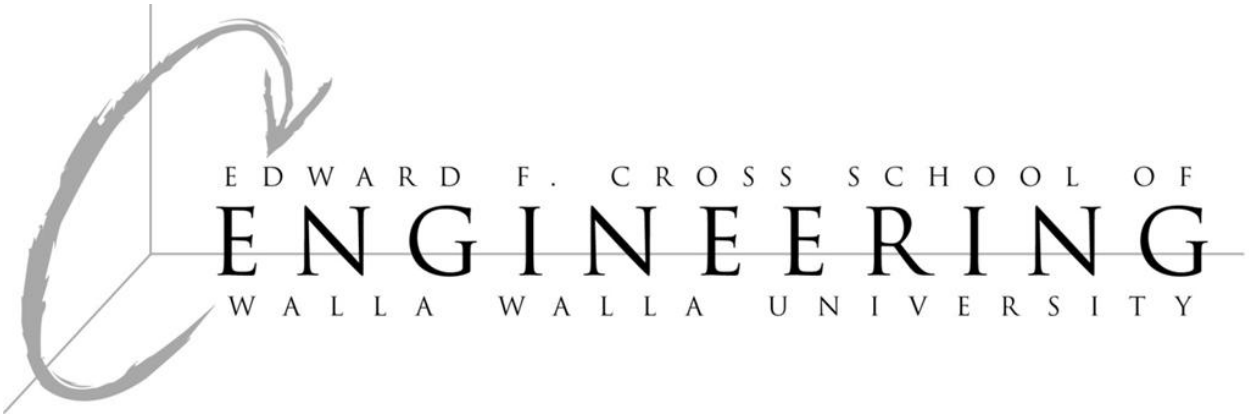

Robotic Flashlight Assembly Instruction Manual

6/7/2012

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Table of Contents

Table of Figures

List of Tables

No table of figures entries found.

1 Introduction

The intent of this manufacturing project was to create an assembly station that would support the assembly of a small flashlight. Assembly operations would be carried out by a 6 axis Motoman MH5L robot. All support rigging for holding flashlight parts were fabricated and assembled from scratch. In addition to the custom support rigging, an end effecter unit for the robot arm was designed to enable the robot to carry out pick and place assembly operations.

2 Flashlight Components

Figure 1. Flashlight Components

Before the manufacturing process could occur a final flashlight design had to be chosen and implemented. It was necessary to finalize the flashlight design so that customized manufacturing stations could be fabricated for each individual part of the flashlight. The

finalized flashlight design consisted of eight unique parts. The following is a list of all the required parts to build one flashlight.

Flashlight Parts list:

- Main body
- Nose piece
- Heat sink unit (pre fabricated)
- Hall Effect switch
- 31mm diameter o-ring (seals battery compartment)
- 24mm diameter o-ring (seals lens/heat sink)
- 26650 lithium phosphate battery
- 29.1mm fiberglass washer (holds heat sink in place)

Figure 2. Fully assembled flashlight

3 System Components

The following part of the document shows detailed pictures of the stations involved with our flashlight assembly system.

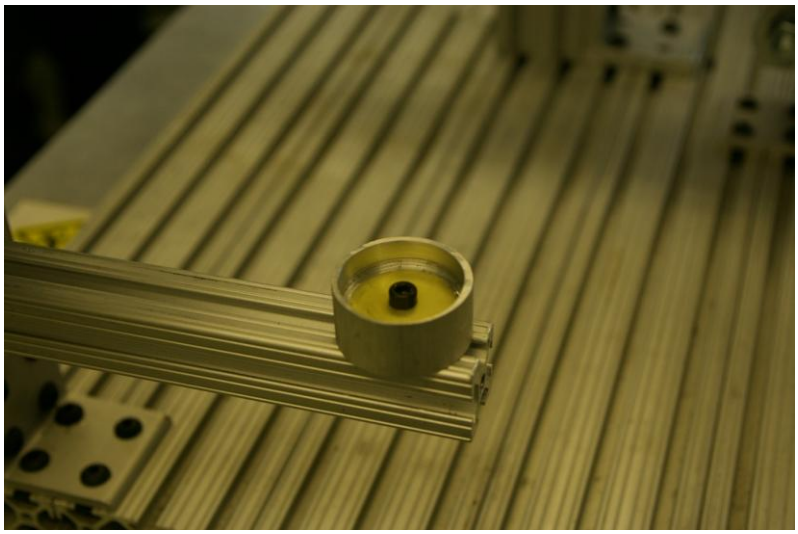


Figure 3. Showing fiberglass washer station.

This station housed the 29.1mm fiberglass washers that were used to hold the heat sink in place. To keep the washers centered and ready for pickup a centralized screw head was implemented.

Figure 4. Showing heat sink station.

For the heat sink stations a plastic tube was used to funnel and singulate the heat sinks for pickup. For this station the heat sink had to be orientated as seen in figure 2 as to allow for proper flashlight assembly.

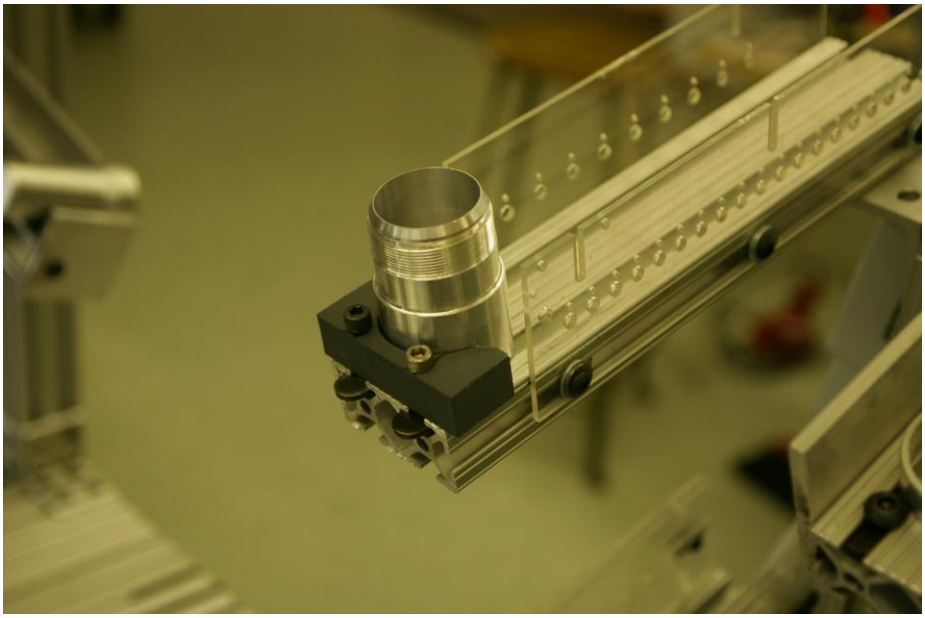


Figure 5. Showing flashlight nose station.

