

2221114

by Kai White

Submission date: 17-Apr-2023 10:57AM (UTC+0100)

Submission ID: 202326488

File name: 17313_Kai_White_2221114_181751_1513586127.pdf (1.26M)

Word count: 2809

Character count: 15353

Course: HNC Electrical and Electronic Engineering

Module: SGEE4004 Programmable Logic Controllers

Assignment: 2. Factory IO Control System

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University number: 2221114

Date submitted: 17/04/23

Word count: 2500

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1. Work Plan for Lifelong Learning

"And" is a joining word and should not be used to start a sentence.

Research the five IEC languages with images in the appendix. And discuss the applications for each and find out which language will be the most suitable for the assignment.

Design a table with all the hardware that needs to be used with an input and output table with tags needed for the PLC.

Start to build the program by filling and emptying the tank and show its current position of all the devices. Then the semi-automatic mode will be made and the level will have a setpoint. There need to be tuning values which can be adapted/changed, this will need to be repeated for flow. For automatic mode the tank will be filled to an exact level and the flow will have a flowrate setpoint. When the automatic mode is stopped the tank will begin to drain. Also, there will be multiple HMI screens with the data for flow, level, auto mode, manual mode with graphs so show what's happening to the tank, and all the other data will be available to see.

Furthermore, testing will then need to be carried out this will be done on TIA portal and Factory IO. There will be multiple tests to try and see if there is any errors or mistakes in the software.

Next, a group will be formed where they act as my customers as review my program to see if it fits and suits their needs. A brief summary will need to be written including any improvements that need to be made and how the teamwork went.

Conclusions and recommendations will be made of the overall project.

A full detailed summary of how the teamwork went and how teamwork is beneficial in the engineering department.

Citation list with all used citations

Appendix filled with images and tables from the project.

2. Research

Ladder Diagram

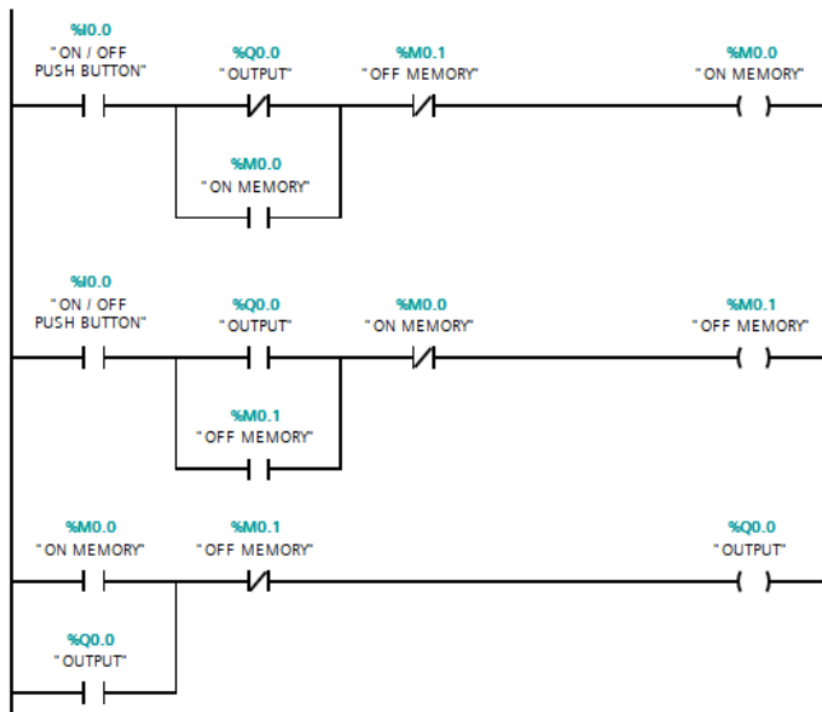


Figure R1, shows an example of Ladder Diagram. (Arena, 2022)

Ladder is one of the easier IEC languages to use and it includes logic gates (NO or NC gates). The benefits to this are it is a simple way to do tasks repetitively or sequences.

Some ladder applications are Logistics Package Conveying and Sorting, Cement Batching, Beverage Bottling and Labelling, Hopper and Tank Level Control and Air and Liquid Flow and Pressure Control. (LadderLogicWorld, 2021)

Instruction List

FB1 : Title:

LOGIC FOR ALWAYS ON AND OFF BIT

▢ Network 1: ALWAYS ON

AN	M	0.0
S	M	0.0

▢ Network 2: ALWAYS OFF

AN	M	0.1
R	M	0.1

Figure R2, shows an example of Instruction List. (InstTools, 2023)

Instruction list is similar to ladder but whereas ladder is graphical, [instruction](#) structure list is text based. It is made up of short instructions to command the PLC. It is a lot easier to do all basic mathematics with this type of programming instead of using ladder. Using instruction list will benefit the program as it works at a fast speed and they tend to take up less storage, so this would be used on a PLC with less space. This language is harder to understand for beginners so depending on who is reading your program you would have to either use ladder or ILs. (MotionControlClips, 2023)

Function Block Diagram

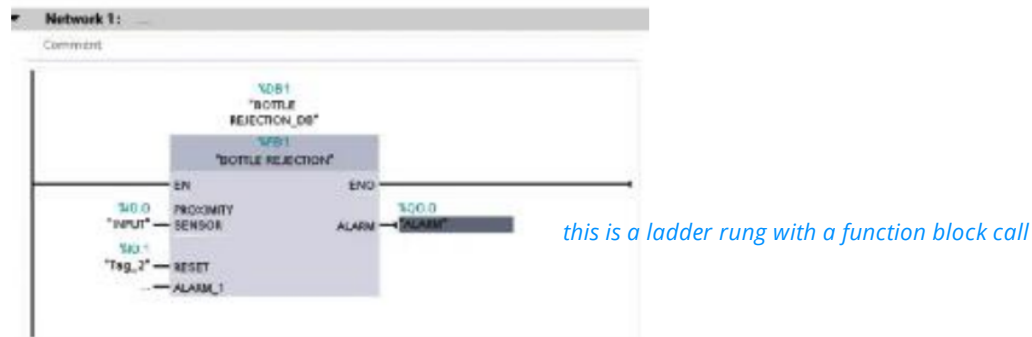


Figure R3, shows an example of a Function Block. (InstTools, 2023)

Function block programming is where functions are being used in function blocks. In structured text you have to write functions and still connect them but in this it is a lot simpler and quicker. Function blocks are easy to understand because the title of the block shows what it is doing and the IOs are well understandable. The FB can have a variety of inputs depending on how much the user wants and FB can be linked into each other. There are so many different function blocks, it makes it easy to do any commands or calculations with it.

