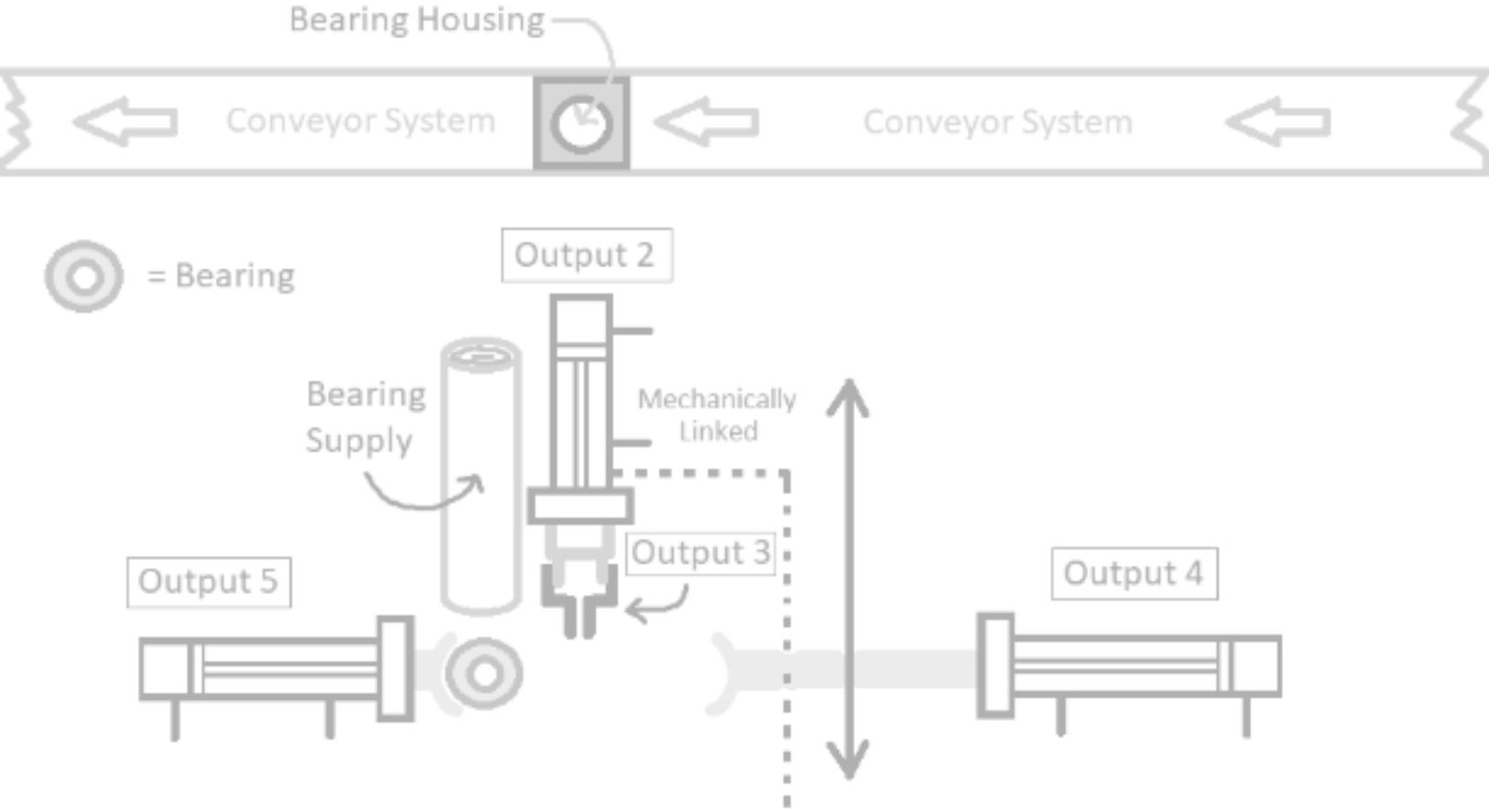


Bearing Supply, Sorting, & Placement Automated System

By Kurt Foster, 2018

Please note: Although I worked on this project with a team, the following sections show everything I accomplished on my own.

This project was a continuation from previous years students at my college. The following sections explain what I did to develop the project.

System Operation at High Level:

Please refer to the next page to see “visually” what the outputs are doing

If there is a bearing with the correct size:

1. Bearing presence sensor should be made
2. Right side cylinder extend completely (output 4)
3. Left side cylinder extend completely (output 5)
4. Both left and right cylinder turn off at the same time (output 4 and 5)
5. Vertical cylinder extends (output 2)
6. Gripper arms opens (output 3)
7. Vertical cylinder retracts (output 2)
8. Horizontal placement cylinder extends (output 1)
9. Vertical cylinder extends (output 2)
10. Gripper arms close (output 3)
11. Vertical cylinder retracts (output 2)
12. Horizontal placement cylinder retracts (output 1)

If there is a bearing with the wrong size:

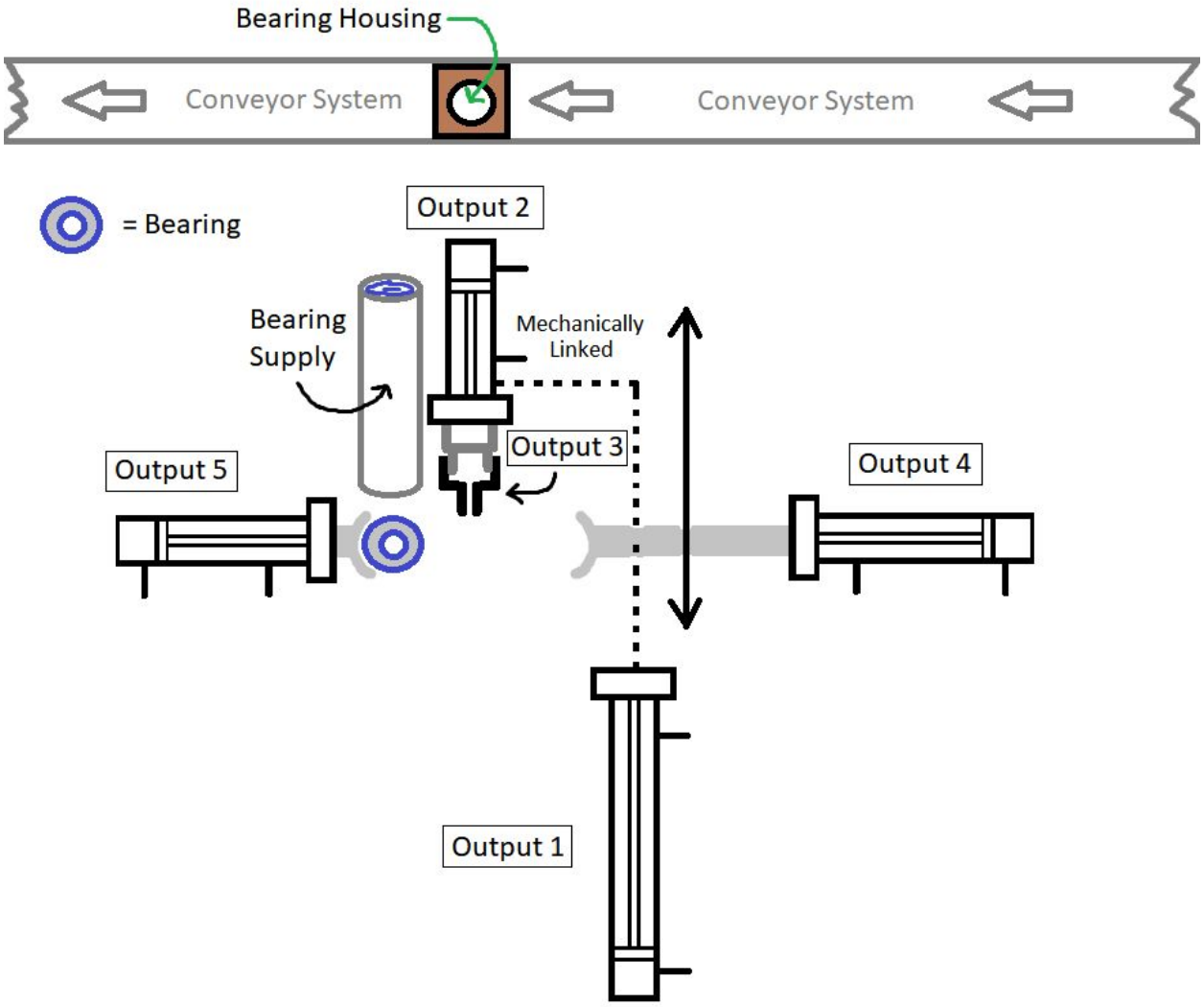
1. Bearing presence sensor should be made
2. Left side cylinder extend completely (pushes bearing onto reject ramp)

Alarm light feature:

1. Alarm light will flash quickly if there is a bearing present, the system has started and no outputs are getting power

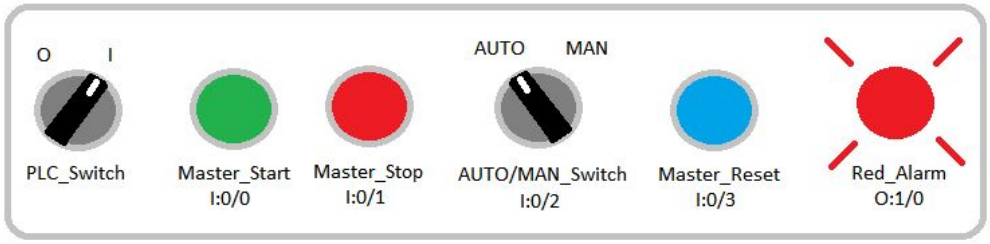
Part Counting Operation:

1. If the last operation is done for the tall bearing section, the tall bearing count will go up once each rotation
2. If the last operation was done for the short bearing (reject), the short bearing count will go up once each reject rotation



OPERATOR INTERFACE

Kurt Foster 2017



Inputs and Outputs:

Inputs:

I:0/0	Master_Start - Normally Open Pushbutton
I:0/1	Master_Stop - Normally Closed Pushbutton
I:0/2	Automatic_Mode/Manual_Mode - SPST Switch
I:0/3	Master_Reset - Normally Open Pushbutton
I:0/4	Sensor 1 - Left Side cylinder extended
I:0/5	Sensor 2 - Left Side cylinder retracted
I:0/6	Sensor 3 - Vertical cylinder retracted
I:0/7	Sensor 4 - Vertical cylinder extended
I:0/8	Sensor 5 - Horizontal Placement cylinder extended
I:0/9	Sensor 6 - Horizontal Placement cylinder retracted
I:0/10	Sensor 7 - Right placement cylinder extended
I:0/11	Sensor 8 - Right placement cylinder retracted
I:0/14	Sensor 9 - Bearing Height Sensor
I:0/12	Sensor 10 - Bearing Gripper Close
I:0/13	Sensor 11 - Bearing Gripper Open
I:0/15	Sensor 12 - Bearing Presence sensor

Outputs:

O:1/0	Red_Alarm - Light
O:1/1	DCV 1 - Horizontal Placement Cylinder
O:1/2	DCV 2 - Vertical Cylinder
O:1/3	DCV 3 - Bearing Gripper
O:1/4	DCV 4 - Right side bearing placement cylinder
O:1/5	DCV 5 - Left side bearing placement cylinder

IF/THEN Statements Developed from Requirements:

The following statements describe the operation while in AUTOMATIC mode. Meaning the system will autonomously continue as long as there is a supply of bearings and that the program has been started from the start button and the operator has set the switch to "AUTO" mode.
Rung 0: IF MASTER_START AND NOT MASTER_STOP then AUTO_ON_MEMORY

IF SHORT BEARING IS PRESENT THEN **REJECT**:
Rung 1: IF AUTO_ON_MEMORY AND SENSOR_2 AND SENSOR_8 AND SENSOR_3 AND SENSOR_6 AND SENSOR_12 AND SENSOR_10 AND NOT SENSOR_9 THEN DCV_5.0 with memory latcher.
Rung 2: IF AUTO_ON_MEMORY AND DCV_5.0 AND SENSOR_1 AND SENSOR_3 AND SENSOR_6 AND SENSOR_8 AND SENSOR_10 THEN ONE_SEC_REJECT for One Second (TON timer)
Rung 3: IF AUTO_ON_MEMORY AND ONE_SEC_REJECT_DONE_BIT AND SENSOR_1 AND SENSOR_3 AND SENSOR_6 AND SENSOR_8 AND SENSOR_10 THEN CUT_DCV_5.0 memory latcher

IF TALL BEARING IS PRESENT THEN **DON'T REJECT** BEARING SECTION:
Rung 4: IF AUTO_ON_MEMORY AND SENSOR_2 AND SENSOR_8 AND SENSOR_3 AND SENSOR_6 AND SENSOR_12 AND SENSOR_9 AND SENSOR_10 THEN DCV_4.0 with memory latcher.
Rung 5: IF AUTO_ON_MEMORY AND DCV_4.0 AND SENSOR_7 AND SENSOR_2 AND SENSOR_3 AND SENSOR_6 AND SENSOR_9 AND SENSOR_10 THEN DCV_5.1 with memory latcher
Rung 6: IF AUTO_ON_MEMORY AND DCV_5.1 AND DCV_4.0 AND SENSOR_1 AND SENSOR_7 AND SENSOR_3 AND SENSOR_6 AND SENSOR_10 AND NOT SENSOR_12 THEN CUT_ DCV_4.0 memory latcher AND CUT_DCV_5.1 memory latcher
Rung 7: IF AUTO_ON_MEMORY AND CUT_DCV_4 AND CUT_DCV_5 AND SENSOR_2 AND SENSOR_3 AND SENSOR_6 AND SENSOR_8 AND SENSOR_10 THEN DCV_2.0 with memory latcher
Rung 8: IF AUTO_ON_MEMORY AND DCV_2.0 AND SENSOR_2 AND SENSOR_4 AND SENSOR_6 AND SENSOR_8 AND SENSOR_10 THEN DCV_3.0 with memory latcher
Rung 9: IF AUTO_ON_MEMORY AND DCV_3.0 AND SENSOR_2 AND SENSOR_4 AND SENSOR_6 AND SENSOR_8 AND SENSOR_11 THEN CUT_DCV_2.0 memory latcher
Rung 10: IF AUTO_ON_MEMORY AND CUT_DCV_2.0 AND SENSOR_2 AND SENSOR_3 AND SENSOR_6 AND SENSOR_8 AND SENSOR_11 THEN DCV_1.0 with memory latcher

