

PSDE4005 Assignment 2

by Jonathan Phillips

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HNC Electrical & Electronic Engineering
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Programmable Logic Controllers:
Assignment 2

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Hardware Investigation, System Design and I/O List

The robotic arm machine being tested in this report operates using both electrical power and pneumatic power from pistons. This machine is a basic robotic manufacturing machine used to simulate industrial purposes. The robot can work if programmed from a PLC; in this case, Siemens S-7 1214 PLC is being used. The machine has 4 stations from which the hand can pick up or drop objects to simulate manufacturing, station 1 is connected to the entry chute and station 4 is connected to the exit chute.

The machine uses nine sensors, 8 solenoids, and 3 pushbuttons, and 2 toggle switches. Most of the sensors are reed switches connected to the robot arm to detect where the position of the arm is, reed switches used small magnetic fields to do this. A proximity sensor is used on the entry chute to find an object rolling when there's changes in its magnetic field. The pushbuttons and toggle switches are located at the power box in the front of the machine. All of the solenoids operate from electromechanical solenoid valves that open or close depending on electrical current. They're located at the back of the PLC and work with compressed air.

Input	Output
I0.0: up sensor	Q0.0: move down solenoid
I0.1: down sensor	Q0.1: move up solenoid
I0.2: gripper opened sensor	Q0.2: close gripper solenoid
I0.3: gripper closed sensor	Q0.3: open gripper solenoid
I0.4: in sensor	Q0.4: move out solenoid
I0.5: out sensor	Q0.5: move in solenoid
I0.6: right sensor	Q0.6: move left solenoid
I0.7: left sensor	Q0.7: move right solenoid
I1.0: pushbutton X10	
I1.1: pushbutton X11	
I1.2: pushbutton X12	
I1.3: toggle switch X13	
I1.4: toggle switch X14	
I1.5: object sensor	

Each of the figures that follow should be explained. They could be reduced in size.

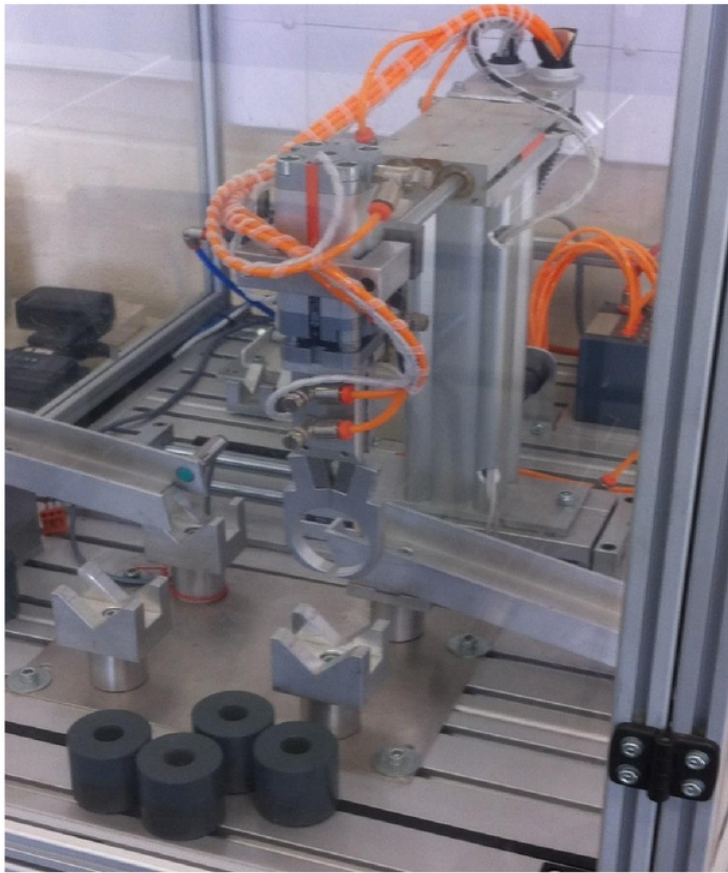


Figure 1 Robotic arm machine



Figure 2: Entry chute

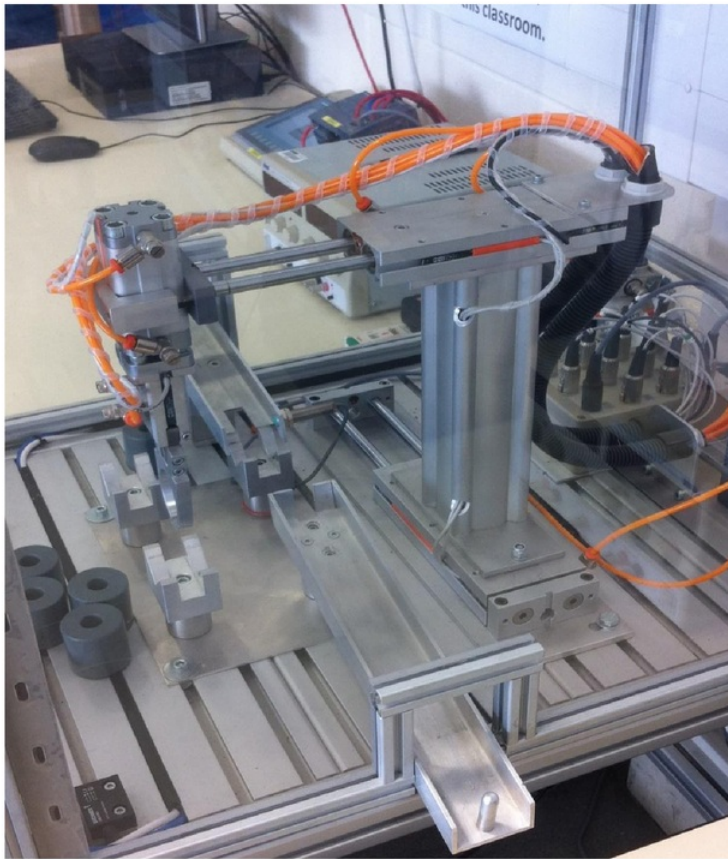


Figure 3: Exit chute



Figure 4: Power box

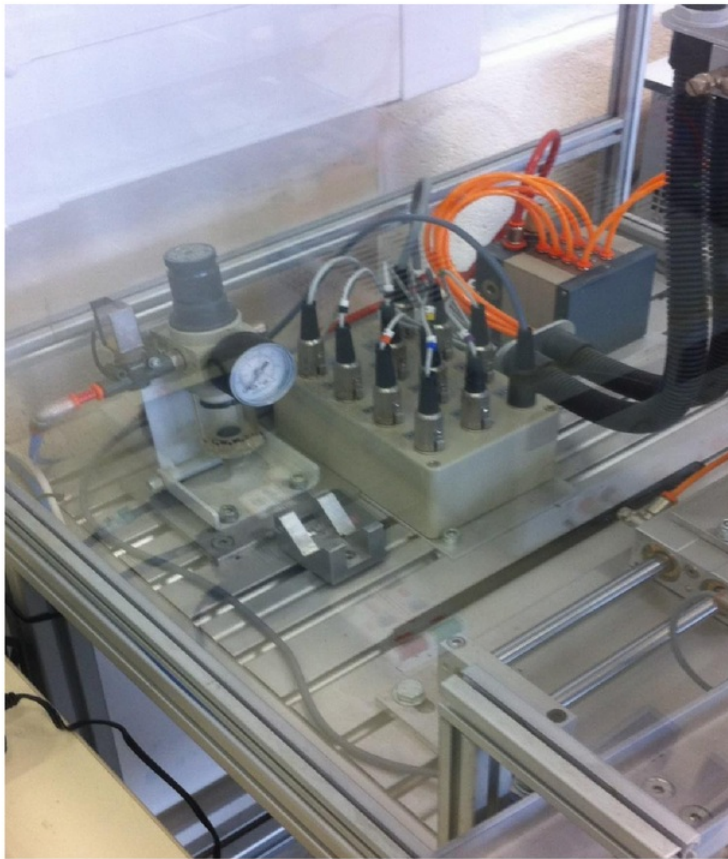
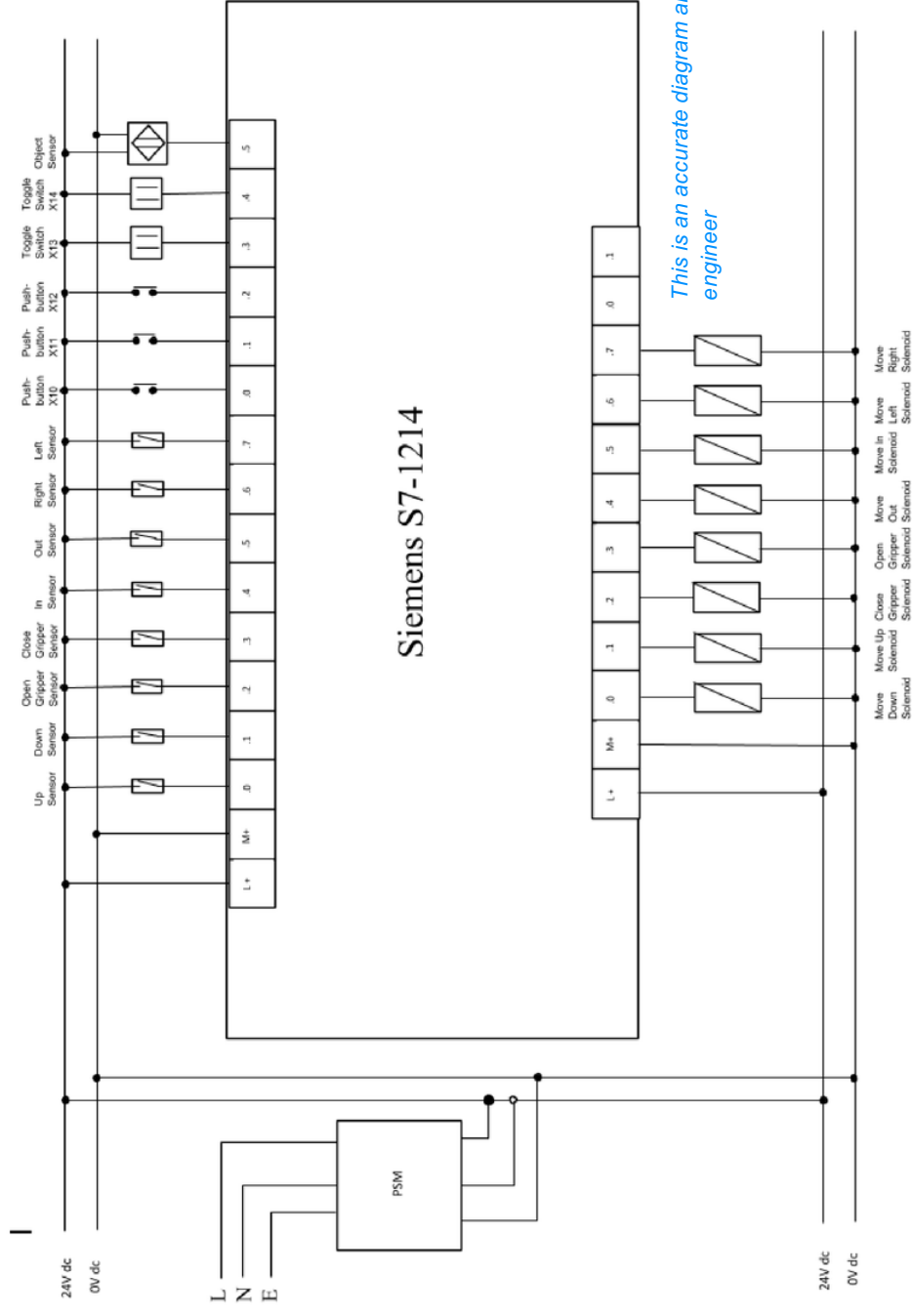


