

2124280

by Thomas Silman

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Module: SGEE4004 Programmable Logic Controllers
Assignment: 1. Pick and Place Robot
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Good Structure

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1. Work Plan for lifelong learning

Write in the third person

The assignment set to me is to create a program using TIA portal to control a pick and place robot, the program must be able to run in both manual and ~~auto with control from~~ the HMI screen having the option for both operator and engineer screens. I will have to approach this assignment by first learning how to use TIA portal, starting with basic logic functions and moving onto byte logic and then timers and counters. I will also have to learn how to create a HMI screen and assign tags to different buttons on the HMI screen with lights that correspond to the function being carried out and the sensor readings.

Write in the third person

What about the assignment tasks, do you know what they are?

This is a reflection not a plan

After completing this assignment, I have learned how to use the basics of TIA portal, creating a suitable program for the pick and place robot. I learned about the safety interlocks in place for in the event a mistake is made so that the robot doesn't get damaged. I also learned the basics of using LAD and SCL language.

2. Research

There are several different manufacturers of PLC's the 2 ~~most common~~ are Siemens and Allen Bradley. Allen Bradley offer 3 different types of PLC's these being the MicroLogix, CompactLogix and ControlLogix. MicroLogix are the cheapest PLC that Allen Bradley offer starting at around £400-£500, its main application is for smaller control systems where there are less required I/Os, the MicroLogix offers 32 fixed/onboard I/Os and 6 analogue I/Os. A rack is not required as the I/Os are connected using ribbon cables, the I/O ports can be expanded upon using 1792 expansion modules, this is limited to 7 per PLC. The MicroLogix PLC has a built in LCD screen which shows the status of the PLC, the MicroLogix uses the RSLogix 500 software. (Rockwell Automation, 2022)

Grocer's apostrophe

No need to underline your citations

CompactLogix are the medium budget PLC offered by Allen Bradley, these start at around £1500, the main application of the CompactLogix PLC is medium control systems which typically require machine control. The CompactLogix also has fixed/onboard I/Os as well as 32 axes of motion control, making it ideal for small-medium scale machine control systems. It has integrated safety features and sports a higher performance than the MicroLogix. The CompactLogix PLC however does not have an LCD display so to access the status of the PLC

you must connect remotely using either an IP or via ethernet. It runs on the RSLogix 5000 software. (Rockwell Automation, 2022)*No need to underline your citations*

ControlLogix are the higher budget PLC that is offered by Allen Bradley, these start at around £4000-£5000, the main application of the ControlLogix PLC is larger scale control systems, mainly in processing and motion control systems. It is a modular PLC so it has no onboard I/Os, this means that it requires rack mounted I/Os. The PLC supports 32 points per module for digital I/Os and on analogue I/Os it supports RTD and thermocouple modules. Much like the CompactLogix it sports integrated safety features and uses the RSLogix 5000 Software however it also doesn't have an inbuilt LCD display so to access the status of the PLC you must connect remotely using either an IP or via ethernet. It runs on the RSLogix 5000 software. (Rockwell Automation, 2022)*No need to underline your citations*

	MicroLogix	CompactLogix	ControlLogix
Suitable For Machine Control	No	Yes	Yes
Onboard I/Os	Yes	Yes	No
Requires Rack	No	No	Yes
Universal Software	No	Yes	Yes
Built In Status Screen	Yes	No	No
Integrated Safety Features	No	Yes	Yes
Cost	£400-£500	~£1500	£400-£5000
Expandable	Yes	Yes	Yes

Table 1: Comparison Table

The robot task assigned only requires the Siemens S7-1214 unit as there are only a small amount of required I/Os, if an alternate PLC was required from the ones mentioned above the CompactLogix would be the best fit due to the support it has for machine control on 32 axes and still being relatively cost effective compared to the ControlLogix PLC. Where the MicroLogix PLC would be the easiest to obtain when considering cost it doesn't have built in axes control so it couldn't safely operate the robot arm. Where the ControlLogix PLC has more than enough features and integrated safety features, it would be overkill for the use it is required for and the cost implications it causes are simply unjustifiable. The PLC unit being used has the ability to use 14 inputs and 10 outputs, these leaves 2 unused outputs and utilizes all of the inputs. The S7-1214 unit is comparably smaller to the other mentioned PLC's

which means it requires less space. As the S7-1214 PLC is modular there is the ability to add additional I/O slots which will give it additional capacity in the scenario more is needed.

3. Hardware Investigation

The pick and place robot consists of several different types of hardware, this includes several sensors and some pneumatic parts. The pick and place robot was moved by pneumatic pistons, the supply for the pistons comes from the manifold where the 8 electro-pneumatic solenoid valves switch the air between outputs. The reed switch acts as a proximity sensor and is used to locate the pistons positions and send the information to the PLC.

When objects were entered through the designated area in to the pick and place robot there was a proximity sensor which sent a signal to the PLC, this was to notify the PLC that an object had entered the pick and place robot. The robot utilized 3 pushbuttons along with 2 toggle switches. The HMI screen allowed the robot to be operated manually through the engineers screen, on this screen there is also information detailing the number of objects that have been inputted into the machine, the step which the program is on and the location of the pick and place robot.

