

PSDE 4005 Assignment 2 Callum Williams

by Callum Williams

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colegsirgâr

HNC ELECTRICAL &

ELECTRONIC

ENGINEERING

PSDE4005

**ASSIGNMENT 2 – Pick & Place
Robot.**

Callum Williams

Date: 10/03/18

Word Count: 3533

Contents

*You must follow the structure given in the brief
as the marking scheme is linked to each
section number*

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Task 1 – Hardware Investigation, System Design and I/O List

Hardware

PLC (Programmable Logic Controller)

For this assignment one item of hardware used was a Siemens PLC, this gave access to a programme called TIA portal where it allowed for multiple programmes to be wrote in different languages using various inputs, outputs and programmable logic. Once the programme was designed it was uploaded to a PLC and HMI where it would operate the pick & place robot.

The PLC used was a Siemens s7-1200 PLC it had 2 analogue inputs and 14 digital inputs and 10 digital outputs, this allowed it to cover all the needs of the pick and place robot system as it had enough I/O slots to give all the hardware an individual slot allowing the programme to function correctly.

HMI (Human Machine Interface)

The HMI screen makes it possible for the programme to be operated/interacted with, it displays buttons and lamps that have been linked with the inputs and outputs that where written on to an I/O list on TIA portal, this works hand in hand with the PLC and allows the user full operation and control with the hardware's movement and operations.

The HMI used was the Siemens, 7 in TFT Touch Screen HMI, this linked with the PLC and hardware. The screen has an 800 x 400 resolution, a required voltage of 24V DC, an input current of 230mA minimum this was ideal as they are easy specifications to meet from a mains power supply.

Solenoid Valves

In the Hardware setup multiple solenoid valves are used to control the airflow in the system which allows hydraulic items to operate when valves are open or closed, the valves are run from the PLC and HMI interface and allow for electronic actions to turn into real actions.

The Solenoid valves in the system are used to move the gripper left, right, up, down, forward and back. They also allow the gripper to be opened and closed.

Sensors

Sensors are used in the circuit to detect when an object is present and also when an object has finished its movement as it ends in the proximity of the sensor, using the sensors allows for the actions requested to be carried out in an automatic sequence, this is because when one sensor detects the gripper it means its finished what it was tasked to do so it is then allowed to go to its next action.

The sensors also act as a prevention system against doing two actions at once this makes sure the system doesn't crash or cause problems as its only allowed to carry out one action at a time.

Photos of
each
component
and device
would have
greatly
enhanced
your
explanations

Push buttons & switches

Buttons and switches on this system can be physical or virtual, there is a stop start button located on the system and there is large variety of virtual push buttons on the HMI, the buttons can be tailored to suit the requirements of the programme and system when edited on TIA portal.

In this system buttons can be used to control the operation of the gripper manually and then they also can be used to operate the system through an automatic sequence.

Indication Lamps

These lamps are used as indicators on the HMI, they are put into the circuit on TIA portal and then assigned to inputs and outputs to display when they are active.

For this system they are used for all of the outputs and they are then used as indicators that certain items are working for example the sensors.

Good I/O list but you are confused about the title of column 2 in both cases

Input / Output List

these become the tag names

this column gives the I/O address

INPUTS	TAG NAMES
Up Sensor	%I0.0
Down Sensor	%I0.1
Gripper Open Sensor	%I0.2
Gripper Closed Sensor	%I0.3
In Sensor	%I0.4
Out Sensor	%I0.5
Right Sensor	%I0.6
Left Sensor	%I0.7
Push Button X10	%I1.0
Push Button X11	%I1.1
Push Button X12	%I1.2
Toggle Switch X13	%I1.3
Toggle Switch X14	%I1.4
Object Sensor	%I1.5

OUTPUTS	TAG NAMES
Move Down Solenoid	%Q0.0
Move Up Solenoid	%Q0.1
Close Gripper Solenoid	%Q0.2
Open Gripper Solenoid	%Q0.3
Move Out Solenoid	%Q0.4
Move In Solenoid	%Q0.5
Move Left Solenoid	%Q0.6
Move Right Solenoid	%Q0.7