Figure 5: Pneumatic valves



This is an accurate diagram and would be very useful to an engineer

Figure 6: Siemens

PLC Electrical Drawing

Program Documentation and Explanation

The program was built for the purpose of creating a basic loading and unloading automatic sequences for the pick and place robot, as well as being able to manually control it. The robot will unload metal or plastic cylinders meant to simulate products in a manufacturing situation. The program was made on TIA Portal 7 with ladder and SCL languages, the output and mains part of program were made in ladder programming, while the sequences were made with SCL programming.

Mains Program

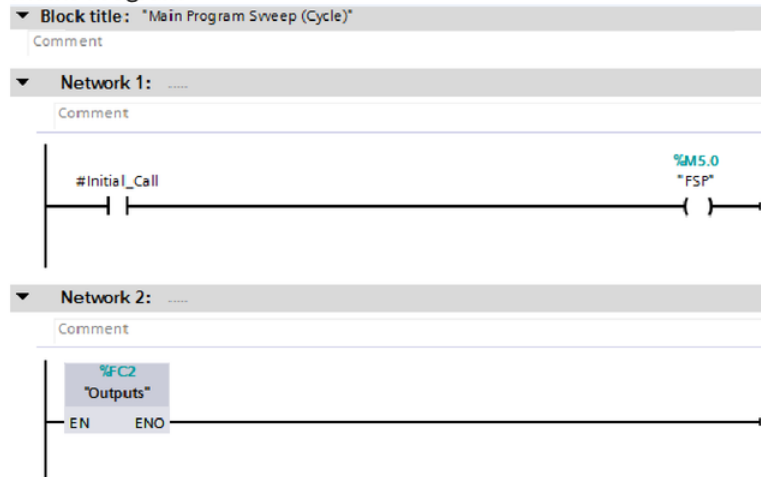


Figure 7: Network 1-2

Network 1-3 are the mains that are constant when working, the first network is simply the initial call that gets the machine starting while network 2 keeps the output program constant.

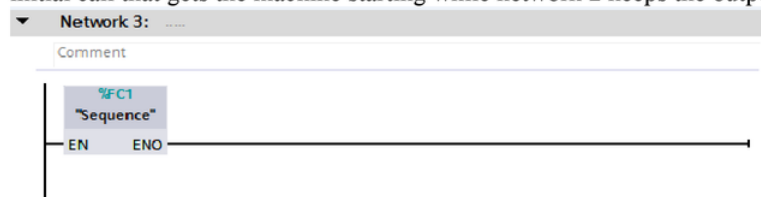


Figure 8: Network 3

Network 3 is like network 2 in that it keeps the sequence program constant.

Output Program

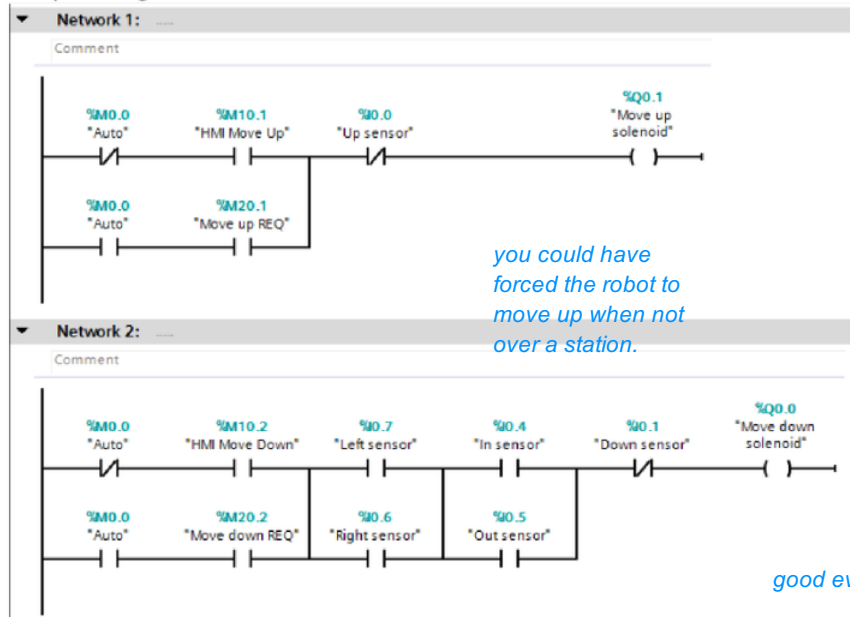


Figure 9:

Network 1-2

There are 12 networks that are part of the output program that allow manual controls; the first network gives the pick and place robot the ability to move up. The second network allows the robot to move down; but as a safety feature, it also doesn't let the hand go down unless the 'in', 'out', 'left', and 'right' sensors are on. The action is carried out until the sensors are reached, hence why the 'up' sensor is closed before the 'up' solenoid; the same thing works with other networks. If 'Auto' is open, then there is manual control of the program; if close, then the sequence is able to be carried out.

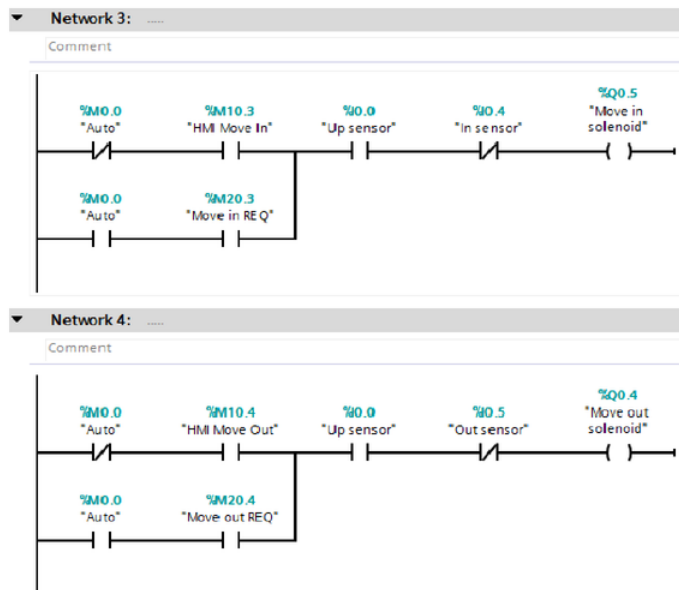


Figure 10: Network 3-4

These networks allows the program to move in or out from an orientation where the viewer is facing toward station 1 and 4. The hand cannot move up unless it's in the up position in these two programs.

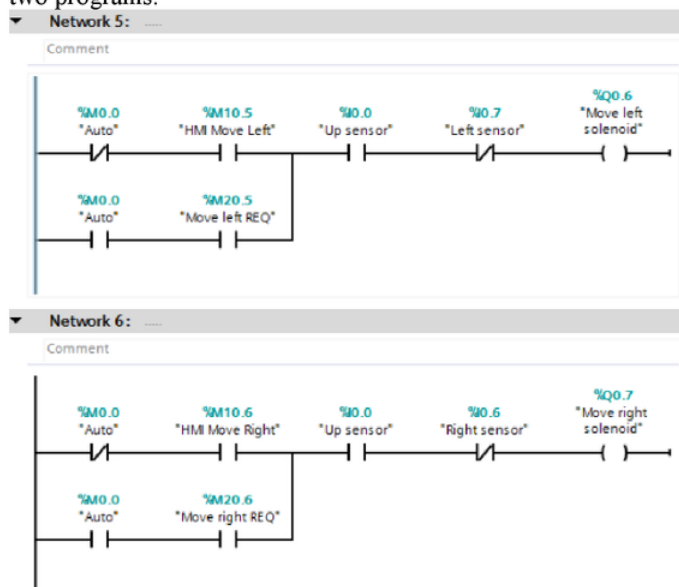


Figure 11: Network 5-6

These networks let the hand move left or right from the same orientation and likewise with network 3 and 4, the hand cannot move left or right in the up position.

