

PLCs

PLC assignment 2 (Practical)

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System Specifications

Introduction

There is a requirement to sort items travelling along a conveyor according to size. This document will outline the proposed solution to the previously mentioned issue, detailing the system components, operations and associated indications, followed by the sequence of operations. I will conclude with a summary of the proposed solution.

Functional specification of solution

The following is a description of the functional requirements for a conveyor control system. The system will sort items of three different sizes into their allocated bins. The user will be able to manually start and stop the conveyor using green and red switches respectively as well as by use of a human machine interface (HMI). The sorting of the items will be automated once the system is started by the user. Item sizes will be detected by two optical sensors positioned at the start of the conveyor. The user will be able to check the number of each item that has been sorted via a counter on the HMI screen.

System Components

Operator Interface

- Green indicator LED
- Red indicator LED
- Start switch (Green)
- Stop switch (Red)
- Human machine interface (HMI)

System Operation

- Siemens SIMATIC S7 programmable logic control
- Optical sensors
- 24V motor to drive conveyor
- Pressurised air cylinders
- Air pressure vessel with manual pump

Operations and indications

Operation	Indication
Start conveyor	
User to press and hold the green start switch or green start button on HMI for 3 seconds to start the conveyor.	>During the 3 second hold, the green lamp will flash. >If the switch is released before 3 seconds, the conveyor will not start. >After the 3 second hold, the green lamp will remain ON to indicate that the conveyor is running.
Stop conveyor	
User can manually stop the conveyor at any time by pressing the red stop switch or red stop button on HMI.	Green lamp will turn OFF, red lamp will turn ON to indicate that the conveyor is stopped.
The conveyor will automatically stop if no items are detected for 30 seconds.	Green lamp will turn OFF, red lamp will turn ON to indicate that the conveyor is stopped.
Item sorting	
Optical sensor 1 will start a timer to count time between its signal being broken to when it is made again (this determines the size of the item). Optical sensor 2 will start a timer to delay the operation of the required cylinder. The corresponding cylinder will push then item into correct bin.	On screen counter will indicate ascending number of operations for each cylinder.