Task 2 – Manual controls and HMI screens

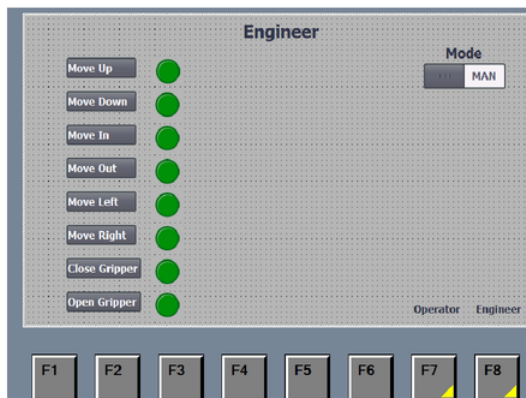
Two HMI screens were created, one to give the user full access to the programme and the pick and place robot, this is called the Engineer Screen. And the other programme to allow for limited use with access to one button but visually able to see all of the indication lamps, this mode is called the operator mode. The main differences between Operator mode and engineer mode is the ease of access with one being limited and one being completely open to the amount of inputs and outputs available to the user.

In the engineer screen Manual mode gives the user full operations over all the outputs using internal commands that are set to buttons that are displayed on the HMI screen. This screen is made available to the engineer as they have a greater understanding of the machine and are able to find problems quicker when fault finding. Every time a button is pressed the corresponding light came on to indicate that that articular piston was in action at that moment in time. This was one of the main indications that the system was working.

In manual modes a few safety precautions were built into the programme to prevent the user from damaging the machine, the precautions in place were not being able to move the robot in, out, left, right if the robot was in the down position and the other safety precaution was to not allow the robot to move down if it wasn't located over a station. These were added to the programme by using AND/OR logic whilst it was being constructed in Ladder programming option on TIA Portal.

The Specification of the assignment required a counter built into the programme to detect how many objects were in the loading/unloading bays this can be achieved by using the object sensor that is built into the robotic pick and place system.

Another switch to be included in the screen is an option to be able to pick between the loading and unloading sequences, this is simply done by using a toggle switch that is connected to two separate programmes depending on where it is switched to both the engineer and the operator have access to this option.



Engineer Screen

Here is a picture of the engineer screen with the option to select between manual and automatic mode and also the ability to be able to press buttons for the different functions listed on the GUI however it is incomplete as the options to switch between the unloading sequence and loading sequence are not present and also the object counter display is not visible.

To correct these issues changes to the programme will have to take place.

This screen should contain the sequence step number and the state of the solenoid valves

Operator Screen

The operator screen is designed for the user to be able to view the process and switch between loading and unloading sequence, however the option to switch between manual and automatic mode is not aloud because the operator is not allowed to control the robotic arm manually as they are not permitted to do so and could cause errors or damage to the machine if they did end up doing so. On this screen the counters are still visible and so are the indication lamps but the buttons that are assigned to the corresponding lamps are not available to the user.

What does the screen look like?

Task 3 – Automatic Sequences

Before starting this task a sequential function chart was created to give a guidance on how the programme was intended to work, this chart was for use with the loading sequence and not the unloading one.

The objective of this chart is to help the user and programmer gain an increased knowledge on the system they are going to build, it shows the step by step actions that they desire to take place and makes it easier to interoperate into programme form as it is similar to a step by step guide.

The first step of the automatic programme is for the gripper to move to its point of origin to start out the sequence.

