TRAIN CROSSING CONTROL SIMULATOR

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CONTENTS

1 INTRODUCTION

This report outlines the progress of TRAIN CROSSING CONTROL SIMULATOR completed during the duration of 20 days. Its focus is on automation within industrial control systems alongside factors like safety and operability of vital components in real word applications.

The aim of this project is to design, program, test and document the process of a train crossing control simulator using a PLC (Programmable Logic Controller) and HMI (Human Machine Interface). This system was developed to simulate operation of train barriers and warning lights, how they communicate and operate together. The project uses PLC and HMI to replicate control logic and how it is used in industrial automation settings. This was to understand how the simulator using an automated control system could ensure safety, efficiency and reliability when operating train crossing under different conditions. This project provided me with practical experience on industrial automation and control that included PLC Programming using system design, documentation for the bill of material and other technical document. This also helped widen my understanding on how control systems are structured and employed in safety-critical industrial environment.

1.1 COMPANY OVERVIEW

Proeon Systems Ltd supplies industrial control and safety solutions for complex and critical applications across a range of highly regulated industry sectors. These sectors include renewable energy, transitional oil and gas, nuclear, utilities, pharmaceutical, chemical and process engineering.

The company provides industrial-grade control and safety solutions supported by specialist knowledge in wind farm supervisory control and data acquisition (SCADA) systems, front-end engineering (PRE-FEED/FEED), detailed design engineering, installation and commissioning, consultancy services, and research and development.

Proeon Systems operates within the energy, manufacturing and utilities industries, working with a mixture of Tier 1 and Tier 2 clients based in the UK while supporting a worldwide installation base. The company focuses on delivering reliable and effective control solutions for applications where safety, performance and operational reliability are essential.

2 PROJECT AIMS AND OBJECTIVES

AIM: The aim of the project is to design, program and test train crossing simulator using PLC and HMI. The project helps highlight how control systems are programmed and applied to achieve safe and reliable operation. The simulator is designed to replicate train crossing by controlling elements like the barriers, warning lights and timer between each operation.

OBJECTIVES:

- Research: This includes researching essential principles in industrial environment like electrician concepts, electrical hardware, control system (i.e. open loop), different programming languages, and network concepts (i.e. profinet) This includes understanding its purpose and how it's being used with the system. This would help provide understanding of how they all collaborate with each other to achieve efficient automation.
- Bill of Material (BOM): This is developing and identifying of all components that would be needed for our system. The BOM includes information like quantity, specification and its manufacturing information (i.e. part number) that is required for our panel. This is done to ensure that we are working alongside specifications in relation to our system which will later be needed for technical calculations like the heat and load calculations.
- Heat and Load Calculations: Utilising the information gathered form the BOM; the heat dissipation of each component and electrical capability. The calculation will be used to evaluate whether each component selected for the system can operate safely within the panel; just in case any iterations is to be made.
- Functional Design and System Design Specifications: These are documents that need to be prepared to understand how the system functions; this would typically include the input and output requirements, control functions and operating sequence of components
- PLC AND HMI using TIA V18 PORTAL: The PLC and HMI will be programmed using Siemsen TIA V18 portal. The process will include creating tags for the systems input and output variable. This will include structured programming methods using Function Blocks (FB), Data Blocks (DB), timers, counters and comparator. These are used to control the sequence of events like the barriers and warning lights being

operated at different preconditions. The HMI interface was also designed and configures using different functions like the button, tagging system and editing the interface with different images.

- Testing and Troubleshooting: After the completion of programming, it is tested to identify any errors and making improvements where there is.
- Documentation: All engineering documents like the BOM will be produced according to industrial documentation standard used by Proeon System Ltd.

2.1 TIMELINE

Stages	Days	Objectives	Role
Research	1–3	Researched PLC hardware Read and saw exemplar of Proeon Systems' internal naming & tagging standards Defined safe-state requirements for the train crossing.	Independent literature review. Discussed industrial automation safety with Proeon mentor.
Bill of Material and Heat/Load Calculations	4–6	Drafted Electrical, Mechanical, and Consumables BOM. Completed Heat and Load	Implemented all mathematical calculations and component selection. Mentor verified calculations against safety standards.
PLC Logic Programming (TIA V18 PORTAL)	7–12	Programmed logic sequence (prechecks, TON timers, sensor input) for barriers and warning lights.	Programmed Ladder Logic code using TIA V18 PEORTAL Software. Reviewed PLC logic with Proeon software engineers.
HMI Design & Linking	13–15	Edited HMI screen layouts Defined HMI control tags	Customized the HMI interface and tag database.
Testing	16–18	Conducted safe isolation procedures Ran simulations; identified and resolved warning light tag mismatches.	Executed tests, troubleshoot errors

Finalization	19–20	Documented projects entire timeline Compiled final Gold CREST project report and.	Wrote and formatted the technical report.

3 BACKGROUND RESEARCH

Industrial Automation: It can be described as a set of computerized systems which are found in a manufacturing facility. These systems can be seen to reduce human labour and automate mundane, mechanical, and repetitive tasks. The automation systems in the industry have evolved over time (Schneider Electric, 2023)

Automation is used in almost every sector because of rise in new technology; it if used to improve efficiency in system operation which will in turn increase peak productivity.

Example of industrial automation from JR AUTOMATION (*Examples of Industrial Automation*, 2024)

Advanced Drainage Systems, a leading manufacturer of stormwater and wastewater solutions, was looking for an automated solution to optimize the strapping and palletizing of 10-foot-long sticks of plastic pipe, which are extruded 24 hours a day, 7 days a week. Due to labour shortages and increasing demand, the company was having a hard time keeping up with packaging and palletizing, leading to piece loss and quality issues. Additionally, the length of the plastic piping and its flexibility led to safety and ergonomic challenges for their employees.

Our team collaborated with ADS to develop a solution that could efficiently mix and match pipe types into different quantity packs before palletizing them. The system fed pipes onto a conveyor that moved parts to a custom-built hopper. The teams worked side-by-side to make sure that the new system would be able to move pipes through the system accurately, and then stack, strap, and finally transfer the stacks of pope to pallets or crates.

CONTROL SYSTEMS: A control system is a system that is used to control the behaviour of a device or process

TYPES:

Open loop: This doesn't need feedback

Closed Loop: These systems use feedback to compare the desired output of the system to the actual output and adjust the input to the system based on the difference between these two signals

(DMM, 2023)

Components in Control system

1. Sensors: They detect change in surrounding and convert it into electrical signal
2. Actuator: They are devices that converts electrical signal into physical movement
3. Human-machine interfaces: Human-Machine Interface (HMI) provides intuitive visual and interactive systems that enable operators to efficiently monitor and control complex equipment or processes across manufacturing, automotive, and other industrial applications.

(*What Is a Human Machine Interface (HMI)? Types, Advantages*, 2023)

PLCs

Programmable Logic Controllers (PLCs) are industrial computers, with various inputs and outputs, used to control and monitor industrial equipment based on custom programming.

There are many kinds of PLCs but most fall into one of two main categories:

fixed and modular

The main difference between the two is that fixed PLCs have a pre-built number of inputs and outputs, while modular PLCs are designed to be much more adaptable. Fixed and modular PLCs are useful for different purposes, with benefits ranging from portability and affordability to scalability and customizability.

(*What Is a Human Machine Interface (HMI)? Types, Advantages*, 2023)

(*Programmable Logic Controllers (PLC)*, n.d.)

4 Electrical Hardware

4.1 Fuse

A fuse is an electrical safety device that operates to provide overcurrent protection of an electrical circuit. Its essential component is a metal wire or strip that melts when too much current flows through it, thereby stopping or interrupting the current.

4.2 Miniature Circuit Breaker (MCB)

An MCB is a Miniature Circuit Breaker designed to protect an electric circuit from overload or short circuit.

To protect an electrical circuit from overload, the MCB is fitted with a bi-metallic strip. When an overload occurs, the bi-metallic strip rapidly heats and bends. This releases a mechanical latch which opens and breaks the circuit.

A short circuit on the other hand causes a sudden rise in electric current. This causes a plunger within the MCB to strike the trip lever which creates an immediate release of the latch mechanism and in turn breaks the circuit.

4.3 Isolator

An electrical isolator is a kind of mechanical switch that isolates a part of a particular circuit when required. They are switching devices utilized to open a circuit in no-load condition and not when the current is flowing through the circuit.

The main function of an isolator is to separate a circuit from its power supply. It ensures the safety of workers and prevents electric shock during maintenance.

4.4 Relay

A relay is an electrical control device which effectively works as an automatic switch, to convert a low electrical input into a high-current output, and therefore facilities the interaction between the input and output circuits.

Relays typically have three separate uses: An automatic adjustment of the current, Safety protection and Interacting between two circuits to convert the current

A relay opens and closes a circuit, and it controls that circuit by opening and closing the contacts of another circuit. So when the relay contacts are normally open, there is an open circuit when the relay is not energised. When the relay contacts are normally closed, there is a closed circuit when the relay is not energised. So in both cases, applying electrical current to the contacts of the relay will change their state.

