Automatic Syringe Feeder for Bioprinting Manual

Manufacturing Systems

ENGR 480

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Instructions

Loading the Machine

1.) Gather four syringes filled to 10 mL with printing filament.
2.) Load them into the syringe holder in the same orientation as the figures below.

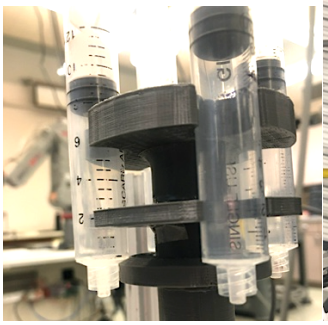


Figure 1

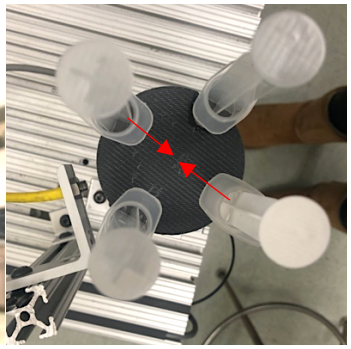


Figure 2

It is very important to make sure the syringes are all at the same height. The bottom ring on the syringe holder is there so all the tips get put in at the same height like in Figure 1. It is also very important to make sure the barrel flange is pointed inward, so the robot doesn't run into the neighboring syringes. Refer to Figure 2 to see how to align the syringes.

Starting the Machine

1. Before starting the program, make sure that the syringe holder is in the proper position
2. Make sure that the syringes are filled to 10 mL
3. Open the pressure valve on the Motoman MH5L
4. Turn on the Motoman MH5L and wait for it to finish setting up
5. Connect the PLC and Servo Motors to power
6. Put the PLC on run mode
7. Set the Motoman MH5L to play by turning the key on the remote
8. Press the "SERVO ON READY" button on the remote
9. Select the job on the remote by going to JOB>SELECT JOB
10. Find the program that you want to run and press the select button
11. To run the program, press the start button.

Stopping the Machine

When the program is complete, and you want to turn off the machine

1. Turn the PLC to stop
2. Disconnect the PLC and servo from power
3. Press down the emergency stop button (the servo on light should be off)

4. The robot can now be turned off

    *If you want to turn off the robot, the pneumatic gripper will release the syringe

5. Close the pressure valve on the robot

Emergency stop

1. Press the emergency stop button the robot

OR

1. Press the hold button to pause the program

Clearing Jams

If a syringe is not properly grabbed.

1. Press the hold button on the robot
2. Change to teach mode to release the syringe
3. Manually move the robot away from the syringe holder, typically toward the middle of the table
4. Start the machine over by following the steps above

If the servo motors aren't power on

1. Make sure everything is connected
2. Make sure PLC has power
3. Check to see if the PLC is in run mode
4. Restart program and check if motors run.

If the program starts printing without a syringe

1. Trip the lower sensor on the syringe extruder to start the replacement process

OR

1. Stop the program
2. Change to teach mode to release the syringe
3. Manually move the robot away from the syringe holder, typically toward the middle of the table
4. Start the machine over by following the steps above

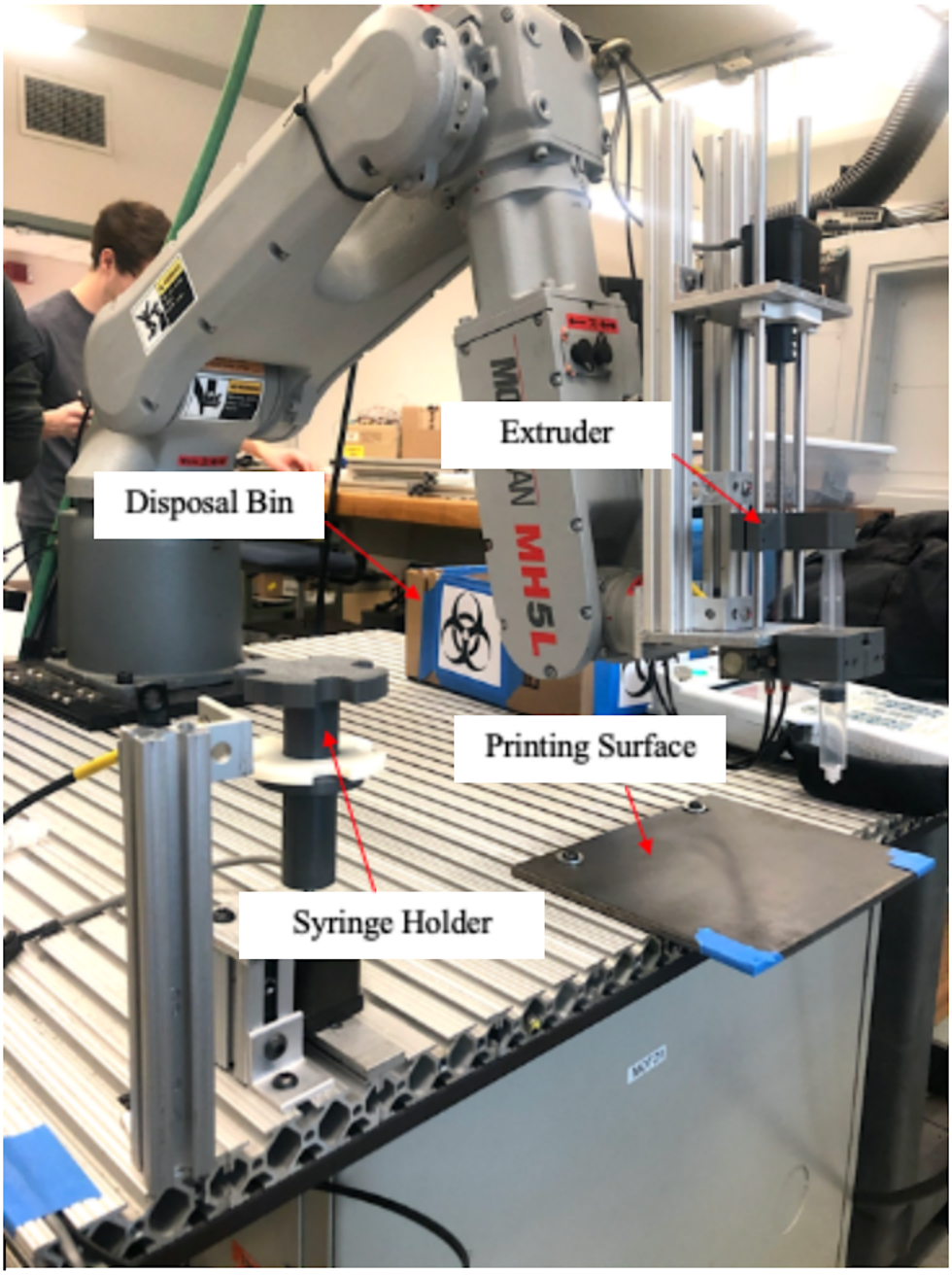
Maintenance Instructions

Follow proper maintenance instructions for the Motoman MH5L and Servo Motors.

