EDWARD F. CROSS SCHOOL OF
ENGINEERING
WALLA WALLA UNIVERSITY

Robotic YO-YO Assembly System Instruction Manual

ENGR 480: Manufacturing

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1 Operating Instructions

This section includes instructions for starting, loading, clearing jams and shutting down the assembly machine. This includes the robotic arm, PLC controller and pneumatic system.

1.1 Starting

1. Ensure that parts are loaded in all stations. This includes: YO-YO halves, bearings, set screws and silicone gel.
2. Power on the robotic arm and controller.
   2.1. Turn the large knob style switch on the side of the robot controller to ‘ON’.
   2.2. Wait for the boot cycle in the robot control pendant to complete
      2.2.1. When complete the control pendant will display ‘Please select a Main Menu’.
   2.3. Ensure the key at the top left of the control pendant is switched to ‘PLAY’.
   2.4. Ensure the E-stop at the top right of the control pendant is off.
3. Power on the PLC.
   3.1. Plug the orange extension cord into a power outlet.
   3.2. Ensure the 3-way switch at the bottom right of the PLC is switched to ‘RUN’.
4. Turn on the system air.
   4.1. Switch the air valve mounted next to the PLC to ‘C-2’.
      4.1.1. You should hear a small release of air when switching from the off position (labeled ‘N’) to the on position (labeled ‘C-2’) or vice versa.
5. Select the job “JOB_1” in the robot control pendant
   5.1. Using the touch screen on the control pendant select ‘JOB’ ➡ ‘JOB_1’
   5.2. Using the arrow buttons scroll to ‘JOB_1’ and push the ‘SELECT’ button
   5.3. Move the key in the upper left-hand corner to ‘REMOTE’.
   5.4. Push the ‘SERVO ON READY’ button and then the green ‘START’ button
6. Start the assembly process by pushing the green button mounted next to the PLC

1.2 Loading

Four stations will be loaded with YO-YO parts.

6.1. Set screws – located in station 1.1, these are laying down in the channel and are allowed to slide down to the stopper at the end of the channel.
6.2. Yo-Yo halves – located in station 1.2, these are simply placed (large, flat side down) on the gravity fed ramp and allowed to slide down to the end of the track.
6.3. Bearings – located in station 1.3, these are placed (flat side down) on the gravity fed ramp and allowed to slide down to the end of the track.
6.4. Silicone gel – located in station 3, the syringe is filled and placed in the stepper motor driven clamp.

1.3 Clearing Part Jams

Feeding station jams – Jams occurring in any of the three feeding substations can be cleared tapping the track or the jammed part, simply allowing the gravity-fed flow of parts to resume. Set screws jammed in the feeding station may need to be straightened at the end of the track.

Silicone station jams – When a jam occurs in the syringe supplying the silicone gel, the syringe may need to be removed and cleaned out. First, check to see that there is no visibly hardened gel that can be removed by hand. Next, remove and clean the attachment on the end of the syringe and if that still doesn't clear it, the gel may be hardened in the syringe itself.

Collet assembly station jams – Jams may result from the collet closing prematurely on the YO-YO halves, in which case the collet simply needs to be released and the YO-YO be repositioned so that it properly fits.

1.4 Issues Involving the Robot

The main issue that will be encountered when using the robot will be in the event of a collision, an event that usually transpires if one of the assembly stations is not assembled or repaired properly, resulting in the robot being misaligned. In the event that there is a collision or an emergency stop is required, simply turn the red emergency stop knob in the upper right corner of the robot's control pendant until it releases. Upon release, the robot should return to its normal operating state, and the necessary steps to resume manufacturing were desired can be carried out (in order to start the robot from a position other than the beginning, simply select the corresponding JOB_2,3,4,etc and follow the same procedure as outlined above).

Shutting Down

1. Wait until no YO-YO parts are in the robot grippers, pneumatic grippers, or the assembly stations.
2. Press the E-stop on the robot control pendant, or using the key switch to 'TEACH' mode
3. Put the switch at the bottom right of the PLC to the 'STOP' position
4. Power down the robot arm and controller
   4.1. Turn the large knob style switch on the side of the robot controller to 'OFF'
5. Power down the PLC
   5.1. Unplug the orange extension cord powering the PLC
6. Turn off the system air
   6.1. Switch the air valve mounted next to the PLC to 'N'

2 System Overview

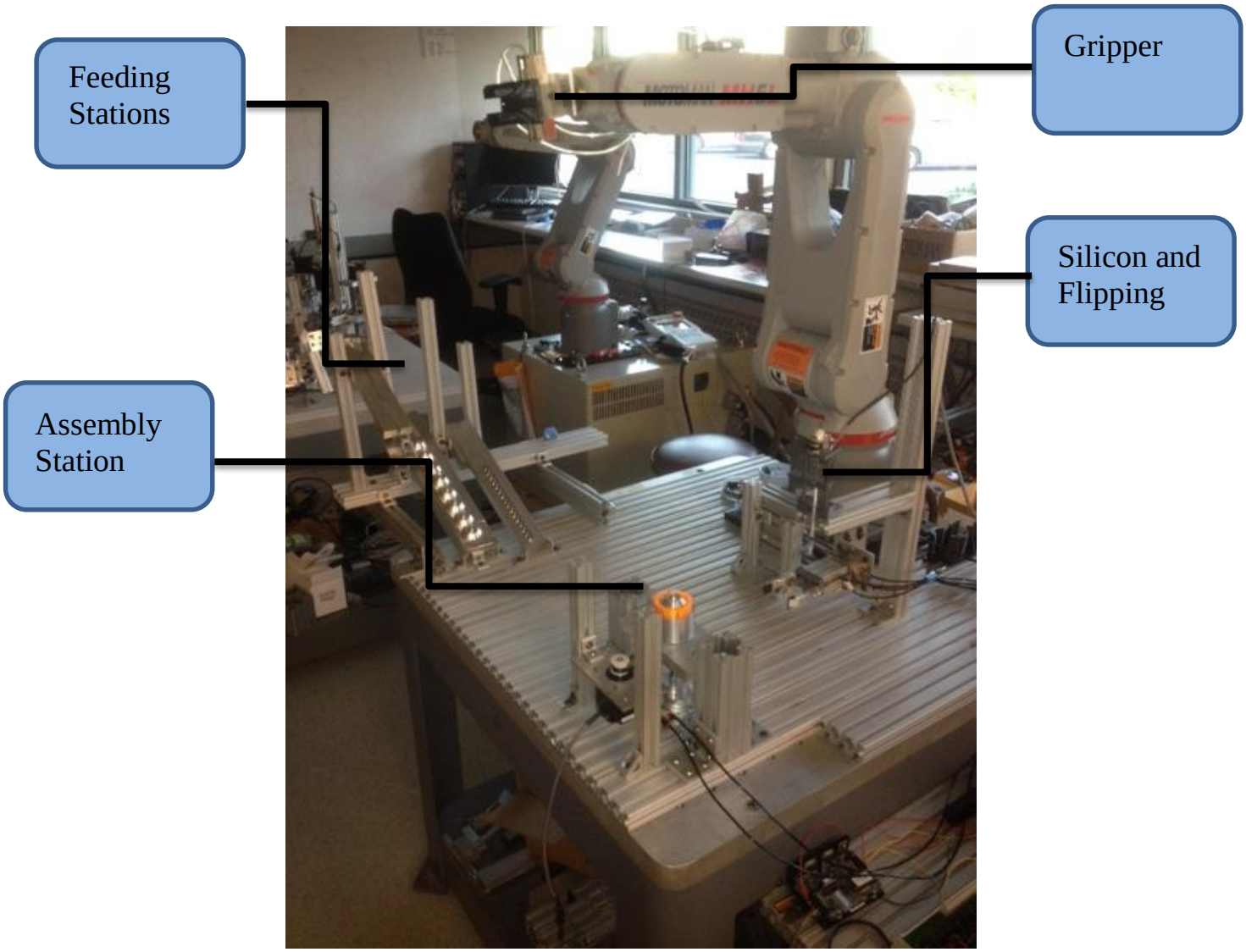

Figure 1 System Overview

This machine assembles YO-YO's using the Motoman MH5L robot. The YO-YO halves are manufactured from 1.5" diameter aluminum stock, while bearings and set screws to connect the halves are purchased. Assembly with the robot allows for repeatability and consistency. This method is sequential, meaning that the robot can only perform one task at a time, limiting efficiency. The part supply stations are positioned in one corner of the table so as to minimize pathway interference. The collet assembly station is positioned in the other corner of the table, near the silicone station, to maximize efficiency. Robot tools are designed to be the same length and stations are assembled with as few extruding parts as possible. This was done so that the tools do not bump any stations during assembly.

The system consists of five stations and the Motoman robot. Station 1, the feeding station, consists of three substations: YO-YO half feeder, bearing feeder and set screw feeder. Station 2, the grip and flip station, takes the YO-YO half from the robot to have silicone applied and flips it before returning it to the robot. Station 3, the silicone station, includes a silicone dispenser. Station 4, the assembly station, is where all parts of the YO-YO are connected together. Station 5, the discard station, is where completed YO-YO's are dispensed.

2.1 Motoman Robot End Effecters

One of the challenging things about using a robotic arm to do the part manipulation is that you need to have all of your end effecters attached to the tip of the robot, while not getting in the way of each other or the machine. For an added safety measure a spring is placed between the tip of the robot and the plate containing the tools. That way, if the robot slightly crashes into something, the tools have some room to deflect before breaking. The robot has two tools, one of which performs three tasks. Tool one, the gripper, is responsible for gripping, moving and assembling the YO-YO halves, set screws and bearings. There is a separate part of the gripper for each of the three parts. It is 3-D printed and consists of two halves that clamp together when the pneumatics are activated. Tool two, the scraper, is responsible for cleaning the silicone gel off of the YO-YO halves. It consists of a milled piece of aluminum with a wedge of a silicone spatula mounted on the end. To clean the silicone off, the robot moves down to a position where the tip of the spatula is resting on the surface of the YO-YO half to be cleaned and spins around in a way that keeps the spatula level with the YO-YO. Once it has reached the starting position, the robot retracts.