Fig. 1- Electrical hardware, GT001-Rev-1- (Faheeza 2026)

4.5 Contactor

A contactor is a device that is for making and breaking an electrical power circuit. For example, we usually use a contractor for turning on and off an electrical motor.

The contractor coil is energized by the PLC output card, an electromagnetic field will be created around it. This electromagnetic field causes the three magnetic contacts to close. Each contact is connected to the power from one of the three phases of the three-phase power supply. Once closed, the contacts complete the circuit, and three-phase power will be applied to the motor and turn it on. It looks like magic, right?

There is no physical electrical connection between the contactor coil and the contacts. The contacts will open and close via the coil's electromagnetic field.

Graduate Training – 001 – Rev 1 Page 9 of 25

In the off state, the coil is not energized, and the contacts are open

Fig. 1.1- Electrical hardware, GT001-Rev-1- (Faheeza 2026)

PLC BRAND

SIESMEN RANGE

SIMATIC S7-1200 G2

The demand for smart, efficient, and reliable automation solutions grows. Industries need scalable solutions that boost productivity without compromising efficiency. The SIMATIC S7-1200 family consists of compact programmable logic controllers (PLCs), that address these requirements through enhanced performance capabilities combining powerful functionality with a space-saving design.

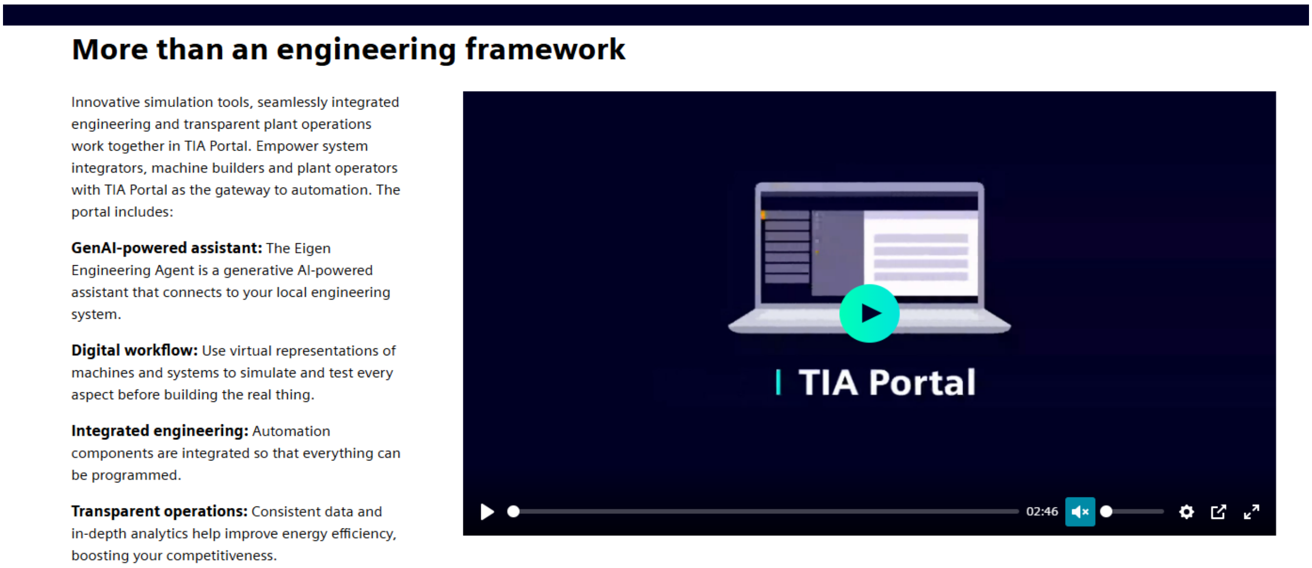
(*Simatic S7-1200 G2*, 2026)

SIMATIC ET 200SP distinguishes itself as an advanced, high-performance I/O system for compact control cabinets. This system impresses with remarkable performance coupled with a particularly compact design.

This innovative I/O system optimizes efficiency, streamlines deployment, and ensures scalable, future-proof architectures across diverse industrial applications.

(*SIMATIC ET 200SP - Compact I/O System*, 2026a)

Siemsen TIA V18 Portal

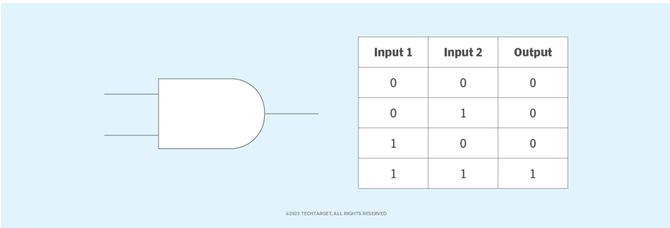


(*Totally Integrated Automation Portal | Siemens*, 2026c)

Logic Gates

AND gate

The AND gate produces an output of true only when both inputs are true. Otherwise, the output is false. In other words, the output is 1 only when both inputs are 1, and 0

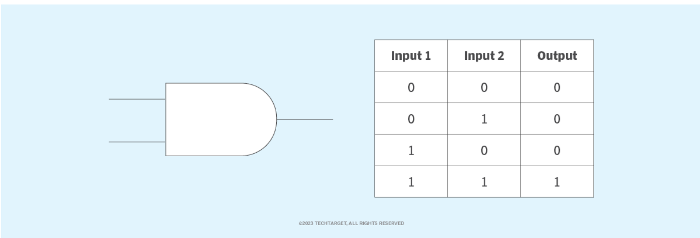


Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

if even one of the inputs is 0.

OR gate

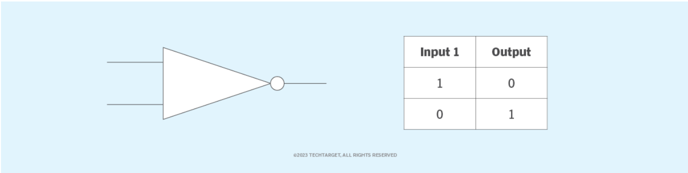
The output is true if one or both inputs are true. If both inputs are false, the output is false. For the output to be 1, at least one input must be 1.



Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

NOT gate

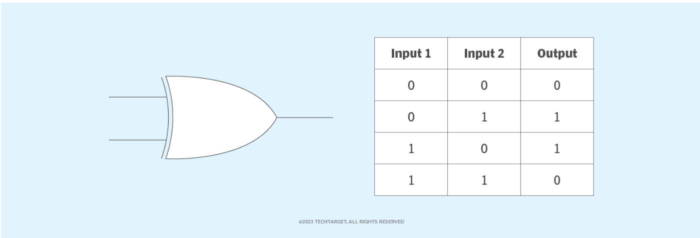
A NOT gate reverses the logic state. If the gate's input is 1, then the output is 0. If the input is 0, the output is 1.



Input 1	Output
1	0
0	1

XOR gate

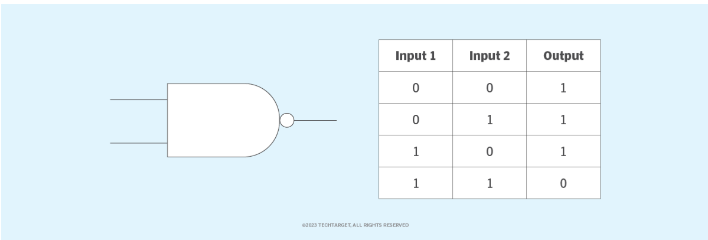
The output is true if either input is true, but not both. The output is false if both inputs are false or both inputs are true.



Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	0

NAND gate

The NAND gate produces a false or low output if both inputs are true. Otherwise, the output is true.



Input 1	Input 2	Output
0	0	1
0	1	1
1	0	1
1	1	0

(Alexander S. Gillis, 2020)

Timers

TP: Generate pulse

The TP timer generates a pulse with a preset width time

TON: Generate ON delay

The TON timer sets output Q to ON after a preset time delay.

TOF: Generate OFF delay

The TOF timer resets output Q to OFF after a preset time delay.

TONR: Time accumulator

The TONR timer sets output Q to ON after a preset time delay. Elapsed time is accumulated over multiple timing periods until the R input is used to reset the elapsed time.

Counter

Operation of CTU (count up)

The CTU counter counts by 1 when the value of parameter CU changes from 0 to 1. The CTU timing diagram shows the operation for an unsigned integer count value (where PV = 3).

- If the value of parameter CV (current count value) is greater than or equal to the value of parameter PV (preset count value), then the counter output parameter Q = 1.
- If the value of the reset parameter R changes from 0 to 1, then the current count value is reset to 0.

Operation of CTD (count down)

The CTD counter counts down by 1 when the value of parameter CD changes from 0 to 1. The CTD timing diagram shows the operation for an unsigned integer count value (where PV = 3).

- If the value of parameter CV (current count value) is equal to or less than 0, the counter output parameter Q = 1.
- If the value of parameter LOAD changes from 0 to 1, the value at parameter PV (preset value) is loaded to the counter as the new CV (current count value).

