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Good list of figures

Aims and Objectives

Aim:

The aim of this project is to gain practical experience in the design, development, and evaluation of an automatic tank mixer system by applying engineering principles and demonstrating planning, implementation, and communication skills within professional and regulatory constraints.

Objectives:

- To define the engineering challenge associated with automating a tank mixing process, and to research potential technologies and methods for achieving consistent, efficient, and safe mixing.
- To select a suitable design solution for the automatic tank mixer, and to plan and organise its implementation within set time and budgetary constraints, while considering environmental sustainability, ethical implications, health and safety regulations, security, risk factors, and applicable engineering standards.
- To implement the selected tank mixer design with minimal supervision, ensuring that it meets performance, reliability, and maintenance requirements, and to manage the development process, including cost tracking and quality assurance.

- To assess the performance of the completed automatic tank mixer against the original specification and functional requirements.
- To clearly communicate the project's aims, design rationale, implementation process, and outcomes through a structured and formal engineering report.

Task 1 – Full report

Introduction and Background research

Automated substance mixing systems are widely used across various industrial sectors. This project was initiated to address the challenge of automating the process of dispensing and mixing two substances within a tank, as well as enabling this process to repeat continuously until manually cancelled or stopped. The motivation behind automation includes enhancing operational efficiency, ensuring process consistency, and improving workplace safety by reducing reliance on human operators in potentially hazardous environments.

The relevance of automated mixing systems to industry is significant. In sectors such as chemical manufacturing, food processing, water treatment, and pharmaceuticals, controlled mixing is a critical process that directly affects product quality and safety. While the solution developed in this project is relatively basic compared to advanced industrial systems, it serves as a conceptual prototype that reflects the core functionality of larger-scale automated mixing technologies.

MXD Direct. (2025). High Performance mixing solutions for every industry. [Online]. Mixer Direct Industrial Agitators. Last Updated: 2025. Available at: <https://www.mixerdirect.com/> [Accessed 12 May 2025].

Key characteristics of effective industrial mixing units include user-friendliness, operational efficiency, compliance with safety regulations, and the ability to integrate with larger automated systems. Modern mixers are often designed with modularity and scalability in mind, enabling future upgrades and connectivity with IoT-based monitoring or control platforms. These features are vital for supporting lean manufacturing, traceability, and process optimization in smart factory environments.

amixon. (2021). Mixing Technology. [Online]. amixon mixing technology. Available at: <https://www.amixon.com/en> [Accessed 12 May 2025].

To achieve automation, several control system options were considered. These included:

- **Programmable Logic Controllers (PLCs):** Known for their robustness and industrial reliability, PLCs are commonly used in factory automation due to their ability to handle complex logic and interface directly with industrial sensors and actuators.

- **Arduino microcontrollers:** Widely used in prototyping and low-cost automation, Arduino boards offer flexibility and ease of programming, making them suitable for *Good argument* small-scale applications and educational projects.
- **Dedicated circuit boards (custom logic circuits):** These provide hard-wired solutions for fixed operations, typically without the need for software programming. While offering speed and simplicity, they lack the flexibility of programmable systems. *Good point here*

Each method presents unique benefits and limitations in terms of cost, complexity, scalability, and programmability. The selection ultimately depends on the application requirements, environmental conditions, and desired level of user interaction. In this project, the choice was to use a PLC as the pros outweighed the cons, and it was clearly the most suitable choice.

Ladder world. (2023). PLC Architecture and Types: With Comparison Table. [Online]. Ladder world. Available at: <https://ladderlogicworld.com/plc-architecture/> [Accessed 12 May 2025].

N. Mughees. (2023). Pros and cons of building custom PCBs for Electronics projects. [Online]. Electronics 360. Last Updated: 23 May 2023. Available at: <https://electronics360.globalspec.com/article/19706/pros-and-cons-of-building-custom-pcbs-for-electr> [Accessed 12 May 2025].

Incorrect citation method

There is good useful information in this section. Harvard ref method must be used.

Specification

Process Overview

This project involves the development of an automated tank mixing system utilizing a Programmable Logic Controller (PLC), control valves, level sensors, a DC motor-driven mixer, and a Human-Machine Interface (HMI). The aim is to automate the sequential addition and mixing of two substances within a tank and to enable continuous operation until the process is manually stopped. *Good points*

The system is designed to dispense two different substances into a mixing tank through solenoid-controlled inlet valves. Each substance is added individually in a defined sequence.

The process is monitored by three level sensors:

- One for **Material 1**
- One for **Material 2**
- One to detect when the **tank is empty**

Good points

Once both materials reach their predefined levels, the mixing phase begins. A DC motor drives a paddle mixer, which is operated on a timer-controlled basis. The mixer runs for a set period to ensure thorough blending of the contents. *Good point*

Following the mixing phase, the outlet valve is opened to allow the mixed product to be discharged from the tank. The valve remains open either for a predetermined duration or until the tank empty level sensor confirms the contents have been fully drained. After this, the valve closes and the cycle resets. This process continues in a loop until cancelled or stopped via the HMI. *Good explanation to point out the automated process*

Control and Automation

A **PLC** is used as the central control unit to manage the timing, sequencing, and interlocking of system components. The integration of a PLC provides enhanced precision, flexibility, and reliability over manual or hard-wired systems. Key automated functions include: *Good point to make as PLC's are becoming the industry standard*

- Valve actuation for sequential substance input and output
- Mixer motor control via timer logic
- Monitoring of level sensors to govern sequence transitions *Good work here*
- Safety interlocks and condition indicators

The **HMI** serves as the user interface, offering real-time visual feedback on system operations including:

- Status of each valve
- Mixer operation
- Sensor readings *Good points for HMI function*
- Timer countdowns
- Alarms and warnings

Operators can use the HMI to initiate or cancel the process, adjust timing parameters, and monitor system health. *Good spec*

Programming and Code Validation

The PLC programming was carried out externally, away from the physical hardware. This approach was taken to eliminate the risk of unintentional code uploads or system interference during development. To ensure functional reliability and safety compliance, the *Good argument*

final control logic underwent peer review for validation and error detection prior to deployment.

Installation and Safety Compliance

The system was installed in strict adherence to relevant UK electrical and industrial safety regulations, including:

- **Electricity at Work Regulations 1989** (HSE, 2015)
- **Health and Safety at Work etc. Act 1974** (UK GOV, 2021) *Good thinking to mention this*

In addition, all installation procedures complied with college-specific safety standards.

Risk assessments were completed prior to any physical work being undertaken. Adequate safety interlocks were implemented to prevent potential hazards such as unintended motor activation, overfilling, or leakage. All wiring and component installation followed proper engineering practices and were reviewed for compliance and safety.