A good use of FB is to control something like a valve or a motor. (PLCAcademy, 2021)

Structured Text

Figure R4, shows an example of Structured Text. (RealPars, 2023)

```
1 (* This routine will start the pump when the control valve is open and stop the pump when the control valve is closed or not open*)
2 IF #ControlValve_Closed = false AND #ControlValve_Open = True THEN
3   #Pump_Start := True;
4 ELSIF #ControlValve_Closed = true OR #ControlValve_Open = False THEN
5   #Pump_Start := False;
6 END_IF;
```

Structured text is code (C or C++) and this is used by most big industries to program PLCs. ST language is where you can use if statements, case of, while do or region statements. All the code is normally broken up into tasks with comments (to show what each line of code is doing in case someone new came onto the job and its easily understood by anyone). With the code the user can implement functions or state machines. The major benefit to using this language over the other is that there is a lot more freedom and a lot more control you have over the program because of the variety of commands that can be entered.

Robots primarily use structured text for their language. And sequences are easily written in this language. (Dietrich, 2022)

Sequential Function Chart

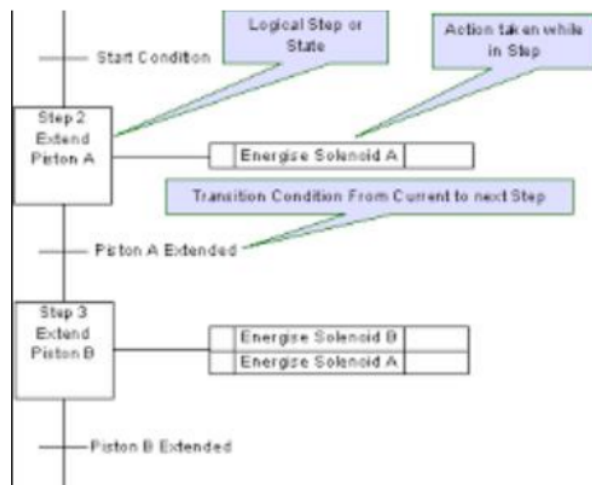


Figure R5, shows an example of a Sequential Function Chart. (PLCDev, 2023)

SFCs are a visual language and it can be compared to flow charts. SFCs are used to show operations and tasks in each order with descriptions about each part. SFCs make it easy to loop whatever steps are needed. Each step will describe what needs to happen in that operation, after the step the diagram will show what happened. Steps are bordered in a square

and the vertical lines after the step show what has happened. To the right of each step is the output (there can be multiple). (Devasia, 2022)

SFCs are an organisation on of sub-programs and can be written in multiple languages (Rao, 2023)

Which language is going to be used in the program?

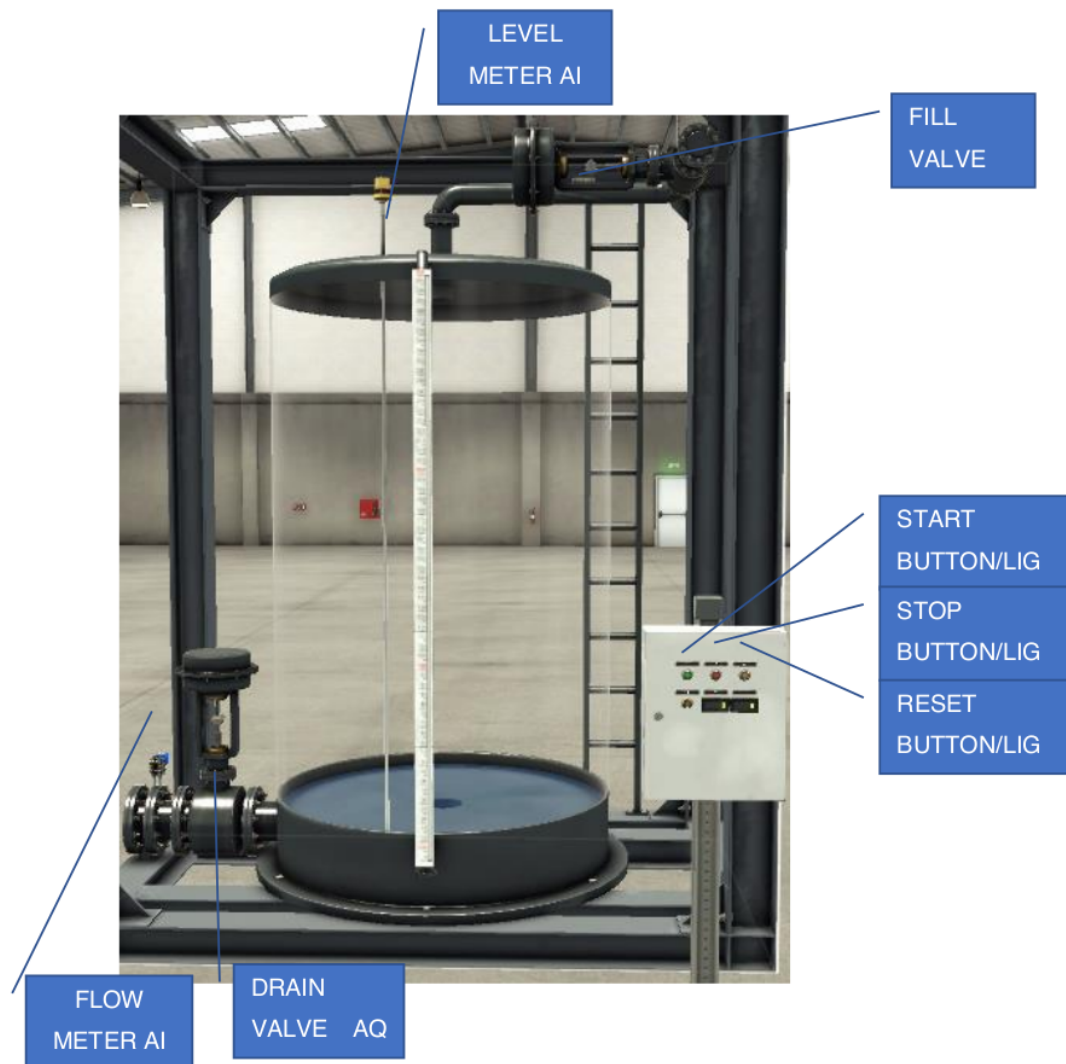
In the following program ladder diagram, Function block and Structured text are going to be used.

