1909365

by Matthew Davies

APPROPRIATE RESEARCH CARRIED OUT WITH CORRECT CITATIONS. GOOD EVIDENCE OF PLANNING THROUGH A GANTT CHART. 3 SOLUTIONS WERE SUGGESTED AND A JUSTIFICATION OF WHY THE FINAL SOLUTION WAS MADE. TESTING WAS GOOD AND FINAL PRODUCT SATISFIED THE BRIEF.

MARK AGREED

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Appropriate list of figures

Good use of tables

1. Introduction and Background research

This project is based on the solving of an industrial problem at the TATA Steel site in Port Talbot where the author and creator of this project works. The issue is at the Power Plant in TATA, which is the production facility for electricity, cooling water and cold blast steam for the site. The Port Talbot site is a fully integrated steelworks, where the steel is made from raw materials and the product is coiled steel, with varying characteristics depending on the customers' needs.

The reason for this project is that there is an ongoing issue on site where the cable tunnels are overflowing with water and the water is running onto the roads. The main problem with this is that the water could permeate into the cables and affect the insulation resistance (IR) readings and potentially cause short circuits between conductors, if the cables aren't in very good condition. The main cables which run through the cable tunnels are sub-station cables which are either feeding into the sub-station sections, or they're supplies from the switchgear out onto the high voltage critical plant.

Currently, the way that the company is keeping the issue under control is by using diesel pumps to pump the water out of the tunnel. This is costly to the company as they have the rental charge and fuelling charges.

Research was carried out into the methods of semi-automating this water level control system to establish potential systems which could be used.

PLC Research

One form of controlling a pump for this application would be the use of a Programmable Logic Controller (PLC) to control the output of the pump depending on the level of the water in the cable tunnel. After extensive research into the various types of PLC's it was determined that for an application of this size, the typical PLC to use would be a unitary PLC. These PLCs contain all the system components within the same housing, meaning that the processor, input/output channels and the software program is all within one unit. (Aries, 2018)



Figure 1 - Unitary PLC

Good explanation with a relevant source

In a case of a PLC controlling a water level, the unit will continuously monitor the field devices, which would be the level switches or ultrasonic sensor and then depending on the state of these devices, it will control the output, which would be the pump, to pump at a specific speed depending on the level value, which will be set in the program. (Ji, 2013)

For interfacing the water level controller with the PLC, communication protocols would be used, which would provide the project with a reliable system to control the water level. Using the relevant Inputs/Outputs (I/O), the PLC will continuously scan the control system for the relevant states of the I/O and then solve the ladder logic which will have been programmed into the PLC, which in turn will change the state of the output, to control the water level. The programming language which would mainly be used in these PLCs for the application would be Ladder, and some SCL coding for alarm systems and control. (Imam, 2016)

This is a possible relevant solution

Arduino Research

An alternative method which could be used is Arduino control boards. These are microcontroller boards which can be used widely in electrical and electronic engineering for a huge variety of things, ranging from reading “lights on a sensor, a finger on a button, or a Twitter message – and turn it into an output – activating a motor, turning on an LED, publishing something online.” (Arduino, 2020)



Figure 2 - Arduino board

Following research into a case study where Arduino is used to control the water tank level, this is clearly another way of controlling the tank level. This is done by using an ‘Arduino UNO’ board as the processor/controller and an ultrasonic sensor to measure the water level, with a phone app called ‘MIT App Inventor 2’ for visualising the water level and switching on the pump.

A possibility associated with Ind 4.0

This case study was for the opposite operation to the one desired for this project, where the setpoint level of water in the tank was for it to be full, therefore, the pump should run when the level is low until it reaches 100% full then it should stop to prevent overflowing and a waste of water & energy. Although this was the opposite function to this project, the principle of operation of how the Arduino can control a water level can be implemented in the project, just with a change of programme settings. The ultrasonic sensor provides a range of 2 – 400cm measurement whilst working off the echolocation principle. This is when the ultrasonic sensor gets a signal from the Arduino board to send out eight sound waves at 40KHz to the surface of the water, then the waves get echoed back off the water to the sensor, where the Arduino

board reads the echo pin to calculate the time taken between the trigger and the receiving of the echo. As the speed of sound is known as 340m/s, the distance can be calculated using: $Distance = \left(\frac{time}{2}\right) X\ 340m/s$. (G, 2020).

Good explanation with relevant supporting ref source

2. Specification

The specification for this project was to produce an automated control system to resolve an industrial issue where the water level of a cable tunnel needs to be controlled automatically to prevent water damaging the cables, as well as providing indication for engineers to monitor the condition.

Project Outcomes	
What must the project achieve?	Efficient and automatic control of the water level in the cable tunnel at TATA Steel Power Plant, without the requirement of human operation.
Expected operation?	Pump must have several alarm levels, which initiate increased/decreased pump speeds depending on the water level. Pump must have option for manual and automatic operation. HMI must provide manual control and indication of cable tunnel water level.
What are the maintenance requirements?	The pump would need regular maintenance (2 weekly) and the hose would need clearing to prevent a build-up in the lines.
Reliability of the project development?	Fortnightly review to see if the required progress is being made, in line with the GANTT chart which was designed at the beginning of project.
Reliability and sustainability of the system	With regular maintenance, the system should run continuously, with the only issues being expected wear and tear.
Health & Safety considerations	Health and Safety at Work Act must be strictly followed, whilst taking into consideration H&S requirements of the work area. Electricity at Work Act must also be followed.
Environmental considerations	Electrically operated submersible pump, therefore no fumes will be generated. Pump will be sat in water regularly, so it must be sufficiently IP rated.
Budget?	£4000.

Table 1 - Project Outcomes

A good specification

3. Planning

A detailed Gantt chart was designed at the beginning of the project, with the expected timescale of each section of the project, running in parallel with the actual timescale, which was filled out as the project progressed. This was a sufficient way of being able to track progress and see how behind or ahead the project was running according to the plan.

A testing plan was also constructed to provide deadlines for when certain project sections would be complete so that they could be tested. The testing plan can be seen below, with the Gantt chart on the following page.

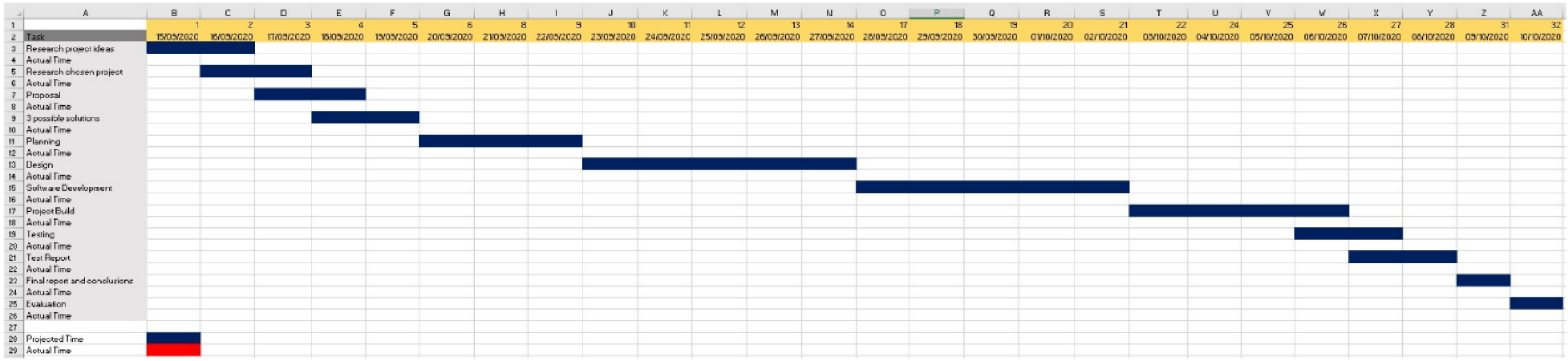
Testing Plan

Test	Description	Date
Simulate program software and HMI	Simulate program on TIA Portal, as well as HMI screen to ensure that there are no errors in program or download errors.	4/05/2021
Commissioning of wiring	Test configuration of wiring in relation to the circuit diagram.	4/05/2021
Alarm levels of water level	Test increasing of water level to ensure alarm indication on HMI was correct.	4/05/2021
Speed response from increased level	Increase water level and observe the speed response of the pump.	4/05/2021
Automatic/Manual interlock	Ensure that no manual control can be done whilst in 'Auto', and vice versa in 'Manual'.	4/05/2021

Table 2 - Test Plan

Good testing plan with relevant detail

Gantt Chart



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1		1	2	3	4	5	6	8	9	10	11	12	13	14	17	18	19	20	21	22	24	25	26	27	28	31	32
2	Task	15/09/2020	16/09/2020	17/09/2020	18/09/2020	19/09/2020	20/09/2020	21/09/2020	22/09/2020	23/09/2020	24/09/2020	25/09/2020	26/09/2020	27/09/2020	28/09/2020	29/09/2020	30/09/2020	01/10/2020	02/10/2020	03/10/2020	04/10/2020	05/10/2020	06/10/2020	07/10/2020	08/10/2020	09/10/2020	10/10/2020	
3	Research project ideas																										
4	Actual Time																										
5	Research chosen project																										
6	Actual Time																										
7	Proposal																										
8	Actual Time																										
9	3 possible solutions																										
10	Actual Time																										
11	Planning																										
12	Actual Time																										
13	Design																										
14	Actual Time																										
15	Software Development																										
16	Actual Time																										
17	Project Build																										
18	Actual Time																										
19	Testing																										
20	Actual Time																										
21	Test Report																										
22	Actual Time																										
23	Final report and conclusions																										
24	Actual Time																										
25	Evaluation																										
26	Actual Time																										
27																											
28	Projected Time																										
29	Actual Time																										

Figure 3 - Gantt Chart

Good chart for expected initial timeline

4. Solutions considered

Solution 1 – PLC Control System

The first solution is a PLC control system using a Siemens S7 PLC, programmed using TIA portal. Physically wired inputs and outputs will be used in the programming of the PLC to control the process by initiating a sequence when certain inputs are made.

The PLC which will be used for this solution will be a Siemens S7-1200. This is because it is of a lower price range, due to its processing capabilities and amount of I/O available on the unit itself. There are 14 digital inputs, 2 analogue inputs and 10 digital outputs. Thus, meaning that it has a lot of I/O available for expansion if the system required it to as there will only be 1 analogue input and 1 digital output used.

A fair argument for future proofing

This solution would meet the specification requirements as it would provide an automated system to control the water level within the cable tunnel, providing accurate control and measurement feedback to the user without manual operation of the pump. This system would allow for alarm levels to be programmed into TIA Portal, using SCL coding which would have the ability to change the speed of the pump depending on the water level by implementing PWM control to a Mosfet transistor to switch the pump on and off. The manual and auto selection would be easily done, by designing the switch on the HMI screen, and programming the interlock into the ladder network. On the HMI would be indication of the water level, as well as alarm indication. If the pump is maintained regularly, this system will run continuously.

Material	Cost
Siemens S7-1200 PLC	£350
Siemens KTP 700 Touch Screen HMI	£775.20
TIA Portal	£2000
Panel and miscellaneous items	£500
Overall Cost	**£3625.20**

Table 3 - Solution 1 costs

This shows that it would be under the budget set out of £4000. The advantages and disadvantages of this solution can be seen in the following table.

Advantages	Disadvantages
Provides accurate control and measurement feedback.	Expensive for resolving the issue, although within budget.
Can easily expand system with available I/O.	
Meets all specifications and has a lot more potential for growth.	
Easy fault finding.	
HMI provides simple real time information.	

Table 4 - Solution 1 Advantages & Disadvantages

A good argument and evaluation for this solution

Solution 2 – Arduino Control

This solution is for an Arduino microcontroller to control the water level system. This controller is programmed using Arduino's own programming system called 'Arduino IDE'. This programming system is easily available to users and is free to download and easy to use as it is a text-based programming language.

To make the Arduino control the water level, it would need to use an ultrasonic sensor on the tank to feedback a distance measurement to the micro-controller, which would use this measurement to control the speed output of the pump. A Bluetooth connection would be required to make it compatible with the phone app to monitor the process. An example of this circuit diagram can be seen below, from (Ramesh, 2020).

The option for remote control is a good idea and very possible with this system.

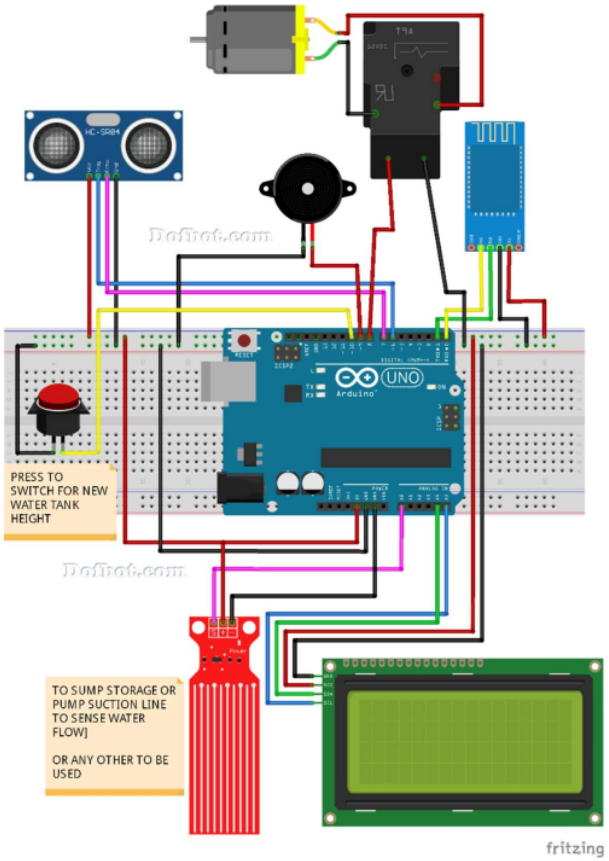


Figure 4 - Arduino Schematic

As this system only has 1 output and 1 input, there would only need to be 2 relays, as a relay would be required for each I/O as the Arduino board only has a 5VDC control signal, so it won't be able to switch on the pump. The relay coil will be switched by the 5VDC, with the contact on the relay carrying the 12VDC for the pump when it is called on.

This solution would provide an efficient and automatic control of the water level, by using the programming software to automate the system. The required alarm levels would be able to dictate the pump speed by programming them into the Arduino IDE. It wouldn't be able to provide a manual/automatic selection as this system wouldn't be controlled by a HMI, however it would still run continuously without issues to the system, however if these were to occur then the Arduino cards are inexpensive and easily available so they can easily be changed over.