This would be better suited in research section

Industry 4.0 and Future Integration

While the system is educational in scale, it has been designed with Industry 4.0 compatibility in mind (I-Scoop, 2021). The modular architecture supports potential future upgrades, such as:

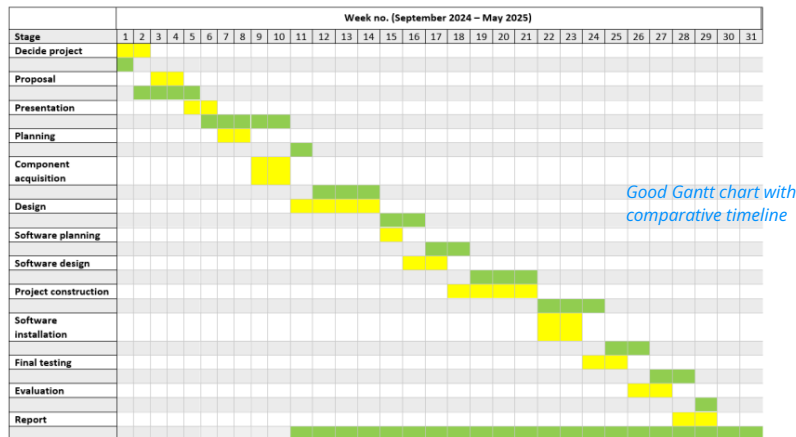
- Data logging and analytics
- Networked monitoring *This is a good requirement feature to add to the spec as it would be difficult to add the functions for this if the wrong controller is chosen.*
- Remote control and diagnostics

This ensures the system is scalable and suitable for integration into more complex industrial automation environments.

Environmental and Sustainability Considerations

To support sustainable operation, materials were used only as required, minimizing waste. Any waste generated was disposed of properly using the appropriate receptacles according to environmental regulations and institutional guidelines. These practices reflect an environmentally conscious approach and align with best practices in sustainable engineering. *Good points*

Planning



Good Gantt chart with comparative timeline

Figure 1 - Gantt chart showing the expected timeline vs the actual timeline of the project

The diagram above shows that the project was originally planned with evenly spaced development phases. However, as work progressed, the project gradually started to fall behind schedule.

The system will be developed using well-established methods typically applied in PLC systems. Once development is complete, a full functional test will be carried out. Each stage of the process will be tested and results carefully recorded.

To evaluate how well the final system meets the expected criteria, a test table has been prepared (see below). This will help compare actual performance with what was planned, using a simple pass/fail system. Fault conditions will also be simulated to test the system's limits and make sure all indicators respond as expected.

There are relevant points made

More explanations with reasons for discrepancies in the timeline should be included

Test No	Sequence Description	Expected Result	Indicator Status	Pass / Fail
1	Start			
2	Outlet valve open			
3	5s delay			
4	Outlet valve closed			
5	Inlet valve 1 open			
6	Inlet valve 1 closed at sensor 1 level detection			
7	Inlet valve 2 open			
8	Inlet valve 2 closed at sensor 2 level detection			
9	Stirrer motor after activated			
10	Timer times out			
11	Outlet valve opens			
12	Timer valve opens			
13	Timer delay 5s			
14	Outlet valve closed			
15	Process repeats			
16	Start / stop pushbuttons			

Good test plan that saves time further along the development process

Figure 2 - Example test table to display the test results in a simpler form

Solutions Considered

Solution 1 – PLC (Chosen solution)

A Programmable Logic Controller (PLC) is a type of industrial computer designed specifically for controlling and monitoring machinery and processes. PLCs are widely used in automation because they're reliable, flexible, and built to handle demanding environments.

They can manage many different types of input and output signals, which means they're suitable for a wide range of tasks—from reading data from sensors to controlling motors, lights, or valves. This makes them an excellent fit for everything from small standalone systems to large, complex industrial setups.

Easy to Integrate and Expand

One of the major strengths of PLCs is how easily they can integrate with other systems. Most PLCs are designed to work smoothly with Human-Machine Interfaces (HMIs), SCADA systems, and additional modules that can expand the PLC's capabilities. This modular approach allows engineers to add more features—like motion control, extra I/O, or advanced communication options—without redesigning the entire system.

This flexibility makes PLCs a solid long-term investment. Whether the system needs to stay small or scale up later, PLCs are designed to grow with it.

Software and Compatibility

Programming a PLC requires manufacturer-specific software, which can sometimes be expensive. The software also comes with its own learning curve, especially for those new to PLC programming. Different PLC brands use different programming tools and languages, such as Ladder Logic or Structured Text, which can affect how quickly someone can get up to speed. *This is a good point that must be considered if the timeline is too narrow*

Another thing to watch out for is compatibility. Mixing equipment from different manufacturers can lead to communication issues or reduced functionality, especially if firmware versions or software tools aren't aligned. So, careful planning is needed when combining components from different brands. *Good point*

Popular PLC Brands

There are three main PLC manufacturers that are commonly used:

- **Siemens** – Known for their S7 range and the TIA Portal software. Siemens PLCs are powerful, widely supported, and used a lot in Europe and large-scale industrial settings.
- **Mitsubishi** – Offers compact, reliable, and cost-effective PLCs. Their GX Works software is easy to use and is a popular choice for small to medium-sized automation projects.
- **Alspa** – Often found in more specialized or legacy systems, especially in energy and process-related industries. Depending on the context, Alspa systems may be tied to GE or Schneider Electric. *Good options given*

Choosing the right brand depends on your budget, project requirements, and existing equipment. It also helps to consider which platforms your team is already familiar with.

Mohsin Ali Koondhar. (2023). The role of PLC in automation, industry, and education purpose: A review. [Online]. ResearchGate. Last Updated: 31 December 2023. Available at: https://www.researchgate.net/publication/379937523_The_Role_of_PLC_in_Automation_Industry_and_Educat [Accessed 12 May 2025]. *Incorrect citation method*

Summary: Pros and Cons

Advantages	Challenges
Very reliable in industrial settings	Software can be expensive and brand-specific

Easy to update or modify as needs change	Requires training and experience to program effectively
Can expand and scale over time	Mixing brands can cause compatibility problems
Designed for integration with other tools	Initial setup can be costly depending on the system

Good table for evaluation

In summary, PLCs offer a strong and dependable solution for automation. They're built for tough environments, can be tailored to specific needs, and are designed to work well with other automation tools. While there are some upfront costs and learning involved, the long-term benefits, especially in terms of performance and flexibility is what makes them a smart choice for many control system projects.

Good argument for this solution

Images to support content could be included

Solution 2 - Arduino board

Arduino is a popular open-source platform that combines simple hardware and software to make building control systems more accessible. It's widely used for learning, prototyping, and smaller automation tasks thanks to its low cost and ease of use.

One of the biggest advantages of using an Arduino is how customizable it is. There's a wide range of compatible sensors, modules, and libraries available, and the open-source community around Arduino is large and active—making it easy to find support or ready-made solutions. Whether you're tweaking the code or adding hardware, Arduino is very flexible.

However, as the demands of a project grow, Arduino can start to show its limits. It works well for simple systems, but it can struggle with more complex tasks, especially those that require real-time performance or smooth integration with Human-Machine Interfaces (HMI's).

Connecting an HMI to an Arduino is possible, but it often involves extra components and a lot more programming effort.

Another thing to consider is durability. Arduino boards aren't built for tough industrial environments, so they may need extra protection or support hardware to stay reliable in more demanding settings.