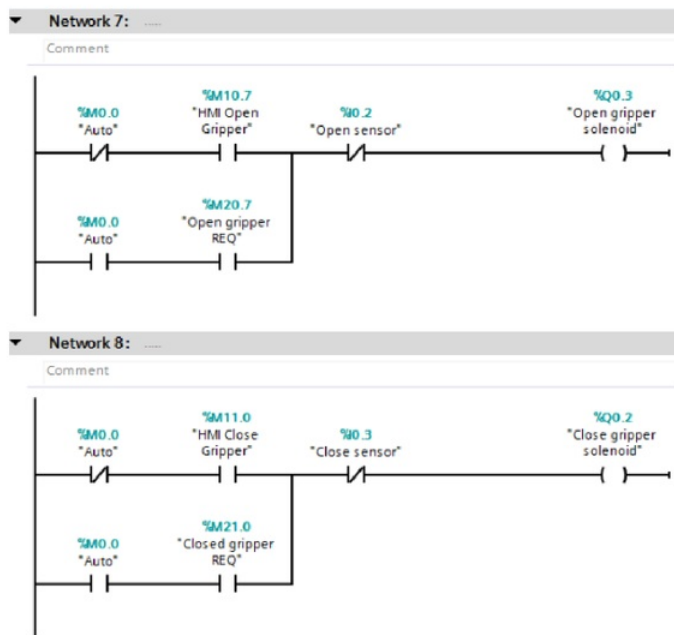


Figure 12: Network 7-8

Network 7 and 8 lets the hand open or close, the operator can close or open during manual mode at any time.

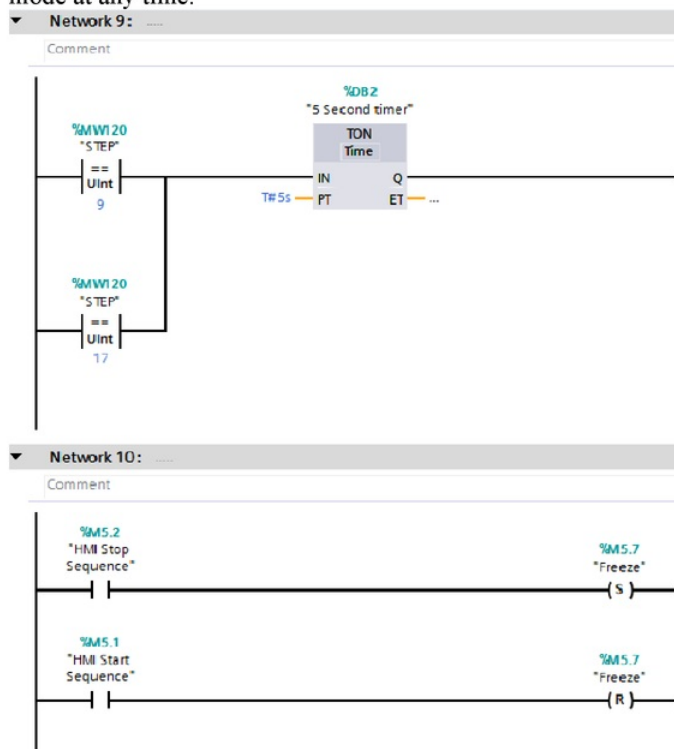


Figure 13: Network 9-8

Network 9 provides the timer that delays the hand at step 9 and 17 in the sequence program. In network 10, the ability to stop or start the sequence is given to the operator as a safety feature to prevent disruption or damage to the machine and then to continue after the obstruction has been dealt with.

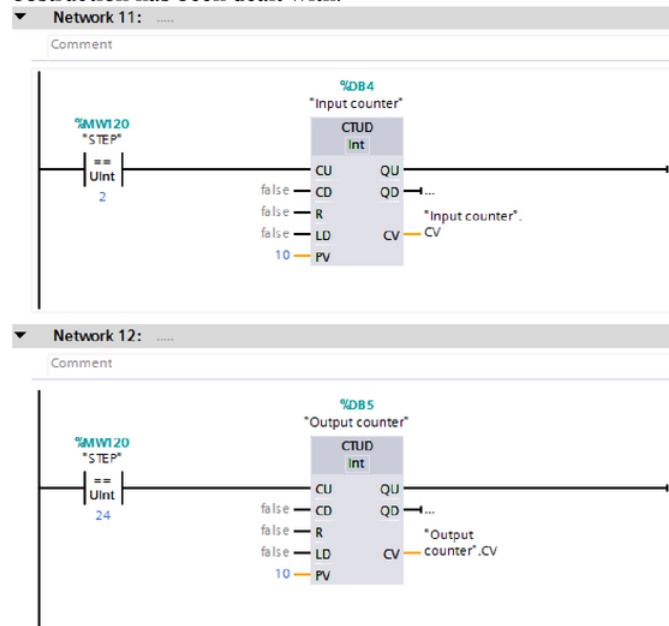


Figure 14: Network 11-12

Network 11 is responsible for the counters that count the number of objects coming into the machine, while network 12 counts the number of objects leaving the machine. 'PV' represents the starting value and 'CV' shows the current value being counted.

Sequence Program

1	IF "FSP"=1 THEN	"FSP"	MMS.0
2	"STEP" := 0;	"STEP"	MMS.120
3	"Next_STEP" := 0;	"Next_STEP"	MMS.130
4	"Move in REQ" := 0;	"Move in REQ"	MMS.20.3
5	"Move down REQ" := 0;	"Move down..."	MMS.20.2
6	"Move left REQ" := 0;	"Move left..."	MMS.20.5
7	"Move out REQ" := 0;	"Move out ..."	MMS.20.4
8	"Move right REQ" := 0;	"Move righ..."	MMS.20.6
9	"Move up REQ" := 0;	"Move up REQ"	MMS.20.1
10	END_IF;		
11	IF ("Freeze" = 0) THEN	"Freeze"	MMS.7
12	CASE "STEP" OF	"STEP"	MMS.120
13	0:		
14	"Move up REQ" := 1;	"Move up REQ"	MMS.20.1
15	IF ("Up sensor" = 1) THEN	"Up sensor"	MMS.10.0
16	"Move up REQ" := 0;	"Move up REQ"	MMS.20.1
17	"Next_STEP" := 1;	"Next_STEP"	MMS.130
18	END_IF;		
19	1:		
20	"Move left REQ" := 1;	"Move left..."	MMS.20.5
21	"Move in REQ" := 1;	"Move in REQ"	MMS.20.3
22	"Open gripper REQ" := 1;	"Open grip..."	MMS.20.7
23	IF ("Open sensor" = 1) AND ("Left sensor" = 1) AND ("In sensor" = 1) THEN	"Open sensor"	MMS.10.2
24	"Move left REQ" := 0;	"Move left..."	MMS.20.5
25	"Move in REQ" := 0;	"Move in REQ"	MMS.20.3
26	"Open gripper REQ" := 0;	"Open grip..."	MMS.20.7
27	IF ("HMI Load/Unload selector" = 1) AND ("HMI Start Sequence" = 1) OR ("Object sensor" = 1) THEN	"HMI Load/..."	MMS.5.6
28	"Next_STEP" := 2;	"Next_STEP"	MMS.130
29	END_IF;		
30			
31	IF ("HMI Load/Unload selector" = 0) AND ("HMI Start Sequence" = 1) THEN	"HMI Load/..."	MMS.5.6
32	"Next_STEP" := 50;	"Next_STEP"	MMS.130
33	END_IF;		
34	END_CASE;		
35	END_IF;		
36			

Figure 15: FSP, steps 0 and 1

This is the beginning of the SCL sequence program for both 'load' and 'unload' sequences. Starting with 'if freeze equals zero', this is where the stop sequence button isn't pressed and the auto button is, then the whole program continues from 'Case "STEP" of'. Almost every step begins with a 'REQ = 1' (for request), this is the program giving the command to the machine. Following this, 'IF 'sensor = 1' THEN 'REQ = 0'' tells the machine to end the command when the sensor has been complete; then gives the next step and 'END_IF'. Step 0, the program tells the robot to move up, then step 1 tells the machine to move left, in, and open gripper; the hand is over station 1 here. From here there are two options: if 'load' is selected or if there is an object, then the program goes to step 2; if 'unload' is selected, then the program goes to step 50.

37	2:			
38		"Move down REQ" := 1;		"Move down..." MM20.2
39	IF ("Down sensor" = 1) THEN			"Down sensor" \$I0.1
40		"Move down REQ" := 0;		"Move down..." MM20.2
41		"Next_STEP" := 3;		"Next_STEP" MMW130
42	END_IF;			
43	3:			
44		"Closed gripper REQ" := 1;		"Closed gr..." MM21.0
45	IF ("Close sensor" = 1) THEN			"Close sen..." \$I0.3
46		"Closed gripper REQ" := 0;		"Closed gr..." MM21.0
47		"Next_STEP" := 4;		"Next_STEP" MMW130
48	END_IF;			
49	4:			
50		"Move up REQ" := 1;		"Move up REQ" MM20.1
51	IF ("Up sensor" = 1) THEN			"Up sensor" \$I0.0
52		"Move up REQ" := 0;		"Move up REQ" MM20.1
53		"Next_STEP" := 5;		"Next_STEP" MMW130
54	END_IF;			
55	5:			
56		"Move out REQ" := 1;		"Move out ..." MM20.4
57	IF ("Out sensor" = 1) THEN			"Out sensor" \$I0.5
58		"Move out REQ" := 0;		"Move out ..." MM20.4
59		"Next_STEP" := 6;		"Next_STEP" MMW130
60	END_IF;			
61	6:			
62		"Move down REQ" := 1;		"Move down..." MM20.2
63	IF ("Down sensor" = 1) THEN			"Down sensor" \$I0.1
64		"Move down REQ" := 0;		"Move down..." MM20.2
65		"Next_STEP" := 7;		"Next_STEP" MMW130
66	END_IF;			
67	7:			
68		"Open gripper REQ" := 1;		"Open grip..." MM20.7
69	IF ("Open sensor" = 1) THEN			"Open sensor" \$I0.2
70		"Open gripper REQ" := 0;		"Open grip..." MM20.7
71		"Next_STEP" := 8;		"Next_STEP" MMW130
72	END_IF;			

Figure 16: Steps 2-7

Assuming an object has rolled into station one, the machine moves down (step 2) and closes its grip (step 3) to pick it up (step 4) and moves it to station 2 (step 5). Here, the hand will move down (step 6) and open the gripper (step 7) to let it go.