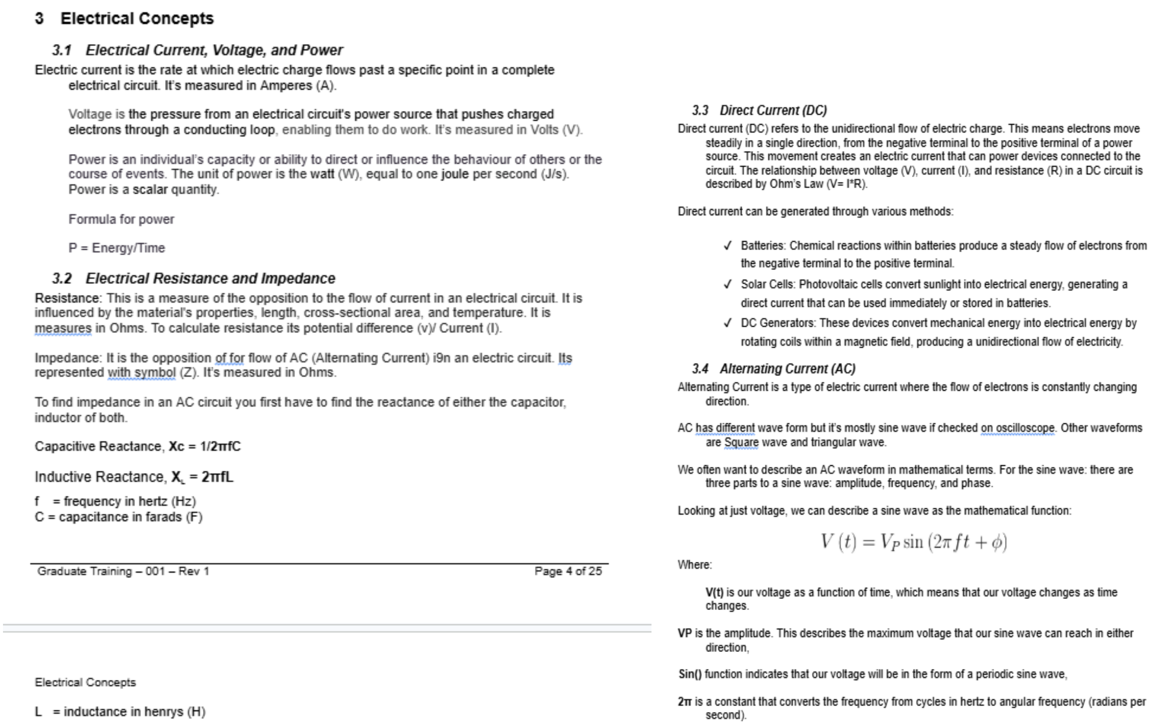
Operation of CTUD (count up and down)

The CTUD counter counts up or down by 1 on the 0 to 1 transition of the count up (CU) or count down (CD) inputs. The CTUD timing diagram shows the operation for an unsigned integer count value (where PV = 4).

- If the value of parameter CV is equal to or greater than the value of parameter PV, then the counter output parameter QU = 1.

- If the value of parameter CV is less than or equal to zero, then the counter output parameter QD = 1.
- If the value of parameter LOAD changes from 0 to 1, then the value at parameter PV is loaded to the counter as the new CV.
- If the value of the reset parameter R is changes from 0 to 1, the current count value is reset to 0.

(*TIA Portal Information System*, 2026c)



3 **Electrical Concepts**

3.1 Electrical Current, Voltage, and Power

Electric current is the rate at which electric charge flows past a specific point in a complete electrical circuit. It's measured in Amperes (A).

Voltage is the pressure from an electrical circuit's power source that pushes charged electrons through a conducting loop, enabling them to do work. It's measured in Volts (V).

Power is an individual's capacity or ability to direct or influence the behaviour of others or the course of events. The unit of power is the watt (W), equal to one joule per second (J/s). Power is a scalar quantity.

Formula for power

P = Energy/Time

3.2 Electrical Resistance and Impedance

Resistance: This is a measure of the opposition to the flow of current in an electrical circuit. It is influenced by the material's properties, length, cross-sectional area, and temperature. It is measures in Ohms. To calculate resistance its potential difference (v)/ Current (I).

Impedance: It is the opposition of for flow of AC (Alternating Current) i9n an electric circuit. Its represented with symbol (Z). It's measured in Ohms.

To find impedance in an AC circuit you first have to find the reactance of either the capacitor, inductor of both.

Capacitive Reactance, **Xc = 1/2πfC**

Inductive Reactance, $\mathbf{X_L = 2\pi fL}$

f = frequency in hertz (Hz)
C = capacitance in farads (F)

Graduate Training – 001 – Rev 1 Page 4 of 25

Electrical Concepts

L = inductance in henrys (H)

3.3 Direct Current (DC)

Direct current (DC) refers to the unidirectional flow of electric charge. This means electrons move steadily in a single direction, from the negative terminal to the positive terminal of a power source. This movement creates an electric current that can power devices connected to the circuit. The relationship between voltage (V), current (I), and resistance (R) in a DC circuit is described by Ohm's Law (V= I*R).

Direct current can be generated through various methods:

- ✓ Batteries: Chemical reactions within batteries produce a steady flow of electrons from the negative terminal to the positive terminal.
- ✓ Solar Cells: Photovoltaic cells convert sunlight into electrical energy, generating a direct current that can be used immediately or stored in batteries.
- ✓ DC Generators: These devices convert mechanical energy into electrical energy by rotating coils within a magnetic field, producing a unidirectional flow of electricity.

3.4 Alternating Current (AC)

Alternating Current is a type of electric current where the flow of electrons is constantly changing direction.

AC has different wave form but it's mostly sine wave if checked on oscilloscope. Other waveforms are Square wave and triangular wave.

We often want to describe an AC waveform in mathematical terms. For the sine wave: there are three parts to a sine wave: amplitude, frequency, and phase.

Looking at just voltage, we can describe a sine wave as the mathematical function:

$$V(t) = V_P \sin(2\pi f t + \phi)$$

Where:

V(t) is our voltage as a function of time, which means that our voltage changes as time changes.

VP is the amplitude. This describes the maximum voltage that our sine wave can reach in either direction,

Sin() function indicates that our voltage will be in the form of a periodic sine wave,

2π is a constant that converts the frequency from cycles in hertz to angular frequency (radians per second).

Fig 2- Electrical concepts- GT001-Rev-1- (Faheeza. A 2026)

Documentation

Naming of different version

The 1st ladder rung / line of code for a PLC should contain a header containing the minimum
Program Title
FDS / SDS Version
Software Engineer
Client
End User
Name and Version of programming software, i.e. RSLogix 5000 Version 20.03
All rungs/ functions should have a comment and descriptions are used on each variable. All rung comments are to detail the purpose of the code, i.e. Control & Monitor Recycle Pump P1234.

Tag-naming PLC

All variable names should comply with the following requirements:
1. All Inputs should be prefixed by 'L'
2. All Outputs should be prefix by 'O_
3. All data entering the PLC from should be clearly defined
All tags should be of the format:
Prefix_ Plant Tag _ Suffix
Where:
Plant Tag:
Prefix :
Suffix:
Is the customers tag number
Denotes where the signal comes from or if the signal is internal, no prefix is required
Will be taken from the following list, where possible or an appropriate abbreviation developed and used consistently throughout the project:
Thus:
I_ZSH01010_Pos
Input from Tag ZSH01010 Used to indicate Position
WIOO3A - Programming Standards - PLC and HMI SCADA

(Proeon System- Work Instructions-003A)

Testing

Point to point Testing: Point-to-Point (P2P) testing is a procedure done to verify that the connectivity between two points or devices, whether in an electrical system (wirings, circuits) or a network system (data communication links), is correctly installed and functions as intended. *(Gadugdug, 2025)*

Prove dead Testing: Process

Identify the correct circuit
Find the right MCB at the consumer unit, but don't rely only on labels—always confirm by testing at the work point.

Switch off and lock out
Turn off the MCB, apply a lockout device, and add a warning notice to prevent accidental re-energising.

Prove your tester works (first prove)
Check your voltage tester on a proving unit (or self-test) to ensure its functioning correctly.

Test the circuit
At the work location, test:

- Live–Neutral
- Live–Earth
- Neutral–Earth
  All must read zero to confirm the circuit is dead.

Prove your tester again (second prove)
Recheck the tester to ensure it hasn't failed during testing.

Work safely
Only begin work once the circuit is isolated, locked off, and proven dead.

(Safe Isolation and Proving Dead: The Procedure That Stops People Getting Killed, 2017#)

Overall, all the research from this section helped build foundation for the train crossing simulator. Automation and control system logic are essential for ensuring reliability and efficiency in real world. The use of the PLC allows the system to control the sequence of operation for the warning lights and barrier position through ladder logic, whilst the HMI provided monitoring and control. Logic gates and basic programming instructions such as timers and comparators are crucial as it allows the system to manage sequence of events including delayed timing for warning lights and barrier positions.