Dejan. (2015). Ultrasonic Sensor HC-SR04 and Arduino – Complete Guide. [Online]. How to Mechatronics. Last Updated: July 15, 2020. Available at: <https://howtomechatronics.com/tutorials/arduino/ultrasonic-sensor-hc-sr04/> [Accessed 12 May 2025].

Summary: Pros and Cons

Pros	Cons

Very affordable	Not ideal for complex or time-sensitive tasks
Highly customizable and flexible	HMI integration can be challenging
Great community support and resources	Hardware is fragile compared to industrial controllers

In summary, Arduino is a great option for smaller or simpler automation systems, especially when keeping costs low is a priority. It's best suited for educational projects, prototypes, or low-risk environments. For more advanced or industrial-grade systems, a more robust solution like a PLC may be a better fit.

Solution 3 - Relays and timers

Another option for controlling the automated mixing system is a custom-built circuit board that uses relays and timers. This is a straightforward, hardware-only approach where specific components are wired together to carry out a single task—no software or programming is needed.

One of the biggest advantages of this method is that it's designed specifically for the job at hand. Because it's purpose-built, it should perform its task reliably and efficiently. Maintenance is also simple and inexpensive since the individual components, like relays and timers, are easy to find and replace.

However, there are a few downsides. This type of system isn't very flexible—if the process needs to change later on, you might need to redesign or replace the entire board. Even though the parts are cheap, the total cost can add up when you factor in custom design and assembly. And from an environmental point of view, replacing the whole board in the event of a failure isn't ideal, especially when more modular or upgradable solutions are available.

Engineering solutions. (2020). What Is Your Control Complexity? Do You Need a PLC or Electrical Relay/Timer?. [Online]. AIC. Available at: <https://aic-controls.com/relays-applied-industrial-controls/> [Accessed 12 May 2025].

Summary: Pros and Cons

Pros	Cons
Built specifically for the task	Not easily adaptable to future changes
No software or programming required	Total cost can be high despite low-cost components

Low maintenance and simple operation	Full replacement often needed if something fails
Reliable once installed	Generates more waste compared to modular systems

In summary, a relay and timer-based circuit board can be a solid, dependable solution for a simple, unchanging task. But if flexibility, future upgrades, or sustainability are important, it may not be the best long-term choice.

Critical choice

Below is a table made to better compare the three choices:

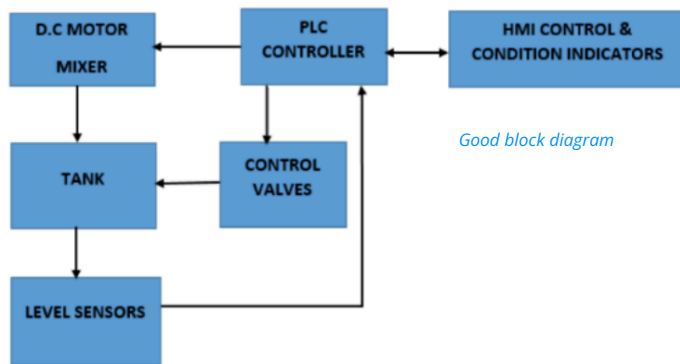
Criteria	PLC System	Arduino System	Relay & Timer Circuit Board
Cost	High initial cost (hardware & software)	Very low cost	Low individual part cost, but moderate overall cost
Ease of Use	Requires specialized knowledge and software	User-friendly for beginners; large support community	Simple once built, no programming required
Flexibility / Scalability	Highly flexible, easily expandable with modules	Highly customizable, great for prototyping	Not easily adaptable; fixed function
Integration	Excellent integration with HMIs and other systems	Possible but more complex and limited	Poor HMI integration; not designed for interfacing
Reliability	Industrial-grade, highly reliable	Less stable for complex or long-term tasks	Reliable if built well, but less robust
Programming Required	Yes – with specialized software	Yes – with open-source IDE (e.g., Arduino IDE)	No
Maintenance	Easy with modular replacement	Easy, but hardware can be fragile	Inexpensive but may require full board replacement
Environmental Impact	Modular, parts can be replaced/upgraded	Good – reusable boards and low power	Poor – entire board often discarded if damaged
Best For	Industrial systems needing reliability and scale	Educational projects, prototypes, and low-risk systems	Simple, fixed-function control without future changes

Figure 3 - Table to compare the three solution choices

Final Solution and Implementation

After evaluating all available options, a PLC-based system was selected as the final solution, as its overall benefits clearly outweighed those of the alternatives. Siemens was chosen as the PLC manufacturer due to the author's strong familiarity and prior experience with both the hardware and its associated programming software, ensuring efficient development and reliable implementation.

How?



Good block diagram

Figure 4 - Flow chart to show how the PLC operates and it's process

The Tank will be fitted with a mixing motor and 3 sensors for level detection, these will be used as indicators which will be displayed on the HMI. There will be 2 inlet valves for adding 2 materials to the tank, and 1 outlet valve for draining the tank. There will be a power on / off control and indicator. Timers will play a critical role on the system and will be displayed on the HMI. *Good significant points covered*

Animated graphics will give the real time state of the process, and the system will be safeguarded using interlocks in the TIA program.

How much? *No need for a question*

The estimated cost of the project is as follows:

PLC and TIA software - £400

Laptop PC with min 8G RAM - £1000

Valves - £300

Level sensors x3 - £300

DC motor – £200

Mix paddle - £100

Tank - £200

Total cost of project - £2500

Good costings breakdown

Design requirements

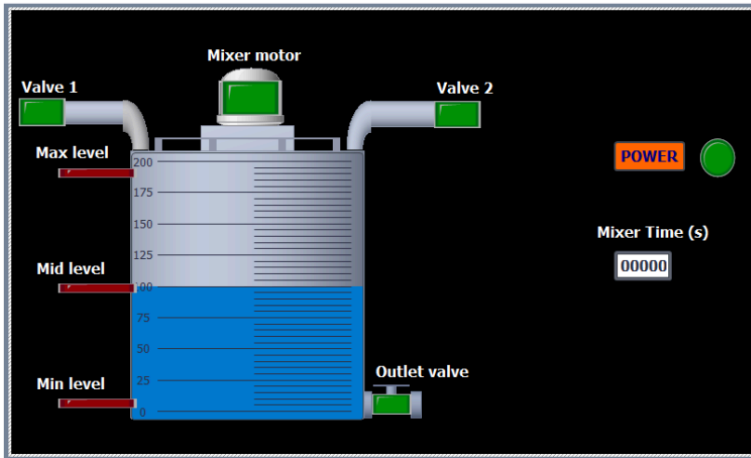


Figure 5 - What the screen looks like

Good HMI design

Valve 1- inlet valve for liquid level 1.

Valve 2- Inlet valve for liquid level 2.

Outlet valve- Tank drain valve.

Max level- Max level sensor

Mid Level- Middle level sensor

Min level- Min level sensor

Mixer motor- Timed motor to mix 2 liquids.

Valve 1 opens and liquid fills to a set point level, once setpoint level is reached valve 1 closes and valve 2 opens. Valve 2 stays open until setpoint 2 for liquid level is reached and then valve closes.