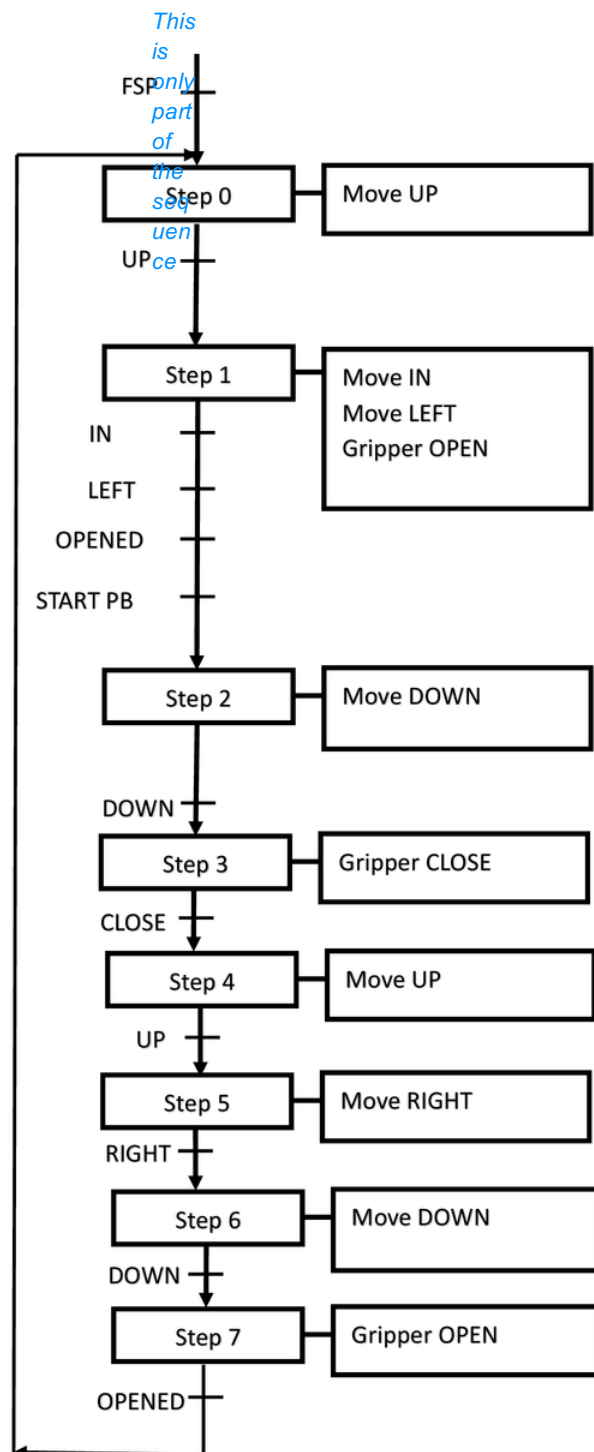
Once it has done so and the loading option is selected the 'automatic' sequence should start

The robotic arm should move to the first station where the gripper would move down and pick up the object if the object is present, once it does this it shall return into the up position.

Once the object is picked up and in the up position it should proceed to station 2 and remain there for 5 seconds, after doing so the object should continue to station 3 repeating the same process.

After the waiting above stations the object should then be moved to station 4 where it will be moved into the down position and then the gripper will be released allowing for the object to move down the chute.

Whenever an object goes down the chute it interacts with another object sensor in which sends the signal to the plc indicating that there is a new object in the output chute, this goes into a counter on the PLC and is then displayed as a digit on the HMI.



For the unloading sequence of the pick and place robot the robot is to safely remove the object from the system with no error after a pushbutton is pressed.

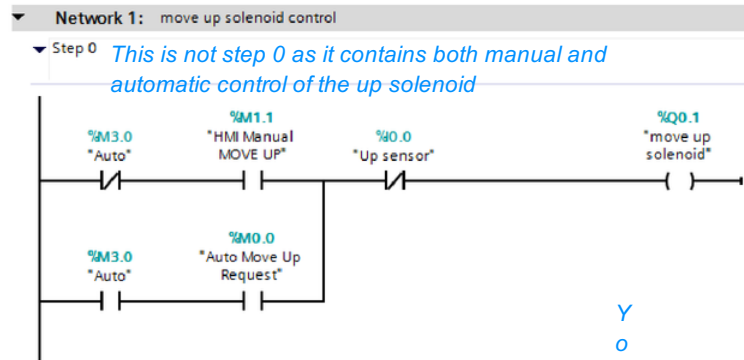
Another button in the programme must be allocated to stop the sequence at any given moment when the button is interacted with, after this button is pressed there must be a reset feature in place to start the system back up and continue from where it left off. The robot sequence **MUST** continue where it left off to prevent the robotic arm from restarting the sequence and placing one object on top of another.