73	8:			
74		"Move up REQ" := 1;		"Move up REQ" MM20.1
75	IF ("Up sensor" = 1) THEN			"Up sensor" \$I0.0
76		"Move up REQ" := 0;		"Move up REQ" MM20.1
77		"Next_STEP" := 9;		"Next_STEP" MMW130
78	END_IF;			
79	9:			
80	IF ("5 Second timer".Q = 1) THEN			"5 Second ..." \$DB2
81		"Next_STEP" := 10;		"Next_STEP" MMW130
82	END_IF;			
83	10:			
84		"Move down REQ" := 1;		"Move down..." MM20.2
85	IF ("Down sensor" = 1) THEN			"Down sensor" \$I0.1
86		"Move down REQ" := 0;		"Move down..." MM20.2
87		"Next_STEP" := 11;		"Next_STEP" MMW130
88	END_IF;			
89	11:			
90		"Closed gripper REQ" := 1;		"Closed gr..." MM21.0
91	IF ("Close sensor" = 1) THEN			"Close sen..." \$I0.3
92		"Closed gripper REQ" := 0;		"Closed gr..." MM21.0
93		"Next_STEP" := 12;		"Next_STEP" MMW130
94	END_IF;			
95	12:			
96		"Move up REQ" := 1;		"Move up REQ" MM20.1
97	IF ("Up sensor" = 1) THEN			"Up sensor" \$I0.0
98		"Move up REQ" := 0;		"Move up REQ" MM20.1
99		"Next_STEP" := 13;		"Next_STEP" MMW130
100	END_IF;			
101	13:			
102		"Move right REQ" := 1;		"Move righ..." MM20.6
103	IF ("Right sensor" = 1) THEN			"Right sen..." \$I0.6
104		"Move right REQ" := 0;		"Move righ..." MM20.6
105		"Next_STEP" := 14;		"Next_STEP" MMW130
106	END_IF;			

Figure 17: Steps 8-13

Step 8 tells the hand to move up, after that happens, the 5 second timer turns on (step 9). After the delay (meant to simulate manufacture), the hand comes down (step 10) to pick up the object (step 11 and 12) and move right (step 13) to station 3.

107	14:		
108		"Move down REQ" := 1;	"Move down..." %M20.2
109		IF ("Down sensor" = 1) THEN	"Down sensor" %I0.1
110		"Move down REQ" := 0;	"Move down..." %M20.2
111		"Next_STEP" := 15;	"Next_STEP" %MW130
112		END_IF;	
113	15:		
114		"Open gripper REQ" := 1;	"Open grip..." %M20.7
115		IF ("Open sensor" = 1) THEN	"Open sensor" %I0.2
116		"Open gripper REQ" := 0;	"Open grip..." %M20.7
117		"Next_STEP" := 16;	"Next_STEP" %MW130
118		END_IF;	
119	16:		
120		"Move up REQ" := 1;	"Move up REQ" %M20.1
121		IF ("Up sensor" = 1) THEN	"Up sensor" %I0.0
122		"Move up REQ" := 0;	"Move up REQ" %M20.1
123		"Next_STEP" := 17;	"Next_STEP" %MW130
124		END_IF;	
125	17:		
126		IF ("5 Second timer".Q = 1) THEN	"5 Second ..." %DB2
127		"Next_STEP" := 18;	"Next_STEP" %MW130
128		END_IF;	
129	18:		
130		"Move down REQ" := 1;	"Move down..." %M20.2
131		IF ("Down sensor" = 1) THEN	"Down sensor" %I0.1
132		"Move down REQ" := 0;	"Move down..." %M20.2
133		"Next_STEP" := 19;	"Next_STEP" %MW130
134		END_IF;	
135	19:		
136		"Closed gripper REQ" := 1;	"Closed gr..." %M21.0
137		IF ("Close sensor" = 1) THEN	"Close sen..." %I0.3
138		"Closed gripper REQ" := 0;	"Closed gr..." %M21.0
139		"Next_STEP" := 20;	"Next_STEP" %MW130
140		END_IF;	

Figure 18: Step 14-19

Step 14 commands the robot to move down, then it drops the object (step 15) and moves up (step 16). The same 5 second delay comes in again at step 17. Once that has finished, the hand moves down (step 18) and closes the gripper (step 19).

141	20:		
142		"Move up REQ" := 1;	"Move up REQ" %M20.1
143		IF ("Up sensor" = 1) THEN	"Up sensor" %I0.0
144		"Move up REQ" := 0;	"Move up REQ" %M20.1
145		"Next_STEP" := 21;	"Next_STEP" %MW130
146		END_IF;	
147	21:		
148		"Move in REQ" := 1;	"Move in REQ" %M20.3
149		IF ("In sensor" = 1) THEN	"In sensor" %I0.4
150		"Move in REQ" := 0;	"Move in REQ" %M20.3
151		"Next_STEP" := 22;	"Next_STEP" %MW130
152		END_IF;	
153	22:		
154		"Move down REQ" := 1;	"Move down..." %M20.2
155		IF ("Down sensor" = 1) THEN	"Down sensor" %I0.1
156		"Move down REQ" := 0;	"Move down..." %M20.2
157		"Next_STEP" := 23;	"Next_STEP" %MW130
158		END_IF;	
159	23:		
160		"Open gripper REQ" := 1;	"Open grip..." %M20.7
161		IF ("Open sensor" = 1) THEN	"Open sensor" %I0.2
162		"Open gripper REQ" := 0;	"Open grip..." %M20.7
163		"Next_STEP" := 24;	"Next_STEP" %MW130
164		END_IF;	
165	24:		
166		"Move up REQ" := 1;	"Move up REQ" %M20.1
167		IF ("Up sensor" = 1) THEN	"Up sensor" %I0.0
168		"Move up REQ" := 0;	"Move up REQ" %M20.1
169		"Next_STEP" := 1;	"Next_STEP" %MW130
170		END_IF;	
171	50:		
172		"Move down REQ" := 1;	"Move down..." %M20.2
173		IF ("Down sensor" = 1) THEN	"Down sensor" %I0.1
174		"Move down REQ" := 0;	"Move down..." %M20.2
175		"Next_STEP" := 51;	"Next_STEP" %MW130
176		END_IF;	

Figure 19: Steps 20-50

At step 20, the program tells the robot to bring it up (step 20) and move to the last station (step 21). Once over the final station, the hand drops the (finished) product (steps 22 and 23) into the assembly chute and then moves up (step 24). The robot will then go back to step 1 and the load sequence is finished. Step 50 is the beginning of the unload sequence where it starts with the hand moving down.

177	51:		
178	"Closed gripper REQ" := 1;	"Closed gr...	%M21.0
179	IF ("Close sensor" = 1) THEN	"Close sen...	%IO.3
180	"Closed gripper REQ" := 0;	"Closed gr...	%M21.0
181	"Next_STEP" := 52;	"Next_STEP"	%MW130
182	END_IF;		
183	52:		
184	"Move up REQ" := 1;	"Move up REQ"	%M20.1
185	IF ("Up sensor" = 1) THEN	"Up sensor"	%IO.0
186	"Move up REQ" := 0;	"Move up REQ"	%M20.1
187	"Next_STEP" := 53;	"Next_STEP"	%MW130
188	END_IF;		
189	53:		
190	"Move right REQ" := 1;	"Move righ...	%M20.6
191	IF ("Right sensor" = 1) THEN	"Right sen...	%IO.6
192	"Move right REQ" := 0;	"Move righ...	%M20.6
193	"Next_STEP" := 54;	"Next_STEP"	%MW130
194	END_IF;		
195	54:		
196	"Move down REQ" := 1;	"Move down...	%M20.2
197	IF ("Down sensor" = 1) THEN	"Down sensor"	%IO.1
198	"Move down REQ" := 0;	"Move down...	%M20.2
199	"Next_STEP" := 55;	"Next_STEP"	%MW130
200	END_IF;		
201	55:		
202	"Open gripper REQ" := 1;	"Open grip...	%M20.7
203	IF ("Open sensor" = 1) THEN	"Open sensor"	%IO.2
204	"Open gripper REQ" := 0;	"Open grip...	%M20.7
205	"Next_STEP" := 56;	"Next_STEP"	%MW130
206	END_IF;		
207	56:		
208	"Move up REQ" := 1;	"Move up REQ"	%M20.1
209	IF ("Up sensor" = 1) THEN	"Up sensor"	%IO.0
210	"Move up REQ" := 0;	"Move up REQ"	%M20.1
211	"Next_STEP" := 57;	"Next_STEP"	%MW130
212	END_IF;		

Figure 20: Steps 51-56

Once the hand is down the machine will close the gripper (step 51) and move up (step 52) to pick up an object from station 1. The machine will then move right to station 4 (step 53) to drop it into the exit chute (step 54 and 55), step 56 tells the machine to move up

213	57:			
214	"Move out REQ" := 1;	"Move out ...	%M20.4	
215	"Move left REQ" := 1;	"Move left...	%M20.5	
216	IF ("Out sensor" = 1) AND ("Left sensor" = 1) THEN	"Out sensor"	%I0.5	
217	"Move out REQ" := 0;	"Move out ...	%M20.4	
218	"Move left REQ" := 0;	"Move left...	%M20.5	
219	"Next_STEP" := 58;	"Next_STEP"	%MW130	
220	END_IF;			
221	58:			
222	"Move down REQ" := 1;	"Move down...	%M20.2	
223	IF ("Down sensor" = 1) THEN	"Down sensor"	%I0.1	
224	"Move down REQ" := 0;	"Move down...	%M20.2	
225	"Next_STEP" := 59;	"Next_STEP"	%MW130	
226	END_IF;			
227	59:			
228	"Closed gripper REQ" := 1;	"Closed gr...	%M21.0	
229	IF ("Close sensor" = 1) THEN	"Close sen...	%I0.3	
230	"Closed gripper REQ" := 0;	"Closed gr...	%M21.0	
231	"Next_STEP" := 60;	"Next_STEP"	%MW130	
232	END_IF;			
233	60:			
234	"Move up REQ" := 1;	"Move up REQ"	%M20.1	
235	IF ("Up sensor" = 1) THEN	"Up sensor"	%I0.0	
236	"Move up REQ" := 0;	"Move up REQ"	%M20.1	
237	"Next_STEP" := 61;	"Next_STEP"	%MW130	
238	END_IF;			
239	61:			
240	"Move in REQ" := 1;	"Move in REQ"	%M20.3	
241	"Move right REQ" := 1;	"Move righ...	%M20.6	
242	IF ("In sensor" = 1) AND ("Right sensor" = 1) THEN	"In sensor"	%I0.4	
243	"Move in REQ" := 0;	"Move in REQ"	%M20.3	
244	"Move right REQ" := 0;	"Move righ...	%M20.6	
245	"Next_STEP" := 62;	"Next_STEP"	%MW130	
246	END_IF;			

Figure 21: Steps 57-61

Step 57 tells the robot to move directly to station 2 (step 57), afterward the robot move down (step 58) to pick up an object sitting there (step 59 and 60), then move back over station 4 (step 61).