If problems occur, check manufactured parts for signs of wear. Replace parts as needed.

Automatic Syringe Feeder for Bioprinting

Diagrams



Operation Description

The main functions of the Automatic Syringe Feeder for Bioprinting is replacing empty syringes with new ones. It does this by stopping the bioprinting program when it senses if the syringe is empty. If the syringe is empty the Motoman MH5L moves over to the disposal bin and disposes the syringe. Once the syringe is disposed of, the Motoman moves over to the syringe holder and grabs a new syringe. The system will then move to a location and apply pressure to the plunger of the syringe, collecting any biomaterial that may come out of the syringe. This step is to ensure that the extruder is in contact with the syringe plunger before printing begins. The syringe is now ready for printing and returns to the printing position where it can resume printing. For more information on the syringe holder and syringe extruder, go to the Syringe Holder and Syringe Extruder sections of the manual. For more information on how the system performs its functions check the stage diagrams for the Motoman and the PLC that are found under Stage Diagrams.

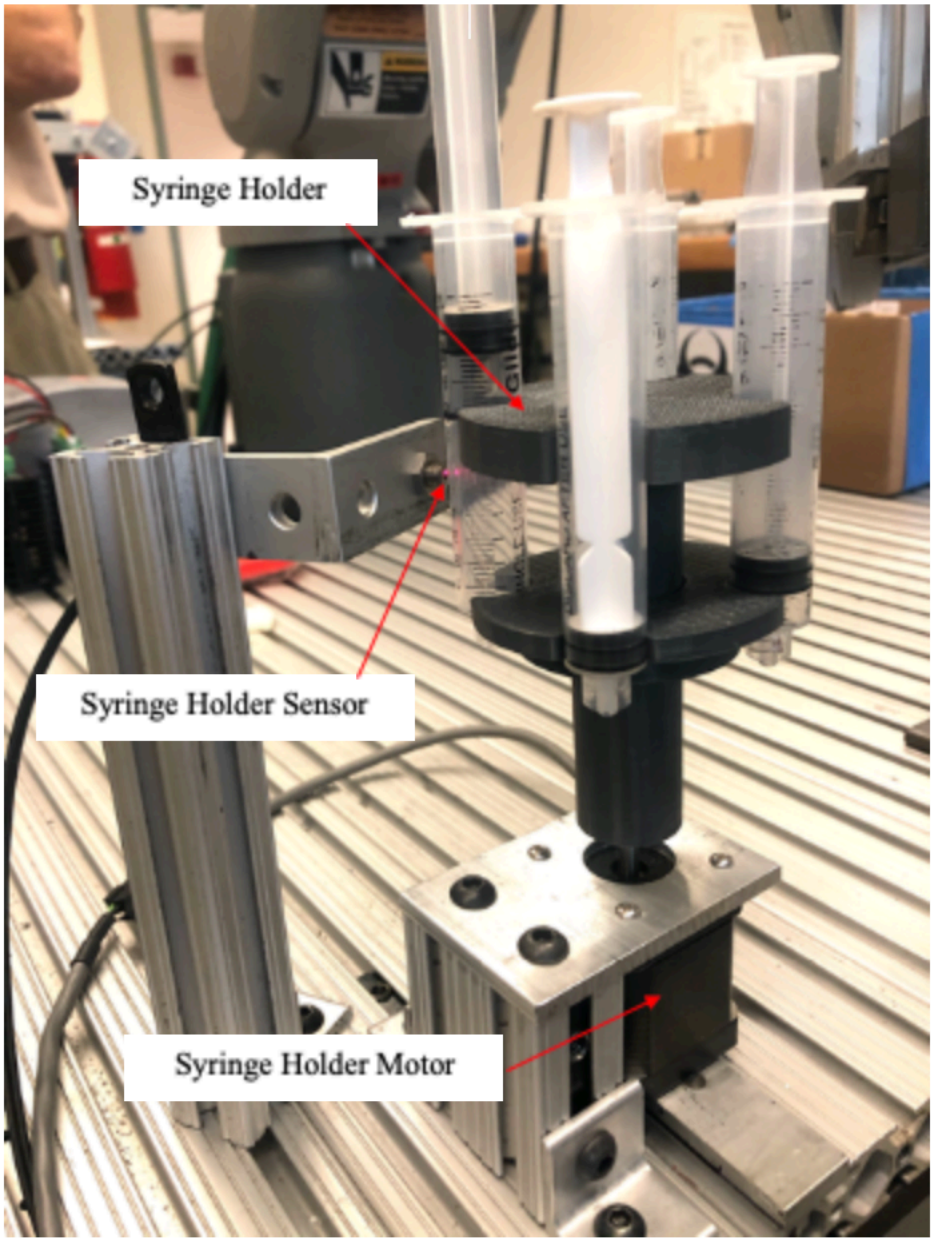
Future Improvements

There are some future improvements that can be made to the system as a whole, such as optimizing the speed of each function to reduce time through each cycle. The speed of the robot between stages could be increased to a limit, in order to reduce time between stages. In addition, the speed of the motors needs to change depending on the material that is used to be printing. Testing was not done using this system, so improvement can be made once testing and analysis has occurred.

The program for the Robot could use improvement. The code was written without prior experience, so it may not be the most efficient or robust code. With an experience coder, the program could be rewritten.

Syringe Holder

Diagrams



Operation Description

The main function of the syringe holder is to hold the syringes so the robot can come and grab them. There syringe holder system includes a sensor, so that the position of the syringe that is being picked up

remains constant. The sensor sense when the syringe, adjacent to the syringe being picked up, is in the correct position. After the robot grabs the syringe it rotates the syringe holder, so the sensor doesn't sense the syringe anymore. This causes the syringe holder to rotate so a new syringe will be ready for the robot to pick up.

The syringe holder has two points of contact to hold the syringe in. It also has a ring with a similar profile to the tip of a syringe. This ring is in place so the syringes get put in at the same height every time. There is gear press fit into the tube of the syringe holder that connects it to the motor. All pieces of the syringe holder are 3D printed except the gear pressed in the bottom.