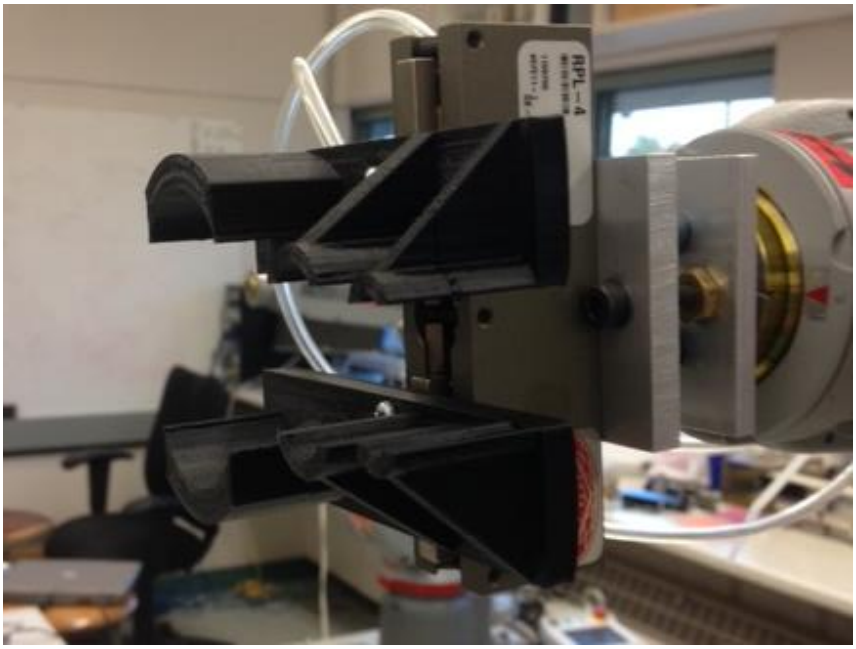

Figure 2 Robotic Grippers

2.2 Feeding Station

This station, station 1, consists of three substations, one for the set screws, one for the YO-YO halves and one for the bearings. Each of the substations are gravity fed, allowing the parts to slide down their track and stop at the end where they wait to be picked up by the Motoman robot. The three tracks are made of milled aluminum plates and mounted to extruded aluminum t-slots. At the end of the set screw track, a thin piece of aluminum is attached a small distance away to stop the set screws and allow the robot grippers to close around the stopper and lift up a single set screw. The YO-YO half and bearing tracks are milled in a way that the pieces stop at the end and the robot picks them up from above.

Figure 3 Feeder Stations- Set Screw, YoYo and Bearing

2.3 Grip and Flip Station

This station, station 2, consists of a pneumatic gripper mounted on a pneumatic rotary actuator, which is connected to a pneumatic linear actuator that is attached to the table. Once the robot picks up a YO-YO half it will bring it to this station where a pneumatic gripper grips the YO-YO half. The robot then releases its grip and backs away. Another pneumatic then extends to the silicone station and retracts once the silicone gel has been applied. Once retracted, the cleaning tool on the robot comes down and spins around to remove the excess silicone. On YO-YO half number one the robot will simply return to pick up the YO-YO half. On part number two, once the silicone gel has been applied and the YO-YO half is retracted to its initial position, the pneumatic rotary actuator flips the YO-YO over and the robot returns to pick it up.

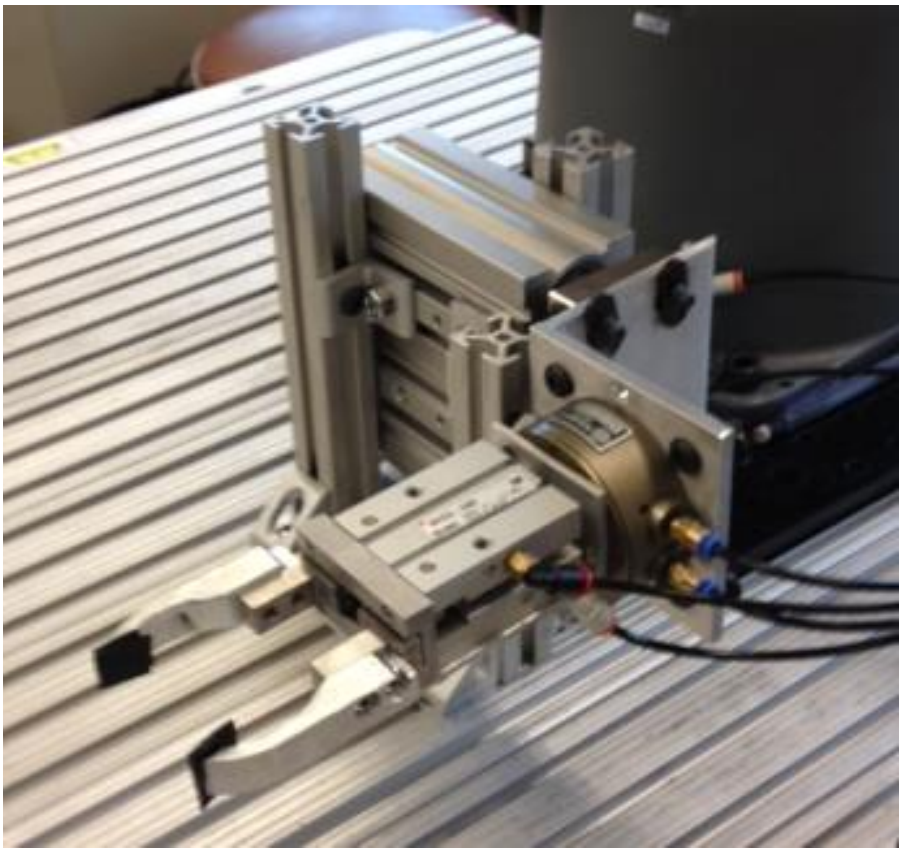

Figure 4 Gripper/Flipper for the silicon station

2.4 Silicone Station

This station, station 3, consists of a syringe mounted on a 3-D printed plate and another plate connected above the syringe. The upper plate is driven by a stepper motor and compresses the syringe to dispense the silicone. This whole setup is mounted on extruded aluminum t-slots.

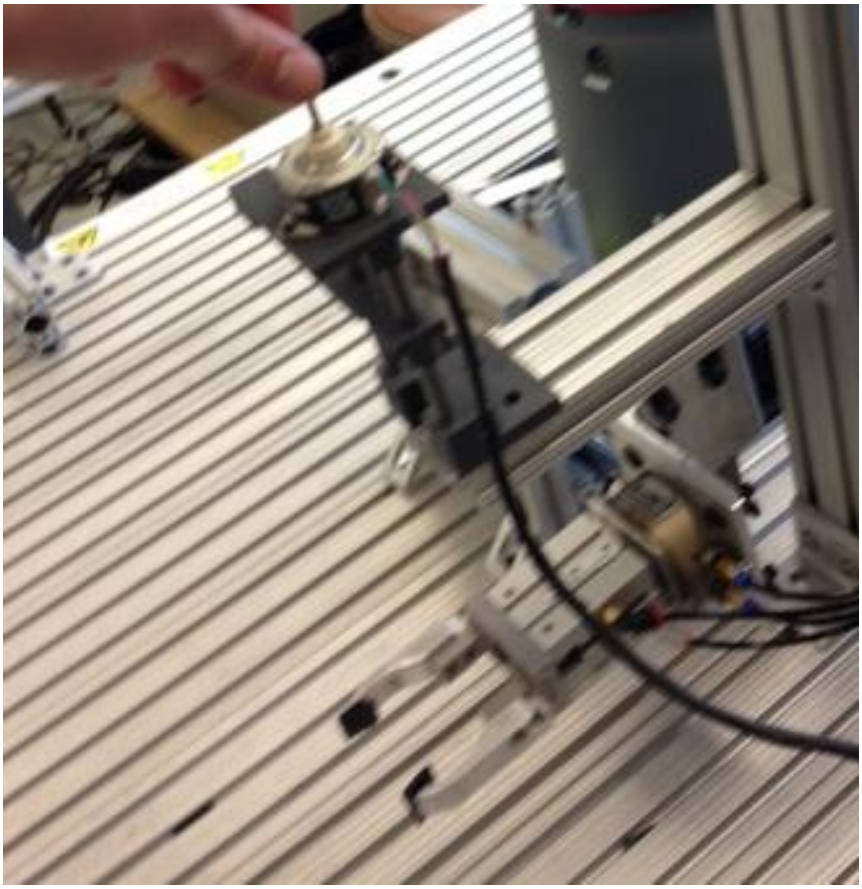

Figure 5 Silicon Dispenser

When the YO-YO half brought over from station 2 is in place beneath the syringe, the silicone is dispensed and station 2 retracts.

Figure 6 Excess Silicon Device

2.5 Assembly Station

This station, station 4, is where all parts of the YO-YO are brought for assembly. It consists of a 3-D printed collet and an aluminum collet housing and horizontal plate mounted on extruded aluminum t-slots. Inside the collet is a piece of aluminum for the YO-YO half to rest on and ensure that the set screw is not inserted beyond the surface of the YO-YO. Attached to the base of the collet, beneath the horizontal plate, is a pneumatic actuator that lifts the collet up to open it up. Also attached is a stepper motor that turns the collet. At this station a YO-YO half is brought over and placed on top of the closed collet. The pneumatic actuator lifts and allows the YO-YO half to fall down on top of the inner piece of aluminum and be held in place. The robot then retrieves a bearing and places it on the YO-YO half. Once the robot retrieves the set screw and is holding it in place, the stepper motor is activated and spins the YO-YO half as the set screw is pressed down and screwed in. The second YO-YO half is then brought over and screwed on in a manner similar to that of the set screw. Once assembled, collet is raised and the robot removes the completed YO-YO.

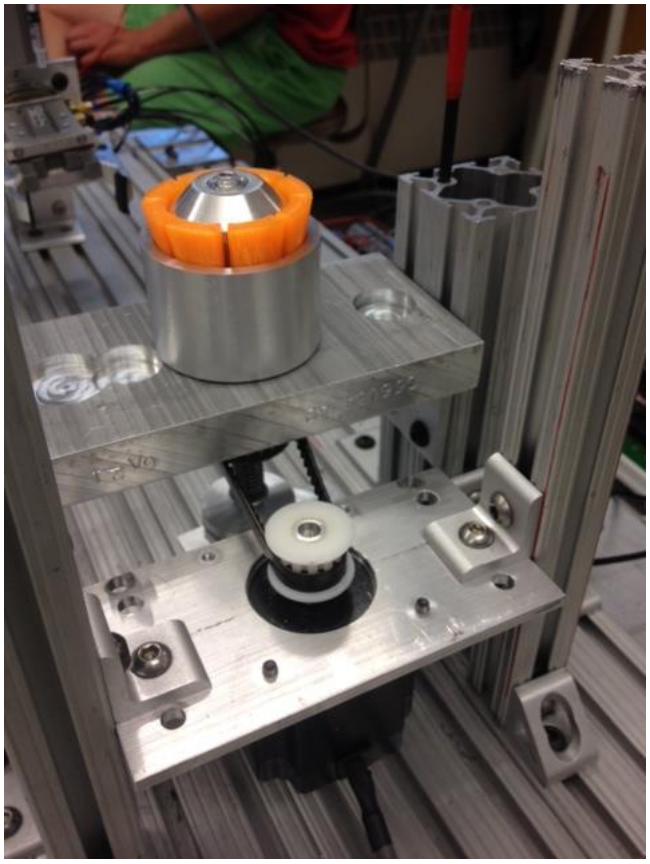

Figure 7 Assembly Collet

2.6 Discard Station

This station, station 5, is where the completed YO-YO's are dropped off. The robot carries the completed YO-YO to the top of the box and places it inside.