This station is for the nose piece of the flashlight. This station singulated each nose piece. To make sure that each nose piece was in the exact location for pick up a bumper with rounded edges was installed.

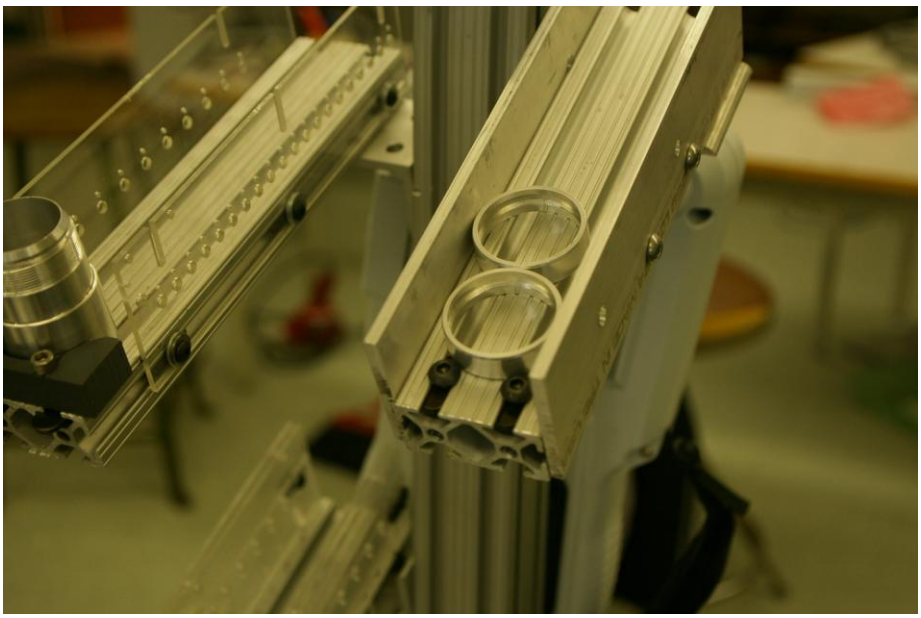


Figure 6. Showing magnet ring station.

This station housed the Hall Effect switch which was used to turn the flashlight on and off. This station singulated each switch. Two screws were used to orientate the leading switch for pickup.

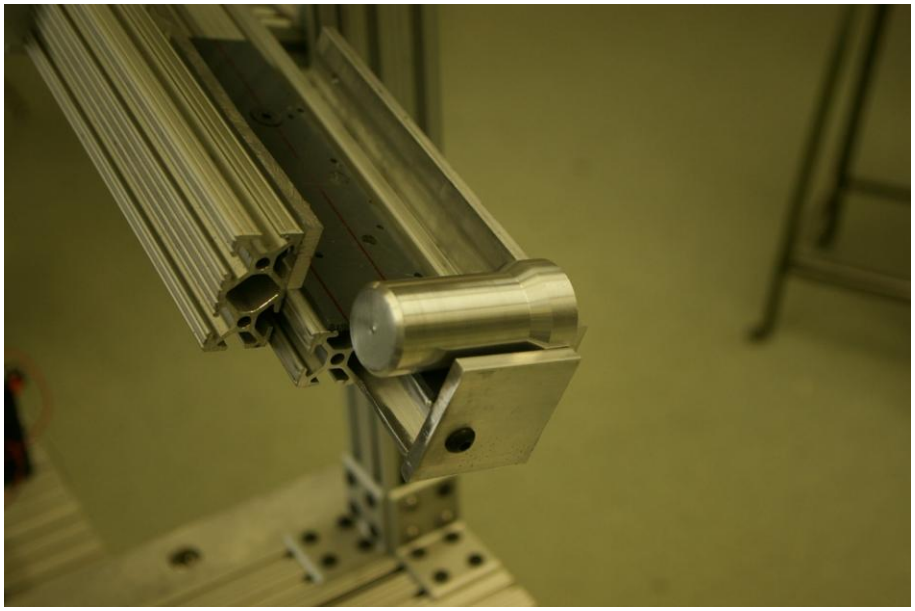


Figure 7. Showing flashlight body station.

For the flashlight body station two walls where used to prevent jams, also due to the shape of the body a piece of plastic was used to keep each body level. To allow for robot pickup, the track that the leading flashlight body was positioned on was cut away.

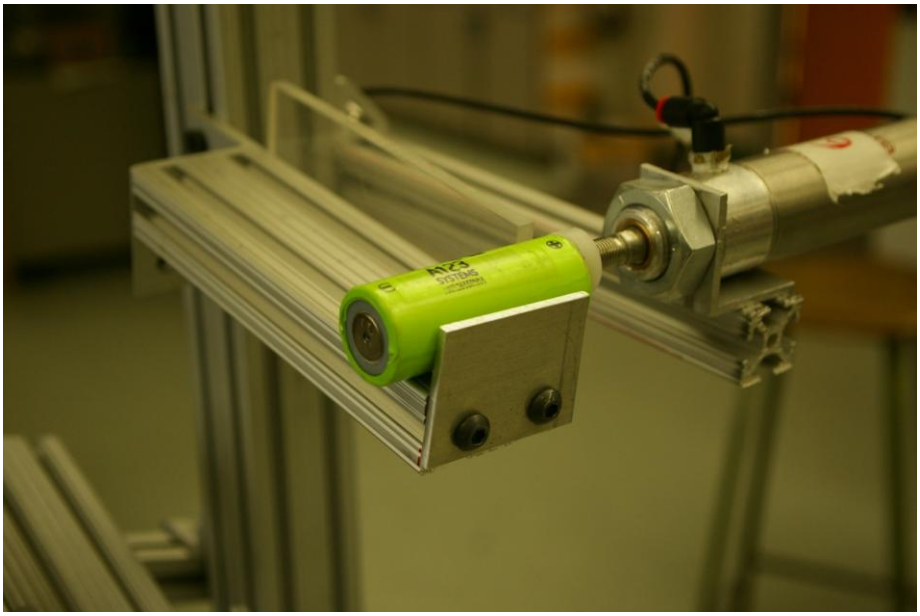


Figure 8. Showing battery station.