247	62:			
248	"Move down REQ" := 1;	"Move down...	%M20.2	
249	IF ("Down sensor" = 1) THEN	"Down sensor"	%I0.1	
250	"Move down REQ" := 0;	"Move down...	%M20.2	
251	"Next_STEP" := 63;	"Next_STEP"	%MW130	
252	END_IF;			
253	63:			
254	"Open gripper REQ" := 1;	"Open grip...	%M20.7	
255	IF ("Open sensor" = 1) THEN	"Open sensor"	%I0.2	
256	"Open gripper REQ" := 0;	"Open grip...	%M20.7	
257	"Next_STEP" := 64;	"Next_STEP"	%MW130	
258	END_IF;			
259	64:			
260	"Move up REQ" := 1;	"Move up REQ"	%M20.1	
261	IF ("Up sensor" = 1) THEN	"Up sensor"	%I0.0	
262	"Move up REQ" := 0;	"Move up REQ"	%M20.1	
263	"Next_STEP" := 65;	"Next_STEP"	%MW130	
264	END_IF;			
265	65:			
266	"Move out REQ" := 1;	"Move out ...	%M20.4	
267	IF ("Out sensor" = 1) THEN	"Out sensor"	%I0.5	
268	"Move out REQ" := 0;	"Move out ...	%M20.4	
269	"Next_STEP" := 66;	"Next_STEP"	%MW130	
270	END_IF;			
271	66:			
272	"Move down REQ" := 1;	"Move down...	%M20.2	
273	IF ("Down sensor" = 1) THEN	"Down sensor"	%I0.1	
274	"Move down REQ" := 0;	"Move down...	%M20.2	
275	"Next_STEP" := 67;	"Next_STEP"	%MW130	
276	END_IF;			
277	67:			
278	"Closed gripper REQ" := 1;	"Closed gr...	%M21.0	
279	IF ("Close sensor" = 1) THEN	"Close sen...	%I0.3	
280	"Closed gripper REQ" := 0;	"Closed gr...	%M21.0	
281	"Next_STEP" := 68;	"Next_STEP"	%MW130	
282	END_IF;			

Figure 22: Steps 62-67

Step 62 and 63 tells the machine drop the object into station 4, then the machine moves up (step 64) and out (step 65) toward station 3. The program would pick up another object here (step 66 and 67).

283	68:		
284	"Move up REQ" := 1;	"Move up REQ"	%M20.1
285	IF ("Up sensor" = 1) THEN	"Up sensor"	%I0.0
286	"Move up REQ" := 0;	"Move up REQ"	%M20.1
287	"Next_STEP" := 69;	"Next_STEP"	%M0130
288	END_IF;		
289	69:		
290	"Move in REQ" := 1;	"Move in REQ"	%M20.3
291	IF ("In sensor" = 1) THEN	"In sensor"	%I0.4
292	"Move in REQ" := 0;	"Move in REQ"	%M20.3
293	"Next_STEP" := 70;	"Next_STEP"	%M0130
294	END_IF;		
295	70:		
296	"Move down REQ" := 1;	"Move down..."	%M20.2
297	IF ("Down sensor" = 1) THEN	"Down sensor"	%I0.1
298	"Move down REQ" := 0;	"Move down..."	%M20.2
299	"Next_STEP" := 71;	"Next_STEP"	%M0130
300	END_IF;		
301	71:		
302	"Open gripper REQ" := 1;	"Open grip..."	%M20.7
303	IF ("Open sensor" = 1) THEN	"Open sensor"	%I0.2
304	"Open gripper REQ" := 0;	"Open grip..."	%M20.7
305	"Next_STEP" := 72;	"Next_STEP"	%M0130
306	END_IF;		
307	72:		
308	"Move up REQ" := 1;	"Move up REQ"	%M20.1
309	IF ("Up sensor" = 1) THEN	"Up sensor"	%I0.0
310	"Move up REQ" := 0;	"Move up REQ"	%M20.1
311	"Next_STEP" := 1;	"Next_STEP"	%M0130
312	END_IF;		
313	END_CASE;		
314	"STEP" := "Next_STEP";	"STEP"	%M0120
315	END_IF;		
316			

Figure 23: Step 68-72

Step 68 tells the machine to move up, then the machine goes back into station 4 (step 69). The machine will then drop the final object into the exit chute (step 70 and 71), then move up (step 72) and move back to station 1 (step 1) to end the sequence.

PLC tag list

PLC tags									
	Name	Tag table	Data type	Address	Retain	Acces...	Writa...	Visibl...	
1	Up sensor	Input tag list	Bool	%I0.0	☐	☒	☒	☒	
2	Down sensor	Input tag list	Bool	%I0.1	☐	☒	☒	☒	
3	Open sensor	Input tag list	Bool	%I0.2	☐	☒	☒	☒	
4	Close sensor	Input tag list	Bool	%I0.3	☐	☒	☒	☒	
5	In sensor	Input tag list	Bool	%I0.4	☐	☒	☒	☒	
6	Out sensor	Input tag list	Bool	%I0.5	☐	☒	☒	☒	
7	Right sensor	Input tag list	Bool	%I0.6	☐	☒	☒	☒	
8	Left sensor	Input tag list	Bool	%I0.7	☐	☒	☒	☒	
9	Move down solenoid	Output tag list	Bool	%Q0.0	☐	☒	☒	☒	
10	Move up solenoid	Output tag list	Bool	%Q0.1	☐	☒	☒	☒	
11	Close gripper solenoid	Output tag list	Bool	%Q0.2	☐	☒	☒	☒	
12	Open gripper solenoid	Output tag list	Bool	%Q0.3	☐	☒	☒	☒	
13	Move out solenoid	Output tag list	Bool	%Q0.4	☐	☒	☒	☒	
14	Move in solenoid	Output tag list	Bool	%Q0.5	☐	☒	☒	☒	
15	Move left solenoid	Output tag list	Bool	%Q0.6	☐	☒	☒	☒	
16	Move right solenoid	Output tag list	Bool	%Q0.7	☐	☒	☒	☒	
17	X10 pushbutton	Input tag list	Bool	%I1.0	☐	☒	☒	☒	
18	X11 pushbutton	Input tag list	Bool	%I1.1	☐	☒	☒	☒	
19	X12 pushbutton	Input tag list	Bool	%I1.2	☐	☒	☒	☒	
20	X13 pushbutton	Input tag list	Bool	%I1.3	☐	☒	☒	☒	
21	X14 pushbutton	Input tag list	Bool	%I1.4	☐	☒	☒	☒	
22	Object sensor	Input tag list	Bool	%I1.5	☐	☒	☒	☒	
23	FSP	Default tag table	Bool	%M5.0	☐	☒	☒	☒	
24	HMI Start Sequence	Default tag table	Bool	%M5.1	☐	☒	☒	☒	
25	STEP	Default tag table	UInt	%MW120	☐	☒	☒	☒	
26	Next_STEP	Default tag table	UInt	%MW130	☐	☒	☒	☒	
27	Auto	Default tag table	Bool	%M0.0	☐	☒	☒	☒	
28	HMI Move Up	Default tag table	Bool	%M10.1	☐	☒	☒	☒	
29	HMI Move Down	Default tag table	Bool	%M10.2	☐	☒	☒	☒	
30	Move down REQ	Default tag table	Bool	%M20.2	☐	☒	☒	☒	
31	Manual	Default tag table	Bool	%M0.1	☐	☒	☒	☒	
32	HMI Move In	Default tag table	Bool	%M10.3	☐	☒	☒	☒	
33	HMI Move Out	Default tag table	Bool	%M10.4	☐	☒	☒	☒	
34	HMI Move Left	Default tag table	Bool	%M10.5	☐	☒	☒	☒	
35	HMI Move Right	Default tag table	Bool	%M10.6	☐	☒	☒	☒	
36	HMI Open Gripper	Default tag table	Bool	%M10.7	☐	☒	☒	☒	
37	HMI Close Gripper	Default tag table	Bool	%M11.0	☐	☒	☒	☒	
38	Move up REQ	Default tag table	Bool	%M20.1	☐	☒	☒	☒	
39	Move in REQ	Default tag table	Bool	%M20.3	☐	☒	☒	☒	
40	Move out REQ	Default tag table	Bool	%M20.4	☐	☒	☒	☒	
41	Move left REQ	Default tag table	Bool	%M20.5	☐	☒	☒	☒	

Figure 24: PLC tags 1-41

42	Move right REQ	Default tag table	Bool	%M20.6	☐	☒	☒	☒	
43	Open gripper REQ	Default tag table	Bool	%M20.7	☐	☒	☒	☒	
44	Closed gripper REQ	Default tag table	Bool	%M21.0	☐	☒	☒	☒	
45	HMI Stop Sequence	Default tag table	Bool	%M5.2	☐	☒	☒	☒	
46	HMI Load/Unload selector	Default tag table	Bool	%M5.6	☐	☒	☒	☒	
47	Freeze	Default tag table	Bool	%M5.7	☐	☒	☒	☒	