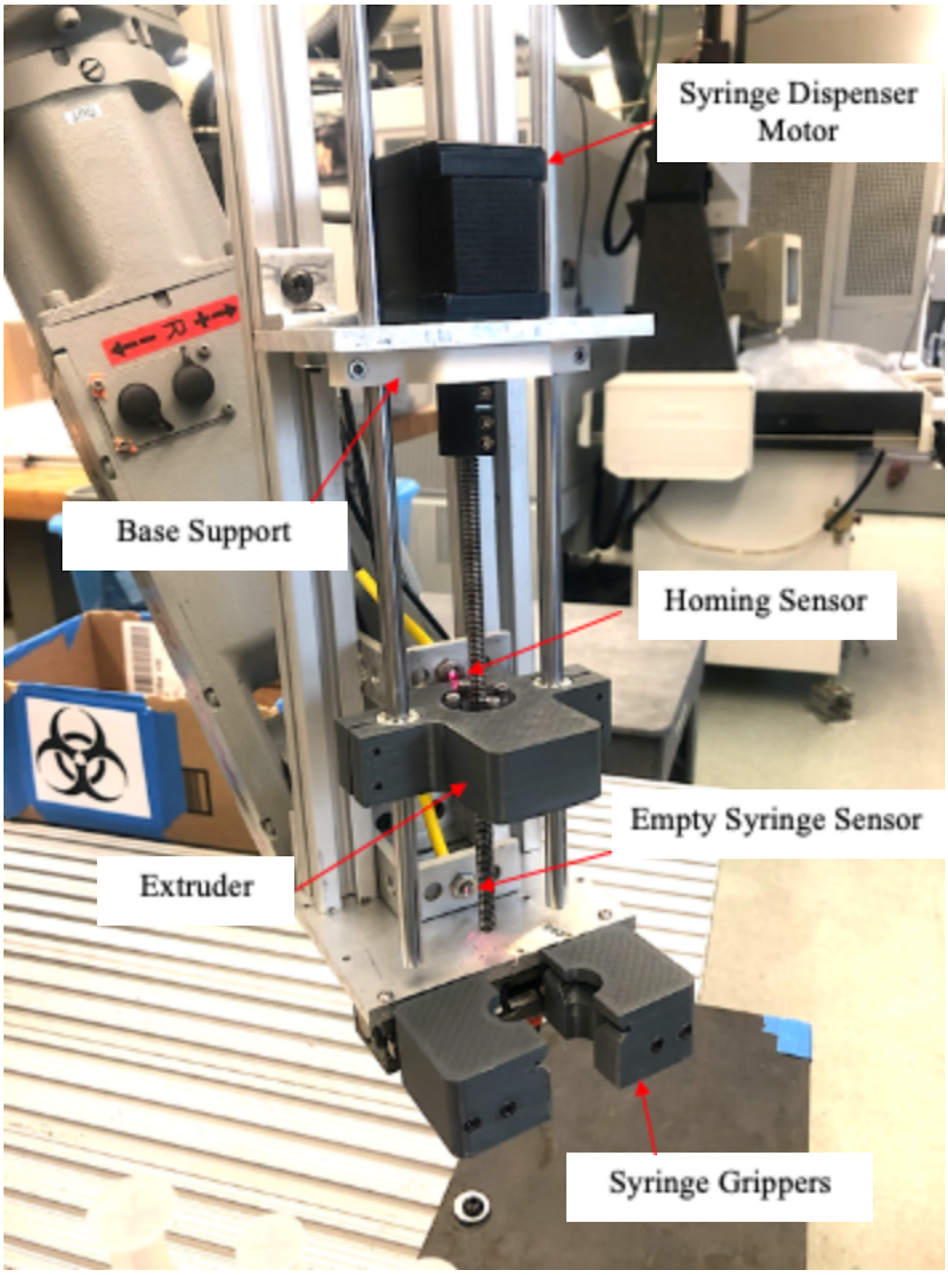
Future Improvements

There is room for improvement with the syringe holder. The main improvement would be to make the diameter of the portion that holds the syringes bigger to allow the robot more room to go in and grab a syringe without messing up the orientation of any other syringes. In addition, a bigger radius could allow more syringes to be loaded into the syringe holder at one time. Currently, the syringe holder makes sure that the syringe that is being picked up is in the right location, by sensing the location of the syringe behind it. Without that second syringe, the syringe holder will not work properly. In a future design, the sensor should sense the syringe that is being picked up.

This design is a prototype and doesn't use materials that meet every design criteria. This design could be made more sanitary if all three pieces were machined from stainless steel. The tube portion could be cut from stainless steel rod while the circular portions that hold the syringe could be laser cut from sheet stainless steel and welded to the rod. A more sophisticated way to hold the syringe holder onto the motor could be manufactured besides a gear pressed in to the bottom. Besides the material, this design is sanitary. There aren't any laminations that would make it hard to clean.

Syringe Extruder

Diagrams



Operation Description

The main operation of the syringe extruder is to use a lead screw and motor to slowly extrude the filament out of the syringe. The syringe extruder is made up of a motor, lead screw, guide rods, the extruder, grippers, a base support, and two sensors. The extruder, base support, and grippers are all 3D printed parts.

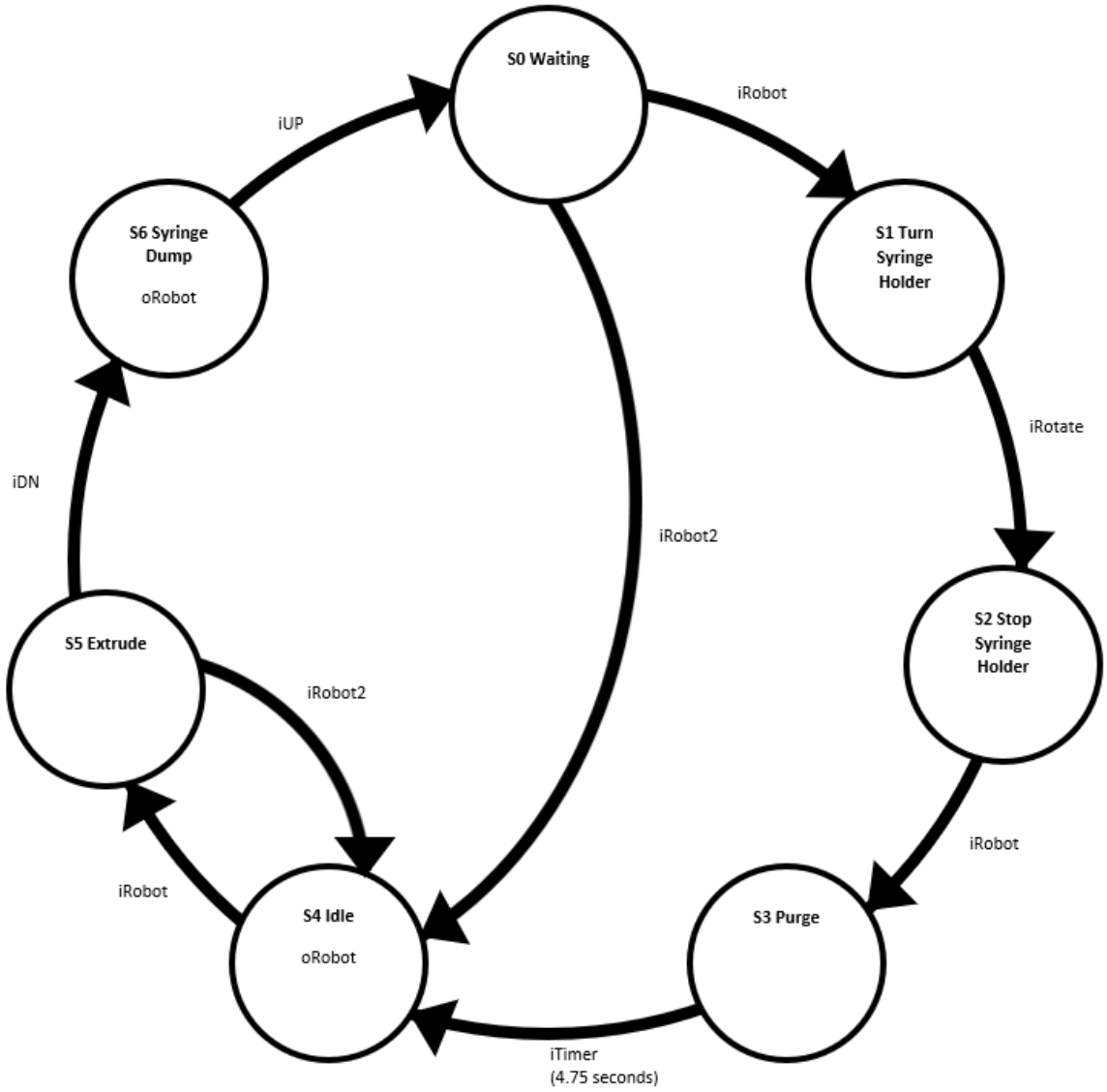
The grippers are opened and closed using pneumatics to grab or release a syringe. The extruder is moved up and down by the motor turning the lead screw. The extruder is extended out enough to push down on the top of the syringe to push filament out the end of the syringe. The base support is used to hold the guide rods and motor together through the aluminum plate.