3 Interesting Parts List

- 5-40 .15 screws for the robot's pneumatic gripper
- Custom 3-D printed collet
- Custom 3-D printed grippers
- Custom Gripper/Flipper with bicycle tire rubber and cement glue
- Gripper bolt plates (these need to be standardized for a uniform attachment system)
- Servo bolt plates (these need to be standardized for a uniform attachment system)
- Custom Silicon Nozzle
- Silicon Glue "Swiper" made out of bar stock and a piece of spatula
- Feeder Part Trays to work with the gripper
- Springs with the correct spring constant for the gripper and collet
- Actuators:
    - 1 Robot
    - 2 Servo Motors
    - 2 Linear Pneumatic Pistons
    - 2 Pneumatic Gripper
    - 1 Pneumatic Rotator

4 Performance

The system design was not operational due to a failure in the Motoman's handshake with the PLC. Had that been working, the entire system except for the silicon station should have been working with one day's work. The feeder system works exceedingly well- nothing ever got stuck or didn't feed down to the bottom. The custom grippers that the robot used were able to consistently pick up and move the yo-yo halves, set screws and ball bearings from the feeder trays to the silicon station and to the assembly collet. The gripper/flipper pneumatic didn't successfully complete a handoff, but that was more due to the fact that it was attempted manually. The grippers on that gripper/flipper could easily be improved by being made with an actual machined part rather than scraps.

The assembly collet was working to begin with, but the collet had to be replaced twice due to broken fingers. The concept is good, but the execution was poor. The collet needs some slight geometric modifications as well as a more precisely sized spring- the springs that were used either provided to much force and the collet was hard to release or they provided to little force and the collet couldn't effectively grip the yo-yo. Replacing the 3D printed part with a machined aluminum piece would greatly improve the durability and consistency of the collet, however it would be challenging to produce.

The stepper motors were both working quite well, however because of the communication between the PLC and the Motoman, they were only able to be controlled manually during the process.

The robot was also able to consistently deliver the set screw and bearing to the correct position on the yoyo, but the set screw was not able to be screwed in because the timing requires the use of the PLC and the Motoman.

5 Future Improvements

- Install sensors
    - At each feeder station to check for parts
    - At the silicon station to make sure the YO-YO is there
    - At the collet to verify the YO-YO is in the correct position for the set screw and ball bearing
- Improve the robot gripper
    - Optimize the spring so that it is stiff enough for precision, but still flexible enough to screw the set screw in
    - Tighten the tolerance on the bolt holes so that the gripper can only move vertically against the spring
- Machine a new gripper for the gripper/flipper silicon station
- Improve the silicon station
    - Get consistent delivery of silicon
    - Clear the yoyo of excess silicon
- Calibrate the set screw placement
- Package the finished YO-YO's
- General improvements
    - Machine modular brackets
    - Improve the rigidity of each station
    - Organize the cables and wires
    - Optimize for speed

Appendix A – Robot Programs

While listed here as separate programs, the programming works in such a way that the entire procedure will run start to finish once the first job is iniated.

This is the start of the assembly process. JOB_1 is the job that carries out the first step of the process, that is taking one of the YO-YO halves from the feeder stations and placing in into the pneumatic grippers that feed into Station 2 that applies silicone gel.

```
/JOB
//NAME JOB_1
//POS
///NPOS 10,0,0,0,0,0
///TOOL 1
///POSTYPE PULSE
///PULSE
C00000=-2,0,0,0,-5,0
C00001=-26109,39984,22496,-1392,-73490,10730
C00002=-33766,67032,2033,-1876,-41395,13943
C00003=-25250,81786,-719,37943,-32578,-9214
C00004=-25461,91968,2063,40199,-29114,-11303
C00005=-33766,67032,2033,-1876,-41389,13942
C00006=-51980,-5644,-5390,-1741,-80228,20149
C00007=39663,-13907,-11510,705,-80164,-15085
C00008=39661,31403,-57815,1967,-19233,-16224
C00009=40550,51244,-52811,3540,-10891,-17591
//INST
///DATE 2014/06/11 18:08
///COMM PICK UP YOYO AND PLACE IN GLUE S
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(1) OFF
MOVL C00000 V=200.0
MOVL C00001 V=200.0
MOVL C00002 V=200.0
MOVL C00003 V=200.0
MOVL C00004 V=50.0
TIMER T=1.50
DOUT OT#(1) ON
TIMER T=2.00
MOVL C00005 V=100.0
MOVL C00006 V=200.0
MOVL C00007 V=200.0
MOVL C00008 V=200.0
MOVL C00009 V=50.0
END
```

JOB_2 is responsible for simply releasing the robot's grip on the YO-YO half and returning to a higher point to wait for the silicon to be applied.

```
/JOB
//NAME JOB_2
//POS
///NPOS 1,0,0,0,0,0
///TOOL 1
///POSTYPE PULSE
///PULSE
C00000=40549,-8985,-22080,751,-69533,-15521
//INST
///DATE 2014/06/11 18:08
///COMM LEAVE YO AND WAIT FOR GLUE
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(1) OFF
TIMER T=0.50
MOVL C00000 V=200.0
END
```

JOB_3 is responsible for returning to Station 2 to grip the YO-YO half that now has silicon. This is simply a separate program to allow better communication with the PLC on the part of the pneumatic gripper.

```
/JOB
//NAME JOB_3
//POS
///NPOS 2,0,0,0,0,0
///TOOL 1
///POSTYPE PULSE
///PULSE
C00000=40548,20730,-51514,1337,-30255,-16111
C00001=40548,51506,-52783,3583,-10756,-17620
//INST
///DATE 2014/06/11 18:08
///COMM GRIP YOYO IN GLUE GRIPPER
///ATTR SC,RW
///GROUP1 RB1
NOP
MOVL C00000 V=200.0
MOVL C00001 V=50.0
TIMER T=0.50
DOUT OT#(1) ON
END
```

JOB_4 takes the now gripped YO-YO half and places it in the collet.

```
/JOB
//NAME JOB_4
//POS
///NPOS 4,0,0,0,0,0
///TOOL 1
///POSTYPE PULSE
///PULSE
C00000=40548,12976,-49175,1133,-36645,-15953
C00001=36365,55186,3951,326,-52837,-13897
C00002=36831,47156,-6937,1026,-48697,37422
C00003=38286,59340,-13504,1285,-36594,36627
//INST
///DATE 2014/06/11 18:26
///COMM PICK AND PLACE IN SPINNER
///ATTR SC,RW
///GROUP1 RB1
NOP
TIMER T=1.00
MOVL C00000 V=100.0
MOVL C00001 V=200.0
MOVL C00002 V=200.0
MOVL C00003 V=100.0
TIMER T=1.00
DOUT OT#(1) OFF
END
```

JOB_5 moves away from the collet, and gets both the bearing and set screw and assembles them onto the YO-YO half that is located in the collet.

```
/JOB
//NAME JOB_5
//POS
///NPOS 19,0,0,0,0,0
///TOOL 1
///POSTYPE PULSE
///PULSE
C00000=37170,34463,6415,-397,-65873,37457
C00001=-33442,31863,3434,-612,-65706,64620
C00002=-33697,54722,-20370,6,-34074,13972
C00003=-25127,77086,-24267,64476,-26592,-27054
C00004=-26786,82643,-22073,67817,-25088,-28935
C00005=-26788,39232,-24001,37108,-39151,-5823
C00006=-32285,22305,531,-4,-68586,13351
C00007=32037,35183,14724,561,-71312,-11426
C00008=33499,64300,-7618,851,-37536,-12306
C00009=33500,44604,-21,644,-54942,-12103
C00010=-9385,63215,24935,227,-61592,4514
C00011=-4333,102320,18623,100410,-100282,-27538
C00012=-22580,107851,27175,110415,-93839,-27715
```

```
C00013=-16892,89747,18359,108972,-93570,-24434
C00014=-22422,62891,45828,2779,-75832,9278
C00015=27018,66577,50982,1095,-78424,-9576
C00016=31136,57945,-8677,1622,-40456,-11837
C00017=31156,62102,-9916,1742,-37048,-11940
C00018=31075,34338,15965,1151,-72575,-11215
//INST
///DATE 2014/06/11 18:41
///COMM PICK AND PLACE BEARING
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(1) OFF
TIMER T=0.50
MOVL C00000 V=200.0
MOVL C00001 V=200.0
MOVL C00002 V=200.0
MOVL C00003 V=150.0
TIMER T=0.25
MOVL C00004 V=50.0
TIMER T=0.50
DOUT OT#(1) ON
TIMER T=0.50
MOVL C00005 V=50.0
MOVL C00006 V=200.0
MOVL C00007 V=200.0
MOVL C00008 V=50.0
TIMER T=0.50
DOUT OT#(1) OFF
TIMER T=0.50
MOVL C00009 V=200.0
MOVL C00010 V=200.0
MOVL C00011 V=200.0
MOVL C00012 V=50.0
TIMER T=0.50
DOUT OT#(1) ON
MOVL C00013 V=50.0
MOVL C00014 V=200.0
MOVL C00015 V=200.0
MOVL C00016 V=200.0
MOVL C00017 V=50.0
TIMER T=3.00
DOUT OT#(1) OFF
TIMER T=0.50
MOVL C00018 V=200.0
JUMP JOB:JOB_1
END
```