Rung 11: IF AUTO_ON_MEMORY AND DCV_1.0 AND SENSOR_2 AND SENSOR_3 AND SENSOR_5 AND SENSOR_8 AND SENSOR_11 THEN DCV_2.1 with memory latcher
Rung 12: IF AUTO_ON_MEMORY AND DCV_2.1 AND SENSOR_2 AND SENSOR_4 AND SENSOR_5 AND SENSOR_8 AND SENSOR_11 THEN CUT_DCV_3.0 memory
Rung 13: IF AUTO_ON_MEMORY AND CUT_DCV_3.0 AND SENSOR_2 AND SENSOR_4 AND SENSOR_5 AND SENSOR_8 AND SENSOR_10 THEN CUT_DCV_2.1 memory
Rung 14: IF AUTO_ON_MEMORY AND CUT_DCV_2.1 AND SENSOR_2 AND SENSOR_3 AND SENSOR_5 AND SENSOR_8 AND SENSOR_10 THEN CUT_DCV_1 memory
Rung 15: IF AUTO_ON_MEMORY AND CUT_DCV_3.0 AND CUT_DCV_2.1 AND CUT_DCV_1.0 AND SENSOR_2 AND SENSOR_3 AND SENSOR_6 AND SENSOR_8 AND SENSOR_10 THEN CUT_DCV_3.0_2.1_1.0 memory

DCV **OUTPUT RUNGS** FOR EASE OF SEEING WHICH OUTPUTS ARE ON:
Rung 16: IF DCV_1.0 MEMORY LATCH THEN POWER DCV_1
Rung 17: IF DCV_2.0 MEMORY LATCH OR DCV_2.1 MEMORY LATCH THEN POWER DCV_2
Rung 18: IF DCV_3.0 MEMORY LATCH THEN POWER DCV_3
Rung 19: IF DCV_4.0 MEMORY LATCH THEN POWER DCV_4
Rung 20: IF DCV_5.0 MEMORY LATCH OR DCV_5.1 MEMORY LATCH THEN POWER DCV_5

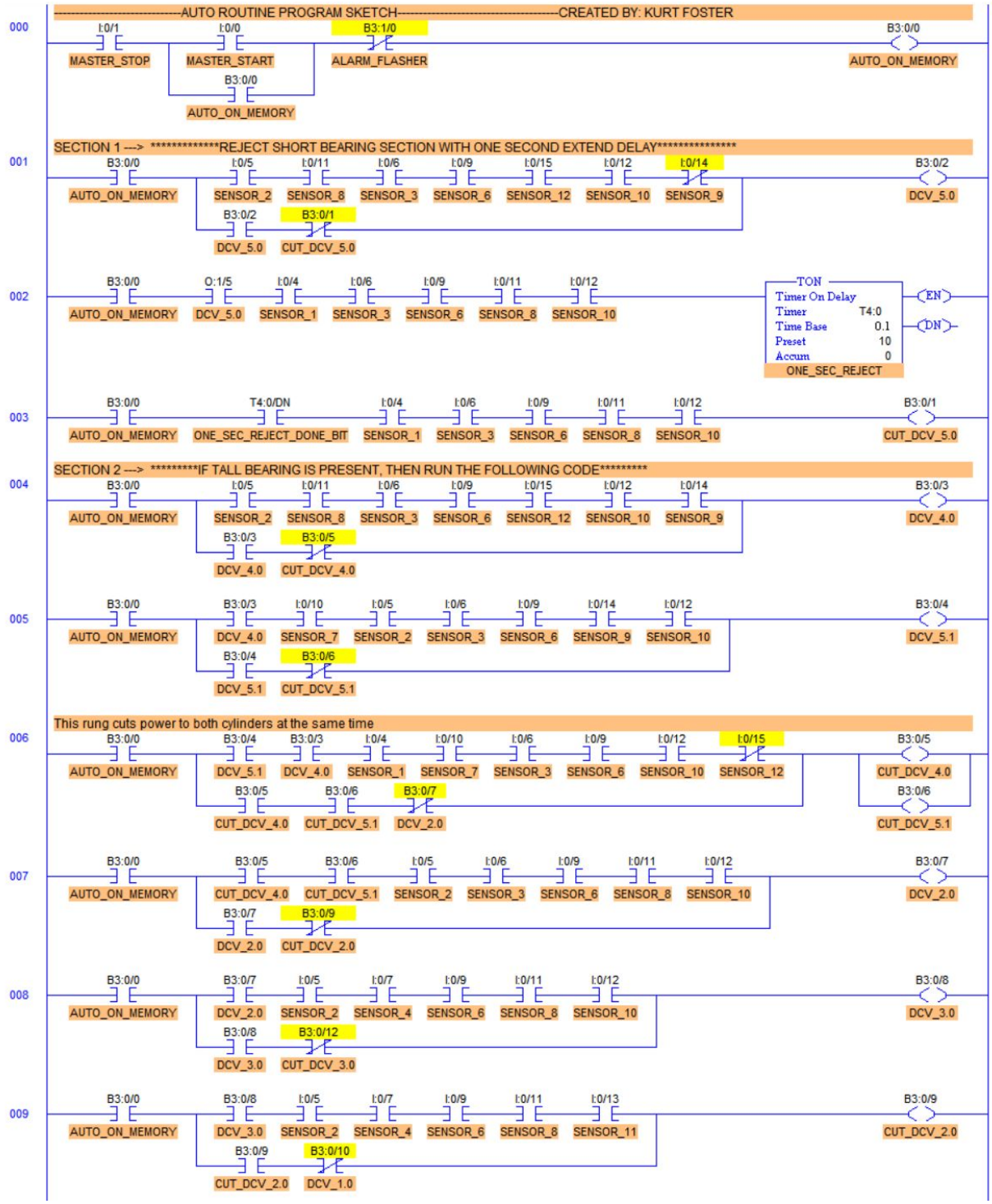
ALARM FLASHER OPERATION:
Rung 21: IF AUTO_ON_MEMORY AND SENSOR_12 AND NOT DCV_1 AND NOT DCV_2 AND NOT DCV_3 AND NOT DCV_4 AND NOT DCV_5 THEN ALARM_FLASHER with memory latch
Rung 22: IF ALARM_FLASHER AND NOT QUICK_FLASH_OFF_TIME/DN THEN QUICK_FLASH_ON_TIME FOR 0.3 SECONDS
Rung 23: IF QUICK_FLASH_ON_TIME/DN THEN QUICK_FLASH_OFF_TIME FOR 0.3 SECONDS
Rung 24: IF QUICK_FLASH_ON_TIME/DN THEN RED_ALARM