Future Improvements

There are several improvements that could be made to this design. The main improvement is to design a better gripper system. The current gripper design is fine if it is 3D printed, however, it would be difficult to machine. There are also laminations between the 3D printed portion of the gripper and the metal portion that uses pneumatics. These laminations could make it hard to keep clean and sterile. The extruder could be improved by cutting it out of sheet stainless steel and then doing some post machining on it. The base support is very similar to the extruder and could be cut out of sheet stainless steel and then have some post machining. There are also other places that would be hard to clean like around all the screws we used and around the sensors. Two other improvements would be to reduce the overall size of the extruder system and to improve rigidity so when the extruder is moving it doesn't wobble. In addition, The grippers could be improved on this system. Their current design requires the robot to be very accurate when picking up a syringe. They could also be improved from a sanitary stand point as well.

Stage Diagrams

PLC Stage Diagram



Stage Description

S0: Waiting

The PLC waits until the robot communicates that a printing program has been started. If the robot senses that a syringe is needed (iRobot), it will jump to stage 1. If the robot senses that a syringe is already in position (iRobot2) it will jump to stage 4.

S1: Turn Syringe Holder

The sensor that is part of the syringe holder senses if the syringe is in position. If it is not in position, the stepper motor rotates the holder. Once the sensor (iRotate) is trigged the PLC jumps to stage 2.

S2: Stop Syringe Holder

Stage 2 stops the syringe holder from rotating and waits for the robot to send an input (iRobot) that it can move to stage 3. This input is sent to the PLC when the robot has picked up a syringed and moved away from the syringe holder.

S3: Purge

When the PLC is in stage 3, it means that the robot has moved into position to get the extruder ready. Stage three rotates the stepper motors of the syringe extruder, for a duration of time, which moves the extruder down pressing down on the syringe. This is done because they extruder has to be higher than the syringe when the syringe is being picked up. Once it has been picked up the extrude needs to come in contact with the syringe before it can print. In this stage the syringe is held above a cup, or some sort of catcher, to catch any material that may come out the needle of the syringe. Once the timer is complete (iTimer), the PLC jumps to stage 4.

S4: Idle

Stage 4 is the idle stage. In this stage, there should be a syringe in the syringe holder ready for printing. The PLC waits for the robot to tell it to start a program (iRobot). At this stage, the PLC sends an output to the robot saying that it can start or continue running the printing program. During this stage the PLC sends an output to the robot, telling it that it can start its program.

