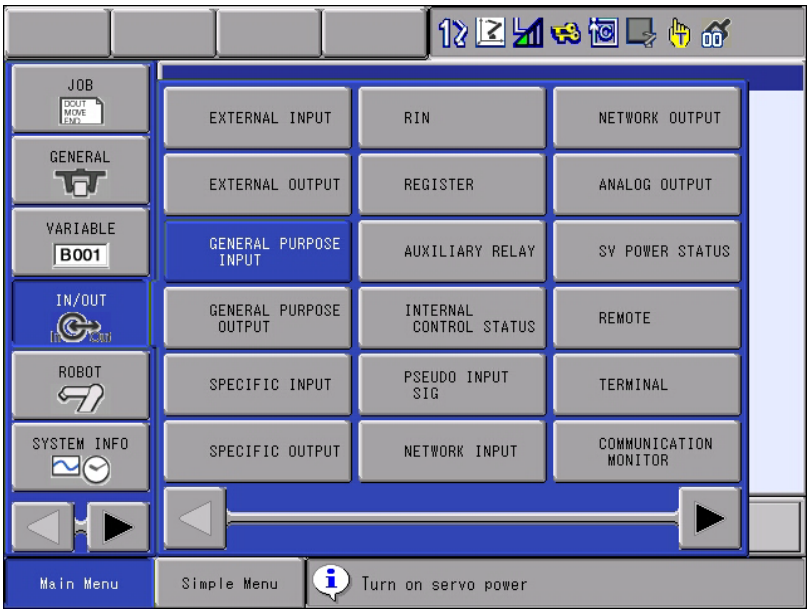
The tasks below require that a digital (conventional/non-smart) optical sensor is mounted onto the conveyor and that a second optical sensor is mounted onto the rotary table.

6.2. Testing Digital Input and Output Devices

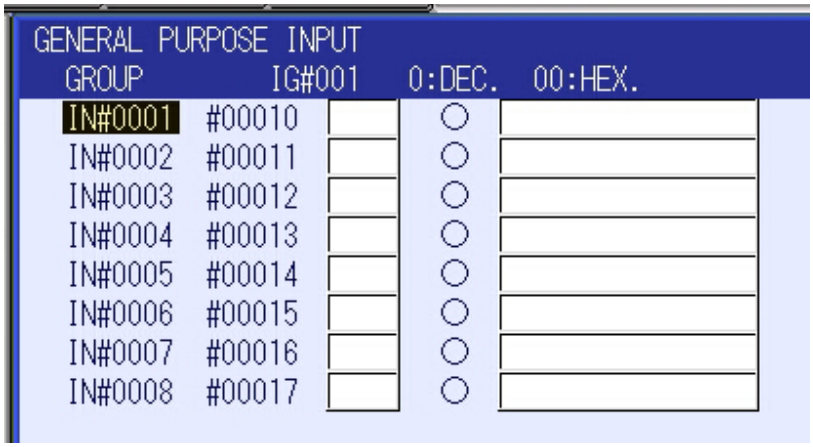
In this section, you will test the SmartCart's digital input and digital output devices.

Perform these steps.

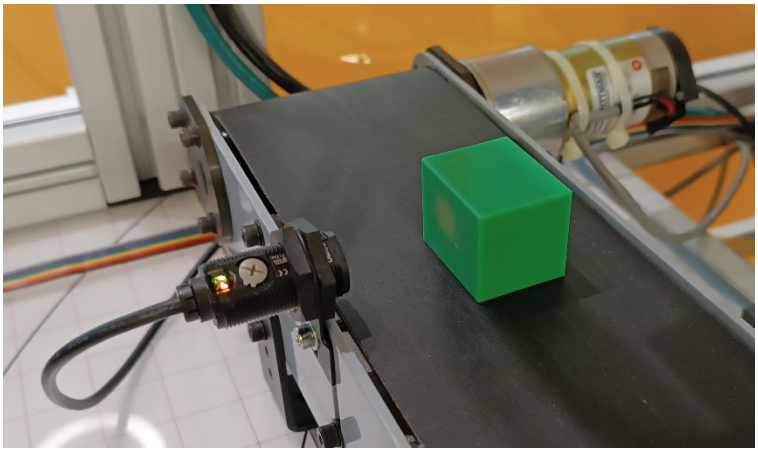
1. Power up the I/O box.
2. Turn on the air compressor.
3. Power up the robot controller. Wait for the robot to boot up.
4. Ensure that the programming pendant mode key is set to Teach mode.
5. Using the pendant, navigate to **IN/OUT > GENERAL PURPOSE INPUT**.