Figure 25: PLC tag 42-47

HMI screens

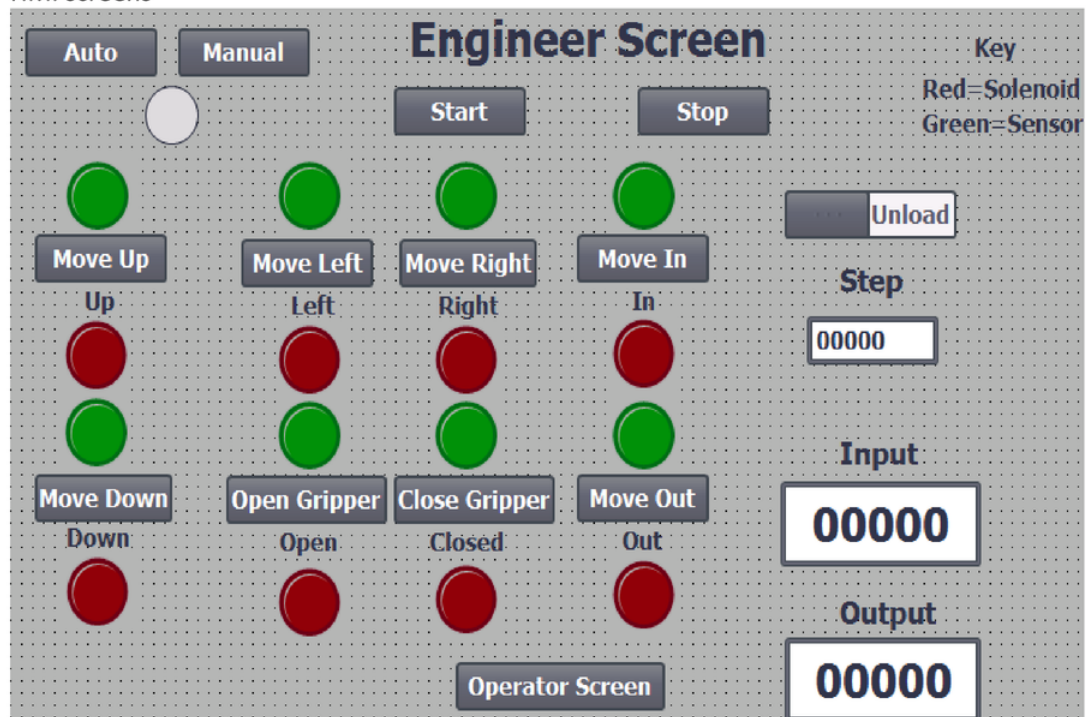


Figure 26: Engineer's HMI screen

There are two HMI screens, one for the engineer doing maintenance and one for the operator to control the machine. Both have auto/manual buttons, stop and start controls, load/unload switch, and input/output counters, the engineer's has everything the operator screen has. It comes with a step counter to let the technician know where the machine is in the sequence as well as manual controls with lights for sensors and solenoids (red is solenoid, green is sensor).

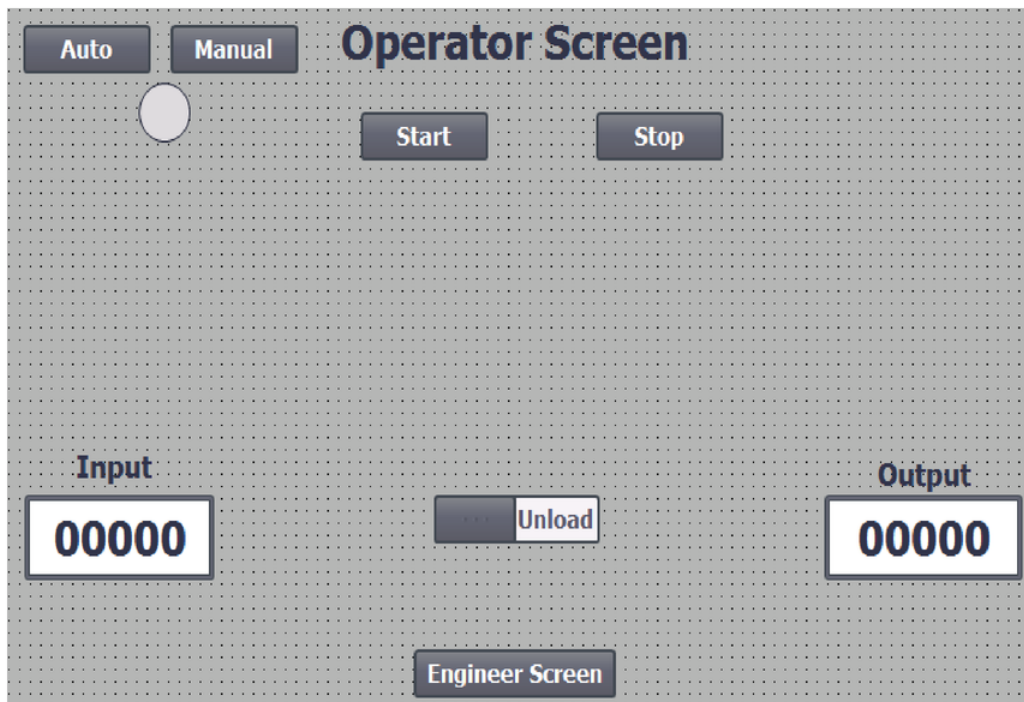


Figure 27: Operator's HMI screen

HMI Tags

Name	Tag table	Data type	Connection	PLC name	PLC tag
5 second timer	Tag table_1	Time	HIM_Connect...	PLC_124	"5 Second timer".PT
Auto	Tag table_1	Bool	HIM_Connect...	PLC_124	Auto
Close gripper	Tag table_1	Bool	HIM_Connect...	PLC_124	"Close gripper solenoid"
Closed sensor	Tag table_1	Bool	HIM_Connect...	PLC_124	"Close sensor"
Down sensor	Tag table_1	Bool	HIM_Connect...	PLC_124	"Down sensor"
Freeze	Tag table_1	Bool	HIM_Connect...	PLC_124	Freeze
HMI Load/Unload selector	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Load/Unload select..."
HMI Main Close Gripper	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Close Gripper"
HMI Main Move Down	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Move Down"
HMI Main Move In	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Move In"
HMI Main Move Left	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Move Left"
HMI Main Move Out	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Move Out"
HMI Main Move Right	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Move Right"
HMI Main Move Up	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Move Up"
HMI Main Open Gripper	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Open Gripper"
HMI Start sequence	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Start Sequence"
HMI Stop sequence	Tag table_1	Bool	HIM_Connect...	PLC_124	"HMI Stop Sequence"
In sensor	Tag table_1	Bool	HIM_Connect...	PLC_124	"In sensor"
Input counter	Tag table_1	Int	HIM_Connect...	PLC_124	"Input counter".PV
Left sensor	Tag table_1	Bool	HIM_Connect...	PLC_124	"Left sensor"
Manual	Tag table_1	Bool	HIM_Connect...	PLC_124	Manual
Move down	Tag table_1	Bool	HIM_Connect...	PLC_124	"Move down solenoid"
Move down REQ	Tag table_1	Bool	HIM_Connect...	PLC_124	"Move down REQ"
Move in	Tag table_1	Bool	HIM_Connect...	PLC_124	"Move in solenoid"
Move left	Tag table_1	Bool	HIM_Connect...	PLC_124	"Move left solenoid"
Move out	Tag table_1	Bool	HIM_Connect...	PLC_124	"Move out solenoid"

Figure 28: HMI tag list (Part 1)

Move right	Tag table_1	Bool	HMI_Connection...	PLC_124	"Move right solenoid"
Move up	Tag table_1	Bool	HMI_Connection...	PLC_124	"Move up solenoid"
Move up REQ	Tag table_1	Bool	HMI_Connection...	PLC_124	"Move up REQ"
Object sensor	Tag table_1	Bool	HMI_Connection...	PLC_124	"Object sensor"
Open gripper	Tag table_1	Bool	HMI_Connection...	PLC_124	"Open gripper solenoid"
Open sensor	Tag table_1	Bool	HMI_Connection...	PLC_124	"Open sensor"
Out sensor	Tag table_1	Bool	HMI_Connection...	PLC_124	"Out sensor"
Output counter	Tag table_1	Int	HMI_Connection...	PLC_124	"Output counter".PV
Right sensor	Tag table_1	Bool	HMI_Connection...	PLC_124	"Right sensor"
start pushbutton	Tag table_1	Bool	HMI_Connection...	PLC_124	"HM Start Sequence"
STEP	Default tag table	UInt	HMI_Connection...	PLC_124	STEP
stop pushbutton	Tag table_1	Bool	HMI_Connection...	PLC_124	"HM Stop Sequence"
Up sensor	Tag table_1	Bool	HMI_Connection...	PLC_124	"Up sensor"
X10	Tag table_1	Bool	HMI_Connection...	PLC_124	"X10 pushbutton"
X11	Tag table_1	Bool	HMI_Connection...	PLC_124	"X11 pushbutton"
X12	Tag table_1	Bool	HMI_Connection...	PLC_124	"X12 pushbutton"
X13	Tag table_1	Bool	HMI_Connection...	PLC_124	"X13 pushbutton"
X14	Tag table_1	Bool	HMI_Connection...	PLC_124	"X14 pushbutton"

Figure 29: HMI tag list (Part 2)