Documentation and Naming convention are unique to each company however what they all have in common is that they improve clarity and reduce errors during revisions and version control.

4 Method And Project Development

4.1 System Design

This involves developing a structured plan for the train crossing simulator according to the project requirement. The design was guided by the Functional design Specification and System Design Specification as well a flow chart of its operation. This is to ensure system is operating reliably and under safe-critical conditions.

The system was designed to include a PLC for processing software information and HMI. The PLC selected is The Siemens S7-1200 PLC, chosen due to its scalability that boost productivity without compromising efficiency, compared to a microcontroller-based system; the S7-1200 PLC provides high processing power with efficient automation control for versatile automation, and it has wireless access to help with improved monitoring.

Overall, the system is operated using structured sequence of events that's controlled the PLC. The inputs are being processed through the control logic programmed for the system and the outputs are activated to simulate a train crossing system.

Before operations begin; prechecks are carried out to ensure the system is correctly configured. This includes verifying IP address for both PLC, computer and the TIA Portal, making sure there's connection between the PLC and the simulator, confirming the programme is saved, ensuring the system is connected to power and online. These checks are crucial to prevent any unforeseen errors like communication between PLC and simulator to ensure safe operation.

When system is online the sequence can the begin, whilst its being monitored on the PC. The warning lights are activated and a delay timer is set in between using timer functions such as TON (ON-delay timer), to ensure accurate intervals before another operation can begin. After this, the barrier is then closed, another delay timer is set to simulate the train crossing. After this the barrier is then opened and the warning lights stay on for short period before turning off, to return to the initial step in the sequence.

The timer is used often in the program to control the delay between each stage of the operation. This ensures that each stage occurs in a coordinated manner reflecting real train crossing manner.

The HMI also helps monitor and control the system in real time; it gives it a user-friendly interface for observing the status of the warning lights and barrier.

Overall, the system design ensures safe, controlled and consistent operation of the train crossing simulator meeting required functional and design standards.

4.2 BILL OF MATERIAL (BOM)

Electrical BOM

Identifier	Quantity	Part Number	Manufacturer	Description
KF1	1	212-1BE40-0XB0	Siesmen	SIMATIC S7-1200 Series PLC CPU, Relay Output, 8-Input, Analogue Input
KF2	1	223-1BL32-0XB0	Siesmen	SIMATIC S7-1200 Series PLC I/O Module, Digital Input
PF 2-5	4	Q16P1BXXR24E	APEM	Q16 Series Panel Mount LED Indicator, Red Panel Mount Indicator 24V dc 20 mA, IP67, 16 mm
PF 1/6/8	3	249-4337	RS PRO	RS PRO Q8 Series Indicator, Bright Yellow Panel Mount Indicator, Wire Termination 24V dc, IP67, 8 mm
PF7/9	2	723-9479	RS PRO	RS PRO Green Panel Mount Indicator, 24V dc, Lead Wire Termination, IP67
SF1-8	8	T0916-0920	Arcolectric (Bulgin) Ltd	Arcolectric (Bulgin) Ltd 0916 Series Miniature Push Button Switch, Momentary, Panel, 7.1 mm Cutout,

1 Title | 2 Copyright | 3 Index | 4 Electrical - BOM | 5 Mechanical - BOM | 6 Consumables - BOM

Fig. 3- Electrical Bill of Materials (Faheeza.A 2026)

This includes a detailed list of all components with their unique identifier within the enclosure panel of our system. This includes standardised information of each component as they are crucial to ensure safe operability of the system.

Mechanical BOM

Proeon Systems Ltd				
Client :	Proeon Systems			
Project:	Railway Crossing Simulation			
Doc. Title:	Bill Of Material			
Identifier	**Quantity**	**Part Number**	**Manufacturer**	**Description**
Enclosure panel	1	1045000	Rittal	AX Series Sheet Steel Wall Box, IP66, 500 mm x 400 mm x 210 mm

Fig 4- Mechanical Bill of Materials (Faheeza.A 2026)

This enclosure was selected because it protects all the electrical and control components like the I/O, PLC and the wiring, it provides appropriate space for installation and ventilation of elements, and this reduces the risk of damage to any internal components. It has specified information that includes the manufacturer, part number and description, this is important for ease of identification in case of future maintenance or replacement of components.

Consumable

	A	B	C	D	E
8	1 mm2 cable wire R	10m	TRI01503100-E00	Cable Craft	Tri-Rated Cable 1.5mm^2 - Red - 100m
9	6mm cable wire G/Y	10m	4520004	Lapp	Lapp H07V-K Series Green, Yellow 6 mm^2 Hook Up Wire, 100 m, 4520004, Polyvinyl Chloride
10	1 mm2 cable wire BR	10m	TRI01002100	Cable Craft	Tri-Rated Cable 1.0mm^2 - Brown - 100m
11	1 mm2 cable wire BLU	10m	TR1.0BL100	CEF	1.0mm^2 Tri Rated Cable Blue (100m Drum)
12	1 mm2 cable wire BLA	10m	TR 1.00MM BLK	PRO POWER	Tri-Rated Switchgear Wire, 1mm, Black, 100m - TR 1.00MM BLK
13	1 mm2 cable wire W	10m	TRI01004100	Cable Craft	Tri Rated cable is a single core cable with flexible plain stranded copper conductors that are surrounded by a HR PVC (he chloride) insulation
14	0.5MM2 cable wire PK	10m	44A0111-20-2L	TE CONNECTIVITY	Type 44A is a high performance wire used extensively in many applications. Type 44 is made up of dual wall radiation cros
15	0.5MM2 cable wire light PK	10m	EW16/0.2PINK100M	CONCORDIA	Equipment Wire, 16/0.2mm, Pink, 100m - EW16/0.2PINK100M
16	0.5MM2 cable wire PP	10m	208-1115	RS PRO	RS PRO 1569 Series Purple 0.51 mm^2 Hook Up Wire, 20 AWG, 10, 305 m, Polyvinyl Chloride
17	0.5MM2 cable wire BLA	10m	TR 0.50MM BLK	PRO POWER	Tri-Rated Switchgear Wire, 0.5mm, Black, 100m - TR 0.50MM BLK
18	0.5MM2 cable wire Y	10m	EW1/0.6TYELL100M	CONCORDIA TECHNOLOGIES	Wire, PVC, Yellow, 23 AWG, Solid, 328 ft
19	0.5MM2 cable wire BLU	10m	196-4254	RS PRO	RS PRO Blue Hook Up Wire, 20 AWG, 16, 100 m, Polyvinyl Chloride
20	0.5MM2 cable wire BRW	10m	TRI00502100	Cable Craft	1 x 0.5mm^2 Tri-Rated Cable Brown PVC
38	0.5MM2 cable wire W	10m	TR0.5W100	CEF	Plain annealed copper wire,Insulated with PVC approved by both UL and CSA for use at 105°C in air
39	XD1 (8T) / XD2(8T)	16	1021500000	Weidmuller	TERMINAL BLOCK, DIN RAIL, 4 POSITION, 22-12AWG
40	FC1-5	5	1020000000	Weidmuller	WDU 2.5 Series Feed Through Terminal Block Dark Beige, 2.5mm^2, 1-Level, Screw

Fig 5- Consumables Bill of Materials (Faheeza.A 2026)

The Consumables BOM includes all the materials required to assemble and install other components of our system. The include items like cable ties, terminals and labelling material. They aren't part of the main control system, however it allows for proper wiring, so the enclosure panel is neat and organised; for ease during future maintenance. Each item has standardised detail such as the quantity and the type; these are to ensure there's enough materials available during installation process to prevent any delays and efficient process.