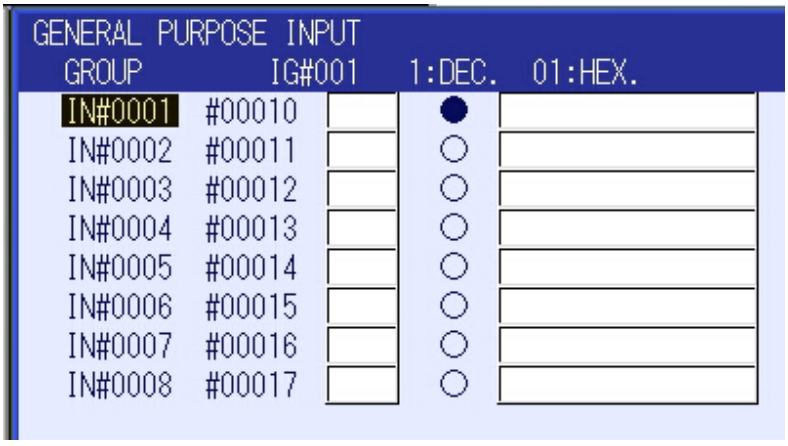
A list of digital input bits is displayed.



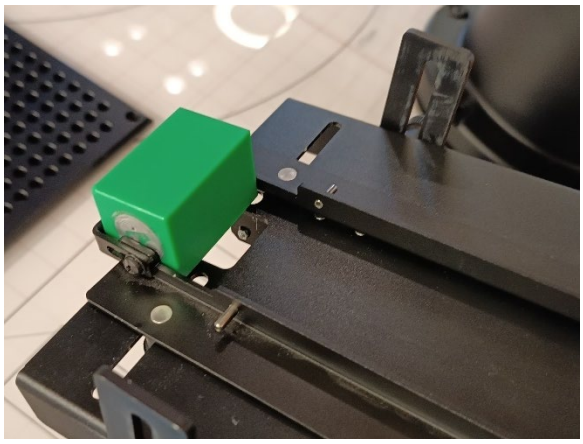
6. Place an object in range of the digital optical sensor on the conveyor.



7. Observe the list of inputs. Make a note of which input bit turns on.

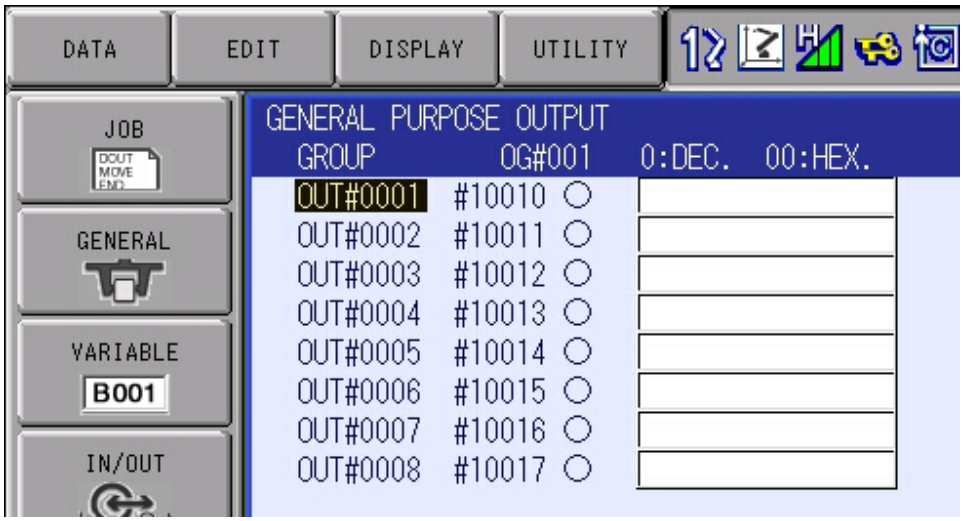


8. Remove the block from range of the optical sensor.
9. Place the block in range of the second optical sensor. Note which input bit turns on.
10. Place blocks on the various microswitches on the gravity feeder and experiment table. Note which input bits turn on when the blocks are placed.