Appendix B- PLC Ladder Diagram

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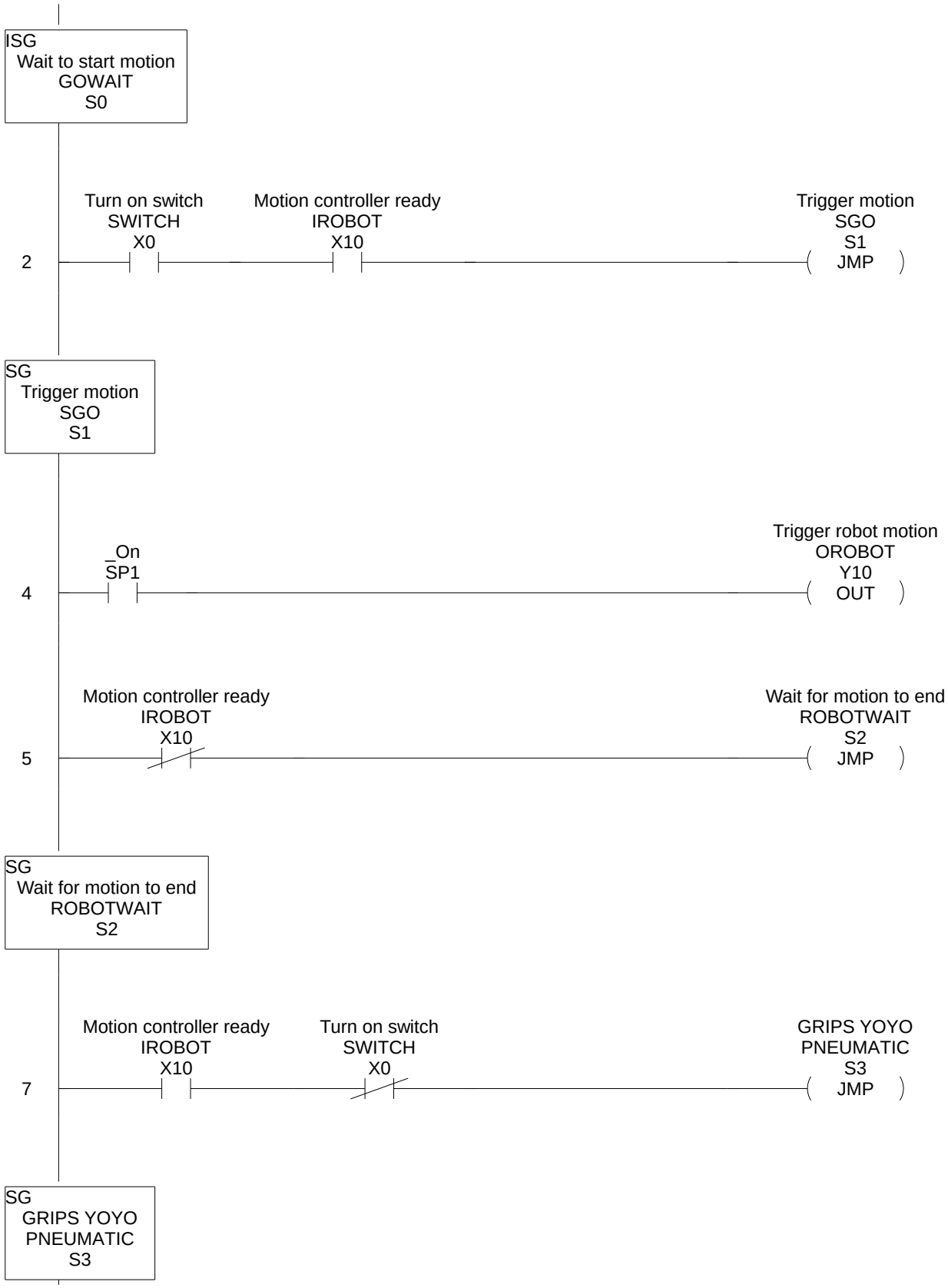
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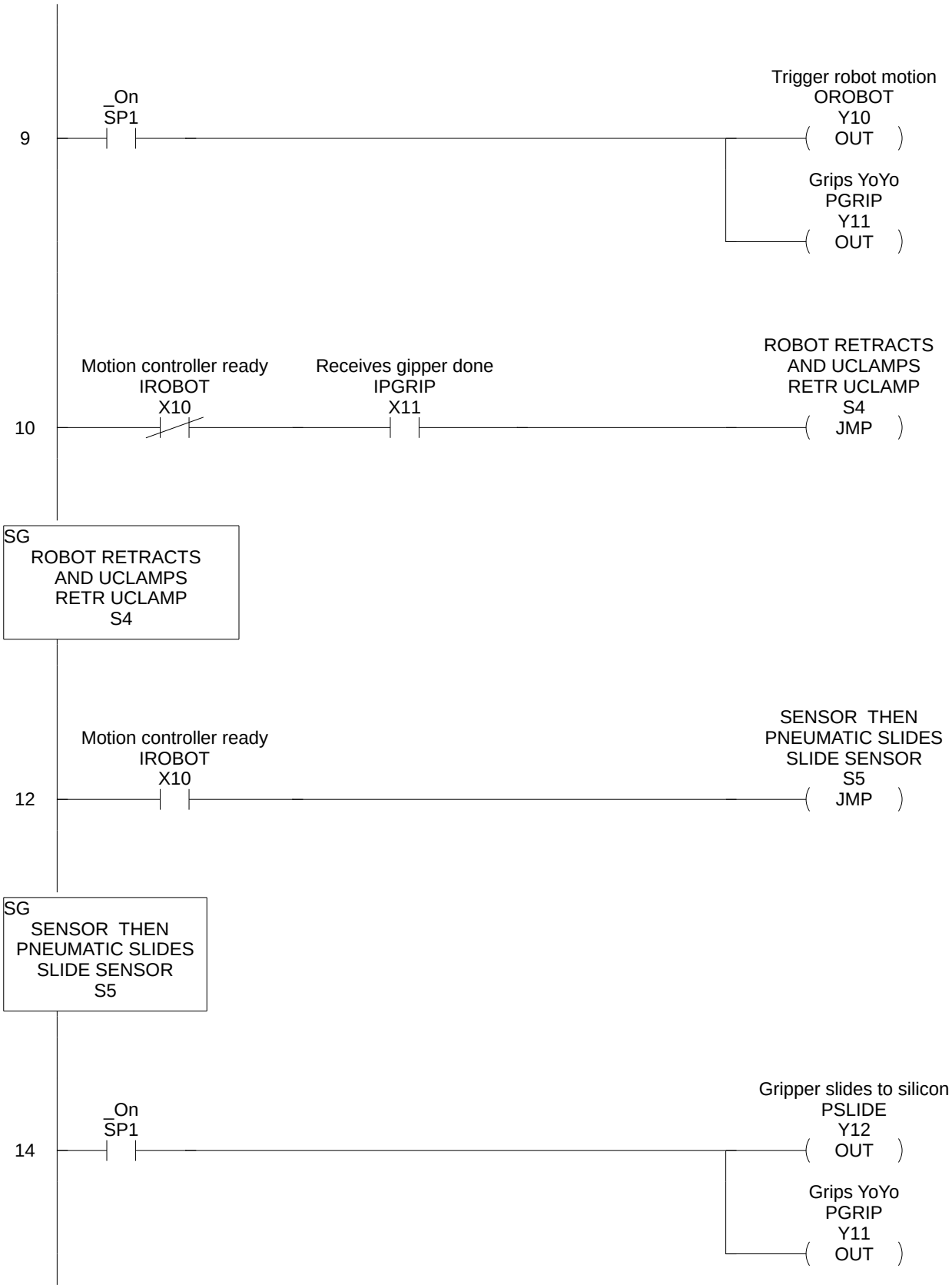
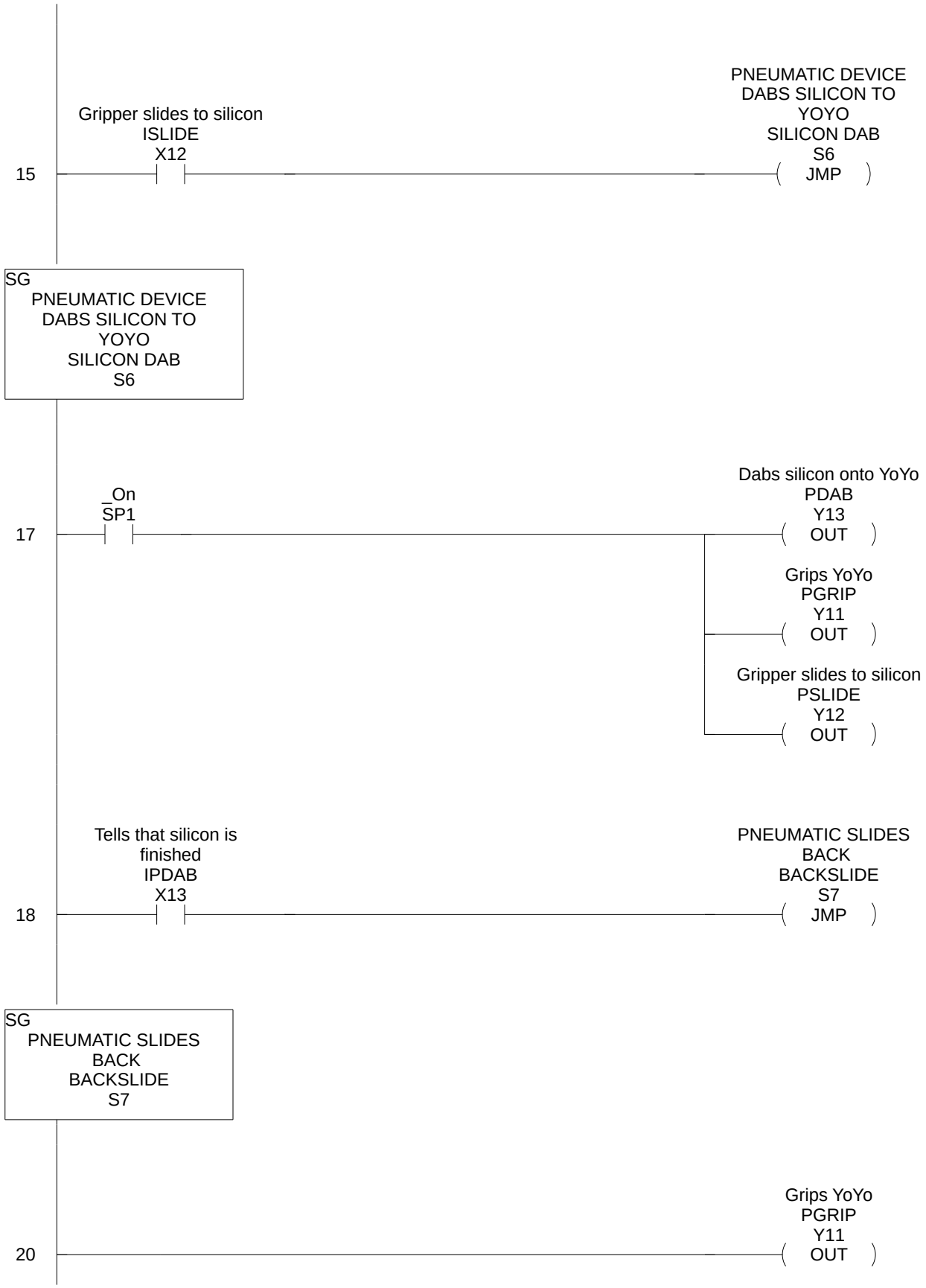
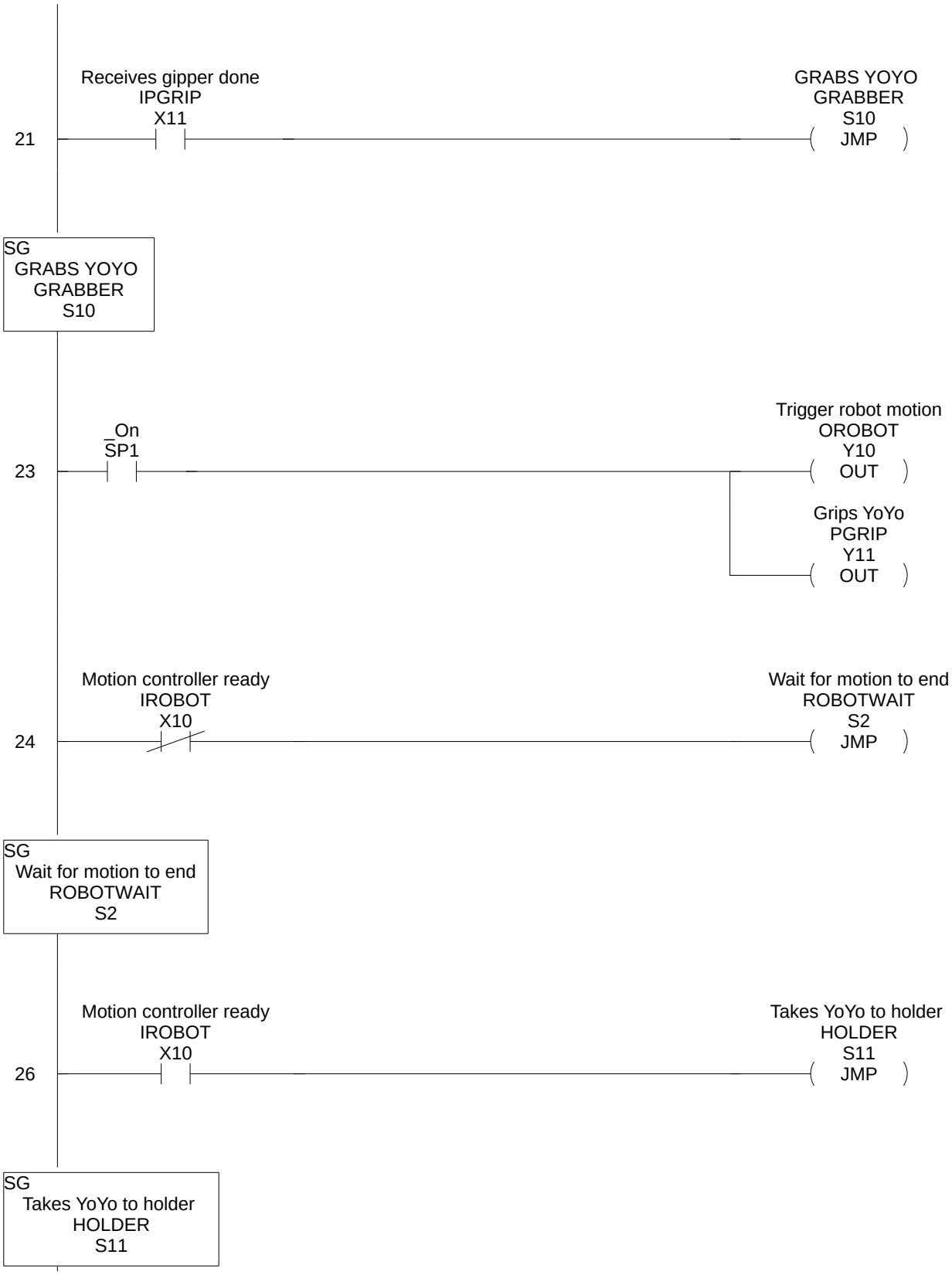
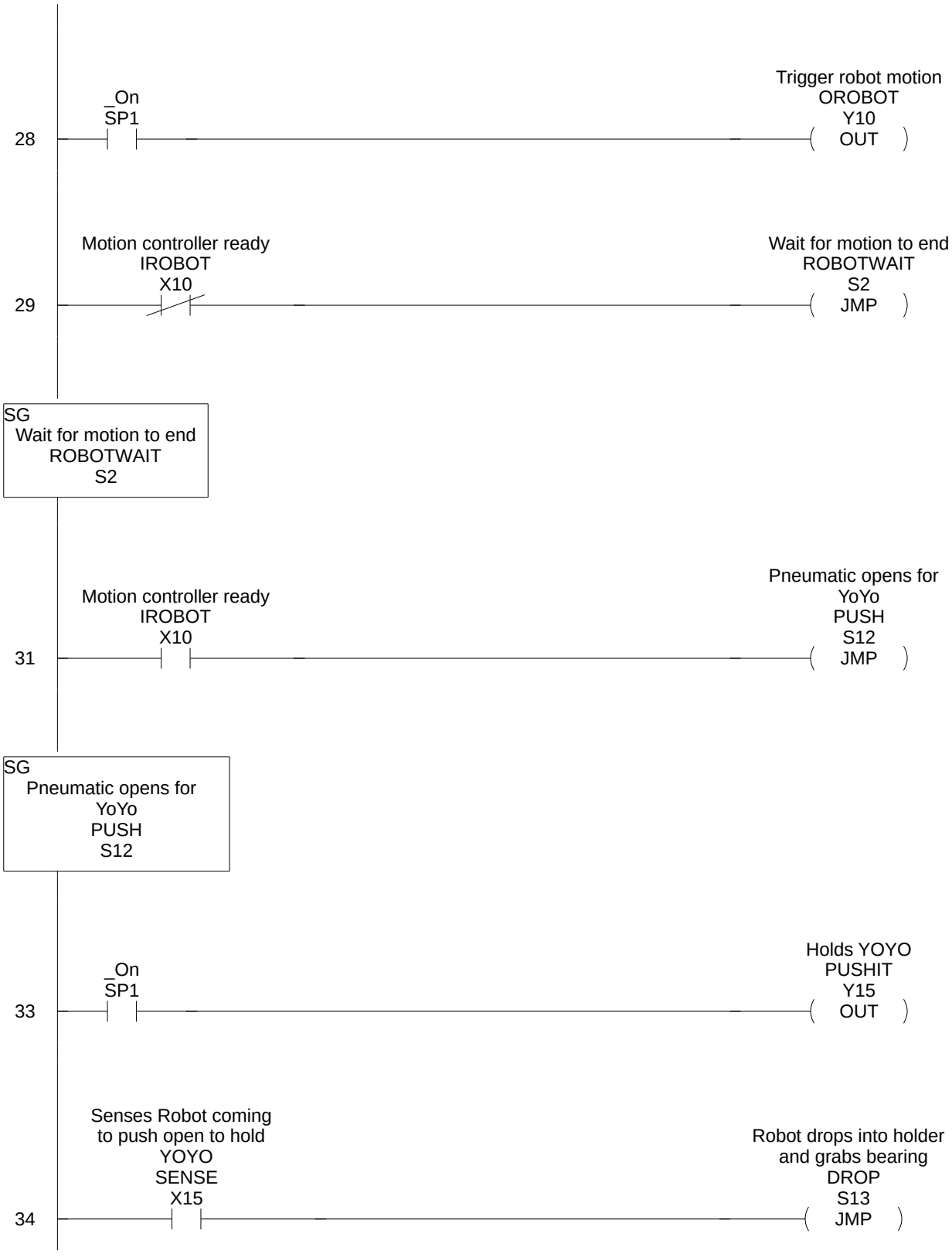
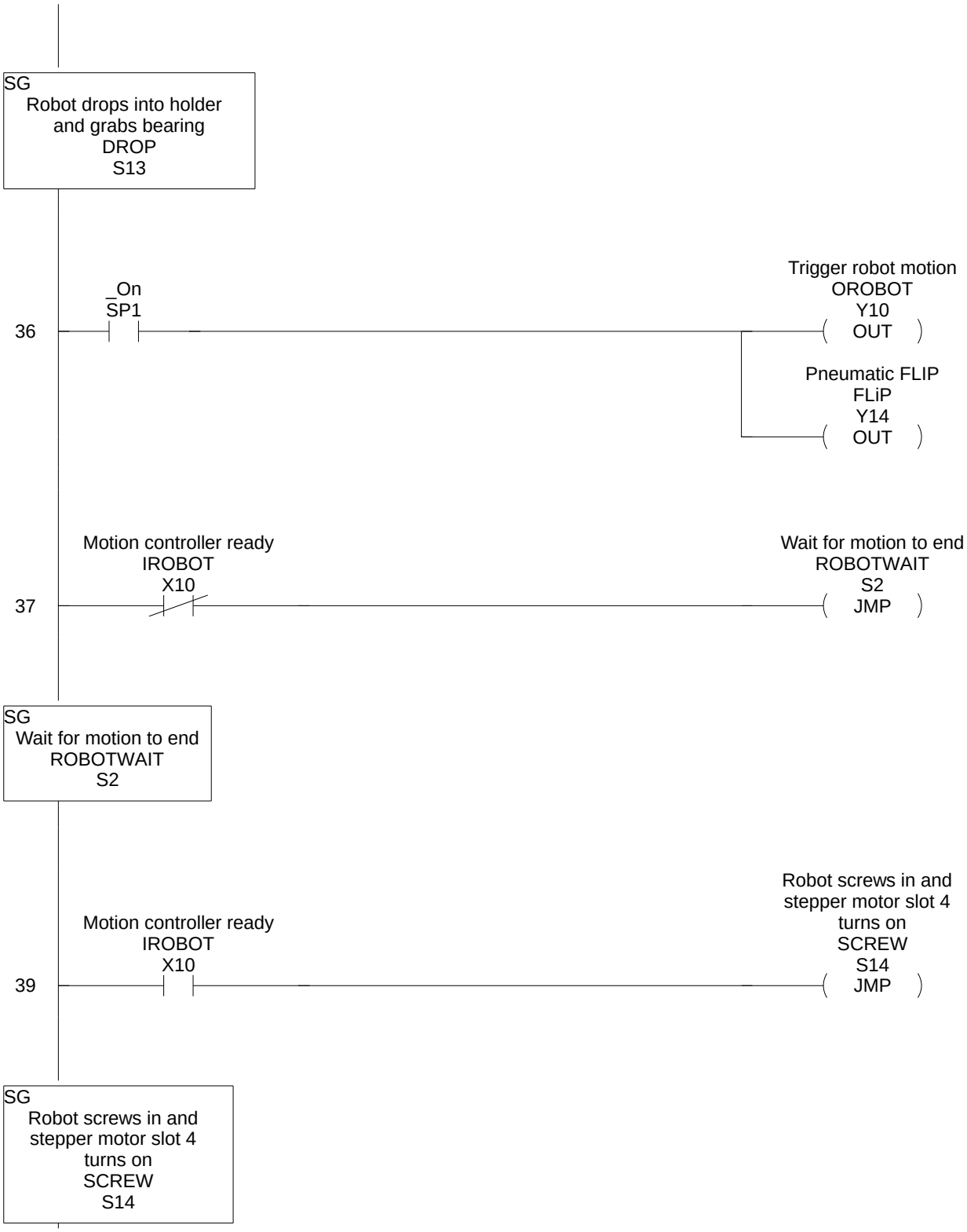
Wait to start motion
GOWAIT
S0
Turn on switch
SWITCH
X0
Motion controller ready
IROBOT
X10
Trigger motion
SGO
S1
JMP
2
SG
Trigger motion
SGO
S1
_On
SP1
Trigger robot motion
OROBOT
Y10
OUT
4
Motion controller ready
IROBOT
X10
Wait for motion to end
ROBOTWAIT
S2
JMP
5
SG
Wait for motion to end
ROBOTWAIT
S2
Motion controller ready
IROBOT
X10
Turn on switch
SWITCH
X0
GRIPS YOYO
PNEUMATIC
S3
JMP
7
SG
GRIPS YOYO
PNEUMATIC
S3