The PLC can receive both digital and analogue inputs, the inputs received by the PLC from the pick and place robot were digital inputs, an example of an analogue input could be a pushbutton or a toggle switch.

Device	I/O Address	Input/output	Digital/analogue
Down Sensor	I0.1	Input	Digital
Gripper Open Sensor	I0.2	Input	Digital
Gripper Closed Sensor	I0.3	Input	Digital
In Sensor	I0.4	Input	Digital
Out Sensor	I0.5	Input	Digital
Right Sensor	I0.6	Input	Digital
Left Sensor	I0.7	Input	Digital
Pushbutton X10	I1.0	Input	Digital
Pushbutton X11	I1.1	Input	Digital
Pushbutton X12	I1.2	Input	Digital
Toggle Switch X13	I1.3	Input	Digital
Toggle Switch X14	I1.3	Input	Digital

Object Sensor	I1.5	Input	Digital
Move Down Solenoid	Q0.0	Output	Analogue
Move Up Solenoid	Q0.1	Output	Analogue
Close Gripper Solenoid	Q0.2	Output	Analogue
Open Gripper Solenoid	Q0.3	Output	Analogue
Move Out Solenoid	Q0.4	Output	Analogue
Move In Solenoid	Q0.5	Output	Analogue
Move Left Solenoid	Q0.6	Output	Analogue
Move Right Solenoid	Q0.7	Output	Analogue

Table 2: I/O List

4. Program Design and Manual Controls

The program was created to meet the specifications outlined in the assignment brief, this included the use of 2 HMI screens, manual mode within the engineer's screen and safety interlocks. The 2 HMI screens had to be one for the pick and place robot operator and one was for the engineer, the operator screen had a display detailing the sequence step and object number in the robot. When manual mode was being operated the pistons had to operate safely with all the sensor information being visible. Safety interlocks had to be added to the program to prevent the robot from being damaged through accidental causes, the interlocks had to stop the robot from moving left, right, in or out whilst not in the up position and they had to prevent the down movement from occurring unless the robot was located over one of the 4 stations.

The function block has the sequence the robot follows, the language this sequence is written in is SCL or structured control language (Anton, 2021), this sequence can be found in the flowchart in the appendices. Upon start up the function block runs through the sequence that the pick and place robot must follow, the counter is used to check the number of objects that are in the robot then using this information the robot moves to the relevant command.

Section 5 was supposed to be simulation testing - see the brief 5. Program Design and Manual Controls *Same title as section 4 ??*

When the sequence starts the first scan pulse is carried out, this scan pulse sets the step to 0, this step raises the pick and place robots' arm. Once the arm is in the up position it moves to step 1 where the arm moves over to its home position which is above station 2. Step 1 is the only step where the robot has the ability to move more than 1 position in a step. Following step 1 the sequence will wait until the pushbutton is made or the input sensor is activated, once this happens the sensors in the machine will check how many objects are already present to determine which step in the sequence to go to.

In the program block, the first network authorizes the first scan pulse following the message from the PLC, the second runs the sequence block if the pick and place robot is in auto. The following networks 3-10 are the operational controls for the pick and place robot. These 8 networks control functions which have a programme for the automated controls which is obtained from the memory bit which has created in the SCL sequence function block. The safety interlocks mentioned earlier are found in each of the networks, this only allows the pick and place robot to move if it meets the criteria outlined earlier. From this a safe to move memory bit was made which enabled the programme to be written to move up if not safe to move down. The next network is network 11 which is the safe to move down interlock. Network

12 uses the object sensors to set a memory bit for observed objects. This takes place to ensure that the program can be used on different pick and place robots which may be lacking sensors. The next network is the pause command of the program, this allows the sequence to be stopped safely and resumed as instructed in the briefing. The final networks to be used in the program block include the delay before the robot moves and the counter which records how many objects have entered and exited the pick and place robot.

6. Program Internal Documentation

Write in the third person

Whilst creating the program I had to include network titles followed by a brief comment which would further describe the function of the selected block. This is vitally important as if someone needs to fault find on your program they may not be able to find the correct block to alter or check, this can result in the wrong value being adjusted or code being altered where it shouldn't be which can further the issue.

This should be section 5

7. Simulation Testing

The table below (table 2) is the testing table which was created during the simulation of the program in manual the other table (table 3) is the testing table for when the simulation was in automatic.