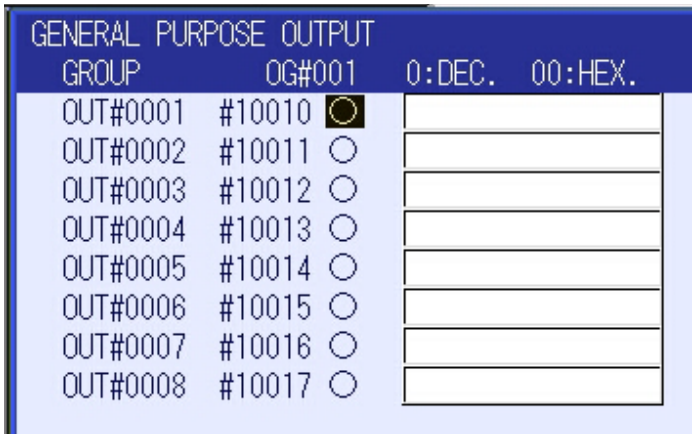



11. Remove all blocks from the microswitches and sensors.
12. Navigate to **IN/OUT > GENERAL PURPOSE OUTPUT**.

    A list of digital output bits is shown.



13. Move the cursor to the circle on the same row as OUT#0001.



14. Press INTERLOCK + SELECT. The circle is filled, indicating that the bit is on. The gripper jaws should open.

15. Press INTERLOCK + SELECT again. The circle becomes empty, indicating that the bit is off. The gripper jaws should close.

16. Move the cursor to the circle on the same row as OUT#0002. Press INTERLOCK + SELECT. The vacuum cup air pressure should turn on. Press INTERLOCK + SELECT a second time. The vacuum cup air pressure should turn off.

17. Move the cursor to the circle on the same row as OUT#0003. Press INTERLOCK + SELECT. The conveyor should turn on.

18. Move the cursor to the circle on the same row as OUT#0007. Press INTERLOCK + SELECT. The conveyor changes direction.

19. Turn off OUT#0003 while keeping OUT#0007 on. Note that output 3 controls the switching (on/off) status of the motor, while output 7 changes its direction. The value of output 7 is irrelevant when output 3 is off.

20. Test outputs 4 and 8, which control the rotary table motor switching status and direction, respectively.

21. Test outputs 5 and 6, which control the experiment table's buzzer and lamp, respectively.

22. When you are finished testing, turn off all outputs on the page.

6.3. Creating Gripper Jobs

In this section, you will program jobs that activate and deactivate the two end effectors: the gripper fingers (jaws) and the vacuum cup. These jobs will ultimately be called by the pick-and-place jobs that you will program later on.

Perform these steps:

1. On the pendant screen, navigate to **JOB > CREATE NEW JOB**.

ⓘ ***Note:*** *Add your initials to all jobs that you create in order to differentiate them from the jobs created by other course participants using the same robotic system.*

2. Enter a name for the new job such as *GRIP-OPEN*. This job will be responsible for opening the gripper fingers. Press **EXECUTE** when you're finished naming the job.

3. With the cursor on the address (left) side of the program (on line 0000), press INFORM LIST to open the Inform List, which is the list of Inform III programming instructions.

4. In the Inform List, navigate to **CONTROL > TIMER**. In the input buffer line, change the time to 0.3 seconds. Press ENTER to add the instruction.

   Your job should now look like this:

```
0000 NOP
0001 TIMER T=0.300
0002 END
```

5. In the Inform List, navigate to **IN/OUT > DOUT**. In the input buffer line, set the output to OT#(1). Press ENTER to add the instruction.

```
0000 NOP
0001 TIMER T=0.300
0002 DOUT OT#(1) ON
0003 END
```

6. Insert an additional timer instruction after the DOUT instruction.

```
0000 NOP
0001 TIMER T=0.300
0002 DOUT OT#(1) ON
0003 TIMER T=0.300
0004 END
```