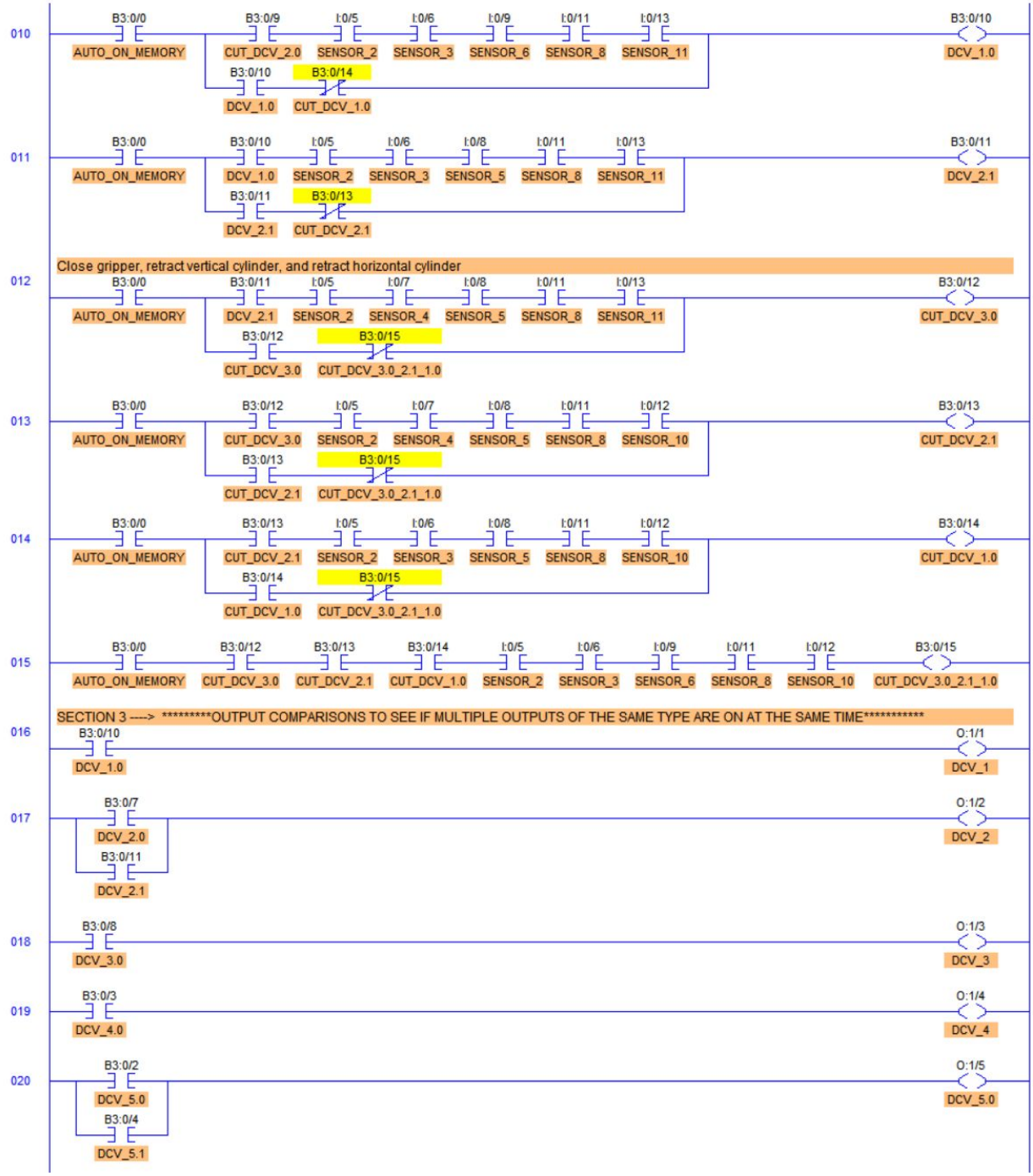
BEARING COUNT OPERATION:
Rung 25: IF CUT_DCV_3.0_2.1_1.0 THEN TALL_BEARINGS COUNTS UP
Rung 26: IF ONE_SEC_REJECT_DONE_BIT THEN SHORT_BEARINGS COUNTS UP
Rung 27: TALL_BEARING.ACC WILL ADD TO SHORT_BEARINGS.ACC THEN STORE IN INTEGER FILE N7:0, N7:0 = TOTAL_BEARINGS_PROCESSED