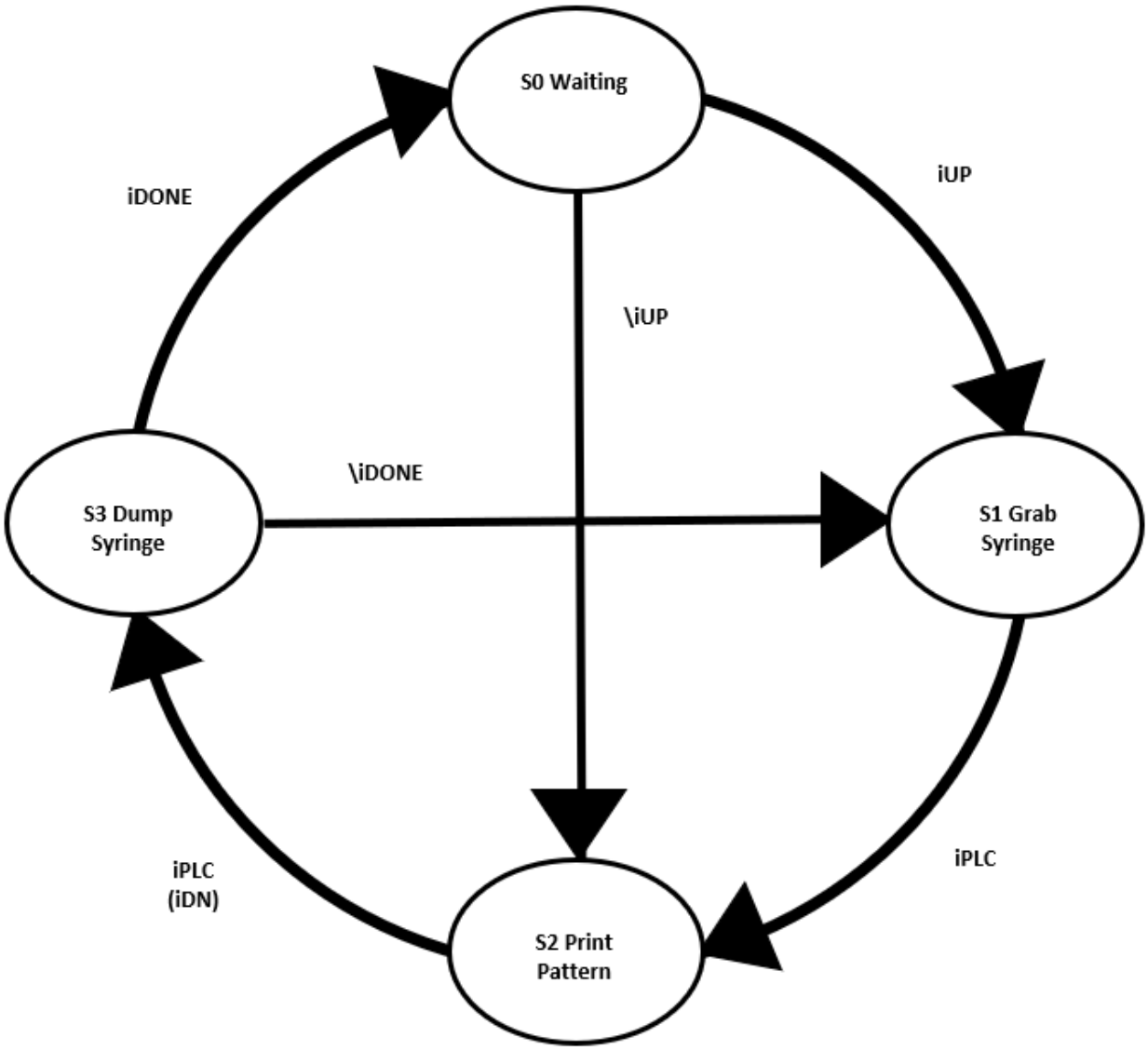
S5: Extrude

During this stage, the stepper motors in the syringe extrude move the extruder downward at a constant velocity. The stepper motors continue until the syringe is empty (iDN) or the printing program is completed (iRobot2). If the syringe is empty it will jump to stage 6, run through the PLC code to add a new syringe, and continue the code. If the code ends while the syringe is not empty, it will jump to stage 4, where it will wait for another program to be run.

S6: Syringe Dump

Once in stage 6, the syringe extrude backs off of the syringe and continues to move away until it returns to its top position. This top position allows enough space for syringes to be picked up. Once the sensor is triggered (iUP) the ladder code jumps back to stage 0.

Motoman Stage Diagram



Stage Description

S0: Waiting

In this stage the program has not started. It's an idle stage where it waits for the user to press the start button to begin the program. Once the program is initiated, the robot looks at the homing sensor (iUP) to see if it is on or off. If the sensor is off the program jumps to stage 2. If the sensor is on the program jumps to stage 1.

S1: Grab Syringe

During stage 1, the robot communicates with the PLC and initiates the program which will grab a syringe off the syringe holder and moves it to a purge location. Once in this stage the robot begins by moving towards the syringe holder. Once it is in position, it takes hold of a syringe and removes it in a way that rotates the syringe holder so the sensor (iRotate) is no longer activated. Next, the robot moves to a location which allows the extruder to come in contact with the syringe plunger, this may cause purging of some of the contents. Once in this location it sends an output to the PLC (PLC stage 3). It will move on to stage 2 once it receives a signal from the PLC that the extruder has finished moving (iPLC).

S2: Print Pattern

The robot will begin the programmed pattern. Since the robot works in the polling fashion, the pattern moves in small segments. If the syringe becomes empty, the PLC will send a signal (iPLC) to the robot. The robot will finish the segment it is currently in and then move on to the next stage, where it will initiate

S3: Dump Syringe

The robot simply dumps out the empty syringe into a box. Depending on whether the robot is done with the printing pattern or not it will change what it does next. If the robot is done with the pattern, (iDONE) then it will go home and stop the program until the user starts it again. If the pattern is not done (\iDONE) then it will jump to stage 1.

Wiring Diagram

Step Motor Drive

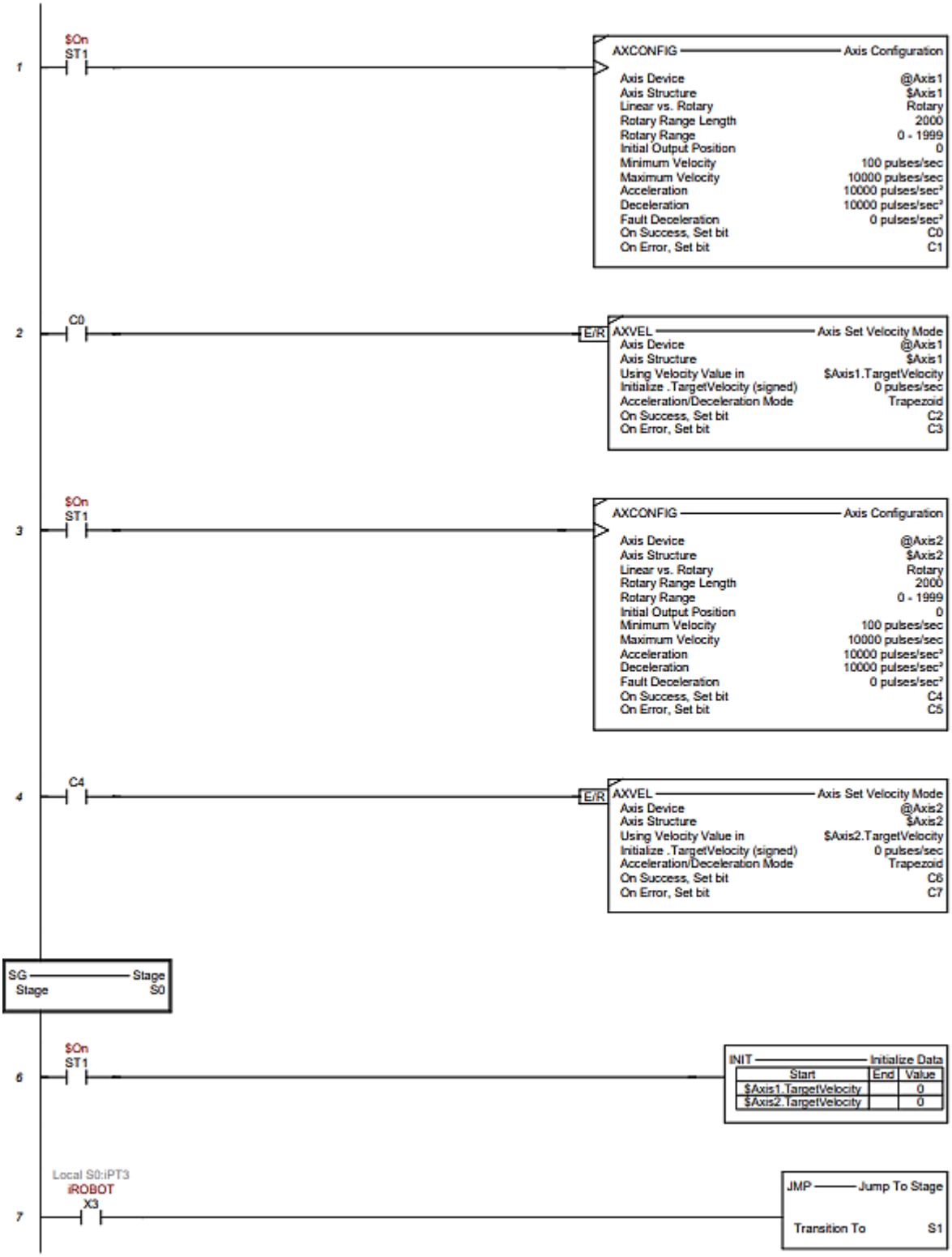
Step Motor Drive Wiring Diagrams					
Step Motor Drive (1)			**Step Motor Drive (2)**		
Name	**Terminal**	**Connection**	**Name**	**Terminal**	**Connection**
Voltage	VDC+	48 Volts	Voltage	VDC+	48 Volts
	VDC-	Ground		VDC-	Ground
Step Motor	A+	Red Wire	Step Motor	A+	Red Wire
	A-	White Wire		A-	White Wire
	B+	Green Wire		B+	Green Wire
	B-	Black Wire		B-	Black Wire
PLC Output	DIR-	Y1	PLC Output	DIR-	Y5
	STEP-	Y0		STEP-	Y4
Motor Power	DIR+	24 Volts	Motor Power	DIR+	24 Volts
	STEP+	24 Volts		STEP+	24 Volts
Rotary Switch Setting:	**7**		Rotary Switch Setting:	**7**	
DIP Switch Setting:	**5,6**	**Only On**	DIP Switch Setting:	**3,4,5,6**	**Only On**