Sequence of Operations

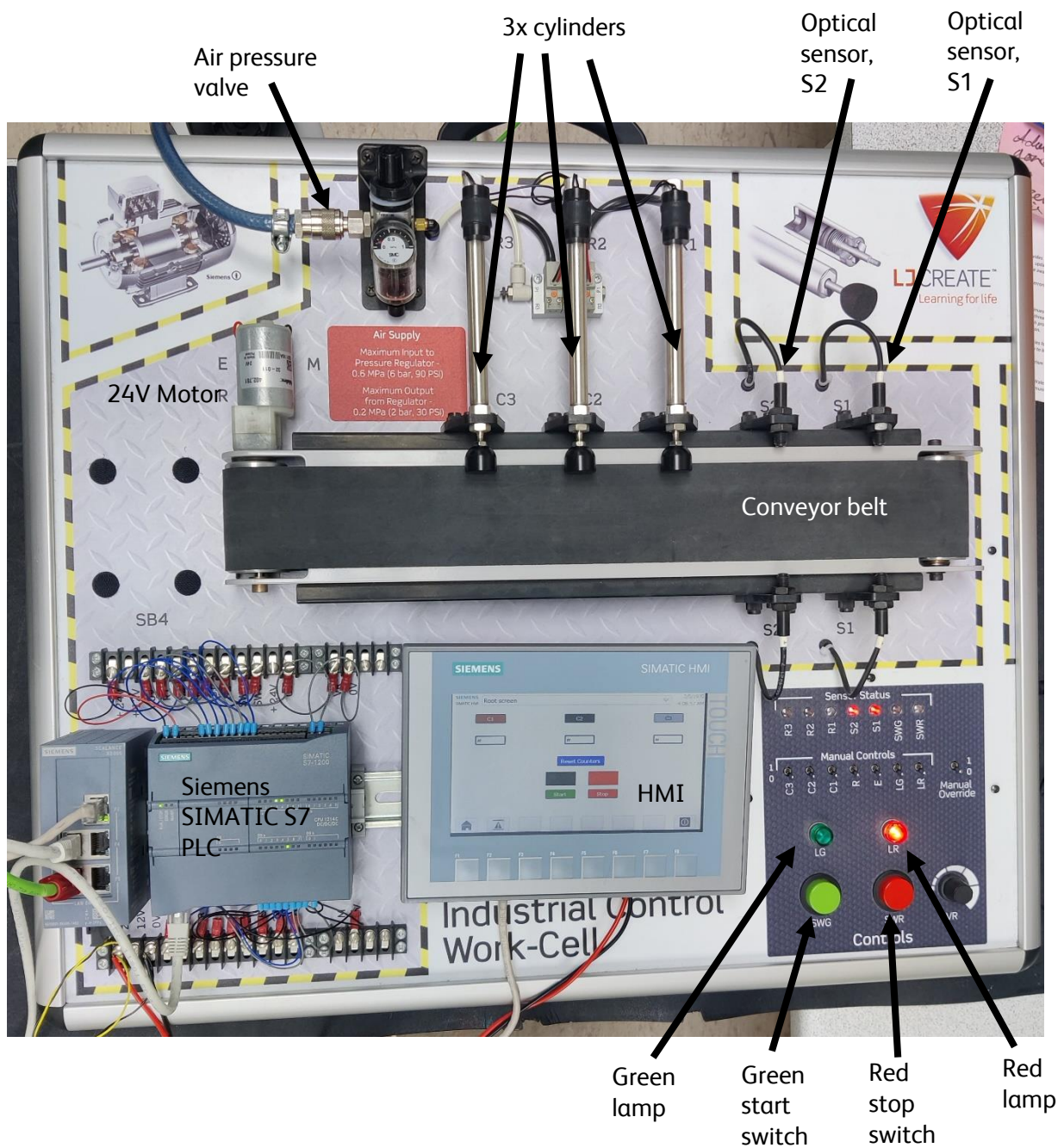
1. The user presses and holds the green start switch or green start button on the HMI.
2. The green lamp starts flashing.
3. The system counts 3 seconds.
4. If the switch is held for the full 3 seconds, the conveyor motor is activated, and the green lamp stays on. If the switch is released before 3 seconds, the green lamp stops flashing, and the conveyor remains off.
5. Optical sensor 1, S1, will wait for its signal to break and start a timer.
6. Optical sensor 1, S1, waits for the signal to make to stop the timer.
7. PLC will decide which size item is on the conveyor.
8. Optical sensor 2, S2, will wait for its signal to break, this will start a timer to delay the action of the required cylinder.
9. Relevant cylinder will activate, pushing item off of the conveyor and into the relevant bin.
10. User can press the red stop switch or wait for 30 seconds of inactivity to switch off the system.
11. Conveyor motor will stop.
12. Red lamp will be on.