At this point both inlet valves are closed, and outlet valve is also closed. The level sensors indicate that the max level with both liquids are detected, and motor mixer is activated. The motor mixer stays on for a timed interval to mix both liquids and then switches off automatically. *Good accurate description*

At this point the outlet valve is opened making sure that no other valve is activated and stays open until the liquid drains to the minimum point. The sensors will indicate the levels as the liquid drains out and once liquid level passes minimum level sensor, the outlet valve closes. *Good explanation*

Once this sequence is completed it automatically restarts from the initial point by opening inlet valve 1 and the process continues. This will keep running until the operator switches off the process using the HMI on/off switch.

The timed interval can be viewed on the HMI and if this needs changing it can be altered in the main program.

Program implementation

Main program:

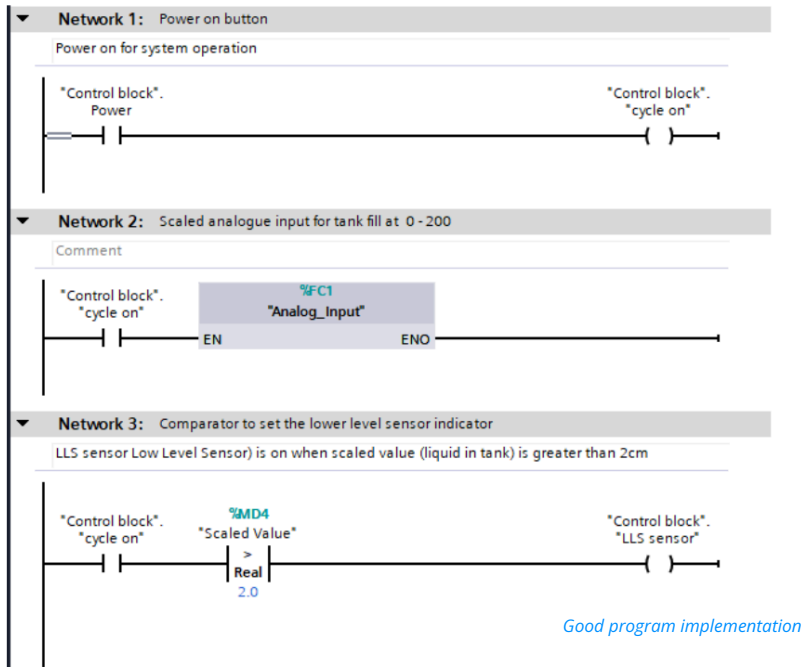


Figure 6 - The program with comments on how it works

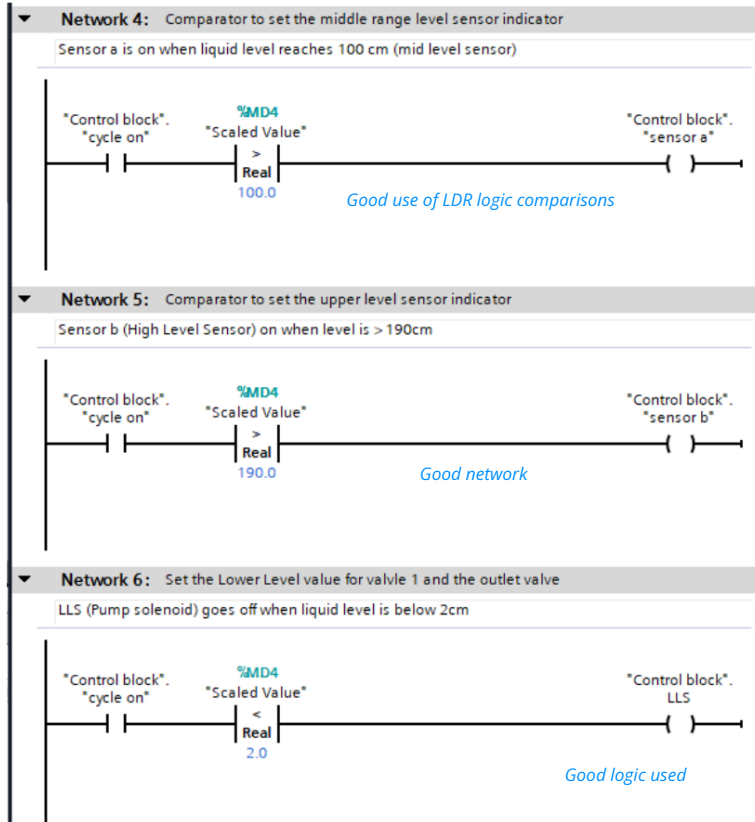


Figure 7 - The program with comments on how it works

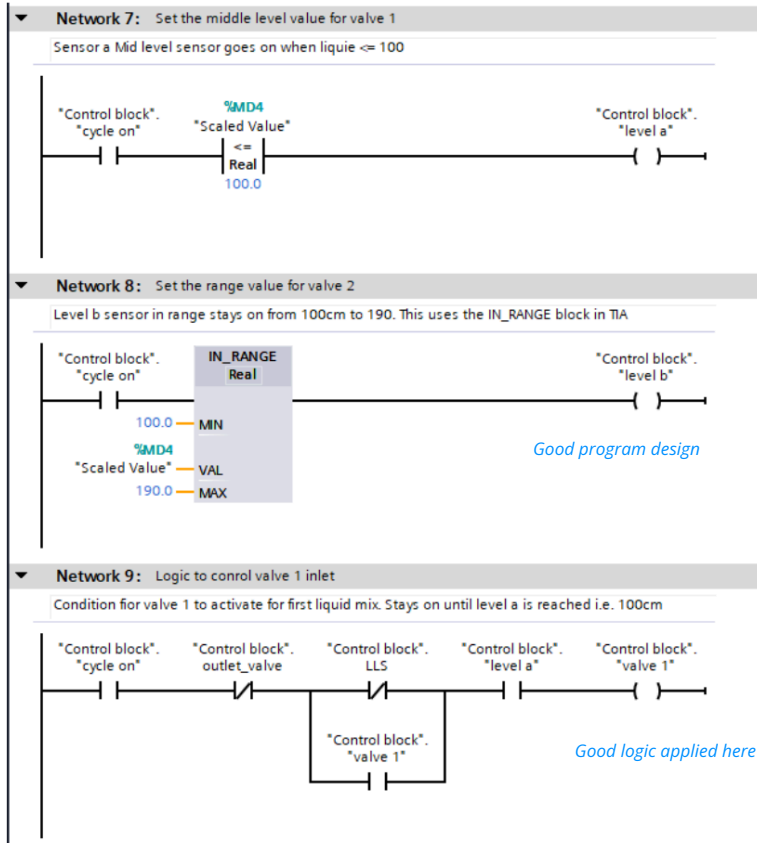


Figure 8 - The program with comments on how it works

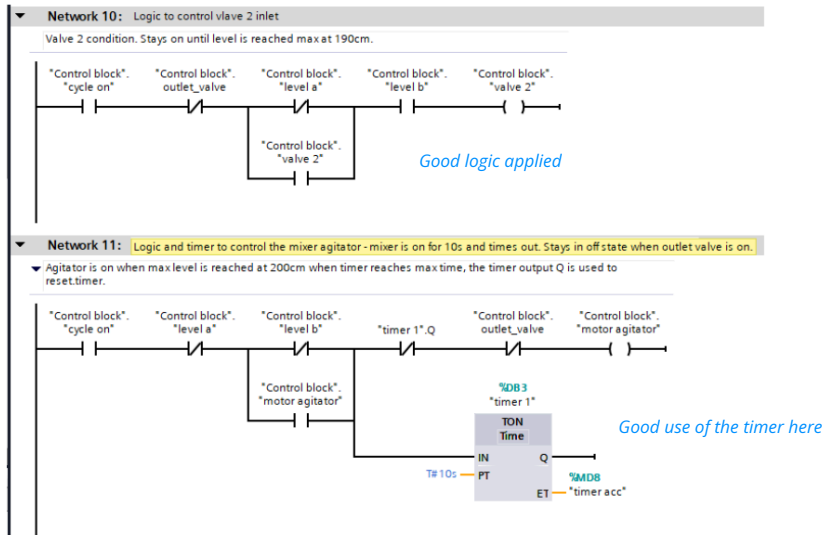


Figure 9 - The program with comments on how it works

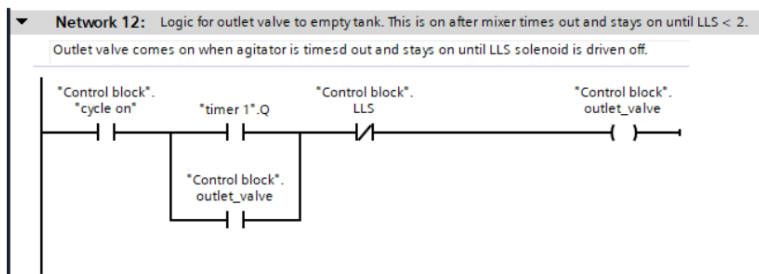
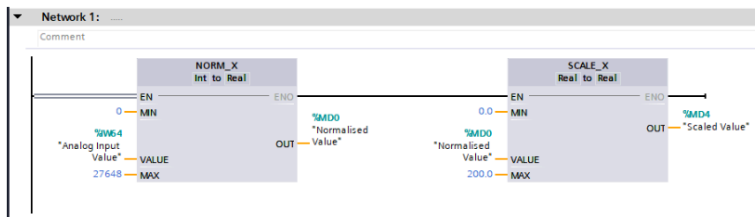


Figure 10 - The program with comments on how it works

Analog input:



Good analogue scaling

Figure 11 - Analog input

Analogue input using a 0 – 10V variable signal generator which is adjustable from 0 to 27648 PLC raw values, and this scaled to 0 to 200cm which is the depth of the tank.

Control block:

Control block								
	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint
1	Static			☐	☐	☐	☐	☐
2	Power	Bool	false	☐	☒	☒	☒	☐
3	outlet_valve	Bool	false	☐	☒	☒	☒	☐
4	cycle on	Bool	false	☐	☒	☒	☒	☐
5	LLS	Bool	false	☐	☒	☒	☒	☐
6	valve 1	Bool	false	☐	☒	☒	☒	☐
7	valve 2	Bool	false	☐	☒	☒	☒	☐
8	level b	Bool	false	☐	☒	☒	☒	☐
9	level a	Bool	false	☐	☒	☒	☒	☐
10	LLS sensor	Bool	false	☐	☒	☒	☒	☐
11	sensor b	Bool	false	☐	☒	☒	☒	☐