4.3 Heat and Load Calculation

Heat Calculations

Doc. Title:		Heat Calculatons						Date:	29/06/2026
Identifier	**Part Number**	**Manufacturer**	**Description**	**Operating Temp Max. (°C)**	**Qty**	**Loss (W)**	**Total Loss (W)**	**Diversity (based on Amps)**	**Loss After Diversity (W)**
KF1	212-1BE40-0XB0	Siemen	SIMATIC S7-1200, CPU 1212C, compact CPU, AC/DC/relay, onboard I/O: 8 DI 24 V DC; 6 DO relay 2 A; 2 AI 0-10 V DC, power supply: AC 85-264 V AC at 47-63 Hz, program/data memory 100 KB	60	1	11.00	11.00	1.00	11.00
PF2-5	Q16P1BXXR24E	APM	APEM Q16 Series Panel Mount LED Indicator, Red Panel Mount Indicator 24V dc 20 mA, IP67, 16 mm	85	4	0.11	0.44	1.00	0.44
PF1/6/8	249-4337	RS PRO	RS PRO Q8 Series Indicator, Bright Yellow Panel Mount Indicator, Wire Termination 24V dc, IP67, 8 mm	85	3	0.11	0.33	1.00	0.33
PF 7/9	723-9479	RS PRO	RS PRO Green Panel Mount Indicator, 24V dc, Lead Wire Termination, IP67	85	2	0.11	0.22	1.00	0.22
KF2	223-1BL32-0XB0	Siemen	SIMATIC S7-1200, Digital I/O SM 1223, 16 DI/16 DO, 16 DI 24 V DC; sourcing/sinking input, 16 DO, sourcing (sinking output), NPN transistor 0.5 A	60	1	4.50	4.50	1.00	4.50
							0.00		*0.00*
							0.00		*0.00*
						Total	**16.49**	**Pd=**	**16.49**

Fig 6 – Heat Calculation (Faheeza.A 2026)

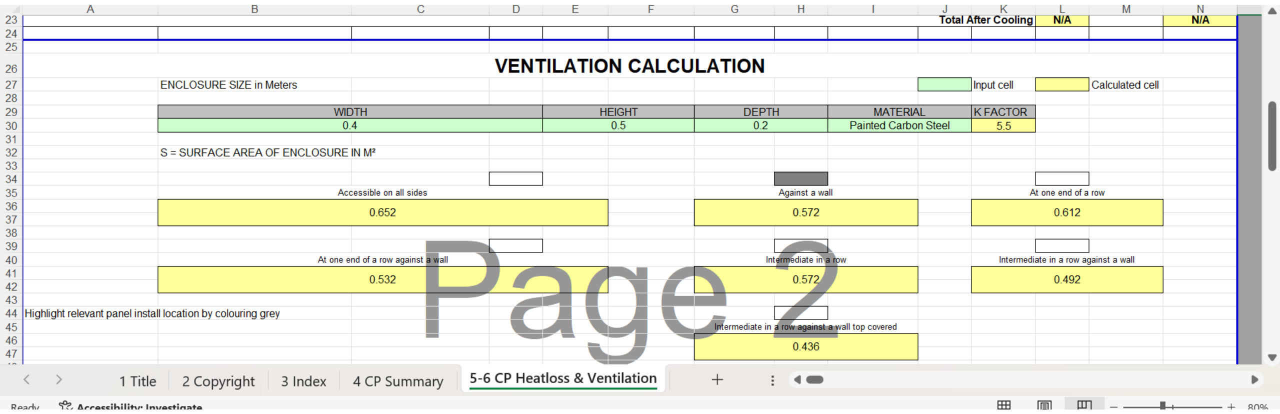


Fig 6.1- Heat Calculation (Faheeza.A 2026)

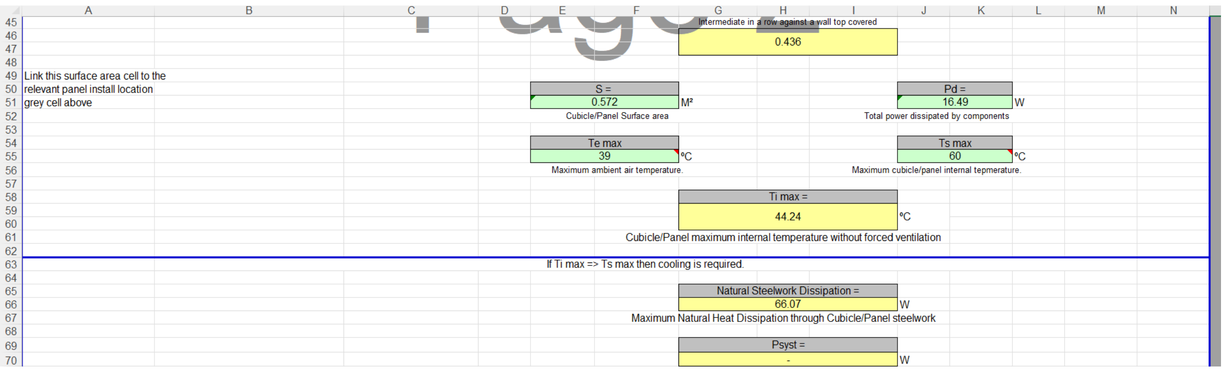


Fig 6.2- Heat Calculation (Faheeza.A 2026)

LOAD CALCULATIONS

Proeon Systems Ltd			
Client:	Proeon Systems		
Project:	Railway Crossing Simulation		
Doc. Title:			
		Doc No.	9990477-LC-001
		Revision:	0
		Date:	26/06/2026

24VDC

ID	QT	Part Numb	DESCRIPTION	LOAD REQUIREMENT	POWER FACT	EFFICIENCY (	DIVERSI	TOTAL LOAD REQUIREMENT (V	MANUFACTUR	NOTES/REMARKS
					1	1.000	1		Siesmen	
KF2	1	223-1BL32-0XB0	SIMATIC S7-1200, Digital I/O SM 1223, 16 DI/16 DO, 16 DI 24 V DC, Sink/Source, 16 DO, transistor 0.5 A	0.185	1.000	1.000	1.00	0.185	Siesmen	
PF 2-5	4	Q16P1BXXR24E	APEM Q16 Series Panel Mount LED Indicator, Red Panel Mount Indicator 24V dc 20 mA, IP67, 16 mm	0.020	1.000	1.000	1.00	0.080	APM	
PF 1/6/8	3	249-4337	RS PRO Q8 Series Indicator, Bright Yellow Panel Mount Indicator, Wire Termination 24V dc, IP67, 8 mm	0.020	1.000	1.000	1.00	0.060	RS PRO	
PF 7/9	2	723-9479	RS PRO Green Panel Mount Indicator, 24V dc, Lead Wire Termination, IP67	0.020	1.000	1.000	1.00	0.040	RS PRO	

24VDC Total Load Requirement (A)	0.365
PSU Capacity (A)	4.000
Maximum Load Used(%)	9.13%

230VAC

ID	QT	Part Numb	DESCRIPTION	LOAD REQUIREMENT	POWER FACT	EFFICIENCY (	DIVERSI	TOTAL LOAD REQUIREMENT (V	MANUFACTUR	NOTES/REMARKS
KF1	1	212-1BE40-0XB0	SIMATIC S7-1200, CPU 1212C, compact CPU, AC/DC/relay, onboard I/O: 8 DI 24 V DC; 6 DO relay 2 A; 2 AI 0-10 V DC, power supply: AC 85-264 V AC at 47-63 Hz, program/data memory 100 KB	0.500	1.000	1.000	1.00	0.500	Siesmen	
								0.000		
								0.000		
								0.000		

230VAC Total Load Requirement (A)	0.500
PSU Capacity (A)	3.000
Maximum Load Used(%)	16.67%

Fig 7 – Load Calculations (Faheeza.A 2026)

HEAT and LOAD CALCULATIONS OVERVIEW

Heat and load calculations were used to confirm whether the enclosure and all electrical components are suitable for operation of the simulator. They helped ensure that reliably and safety whilst preventing excess heat dissipation during operation. It considered the power loss for each component including the Siemsen S7-1200 PLC, the I/O and the panel lamps (warning lights). They were evaluated using the manufacturers specification to determine its operating temperature, quantity, power loss and overall heat loss to the enclosure.

HEAT CALCULATION OVERVIEW

The heat loss was calculated by making sum of all individuals components heat loss. These include:

Siemens S7-1200 PLC: 11.00 W
Red LED indicators: 0.44 W
Yellow LED indicators: 0.33 W
Green LED indicators: 0.22 W
Siemens digital I/O module: 4.50 W

The Total heat loss is 16.49 W

This helps confirm that the enclosure is suitable to dissipate heat during operating process. The S7-1200 PLC and Siemens digital I/O modules have a maximum operating temperature of 60°C, while the panel LED indicators have a maximum operating temperature of 85°C. These help confirm that they can operate safely within the enclosure.

LOAD CALCULATIONS

The load calculation for components using 24DC include:

- Siemens Digital I/O module.
- Panel LED indicators.

The total 24VDC load requirement is 0.365 A

The 24VDC power supply has a rated capacity of 4A

The maximum calculated load utilisation was 9.13%

This shows that the selected power supply has sufficient load capacity to operate with the component.

For 230AC

The component that uses it is

- Siemens S7-1200 PLC

The load requirement is 0.500 A while the power supply capacity is 3A. The maximum calculated load utilisation was16.67%

This shows that the incoming supply is accurately rated and that the equipment will operate below its maximum capacity.

4.4 PLC Programming (TIA V18 PORTAL)

The purpose of using TIA V18 PORTAL was to configure, program, test and diagnose the S7 1200 PLC by processing signals, execute the programmed sequence and outputs which includes the warning lights and barriers.