The battery placement station uses a pneumatic cylinder to push the battery into the flashlight body. For the proper assembly the battery must have the negative end facing outwards.

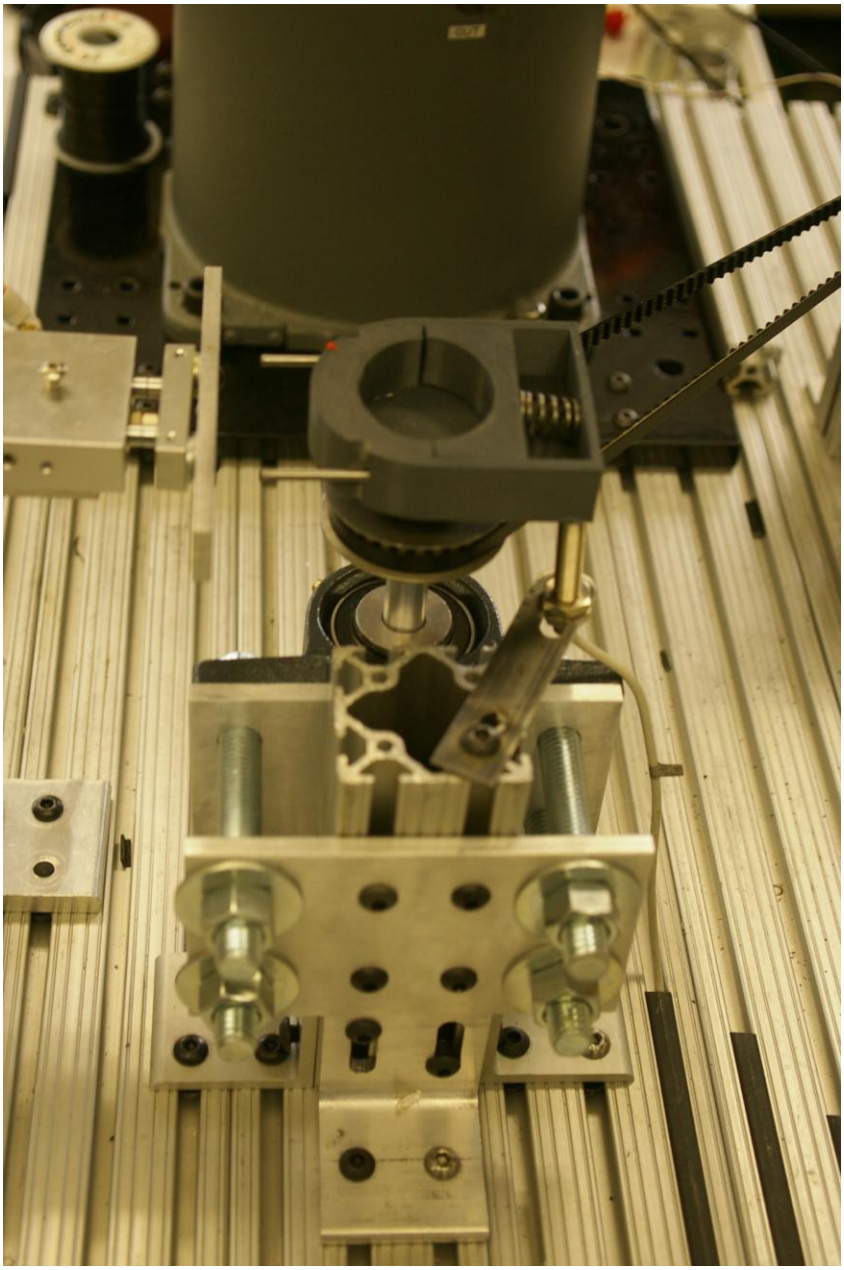


Figure 9. Showing the central rotary station.

This is the central rotary station where many processes occur. The processes that occur here is are the nose piece placement and the placement of the 31mm o-ring. This is central location

where the flashlight is assembled. There is an inductive sensor place on the central rotary housing to tell the plc that the clamp is in the home position.

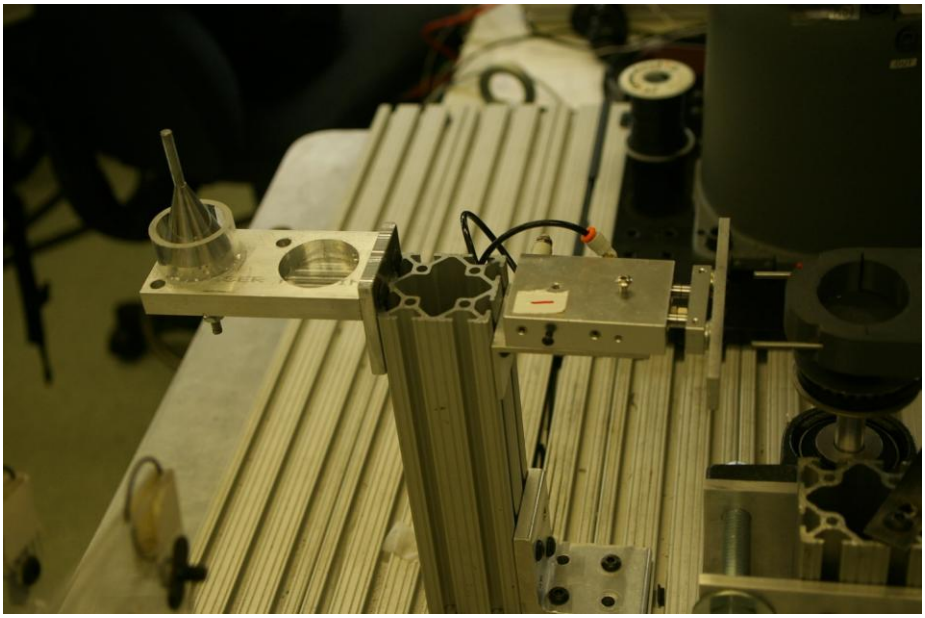


Figure 10. Showing O-ring tool assembly station.