Ladder is going to be used for the simple commands and generic operations.

Function Calls are going to be used when there are parameters to be met.

Structured text will be used for the sequential operation that is going to be performed.

3. Hardware Design and I/O List



PLC hardware design is missing

Inputs	
Address	Description
%I0.0	START BUTTON
%I0.1	RESET BUTTON
%I0.2	STOP BUTTON
%I0.3	FACTORY IO RUNNING DI
%ID30	LEVEL METER AI REAL
%ID34	FLOW METER AI REAL

Outputs	
Address	Description
%Q0.0	START LIGHT
%Q0.1	RESET LIGHT
%Q0.2	STOP LIGHT
%QD30	FILL VALVE AQ REAL
%QD34	DRAIN VALVE AQ REAL

4. Program Design and Explanation

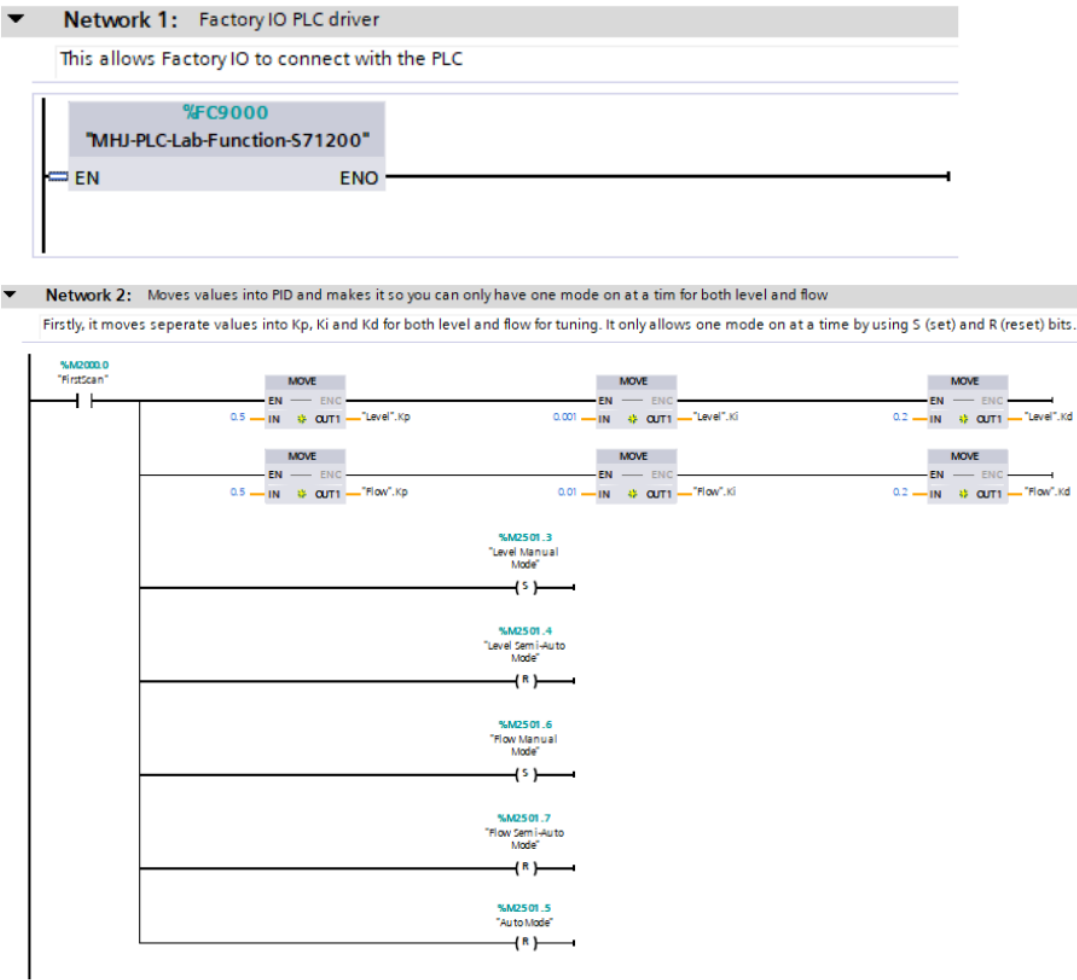
Tag list

My Tags							
	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...
1	 HMI Start Level	Bool	 %M2500.1	☐	☒	☒	☒
2	 HMI Stop Level	Bool	%M2500.2	☐	☒	☒	☒
3	 HMI Start Flow	Bool	%M2500.3	☐	☒	☒	☒
4	 HMI Stop Flow	Bool	%M2500.4	☐	☒	☒	☒
5	 Tank Level	Real	%MD3000	☐	☒	☒	☒
6	 Level RUN	Bool	%M2500.5	☐	☒	☒	☒
7	 Level Inc Valve	Bool	%M2500.6	☐	☒	☒	☒
8	 Level Dec Valve	Bool	%M2500.7	☐	☒	☒	☒
9	 Flow RUN	Bool	%M2501.0	☐	☒	☒	☒
10	 Flow Inc Valve	Bool	%M2501.1	☐	☒	☒	☒
11	 Flow Dec Valve	Bool	%M2501.2	☐	☒	☒	☒
12	 Level Manual Mode	Bool	%M2501.3	☐	☒	☒	☒
13	 Level Semi-Auto Mode	Bool	%M2501.4	☐	☒	☒	☒
14	 Auto Mode	Bool	%M2501.5	☐	☒	☒	☒
15	 Flow Manual Mode	Bool	%M2501.6	☐	☒	☒	☒
16	 Flow Semi-Auto Mode	Bool	%M2501.7	☐	☒	☒	☒
17	 Level Setpoint	Real	%MD3004	☐	☒	☒	☒
18	 Flow Setpoint	Real	%MD3008	☐	☒	☒	☒
19	<Add new>			☐	☒	☒	☒

This tag list contains all the tags that was made for the program not including the automatic tag lists like factory IO or system tags (as they are generated automatically).