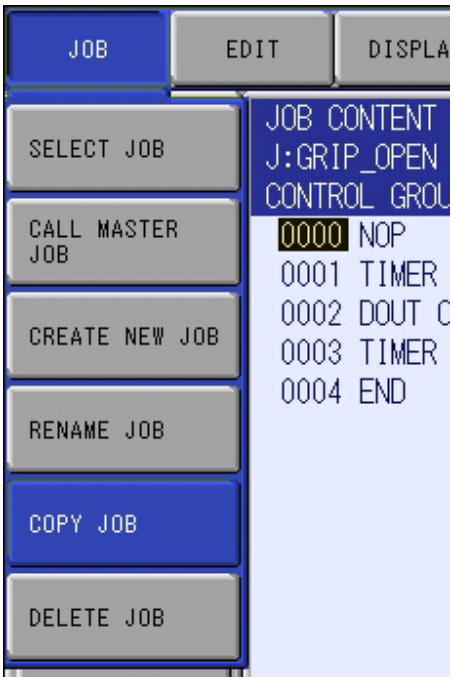
7. The job is now complete. Test the job. To do so:

   a. Press SERVO ON READY to turn servo power on. Grip the enable switch.

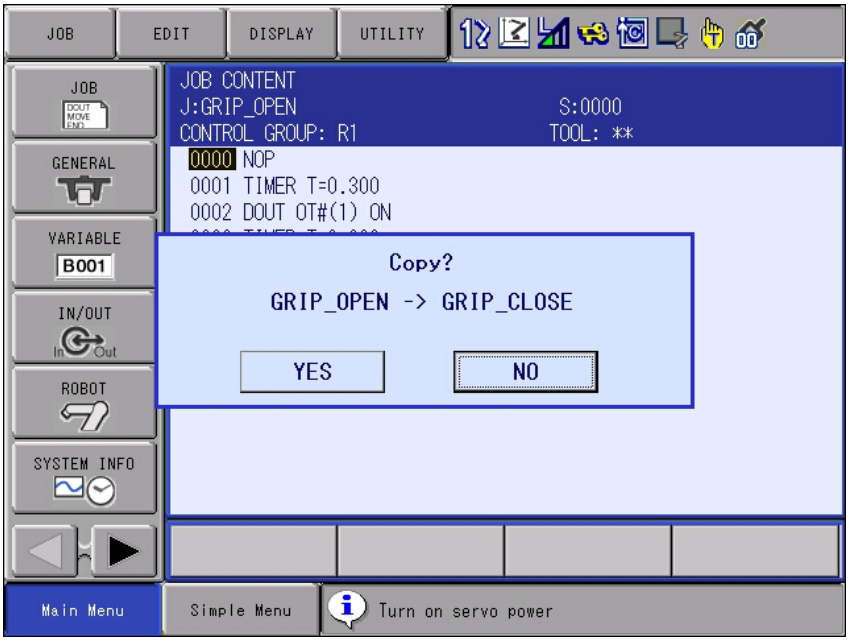
   b. Press INTERLOCK + TEST START.

   c. Observe the job execution and ensure that the gripper opens.

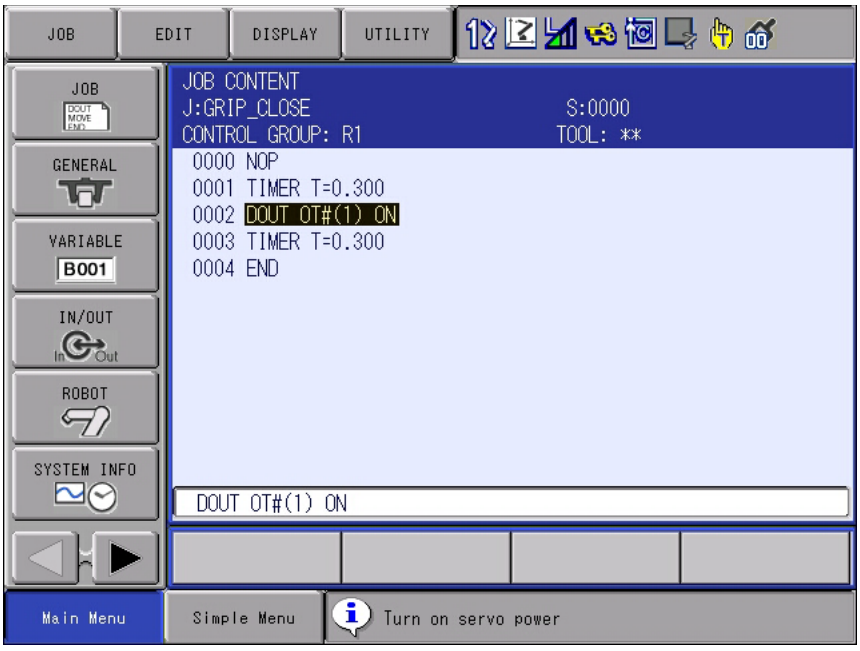
8. This job can be duplicated to quickly create the other gripper jobs. In the menu at the top of the pendant screen, select **JOB > COPY JOB**.