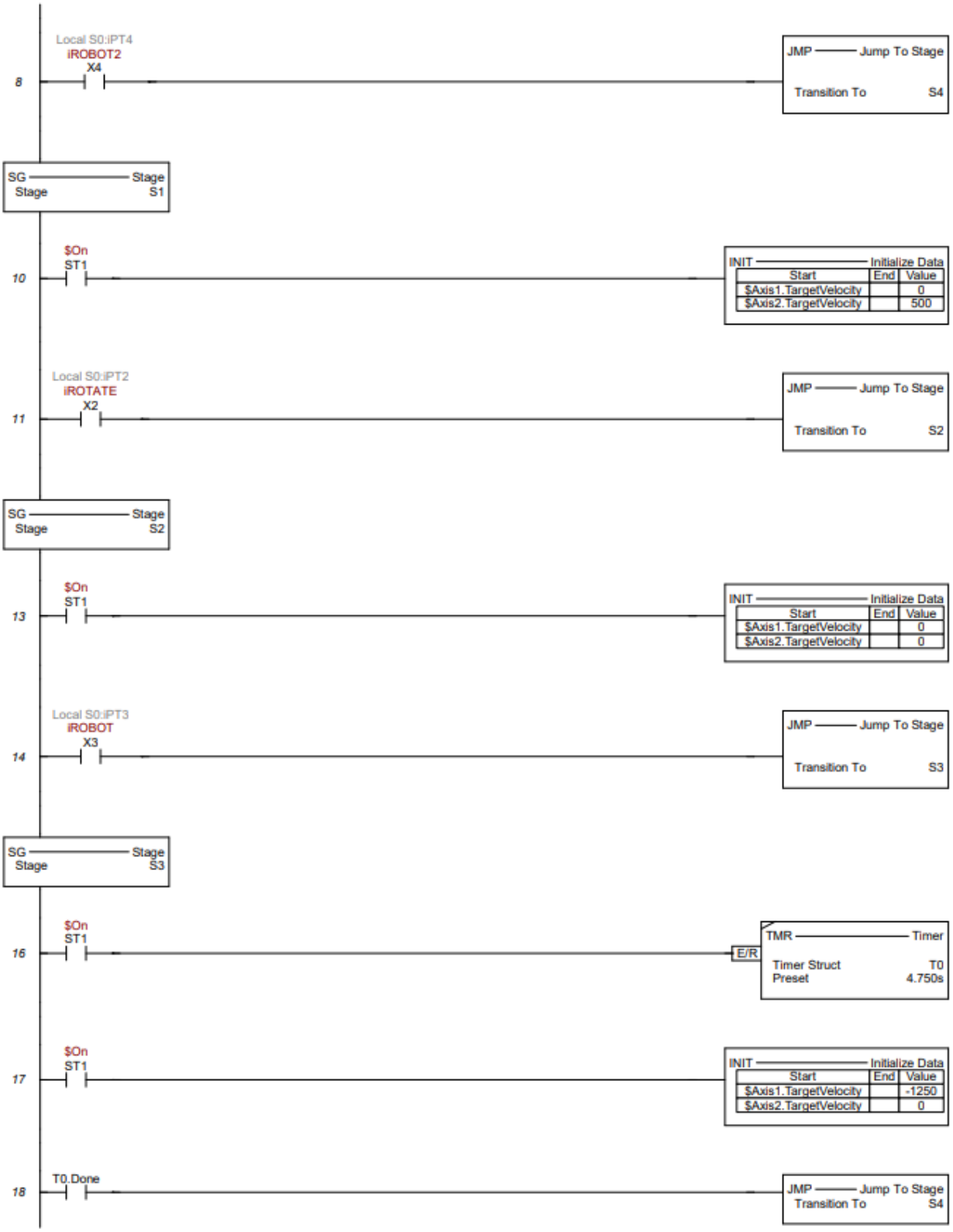
PLC Wiring

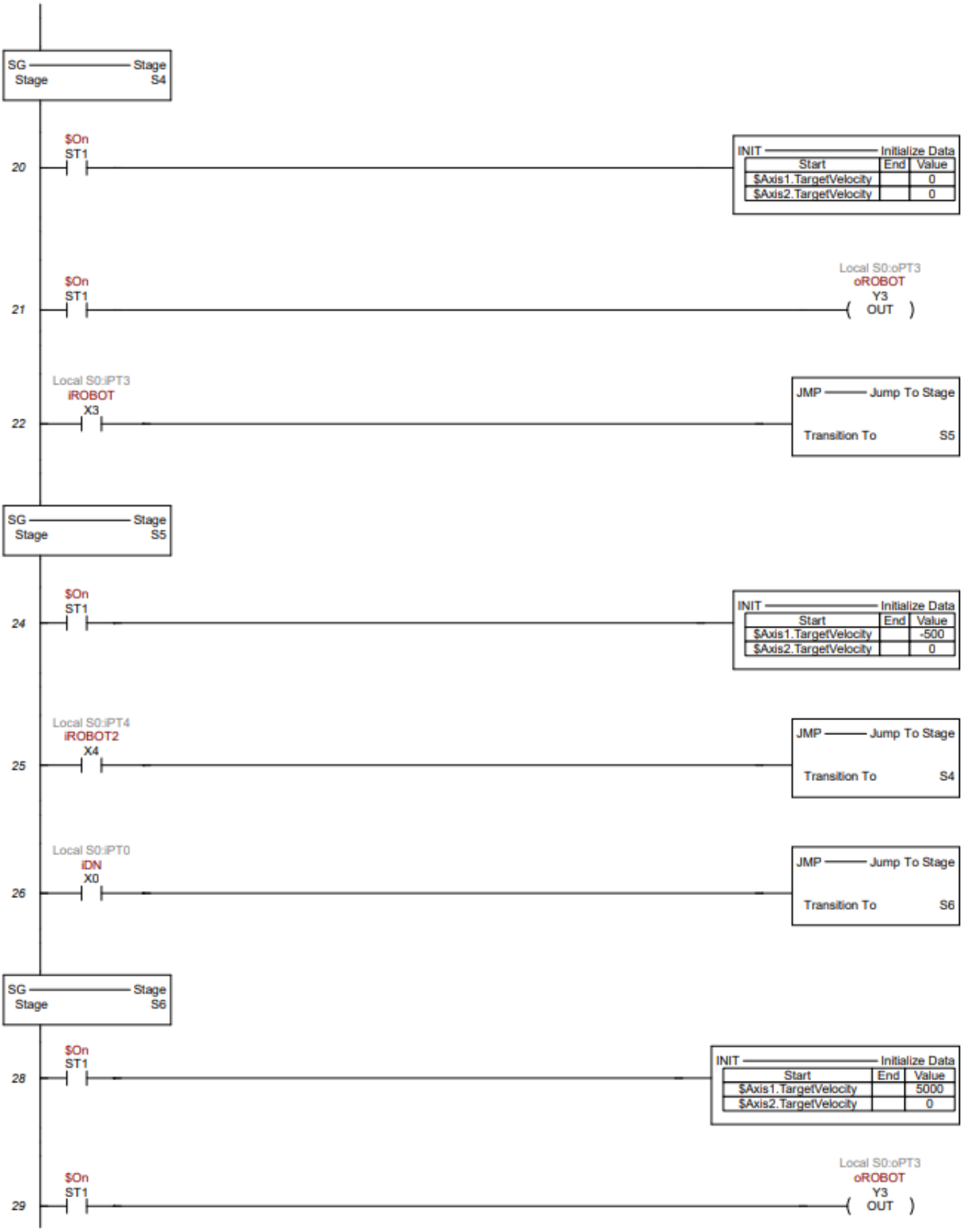
PLC Wiring Table					
Inputs			**Outputs**		
Name	**Terminal**	**Connection**	**Name**	**Terminal**	**Connection**
Input Common	X1C	24 Volts	Output Common	Y1C	Ground
Empty Syringe Sensor	X0	Black Wire	Syringe Dispencer Motor	Y0	STEP- (1)
Homing Sensor	X1	Black Wire		Y1	DIR- (1)
Syringe Holder Sensor	X2	Black Wire	PLC output to Robot #1	Y2	Robot X1
Robot output to PLC #1	X3	Robot Y1	PLC output to Robot #2	Y3	Robot X2
Robot output to PLC #2	X4	Robot Y2	Syringe Holder Motor	Y4	STEP- (2)
				Y5	DIR- (2)

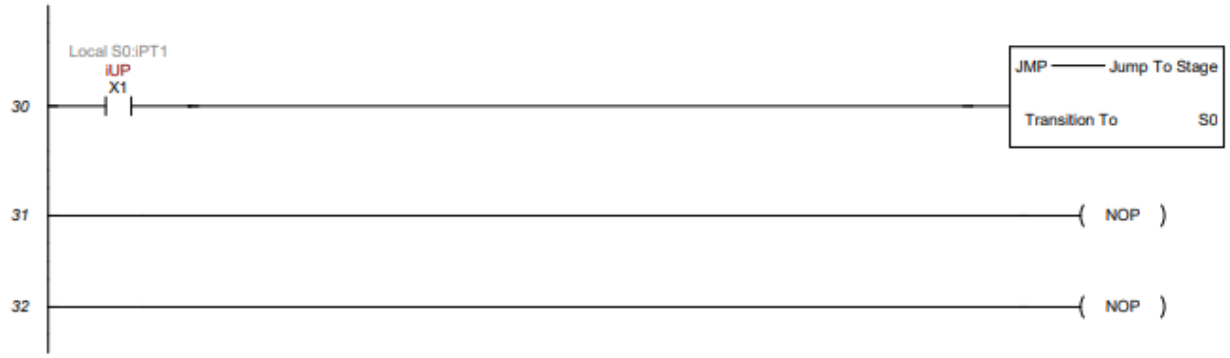
PLC & Motoman Logic

PLC Ladder Logic




Local S0:iPT4
iROBOT2
X4
8
JMP
Jump To Stage
Transition To
S4
SG
Stage
Stage
S1
$On
ST1
10
INIT
Initialize Data
Start
End
Value
$Axis1.TargetVelocity
0
$Axis2.TargetVelocity
500
Local S0:iPT2
iROTATE
X2
11
JMP
Jump To Stage
Transition To
S2
SG
Stage
Stage
S2
$On
ST1
13
INIT
Initialize Data
Start
End
Value
$Axis1.TargetVelocity
0
$Axis2.TargetVelocity
0
Local S0:iPT3
iROBOT
X3
14
JMP
Jump To Stage
Transition To
S3
SG
Stage
Stage
S3
$On
ST1
16
TMR
Timer
E/R
Timer Struct
T0
Preset
4.750s
$On
ST1
17
INIT
Initialize Data
Start
End
Value
$Axis1.TargetVelocity
-1250
$Axis2.TargetVelocity
0
T0.Done
18
JMP
Jump To Stage
Transition To
S4


SG
Stage
Stage
S4
20
$On
ST1