The O-ring tool was use to place and orientate both the 31mm and the 24mm O-rings. To place the 31 mm O-ring the pneumatic griper picks up and places the O-ring tool in a nose piece located at the central rotary station. For the 24mm O-ring the nose piece has to be located on the plastic pedestal shown in figure 9.

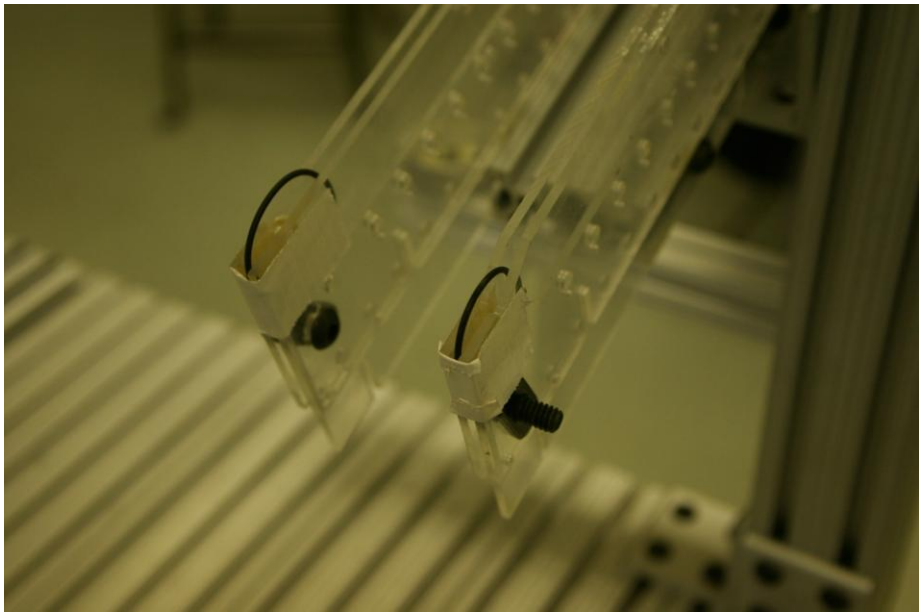


Figure 11. Showing O-ring holding station.

This station singulates both the 24mm and 31mm O-rings and readies them for pick up.

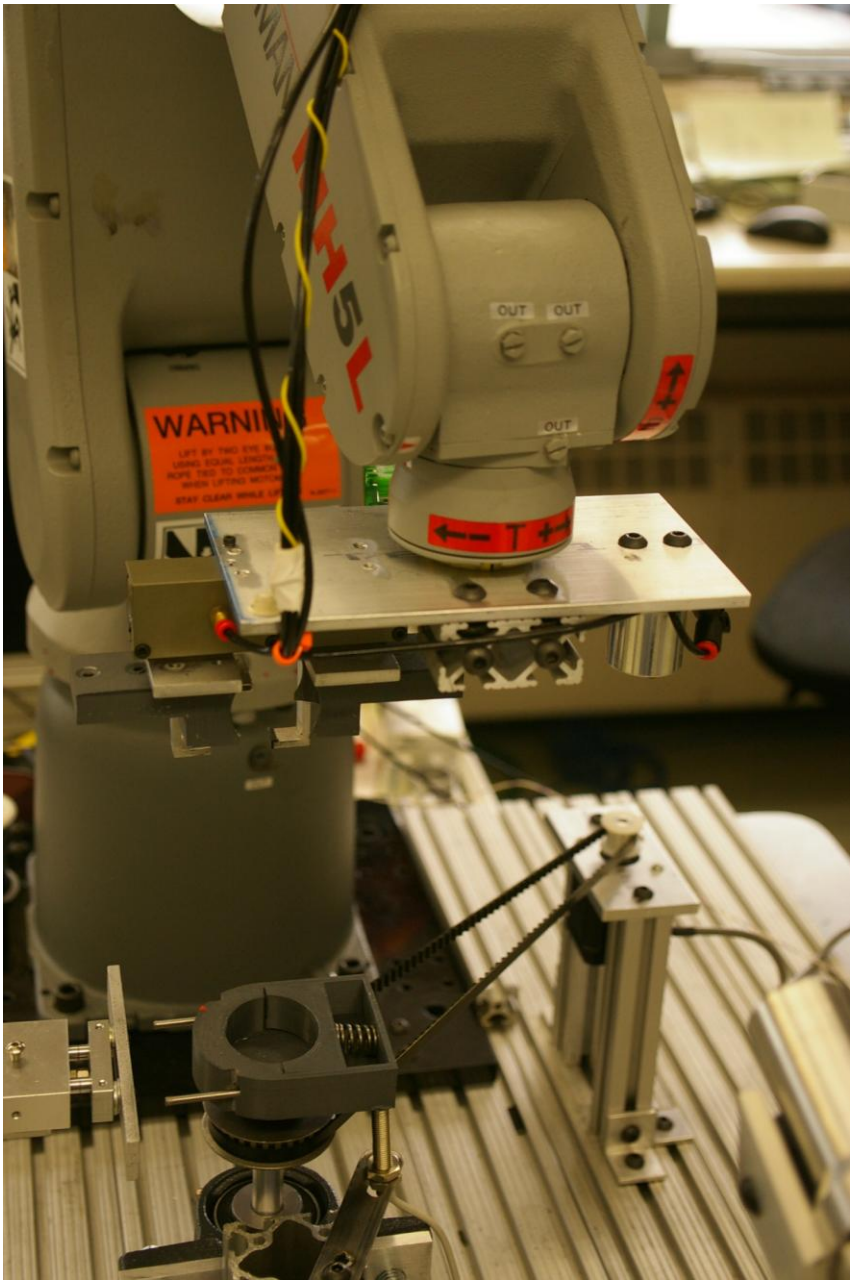


Figure 12. Showing robot end affecter in the home position.