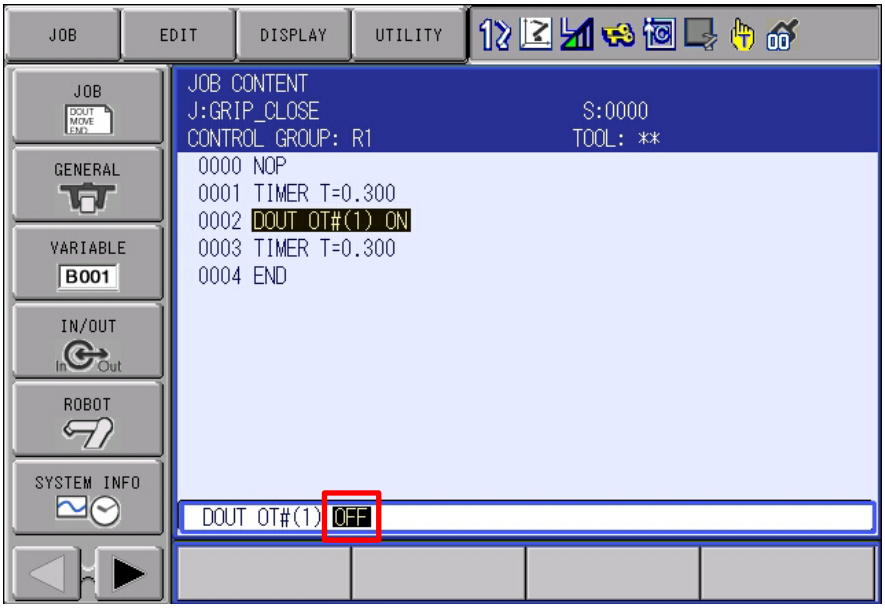
9. Rename the job *GRIP-CLOSE* or similar. The job will be used to close the gripper. Press **YES** when prompted.



10. Move the cursor to the DOUT step (on the instruction/right side) and then press SELECT.



11. In the input buffer line at the bottom of the screen, modify the instruction to turn output #1 **OFF**.



12. Press MODIFY + ENTER to enter the change into the program. The job should look like this:

```
0000 NOP
0001 TIMER T=0.300
0002 DOUT OT#(1) OFF
0003 TIMER T=0.300
0004 END
```

13. Test the job.

14. Repeat steps 8 to 13 to create jobs that control the operation of the vacuum cup.

Job Name	VACUUM ON	VACUUM OFF
Instruction Lines	0000 NOP 0001 TIMER T=0.300 **0002 DOUT OT#(2) ON** 0003 TIMER T=0.300 0004 END	0000 NOP 0001 TIMER T=0.300 **0002 DOUT OT#(2) OFF** 0003 TIMER T=0.300 0004 END

6.4. Pick-and-Place Jobs

In this task, you will create pick-and-place jobs for your project application. The task begins with a brief step-by-step procedure for creating a sample pick-and-place job that moves a workpiece (block) from the rotary table to the conveyor.

Warning: *For VJ motion, do not use a speed that is greater than 20.*

Perform these steps:

1. Ensure that there are no workpieces on the SmartCart. You will use a workpiece in a later step.

2. Create a new job and name it *ROTARY2CONVEYOR* or similar. The goal of this job will be to move a workpiece from a specific position on the rotary table to a specific position on the conveyor.

3. Open the Inform List. Select **MOTION > MOVJ**. In the input buffer line, for the position variable, select the home position or a neutral position in front of the robot. Modify the speed as well.