2 more columns are needed, 1 for decision and 1 for evidence

Test	Expected Result	Actual Result
HMI Up	Moves up	Moved up
HMI Down	Moves down	Moved down
HMI Left	Moves left	Moved left
HMI Right	Moved right	Moved right
HMI In	Moves in	Moved in
HMI out	Moves out	Moved out
HMI Gripper Open	Gripper opens	Gripper opened
HMI Gripper Close	Gripper closes	Gripper closed
Trying to move arm when in down position	No movement	Didn't move
Trying to lower arm when not over a station	Doesn't lower	Didn't lower

Table 3: Manual mode testing table

Test/Step Number	Expected Result	Actual Result
0	Moves up	Moved up
1	Moves to home position	Moved to home position
Object inserted into machine	Two second time delay, object counter +1	Robot waited two seconds, object counter +1
2	Moves in	Moved in
3	Moves down	Moved down
4	Gripper closes	Gripper closed
5	Moves up	Moved up
6	Moves out	Moved out
7	Moves down	Moved down
8	Gripper opens	Gripper opened
9	Moves up	Moved up
Object inserted into machine	Two second time delay, object counter +1	Robot waited two seconds, object counter +1
10	Moves down	Moved down
11	Gripper closes	Gripper closed
12	Moves up	Moved up
13	Moves right	Moved right
14	Moves down	Moved down
15	Gripper opens	Gripper opened
16	Moves up	Moved up
17	Moves left	Moved down
18	Moves in	Moved in
19	Moves down	Moves down
20	Gripper closes	Gripper closed
21	Moves up	Moved up
22	Moves out	Moved out

23	Moves down	Moved down
24	Gripper opens	Gripper opened
25	Moves up	Moved up
Object inserted into machine	Two second time delay, object counter +1	Robot waited two seconds, object counter +1
26	Moves right	Moved right
27	Moves down	
28	Gripper closes	
29	Moves up	
30	Moves in	
31	Moves down	
32	Gripper opens	
33	Moves up	
34	Moves out	
35	Moves left	
36	Moves down	
37	Gripper closes	
38	Moves up	
39	Moves right	
40	Moves down	
41	Gripper opens	
42	Moves up	
43	Moves left	
44	Moves in	
45	Moves down	
46	Gripper closes	
47	Moves up	
48	Moves out	
49	Moves down	
50	Gripper opens	
51	Moves up	

Table 4: Automatic mode testing table

NO evidence provided !

The program passed the tests meaning that the robot operated correctly to the instructions given by the operator and by the program. Using the pushbutton to simulate the input of an object the robot continued to carry out the rest of the sequence as it should have. The pause button proved itself useful in the operating of the machine as it allows the operator/engineer to stop the sequence at anytime to perform maintenance or make an adjustment before the sequence continues as normal.

8. Practical Testing

Write in the third person

We chose to use William's program for the practical testing, when in manual the robot worked flawlessly with the safety interlocks working. When testing we chose to input 3 cylinders and manually mimic what the automatic mode would be carrying out. We encountered no issues in manual.

Write in the third person

When testing in automatic we encountered a fault where the inducted cylinder was getting caught on the object sensor and which was misaligning the cylinder at the bottom of the induct chute. When this was noticed the E-Stop was pressed and the sensor adjusted. Following the adjustment the cylinders inducted no longer became misaligned and we could run the system in automatic again.

9. Conclusion

This PLC program was created with the criteria at the forefront of the design process. Using the brief, it was ensured that the program included everything from the brief. The main block of the program was created in an IEC language in ladder, in ladder there are several features which were utilized such as the counter, timer and a reset for the bits. SCL was also used to create the robot sequence code. Using SCL made the creation of the program easier as it was easier to see each step of the program had its own block of code. The use of SCL does mean that it takes longer to code but it ensures that the risk of a crash is at a minimum and the likelihood of an error being made is reduced. With the robot making one movement per step it makes it a lot easier to fault find the code.

All the criteria set out in the brief was met with the pick and place robot. The pick and place robot utilized the required safety interlocks which prevented it from moving when the

requirements were not met, e.g if the arm is lowered then the arm cannot move in any direction other than up. The HMIs met the criteria outlined in the brief, there was a counter to show how many objects were inside the pick and place robot and a button to switch between manual and automatic. A pause button was implemented onto the operators screen which would halt the sequence safely, this allows an opportunity to work on the robot and once done the sequence can be resumed as normal. There were a handful of input buttons that were not used which means that expansion would be possible.

To empty the pick and place robot the pushbutton X10 was heavily relied on, a potential improvement could be that an auto-empty function be implemented on a button on the operators HMI or a physical switch/pushbutton. Upon pressing this button the system would flush out the objects which are on the stations.

The testing of the pick and place robot was thorough but photographic evidence wasn't viable for some of the steps in the process such as when there is meant to be no movement or the movement is quick e.g gripper opening or closing. Despite this the testing should be thorough enough for the customers needs as the program is shown to be clearly working at each station.

10. Team Working

Working as a team enabled us to fault find and all provide a unique outlook on any potential faults, inclusion of all ideas allowed us to fault find efficiently on one of the programs and solve the problem swiftly. In practical testing a fault was occurring where the inducted cylinder was getting caught on the object sensor and which was misaligning the cylinder at the bottom of the induct chute. When this was noticed the E-Stop was pressed and the sensor adjusted. Following the adjustment the cylinders inducted no longer became misaligned and we could run the system in automatic again. No issues were encountered in manual mode. Relevant evidence in appendix.