When building the software the user will ensure that any necessary information will be put into the HMI displays, on the engineer screen in particular with additional information displayed on the engineers screen it makes it easier for them to fault find when/if required, this is due to the data being displayed and indication lamps lighting up, a fault will commonly show on the system due to an error such as a light not coming on, or a counter not working to a known figure.

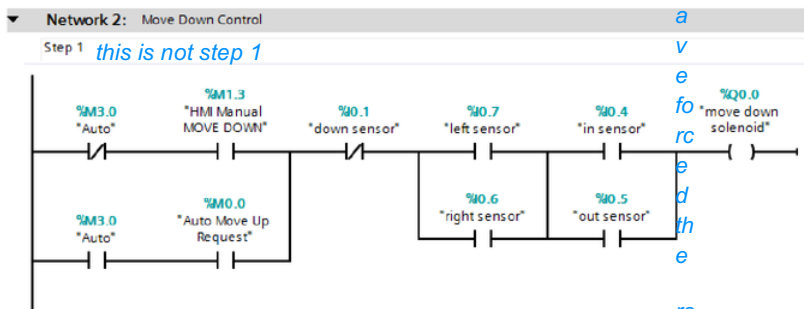
Task 4 – PLC Program Coding and Internal Documentation

For the assignment programmes for both the automatic sequences and manual sequence were to be written, the first sequence written was the manual sequence and this was done using ladder logic style of programming.

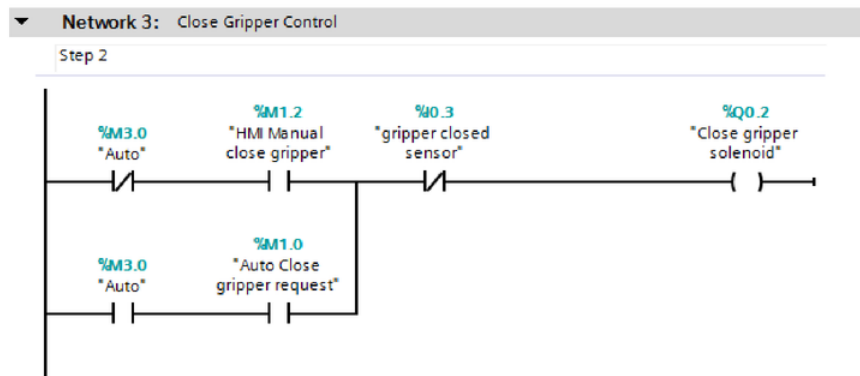
Manual Programme.



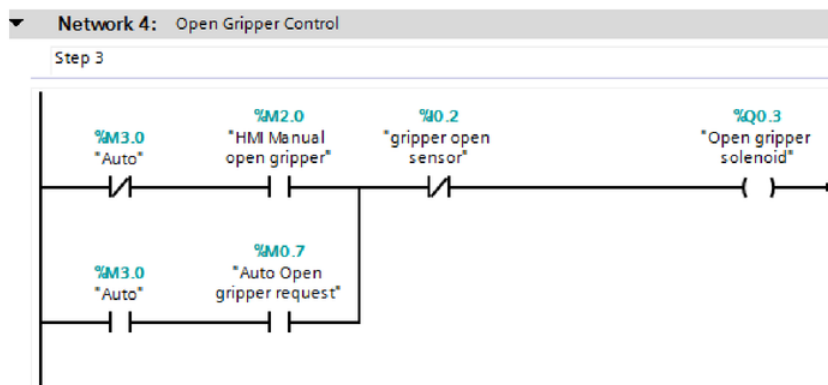
Network 1 of the manual programme is for the operation of the move up solenoid, this is the programme feature that makes the solenoid work when the HMI Manual MOVE UP button is pressed on the HMI display screen. This option also enables the up sensor to tell the programme that the gripper is in the up position.



Network 2 of the programme is for the move down solenoid, this network works when the HMI manual MOVE DOWN button is pressed, when this button is pressed it sends a signal to a determination system that uses AND/OR logic to allow the system to work. The system relies on the right or left sensor being active and the in or out sensor being active. After it determines the sensors to be active it proceeds to 'move down solenoid'.