4. Press ENTER to insert the instruction line.

```
0000 NOP
0001 MOVJ P001 VJ=15.00
0002 END
```

Note: *Your position variable numbers will likely be different than the ones shown here.*

5. Add another MOVJ line to move the tool center point (TCP) to the approach position above the conveyor.

```
0000 NOP
0001 MOVJ P001 VJ=15.00
0002 MOVJ P005 VJ=15.00
0003 END
```

6. In the Inform List, select **CONTROL > CALL**. Select the **GRIP-OPEN** job. Press ENTER to insert the instruction line.

```
0000 NOP
0001 MOVJ P001 VJ=15.00
0002 MOVJ P005 VJ=15.00
0003 CALL JOB:GRIP-OPEN
0004 END
```

7. In the Inform List, select **MOTION > MOVL**. For the position variable, choose the pick position. Adjust the speed, and then press ENTER.

```
0000 NOP
0001 MOVJ P001 VJ=15.00
0002 MOVJ P005 VJ=15.00
0003 CALL JOB:GRIP-OPEN
0004 MOVL P006 V=60.0
0005 END
```

8. You will now test the program lines that you have written to help prepare the upcoming steps. Move the cursor to line 0003.

9. Turn servo power on (SERVO ON READY) and grip the enable switch.

10. Press and hold INTERLOCK + TEST START. The robot should open the gripper and move to the pick position.

11. Place a workpiece at the pick position. If you need to adjust the position variable, press DIRECT OPEN and modify it.

12. Move the cursor to the 0004 instruction line (on the address/left side). Add a CALL instruction to call the job that closes the gripper.

```
0000 NOP
0001 MOVJ P001 VJ=15.00
0002 MOVJ P005 VJ=15.00
0003 CALL JOB:GRIP-OPEN
0004 MOVL P006 V=60.0
0005 CALL JOB:GRIP-CLOSE
0006 END
```

13. Ensure that the cursor is on the 0005 instruction line. Press INTERLOCK + TEST START. The gripper closes on the workpiece.

14. Return the cursor to the address side of the 0005 instruction line. Add additional motion instructions to have the robot move the workpiece to the place position.

```
0000 NOP
0001 MOVJ P001 VJ=15.00
0002 MOVJ P005 VJ=15.00
0003 CALL JOB:GRIP-OPEN
0004 MOVL P006 V=60.0
0005 CALL JOB:GRIP-CLOSE
0006 MOVL P005 V=60.0
0007 MOVJ P007 VJ=15.00
0008 MOVJ P003 VJ=15.00
0009 MOVL P004 V=60.0
0010 END
```

15. Move the cursor to the line of the first new motion instruction (line 0006). Turn servo power on and grip the enable switch. Press and hold INTERLOCK + TEST START to move the robot with the workpiece to the place position. When executing the last motion instruction (line 0009), *proceed with caution*! Use DIRECT OPEN to modify the position if necessary.

16. Add a CALL instruction to open the gripper.

```
…
0009 MOVL P004 V=60.0
0010 CALL JOB:GRIP-OPEN
0011 END
```

17. Move the cursor to the line with the new CALL instruction (0011). Turn servo power on and grip the enable switch. Press and hold INTERLOCK + TEST START to open the gripper and release the workpiece.

18. Complete the job by inserting additional motion instructions and a CALL instruction to close the gripper.

```
...
0009 MOVL P004 V=60.0
0010 CALL JOB:GRIP-OPEN
0011 MOVL P003 V=60.0
0012 MOVJ P007 VJ=15.00
0013 MOVJ P001 VJ=15.00
0014 CALL JOB:GRIP-CLOSE
0015 END
```

19. Add comments to the job.

20. Place the workpiece at the pick position.

21. Move the cursor to job line 0000. Turn servo power on and grip the enable switch. Press and hold INTERLOCK + TEST START to test the entire job.

22. Return the workpiece to the pick position.

Warning: *You will play the job in the next step. Ensure that you are ready to press the emergency stop button if something unexpected happens.*

23. Turn the pendant's mode key to Play mode (center position). Turn servo power on.

24. Press the green play button at the top of the pendant. Observe the manipulator's execution of the entire job and ensure that it is satisfactory.

25. Turn the pendant's mode key back to Teach mode.

26. Repeat the steps in this task to create at least three jobs that will be used in the project application. In the next section (**Section 3: The PLC**), you will use the PLC to call these jobs in a specified order.

6.5. Creating Digital Output Jobs

In this task, you will create jobs that operate the rotary table motor and the conveyor motor.