11. Citation List

A small range of sources (2) but listed correctly yet the underlining is unnecessary

Anton, K., 2021. *PCCWEB*. [Online]

Available at: <https://www.pccweb.com/wp-content/uploads/2019/11/S17-SCL.pdf>

Rockwell Automation, 2022. *Rockwell Automation*. [Online]
Available at: <https://www.rockwellautomation.com/en-gb/products/hardware/allen-bradley/programmable-controllers/micro-controllers/micrologix-family/micrologix-1400-controllers.html>
[Accessed 27 December 2022].

12. Appendices



Image 1: Automatic Mode

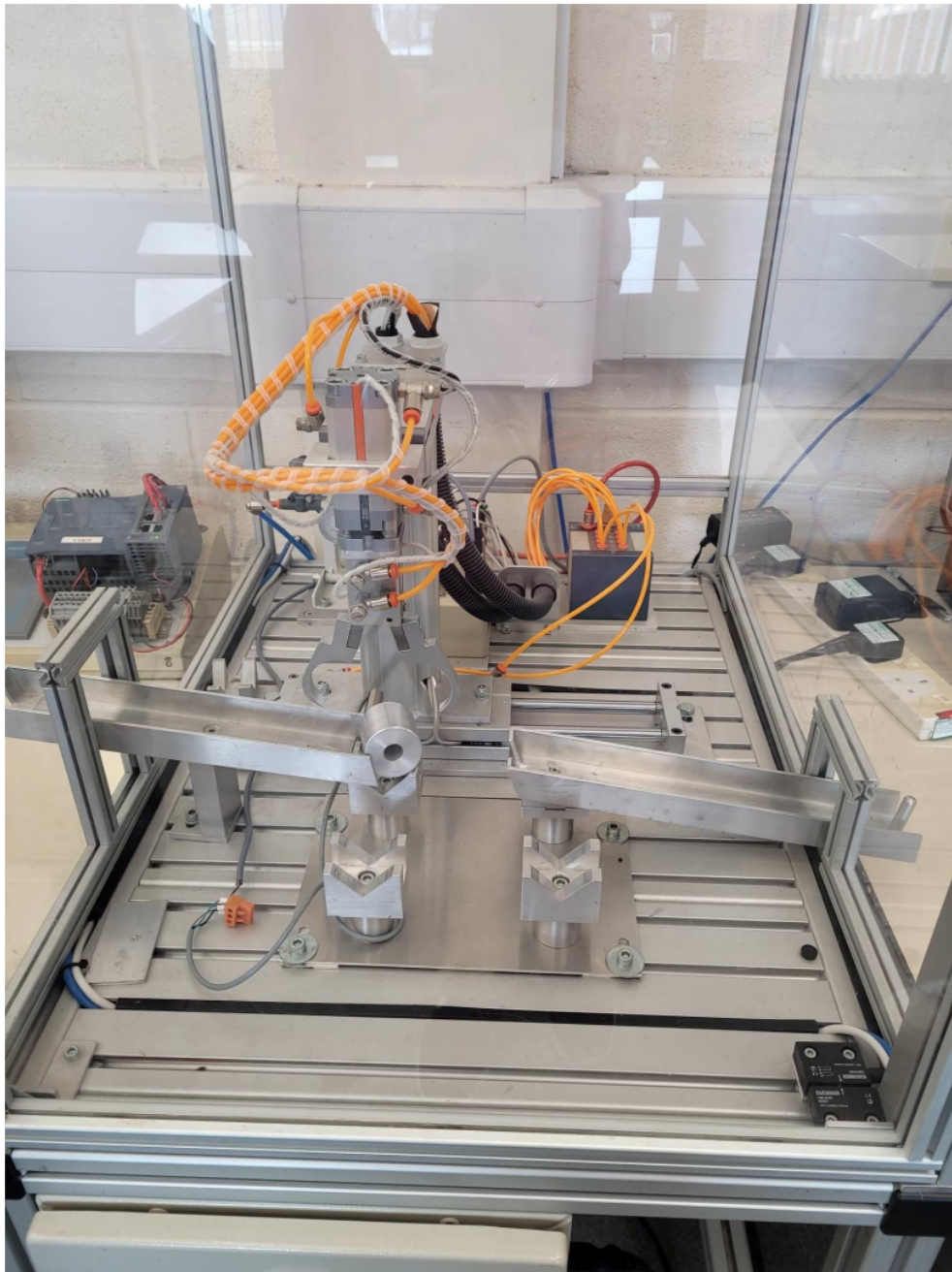


Image 2: Misaligned cylinder

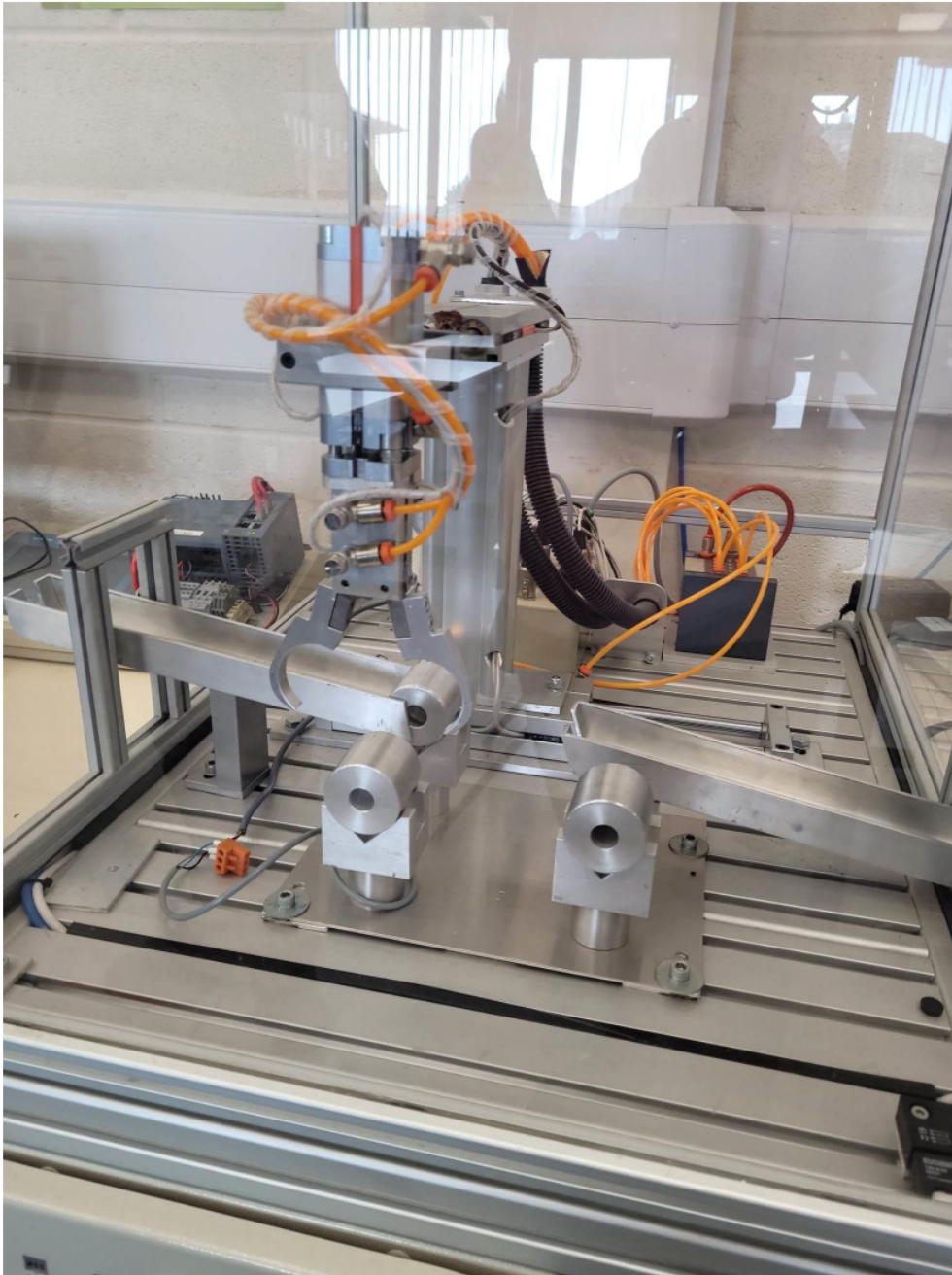


Image 3: Sensor issue rectified, automatic and manual modes now working without fault