Summary

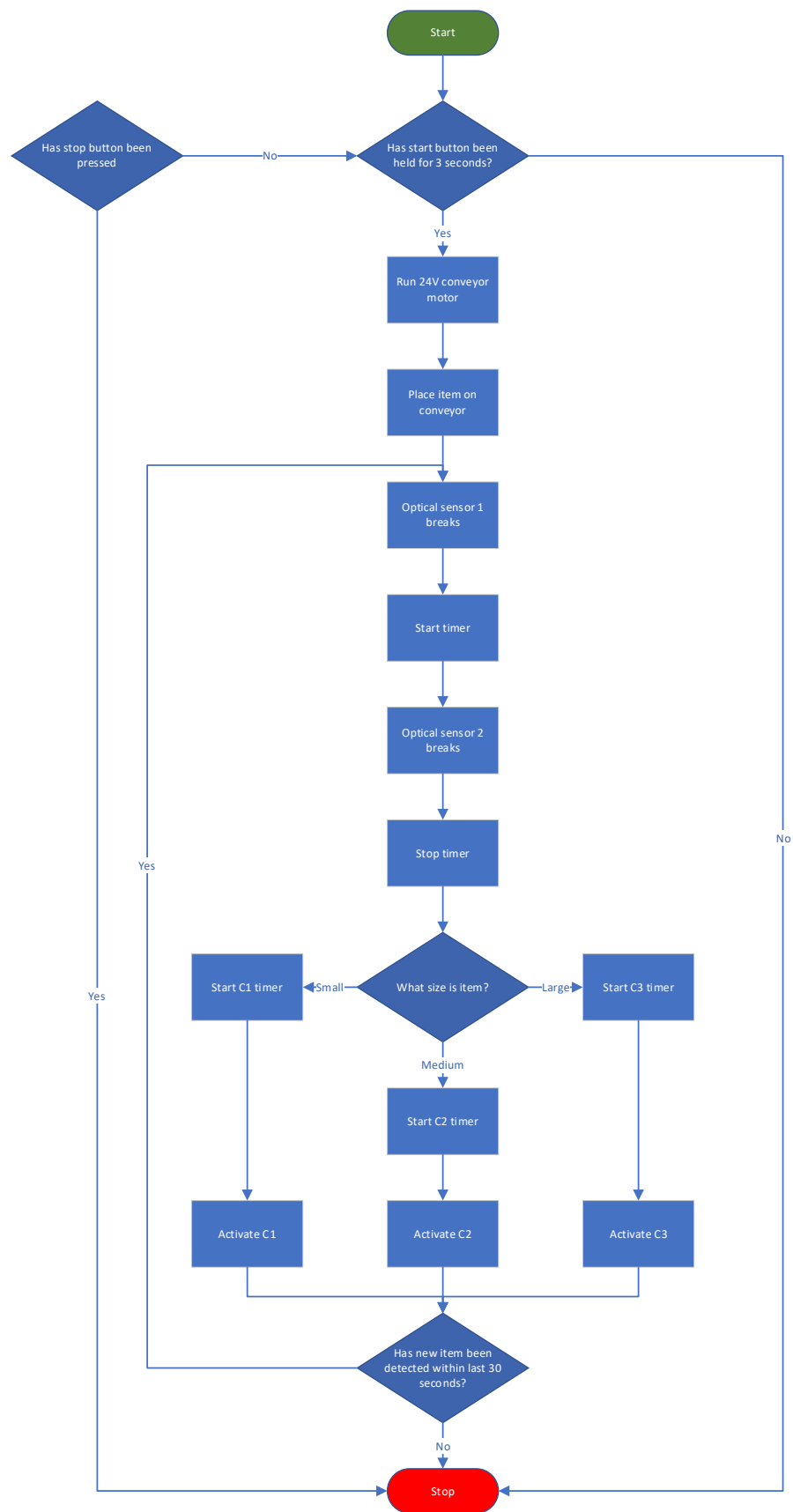
This functional specification outlines the operation, indicators, and automatic controls for the conveyor system, ensuring efficient and safe operation for sorting items into bins.

Design

Below is a labelled photo of the conveyor system that I have programmed.



System Flow Chart



Above is a flow chart that maps the processes and decision made by the conveyor system.