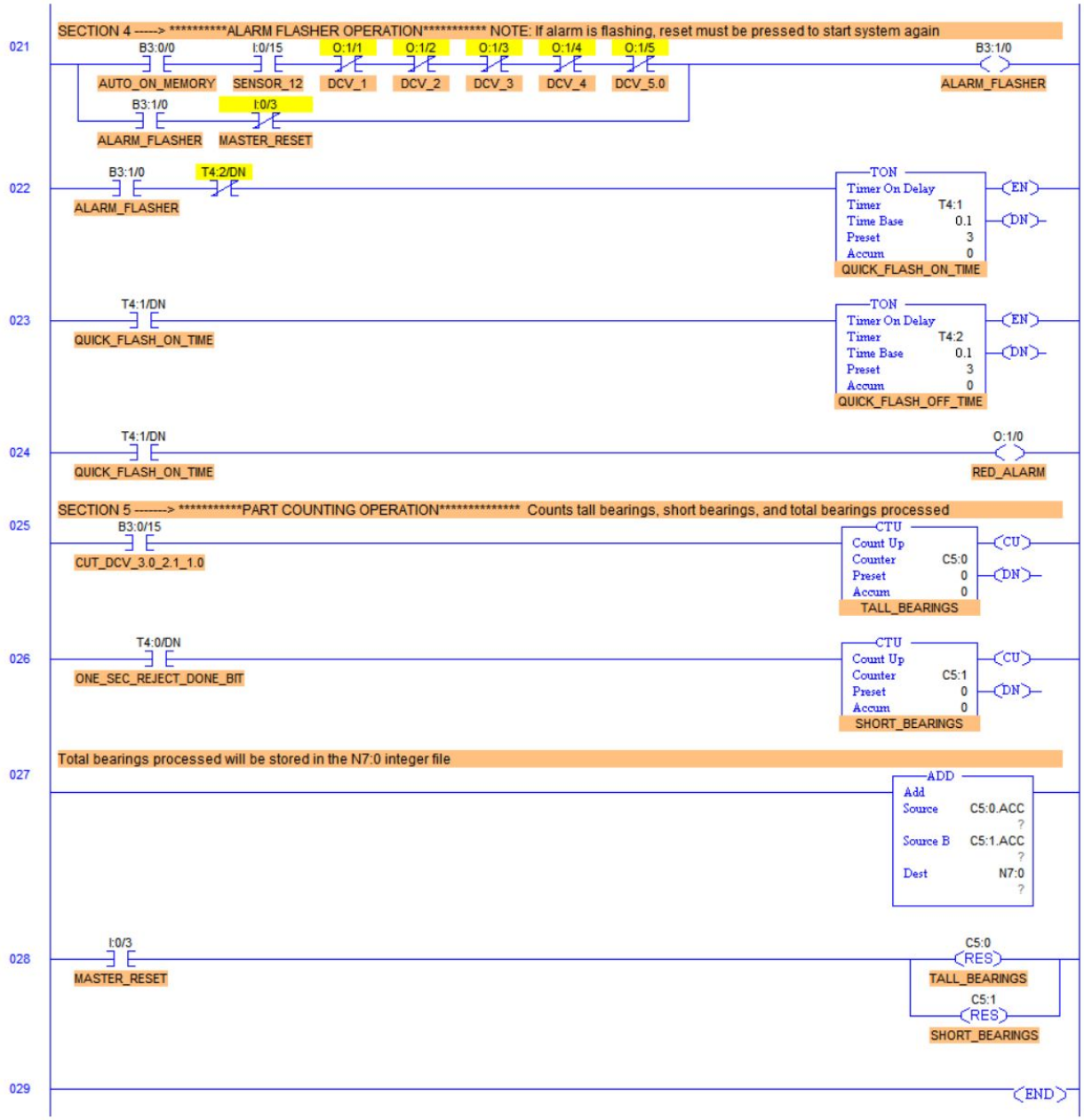
Rung 28: IF MASTER_RESET THEN RESET TALL_BEARINGS COUNT AND SHORT_BEARINGS COUNT

PLC Program:

This program was written using LogixPro Software (Allen Bradley RSLogix Simulation Software) and was fully created by Kurt Foster, finished 12/10/2017