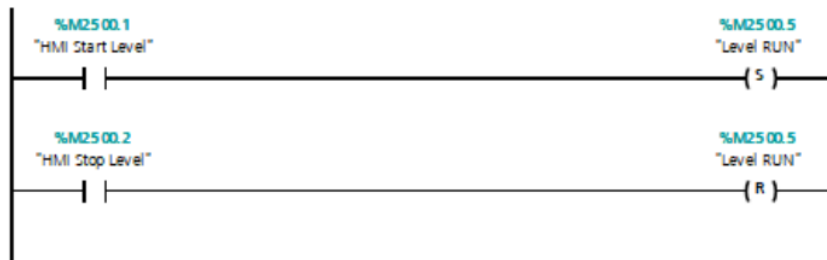
Program code

Main



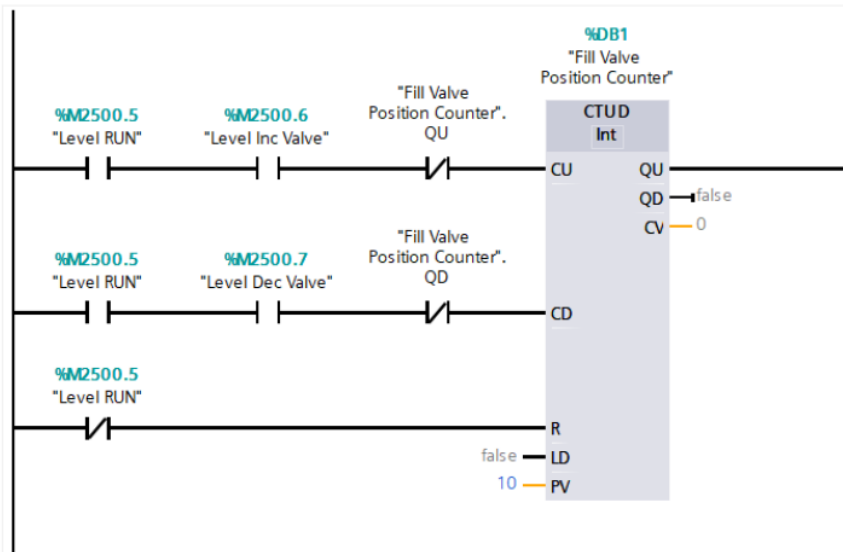
▼ Network 3: Starting and stoping HMI level

Start or stop the HMI level by using S and R.



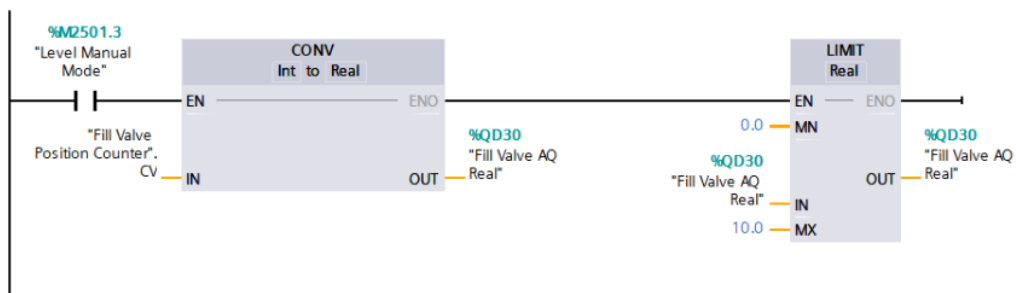
▼ Network 4: Fill valve position counter

- Countup is done when "level run" and the "level inc valve" is on and the "fill valve position counter.QU" is off. Countdown is done when "level run" and the "level dec valve" is on and the "fill valve position counter.QD" is off. With a 10 PV. When the "level run" is turned off it will reset the counter.



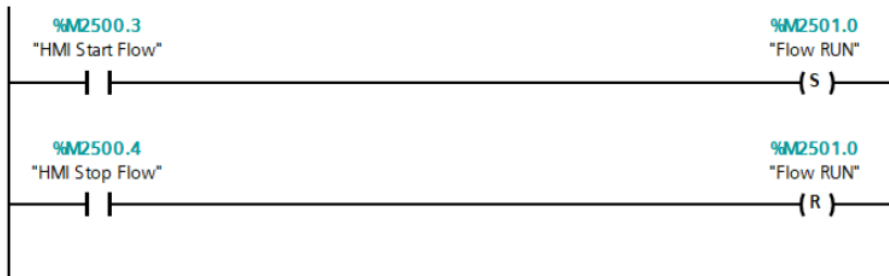
▼ **Network 5:** Converts an int to a real and limits the Fill Valve Position Counter

When "level manual mode" is on, the "fill valve position counter.CV" is converted into a real. Then the value is then limited by the maximum value that it can be is 10.



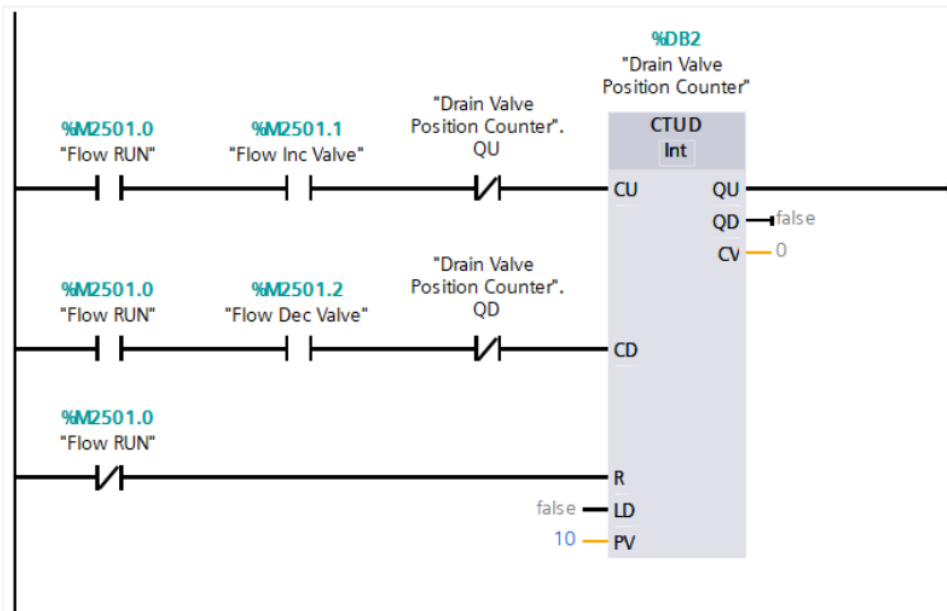
▼ **Network 6:** Starting and stoping HMI flow

Start or stop the HMI flow by using S and R.