After the robot is done assembling a flashlight it will return to the home position shown in figure 11.

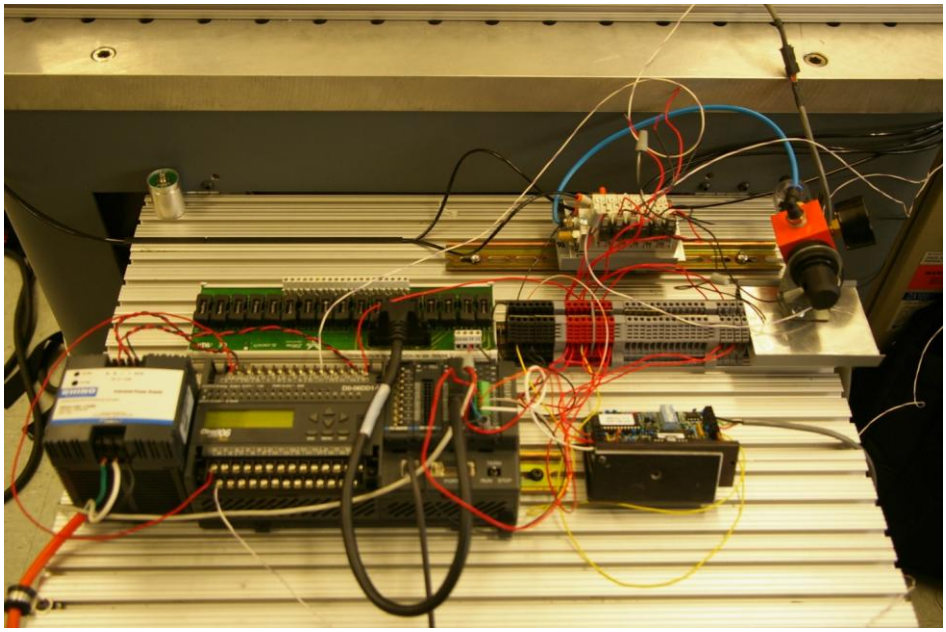


Figure 13. Showing PLC, air solenoid valves and stepper motor controller.

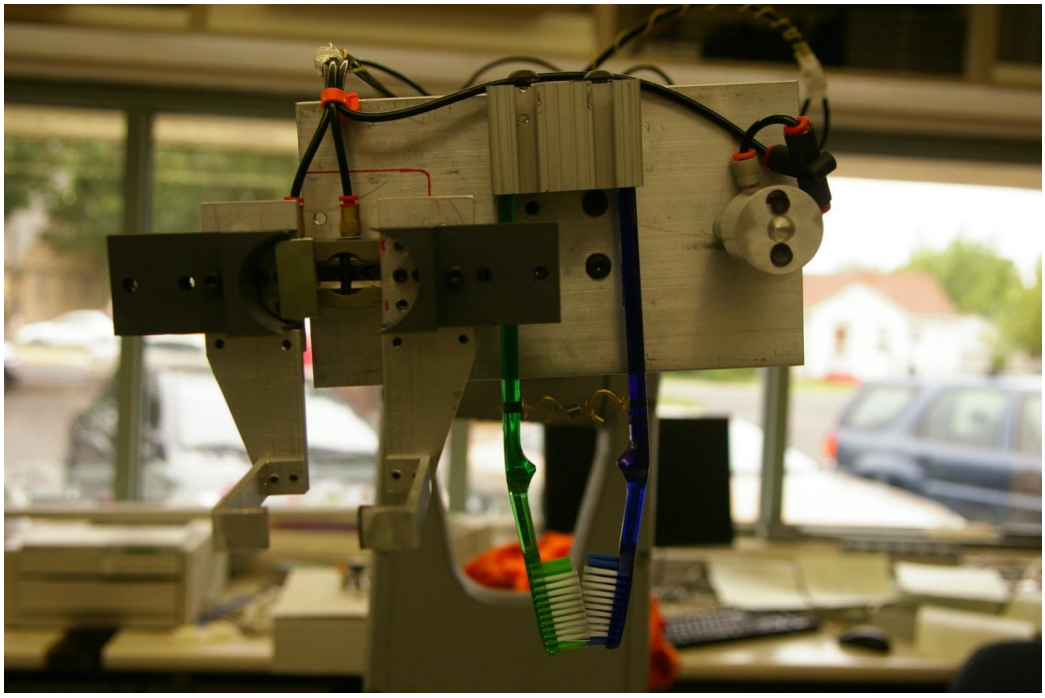


Figure 14. Showing detail of robot end affecter.

This is the tools (gripers) that were used to assemble a flashlight. The pneumatic gripper on the left was used to pick up all of the flashlight components except the battery and the fiberglass washer. The two toothbrushes were used to place the 31mm O-ring in the designed groove located on the nose piece. The last tool was a vacuum used to pick up the fiberglass washer.

4 Instructions

4.1 Machine start up

Step 1……Turn on Motoman MH5L robot.

Step 2……Turn on power to PLC.

Step3……Turn on pneumatics to 50psi.

Step4……Load program points on Motoman teach pendant.

Step5……Using teach pendant switch to PLAY mode.

Step6……Press the SERVO ON READY button to prepare robot to move.

Step7……Press START for assembly to begin.

5 Future Improvements

Reviewing the flashlight assembly there is many improvements that could be implemented. The first major improvement that could be made would be to the gripper. It would have been nice to be able to create a gripper that cut down on the amount of pneumatic lines going to it. It would have also been nice to create a gripper that picked up each part more efficiently. After improving the gripper the next element that needs to be improved is the stepper motor. The stepper motor that is needed has to have more torque so that it can screw the flashlight nose piece and the body together. All of the stations could be cleaned up and made to look better but the one that needs improved the most what the heat sink station. This station needs to orient the heat sink better so that the robot can pick it up easier.