12	sensor a	Bool	false	☐	☒	☒	☒	☐
13	motor agitator	Bool	false	☐	☒	☒	☒	☐

Figure 12 - Control block where all the tags for the controls are kept

Default tag table:

Default tag table							
	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...
1	Tag_1	Bool	%M0.0	☐	☒	☒	☒
2	Tag_3	Bool	%M1.1	☐	☒	☒	☒
3	Tag_2	Bool	%M1.0	☐	☒	☒	☒
4	Tag_4	Bool	%M0.1	☐	☒	☒	☒
5	Tag_5	Bool	%M1.2	☐	☒	☒	☒
6	Tag_6	Bool	%M1.3	☐	☒	☒	☒
7	Analog Input Value	Int	%IW64	☐	☒	☒	☒
8	Normalised Value	Real	%MD0	☐	☒	☒	☒
9	Scaled Value	Real	%MD4	☐	☒	☒	☒
10	timer acc	Time	%MD8	☐	☒	☒	☒
11	timer2 acc	Time	%MD12	☐	☒	☒	☒

Figure 13 - Tag table

HMI Screens:

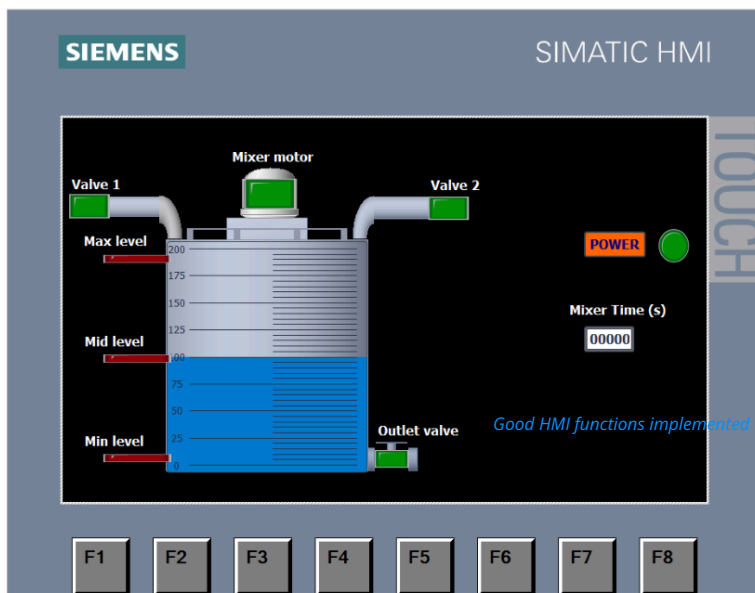


Figure 14 – Control screen



Figure 15 - Home page

Very good implementation of program functions

Testing and Results

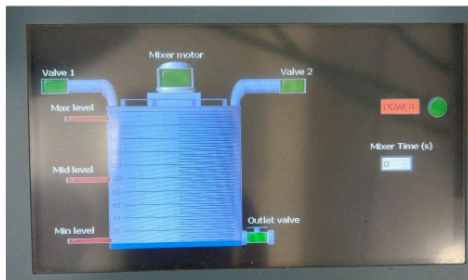
Test results Table

Test No	Sequence Description	Expected Result	Indicator Status	Pass / Fail
1	Start	Process start	Process started	P
2	Outlet valve open	Valve open indicator on	Valve opened with indicator on	P
3	5s delay	5s delay	5s delay	P
4	Outlet valve closed	Outlet valve close with indicator off	Outlet valve closed with indicator off	P
5	Inlet valve 1 open	Valve open with indicator on	Valve opened with indicator on	P
6	Inlet valve 1 closed at sensor 1 level detection	Valve closed with sensor 1 indicator on	Valve closed with sensor 1 indicator on	P
7	Inlet valve 2 open	Valve open with indicator off	Valve opened with indicator off	P
8	Inlet valve closed at sensor 2 level detection	Inlet valve closed with sensor 2 indicator on	Valve closed with sensor 2 indicator on	P
9	Stirrer motor after activated	Stirrer motor activate with timer start	Stirrer motor activate dand timer started	P
10	Timer times out	Timer times out	Timer timed out after 5s	P
11	Stirrer motor deactivated on time out	Stirrer deactivated after timeout of 5s	Stirrer motor deactivated after 5s timeout	P
12	Outlet valve opens	Outlet valve open	Outlet valve opened	P
13	Timer delay 5s	Delay 5s	Delay 5s	P
14	Outlet valve closed	Valve close	Outlet valve closed	P
15	Process repeats	Process starts over	Process starts over	P
16	Start / stop pushbuttons	Start /stop process	Starts and stops process at any point	P