Perform these steps:

1. Create a new job and name it *CONVEYOR* or similar. This job will be used to activate the conveyor motor for a set period of time.
2. Open the Inform List. Select **IN/OUT > DOUT**. In the input buffer line, change the output to **OT#(7)** and set the value to **OFF**. Recall that this output controls the direction of the conveyor.
3. Press ENTER to insert the instruction line.

```
0000 NOP
0001 DOUT OT#(7) OFF
0002 END
```

4. Add another DOUT instruction that turns the conveyor (OT#3) on.

```
0000 NOP
0001 DOUT OT#(7) OFF
0002 DOUT OT#(3) ON
0003 END
```

5. In the Inform List, navigate to **CONTROL > TIMER**. In the input buffer line, change the value of the timer to 10 seconds. Press ENTER to insert the instruction.

```
0000 NOP
0001 DOUT OT#(7) OFF
0002 DOUT OT#(3) ON
0003 TIMER T=10.000
0004 END
```

ⓘ ***Note:*** *For now, we have added a timer to the job for testing purposes. However, later, we will modify the job so that motor operation is controlled by the PLC. It is preferable not to use timers in an actual application.*

6. Complete the job by inserting another DOUT instruction to turn the conveyor motor off.

```
0000 NOP
0001 DOUT OT#(7) OFF
0002 DOUT OT#(3) ON
0003 TIMER T=10.000
0004 DOUT OT#(3) OFF
0005 END
```

7. Test the job in Teach mode (Using INTERLOCK + TEST START). If the test run is satisfactory, play the job in Play mode.

ⓘ ***Note:*** *The motor speeds for the rotary table and conveyor are controlled by the dials on the front of the cart. Now is a good time to get familiar with these dials. You can place a workpiece on the conveyor and see how fast the block travels at each speed level.*

8. Return the pendant mode key to Teach mode.

9. Create additional jobs for the conveyor to run in the opposite direction, as well as jobs for the rotary table to run in both directions. Use the Copy Job feature to speed up the job creation process.

Job Name	Conveyor Direction B	Rotary Table Direction A	Rotary Table Direction B
Instruction Lines	0000 NOP **0001 DOUT OT#(7) ON** 0002 DOUT OT#(3) ON 0003 TIMER T=10.000 0004 DOUT OT#(3) OFF 0005 END	0000 NOP **0001 DOUT OT#(8) OFF** **0002 DOUT OT#(4) ON** 0003 TIMER T=10.000 **0004 DOUT OT#(4) OFF** 0005 END	0000 NOP **0001 DOUT OT#(8) ON** 0002 DOUT OT#(4) ON 0003 TIMER T=10.000 0004 DOUT OT#(4) OFF 0005 END

10. If time remains, create several jobs that combine each of the rotary table and conveyor motors with digital input signals. For example, one possible job that you can create is that the conveyor will operate in one direction until (**CONTROL > WAIT** instruction) the optical sensor (IN#1) detects an object. The conveyor will pause for 1 second and then move in the opposite direction for 5 seconds.

```
0000 NOP
0001 DOUT OT#(7) OFF
0002 DOUT OT#(3) ON
0003 WAIT IN#(1) ON
0004 DOUT OT#(3) OFF
0005 TIMER T=1.000
0006 DOUT OT#(7) ON
0007 DOUT OT#(3) ON
0008 TIMER T=5.000
0009 DOUT OT#(3) OFF
0010 END
```

7. Summary and Next Steps

You have now completed *Section 2: Robotics*. In the next section, *Section 3: PLC*, you will learn about the Programmable Logic Controller and its role in the SmartCart 4.0 manufacturing system. One of the key responsibilities of the PLC will be to call the various robot jobs that you created in the correct order for the purposes of the project application.

8. Authentic Skill Assessment

Have your instructor verify that your work meets the requirements in the performance objectives and sign below. Keep this lab activity sheet for future reference.

Instructor Signature	Date

9. Reset Steps

This lab activity does not have any reset steps. However, ensure that the names of your jobs include your initials or name so they are not confused with the jobs of other course participants using the same robot.

10. Shutdown

Unless instructed otherwise by your instructor, review and complete each of the items on the checklist below.

- ☐ Jog the robot to a safe position with the gripper jaws pointing downwards.
- ☐ Power down the robot controller.
- ☐ Ensure the pendant mode key is in Teach mode.
- ☐ Return the pendant to its storage hook on the side of the SmartCart.
- ☐ Power down the I/O box.