This system would be better off using PWM. The small signal can be handled by a signal MOSFET and this can be used to control power MOSFET to drive the pump.

This is not really a disadvantage

Materials	Cost
Arduino board starter kit	£81.60
2 x Arduino relays	£40.80
Overall Cost	**£122.40**

Table 5 - Solution 2 Costs

This shows that the Arduino solution is very cost effective as it is significantly cheaper than the budget.

Advantages	Disadvantages
Inexpensive	Fault finding can be difficult
Easy to program	Not as easy to expand
Meets majority of specification	Not as reliable as PLC
Hardware and software licenses free	Communication protocols can sometimes be unreliable
Communication protocol is up to the user and free to create	

Table 6 - Solution 2 Advantages & Disadvantages

A fair argument for this system, but the small 5V signal is not a problem to drive a higher voltage

Solution 3 – Hardwired Electrical Control Circuit

This solution would provide the issue with an old-school solution, yet still effective to tackle the problem. This solution would be a start/stop panel, with a manual/auto selector switch with some indication for 'running', 'stopped' and 'supply healthy'. An example of the type of panel that would be used for this solution is below.



Figure 5 - Start/Stop Panel

With this solution, a submersible 110V pump would be used, which would have a float switch on it to control the pump to come on and off when the contact makes or breaks. In the 'auto' selection, the only thing starting the pump would be the float switch and the manual control would be disabled, whereas in 'manual' the float switch would be disabled, and the pump would start from the push-button signal on the front of the panel.

This solution would meet the efficient and automatic control specification; however, this wouldn't be an automated system as it is an electrical control circuit, which doesn't provide any instrument measurements or control to a HMI for the users. An alarm level could be indicated on the panel, but this would only be to show when the float switch contact is made or not, which wouldn't give indication of how high the water level is. If the pump would be regularly maintained, then this system would run continuously unless any electrical faults occur.

Materials	Cost
110V Submersible pump	£140
Panel and internal accessories/wiring	£500
Overall cost	**£640**

Table 7 - Solution 3 Costs

This shows that this solution is cost effective as it is well within the budget.

Advantages	Disadvantages
Relatively inexpensive	Difficult to expand significantly
Easy to use and fault find	No analogue feedback
Simplistic system	No alarm conditions
Reliable	

Table 8 - Solution 3 Advantages & Disadvantages

This is usually a last resort option but more often it is the existing system that will be replaced by automation.

Comparison of Solutions

	Solution 1	Solution 2	Solution 3
Cost	£3625.20	£122.40	£640
Does it meet the specifications requirements?	Meets all specification requirements.	Doesn't meet all specification requirements as it doesn't provide manual/automatic control and interlock, or a HMI for user.	Doesn't meet the specification requirement of it being an automated system.
Ease of use and fault finding	Fault finding is made relatively easy on a PLC and the software programming relates to a schematic drawing when in Ladder diagram.	Programming can quickly be picked up; however, fault finding can be difficult.	Would be easy to use, as it's just a start/stop panel with 'auto/manual' selector switch. Fault finding would be simple as not many components involved.
Accessibility to materials	Materials would be easily accessed in the college.	Materials could be bought online easily and delivered quickly.	Materials would be easily accessed from stores in work.
Reliability of the system	System would be reliable, as it has a strong communication protocol between PLC and programmer via Ethernet.	System not as reliable as PLC as communication is via Bluetooth.	System would be reliable as long as maintenance carried out as planned on the pump.

Table 9 - Solution Comparisons

A good table of comparison

5. Final solution design and implementation

The final solution, which was chosen to go with, was Solution 1 discussed in Task 4 of this report. This will be done as a simulation project in college, to solve the industrial issue discussed previously in the report, as opposed to it being carried out practically in the workplace.

A Siemens S7-1200 PLC was used for controlling the water level, which would have a Pulse Width Modulation (PWM) control duty cycle programmed into it which was controlled by an analogue input to the PLC. The analogue input was a signal generator, which provided a 0-10V signal to the PLC to simulate the water level of the tank, where 0V is a level of 0mm and 10V is 200mm. The PWM is the output of the PLC, which switches the transistor to turn on the motor.

The functional block diagram for the original plan of implementing the project in industry is below.

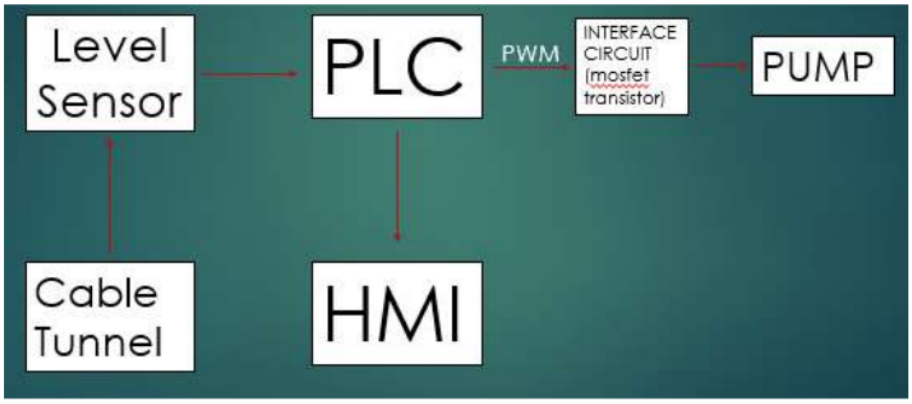


Figure 6 - Original Function Block Diagram

As the project was then being done in college, the functional block diagram changed, as can be seen on the following page.

Good explanation but there should be a statement to explain the

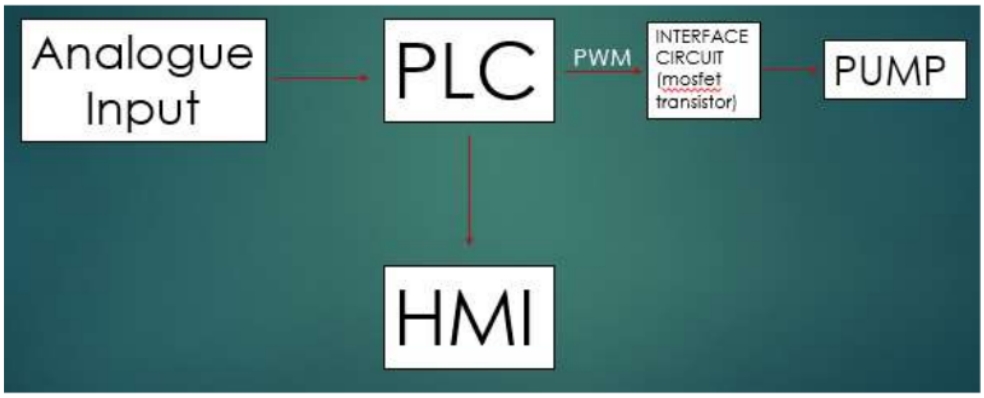


Figure 7 - Analogue Input Functional Block Diagram

Good use of block diagrams

The costs of this project solution can be seen broken down below:

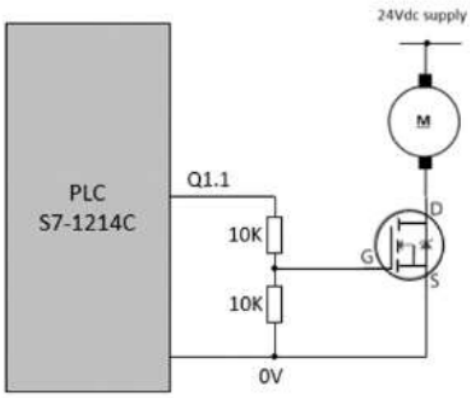
Material	**Cost**
Siemens S7-1200 PLC	£350 (college covered)
Siemens KTP 700 Touch Screen HMI	£775.20 (college covered)
TIA Portal	£2000 (college license covered)
Analogue Simulator	£30 (college covered)
Mosfet Transistor and miscellaneous components	£50 (college covered)
Overall Cost	**£3205.20 (college covered)**

Table 10 - Final Solution costs

The table of costs for the final solution can be seen above which shows a breakdown of all the costs, however all of the costs are covered by the college as the materials were already bought and the licenses were free.

The circuit of the project can be seen below, showing the output from the PLC into the mosfet transistor which switches the pump.

Budget is realistic



Good driver cct

Figure 8 - Circuit diagram

Prototype 1 – Analogue Input

Prototyping was implemented so that the project design could be broken down into sections and then tested individually. The first prototype was the analogue input being programmed into TIA Portal.

The raw value was scaled in the function blocks from an integer into a real value. The real value was then scaled in the 'Scale_X' function block to provide a scaled value between 0-200mm for the program.

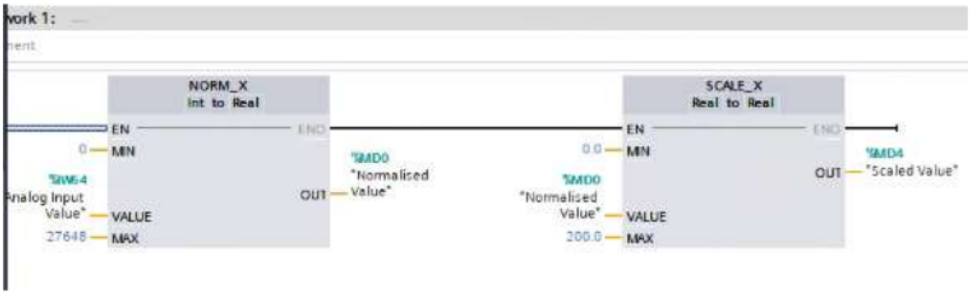


Figure 9 - Analogue Input Network

8	Analog Input Value	Int	%IW64	
9	Normalised Value	Real	%MD0	
10	Scaled Value	Real	%MD4	

Figure 10 - Analogue Input tag table

Good design of analogue input

Prototype 2 – SCL Conditioning

The SCL conditioning was used for the alarm levels and indication provided from the analogue input. This also controlled the speed of the pump, depending on the input from the scaled value function block. These can be seen below, where the value of the analogue input affects the number of alarms on.

```
IF ("Scaled Value" > 50) THEN
    "Alarm data".Alarm0 := 1;// Statement section IF
    "Alarm data".Alarm1 := 0;
    "Alarm data".Alarm2 := 0;
    "Alarm data".Alarm3 := 0;
    "Alarm data".Alarm4 := 0;
    "Alarm data".Alarm5 := 0;
    "Alarm data".Alarm6 := 0;
    "Motor Speed PWM" := 20;
END_IF;
IF ("Scaled Value" > 75) THEN
    "Alarm data".Alarm0 := 1;// Statement section IF
    "Alarm data".Alarm1 := 1;
    "Alarm data".Alarm2 := 0;
    "Alarm data".Alarm3 := 0;
    "Alarm data".Alarm4 := 0;
    "Alar%DB10".Alarm5 := 0;
    "Alarm data".Alarm6 := 0;
    "Motor Speed PWM" := 30;
END_IF;
```

Figure 11 - SCL Conditioning Alarm 0 & 1

```
IF ("Scaled Value" > 100) THEN
    "Alarm data".Alarm0 := 1;// Statement section IF
    "Alarm data".Alarm1 := 1;
    "Alarm data".Alarm2 := 1;
    "Alarm data".Alarm3 := 0;
    "Alarm data".Alarm4 := 0;
    "Alarm data".Alarm5 := 0;
    "Alarm data".Alarm6 := 0;
    "Motor Speed PWM" := 40;
END_IF;
IF ("Scaled Value" > 125) THEN
    "Alarm data".Alarm0 := 1;// Statement section IF
    "Alarm data".Alarm1 := 1;
    "Alarm data".Alarm2 := 1;
    "Alarm data".Alarm3 := 1;
    "Alarm data".Alarm4 := 0;
    "Alarm data".Alarm5 := 0;
    "Motor Speed PWM" := 50;
END_IF;
```

Figure 12 - SCL Conditioning Alarm 2 & 3

This is a good implementation of SCL to handle the conditioning for alarms.

```
IF ("Scaled Value" > 150) THEN
    "Alarm data".Alarm0 := 1;// Statement section IF
    "Alarm data".Alarm1 := 1;
    "Alarm data".Alarm2 := 1;
    "Alarm data".Alarm3 := 1;
    "Alarm data".Alarm4 := 1;
    "Alarm data".Alarm5 := 0;
    "Alarm data".Alarm6 := 0;
    "Motor Speed PWM" := 60;
END_IF;
IF ("Scaled Value" > 175) THEN
    "Alarm data".Alarm0 := 1;// Statement section IF
    "Alarm data".Alarm1 := 1;
    "Alarm data".Alarm2 := 1;
    "Alarm data".Alarm3 := 1;
    "Alarm data".Alarm4 := 1;
    "Alarm data".Alarm5 := 1;
    "Alarm data".Alarm6 := 0;
    "Motor Speed PWM" := 80;
END_IF;
```

Figure 13 - SCL Conditioning Alarm 4 & 5

```
IF ("Scaled Value" > 190) THEN
    "Alarm data".Alarm0 := 1;// Statement section IF
    "Alarm data".Alarm1 := 1;
    "Alarm data".Alarm2 := 1;
    "Alarm data".Alarm3 := 1;
    "Alarm data".Alarm4 := 1;
    "Alarm data".Alarm5 := 1;
    "Alarm data".Alarm6 := 1;
    "Motor Speed PWM" := 100;
END_IF;
IF ("Scaled Value" < 50) THEN
    "Alarm data".Alarm0 := 0;// Statement section IF
    "Alarm data".Alarm1 := 0;
    "Alarm data".Alarm2 := 0;
    "Alarm data".Alarm3 := 0;
    "Alarm data".Alarm4 := 0;
    "Alarm data".Alarm5 := 0;
    "Alarm data".Alarm6 := 0;
    "Motor Speed PWM" := 0;
END_IF;
```

Figure 14 - SCL Conditioning Alarm 6 and No Alarm

The tag table for this prototype is below.

		Static	
2		Alarm1	Bool
3		Alarm2	Bool
4		Alarm3	Bool
5		Alarm4	Bool
6		Alarm5	Bool
7		Alarm6	Bool
8		Alarm0	Bool

Good images to show implementation

Figure 15 - SCL Conditioning Tag Table

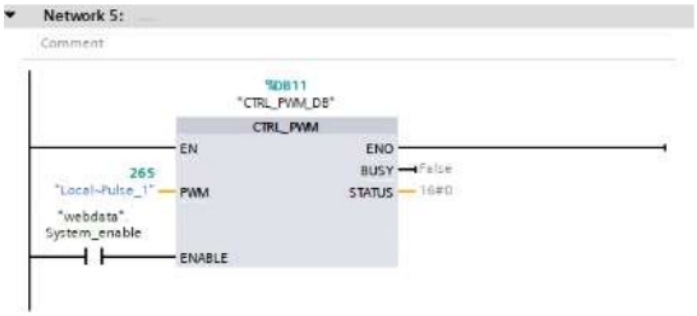
Prototype 3 – PWM Control

The PWM was used for controlling the speed of the motor by controlling the magnitude of the 'ON' waveform depending on the input into the 'QW1000' bit, which can be seen below in the tag table.