Very good table of results

Figure 16 - Results table

HMI Screen shots



Very good evidence

Figure 17 - Tank empty

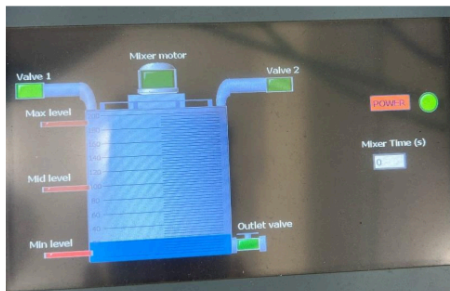


Figure 18 - Valve 1 open

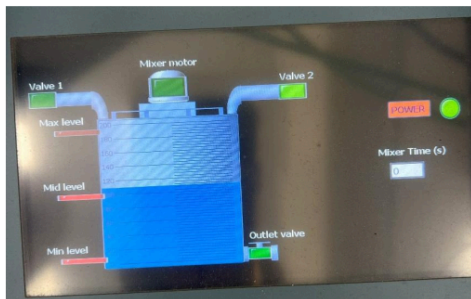


Figure 19 - Valve 2 open

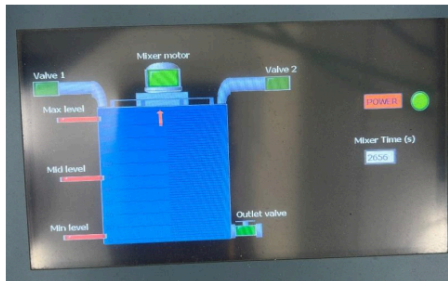


Figure 20 - Mixer motor come on as tank is full and timer started

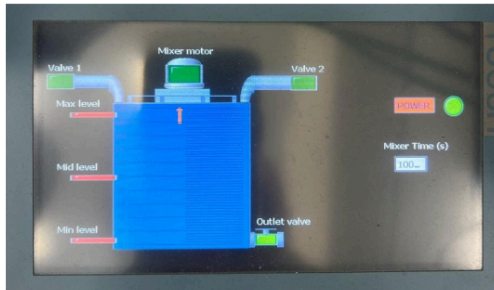


Figure 21 - Outlet valve open as it had finished mixing

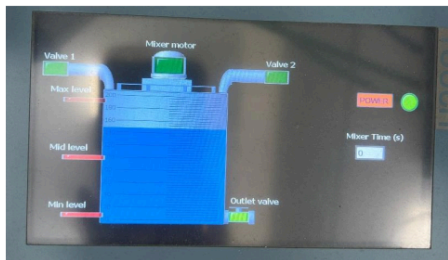


Figure 22 - Tank emptying

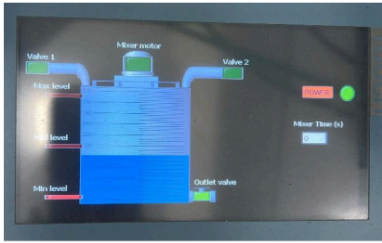


Figure 23 - Tank still emptying

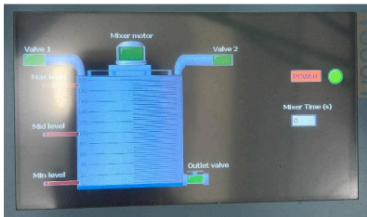
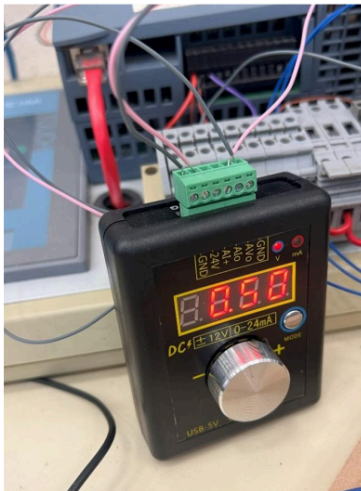


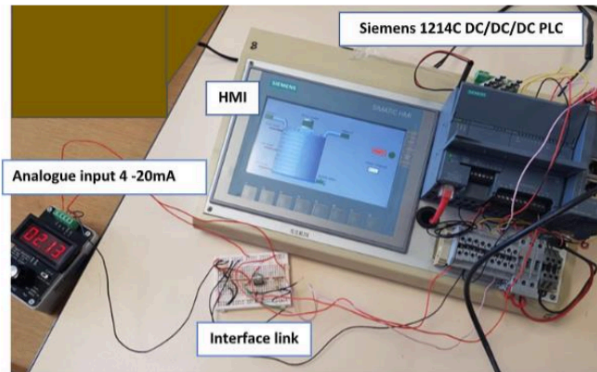
Figure 24 - Tank empty and sequence finished



Good test evidence to support results

Figure 25 – 4 – 20 mA analogue input for testing

Practical Test Setup



Good image evidence

Figure 26 - final setup

Conclusion

The system starts with valves 1 and 2 opening to fill different liquid components at set levels. The levels are set using level sensors (proximity) and logic is used in the ladder program to open and close at the set levels.

The system is failsafe with regards to levels as there are 3 sensors in all. The low-level sensor indicates when the tank is completely empty which is when the level drops below the outlet valve.

There is no pump to worry about at the bottom of the tank, so the tank is allowed to empty out fully.

The sequence starts with tank empty or full, this makes no difference and then follows a sequence to fill with set amounts of 2 different liquids. The timer is used to stir the liquid for a specified time (5s) before the outlet valve is opened. Indicators are placed logically in the program and on the HMI to indicate the stages of the process and the liquid levels.

The process is set so that once the tank is empty there is a trigger using the low-level sensor to start the process over and keep running until the stop pushbutton is activated.

The liquid level for test purposes is proportionally adjusted using a 4 – 20mA analogue input that has been scaled for the correct min and max of the tank using function blocks in TIA.

Discussion, Conclusion and Recommendations

The system has been implemented to justify the factory system that will be developed from this simulation. The System has been developed using Siemens PLC, HMI and software. The components are networked using a Profinet switch, and each has a unique ip address on the same network (subnet).

The program has been created using LDR, Function Block and using a wide range of condition functions for the liquid level indication and limits. The programming languages that are integrated into a single system to function transparently.