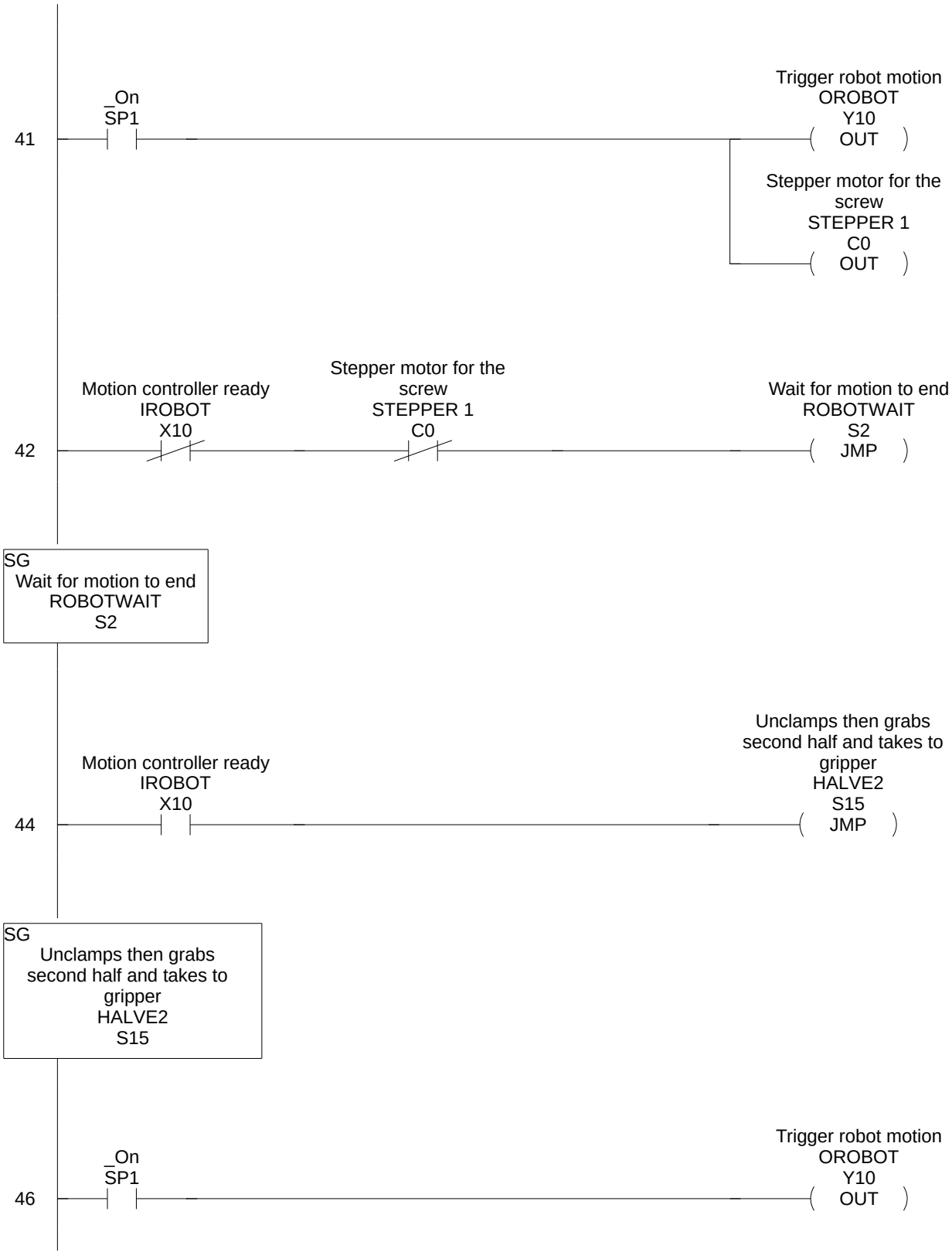

9
_On
SP1
Trigger robot motion
OROBOT
Y10
OUT
Grips YoYo
PGRIP
Y11
OUT
10
Motion controller ready
IROBOT
X10
Receives gipper done
IPGRIP
X11
ROBOT RETRACTS
AND UCLAMPS
RETR UCLAMP
S4
JMP
SG
ROBOT RETRACTS
AND UCLAMPS
RETR UCLAMP
S4
12
Motion controller ready
IROBOT
X10
SENSOR THEN
PNEUMATIC SLIDES
SLIDE SENSOR
S5
JMP
SG
SENSOR THEN
PNEUMATIC SLIDES
SLIDE SENSOR
S5
14
_On
SP1
Gripper slides to silicon
PSLIDE
Y12
OUT
Grips YoYo
PGRIP
Y11
OUT

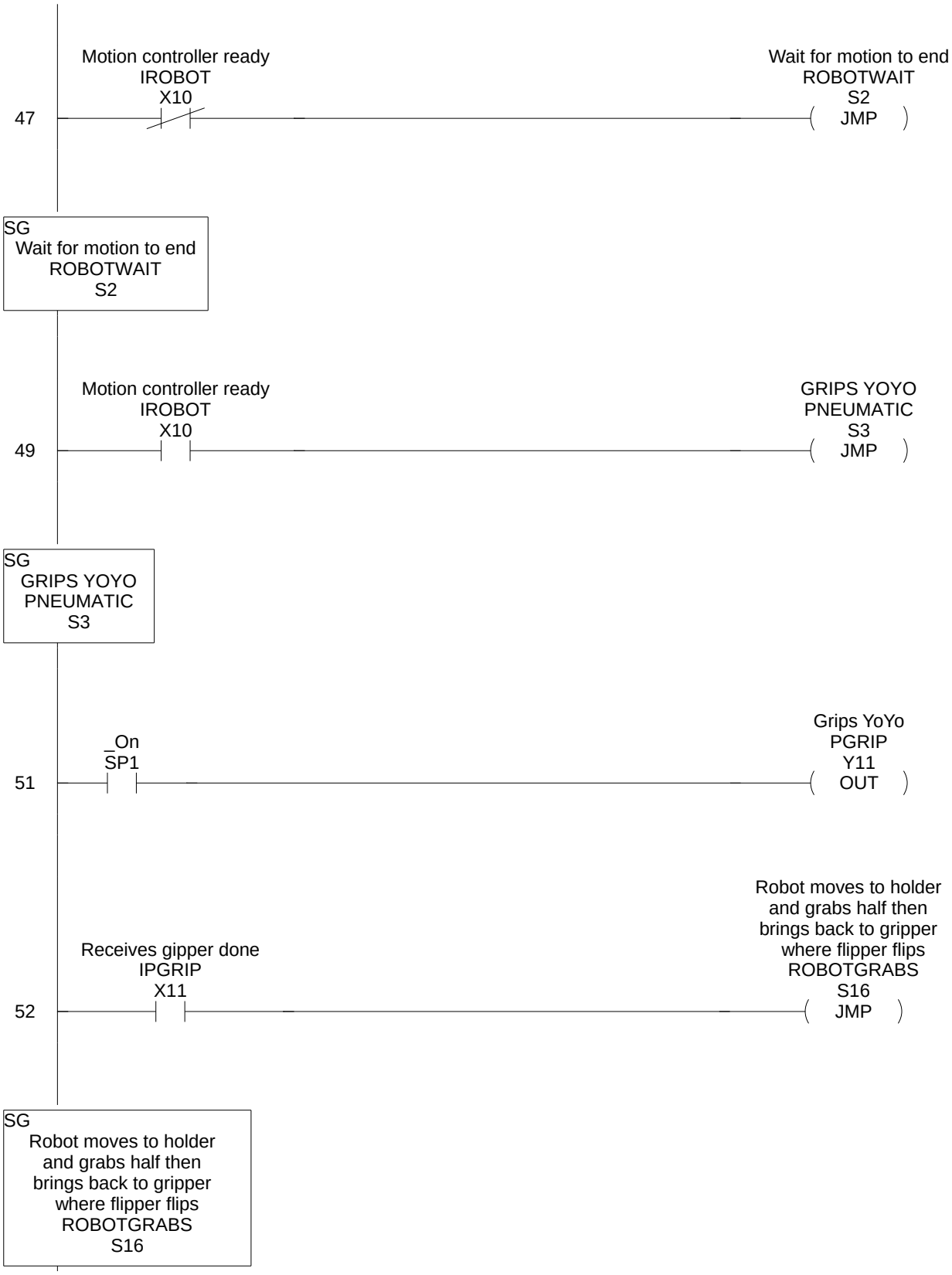

15
Gripper slides to silicon
ISLIDE
X12
PNEUMATIC DEVICE
DABS SILICON TO
YOYO
SILICON DAB
S6
JMP
SG
PNEUMATIC DEVICE
DABS SILICON TO
YOYO
SILICON DAB
S6
17
_On
SP1
Dabs silicon onto YoYo
PDAB
Y13
OUT
Grips YoYo
PGRIP
Y11
OUT
Gripper slides to silicon
PSLIDE
Y12
OUT
18
Tells that silicon is
finished
IPDAB
X13
PNEUMATIC SLIDES
BACK
BACKSLIDE
S7
JMP
SG
PNEUMATIC SLIDES
BACK
BACKSLIDE
S7
20
Grips YoYo
PGRIP
Y11
OUT