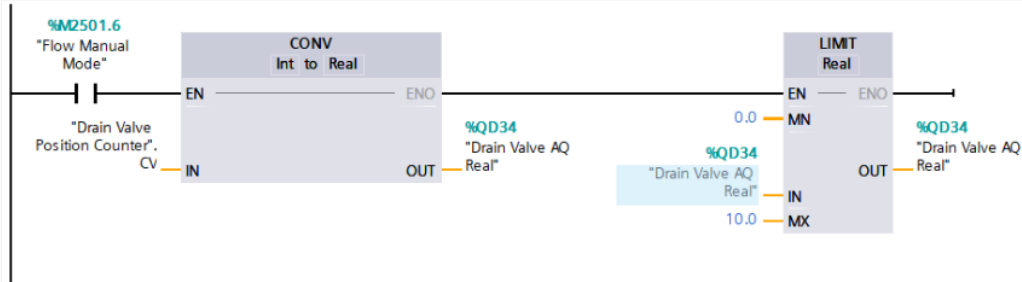
Network 7: Drain Valve Position Counter

- Countup is done when "flow run" and the "flow inc valve" is on and the "drain valve position counter.QU" is off. Countdown is done when "flow run" and the "flow dec valve" is on and the "drain valve position counter.QD" is off. With a 10 PV. When the "flow run" is turned off it will reset the counter.



Network 8: Converts an int to a real and limits the Drain Valve Position Counter

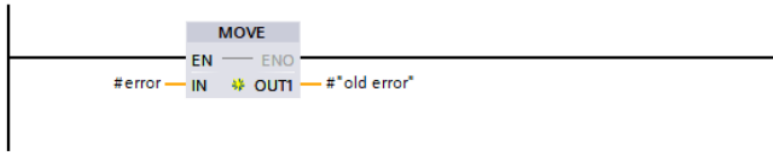
- When "flow manual mode" is on, the "drain valve position counter.CV" is converted into a real. Then the value is then limited by the maximum value that it can be is 10.



PID control

Network 1: store the old error

It moves the error into the old error.



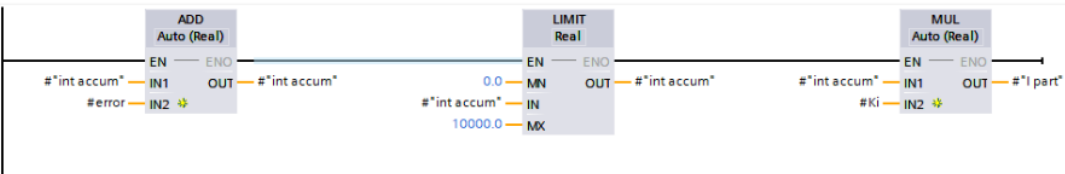
Network 2: Calculate the P part

Subtracts PV from SP to calculate the error. Then Multiplies the error with Kp to calculate the P part.



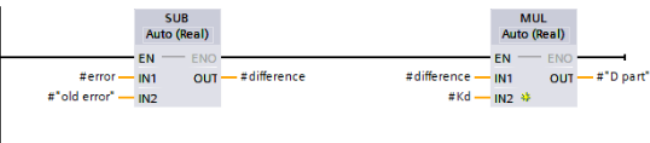
Network 3: Calculates the I Part

Adds the int accum with the error to make a new value of int accum. Then limits the value of int accum so the minimum value is 0 and the maximum is 10000. After that the int accum is multiplied with Kp to get the I part.



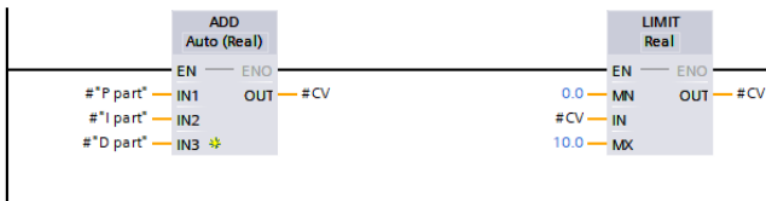
Network 4: Calculates the D part

Subtracts the error from the old error to make the difference. Then the difference is multiplied with Kd to make the D part.



Network 5: Calculates the CV

Add all P, I, D parts together to calculate the CV. Then limit the value of CV so it can be between 0 and 10.



Level data block

Level								
	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint
1	▼ Input			☐	☐	☐	☐	☐
2	■ SP	Real	0.0	☐	☒	☒	☒	☐
3	■ PV	Real	0.0	☐	☒	☒	☒	☐
4	▼ Output			☐	☐	☐	☐	☐
5	■ CV	Real	0.0	☐	☒	☒	☒	☐
6	■ InOut			☐	☐	☐	☐	☐
7	▼ Static			☐	☐	☐	☐	☐
8	■ error	Real	0.0	☐	☒	☒	☒	☐
9	■ old error	Real	0.0	☐	☒	☒	☒	☐
10	■ int accum	Real	0.0	☐	☒	☒	☒	☐
11	■ difference	Real	0.0	☐	☒	☒	☒	☐
12	■ Kp	Real	0.5	☐	☒	☒	☒	☐
13	■ Ki	Real	0.01	☐	☒	☒	☒	☐
14	■ Kd	Real	0.0	☐	☒	☒	☒	☐
15	■ P part	Real	0.0	☐	☒	☒	☒	☐
16	■ I part	Real	0.0	☐	☒	☒	☒	☐
17	■ D part	Real	0.0	☐	☒	☒	☒	☐