5		Motor Speed PWM	Word	%QW1000
6		Motor RUN	Bool	%I0.4
7		Motor PWM output	Bool	%Q1.1

Figure 16 - PWM tag table

The networks below show the function blocks for converting the value inputted from the analogue input into the '%QW1000' bit to drive the PWM output value. The 'move' function block in Figure 18 - Move Block for PWM is where the Motor Speed PWM is converted from a real value into a integer value for display purposes.



Good explanation with supporting images

Figure 17 - Control Block for PWM

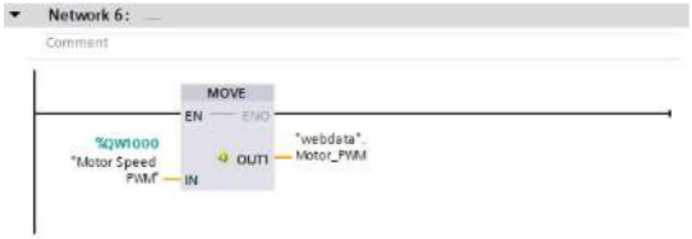


Figure 18 - Move Block for PWM

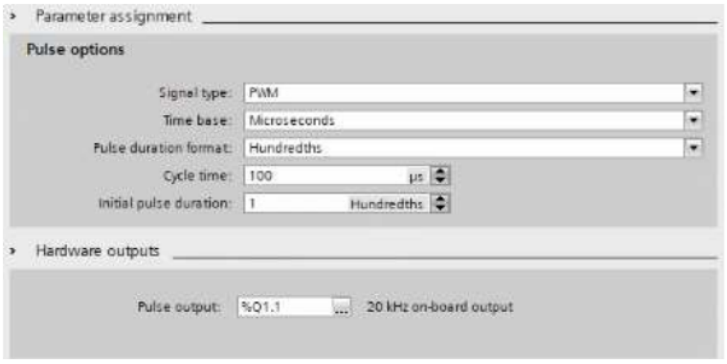


Image shows the configuration for the PWM pulse driver

Figure 19 - Configuration and parameter settings for PWM output



Good image showing the directory source for the PLC project

Figure 20 - PWM control block location

Prototype 4 – Final Program Implementation

The network rungs below show how the full program came together with the Analogue Input ladder program and SCL Alarm conditions program were implemented into the 'Main' network, as well as the PWM control.

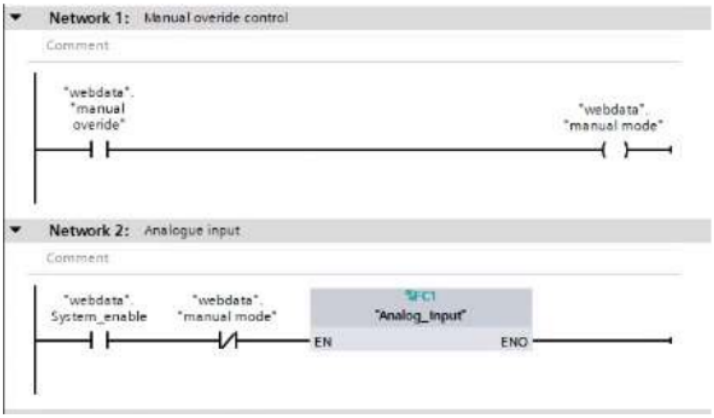


Figure 21 - Final Program Networks 1 & 2

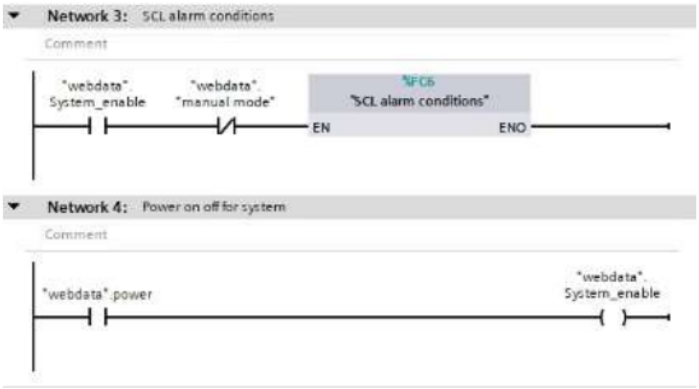


Figure 22 - Final Program Networks 3 & 4

Good image showing implementation

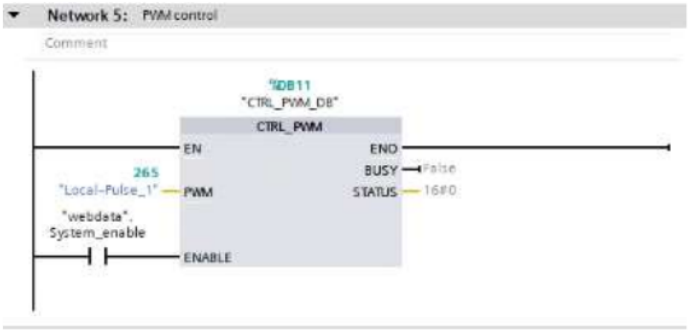


Figure 23 - Final Program Network 5

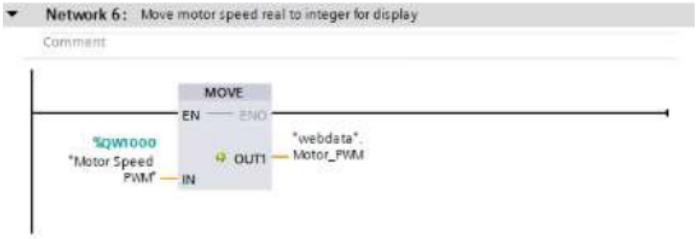


Figure 24 - Final Program Network 6

Prototype 5 – HMI Design and Implementation

The root screen can be seen below, which has a button to select the water level control screen.

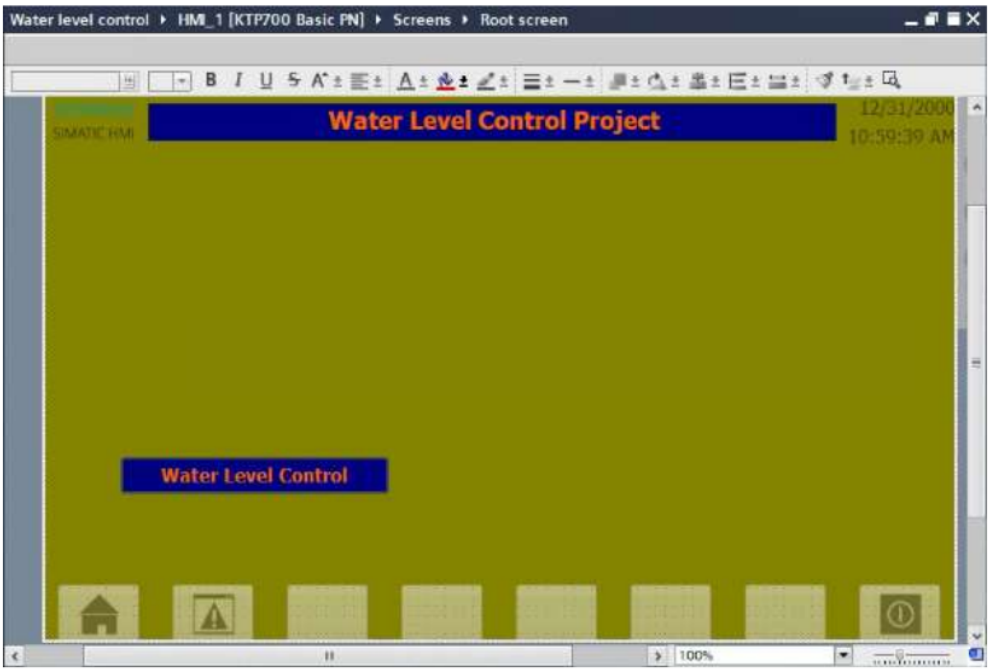


Figure 25 - HMI Root Screen

Good design of initial HMI page with link

The water level control screen can be seen below, which shows the graphical format of the water level, as well as alarm level indicators and pump speed indication. A pump status indicator light and 'power on/off' indicator is on the right-hand side too, with a manual selector switch in the top left providing manual control of the pump, where the speed setpoint can be set underneath the switch.

Good page layout design

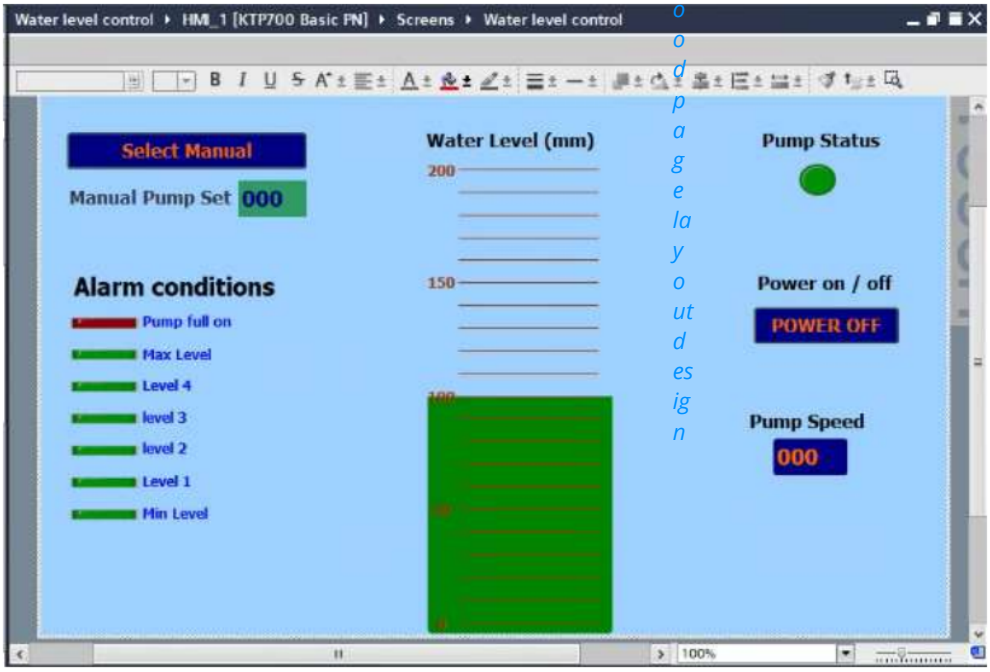
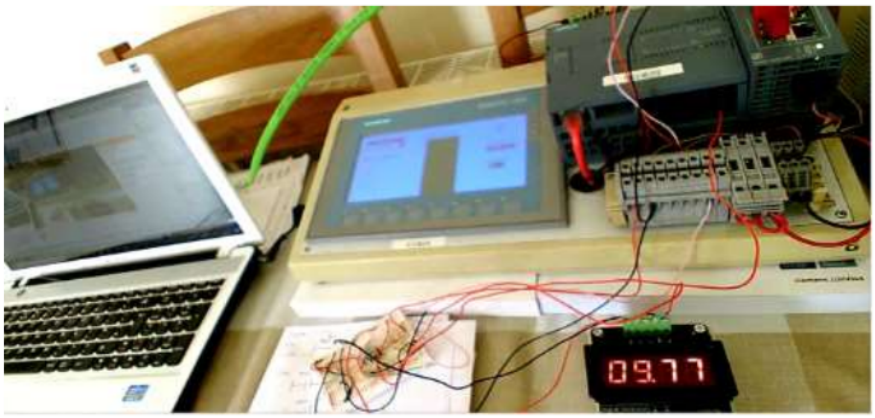


Figure 26 - Water Level Control HMI Screen



Good image of equipment setup

Figure 27 - System Setup

Operation of system

The operation of the control system is relatively straightforward. A HMI screen will be used for control of the system, where the automatic or manual sequence can be selected. The automatic system controls the speed of the pump depending on the raw value that is inputted from the analogue input, which is a signal generator of 0-10V. This is replicating the water level. Therefore, as the voltage rises, the water level is essentially rising. The relationship between water level and pump speed can be seen below.

Automatic Control

Water Level (mm)	Pump Speed (%)
<50	0
>50	20
>75	30
>100	40
>125	50
>150	60
>175	80
>190	100

Table 11 - Automatic Control pump speeds

Manual Control

Selection	Pump Operation
Manual ON	Pump will run to desired setpoint inputted manually.
Manual OFF	Pump will run in automatic control.

Table 12 - Manual Control pump operations

Very good use of table

6. Testing and results

Test	Description	Outcomes	Pass/Fail	Supporting Evidence
Simulate program software and HMI	Simulate program on TIA Portal, as well as HMI screen to ensure that there are no errors in program or download errors.	Program downloaded to the PLC and HMI without any errors.	Pass	Figure 29 - Download to PLC
Commissioning of wiring	Test configuration of wiring in relation to the circuit diagram.	Wiring was correct and system worked correctly.	Pass	Figure 27 - System Setup
Alarm levels of water level	Test increasing of water level to ensure alarm indication on HMI was correct.	Alarm levels made when analogue input reached the required states in relation to analogue input value.	Pass	See between Figure 30 - Analogue Input 0 and Figure 45 - Alarm levels at 9.97V
Speed response from increased level	Increase water level and observe the speed response of the pump.	Pump speed increased and alarm indication worked correctly as input increased.	Pass	See between Figure 47 - HMI 1st alarm set. Pump speed = 20% and Figure 53 - HMI 7th alarm set. Pump speed = 100%

Automatic/Manual interlock	Ensure that no manual control can be done whilst in 'Auto', and vice versa in 'Manual'.	Manual control disabled all auto control, and the graphical values and alarm indications didn't change with the manual control.	Pass	Figure 54 - HMI Manual override in operation

Table 13 - Testing Results

The testing procedure above satisfied the testing criteria and the project specifications, therefore it proved to be a successful project. The supporting evidence section provided the evidence of these tests satisfying the requirements with images of the tests being carried out.

Very good table of results

Very good explanation to overcome this issue with the Pico Scope

PWM Testing

Using a picoscope, the PWM duty cycle was tested to check the magnitude of the waves as the manual setpoint increased. The picoscope can only read 0-20V, and the power supply used is a 24V supply, therefore a voltage divider was used to reduce the voltage to 12V.