The system has been designed to meet budgetary constraints as included in the spec and proposal. The simulation has taken into account that the hardware components are readily available.

The conditions all function as per the spec and the timer has been added to improve the quality of the mixed liquid. The timer is set to mix the 2 different liquid materials enough to maximise the efficiency if the mix before draining out.

Good point about timer

All level conditions have been fully tested using a simulated level analogue input with scaling to match the specification. The test has been carried out filling and emptying the tank with successful results. The test has been carried three times to make sure no errors have been created.

The HMI has been designed to mimic the actual system setup so that the same program can be used with the simulation and physical systems.

Recommendation would be to use a timer set variable input so that the time for the mixer could be changes without going into the program.

A good relevant recommendation

A second recommendation would be to make the system useable form a mobile device so that it conforms with industry 4.0 development.

Good relevant rcommendation

Reference list and Bibliography

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Relays and timers:

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Good number of ref sources

Task 2 – Logbooks

Logbook 1 – Background research

Log Sheet

Log No	1
No hrs	8
Running total hrs	/

The project began with research, looking into tank mixers and how they function best, what they do and what's the best way of doing it. Also looking into what control systems would be best to use which were either, PLC's, Arduino microcontrollers and circuit boards including relays and timers. And finally, most importantly research was made for health and safety.



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Lecturer Signature	R. L.

Log Sheet

Log No	2
No hrs	8
Running total hrs	16

As shown below a timeline gantt chart was made to show what the planned time and actual time of each stage of this project was. There was a lot of planning made for this project as planning is key for an organised and successful project.

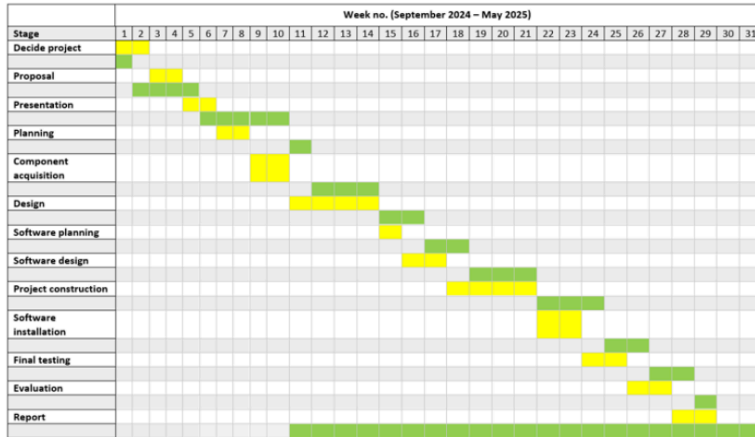


Figure 1 - Gantt chart showing the expected timeline vs the actual timeline of the project

The diagram above shows that the project was originally planned with evenly spaced development phases. However, as work progressed, the project gradually started to fall behind schedule.

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Lecturer Signature	Ad

Log Sheet

Log No	3
No hrs	6
Running total hrs	22

The first solution discussed and researched was PLC's. The three best choices for PLC's were, Siemens, Mitsubishi and Alspa. The pros and cons for using a PLC for this project was discussed and summary was made to make it easier to compare all solutions later.

Summary: Pros and Cons

Advantages	Challenges
Very reliable in industrial settings	Software can be expensive and brand-specific
Easy to update or modify as needs change	Requires training and experience to program effectively
Can expand and scale over time	Mixing brands can cause compatibility problems
Designed for integration with other tools	Initial setup can be costly depending on the system

In summary, PLCs offer a strong and dependable solution for automation. They're built for tough environments, can be tailored to specific needs, and are designed to work well with other automation tools. While there are some upfront costs and learning involved, the long-term benefits, especially in terms of performance and flexibility is what makes them a smart choice for many control system projects.

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Log Sheet

Log No	4
No hrs	6
Running total hrs	28

For solution 2 Arduino boards were chosen. Research was made and everything was discussed. A table was also made to look at the pros and cons in a simpler way and a summary to make it easier to compare later.

Summary: Pros and Cons

Pros	Cons
Very affordable	Not ideal for complex or time-sensitive tasks
Highly customizable and flexible	HMI integration can be challenging
Great community support and resources	Hardware is fragile compared to industrial controllers

In summary, Arduino is a great option for smaller or simpler automation systems, especially when keeping costs low is a priority. It's best suited for educational projects, prototypes, or low-risk environments. For more advanced or industrial-grade systems, a more robust solution like a PLC may be a better fit.

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Log Sheet

Log No	5
No hrs	6
Running total hrs	34

Relays and timers were chosen for the third solution. It's a simple, hardware only approach so therefore no programming is needed. Research was done and everything was discussed thoroughly.

Summary: Pros and Cons

Pros	Cons
Built specifically for the task	Not easily adaptable to future changes
No software or programming required	Total cost can be high despite low-cost components
Low maintenance and simple operation	Full replacement often needed if something fails
Reliable once installed	Generates more waste compared to modular systems

In summary, a relay and timer-based circuit board can be a solid, dependable solution for a simple, unchanging task. But if flexibility, future upgrades, or sustainability are important, it may not be the best long-term choice.

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Logbook 6 – Comparing the three solutions

Log Sheet

Log No	6
No hrs	3
Running total hrs	37

After discussing all three solutions a table was made to show every important criteria to make it easier to compare. All solutions were researched and discussed thoroughly and everything was taken into consideration.

Criteria	PLC System	Arduino System	Relay & Timer Circuit Board
Cost	High initial cost (hardware & software)	Very low cost	Low individual part cost, but moderate overall cost
Ease of Use	Requires specialized knowledge and software	User-friendly for beginners; large support community	Simple once built, no programming required
Flexibility / Scalability	Highly flexible, easily expandable with modules	Highly customizable, great for prototyping	Not easily adaptable; fixed function
Integration	Excellent integration with HMIs and other systems	Possible but more complex and limited	Poor HMI integration; not designed for interfacing
Reliability	Industrial-grade, highly reliable	Less stable for complex or long-term tasks	Reliable if built well, but less robust
Programming Required	Yes – with specialized software	Yes – with open-source IDE (e.g., Arduino IDE)	No
Maintenance	Easy with modular replacement	Easy, but hardware can be fragile	Inexpensive but may require full board replacement
Environmental Impact	Modular, parts can be replaced/upgraded	Good – reusable boards and low power	Poor – entire board often discarded if damaged
Best For	Industrial systems needing reliability and scale	Educational projects, prototypes, and low-risk systems	Simple, fixed-function control without future changes

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Log Sheet

Log No	7
No hrs	6
Running total hrs	43

After comparing the three solutions, the decision was to go with a Siemens PLC as when compared with the others it was obvious that it was the best option. The reasons why are stated below:

Final Solution and Implementation

After evaluating all available options, a PLC-based system was selected as the final solution, as its overall benefits clearly outweighed those of the alternatives. Siemens was chosen as the PLC manufacturer due to the author's strong familiarity and prior experience with both the hardware and its associated programming software, ensuring efficient development and reliable implementation.