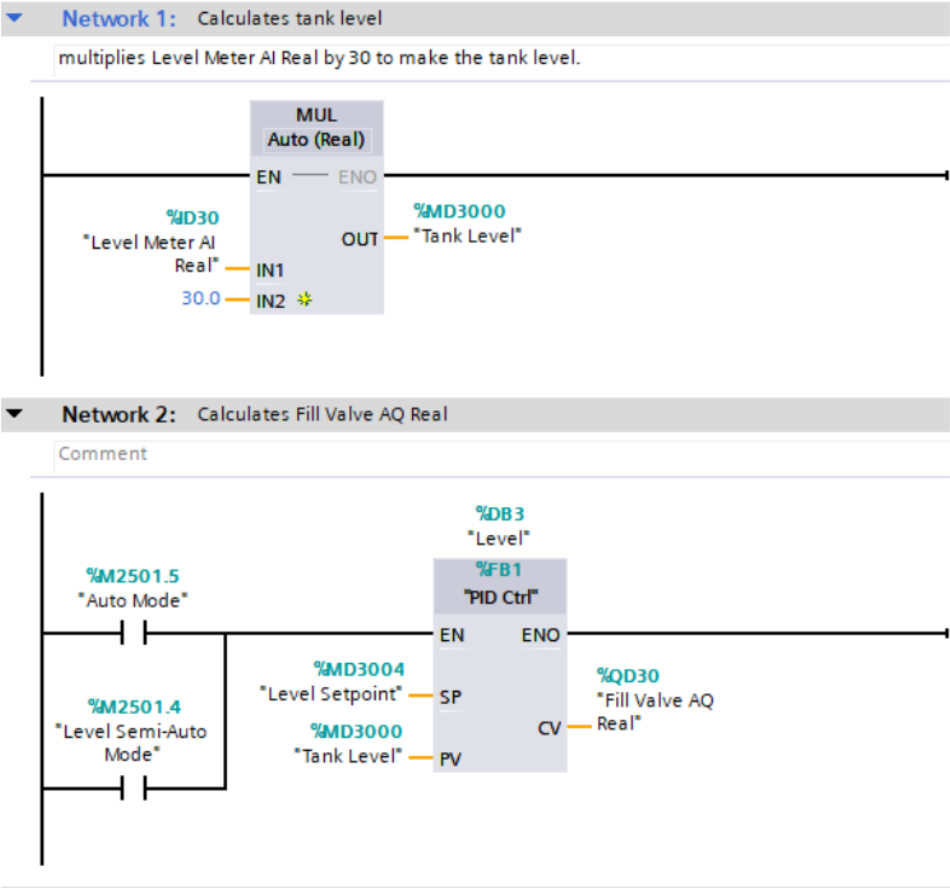
These are all the data types for level

Flow data block

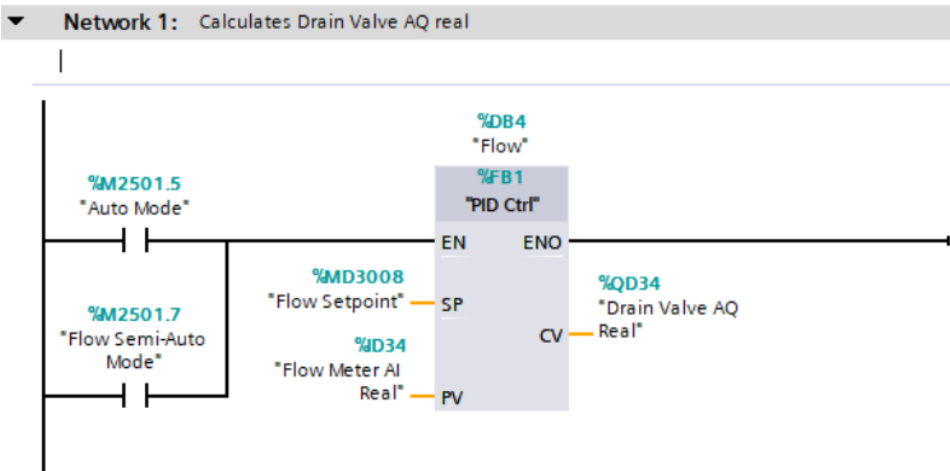
Flow								
	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint
1	▼ Input			☐	☐	☐	☐	☐
2	■ SP	Real	0.0	☐	☒	☒	☒	☐
3	■ PV	Real	0.0	☐	☒	☒	☒	☐
4	▼ Output			☐	☐	☐	☐	☐
5	■ CV	Real	0.0	☐	☒	☒	☒	☐
6	■ InOut			☐	☐	☐	☐	☐
7	▼ Static			☐	☐	☐	☐	☐
8	■ error	Real	0.0	☐	☒	☒	☒	☐
9	■ old error	Real	0.0	☐	☒	☒	☒	☐
10	■ int accum	Real	0.0	☐	☒	☒	☒	☐
11	■ difference	Real	0.0	☐	☒	☒	☒	☐
12	■ Kp	Real	0.0	☐	☒	☒	☒	☐
13	■ Ki	Real	0.0	☐	☒	☒	☒	☐
14	■ Kd	Real	0.0	☐	☒	☒	☒	☐
15	■ P part	Real	0.0	☐	☒	☒	☒	☐
16	■ I part	Real	0.0	☐	☒	☒	☒	☐
17	■ D part	Real	0.0	☐	☒	☒	☒	☐