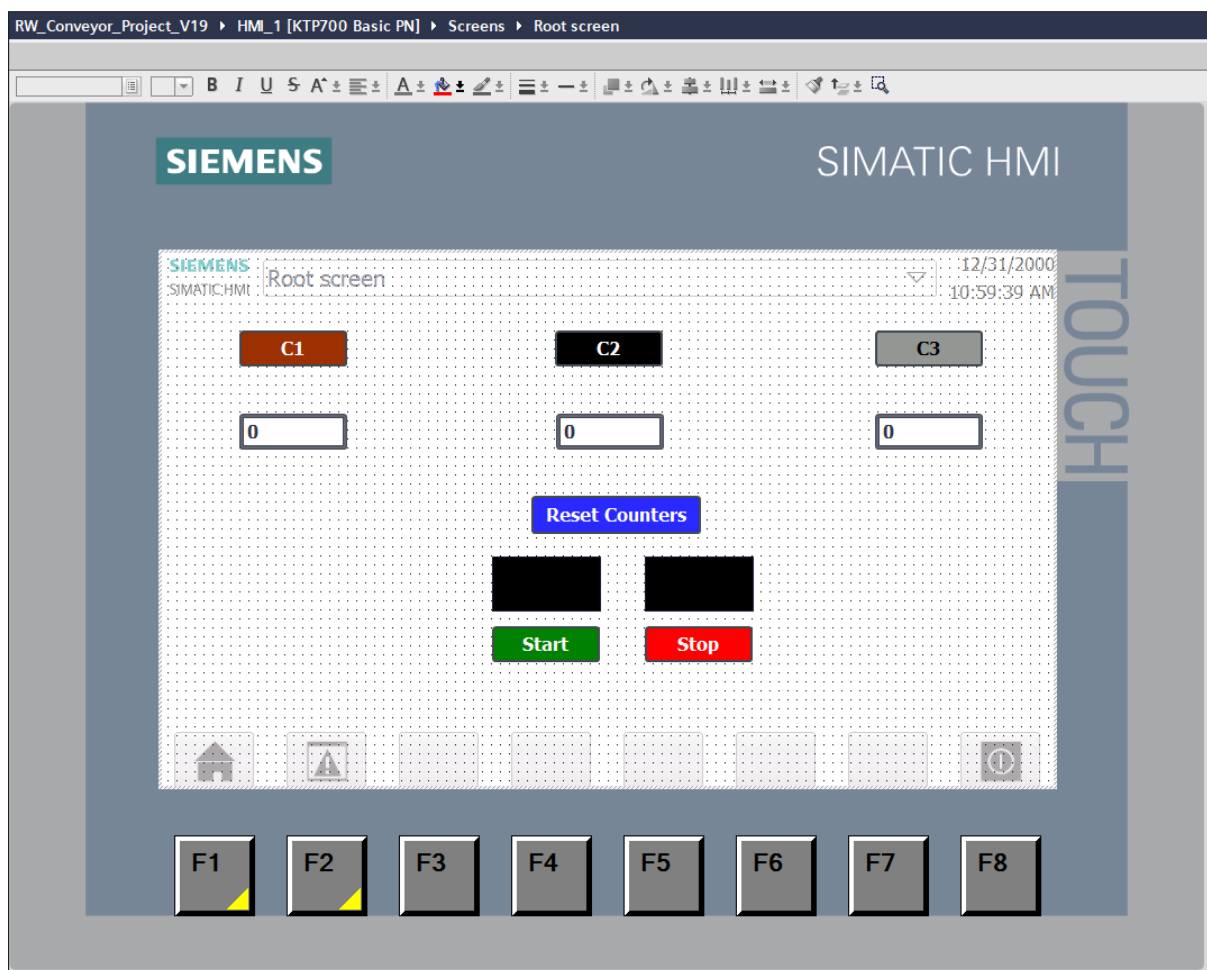
HMI

Below is the HMI screen that I designed. C1, C2 and C3 buttons allow the user to manually operate each of the corresponding cylinders. These can be used for maintenance to check the operation of the cylinders when the system is not in use.

Below the cylinder buttons are the counters for each corresponding cylinder. They will count up each time the relevant cylinder is operated.

In the middle is the counter reset button. Pressing this button will reset all of the counters to zero.

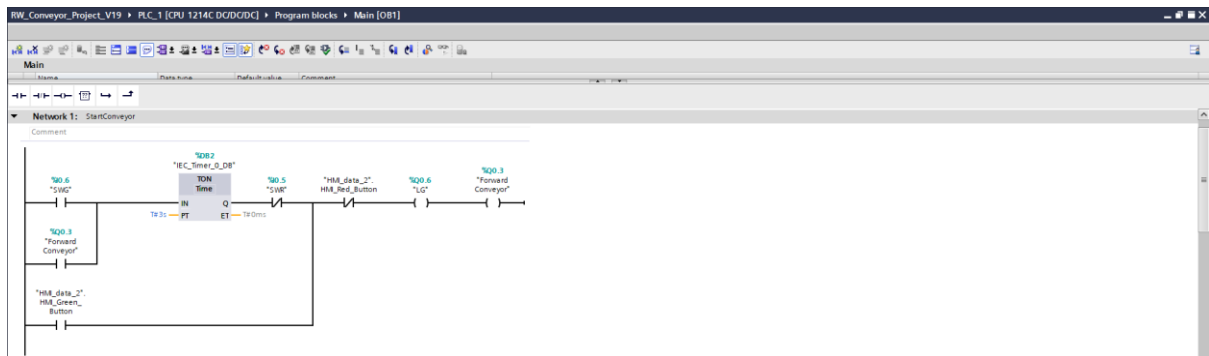
Finally, the green start button and red stop button are at the bottom of the screen. To start the operation of the conveyor, the start button will need to be held for a period of three seconds. If the start button is not held for three seconds, the conveyor will not start. In order to stop the conveyor, the user must only press the stop button. There is no requirement to hold the stop button for any period of time.