010
B3:0/0
AUTO_ON_MEMORY
B3:0/9
CUT_DCV_2.0
I:0/5
SENSOR_2
I:0/6
SENSOR_3
I:0/9
SENSOR_6
I:0/11
SENSOR_8
I:0/13
SENSOR_11
B3:0/10
DCV_1.0
B3:0/14
CUT_DCV_1.0
B3:0/10
DCV_1.0
011
B3:0/0
AUTO_ON_MEMORY
B3:0/10
DCV_1.0
I:0/5
SENSOR_2
I:0/6
SENSOR_3
I:0/8
SENSOR_5
I:0/11
SENSOR_8
I:0/13
SENSOR_11
B3:0/11
DCV_2.1
B3:0/13
CUT_DCV_2.1
B3:0/11
DCV_2.1
Close gripper, retract vertical cylinder, and retract horizontal cylinder
012
B3:0/0
AUTO_ON_MEMORY
B3:0/11
DCV_2.1
I:0/5
SENSOR_2
I:0/7
SENSOR_4
I:0/8
SENSOR_5
I:0/11
SENSOR_8
I:0/13
SENSOR_11
B3:0/12
CUT_DCV_3.0
B3:0/15
CUT_DCV_3.0_2.1_1.0
B3:0/12
CUT_DCV_3.0
013
B3:0/0
AUTO_ON_MEMORY
B3:0/12
CUT_DCV_3.0
I:0/5
SENSOR_2
I:0/7
SENSOR_4
I:0/8
SENSOR_5
I:0/11
SENSOR_8
I:0/12
SENSOR_10
B3:0/13
CUT_DCV_2.1
B3:0/15
CUT_DCV_3.0_2.1_1.0
B3:0/13
CUT_DCV_2.1
014
B3:0/0
AUTO_ON_MEMORY
B3:0/13
CUT_DCV_2.1
I:0/5
SENSOR_2
I:0/6
SENSOR_3
I:0/8
SENSOR_5
I:0/11
SENSOR_8
I:0/12
SENSOR_10
B3:0/14
CUT_DCV_1.0
B3:0/15
CUT_DCV_3.0_2.1_1.0
B3:0/14
CUT_DCV_1.0
015
B3:0/0
AUTO_ON_MEMORY
B3:0/12
CUT_DCV_3.0
B3:0/13
CUT_DCV_2.1
B3:0/14
CUT_DCV_1.0
I:0/5
SENSOR_2
I:0/6
SENSOR_3
I:0/9
SENSOR_6
I:0/11
SENSOR_8
I:0/12
SENSOR_10
B3:0/15
CUT_DCV_3.0_2.1_1.0
SECTION 3 ----> *********OUTPUT COMPARISONS TO SEE IF MULTIPLE OUTPUTS OF THE SAME TYPE ARE ON AT THE SAME TIME**********
016
B3:0/10
DCV_1.0
O:1/1
DCV_1
017
B3:0/7
DCV_2.0
B3:0/11
DCV_2.1
O:1/2
DCV_2
018
B3:0/8
DCV_3.0
O:1/3
DCV_3
019
B3:0/3
DCV_4.0
O:1/4
DCV_4
020
B3:0/2
DCV_5.0
B3:0/4
DCV_5.1
O:1/5
DCV_5.0