INIT
Initialize Data
Start
End
Value
$Axis1.TargetVelocity
0
$Axis2.TargetVelocity
0
21
$On
ST1
Local S0:oPT3
oROBOT
Y3
OUT
22
Local S0:iPT3
iROBOT
X3
JMP
Jump To Stage
Transition To
S5
SG
Stage
Stage
S5
24
$On
ST1
INIT
Initialize Data
Start
End
Value
$Axis1.TargetVelocity
-500
$Axis2.TargetVelocity
0
25
Local S0:iPT4
iROBOT2
X4
JMP
Jump To Stage
Transition To
S4
26
Local S0:iPT0
iDN
X0
JMP
Jump To Stage
Transition To
S6
SG
Stage
Stage
S6
28
$On
ST1
INIT
Initialize Data
Start
End
Value
$Axis1.TargetVelocity
5000
$Axis2.TargetVelocity
0
29
$On
ST1
Local S0:oPT3
oROBOT
Y3
OUT



Motoman Job Programs

Printing Code

/JOB

//NAME PRINTING

//POS

///NPOS 77,0,0,0,0,0

///TOOL 0

///POSTYPE PULSE

///PULSE

C00000=7889,55880,-62505,-5833,75455,103630

C00001=16457,81572,-38495,-5839,74261,103610

C00002=6046,66568,-50834,-5840,74018,103609

C00003=13321,81608,-38502,-5839,74240,103609

C00004=6046,66568,-50834,-5840,74013,103610

C00005=11466,81608,-38502,-5840,74223,103609

C00006=6046,66569,-50834,-5841,74008,103611

C00007=9738,81608,-38502,-5840,74212,103609

C00008=6045,66568,-50833,-5842,74003,103611

C00009=8106,81608,-38502,-5840,74195,103609

C00010=6045,66569,-50833,-5843,73998,103611

C00011=6408,81609,-38502,-5840,74185,103609

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C00019=-1207,81609,-38502,-5840,74133,103607