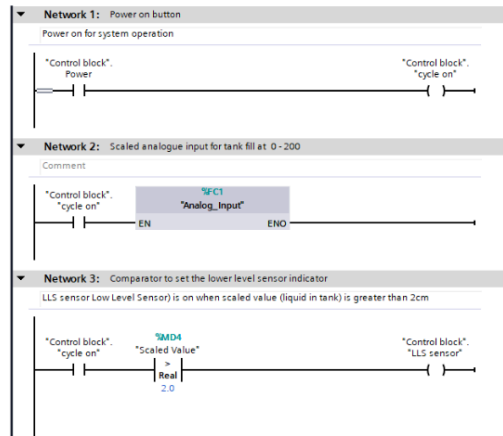
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Lecturer Signature	RL

Logbook 8 – Implementing and program development

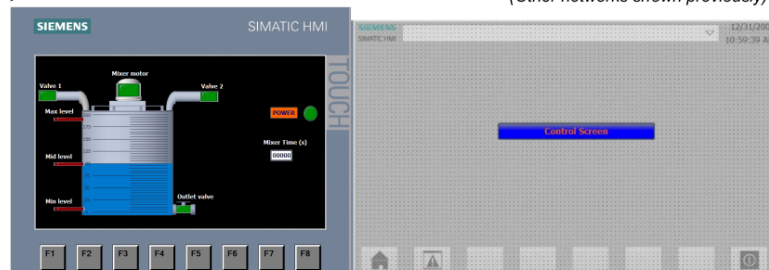
Log Sheet

Log No	7
No hrs	25
Running total hrs	68

The implementation and program development were one of the most time-consuming parts of the project as there was lot of accuracy and thought needed to make sure it all worked correctly. All automation and HMI screens were developed in this part of the program and after a few hiccups its developed into a fully functional tank mixer as planned.



(Other networks shown previously)

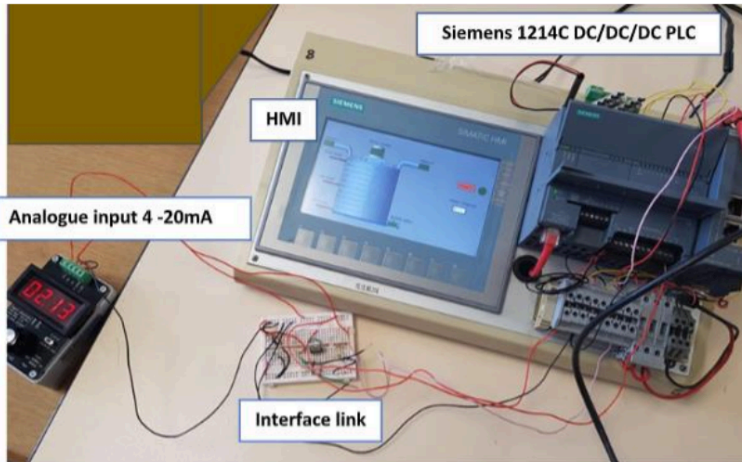


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Lecturer Signature	Ad

Log Sheet

Log No	9
No hrs	4
Running total hrs	72

The hardware development was quite simple and straight forward. There wasn't much that could go wrong. There was some head scratching along the way but everything worked as intended.



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Lecturer Signature	<i>[Signature]</i>

Log Sheet

Log No	10
No hrs	30
Running total hrs	102

The testing was very successful and went just as planned with no errors. A table was made to show the results at each stage of the process as shown below.

Test No	Sequence Description	Expected Result	Indicator Status	Pass / Fail
1	Start	Process start	Process started	P
2	Outlet valve open	Valve open indicator on	Valve opened with indicator on	P
3	5s delay	5s delay	5s delay	P
4	Outlet valve closed	Outlet valve close with indicator off	Outlet valve closed with indicator off	P
5	Inlet valve 1 open	Valve open with indicator on	Valve opened with indicator on	P
6	Inlet valve 1 closed at sensor 1 level detection	Valve closed with sensor 1 indicator on	Valve closed with sensor 1 indicator on	P
7	Inlet valve 2 open	Valve open with indicator off	Valve opened with indicator off	P
8	Inlet valve closed at sensor 2 level detection	Inlet valve closed with sensor 2 indicator on	Valve closed with sensor 2 indicator on	P
9	Stirrer motor after activated	Stirrer motor activate with timer start	Stirrer motor activate and timer started	P
10	Timer times out	Timer times out	Timer timed out after 5s	P
11	Stirrer motor deactivated on time out	Stirrer deactivated after timeout of 5s	Stirrer motor deactivated after 5s timeout	P
12	Outlet valve opens	Outlet valve open	Outlet valve opened	P
13	Timer delay 5s	Delay 5s	Delay 5s	P
14	Outlet valve closed	Valve close	Outlet valve closed	P
15	Process repeats	Process starts over	Process starts over	P
16	Start / stop pushbuttons	Start /stop process	Starts and stops process at any point	P

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Lecturer Signature	

66/100

PAGE 1

PAGE 2

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PAGE 3

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Text Comment. Good points covered

PAGE 4

Text Comment. Applications identified which gives the project purpose

Text Comment. Incorrect citation method

Text Comment. Good points

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Text Comment. Good argument

PAGE 5

Text Comment. Good argument

Text Comment. Good point here

Text Comment. Incorrect citation method

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Text Comment. Good points

Text Comment. Good points

PAGE 6

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Text Comment. Good work here

Text Comment. Good points for HMI function

Text Comment. Good spec

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PAGE 7

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Text Comment. This would be better suited in research section

Text Comment. This is a good requirement feature to add to the spec as it would be difficult to add the functions for this if the wrong controller is chosen.

Text Comment. Good points

PAGE 8

Text Comment. Good Gantt chart with comparative timeline

Text Comment. There are relevant points made

Text Comment. More explanations with reasons for discrepancies in the timeline should be included

PAGE 9

Text Comment. Good test plan that saves time further along the development process

PAGE 10

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PAGE 11

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PAGE 15

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PAGE 16

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PAGE 19

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PAGE 20

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PAGE 21

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PAGE 22

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PAGE 27

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PAGE 28

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Text Comment. Very good informative conclusion that points out significant parts of the system that improves performance

PAGE 29

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RESEARCH-INFORMED LITERATURE

Research has good relevant points included. There should be more content and supporting images should be used. 5/10
 Good number of ref sources used. Ref method is incorrect in many parts. 4/10

9/20**KNOWLEDGE AND UNDERSTANDING**

Good spec that identifies the requirements with details of functions. 6.5/10
 Good relevant solutions considered with good realistic evaluations included. 6.5/10

13/20**ANALYSIS**

Very good test table of results with good evidence images to support results. 7.5/10
 Conclusion and recommendations are very relevant and include good significant details for the system. 8.5/10

16/20**PRACTICAL APPLICATION AND DEP.**

Good Gantt chart with comparative timelines. This should include more explanations of how the project progressed through the timeline. 3/5
 Good solutions considered with a good practical argument for each solution. 6.5/10

17/25

Implementation has been very methodical with good program network comments and labels.
 Good explanations included.
 Very good HMI design. 7.5/10

SKILLS FOR PROFESSIONAL PRAC.



A very good report with good structure and neatly presented content.

11/15