6 PLC Ladder Diagram

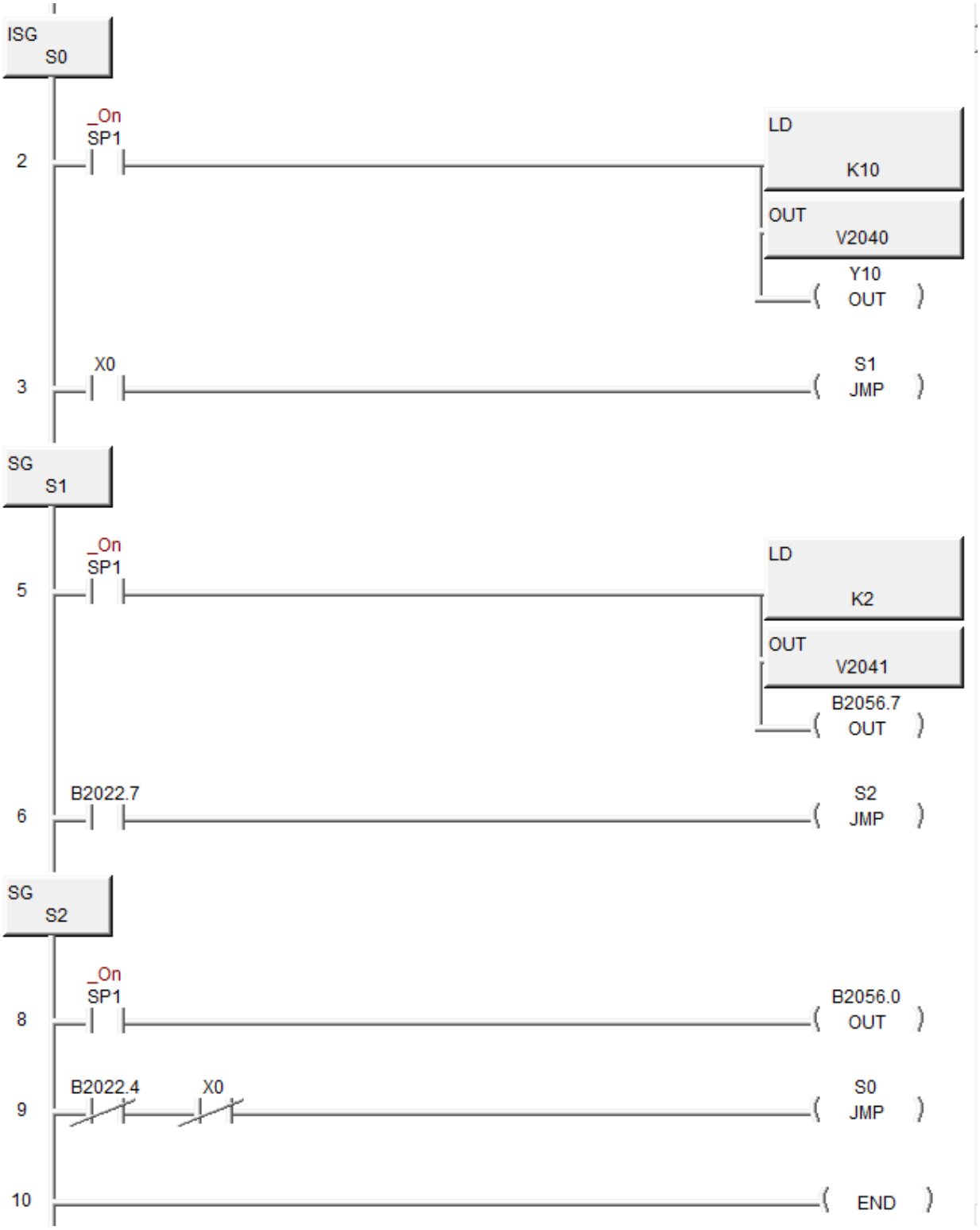


Figure 15.PLC Ladder Diagram

7 Robot Assembly Code

/JOB

//NAME 2012FLASHLIGHT

//POS

///NPOS 0,0,0,53,0,0

///TOOL 0

///POSTYPE PULSE

///PULSE

P00001=-34743,5765,-5087,-6294,-62725,-38068 \Pre Nose Pickup

P00002=-33218,12639,-13732,-6715,-52274,-37789 \Nose Pickup

P00003=13501,-7423,-59812,-600,-43103,-57349 \Rotary Home

P00004=13715,17190,-66525,-1016,-23371,-57110 \Rotary Drop Nose

P00005=-63906,22450,-44152,-13315,-30510,80852 \Pre Big Oring 1

P00006=-54914,30758,-30676,-10691,-34283,75724 \Pre Big Oring 2

P00007=-54611,33420,-30992,-11166,-32467,75994 \Big Oring Pickup

P00008=-66222,33552,-32825,-13041,-32226,81520 \Pre Small Oring 1

P00009=-61394,36949,-23082,-11031,-36629,78262 \Pre Small Oring 2

P00010=-60684,40794,-22901,-11528,-34425,78414 \Small Oring Pickup

P00011=-88973,18245,-14103,-21702,-51577,80603 \Pre Magnet Ring 1

P00012=-74105,33832,15616,-17267,-60264,81453 \Pre Magnet Ring 2

P00013=-71480,39786,11253,-18052,-53366,82001 \Magnet Ring Pickup

P00014=-61952,-24405,-49542,-2129,-60744,24174 \Pre Cone Pickup

P00015=-60721,-4033,-65016,-2975,-37225,24589 \Cone Pickup

P00016=16901,-44683,-63055,-766,-61857,-6459 \Pre Cone Drop

P00017=17282,-30905,-75310,-931,-44647,-6406 \Cone Drop

P00018=26536,-14115,-56395,-617,-48149,-10099 \Pre Toothbrush 1

P00019=26963,34409,-66505,-2209,-11500,-9146 \Toothbrush 1

P00020=37436,36264,-62273,-951,-13029,-13945 \Toothbrush 1 Out

P00021=-4435,8835,-33716,-1405,-51034,-52004 \Pre Toothbrush 2

P00022=-3579,47263,-43663,-2990,-20611,-51092 \Toothbrush 2

P00023=-3859,52054,-35072,-2611,-23952,-51248 \Toothbrush 2 Out

P00024=-4640,17475,-25990,-1404,-51422,-51932 \Post Toothbrush 2

P00025=-15171,36697,2517,-576,-61675,107539 \Pre Washer Pickup 1

P00026=-17795,77109,9475,-466,-41729,108289 \Pre Washer Pickup 2

P00027=-17550,88509,11009,-513,-35952,-98088 \Washer Pickup

P00028=27492,12506,-74090,-16841,44692,-4628 \Pre Body Pickup

P00029=22940,38856,-52890,-15531,44598,-4650 \Body Pickup

P00030=19311,-20120,-64978,-16441,35914,55923 \Pre Battery Pickup