Before creating the control logic programmes, an input and output tag table was made within TIA Portal. The tag table defined the variable its data type and address for all the inputs and out puts in the system and its clearly shown in *fig 8*

PLC tags

	Name	Tag table	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment
1	I_T1_Outer_Wst_Act	Inputs	Bool	%I8.0	☐	☑	☑	☑	SF1
2	I_T1_Inner_Wst_Act	Inputs	Bool	%I8.1	☐	☑	☑	☑	SF2
3	I_T1_Inner_Est_Act	Inputs	Bool	%I8.2	☐	☑	☑	☑	SF3
4	I_T1_Outer_Est_Act	Inputs	Bool	%I8.3	☐	☑	☑	☑	SF4
5	I_T2_Outer_Wst_Act	Inputs	Bool	%I8.4	☐	☑	☑	☑	SF5
6	I_T2_Inner_Wst_Act	Inputs	Bool	%I8.5	☐	☑	☑	☑	SF6
7	I_T2_Inner_Est_Act	Inputs	Bool	%I8.6	☐	☑	☑	☑	SF7
8	I_T2_Outer_Est_Act	Inputs	Bool	%I8.7	☐	☑	☑	☑	SF8
9	O_Wrn_Lgt_Wst_1	Outputs	Bool	%Q8.0	☐	☑	☑	☑	PF2
10	O_Wrn_Lgt_Est_1	Outputs	Bool	%Q8.1	☐	☑	☑	☑	PF3
11	O_Wrn_Lgt_Wst_2	Outputs	Bool	%Q8.2	☐	☑	☑	☑	PF4
12	O_Wrn_Lgt_Est_2	Outputs	Bool	%Q8.3	☐	☑	☑	☑	PF5
13	O_Barrier_Nth_Opn	Outputs	Bool	%Q8.5	☐	☑	☑	☑	PF6
14	O_Barrier_Nth_Cld	Outputs	Bool	%Q8.4	☐	☑	☑	☑	PF7
15	O_Barrier_Sth_Opn	Outputs	Bool	%Q8.7	☐	☑	☑	☑	PF8
16	O_Barrier_Sth_Cld	Outputs	Bool	%Q8.6	☐	☑	☑	☑	PF9
17	M_T1_Outer_Wst_Act	Memory	Bool	%M2.0	☐	☑	☑	☑	SF1
18	M_T1_Inner_Wst_Act	Memory	Bool	%M2.1	☐	☑	☑	☑	SF2
19	M_T1_Inner_Est_Act	Memory	Bool	%M2.2	☐	☑	☑	☑	SF3
20	M_T1_Outer_Est_Act	Memory	Bool	%M2.3	☐	☑	☑	☑	SF4
21	M_T2_Outer_Wst_Act	Memory	Bool	%M2.4	☐	☑	☑	☑	SF5
22	M_T2_Inner_Wst_Act	Memory	Bool	%M2.5	☐	☑	☑	☑	SF6
23	M_T2_Inner_Est_Act	Memory	Bool	%M2.6	☐	☑	☑	☑	SF7
24	M_T2_Outer_Est_Act	Memory	Bool	%M2.7	☐	☑	☑	☑	SF8

Fig 8 Tag Table for Train Crossing Simulator (Faheeza.A incl Proeon Team member 2026)

The software consists of programme blocks containing organisation, function and data blocks. The organisation block is the block of code that's called from the processor operating system while the function block performs specific routine. Data block is a memory area that could contain a function or data to be used within the programme. An example of a code block is shown in *fig 9*. Within these function blocks they are basic instructions used to be able to make them these could include the TON, MOVE block and different gates. These are also show in fig9 and *fig 9.1*.

The first function block is the Power-Up Timer block, shown in *fig 9*. This block was created to manage the initial timing sequence of step precondition before the first step could begin. The use of a TON (Timer on Delay) allowed the PLC to introduce a delay before the first step which is the warning lights and barriers closing. This ensures that the system completes this as part of preconditions that need to be meet before output (warning lights and barriers closing) are activated, improving reliability during operation.

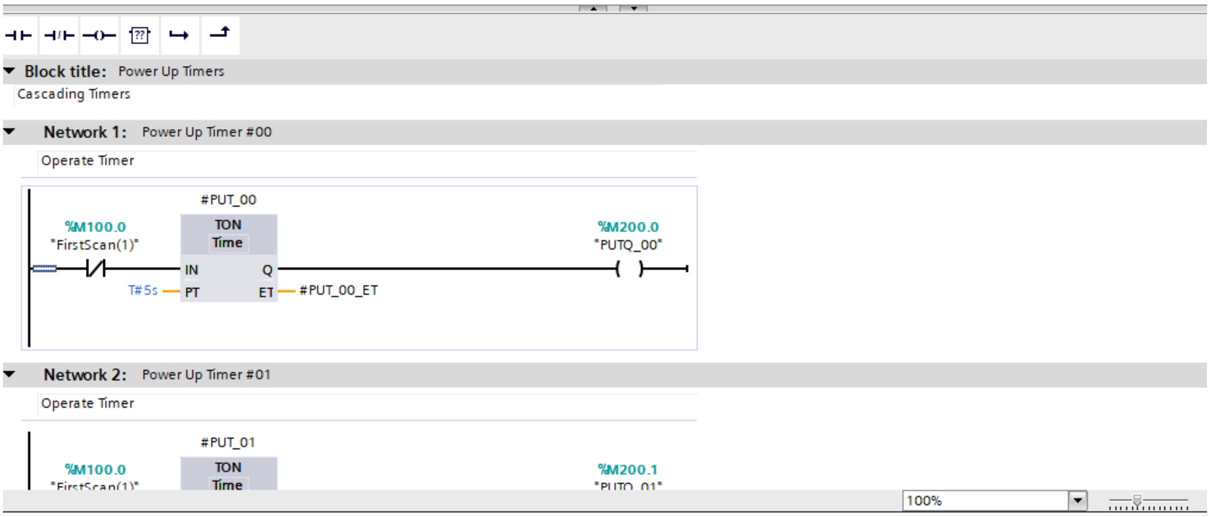


Fig 9 – EXAMPLAR FUNCTION BLOCK TABLE POWER UP TIMER FOR TRAIN CROSSING SIMULATOR (Faheeza.A incl Proeon Team members- 2026)

The second function block includes a range of basic instructions, including which are MOVE block and comparator in *Fig 9.1*. These were used in system to determine the appropriate response from the simulator. Comparator allowed the program to assess value and confirm whether preconditions were met before allowing the sequence to continue. Logic gates were used to combine multiple input, ensuring that outputs were only activated when the preconditions were met.

The MOVE block was also executed to transfer data values between portals memory locations in data block. This helped communication between different blocks within the program.

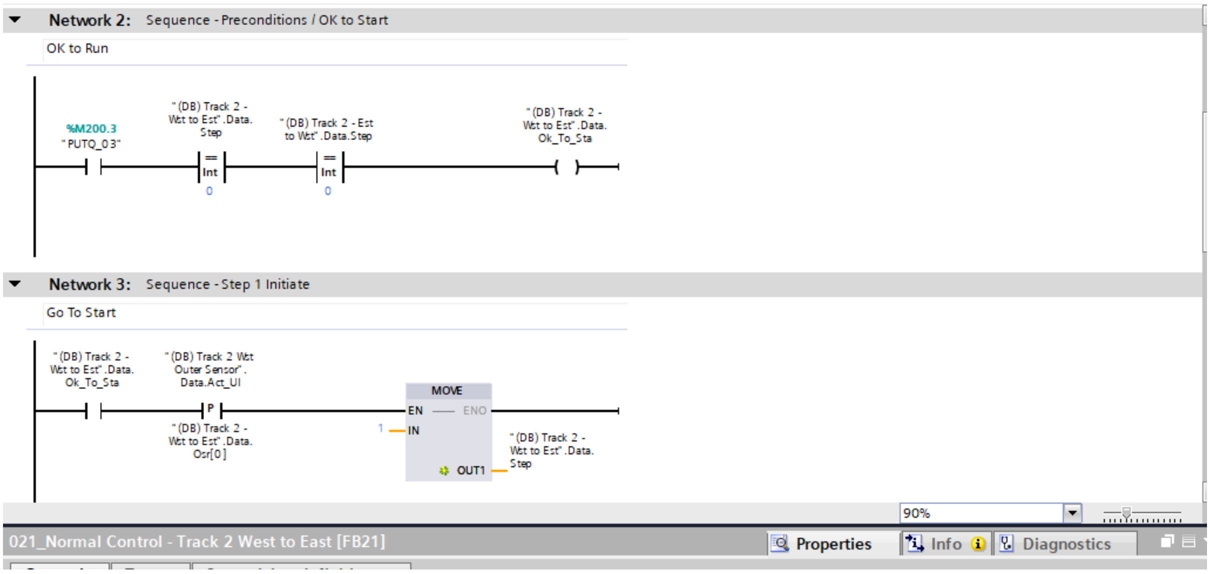


Fig 9.1- EXAMPLAR FUNCTION BLOCK WITH DIFFERENT BASIC INSTRUCTIONS I.E COMPARATOR FOR TCCS (Faheeza.A incl Proeon Team members- 2026)

These function blocks demonstrate how the portal and elements is used within the project. By separating different control functions into different blocks, the simulator program became easier to modify and troubleshoot.

4.5 HMI Design

The purpose of the HMI was to allow users to interact with the system, by allowing them to be able to monitor operating status whilst being able to observe the sequence of operation between each stage. The process included creating HMI tags, designing graphical screens, and assigning functions to different interface elements.