Network design

Network 1

Network 1 is my start conveyor network. There is a timer that counts down for three seconds from when the green start switch, SWG, is pressed and held. Once the three seconds is met, the green lamp, LG, comes on and the conveyor starts to move forward. Within this network is a normally closed function for the red stop switch. This means that it does not affect the operation of the system until it is pressed. When the red stop switch is pressed, it breaks the circuit and causes the conveyor to stop.



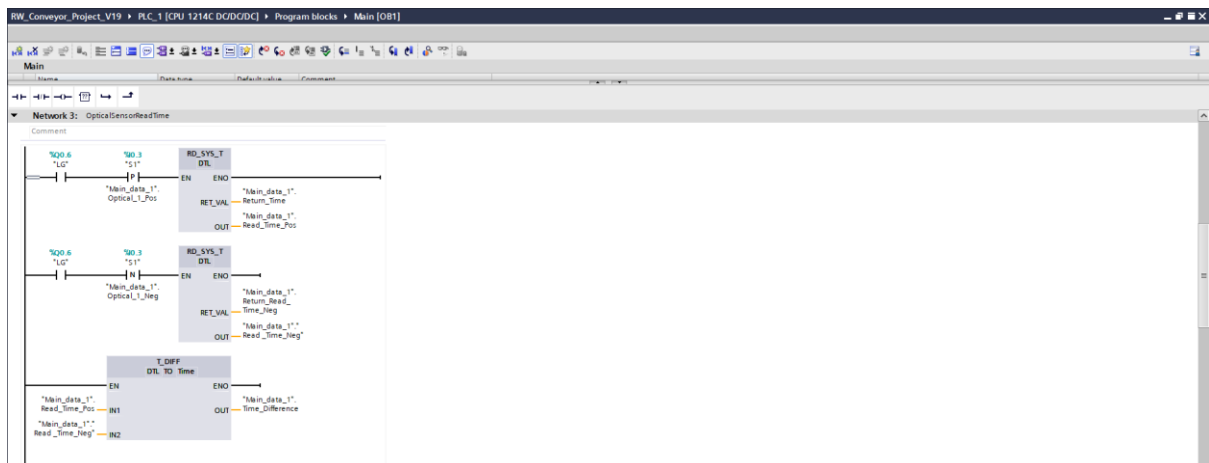
Network 2

Network 2 is my flashing green lamp network. For the three second duration that the green start switch is being held, the green lamp will flash at a rate of 1Hz. If the green switch is held for greater than three seconds, the conveyor starts and this becomes the input to maintain the supply to the green lamp and it will stay on and steady for as long as the conveyor is running.



Network 3

Network 3 is the optical sensor read time. The green lamp becomes the input for this network and starts the optical sensor, S1, timers for both positive and negative signals. The readings for each are sent to T_DIFF where the time difference is calculated indicating the size of the item.