P00031=14814,7812,-43793,-11758,36813,53497 \Battery Pickup

P00032=2054,-210,-47753,-1329,-46240,-53355 \Oring Pre Drop

P00033=14485,1985,-45593,-985,-46348,-58263 \Oring Drop

P00034=35662,-9985,-53671,-360,-47268,-13704 \Post Toothbrush 1

P00035=-48219,2713,-46894,-854,-46796,-33579 \Pre Nose Drop On Cone

P00036=-47986,18862,-53480,-1148,-32264,-33407 \Nose Drop On Cone

P00037=-81323,9834,-37979,-792,-49212,82069 \Pre Small Oring Drop

P00038=-81251,14154,-40817,-852,-44545,82102 \Small Oring Drop

P00039=-79396,13330,-42077,-864,-44114,81342 \Small Oring Drop 2

P00040=13043,-12013,-56464,-1194,-48226,-56970 \Pre Nose After Oring

P00041=13627,18304,-66240,-2244,-22821,-56364 \Nose Down After Oring

P00042=70,17183,18029,72708,83466,-105465 \Pre Heatsink Pickup 1

P00043=8754,18162,21564,71547,77998,-106021 \Pre Heatsink Pickup 2

P00044=10270,16791,11494,71040,78396,-101925 \Heatsink Pickup

P00045=11421,-1261,-42902,-1153,-51584,-56401 \Pre Heatsink Drop

P00046=11763,13190,-51046,-1478,-36947,-56224 \Heatsink Drop

P00047=10503,21304,-42413,-1448,-38305,-55774 \Post Heatsink Drop

P00048=-3166,1555,-49047,-607,-45449,-206 \Pre Washer Drop

P00049=-2914,29560,-56740,-1090,-22954,73 \Washer Drop

P00050=11438,458,-43860,-1181,-49852,-56376 \Pre Magnet Ring Drop

P00051=11771,15220,-51326,-1530,-35513,-56186 \Magnet Ring Drop

P00052=13682,-12432,-56353,-546,-48646,-57465 \Pre Body Down

P00053=13841,3260,-63669,-726,-33853,-57374 \Body Down

//INST

///DATE 2012/06/05 12:13

///ATTR SC,RW

///GROUP1 RB1

NOP

WAIT IN#(1)=ON

DOUT OT#(4) ON

WAIT IN#(1)=OFF

DOUT OT#(4) OFF

WAIT IN#(1)=ON

MOVL P003 V=50.0

MOVL P001 V=50.0

DOUT OT#(2) OFF

MOVL P002 V=50.0

DOUT OT#(2) ON

TIMER T=1.00

MOVL P001 V=50.0

MOVL P003 V=50.0

DOUT OT#(1) ON

MOVL P004 V=50.0

DOUT OT#(2) OFF

TIMER T=1.00

DOUT OT#(1) OFF

MOVL P003 V=50.0

MOVL P014 V=50.0

MOVL P015 V=50.0

DOUT OT#(2) ON

MOVL P014 V=50.0

MOVL P016 V=50.0

MOVL P017 V=50.0

DOUT OT#(2) OFF

MOVL P016 V=50.0

MOVL P005 V=50.0

MOVL P006 V=50.0

MOVL P007 V=50.0

DOUT OT#(2) ON

TIMER T=1.00

MOVL P006 V=50.0

MOVL P005 V=50.0

MOVL P032 V=50.0

MOVL P033 V=50.0