FSP

this is a good SFC chart

Step 0

Move arm up

Up Sensor

Pause = 0

Step 1

Move arm left, out
and open gripper

Left Sensor

Out Sensor X10

Gripper O Sensor

Pause = 0

Timer

Count 3

No

Yes

Step 2

Move arm right

Right Sensor

Step 3

Move arm down

Down Sensor

Step 4

Close Gripper

Gripper C
Sensor

Step 5

Move arm up

Up Sensor

Step 6

Move arm in

In Sensor

Step 7

Move arm down

Down Sensor

Step 8

Gripper Open

Gripper O
Sensor

Step 9

Move arm up

Up Sensor

Step 10

Move arm left

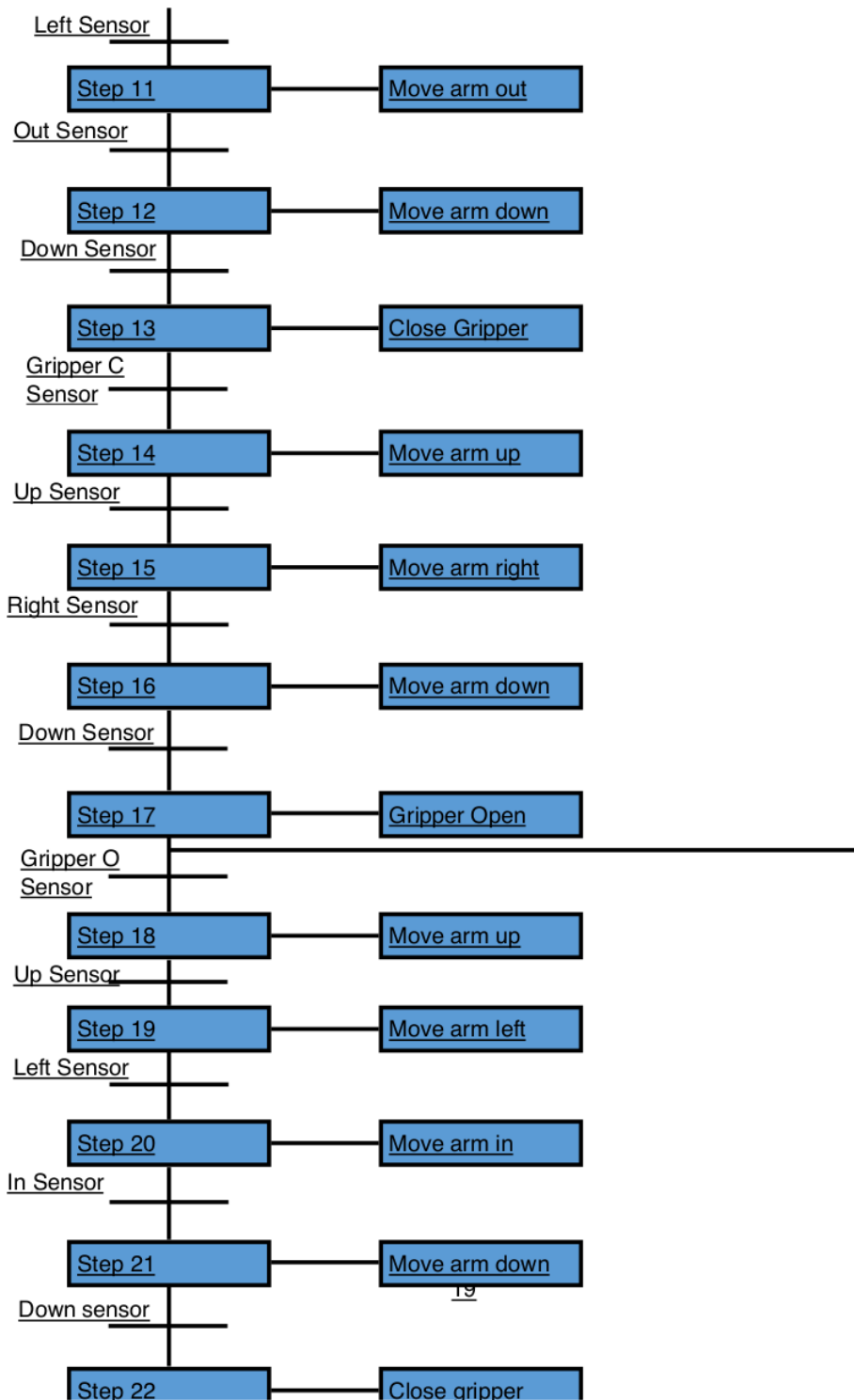
18

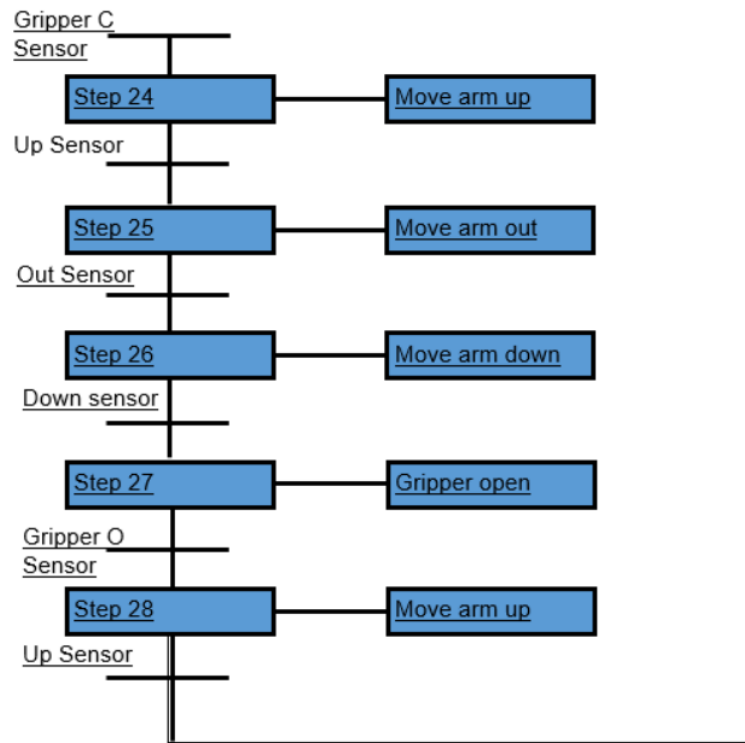
Count 2

N

Count 1

Yes





Drawing 1: Flow Chart

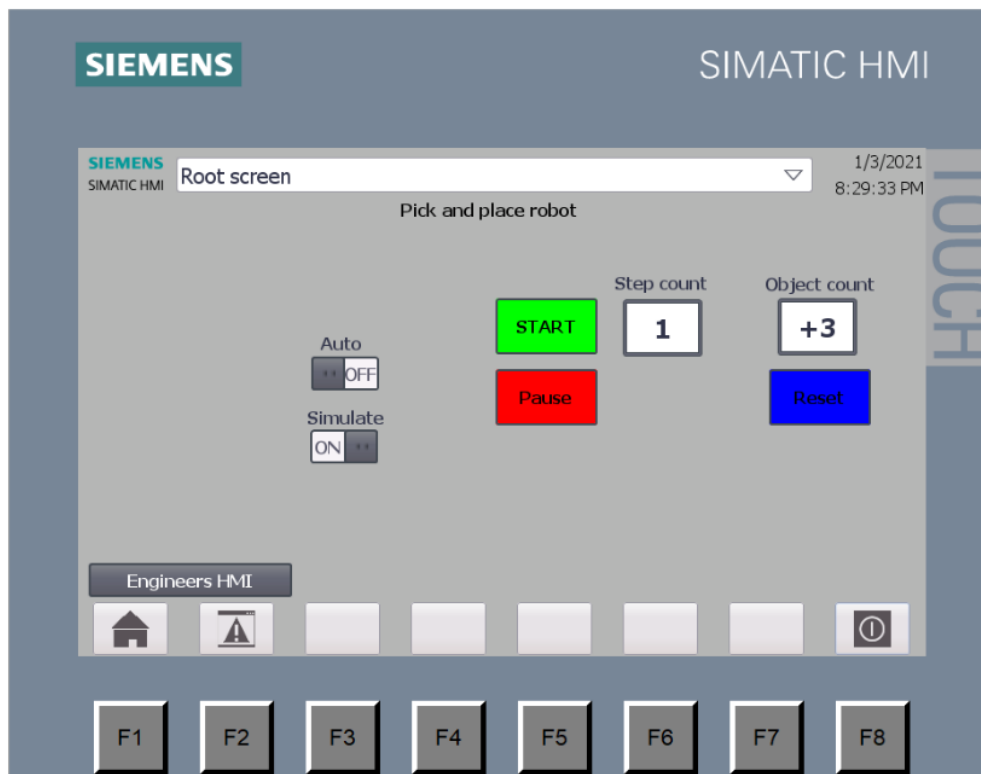
```

0001 IF ("FSP" = 1) OR ("AUTO" = 0) THEN
0002 "STEP" := 0; //Set bits to 0
0003 "next_STEP" := 0; //Sets all to SP