In *fig 10* we have the template of the main screen and the background for the rest of screens created later.

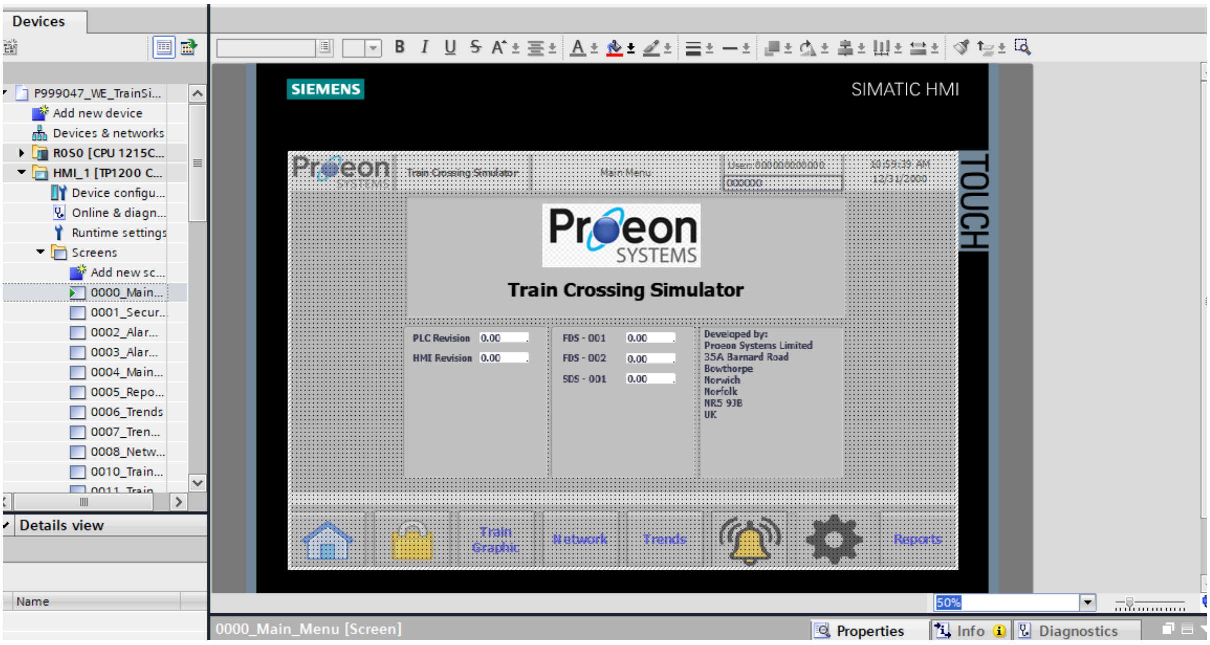


Fig 10- Main Screen from template 1 HMI DESIGN WITH FEATURES (Faheeza.A incl. Proeon Team members 2026)

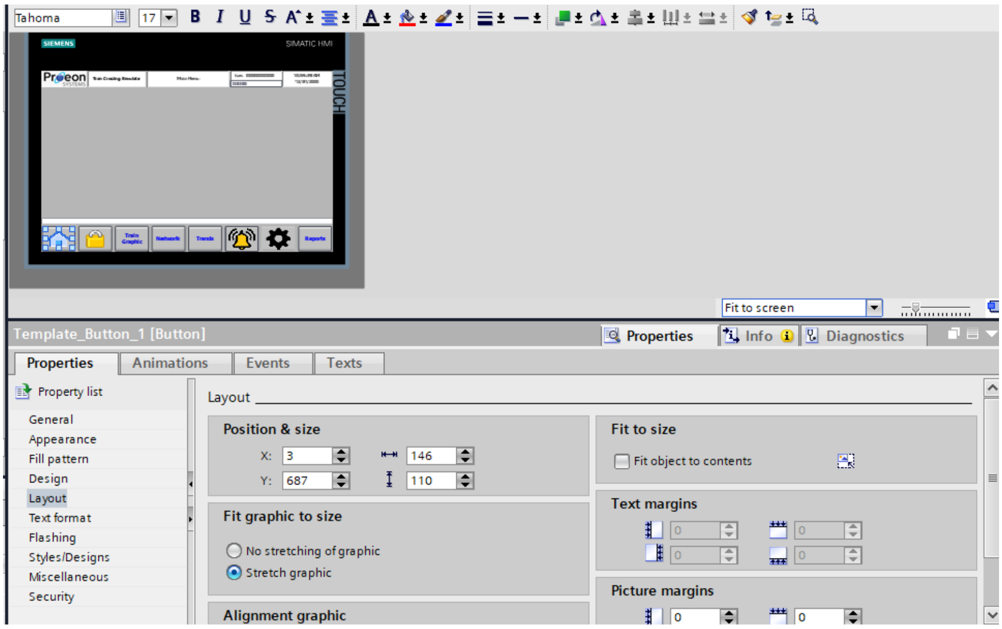


Fig 10.1- How Elements/other basic object are modified (*Faheeza.A* incl Proeon Team members 2026)

The image above shows the process used to customise each HMI element. Each element was modified according to its purpose within the system. For example, home graphic was placed on top of a button, this had standardised modification of its position and size as its same for the rest along that line. This also includes its appearance (colour), the text font and size as well as the design layout. This process was replicated throughout the HMI design for different elements with different function.

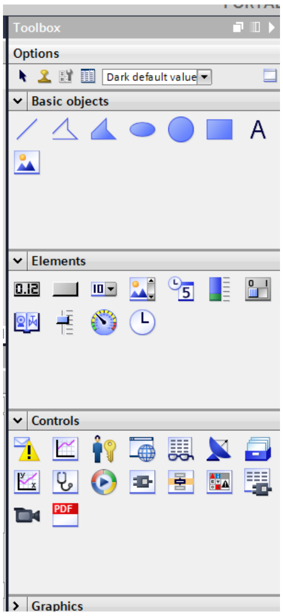


Fig 11-: TIA Portal V18 HMI Toolbox – Faheeza incl Proeon Team members 2026

This how what was used and what's needed to customise different screens for the HMIs interface

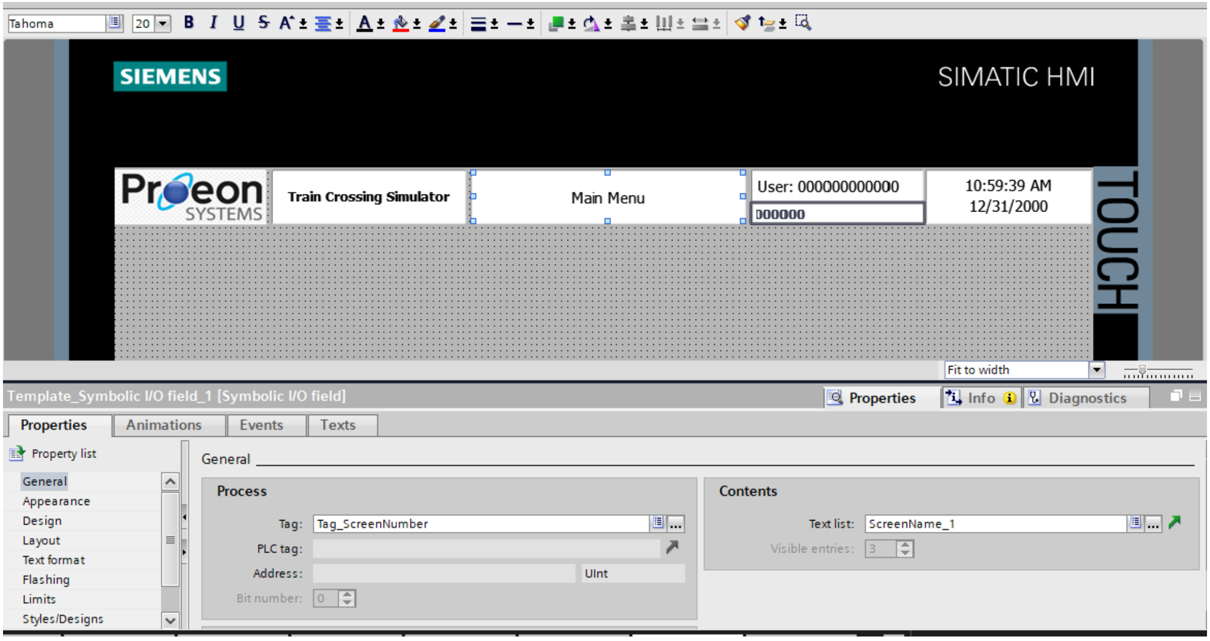


Fig 12- HMI Main Menu Modification for Navigation Between Multiple Screens in TIA Portal V18 (Faheeza incl Proeon Team members 2026)