DOUT OT#(2) OFF

MOVL P016 V=50.0

MOVL P018 V=50.0

MOVL P019 V=50.0

MOVL P020 V=50.0

MOVL P034 V=50.0

MOVL P021 V=50.0

DOUT OT#(2) ON

MOVL P022 V=50.0

MOVL P023 V=50.0

MOVL P024 V=50.0

MOVL P016 V=50.0

DOUT OT#(2) OFF

MOVL P017 V=50.0

DOUT OT#(2) ON

MOVL P016 V=50.0

MOVL P014 V=50.0

MOVL P015 V=50.0

DOUT OT#(2) OFF

MOVL P014 V=50.0

MOVL P040 V=50.0

MOVL P041 V=50.0

DOUT OT#(1) ON

DOUT OT#(2) ON

MOVL P040 V=50.0

MOVL P035 V=50.0

MOVL P036 V=50.0

DOUT OT#(2) OFF

MOVL P035 V=50.0

MOVL P008 V=50.0

MOVL P009 V=50.0

MOVL P010 V=50.0

DOUT OT#(2) ON

TIMER T=1.00

MOVL P009 V=50.0

MOVL P008 V=50.0

MOVL P037 V=50.0

MOVL P038 V=50.0

MOVL P039 V=50.0

PAUSE

DOUT OT#(2) OFF

MOVL P037 V=50.0

MOVL P035 V=50.0

MOVL P036 V=50.0

DOUT OT#(2) ON

MOVL P035 V=50.0

MOVL P040 V=50.0

MOVL P041 V=50.0

DOUT OT#(2) OFF

TIMER T=1.00

DOUT OT#(1) OFF

MOVL P040 V=50.0

MOVL P042 V=50.0

MOVL P043 V=50.0

MOVL P044 V=10.0

DOUT OT#(2) ON

MOVL P043 V=10.0

MOVL P042 V=50.0

MOVL P040 V=50.0

MOVL P045 V=50.0

MOVL P046 V=50.0

DOUT OT#(2) OFF

MOVL P047 V=10.0

MOVL P040 V=50.0

MOVL P025 V=50.0

MOVL P026 V=50.0

MOVL P027 V=30.0

TIMER T=1.00

MOVL P026 V=40.0

MOVL P025 V=40.0

MOVL P048 V=50.0

MOVL P049 V=30.0

DOUT OT#(2) ON

TIMER T=1.00

MOVL P048 V=50.0

MOVL P011 V=50.0

MOVL P012 V=50.0

DOUT OT#(2) ON

MOVL P013 V=50.0

DOUT OT#(2) OFF

TIMER T=1.00

MOVL P012 V=50.0

MOVL P011 V=50.0

MOVL P050 V=50.0

MOVL P051 V=50.0

DOUT OT#(2) ON

MOVL P050 V=50.0

MOVL P028 V=50.0

DOUT OT#(2) OFF

MOVL P029 V=50.0

DOUT OT#(2) ON

TIMER T=1.00

MOVL P028 V=50.0

MOVL P030 V=50.0

MOVL P031 V=50.0

DOUT OT#(3) ON

TIMER T=1.00

DOUT OT#(3) OFF

MOVL P030 V=50.0

MOVL P052 V=50.0

MOVL P053 V=30.0

DOUT OT#(4) ON

WAIT IN#(2)=ON

DOUT OT#(2) OFF

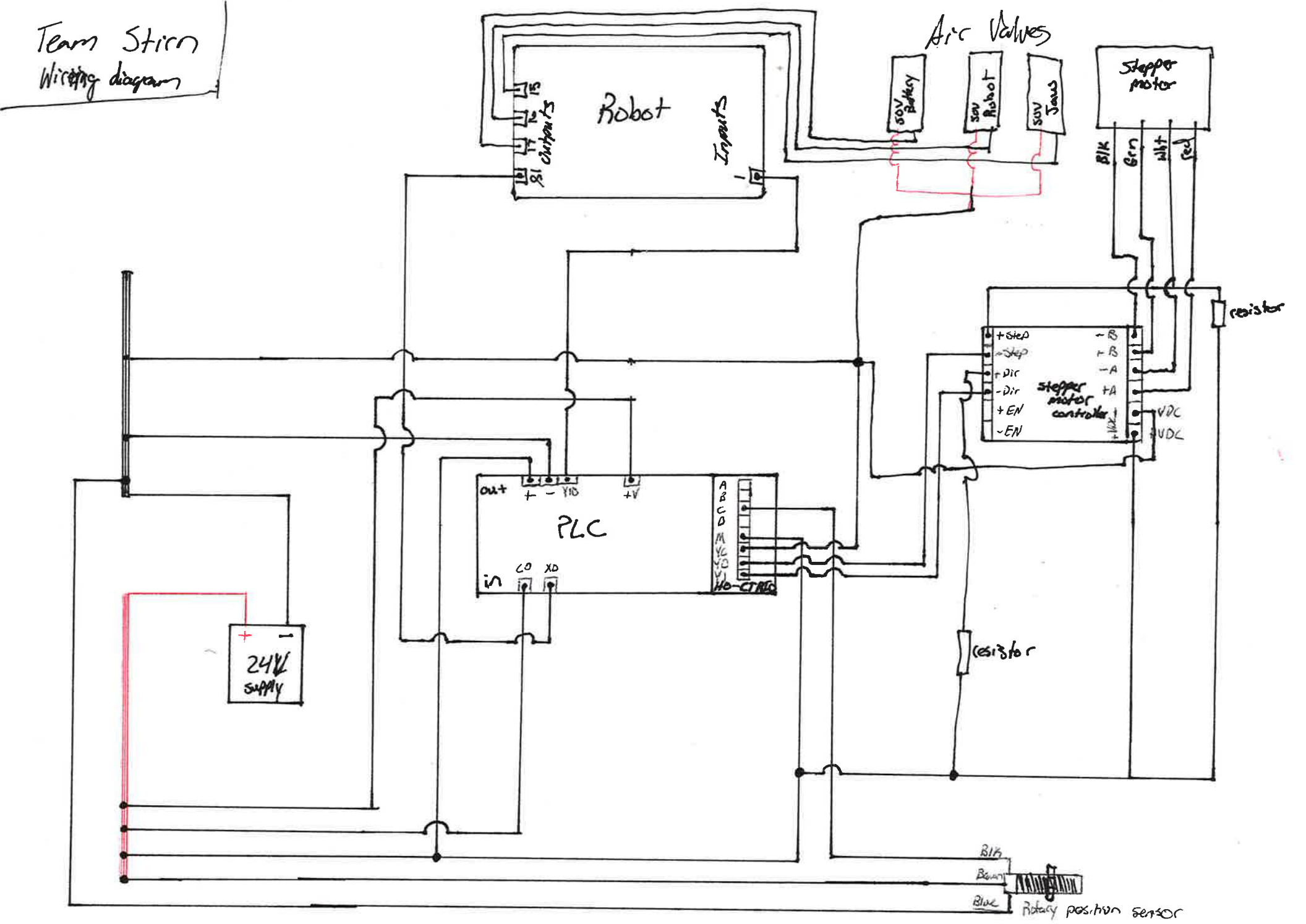
```
DOUT OT#(4) ON

WAIT IN#(2)=ON

DOUT OT#(1) ON

MOVL P052 V=30.0

END
```


Team Stirn
Wiring diagram
Robot
Inputs
outputs
Air Valves
Stepper motor
Blk
Grn
Wht
Red
resistor
+Step
-Step
+Dir
-Dir
+EN
-EN
-B
+B
-A
+A
stepper motor controller
VDC
PLC
out+
24V
supply
resistor
Blk
Brown
Blue
Rotary position sensor