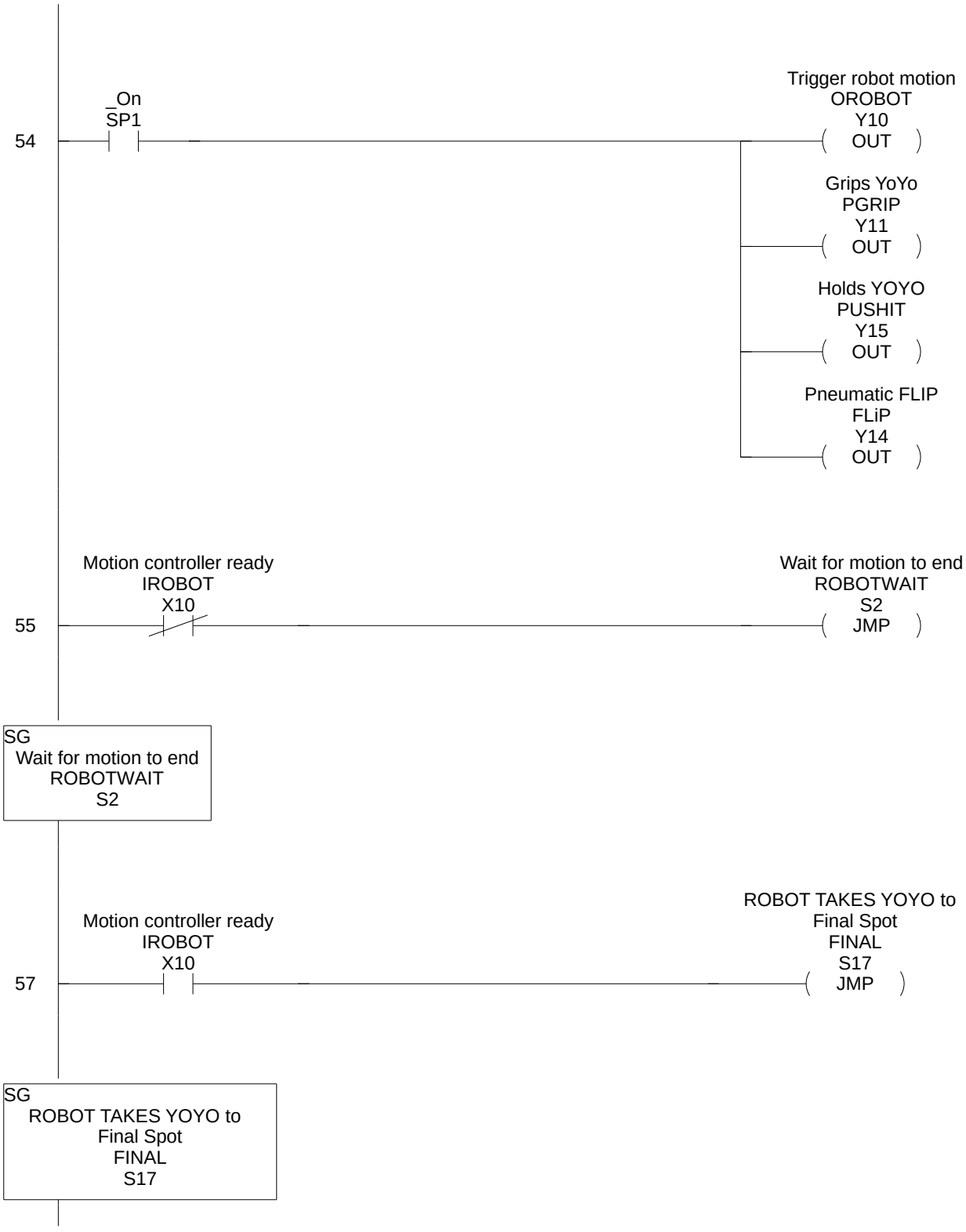

Receives gipper done
IPGRIP
X11
21
GRABS YOYO
GRABBER
S10
JMP
SG
GRABS YOYO
GRABBER
S10
Trigger robot motion
OROBOT
Y10
OUT
_On
SP1
23
Grips YoYo
PGRIP
Y11
OUT
Motion controller ready
IROBOT
X10
24
Wait for motion to end
ROBOTWAIT
S2
JMP
SG
Wait for motion to end
ROBOTWAIT
S2
Motion controller ready
IROBOT
X10
26
Takes YoYo to holder
HOLDER
S11
JMP
SG
Takes YoYo to holder
HOLDER
S11

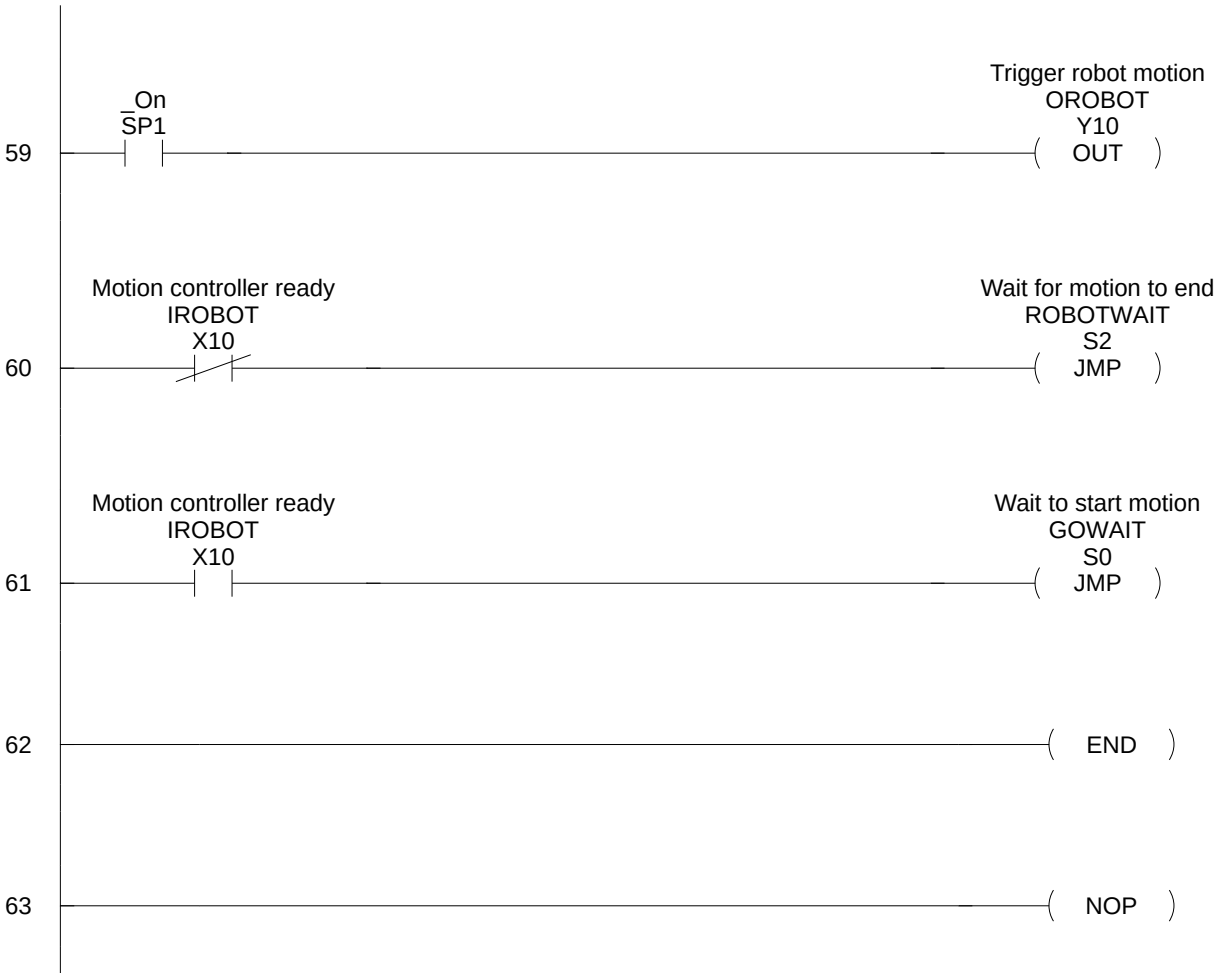

28
_On
SP1
Trigger robot motion
OROBOT
Y10
OUT
29
Motion controller ready
IROBOT
X10
Wait for motion to end
ROBOTWAIT
S2
JMP
SG
Wait for motion to end
ROBOTWAIT
S2
31
Motion controller ready
IROBOT
X10
Pneumatic opens for
YoYo
PUSH
S12
JMP
SG
Pneumatic opens for
YoYo
PUSH
S12
33
_On
SP1
Holds YOYO
PUSHIT
Y15
OUT
34
Senses Robot coming
to push open to hold
YOYO
SENSE
X15
Robot drops into holder
and grabs bearing
DROP
S13
JMP


SG
Robot drops into holder and grabs bearing
DROP
S13
_On
SP1
36
Trigger robot motion
OROBOT
Y10
OUT
Pneumatic FLIP
FLiP
Y14
OUT
Motion controller ready
IROBOT
X10
37
Wait for motion to end
ROBOTWAIT
S2
JMP
SG
Wait for motion to end
ROBOTWAIT
S2
Motion controller ready
IROBOT
X10
39
Robot screws in and stepper motor slot 4 turns on
SCREW
S14
JMP
SG
Robot screws in and stepper motor slot 4 turns on
SCREW
S14