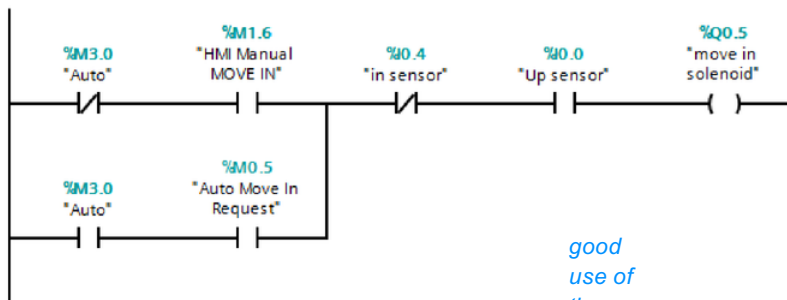
Network 3 of the programme is to close the gripper solenoid the system first checks to see if the HMI Manual close gripper button is pressed and after it gets a signal it activates the gripper closed sensor and the close gripper solenoid, this action can be taken wherever the gripper is in the robotic system whether the gripper be in or out, up or down, left or right it is allowed to carry out its operation.



Network 4 of the programme is to use the open gripper solenoid, it runs to the same principle as the close gripper solenoid and can be opened at any given time during the sequence as long as the programme is in manual mode. Identical to the close gripper solenoid this function relies on the HMI Manual open gripper solenoid button on the HMI to be pressed, once pressed it carries out the action and also activates the gripper open sensor.

Network 5: Move In Control

Step 4

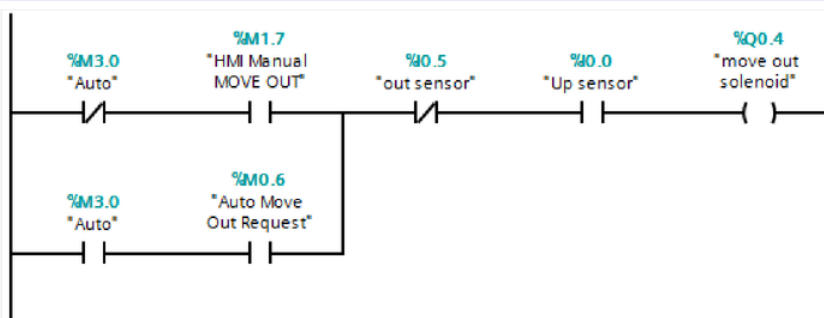


good
use of
the
interlock

Network 5 is used to activate the move in solenoid , when the HMI manual move in button is pressed on the HMI it sends a signal to the PLC which then checks that the gripper is in the UP position using the up sensor , this is due to the requirements of the gripper only being able to move left, right, in or out when it is in the up position , once the PLC has agreed that the gripper is in the up position it turns on the in sensor and the solenoid moves in.

Network 6: Move Out Control

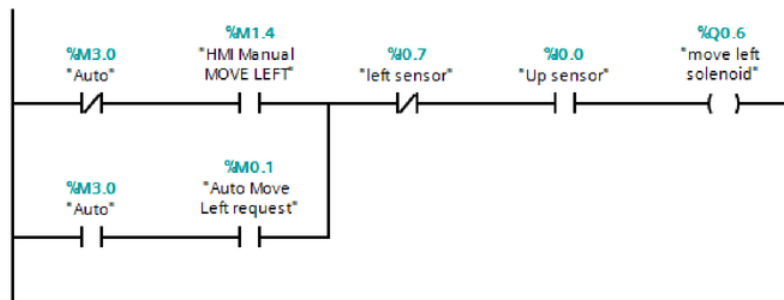
Step 5



Network 6 is used to activate the move out solenoid this is done by receiving an input signal from the HMI manual move out button, when this button is pressed the system will check that the gripper is in the up position due to the reasons explained in Network 5 after doing so and determining it safe to use the solenoid it turns on the out sensor and uses the move out solenoid.