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C00021=-3161,81609,-38502,-5840,74122,103607

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C00026=6045,66574,-50833,-5850,73963,103612

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C00073=10225,80157,-41301,-5840,73936,103602
C00074=6045,66640,-50848,-5852,73906,103611
C00075=10225,78869,-43041,-5840,73929,103602
C00076=5446,27893,-78688,-5836,67233,103539
//INST
///DATE 2019/11/29 16:46
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(1) ON
DOUT OT#(3) ON
TIMER T=0.25
DOUT OT#(3) OFF
MOVJ C00000 VJ=3.00
MOVJ C00001 VJ=2.00
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00002 VJ=3.00
ELSE
        MOVJ C00003 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
```

```
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00004 VJ=3.00
ELSE
        MOVJ C00005 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00006 VJ=3.00
ELSE
        MOVJ C00007 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00008 VJ=3.00
ELSE
        MOVJ C00009 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
```

```
        MOVJ C00010 VJ=3.00
ELSE
        MOVJ C00011 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00012 VJ=3.00
ELSE
        MOVJ C00013 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00014 VJ=3.00
ELSE
        MOVJ C00015 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00016 VJ=3.00
ELSE
```

```
        MOVJ C00017 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00018 VJ=3.00
ELSE
        MOVJ C00019 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00020 VJ=3.00
ELSE
        MOVJ C00021 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00022 VJ=3.00
ELSE
        MOVJ C00023 VJ=0.25
        DOUT OT#(2) ON
```

```
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00024 VJ=3.00
ELSE
        MOVJ C00025 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00026 VJ=3.00
ELSE
        MOVJ C00027 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00028 VJ=3.00
ELSE
        MOVJ C00029 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
```

```
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00030 VJ=3.00
ELSE
        MOVJ C00031 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00032 VJ=3.00
ELSE
        MOVJ C00033 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00034 VJ=3.00
ELSE
        MOVJ C00035 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
```

```
        CALL JOB:SYRINGE_GRAB
        MOVJ C00036 VJ=3.00
ELSE
        MOVJ C00037 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00038 VJ=3.00
ELSE
        MOVJ C00039 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00040 VJ=3.00
ELSE
        MOVJ C00041 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00042 VJ=3.00
```

```
ELSE
        MOVJ C00043 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00044 VJ=3.00
ELSE
        MOVJ C00045 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00046 VJ=3.00
ELSE
        MOVJ C00047 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00048 VJ=3.00
ELSE
        MOVJ C00049 VJ=0.25
```

```
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00050 VJ=3.00
ELSE
        MOVJ C00051 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00052 VJ=3.00
ELSE
        MOVJ C00053 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00054 VJ=3.00
ELSE
        MOVJ C00055 VJ=0.25
        DOUT OT#(2) ON
ENDIF
```

```
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00056 VJ=3.00
ELSE
        MOVJ C00057 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00058 VJ=3.00
ELSE
        MOVJ C00059 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00060 VJ=3.00
ELSE
        MOVJ C00061 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
```

```
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00062 VJ=3.00
ELSE
        MOVJ C00063 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00064 VJ=3.00
ELSE
        MOVJ C00065 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00066 VJ=3.00
ELSE
        MOVJ C00067 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
```

```
        MOVJ C00068 VJ=3.00
ELSE
        MOVJ C00069 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00070 VJ=3.00
ELSE
        MOVJ C00071 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00072 VJ=3.00
ELSE
        MOVJ C00073 VJ=0.25
        DOUT OT#(2) ON
ENDIF
IFTHEN IN#(2)=ON
        DOUT OT#(2) OFF
        CALL JOB:SYRINGE_DUMP
        CALL JOB:SYRINGE_GRAB
        MOVJ C00074 VJ=3.00
ELSE
```

```
        MOVJ C00075 VJ=0.25
        DOUT OT#(2) ON
ENDIF
DOUT OT#(2) OFF
DOUT OT#(3) ON
TIMER T=0.25
DOUT OT#(3) OFF
MOVJ C00076 VJ=3.00
END
```

Syringe Dump Code

```
/JOB
//NAME SYRINGE_DUMP
//POS
///NPOS 2,0,0,0,0,0
///TOOL 0
///POSTYPE PULSE
///PULSE
C00000=4655,22835,-83826,-5830,75520,103620
C00001=85807,23428,-87366,-5830,75517,103620
//INST
///DATE 2019/11/25 14:57
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(1) ON
MOVJ C00000 VJ=3.00
MOVJ C00001 VJ=3.00
DOUT OT#(1) OFF
END
```

Syringe Grab Code

```
/JOB
//NAME SYRINGE_GRAB
//POS
///NPOS 10,0,0,0,0,0
///TOOL 0
///POSTYPE PULSE
///PULSE
C00000=-8061,80247,-24767,-51555,73280,110405
C00001=-16789,80115,-24087,-37603,69984,110249
C00002=-16038,80111,-23883,-37604,69960,110247
C00003=-15518,80111,-23319,-37604,69960,110247
C00004=-14866,80251,-22939,-37604,69960,110247
C00005=-14866,80251,-21275,-37604,69960,110247
C00006=-10874,80251,-21275,-37604,69960,110247
C00007=-10875,50222,-48815,-37605,69940,110248
C00008=-38395,50222,-48815,-37605,69940,110248
C00009=-38395,76952,-41465,-37605,77012,106750
//INST
///DATE 2019/11/29 15:01
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(1) OFF
MOVJ C00000 VJ=3.00
MOVJ C00001 VJ=0.78
DOUT OT#(1) ON
MOVJ C00002 VJ=0.78
MOVJ C00003 VJ=0.78
```

```
MOVJ C00004 VJ=0.78
MOVJ C00005 VJ=0.78
MOVJ C00006 VJ=0.78
DOUT OT#(2) ON
TIMER T=0.25
DOUT OT#(2) OFF
MOVJ C00007 VJ=3.00
MOVJ C00008 VJ=3.00
MOVJ C00009 VJ=3.00
DOUT OT#(2) ON
TIMER T=0.25
DOUT OT#(2) OFF
WHILE IN#(1)=OFF
        CWAIT
ENDWHILE
END
```

Final Code

```
/JOB
//NAME FINAL
//POS
///NPOS 0,0,0,0,0,0
//INST
///DATE 2019/11/29 15:30
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(3) OFF
DOUT OT#(2) OFF
IFTHEN IN#(3)=ON
```

```
        CALL JOB:SYRINGE_GRAB
ENDIF
CALL JOB:PRINTING
END
```