0004 "MOVE IN " := 0;
0005 "MOVE OUT " := 0;
0006 "MOVE LEFT " := 0;
0007 "MOVE RIGHT " := 0;
0008 "GRIPPER OPEN " := 0;
0009 "GRIPPER CLOSED " := 0;
0010 END_IF;
0011
0012 //set the step and next step to 0
0013
0014 IF "FSP" THEN
0015 "STEP" := 0;
0016 "next_STEP" := 0;
0017
0018 END_IF;
0019
0020 //Set all of the bits to 0 bar move up
0021
0022 CASE "STEP" OF
0023 0:
0024 "MOVE DOWN " := 0;
0025 "MOVE UP " := 1;
0026 "MOVE IN " := 0;
0027 "MOVE OUT " := 0;
0028 "MOVE LEFT " := 0;
0029 "MOVE RIGHT " := 0;
0030 "GRIPPER OPEN " := 0;
0031 "GRIPPER CLOSED " := 0;
0032
0033 IF "UP sensor" = 1 THEN //If up sensor is 1
0034 "next_STEP" := 1; //next step is set to 1
0035 END_IF;
0036
0037 //Move to home position
0038 //set bits to 0 aside from out, left, and open
0039 1:
0040
0041 "MOVE OUT " := 1;
0042 "MOVE LEFT " := 1;
0043 "GRIPPER OPEN " := 1;
0044
0045 IF ("OUT sensor" = 1) AND //if the out and the, left, open, and start are triggered
0046 ("OPEN sensor" = 1) AND //Move to IF statements
0047 ("LEFT sensor" = 1) AND
0048 ("Start sequence" = 1) THEN
0049
0050 //Move object from station 1-2
0051 IF ("Object counter".CV = 1) THEN //set next step to 2
0052 "next_STEP" := 2; //object counter reads 1
0053 END_IF;
0054
0055 //Move object from station 2-3
0056 IF ("Object counter".CV = 2) THEN //set next step to 3
0057 "next_STEP" := 3; //object counter reads 2
0058 END_IF;
0059
0060 //Move object from station 3-4
0061 IF ("Object counter".CV = 3) THEN //will set next step to 3
0062 "next_STEP" := 2; //object counter reads 2
0063 END_IF;
0064

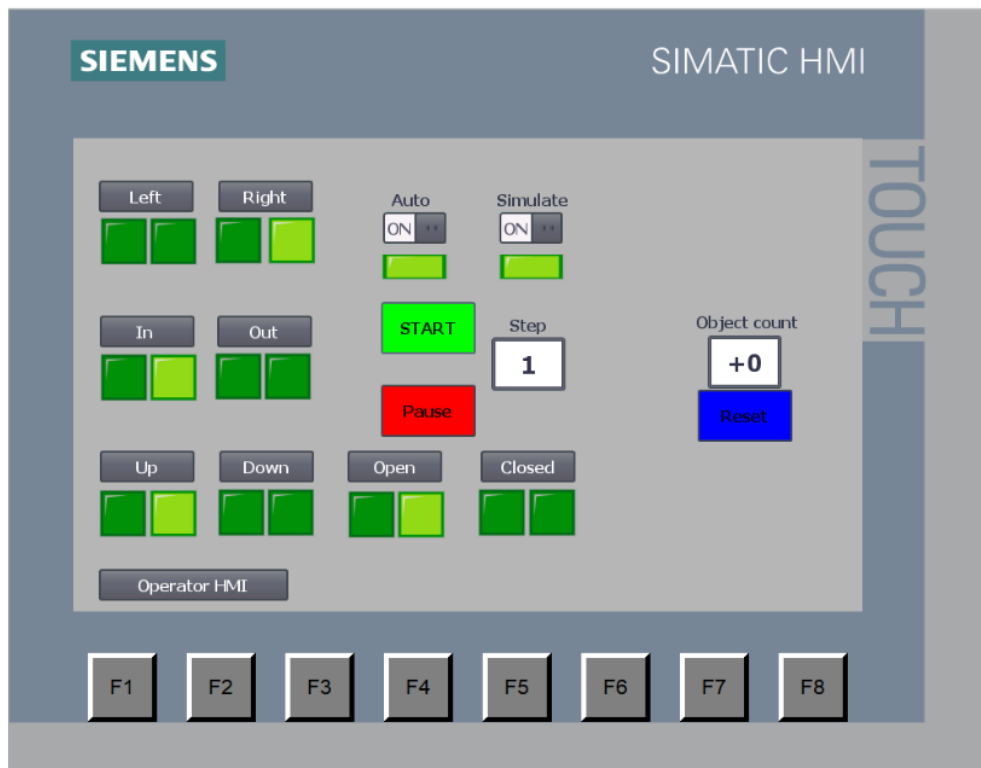
```