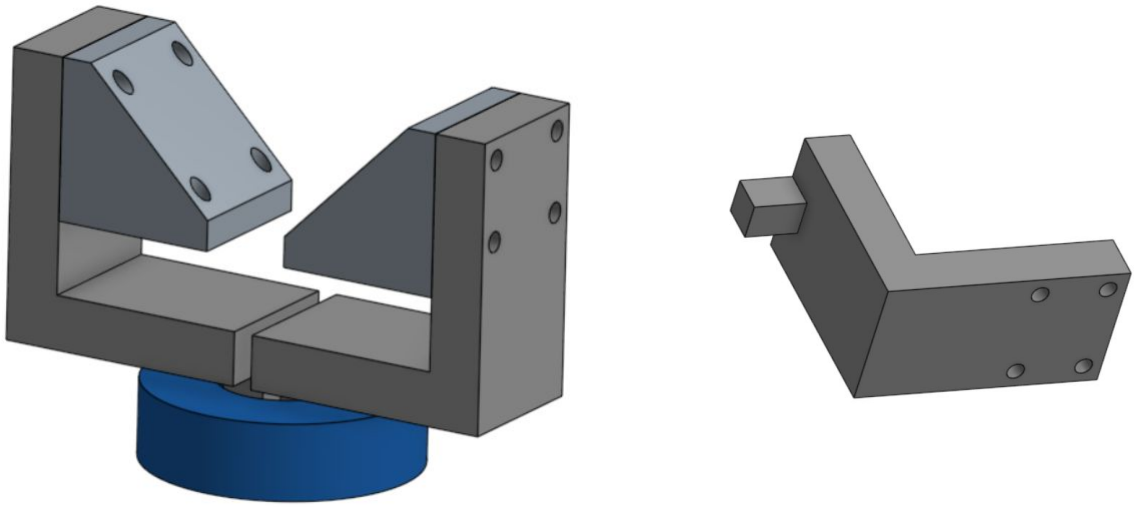

SECTION 4 -----> **********ALARM FLASHER OPERATION********** NOTE: If alarm is flashing, reset must be pressed to start system again
021
B3:0/0
AUTO_ON_MEMORY
I:0/15
SENSOR_12
O:1/1
DCV_1
O:1/2
DCV_2
O:1/3
DCV_3
O:1/4
DCV_4
O:1/5
DCV_5.0
B3:1/0
ALARM_FLASHER
B3:1/0
ALARM_FLASHER
I:0/3
MASTER_RESET
B3:1/0
ALARM_FLASHER
022
T4:2/DN
TON
Timer On Delay
Timer T4:1
Time Base 0.1
Preset 3
Accum 0
QUICK_FLASH_ON_TIME
EN
DN
T4:1/DN
QUICK_FLASH_ON_TIME
023
TON
Timer On Delay
Timer T4:2
Time Base 0.1
Preset 3
Accum 0
QUICK_FLASH_OFF_TIME
EN
DN
T4:1/DN
QUICK_FLASH_ON_TIME
024
O:1/0
RED_ALARM
SECTION 5 -------> **********PART COUNTING OPERATION********** Counts tall bearings, short bearings, and total bearings processed
025
B3:0/15
CUT_DCV_3.0_2.1_1.0
CTU
Count Up
Counter C5:0
Preset 0
Accum 0
TALL_BEARINGS
CU
DN
T4:0/DN
ONE_SEC_REJECT_DONE_BIT
026
CTU
Count Up
Counter C5:1
Preset 0
Accum 0
SHORT_BEARINGS
CU
DN
Total bearings processed will be stored in the N7:0 integer file
027
ADD
Add
Source C5:0.ACC
?
Source B C5:1.ACC
?
Dest N7:0
?
I:0/3
MASTER_RESET
028
C5:0
RES
TALL_BEARINGS
C5:1
RES
SHORT_BEARINGS
029
END

Design of Parts:

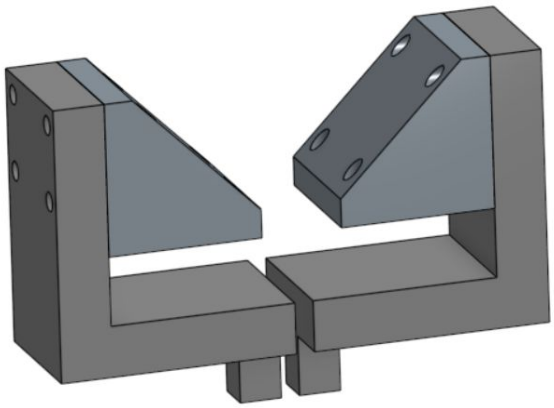
I made two versions of grippers that attached to a pneumatic component. My design had to grab the bearing and pick it up so it could be placed into a bearing housing.

The first design was not faulty, however the component it was attached to did not operate properly due to unknown reasons. The component was used in a seperate application so dirty pneumatic lines could have been the problem.

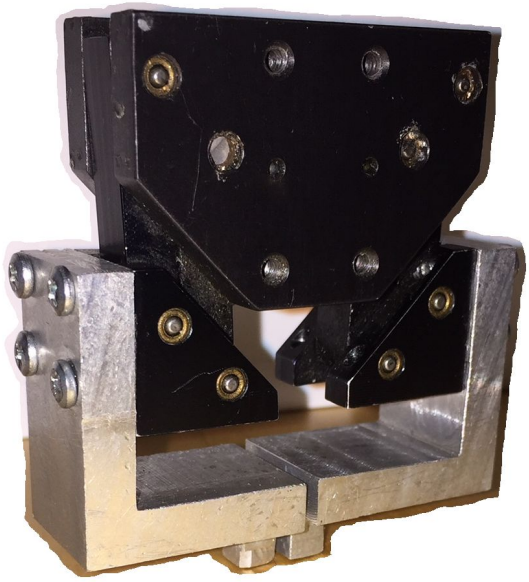
My team assumed we could fix it in time for the following week's meeting and so that evening I milled out of aluminum the following CAD design:



The blue cylinder is the bearing and the grey parts are what I designed.
The triangle shapes show what part I had to attach to.

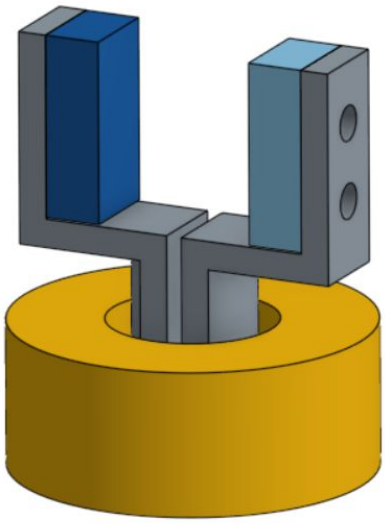


Luckily this happened.



Then it wasn’t so lucky after all.

It turns out air couldn’t get through this black pneumatic anodized component.
It was broken. So a different gripper had to be ordered and new arms had to be designed.



Version 2

This part was attached to an SMC product, it's arms represented by the blue shapes. The bearing represents the yellow cylinder. Then finally the part I designed, in grey.

Our team thought it would be a good idea to test a 3-D printed version out of nylon.

If time persisted, the next step would be to integrate the Master PLC to this station in order to have complete control of the counting, bearing type and speed control.

Thank you for spending the time viewing my work.