Setpoint	PWM magnitude	Pass/Fail	Supporting Evidence
20%	24%	Pass	Figure 56 - Manual setpoint set to 20%. Reading 24%
30%	32%	Pass	Figure 57 - Manual setpoint set to 30%. Reading 32%
40%	41.99%	Pass	Figure 58 - Manual setpoint set to 40%. Reading 41.99%
50%	51.4%	Pass	Figure 59 - Manual setpoint set to 50%. Reading 51.4%
60%	61%	Pass	Figure 51 - HMI 5th alarm set. Pump speed = 60%
80%	80.29%	Pass	Figure 52 - HMI 6th alarm set. Pump speed = 80%
100%	100%/12V	Pass	Figure 62 - Manual setpoint set to 100%. Reading 100% and 12V

Table 14 - PWM testing results

This test proved how the PWM was affected by the analogue input and the manual setpoints on the HMI to control the pump speed. The supporting evidence section provides proof with the images of the testing being carried out.

Good tab

7. Discussion, Conclusions and Recommendations

The project outcomes were met during this project as the PLC control system provided the solution with an efficient and automated control system, which was designed carefully with environmental conditions taken into consideration. This system proved to efficient and automatic as the tests carried out met the system requirements. The system provided several alarm levels to initiate the pump speed to increase/decrease with PWM control. The manual/automatic operation was achieved via the selector switch on the HMI and allowed the pump to be controlled manually which totally disabled the automatic system and the pump would spin at the desired setpoint set on the HMI, regardless of the water level. *Good point explained*

The system would require very minimal maintenance and the environmental issues were very limited as there would be no fumes or pollution created as a by-product of the pump running.

The project was an overall success due to the success of the construction, system development and the testing which was carried out on it. The testing proved that the system was working within its required parameters and would be a success at rectifying the industrial issue.

The budget was a key factor to consider for the selection of which solution would be the final one. This solution provided a very cost-effective solution as the college had all the costs covered already, as the materials and equipment were readily available. The budget set out was £4000 and the college covered all the materials costs, therefore the actual money which was spent was £0.

The time constraints were successfully met, as the Gantt chart on the following page proves. Certain aspects of the project ran over into further weeks than planned, however the final deadline was successfully met with the project constructed, programmed and tested successfully.

High levels of professionalism and ethical conduct was demonstrated throughout by following the college and university procedures, whilst ensuring that all my written work was my own without plagiarism or copyright.

Good conclusion

Final Gantt Chart

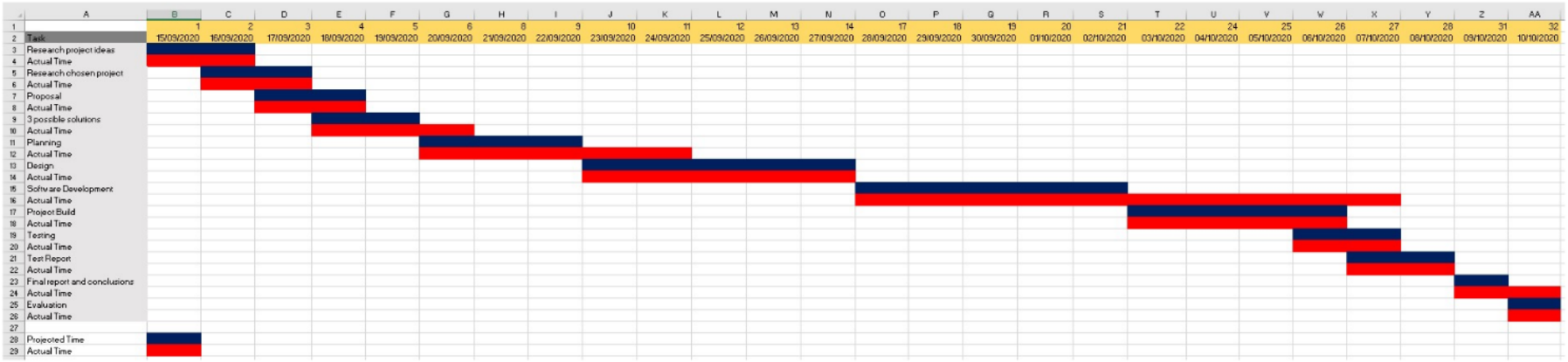


Figure 28 - Gantt Chart

A good realistic comparison Gantt chart

8. Reference list and Bibliography

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[Accessed 17 05 2021].

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[Accessed 17 05 2021].

Ramesh, G., 2020. *Project Hub.* [Online]
Available at: https://create.arduino.cc/projecthub/Ramesh_Dofbot/water-level-monitoring-33aa4c
[Accessed 17 05 2021].

Reasonable number of relevant sources

9. Appendix

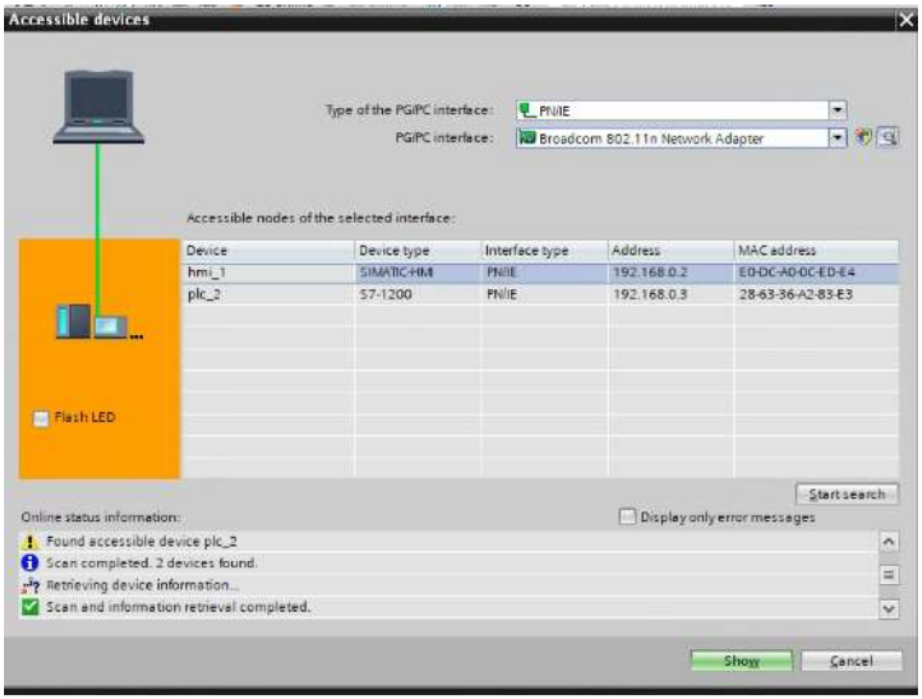


Figure 29 - Download to PLC



Figure 30 - Analogue Input 0

Good supporting images

Water level control ▸ PLC_2 [CPU 1214C DC/DC/DC] ▸ Watch and force tables ▸ Watch table_3

	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	0	
2	"Scaled Value"	%MD4	Floating-point nu...	0.0	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	FALSE	
5	"Alarm data".Alar...		Bool	FALSE	
6	"Alarm data".Alar...		Bool	FALSE	
7	"Alarm data".Alar...		Bool	FALSE	
8	"Alarm data".Alar...		Bool	FALSE	
9	"Alarm data".Alar...		Bool	FALSE	
10	"webdata".Motor...		DEC+/-	1	
11		<Add new>			

Figure 31 - Alarm levels at 0V

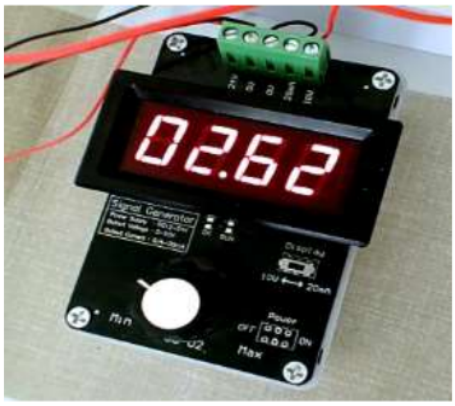


Figure 32 - Analogue Input at 2.62V

Water level control ▸ PLC_2 [CPU 1214C DC/DC/DC] ▸ Watch and force tables ▸ Watch table_3

	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	7167	
2	"Scaled Value"	%MD4	Floating-point nu...	51.84462	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	FALSE	
5	"Alarm data".Alar...		Bool	FALSE	
6	"Alarm data".Alar...		Bool	FALSE	
7	"Alarm data".Alar...		Bool	FALSE	
8	"Alarm data".Alar...		Bool	FALSE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	20	

Figure 33 - Alarm levels at 2.62V

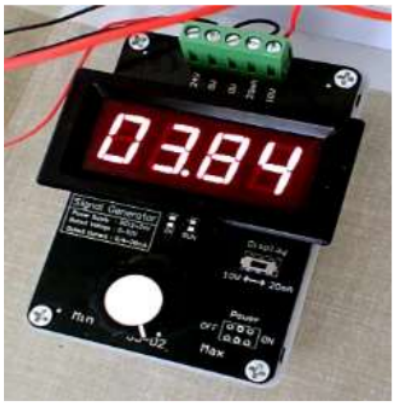


Figure 34 - Analogue input at 3.84V

Water level control ▸ PLC_2 [CPU 1214C DC/DC/DC] ▸ Watch and force tables ▸ Watch table_3

	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	10546	
2	"Scaled Value"	%MD4	Floating-point nu...	76.28761	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	FALSE	
5	"Alarm data".Alar...		Bool	FALSE	
6	"Alarm data".Alar...		Bool	FALSE	
7	"Alarm data".Alar...		Bool	FALSE	
8	"Alarm data".Alar...		Bool	TRUE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	30	

Figure 35 - Alarm levels at 3.84V

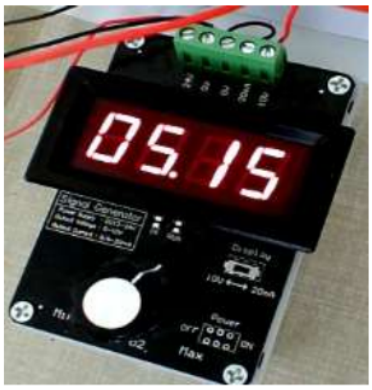
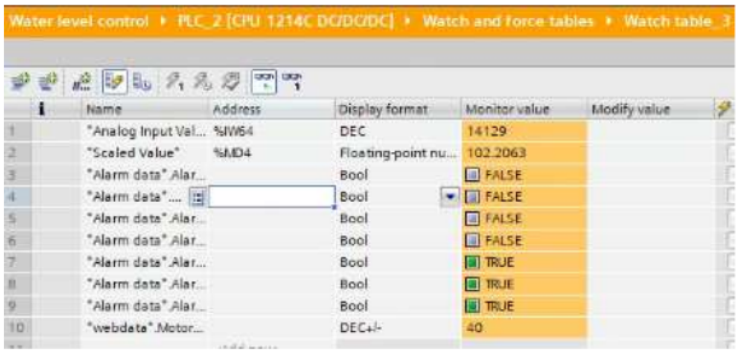


Figure 36 - Analogue input at 5.15V

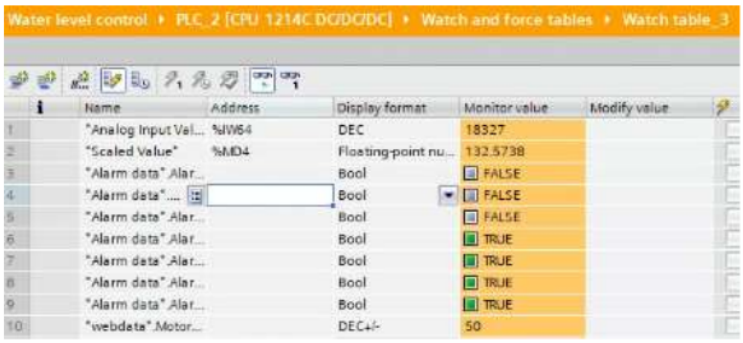


	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	14129	
2	"Scaled Value"	%MD4	Floating-point nu...	102.2063	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	FALSE	
5	"Alarm data".Alar...		Bool	FALSE	
6	"Alarm data".Alar...		Bool	FALSE	
7	"Alarm data".Alar...		Bool	TRUE	
8	"Alarm data".Alar...		Bool	TRUE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	40	

Figure 37 - Alarm levels at 5.15V



Figure 38 - Analogue input at 6.66V



	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	18327	
2	"Scaled Value"	%MD4	Floating-point nu...	132.5738	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	FALSE	
5	"Alarm data".Alar...		Bool	FALSE	
6	"Alarm data".Alar...		Bool	TRUE	
7	"Alarm data".Alar...		Bool	TRUE	
8	"Alarm data".Alar...		Bool	TRUE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	50	

Figure 39 - Alarm levels at 6.66V

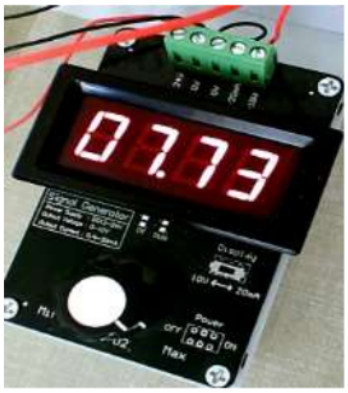


Figure 40 - Analogue input at 7.73V

Water level control ▸ PLC_2 [CPU 1214C DC/DC/DC] ▸ Watch and force tables ▸ Watch table_3

	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	21213	
2	"Scaled Value"	%MD4	Floating-point nu...	153.4505	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	FALSE	
5	"Alarm data".Alar...		Bool	TRUE	
6	"Alarm data".Alar...		Bool	TRUE	
7	"Alarm data".Alar...		Bool	TRUE	
8	"Alarm data".Alar...		Bool	TRUE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	60	

Figure 41 - Alarm levels at 7.73V



Figure 42 - Analogue input at 8.85V

Water level control ▸ PLC_2 [CPU 1214C DC/DC/DC] ▸ Watch and force tables ▸ Watch table_3

	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	24300	
2	"Scaled Value"	%MD4	Floating-point nu...	175.7813	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	TRUE	
5	"Alarm data".Alar...		Bool	TRUE	
6	"Alarm data".Alar...		Bool	TRUE	
7	"Alarm data".Alar...		Bool	TRUE	
8	"Alarm data".Alar...		Bool	TRUE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	80	

Figure 43 - Alarm levels at 8.85V



Figure 44 - Analogue input at 9.97V

Water level control ▸ PLC_2 [CPU 1214C DC/DC/DC] ▸ Watch and force tables ▸ Watch table_3