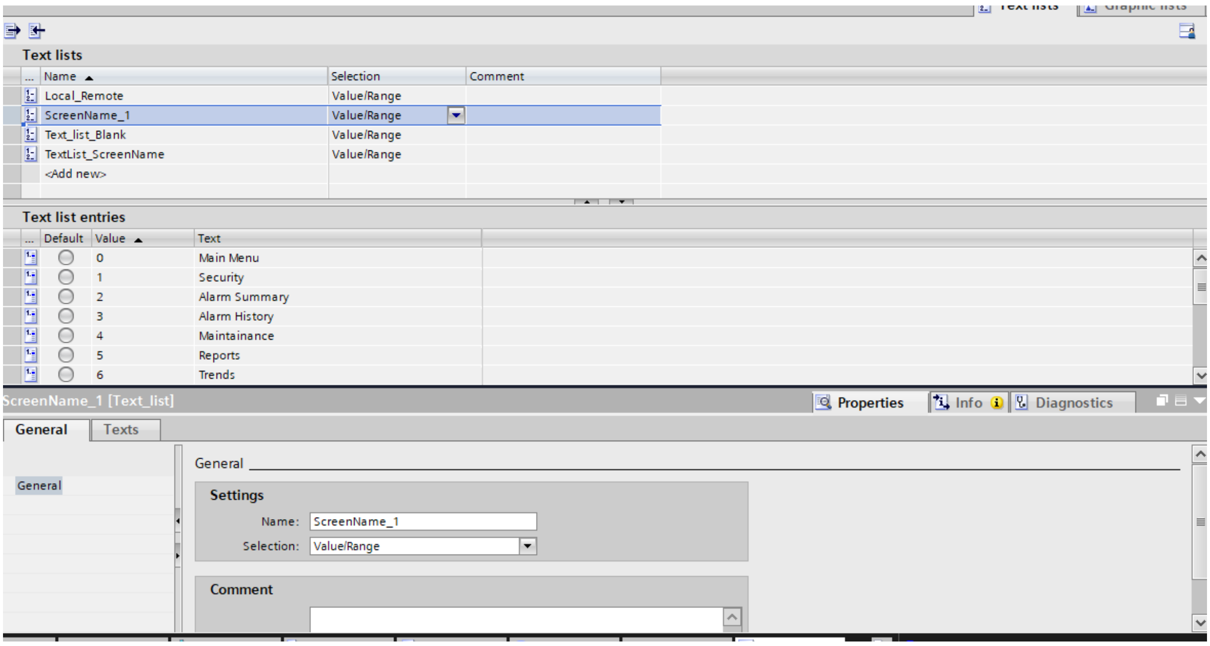


Fig 12.1- HMI Main Menu Modification for Navigation Between Multiple Screens in TIA Portal V18 (Faheeza incl Proeon Team members 2026)

5 Testing and Results

Testing was carried out to ensure that the Train Crossing Simulator operated in accordance with the Functional Design Specification (FDS). The testing process focused on verifying the programme logic, HMI and the overall sequence of system operation shown in *fig 13* and *fig 13.1* below

The approach taken was going through each stage and making sure logic sequence was accurate alongside the master copy provided by authoritarian under strict supervision; any error identified by them the team would then have to do extensive research on the function block to figure out how to troubleshoot and configure it.

This included confirming that all inputs were correct, outputs responded as expected and timing functions using TON timers operated accurately.

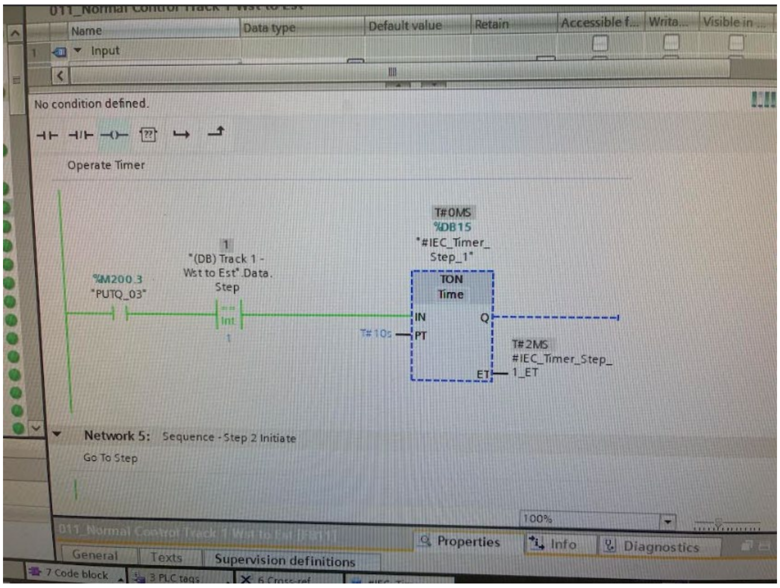


Fig 13- Monitoring of Program Block in Online Mode TIA Portal V18 (Faheeza.A incl Proeon Team members 2026)

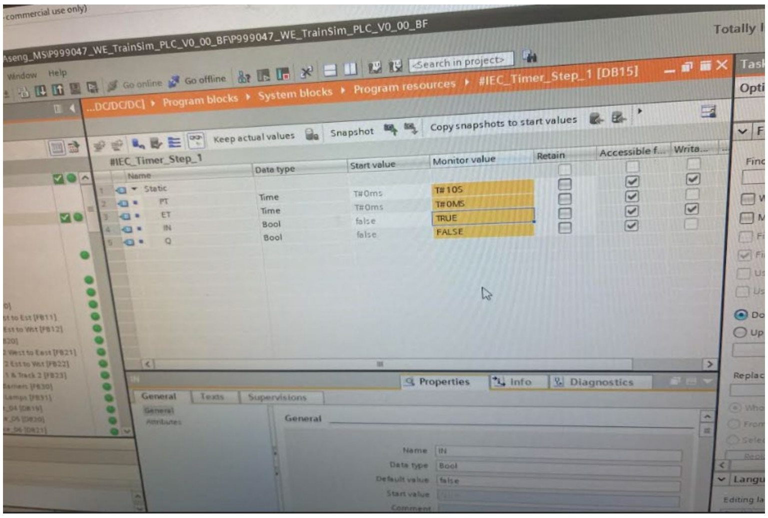


Fig 13.1- Monitoring of Program Block in Online Mode TIA Portal V18 (Faheeza incl Proeon Team members 2026)

Fig 13.2

Test Summary Outcome

During initial testing, the issue was identified where some of the warning lights did not operate. After further investigation and several troubleshooting attempts, it was identified we incorrectly assigned tag within certain function blocks. As a result, the outputs were not correctly executed for its intended purpose.

This issue was solved by reviewing and correcting the tags within the software. After executing these modifications, the simulator operated as expected, with all outputs responding accurately. it was also observed by team members that accurate evaluation of timing functions required the use of monitoring within TIA Portal.

Due to the use of TON timers, it was necessary to observe the system in real time to confirm the delays were functioning correctly before using the buttons. After the adjustments were made, the system was reset and all functions operated in the correct sequence.

6 Evaluation

This project goal was to use a PLC and HMI to build, program, and test a train crossing simulator that would show how a real-world train crossing would safely operate under certain preconditions. Overall, the system was able to achieve this goal by operating in the appropriate order, which included turning on the warning lights, delay timers, and barrier.

The TIA V18 Portal operated by controlling the sequence with a variety of components, including function blocks, timers (TON), and comparators. The delay timer made sure that every step of the procedure took place in the exact sequence. Additionally, the HMI functioned effectively, offering a clear visual depiction of the system and enabling user engagement via buttons and indications. To ensure that the system was both practical and easy to use, the project also required creative thinking in the design of the HMI interface.

During the testing stage under supervision, a problem identified with several of the warning lights not working properly was found during the testing phase under supervision. This resulted from certain function blocks' incorrect tag name. The system worked as intended after the tag was examined and corrected. This demonstrated how crucial it is to accurately tag program blocks and double-check the program once it has been imputed. Additionally, it was found that real-time system monitoring was crucial when using timers because it made it possible to identify delays.

Throughout the project, support was provided by members of the Proeon Systems team and critical thinking skill of other interns who offered guidance and support during the development and testing stages. Their contribution was useful when troubleshooting issues within the PLC program, such as identifying errors in tag naming and improving the overall structure of the function blocks. This support helped ensure that the system was developed in line with the company standards and improved the overall outcome of the project.

Another strength of this project was the integration of the PLC and HMI; this shows how industrial systems combine automation and operator control. The programming approach also made the system easier to understand and troubleshoot in case of any error.

Overall, the project exhibited a strong identification of the importance of PLC programming alongside HMI design and system testing within an industrial automation application.

7 Conclusion

In conclusion, the project successfully achieved its aim of designing, programming and testing a Train Crossing Simulator using a PLC and HMI. The simulator was able to operate in a controlled sequence, similarly to how a real train crossing system works.

The project showed how PLCs and HMIs are used together in industrial automation to control processes and provide user interaction. It also helped develop key skills such as programming, design and troubleshooting.

Overall, this project provided a clear understanding of how automated control systems work and how they can be applied to real-world engineering situations.

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