Network 7: Move Left Control

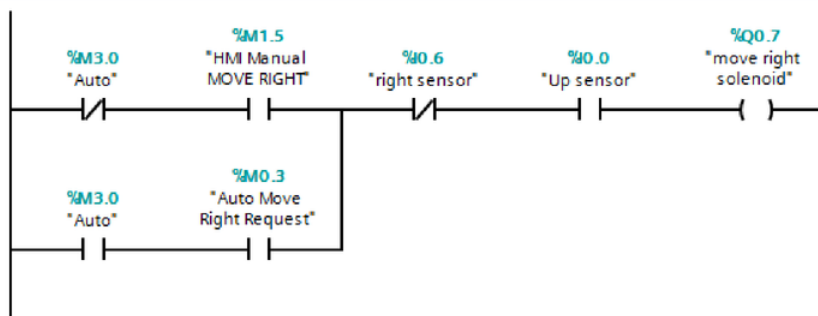
Step 6



Network 7 uses the same principle as network 5&6 and relies on the up sensor to be activated to carry on with its function. This is the move left system and the command it's put into action when the HMI Manual move in button is pressed on the HMI once this button is pressed it checks the up sensor to make sure it is in the correct position, once doing so it then activated the move left solenoid.

Network 8: Move Right Control

Step 7



Network 8 is the same as the previous 3 networks in the essence it relies on the up sensor to be active to carry out its main function, this is the Move right command, when the HMI Manual move right button is pressed on the display screen a signal is sent down the line to check the operation of the up sensor, once it has done so and determined that the up sensor is activated it then proceeds to activate the right sensor and the move right solenoids carries out its duties.

Automatic Sequence

The automatic sequence contains both the loading and unloading sequence, it carries out the sequences automatically hence the name. This type of programming was done with a different method in this instance Structured Text (ST) method of writing was used

Loading Sequence

The first part of the sequence is the loading sequence, once a toggle switch is pressed on the HMI display screen and the robotic arm is switched into automatic mode it goes back to its starting station and follows the sequence that is written out.

The gripper first moves to the first station where the gripper will open and then move down. Using the object sensor it is able to detect when an object is present, if so the gripper will then continue to close on the object and lift it back into the up position. After doing so it will then proceed to the next step using the 'Next Step := ... ;' command built into the programme.

The gripper will proceed to move out where it will be in line with station 2 after doing so it will be lowered into the station and the gripper will open releasing the object from its grasps, the gripper will then move back into the up position where it will remain idle for 5 seconds.

Once the time has elapsed the gripper will then move back down and pick up the object, after doing so it will move the object back into the up position and it will then move to the right to be holding above station 3.

When above station 3 and in possession of the object the gripper will lower itself and release the object into the station, this process is similar to how cars are built as they are dropped into the work area, have parts removed/added and then moved out of the work area to the next. Once at the station the gripper opens leaving the object where it stands, it returns to the UP position where it remains for 5 seconds before moving back down and picking the object up.

Once the object is back above station 3 it moves onto the final step of the loading sequence, it moves the object above station four, which is the unloading station where the object is released, to move to this station the gripper is to move in the inward direction with the object but similar to how the manual mode worked the up sensor is to be activated and the gripper can only move, in, out, left, or right when the up sensor is activated. with the PLC determine that the object/gripper are/is in the UP position it moves the object above the final station and proceeds to lower it, once doing so the gripper moves back up and into its starting position ready for the sequence to take place all over again.

Unloading Sequence

Once the loading sequence has taken place an option to carry out the unloading sequence is made available and this can be carried out at any time given the condition that the unloading sequence button is pressed.

The first step of the sequence is for the gripper to move above the 4 station (unloading station) when above this station it waits for a signal from the object sensor to tell the robotic arm that it is allowed to continue with what is programmed to do. Once this signal is received the robotic arm moves into the down position and the gripper closes thus picking up the object.

When the object is picked up the gripper moves into the up position after the programme follows the 'next step' command. The gripper then proceeds to move out and above station 4, when above

station four the robotic arm moves down with the object and then opens the gripper leaving the object in station 4 , the gripper then moves into the up position it then proceeds to move to station.

Task 5 – System Testing, Maintenance and Reliability

Here below is a testing table for the manual mode of the programme that is on the PLC, this testing table also covers aspects of the HMI and helps test the buttons and indication lamps.