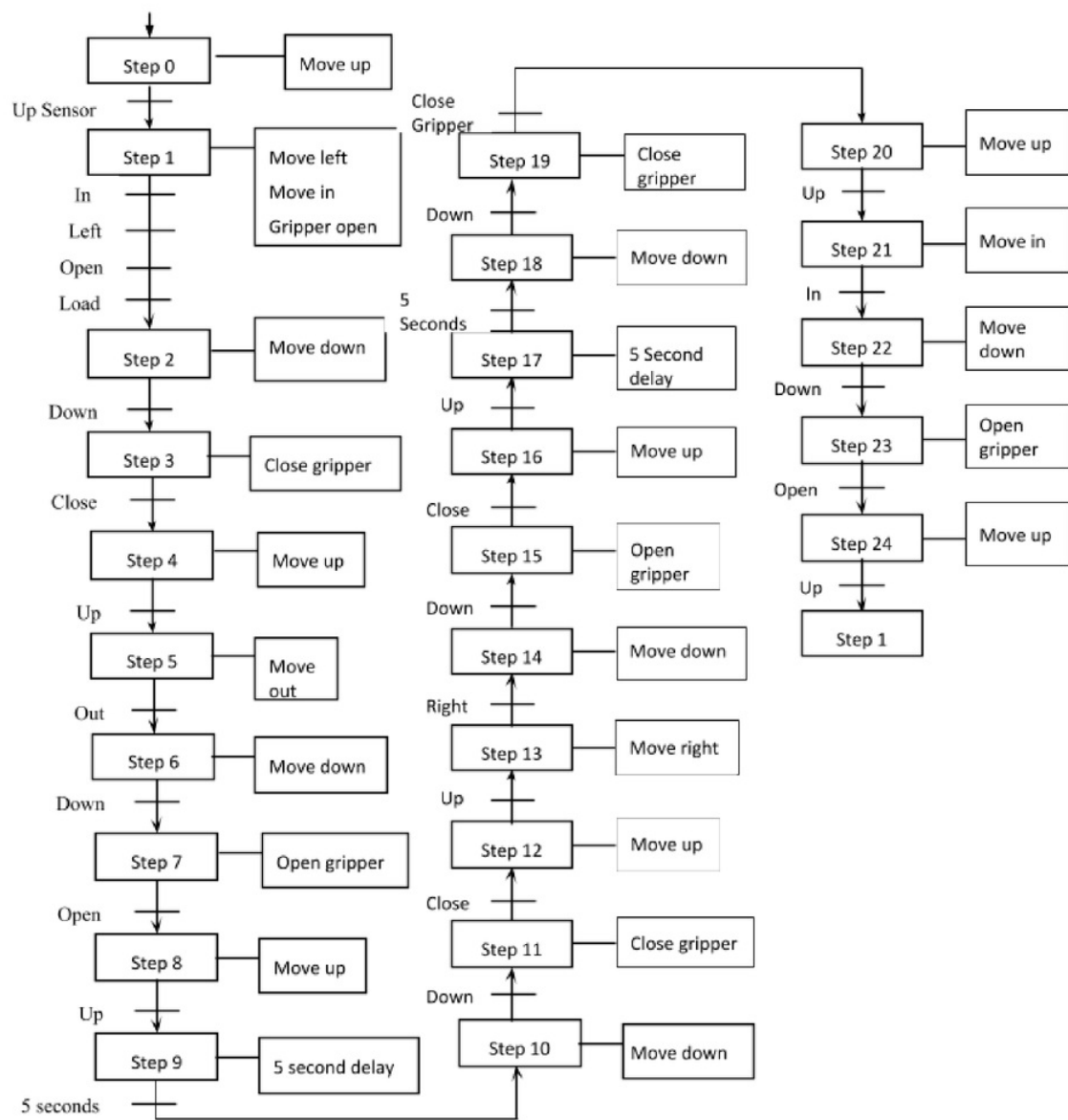


Figure 30: Load sequence flowchart

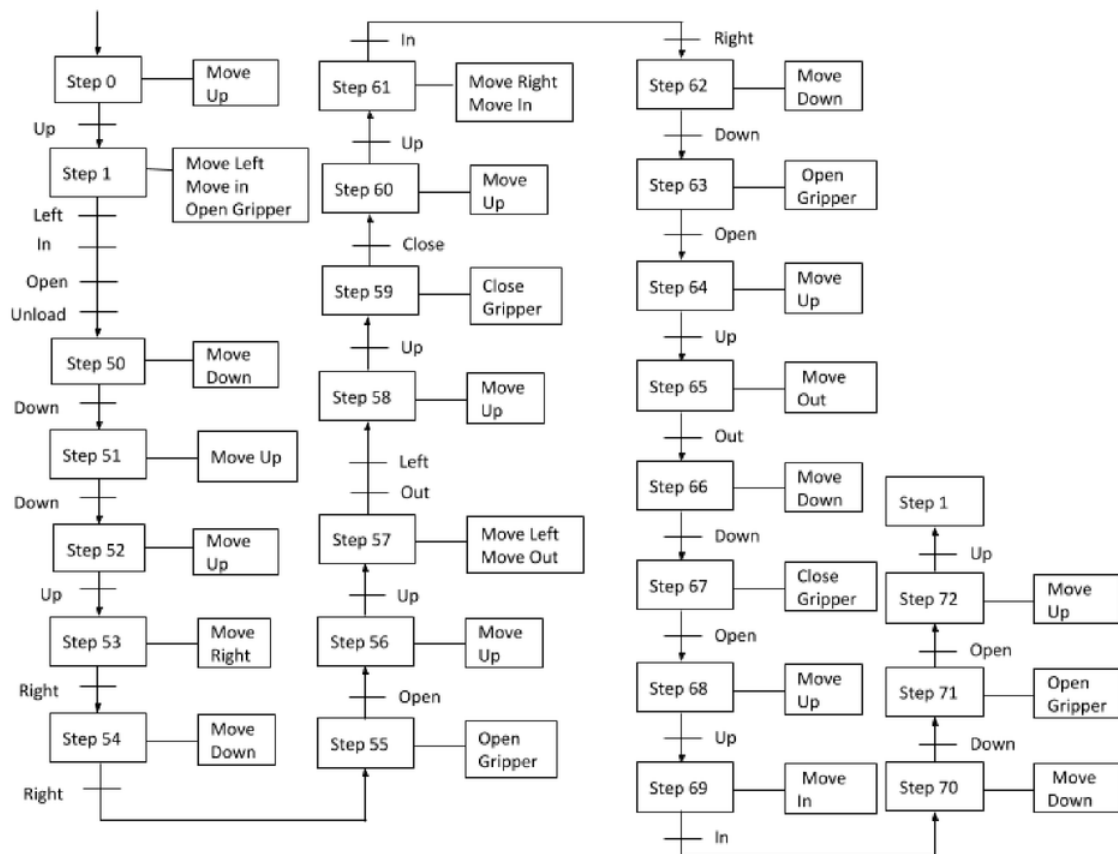


Figure 31: Unload sequence flowchart

System Testing, Maintenance and Reliability

Test Table

Number	Description	Expected result	Actual results
1	Both engineer and operator screen must have a switch for automatic and manual modes.	The automatic switch carries out the sequence procedure and the manual switch allows manual control.	The automatic and manual controls work on the HMI screens.
2	The piston must operate safely and sensor information must be visible on the engineer screen.	The piston performs its commands and the sensor information is available on the HMI.	The hand followed any command from the manual controls.
3	Safety interlocks such as not allowing the robot to move left, right, in, or out in the up position; or moving down outside of the 4 stations.	The robot in the up position can't move left, right, in, or out; nor can it move down outside the 4 stations.	The hand didn't move right, left, in, or out in the up position; nor did it move down outside the 4 stations.

4	The number of objects inside the machine and exiting the machine must be displayed in the operator screen	The amount of objects in the machine is counted in the input and output counter on the HMI.	The output counter was counted from 10 instead of zero and couldn't be reset, but the input counter worked as expected and could be reset.
5	The operator screen must have a selection between loading and unloading sequences in the machine	The load sequence follows when the load button is switched on and vice versa with the unload sequence	Both the load and unload sequences followed as the buttons are switched on.
6	On power up, the robot must move safely to the home position (up, left, open, and in) and wait until further instructions.	When the machine powers up, the hand goes the home position until further steps.	The hand went to the home position when the machine powers up.
7	If the load option is selected and an object is rolled down the entry chute, the robot must pick it up and move it to station 2 where it must be left for 5 seconds during which time, the robot must be held in the up position. After this delay, the object must be moved to station 3 and left there for 5 seconds during which time the robot must be held in the up position. After this time, the object must be moved to station 4 where it will roll down the exit chute. The number of objects exiting the machine must be counted and displayed for the operator.	When instructed to load and an object is rolled, the hand picks it up and brings it to station and leaves it there for 5 seconds while in the up position. Afterward, the robot picks it up and brings it to station 3 and follows the same delay while in the up position. Afterward the robot carries it over to the final station to be dropped into the exit chute. The numbers of objects are counted on the display for the operator.	The sequence was followed step by step to each station starting from station 1 to 2 to 3 to 4. All the delays worked and the objects were counted and displayed on the HMI.
8	If the unload option is selected, the machine must be emptied safely when a start button is pressed.	When the unload button is selected and the start button is pressed, the hand brings 1 object from each station at a time to station to be dropped in the exit chute.	When the unload button was pressed, the robot picked up an object from each station and brought it to the exit chute.
9	Provide a stop button that freezes either of the sequences. The start button must be used to allow the sequence to continue.	The stop button when pressed, stops the whole sequence until the start button is pressed.	The sequence would always pause when the stop button was pushed and started when the start button was pressed.

10	Suitable safety features must be incorporated to prevent the robot placing an object on top of another object when the sequence has been interrupted.	The robot doesn't place another object on top of another when the sequence has been interrupted.	The sequence has been stopped to prevent an instance like this from happening.
----	---	--	--

Manual test photos

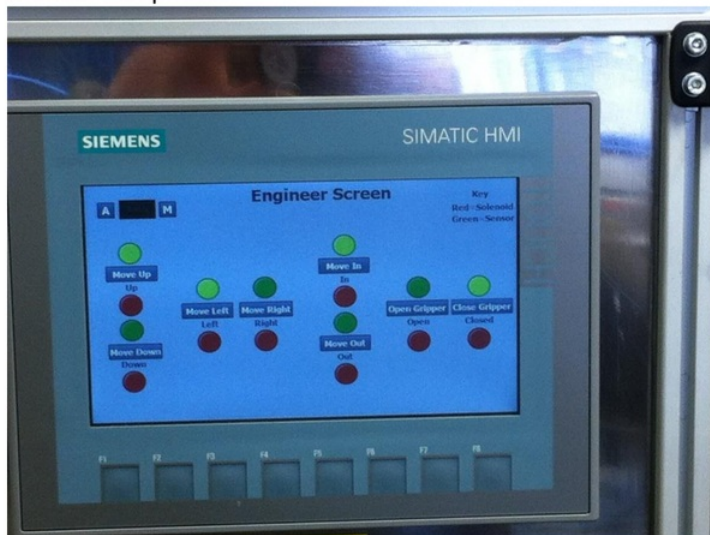


Figure 32: Test photo 1

This HMI screen says the arm is in the up position over station 1 with a closed gripper.