These are all the data types for flow

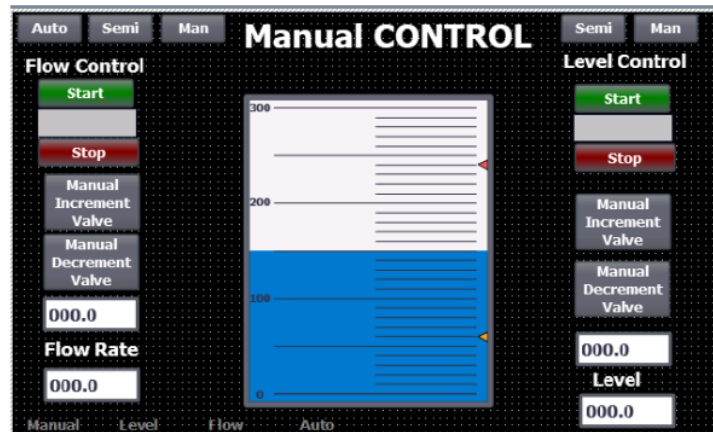
Level cyclic interrupt



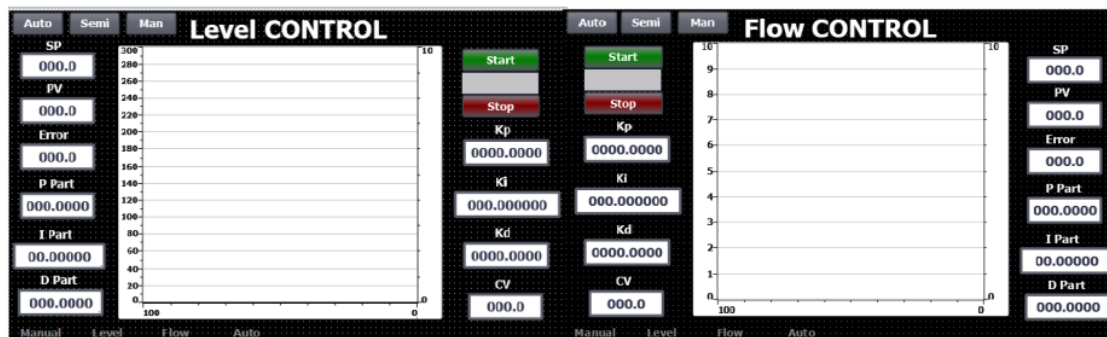
Flow cyclic interrupt



HMI Screens



The Manual Control Screen is for when flow or level is in manual mode. On this screen a start and stop button will determine whether or not the flow or level are on or off. Also, the valve can be adjusted for 0 – 100%, depending on the value that has been chosen for the valve. There's a tank on the screen to display how full the tank is. And the flow rate and the level values will be displayed.



Both the Level/Flow Control Screen shows all the important values for level. The SP (setpoint) can be adjusted to any needed value. In manual mode the P part, I part, D part can be changed if needed. But in semi-automatic mode the program will do the PID on its own but the value of SP will still need to be inputted. Also, a start and stop button on this page for quick and easy changes. The graph will display the level/flow and its changes, and the setpoint.

5. System Testing

Test description	Expected Results	Actual Results	Decision	Evidence
Flow Start and Stop Button	The tank should start and stop the flow	The tank started to flow	Passed	Figure t1, Figure t2
Level Start Button	The tank should start to fill	The tank started to fill	Passed	Figure t3
Level Stop Button	The tank should stop filling	The tank stopped filling	Passed	Figure t4
Flow manual and semi-automatic mode	When pressed the flow should only be in one of the modes	When pressed the flow was only in one of the modes	Passed	Figure t5, Figure t6
Level manual and semi-automatic mode	When pressed the level should only be in one of the modes	When pressed the level was only in one of the modes	Passed	Figure t7
Auto mode	When pressed this should be the only mode active in the program	When pressed this was the only mode active in the program	Passed	Figure t9
Manual Mode				

Flow Manual Increment Valve	Every time pressed, it should open the valve more and more allowing more flow	Every time pressed, it opened the valve more and more allowing more flow	Passed	Figure t10
Flow Manual decrement Valve	Every time pressed, it should close the valve more and more allowing less flow	Every time pressed, it closed the valve more and more	Passed	Figure t11
Level Manual Increment Valve	Every time pressed, it should open the valve more and more allowing the tank to fill more	Every time pressed, it opened the valve more and more allowing the tank to fill more	Passed	Figure t12
Level Manual decrement Valve	Every time pressed, it should close the valve more and more allowing the tank to fill less	Every time pressed, it closed the valve more and more allowing the tank to fill less	Passed	Figure t13
Flow Valve text box	Should display the value of how much the flow	Displayed the value of how much the flow	Passed	Figure t14

	valve is open on a scale 0 - 10	valve is open on a scale 0 - 10		
Level Valve text box	Should display the value of how much the level valve is open on a scale 0 - 10	Displayed the value of how much the level valve is open on a scale 0 - 10	Passed	Figure t15
Flow rate text box	Should display the flow rate on a scale	Display the flow rate	Passed	Figure t16
Level text box	Should display the level	Displayed the level	Passed	Figure t17
Flow control (Semi auto mode)				
The graph	The graph should display the flow of the tank	The graph displayed the flow of the tank	Passed	Figure t18
Kp, Ki, Kd box	Should be able to be adjusted and displayed	Can be adjusted and display is working	Passed	Figure t18
CV text box	The value should be displayed in the text box	The value was displayed in the text box	Passed	Figure t18

SP text box	The value should be displayed in the text box	The value was displayed in the text box	Passed	Figure t18
PV text box	The value should be displayed in the text box	The value was displayed in the text box	Passed	Figure t18
ERROR text box	The value should be displayed in the text box	The value was displayed in the text box	Passed	Figure t18
P, I, D part boxes	The value should be displayed in the text box	The value was displayed in the text box	Passed	Figure t18
Level control (Semi auto mode)				
The graph	The graph should display the flow of the tank	The graph displayed the flow of the tank	Passed	Figure t19
Kp, Ki, Kd boxes	Should be able to be adjusted and displayed	Can be adjusted and display is working	Passed	Figure t19
CV text box	The value is displayed in the box	The value was displayed in the text box	Passed	Figure t19
SP text box	The value is displayed in the box	The value was displayed in the text box	Passed	Figure t19

PV box	The value is displayed in box	The value was displayed in the text box	Passed	Figure t19
ERROR box	The value is displayed in box	The value was displayed in the text box	Passed	Figure t19
P, I, D part boxes	The value is displayed in boxes	The value was displayed in the text box	Passed	Figure t19

6. Meeting the Customer Needs

The customer was happy with the program as the tank filled and drained when wanted manually and the PID was successful. The customer also liked how easy it was to navigate through each screen and said how all the data that was needed for easily readable and displayed for everyone. The customer said to stick with the black and white colours so that it won't be distracting unlike if bright colours were used. The customer went over the testing results to see all the tests and the evidence of testing. The customer was very happy and polite about the program.

What about Automode?