Test Number	Description	Expected Result	Actual Result
1	Gripper moves up.	Gripper moves up when the up button is pressed.	The gripper moved upwards.
2	Move up lamp comes on.	The lamp to illuminate.	The lamp emitted light.
3	Gripper moves in.	Gripper moves in when the in button is pressed.	The gripper moved in.
4	Move in lamp lights up.	The lamp to illuminate.	The lamp emitted light.
5	Gripper moves left.	Gripper moves left when the left button is pressed.	The gripper moved left.
6	Move left lamp lights up	The lamp to illuminate.	The lamp emitted light.
7	Gripper Opens	The gripper should open when button is pressed.	The gripper opened.
8	Gripper open lamp lights up	The lamp should illuminate.	The lamp emitted light.
9	Gripper moves down	The gripper should move down when the down button is pressed.	The gripper moved down.
10	Move down lamp lights up	The lamp should illuminate	The lamp emitted light.
11	Gripper closes	The gripper should close when the button is pressed	The gripper closed.
12	Gripper close lamp illuminates	The light on the HMI should light up when button is pressed	The lamp illuminated.
13	Gripper moves right	The gripper should move right when a button is pressed	The gripper moved right
14	Move right light illuminates	The right light comes on	The right light did let off some light illuminating when button is pressed.

To maintain the machine the programme must be written with care so not movements are too fast or no unusual crashes due to the overlapping of materials and tools in the system. When fault finding in the machine viewing the HMI screen for indication lamp and also looking for any errors when the newest date of the programme is loaded to the system.

[Task 6 – Conclusions and Recommendations](#)

Task 7 – Report

PSDE 4005 Assignment 2 Callum Williams

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

35/100

PAGE 1

PAGE 2

Text Comment. You must follow the structure given in the brief as the marking scheme is linked to each section number.

PAGE 3

Text Comment. Photos of each component and device would have greatly enhanced your explanations

PAGE 4

PAGE 5

Text Comment. Good I/O list but you are confused about the title of column 2 in both cases

Text Comment. this column gives the I/O address

Text Comment. these become the tag names

PAGE 6

Text Comment. This screen should contain the sequence step number and the state of the solenoid valves

PAGE 7

Text Comment. What does the screen look like?

PAGE 8

Text Comment. This is only part of the sequence

PAGE 9

Text Comment. This is not step 0 as it contains both manual and automatic control of the up solenoid

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

Text Comment. this is not step 1

Text Comment. Good use of interlocks

Text Comment. good use of the interlock

GRADING FORM: CSG-RUBIC

CALLUM WILLIAMS

35

RESEARCH-INFORMED LITERATURE



n/a

KNOWLEDGE AND UNDERSTANDING



Section 1: Hardware Investigation - Brief descriptions given but no photos of the system which is a shame as this would have greatly enhanced your explanations. (5/10) Section 1: System Design and I/O list - A good I/O list and ladder rungs are mostly well designed. However, your SFC chart is incomplete showing only 8 steps. The SCL code for the sequence is missing from the report. (3/10) Section 2: Program Explanation – The ladder networks presented have been explained to a good standard but since the SCL code is missing, no explanation has been given. (5/10)

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ANALYSIS



Section 3: System Testing – Manual testing table provided but no evidence in the form of photos. No evidence of auto sequence testing provided. (4/10) Section 3: Maintenance and Reliability - . Some consideration given and manual controls on engineer screen allows for some diagnostics to be performed. (4/10) Section 4: Conclusions and recommendations - None offered. (0/10)

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PRACTICAL APPLICATION AND DEP.



Section 2: Program Network Comments - Network comments are incorrect for the ladder program as you have confused the solenoids with steps and have not fully understood the method of sequencing. However the network title are correct. No SCL code given so no comments are available. (3/10) Section 2: HMI Screen Designs – Only the engineer's screen is shown in the report and this is incomplete. (3/10) Section 3: Presentation of Test Results - Results are presented in a table but no

10

supporting evidence is given . (4/10)

SKILLS FOR PROFESSIONAL PRAC.



All sections - The report has structure and is generally well written and presented. However, your structure does not follow the brief. Pages have not been numbered. (4/10)

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