Figure 33: Test photo 2

In this figure, the robot is in the same position as in the last figure.

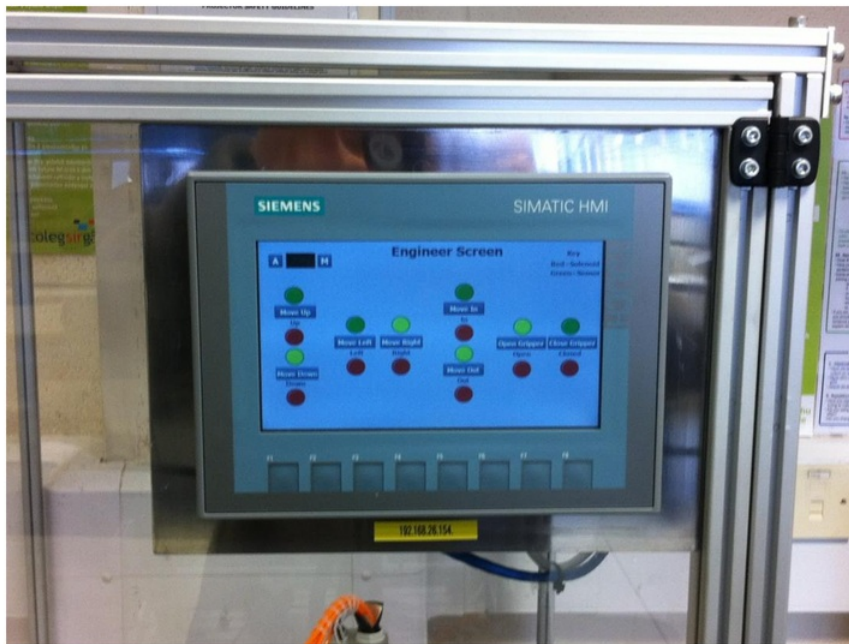


Figure 34: Test

photo 3

The HMI screen says the arm is over Station 4 in the down position with an open gripper.

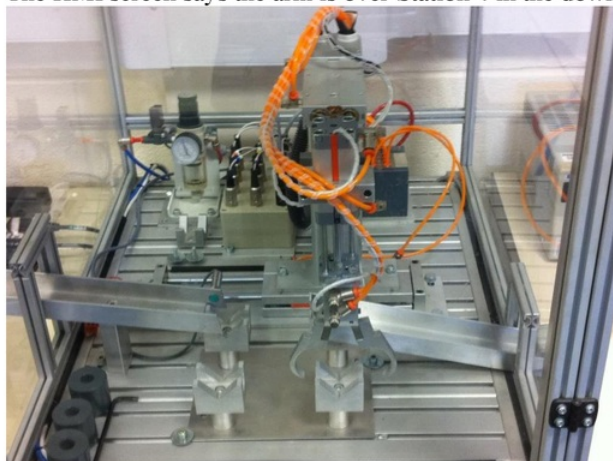


Figure 35: Test photo 4

In this figure, the robot is in the same position as in the last figure.

Sequence photos



Figure 36: Test photo 5

Here, the robot has just started the load sequence by picking up an object.



Figure 37: Test photo 6

The robot has just dropped an object at station 2.

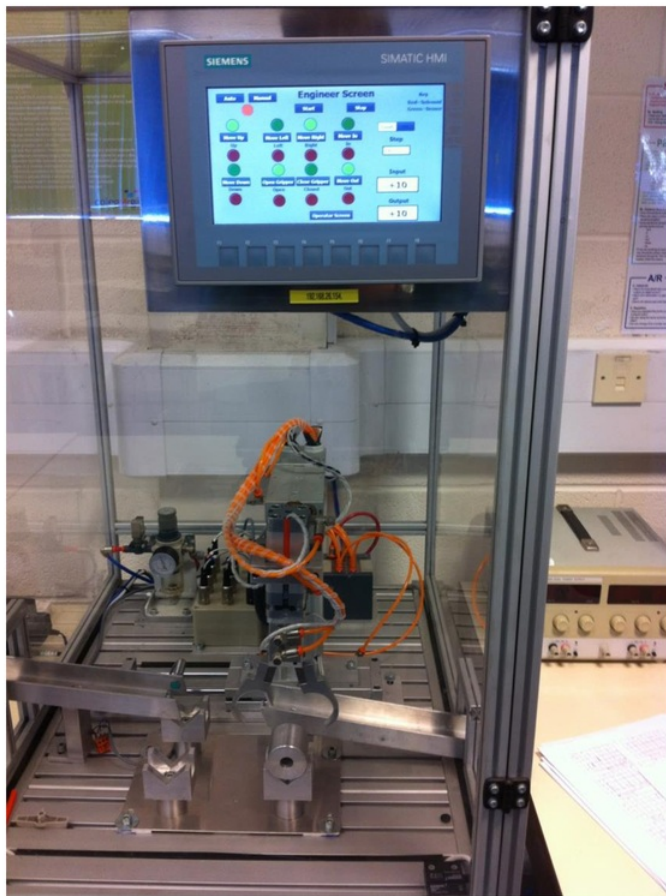


Figure 38: Test photo 7

The machine has just dropped the object at station 3



Figure 39: Test photo 8

Here, the machine has dropped an object into the exit chute.

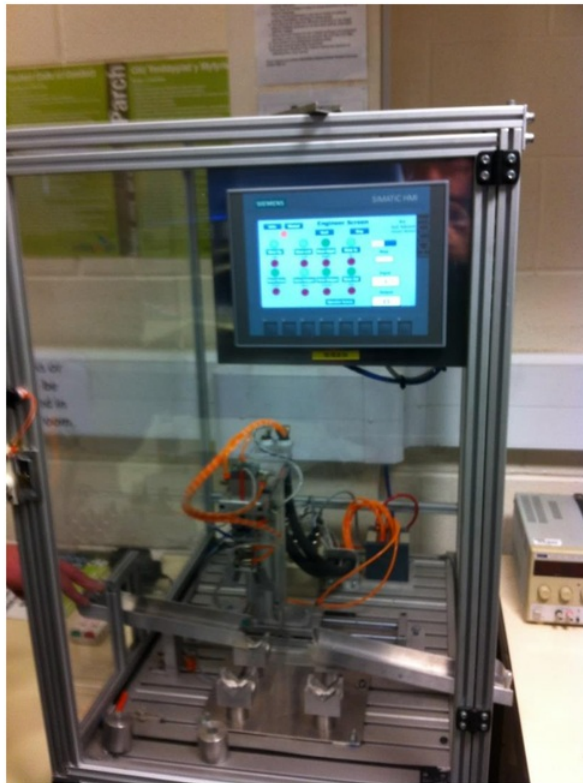


Figure 40: Test photo 9

The robot has returned back over station 1.

Conclusions and Recommendations

Overall, this was a successful test based on the aims and objectives that were set out to be achieved. The manual test worked greatly and the sequences went smoothly as planned in the end. Sometimes there was miss-programming and problems with the HMI controls, other than that there were no other problems. The robot did well the most in simulating a similar situation to programming, testing, and operating a robotic machine in industry.

SCL and ladder programming were very appropriate for this case, but function block could've worked in both areas. Sometimes, the robot would most quite slowly, so there was either a lack of lubrication or not enough air in the machine. There also wasn't a feature to automatically stop the sequence if it was going to drop an object on top of another, which could've been done.

PSDE4005 Assignment 2

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

58/100

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

Text Comment. Each of the figures that follow should be explained. They could be reduced in size.

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

Text Comment. This is an accurate diagram and would be very useful to an engineer

PAGE 11

PAGE 12

Text Comment. you could have forced the robot to move up when not over a station.

Text Comment. good evidence of safety interlocks

PAGE 13

PAGE 14

PAGE 15

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GRADING FORM: CSG-RUBIC

JONATHAN PHILLIPS

58

RESEARCH-INFORMED LITERATURE

KNOWLEDGE AND UNDERSTANDING

- 
- Section 1: Hardware Investigation - A brief explanation given with supporting photos and an accurate wiring diagram. However, each photo needs an explanation. (7/10) Section 1: System Design and I/O list - The system is well designed and this includes the ladder networks, SFC chart, SCL coding and a good I/O list. (7/10) Section 2: Program Explanation – Good brief explanations provided for the ladder networks together with sections of the SCL code. (7/10)
- 21

ANALYSIS

- 
- Section 3: System Testing – Good evidence of testing with supporting photos. However, each manual function should have been tested separately together each step in the sequences. (7/10) Section 3: Maintenance and Reliability - Good evidence of consideration by designs of program and screens and by your testing but the report could have contained a section devoted to addressing these issues directly. (6/10) Section 4: Conclusions and Recommendations - Some conclusions offered and some suggestions. (4/10)
- 17

PRACTICAL APPLICATION AND DEP.

- 
- Section 2: Program Network Comments - Your programs (ladder and SCL code) do not contain any embedded comments. This would make it difficult to read without this report explanation. (0/10) Section
- 14

2: HMI Screen Designs – Good screen design for both operator and engineer. However, the layout of the engineer's screen could be better.(7/10) Section 3: Presentation of Test Results - Very good presentation of results. (7/10)

SKILLS FOR PROFESSIONAL PRAC.



All sections - Report is well structured and presented. However, each section should have been numbered according to the brief and there are spelling errors. (6/10)

6