7. Conclusions and Recommendations

In conclusion the program provided manual controls for filling and emptying the tank, whilst displaying all the needed values. The PID control was also a success as it adapted to each inputted setpoint and the user can tune any of those values. The HMI screens displayed all the data with graphs and text boxes. And values could be edited by the users. There were big START and STOP buttons on each of the screens very easily identified. The operator could switch between manual, semi-automatic and automatic mode at any time.

Recommendations would be to implement a fully automatic mode, where the tank should fill to a fixed value and flow control will kick in depending on the flowrate setpoint.

8. Team Working

Working in a team of 3 makes it a lot easier to better the program as each member will all have different opinions and ideas to be said. So, comparing each other's ideas to see which one is the best would be a lot better than just working on your own. This would make the design of the project a lot better as you have three people with completely different ideas and backgrounds so joining ideas and sharing experience would improve the program a lot and prevent as much errors as the group will all be looking for big or small mistakes.

How did you ensure the members of the team were treated equally?

9. Citation List

Correct method of listing.

Wide Range of Sources

Arena, E., 2022. *Single Push Button Start/Stop Ladder Logic Diagram using Siemens TIA Portal*. [Online]

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10. Appendix



Figure t1



Figure t2



Figure t3



Figure t4



Figure t5



Figure t6



Figure t7



Figure t8

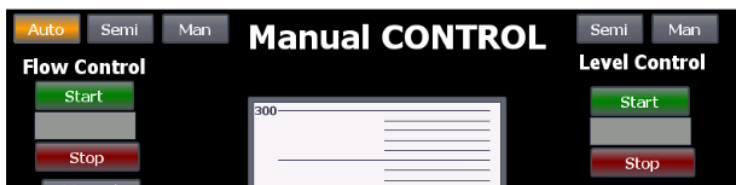


Figure t9

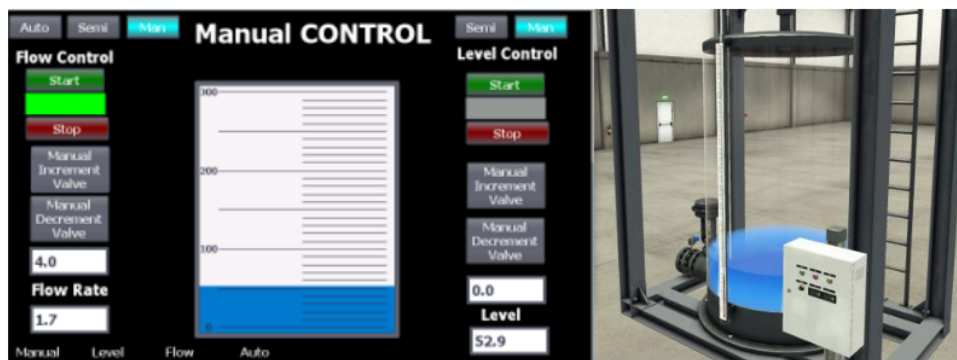


Figure t10



Figure t11



Figure t12



Figure t13



Figure t14



Figure t15



Figure t16



Figure t17

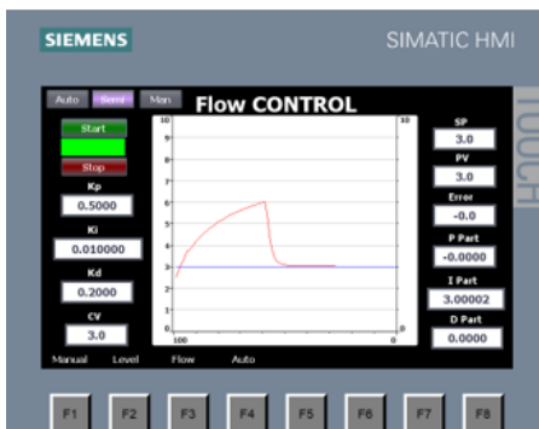


Figure t18

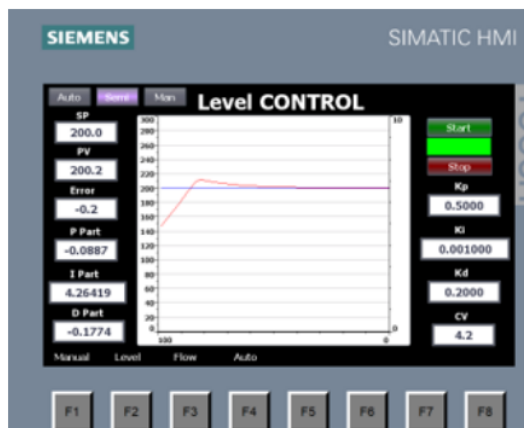


Figure t19

FINAL GRADE

GENERAL COMMENTS

Instructor

70/100

PAGE 1

PAGE 2



Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

Text Comment. detailed work plan

Text Comment. "And" is a joining word and should not be used to start a sentence.

PAGE 4

PAGE 5

Text Comment. instruction

PAGE 6

Text Comment. this is a ladder rung with a function block call

PAGE 7

PAGE 8

PAGE 9

Text Comment. PLC hardware design is missing

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

Text Comment. Excellent testing table

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

Text Comment. What about Automode?

PAGE 27

PAGE 28

Text Comment. How did you ensure the members of the team were treated equally?

PAGE 29



Correct method of listing.

You have listed your sources correctly according to the Harvard method.

QM

Wide Range of Sources

You have shown good evidence of reading from a wide range of sources.

PAGE 30

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PAGE 34

PAGE 35

PAGE 36

PAGE 37

GRADING FORM: NEW CSG-RUBRIC

KAI WHITE

70

1. ENGAGEMENT WITH LITERATURE



Good evidence of reading, wide range of sources cited and listed correctly. 16/20

16

2. KNOWLEDGE AND UNDERSTANDING



Some explanation given of HMI screens, PLC not considered. Good I/O list and comments in

13

program. 13/20

3. COGNITIVE AND INTELLECTUAL

 A good testing table with referenced evidence in the appendix. Good conclusions and recommendations. 15/20 **15**

4. PRACTICAL APPLICATION

 A well designed and documented program but no auto-mode included. 12/20 **12**

5. TRANSFERABLE SKILLS

 Well structured, detailed work plan, team working, meeting needs, word count, use of English and report format. 14/20 **14**