poor image

Figure 1: SCL Code



HMI 1: Auto off, operators screen



PLC 2: Auto on, engineer screen

FINAL GRADE

GENERAL COMMENTS

Instructor

46

/100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

QM

Write in the third person

Don't refer to your self as I, me, my or others as you etc. Avoid personal references. If absolutely necessary, refer to self as "the author".

QM

Write in the third person

Don't refer to your self as I, me, my or others as you etc. Avoid personal references. If absolutely necessary, refer to self as "the author".

Text Comment. What about the assignment tasks, do you know what they are?

Text Comment. This is a reflection not a plan

QM

Grocer's apostrophe

If you meant this as a plural word, don't use an apostrophe. This also applies to acronyms and initialisms such as PLCs

Text Comment. No need to underline your citations

Text Comment. No need to underline your citations

Text Comment. No need to underline your citations



Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. No need to underline your citations

Text Comment. Section 5 was supposed to be simulation testing - see the brief

Text Comment. Same title as section 4 ??



Write in the third person

Don't refer to your self as I, me, my or others as you etc. Avoid personal references. If absolutely necessary, refer to self as "the author".

Text Comment. This should be section 5

Text Comment. 2 more columns are needed, 1 for decision and 1 for evidence

Text Comment. NO evidence provided !



Write in the third person

Don't refer to your self as I, me, my or others as you etc. Avoid personal references. If absolutely necessary, refer to self as "the author".



Write in the third person

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PAGE 13

Text Comment. A small range of sources (2) but listed correctly yet the underlining is unnecessary

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

Text Comment. this is a good SFC chart

PAGE 19

PAGE 20

PAGE 21

Text Comment. poor image

PAGE 22

PAGE 23

GRADING FORM: NEW CSG-RUBRIC

THOMAS SILMAN

46

1. ENGAGEMENT WITH LITERATURE

 A good research section with evidence of reading from a small range of sources cited and listed correctly using the Harvard method. However, you do not need to underline your sources. 8/20

8

2. KNOWLEDGE AND UNDERSTANDING

 Good knowledge and understanding demonstrated in your research findings, hardware investigation, IO list and program design explanations. However, your program contain little comments and ladder code is missing. 12/20

12

3. COGNITIVE AND INTELLECTUAL

 Good simulation and practical test results analysis, discussion and conclusions/recommendations. However, you have provided very little evidence for your simulation testing other than a few screens. Your testing table should be support by a large nnumber of screen captures of the HMI running. Some evidence provided for practical testing but should be linked to your testing table. 9/20

9

4. PRACTICAL APPLICATION

 Good program design for SFC chart and SCL code but no ladder program included. Little evidence of

8

simulation and practical testing methods but good presentation of results yet without evidence. 8/20

5. TRANSFERABLE SKILLS



Good explanation of team working. Report is well structured and presented with clear diagrams. Word count not exceeded. However, your work plan does not contain all the assignment tasks, your report structure does not match the brief and you must learn to write in the third person. 9/20

9