	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	27406	
2	"Scaled Value"	%MD4	Floating-point nu...	198.2494	
3	"Alarm data".Alar...		Bool	TRUE	
4	"Alarm data"....		Bool	TRUE	
5	"Alarm data".Alar...		Bool	TRUE	
6	"Alarm data".Alar...		Bool	TRUE	
7	"Alarm data".Alar...		Bool	TRUE	
8	"Alarm data".Alar...		Bool	TRUE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	100	

Figure 45 - Alarm levels at 9.97V

Good test results using watch table

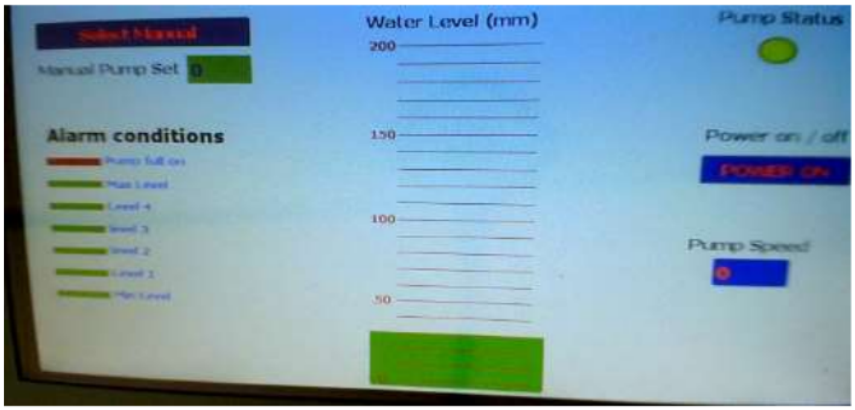


Figure 46 - HMI Power ON

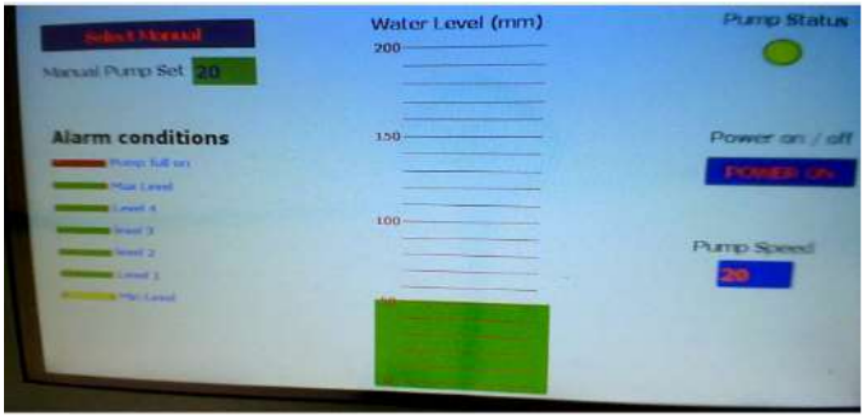


Figure 47 - HMI 1st alarm set. Pump speed = 20%

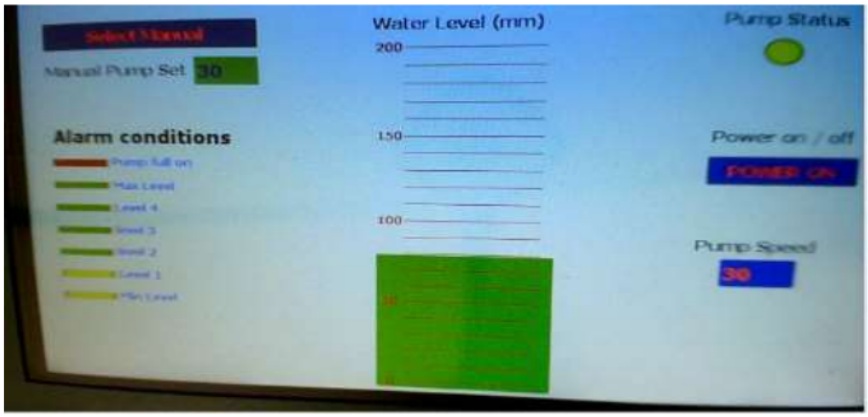


Figure 48 - HMI 2nd alarm set. Pump speed = 30%

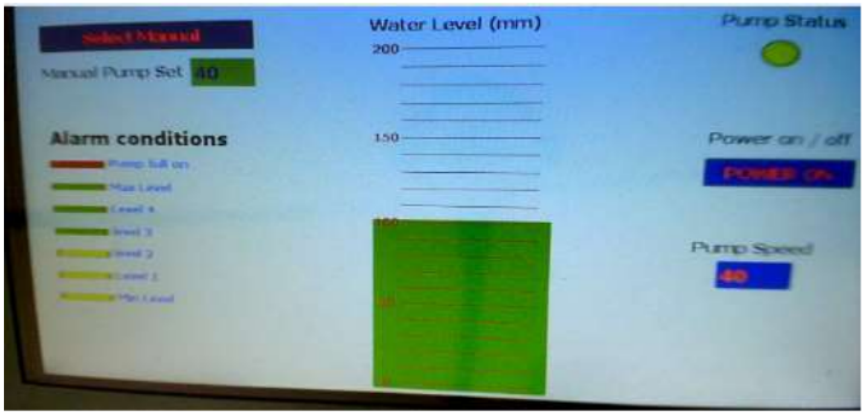


Figure 49 - HMI 3rd alarm set. Pump speed = 40%

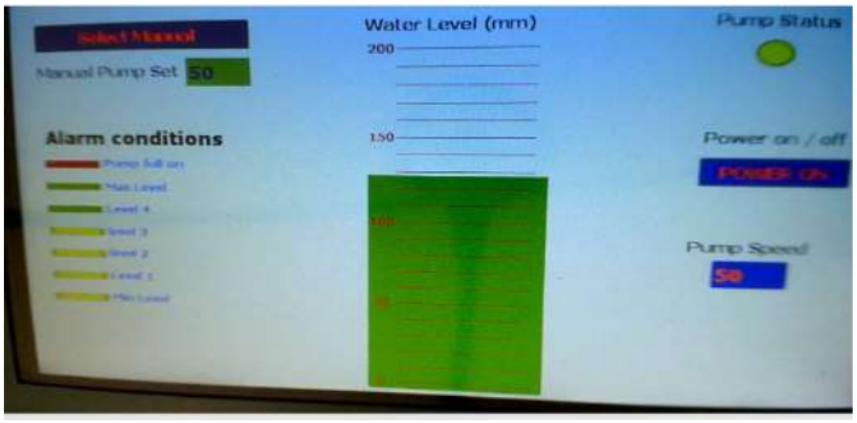


Figure 50 - HMI 4th alarm set. Pump speed = 50%

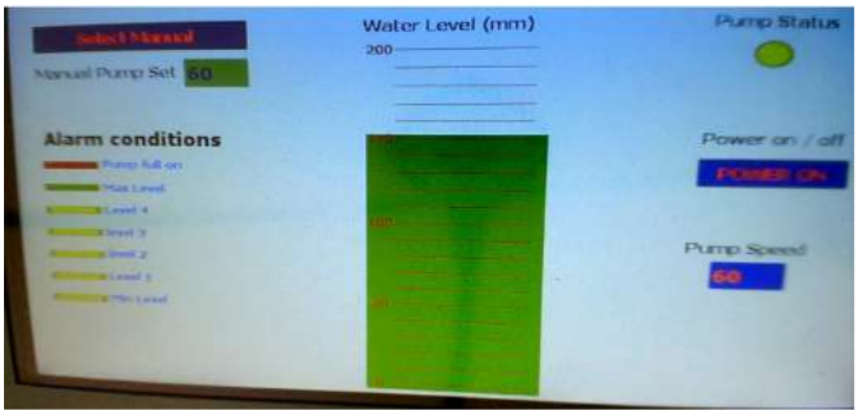


Figure 51 - HMI 5th alarm set. Pump speed = 60%

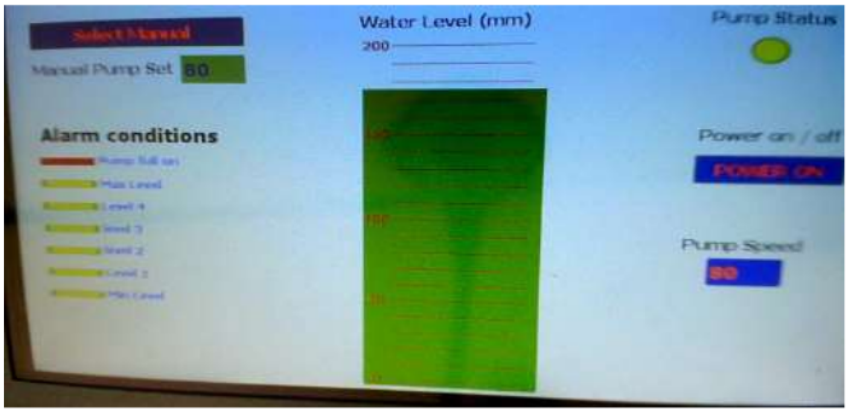


Figure 52 - HMI 6th alarm set. Pump speed = 80%

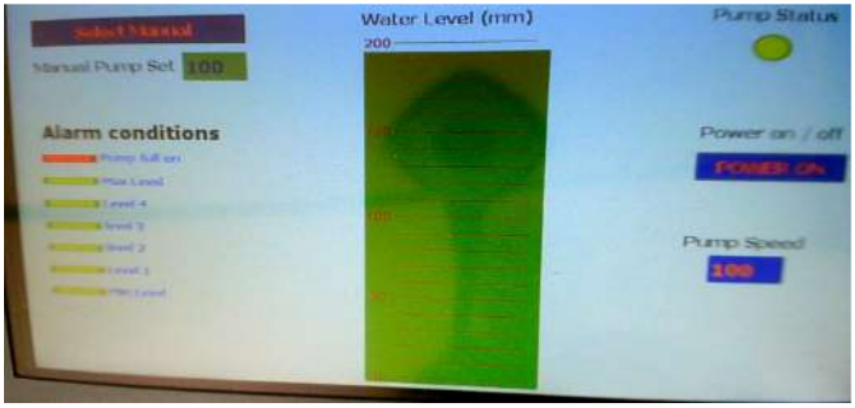


Figure 53 - HMI 7th alarm set. Pump speed = 100%

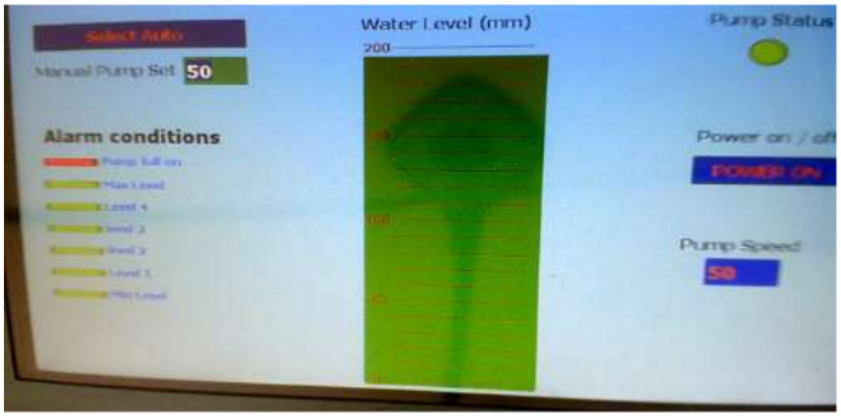


Figure 54 - HMI Manual override in operation

Good supporting images with all conditions tested

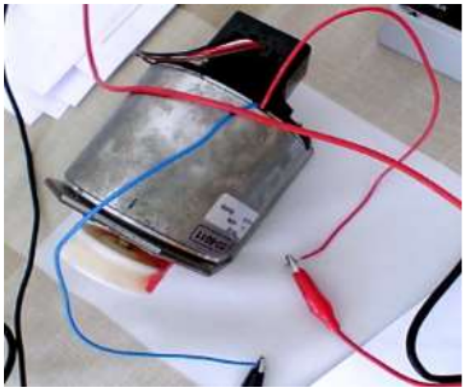


Figure 55 - Pump at 0%

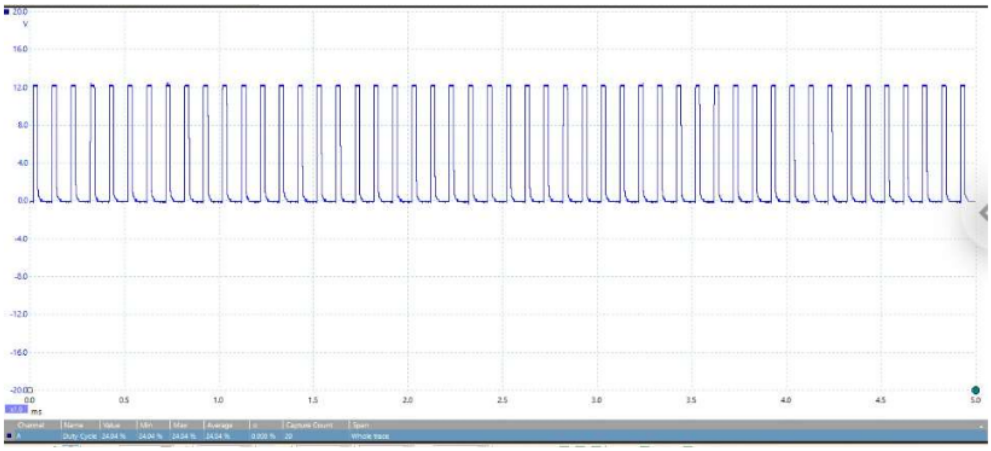


Figure 56 - Manual setpoint set to 20%. Reading 24%

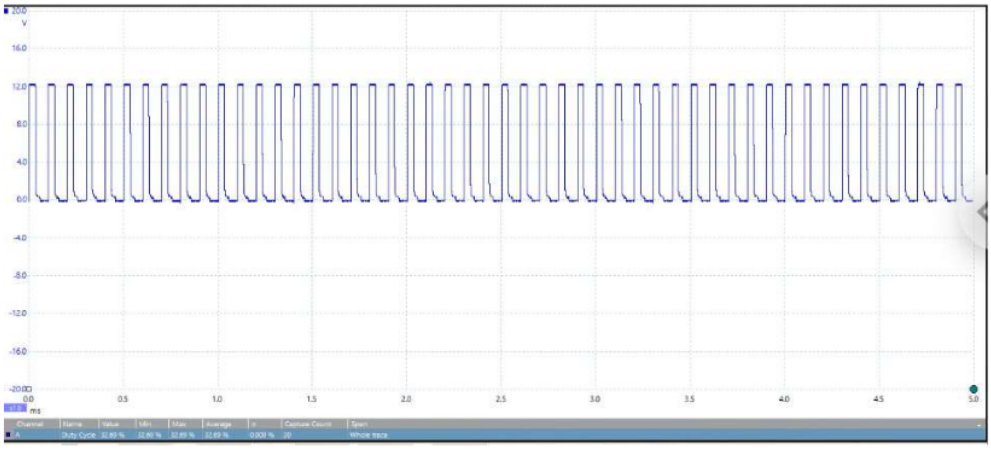


Figure 57 - Manual setpoint set to 30%. Reading 32%

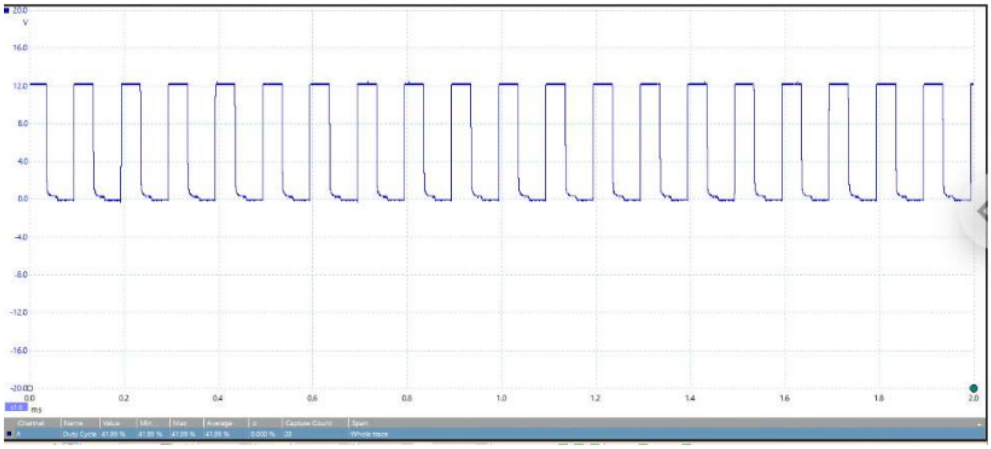


Figure 58 - Manual setpoint set to 40%. Reading 41.99%

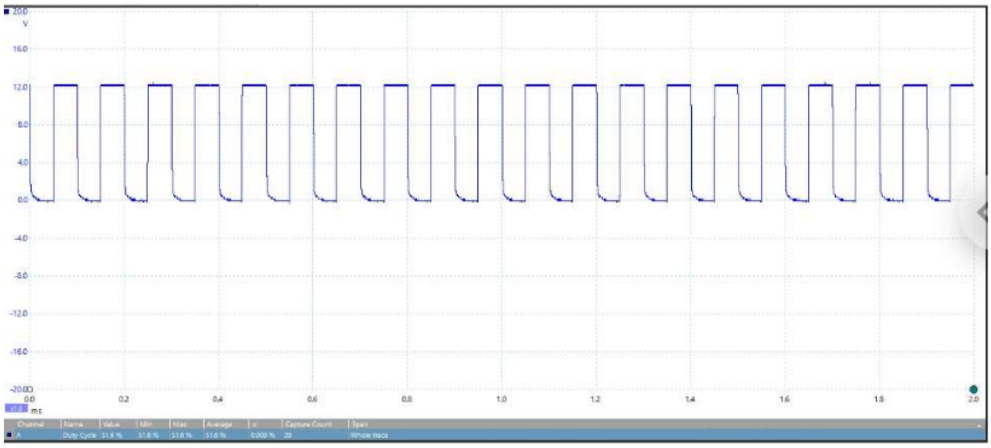


Figure 59 - Manual setpoint set to 50%. Reading 51.4%

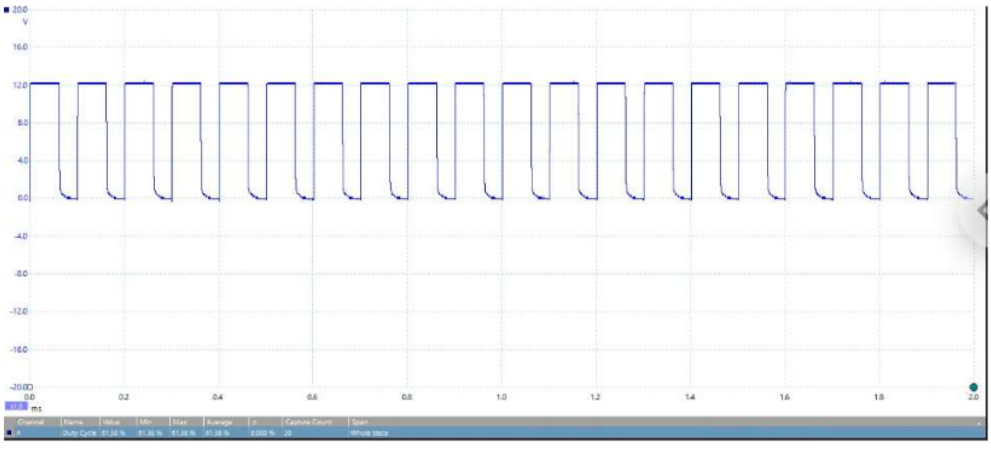


Figure 60 - Manual setpoint set to 60%. Reading 61%

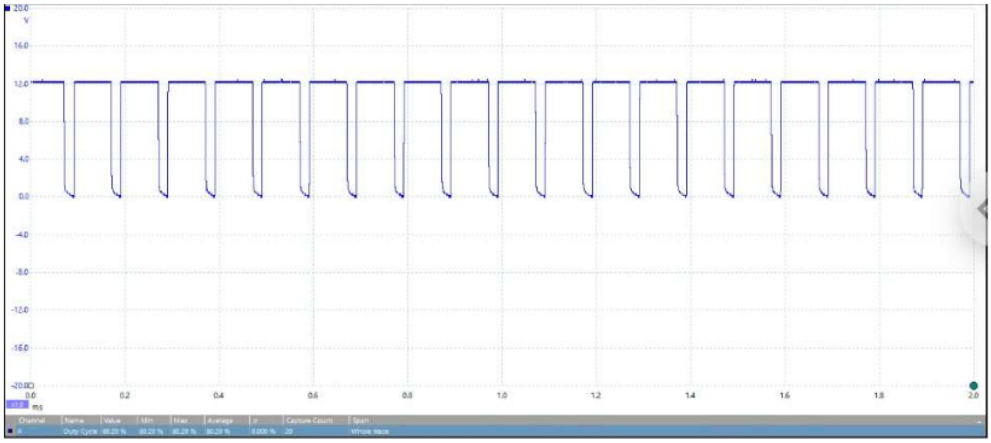


Figure 61 - Manual setpoint set to 80%. Reading 80.29%

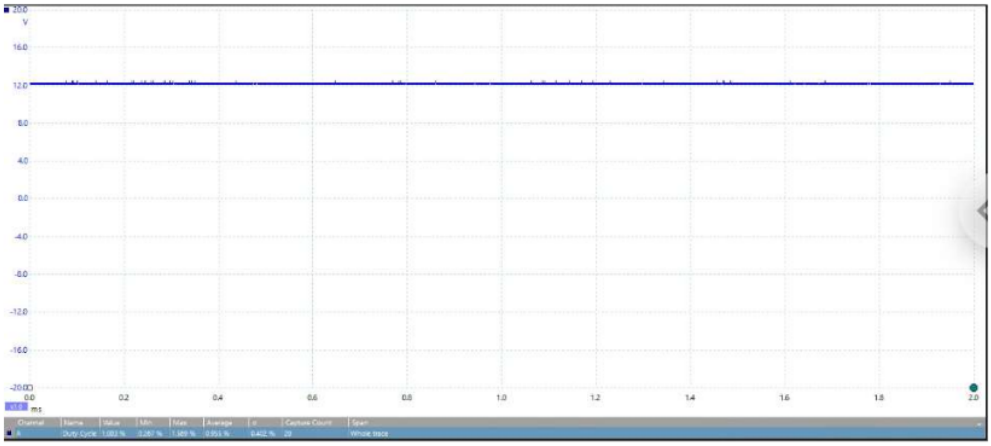


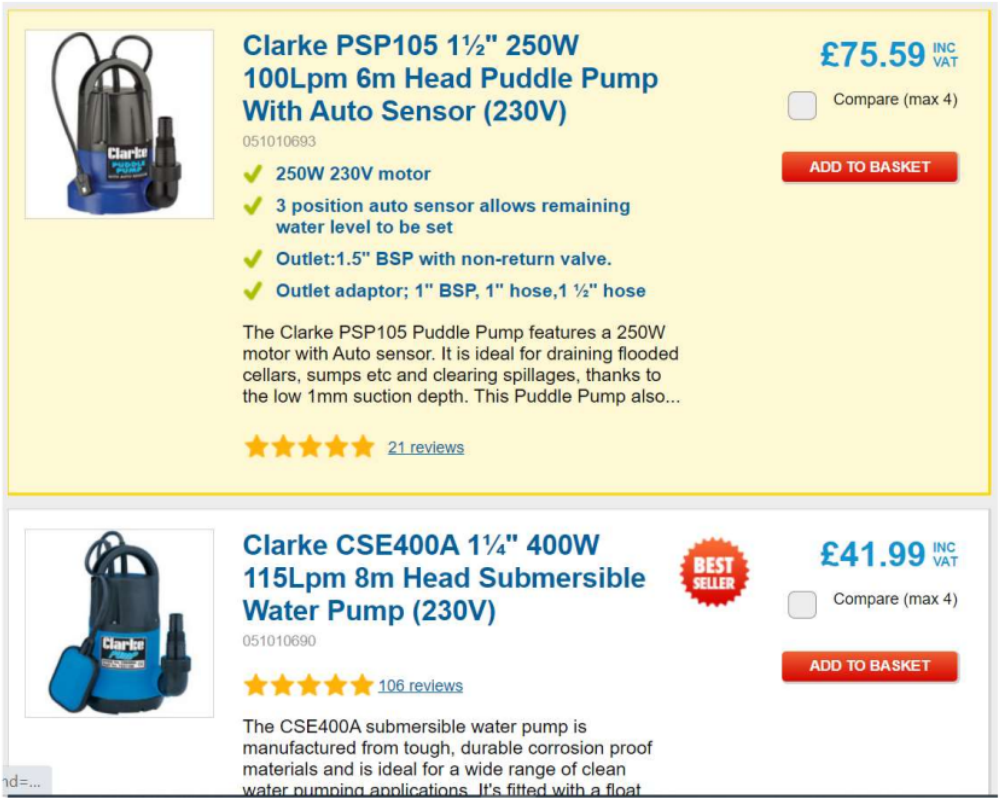