41
_On
SP1
Trigger robot motion
OROBOT
Y10
OUT
Stepper motor for the screw
STEPPER 1
C0
OUT
42
Motion controller ready
IROBOT
X10
Stepper motor for the screw
STEPPER 1
C0
Wait for motion to end
ROBOTWAIT
S2
JMP
SG
Wait for motion to end
ROBOTWAIT
S2
44
Motion controller ready
IROBOT
X10
Unclamps then grabs second half and takes to gripper
HALVE2
S15
JMP
SG
Unclamps then grabs second half and takes to gripper
HALVE2
S15
46
_On
SP1
Trigger robot motion
OROBOT
Y10
OUT


Motion controller ready
IROBOT
X10
47
Wait for motion to end
ROBOTWAIT
S2
JMP
SG
Wait for motion to end
ROBOTWAIT
S2
Motion controller ready
IROBOT
X10
49
GRIPS YOYO
PNEUMATIC
S3
JMP
SG
GRIPS YOYO
PNEUMATIC
S3
_On
SP1
51
Grips YoYo
PGRIP
Y11
OUT
Receives gipper done
IPGRIP
X11
52
Robot moves to holder
and grabs half then
brings back to gripper
where flipper flips
ROBOTGRABS
S16
JMP
SG
Robot moves to holder
and grabs half then
brings back to gripper
where flipper flips
ROBOTGRABS
S16


54
_On
SP1
Trigger robot motion
OROBOT
Y10
OUT
Grips YoYo
PGRIP
Y11
OUT
Holds YOYO
PUSHIT
Y15
OUT
Pneumatic FLIP
FLiP
Y14
OUT
55
Motion controller ready
IROBOT
X10
Wait for motion to end
ROBOTWAIT
S2
JMP
SG
Wait for motion to end
ROBOTWAIT
S2
57
Motion controller ready
IROBOT
X10
ROBOT TAKES YOYO to
Final Spot
FINAL
S17
JMP
SG
ROBOT TAKES YOYO to
Final Spot
FINAL
S17


59
_On
SP1
Trigger robot motion
OROBOT
Y10
OUT
60
Motion controller ready
IROBOT
X10
Wait for motion to end
ROBOTWAIT
S2
JMP
61
Motion controller ready
IROBOT
X10
Wait to start motion
GOWAIT
S0
JMP
62
END
63
NOP

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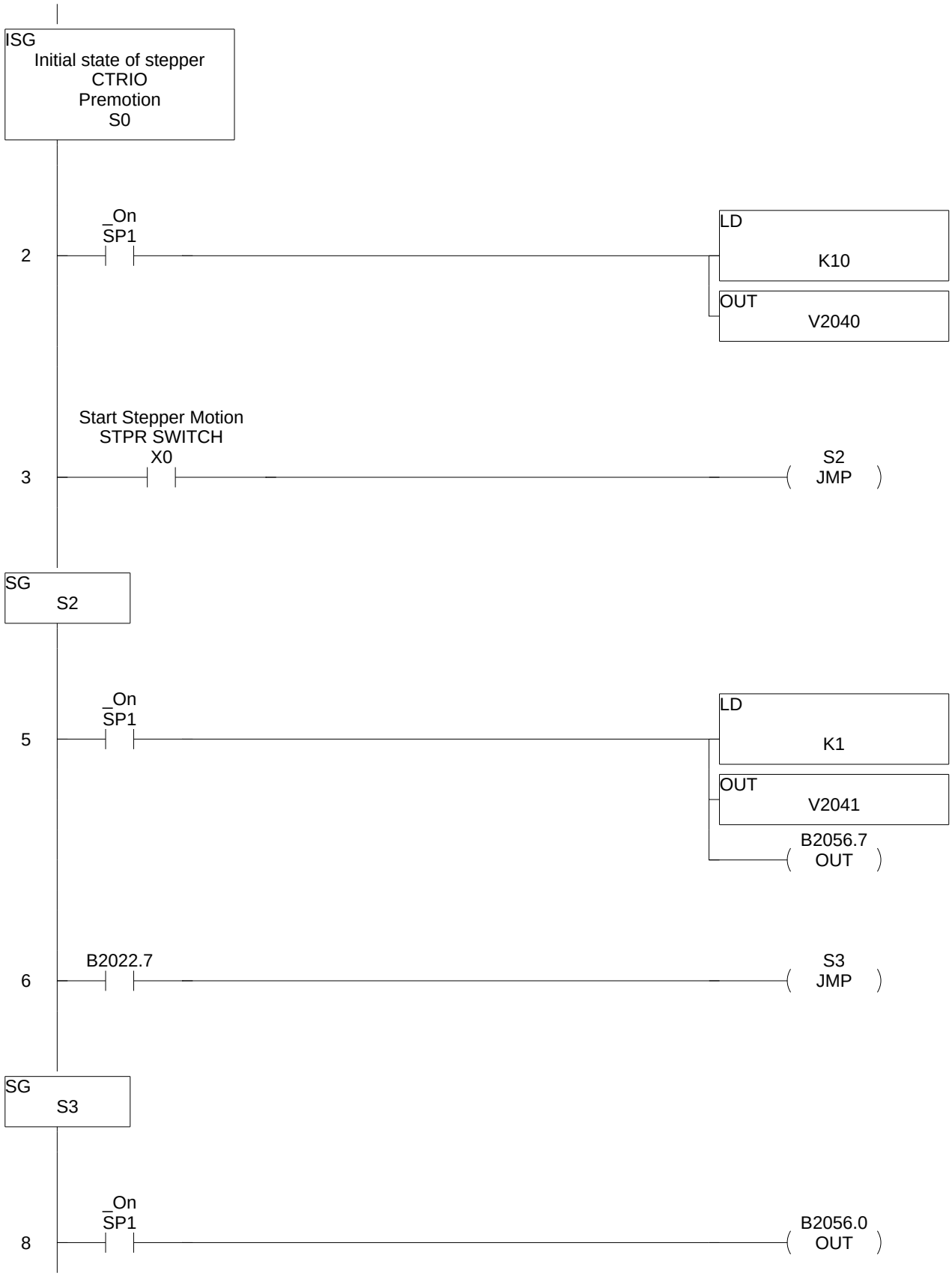
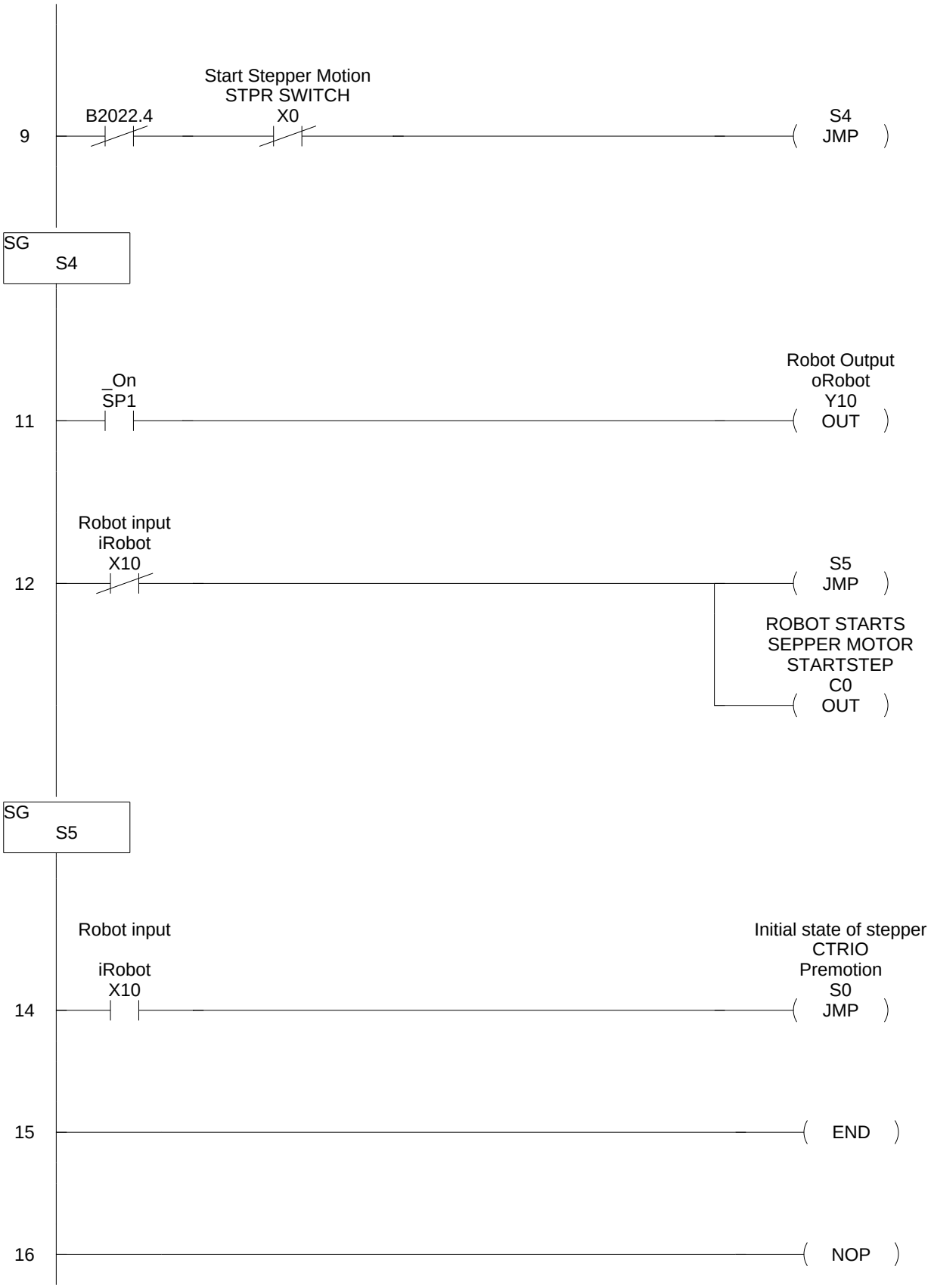

ISG
Initial state of stepper
CTRIO
Premotion
S0
2
_On
SP1
LD
K10
OUT
V2040
3
Start Stepper Motion
STPR SWITCH
X0
S2
JMP
SG
S2
5
_On
SP1
LD
K1
OUT
V2041
B2056.7
OUT
6
B2022.7
S3
JMP
SG
S3
8
_On
SP1
B2056.0
OUT


Start Stepper Motion
STPR SWITCH
X0
B2022.4
9
S4
JMP
SG
S4
Robot Output
oRobot
Y10
_On
SP1
11
OUT
Robot input
iRobot
X10
12
S5
JMP
ROBOT STARTS
SEPPER MOTOR
STARTSTEP
C0
OUT
SG
S5
Robot input
iRobot
X10
Initial state of stepper
CTRIO
Premotion
S0
14
JMP
15
END
16
NOP