Figure 62 - Manual setpoint set to 100%. Reading 100% and 12V

Good Pico Scope results for duty cycle values

Log Sheet

11. Log No	1
No hrs	2
Running total hrs	2

Research into the potential project ideas for this subject this year during the class lesson. Looked into the various types of water pumps, control and automation systems and their compatibility with the application.



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Log Sheet

Log No	2
No hrs	4
Running total hrs	6

Research into Siemens PLC's and their applications.

https://realpars.com/s7-300-versus-s7-1500/

Wrote my project proposal, ready to start making decisions on the solutions for the project.

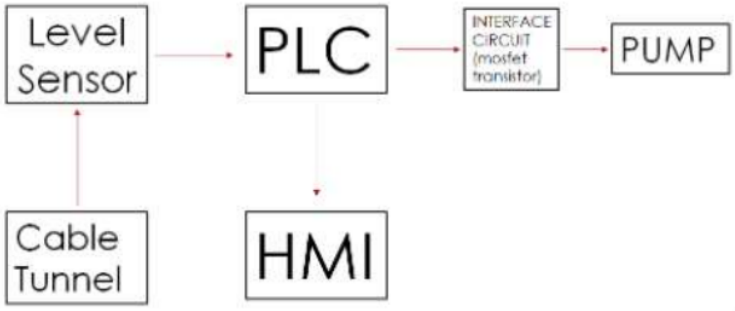
Project name - Cable Tunnel water pumping system

Where?

This project will be situated in the Energy Generation (Power Plant) department in Port Talbot TATA Steelworks. This project will be for one of the cable tunnels which floods heavily when it rains.

Why?

When it rains, the cable tunnels flood quickly, which requires the water to be pumped out whenever it comes to this situation. Currently, there is a diesel powered pump which is used for pumping the water out. However, this comes at a heavy cost as it needs to be refuelled often and it needs to be manually operated.



What?

There is going to be an electric submersible pump placed in the cable tunnel with level sensors and float switches to bring the pump on and off automatically when the water reaches a certain level. There shall be displays/indication on the panel which show the current level of water inside the tunnel.

How Much?

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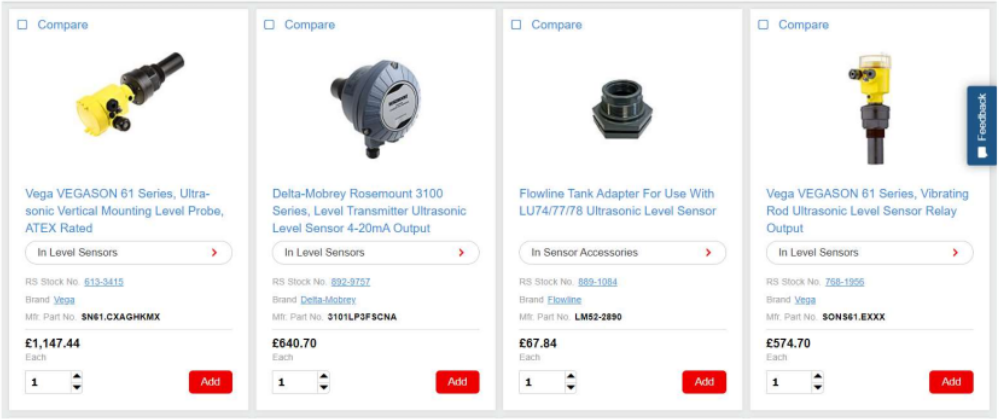
Log Sheet

Log No	3
No hrs	2
Running total hrs	8

Finalised my project proposal and started to investigate the different solutions to resolve the project problem.

Researching into different types of level measurement and what their advantages and disadvantages are.

Looked into ultrasonic level measurement on RS Online.



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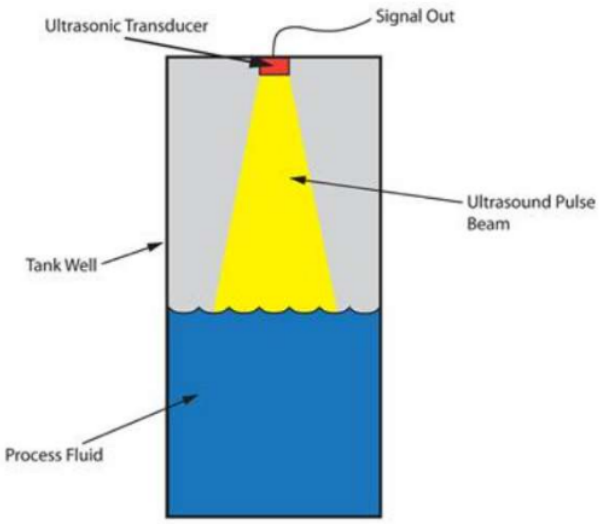
Log Sheet

Log No	4
No hrs	4
Running total hrs	12

Carried on with research into level measurement instruments and which one would be the most applicable for the solution.

Started to develop possible solutions for the project from further research into different ideas.

https://new.abb.com/products/measurement-products/level/a-dozen-ways-to-measure-fluid-level



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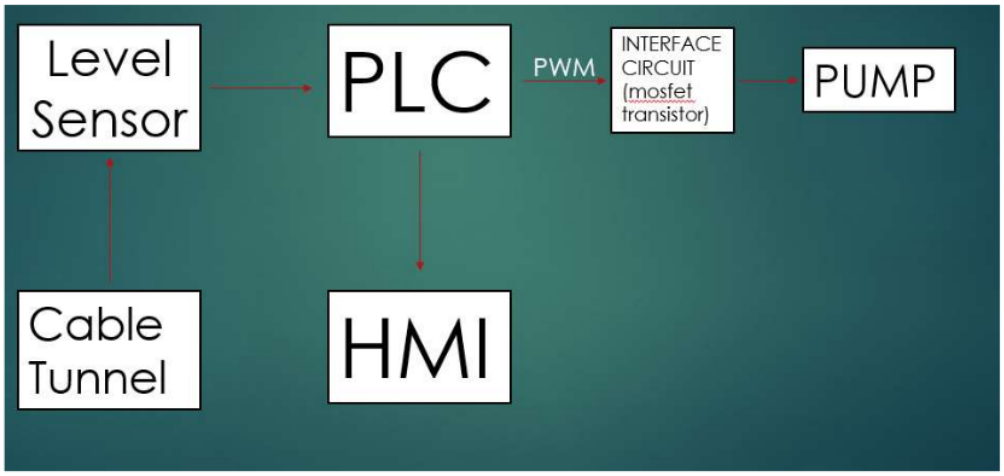
Log Sheet

Log No	5
No hrs	2
Running total hrs	14

Developed a block diagram for the process of the project control system for my presentation.

Looked into the pro's and con's of both solutions to pick a chosen solution.

Started to develop project presentation.



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Lecturer Signature	

Log Sheet

Log No	6
No hrs	2
Running total hrs	16

Carried on with project presentation development. This was investigating the project risks, budget and test plan.

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Lecturer Signature	

Log Sheet

Log No	7
No hrs	2
Running total hrs	18

Carried on with development of project presentation.



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Lecturer Signature	

Log Sheet

Log No	8
No hrs	4
Running total hrs	22

Research into analogue inputs on TIA portal.



Siemens TIA portal: how to use Analog input/output signals modules?

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Lecturer Signature	

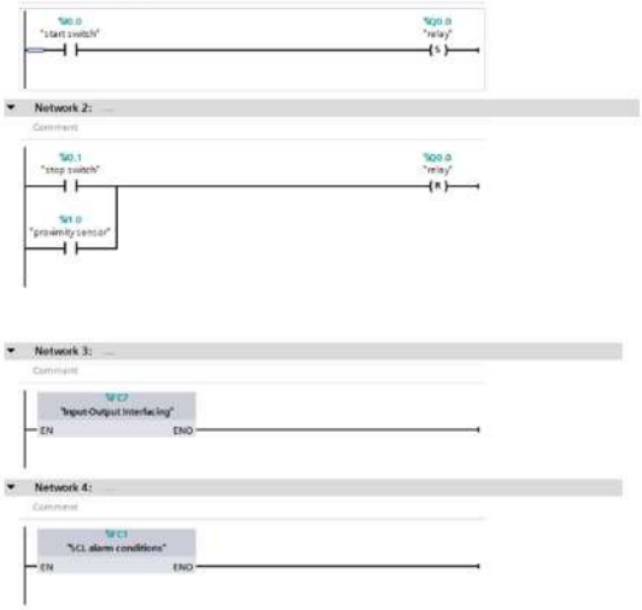
Log Sheet

Log No	9
No hrs	5
Running total hrs	27

Starting the analogue input programming on TIA Portal – prototype 1.

IP Address and subnet mask for PLC



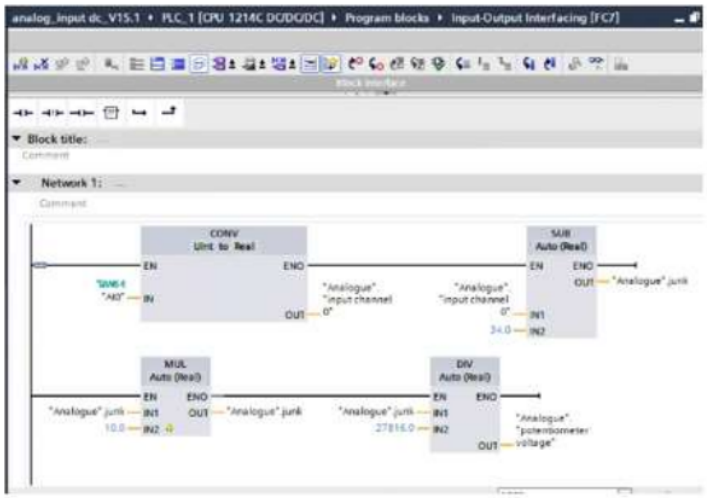


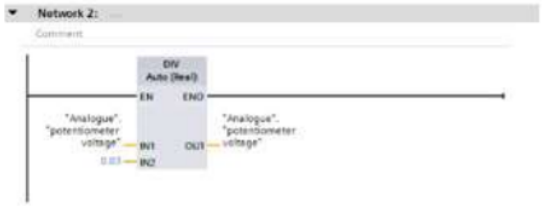
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Lecturer Signature	

Log Sheet

Log No	10
No hrs	5
Running total hrs	32

Carrying on with analogue input - prototype 1.





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Lecturer Signature	

Log Sheet

Log No	11
No hrs	4
Running total hrs	36

Carrying on with analogue input – prototype 1. SCL coding.

```
IF ("Analogue"."potentiometer voltage" > 30) THEN
    "Analogue".Alarm0 := 1;// Statement section IF
    "Analogue".Alarm1 := 0;
    "Analogue".Alarm2 := 0;
    "Analogue".Alarm3 := 0;
    "Analogue".Alarm4 := 0;
    "Analogue".Alarm5 := 0;
    "Analogue".Alarm6 := 0;
END_IF;
IF ("Analogue"."potentiometer voltage" > 50) THEN
    "Analogue".Alarm0 := 1;// Statement section IF
    "Analogue".Alarm1 := 1;
    "Analogue".Alarm2 := 0;
    "Analogue".Alarm3 := 0;
    "Analogue".Alarm4 := 0;
    "Analogue".Alarm5 := 0;
    "Analogue".Alarm6 := 0;
END_IF;

IF ("Analogue"."potentiometer voltage" > 150) THEN
    "Analogue".Alarm0 := 1;// Statement section IF
    "Analogue".Alarm1 := 1;
    "Analogue".Alarm2 := 1;
    "Analogue".Alarm3 := 1;
    "Analogue".Alarm4 := 0;
    "Analogue".Alarm5 := 0;
END_IF;
IF ("Analogue"."potentiometer voltage" > 170) THEN
    "Analogue".Alarm0 := 1;// Statement section IF
    "Analogue".Alarm1 := 1;
    "Analogue".Alarm2 := 1;
    "Analogue".Alarm3 := 1;
    "Analogue".Alarm4 := 1;
    "Analogue".Alarm5 := 0;
    "Analogue".Alarm6 := 0;
END_IF;
```

Student signature	MD
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	12
No hrs	5
Running total hrs	41

Carrying on with analogue input – prototype 1. SCL coding.

```
IF ("Analogue"."potentiometer voltage" > 190) THEN
    "Analogue".Alarm0 := 1;// Statement section IF
    "Analogue".Alarm1 := 1;
    "Analogue".Alarm2 := 1;
    "Analogue".Alarm3 := 1;
    "Analogue".Alarm4 := 1;
    "Analogue".Alarm5 := 1;
    "Analogue".Alarm6 := 0;
END_IF;
IF ("Analogue"."potentiometer voltage" > 220) THEN
    "Analogue".Alarm0 := 1;// Statement section IF
    "Analogue".Alarm1 := 1;
    "Analogue".Alarm2 := 1;
    "Analogue".Alarm3 := 1;
    "Analogue".Alarm4 := 1;
    "Analogue".Alarm5 := 1;
    "Analogue".Alarm6 := 1;
END_IF;

IF ("Analogue"."potentiometer voltage" < 30) THEN
    "Analogue".Alarm0 := 0;// Statement section IF
    "Analogue".Alarm1 := 0;
    "Analogue".Alarm2 := 0;
    "Analogue".Alarm3 := 0;
    "Analogue".Alarm4 := 0;
    "Analogue".Alarm5 := 0;
    "Analogue".Alarm6 := 0;
END_IF;

IF ("Analogue"."potentiometer voltage" > 100) THEN
    "Analogue".Alarm0 := 1;// Statement section IF
    "Analogue".Alarm1 := 1;
    "Analogue".Alarm2 := 1;
    "Analogue".Alarm3 := 0;
    "Analogue".Alarm4 := 0;
    "Analogue".Alarm5 := 0;
    "Analogue".Alarm6 := 0;
END_IF;
```

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Lecturer Signature	

Log Sheet

Log No	13
No hrs	4
Running total hrs	45

Prototype 2 – programming

Directory Tree:



Main Block:



The Power switch (%M0.0) has been implemented before the main input / output block.

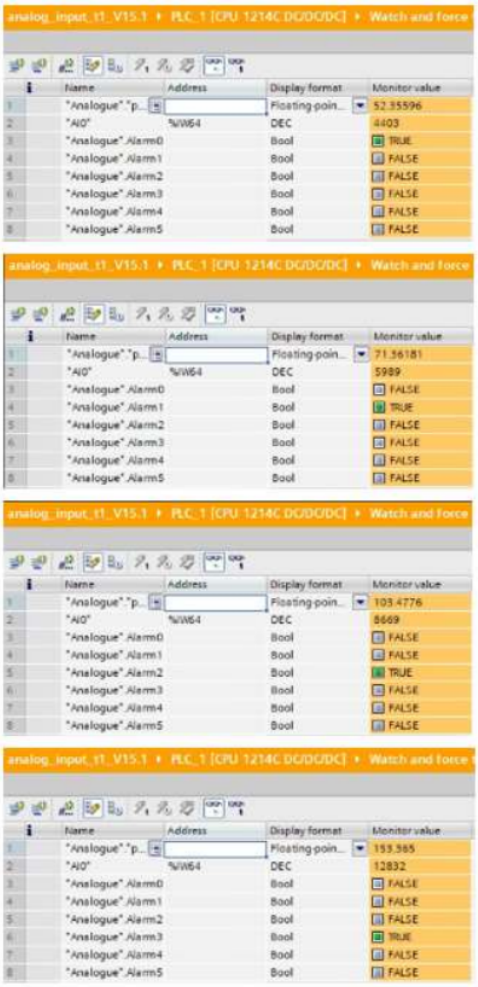


Student signature	MD
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Lecturer Signature	

Log Sheet

Log No	14
No hrs	5
Running total hrs	50

Prototype 2 – watch tables and alarm conditions. Used the potentiometer to simulate the water level to raise alarms.

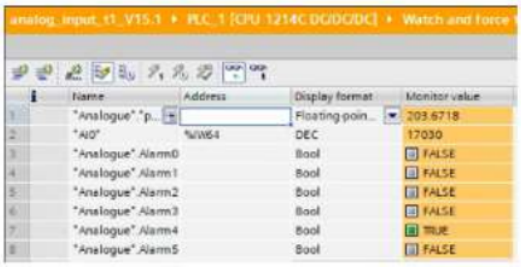


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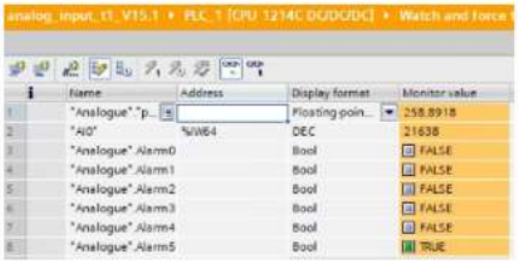
Log Sheet

Log No	15
No hrs	2
Running total hrs	52

Carrying on with prototype 2 – watchtable and alarm conditions.



	Name	Address	Display format	Monitor value
1	"Analogue"."p...		Floating poin...	203.6718
2	"AI0"	%IW64	DEC	17030
3	"Analogue".Alarm0		Bool	FALSE
4	"Analogue".Alarm1		Bool	FALSE
5	"Analogue".Alarm2		Bool	FALSE
6	"Analogue".Alarm3		Bool	FALSE
7	"Analogue".Alarm4		Bool	TRUE
8	"Analogue".Alarm5		Bool	FALSE



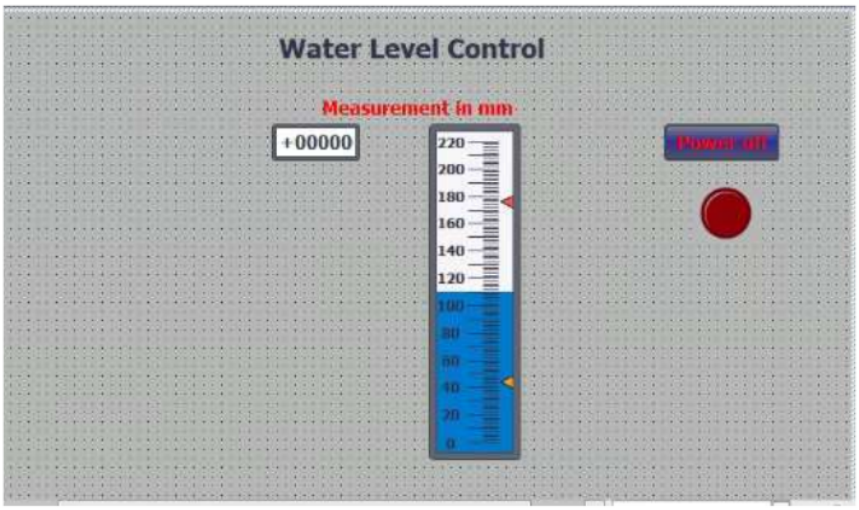
	Name	Address	Display format	Monitor value
1	"Analogue"."p...		Floating poin...	258.8918
2	"AI0"	%IW64	DEC	21638
3	"Analogue".Alarm0		Bool	FALSE
4	"Analogue".Alarm1		Bool	FALSE
5	"Analogue".Alarm2		Bool	FALSE
6	"Analogue".Alarm3		Bool	FALSE
7	"Analogue".Alarm4		Bool	FALSE
8	"Analogue".Alarm5		Bool	TRUE

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Log Sheet

Log No	16
No hrs	2
Running total hrs	54

Designing the HMI screens.



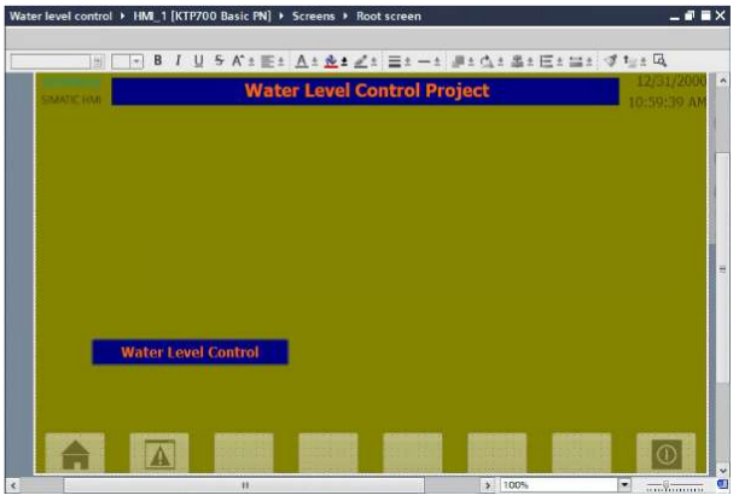


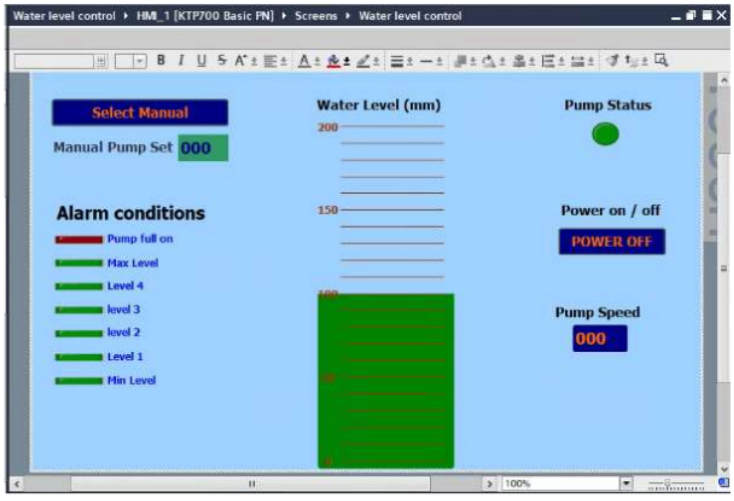
Student signature	MD
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	17
No hrs	6
Running total hrs	60

Making changes to HMI screens and relevant components tagged.



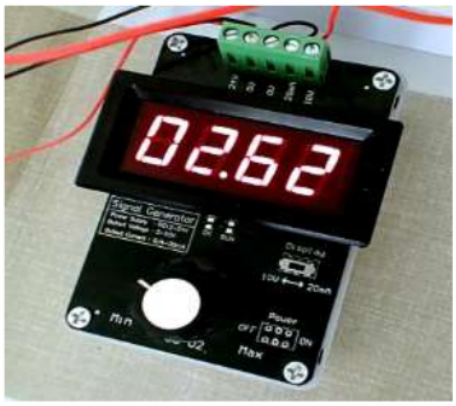


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Lecturer Signature	

Log Sheet

Log No	18
No hrs	5
Running total hrs	65

Testing analogue inputs with alarm levels raised.



Water level control ▸ PLC_2 [CPU 1214C DC/DC/DC] ▸ Watch and force tables ▸ Watch table_3

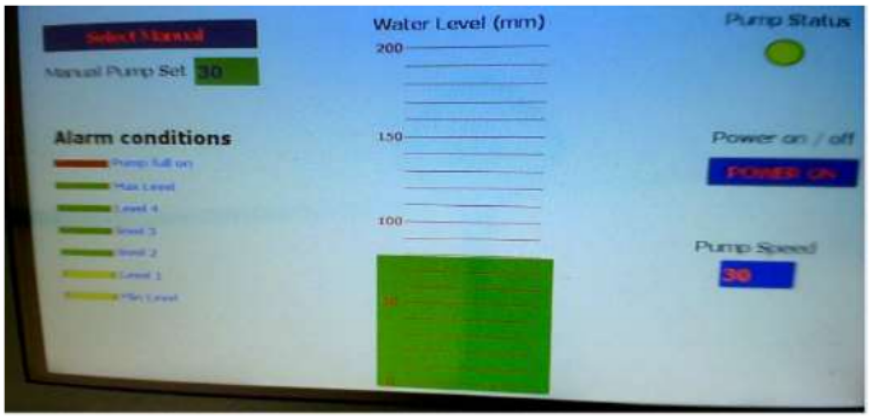
	Name	Address	Display format	Monitor value	Modify value
1	"Analog Input Val...	%IW64	DEC	7167	
2	"Scaled Value"	%MD4	Floating-point nu...	51.84462	
3	"Alarm data".Alar...		Bool	FALSE	
4	"Alarm data"....		Bool	FALSE	
5	"Alarm data".Alar...		Bool	FALSE	
6	"Alarm data".Alar...		Bool	FALSE	
7	"Alarm data".Alar...		Bool	FALSE	
8	"Alarm data".Alar...		Bool	FALSE	
9	"Alarm data".Alar...		Bool	TRUE	
10	"webdata".Motor...		DEC+/-	20	

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Lecturer Signature	

Log Sheet

Log No	19
No hrs	8
Running total hrs	73

Testing HMI for pump speed indication under different level conditions.

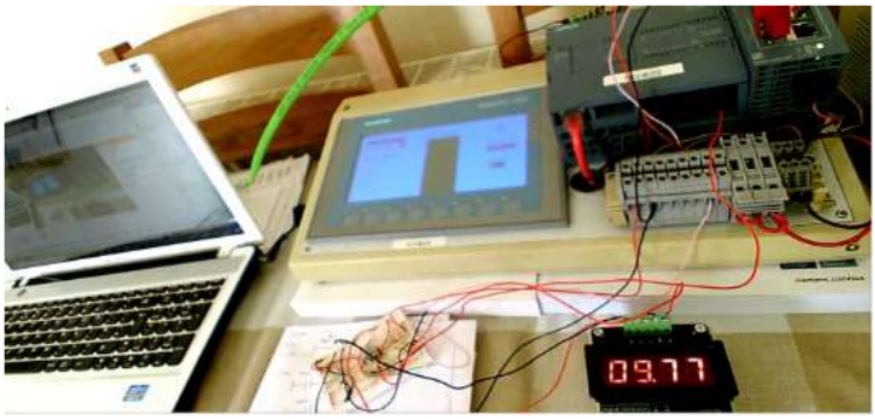


Student signature	MD
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Lecturer Signature	

Log Sheet

Log No	20
No hrs	7
Running total hrs	80

Constructing the project system circuit.

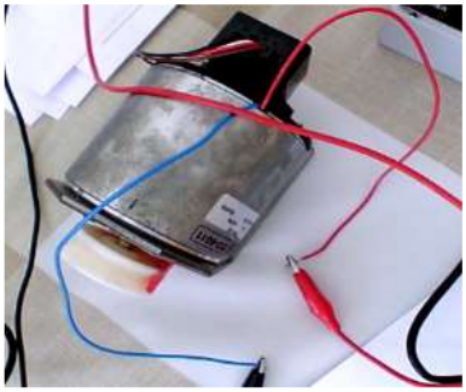


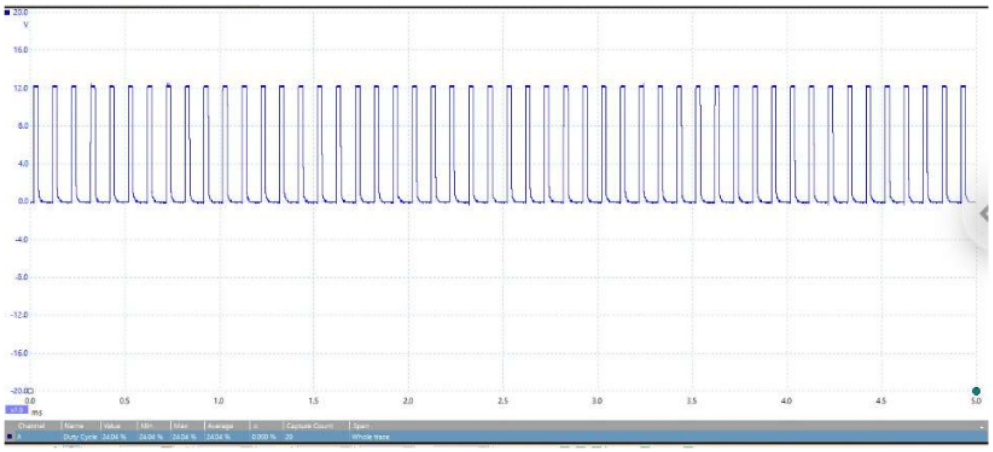
Student signature	MD
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	21
No hrs	5
Running total hrs	85

Testing the PWM output using a picoscope.





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Lecturer Signature	

Log Sheet

Log No	22
No hrs	10
Running total hrs	90

Project research into PLCs, Arduino and electrical control circuits for the written report.





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Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	23
No hrs	15
Running total hrs	105

Writing the full project report.

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A good level of detail in the log sheets and a realistic timeline

1909365

GRADEMARK REPORT

FINAL GRADE

72/100

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

Text Comment. Good table of contents with relevant level of detail

PAGE 3

PAGE 4

Text Comment. Appropriate list of figures

Text Comment. Good use of tables

PAGE 5

PAGE 6

Text Comment. Good explanation with a relevant source

Text Comment. This is a possible relevant solution

PAGE 7

Text Comment. A possibility associated with Ind 4.0

PAGE 8

Text Comment. Good explanation with relevant supporting ref source

PAGE 9

Text Comment. A good specification

PAGE 10

Text Comment. Good testing plan with relevant detail

PAGE 11

Text Comment. Good chart for expected initial timeline

PAGE 12

Text Comment. A fair argument for future proofing

PAGE 13

Text Comment. A good argument and evaluation for this solution

PAGE 14

Text Comment. The option for remote control is a good idea and very possible with this system.

PAGE 15

Text Comment. This system would be better off using PWM. The small signal can be handled by a signal MOSFET and this can be used to switch a power MOSFET to drive the pump.

Text Comment. This is not really a disadvantage

Text Comment. A fair argument for this system, but the small 5V signal is not a problem to drive a higher voltage and current pump.

PAGE 16

PAGE 17

Text Comment. This is usually a last resort option but more often it is the existing system that will be replaced by automation.

PAGE 18

Text Comment. A good table of comparison

PAGE 19

Text Comment. Good explanation but there should be a statement to explain the reason for choosing the PLC.

PAGE 20

Text Comment. Good use of block diagrams

Text Comment. Budget is realistic

PAGE 21

Text Comment. Good driver cct

Text Comment. Good design of analogue input using the NORMX and SCALEX function blocks

PAGE 22

Text Comment. This is a good implementation of SCL to handle the conditioning for alarms.

PAGE 23

Text Comment. Good images to show implementation

PAGE 24

Text Comment. Good explanation with supporting images

PAGE 25

Text Comment. Image shows the configuration for the PWM pulse driver

Text Comment. Good image showing the directory source for the PLC project

PAGE 26

Text Comment. Good image showing implementation

PAGE 27

PAGE 28

Text Comment. Good design of initial HMI page with link

PAGE 29

Text Comment. Good page layout design

Text Comment. Good image of equipment setup

PAGE 30

Text Comment. Very good use of tables for test analysis

PAGE 31

PAGE 32

Text Comment. Very good table of results

PAGE 33

Text Comment. Very good explanation to overcome this issue with the Pico Scope

Text Comment. Good table of results for duty cycle values and conditions

PAGE 34

Text Comment. Good point explained

Text Comment. Good conclusion

PAGE 35

Text Comment. A good realistic comparison Gantt chart

PAGE 36

Text Comment. Reasonable number of relevant sources

PAGE 37

Text Comment. Good supporting images

PAGE 38

PAGE 39

PAGE 40

PAGE 41

PAGE 42

Text Comment. Good test results using watch table

PAGE 43

PAGE 44

PAGE 45

Text Comment. Good supporting images with all conditions tested

PAGE 46

PAGE 47

PAGE 48

Text Comment. Good Pico Scope results for duty cycle values

PAGE 49

PAGE 50

PAGE 51

PAGE 52

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Text Comment. A good level of detail in the log sheets and a realistic timeline

GRADING FORM: CSG-RUBIC

MATTHEW DAVIES	**0**

RESEARCH-INFORMED LITERATURE

There is good evidence that research has been carried out and using a good number of relevant sources. More images should have been included to support the research. 6.5/10 The sources are listed and used in the text using correct method. 6.5/10

13/20

KNOWLEDGE AND UNDERSTANDING

Good specification with a good level of detail. The spec is in a logical sequence and clear. 7/10 Solutions considered are valid and explained in good clear detail. The justification of the chosen solution is not explained even though there is an evaluation. 7/10

14/20

ANALYSIS

Testing and results are clear and presented using a good method. Tables and images are included as evidence and a good test plan has been followed. 8/10 Conclusion covers all the significant points in the project. There could have been some recommendations made especially for Ind 4.0. 7/10

15/20

PRACTICAL APPLICATION AND DEP.

Good planning methods have been implemented and a comparison of the actual and predicted plan timeline is included and explained. 3.5/5 Solutions considered are valid for the project. 6.5/10 Implementation has been explained in good detail. Each section is identified clearly. Implementation follows a good sequence and a good set of logs which indicate a successful and logical sequence of tasks to complete the project. 8/10

18/25

SKILLS FOR PROFESSIONAL PRAC.

Quality of report is very good with a good supporting Appendix.

12/15