Networks 4, 5 and 6

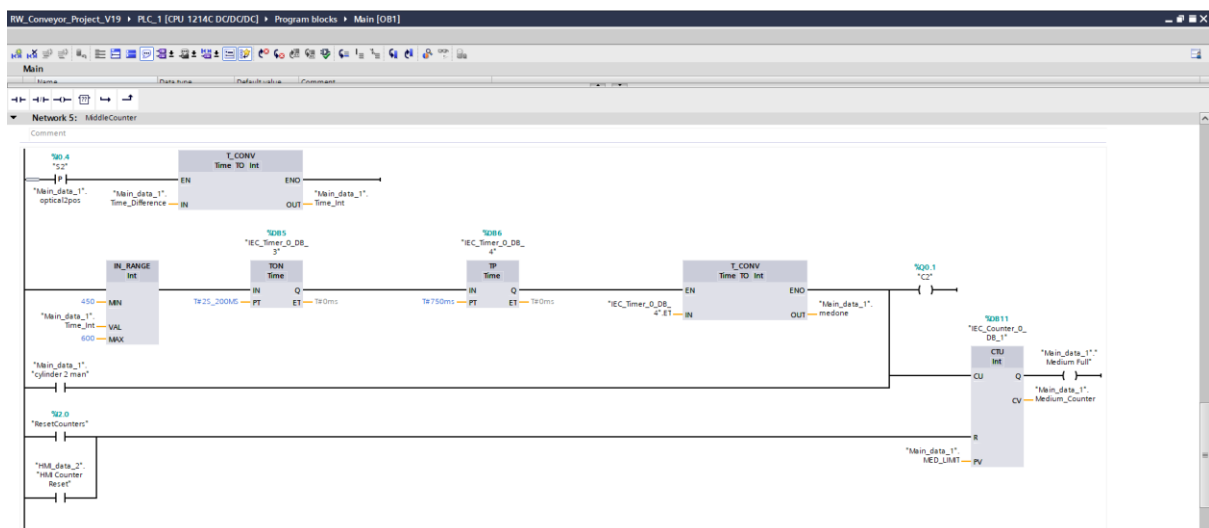
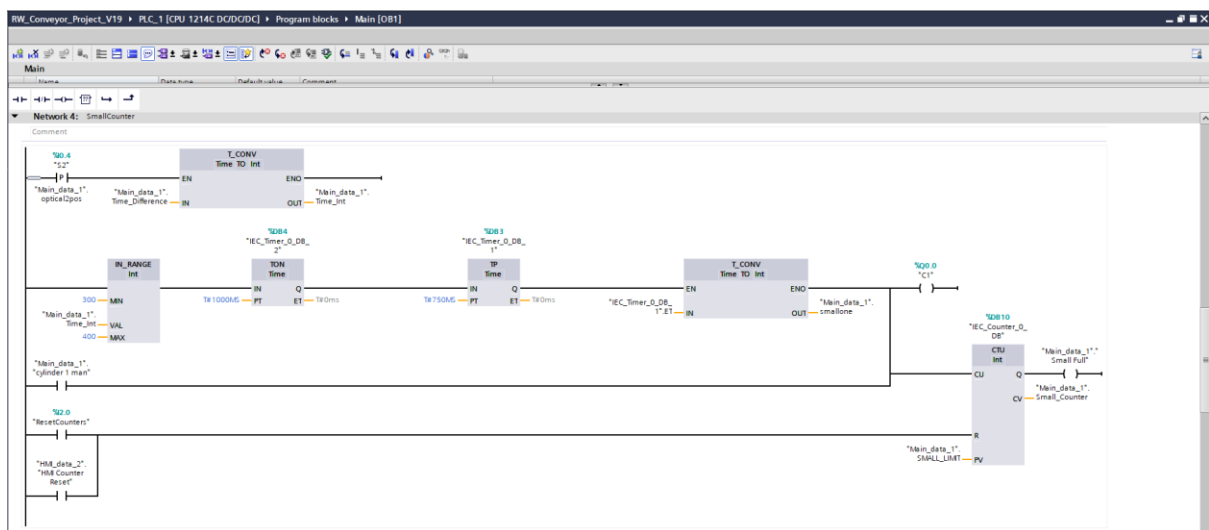
Networks 4, 5, and 6 are the item sorting networks. The time value sent by T_DIFF (above) is sent to the T_CONV where the time value is converted to an integer value. Each network has an integer range, IN_RANGE, that is looking for different ranges of integer before starting their own network.

If the integer sent by T_CONV is between 300 and 400, it will activate the small item network, network 4.

If the integer sent by T_CONV is between 450 and 600, it will activate the medium item network, network 5.

If the integer sent by T_CONV is between 650 and 850, it will activate the large item network, network 6.

Each network then has it's own timer to delay the operation of it's relevant cylinder based on how far down the conveyor the item needs to travel.



Below is a screenshot of my tag table.

RW_Conveyor_Project_V19 ▸ PLC_1 [CPU 1214C DC/DC/DC] ▸ PLC tags

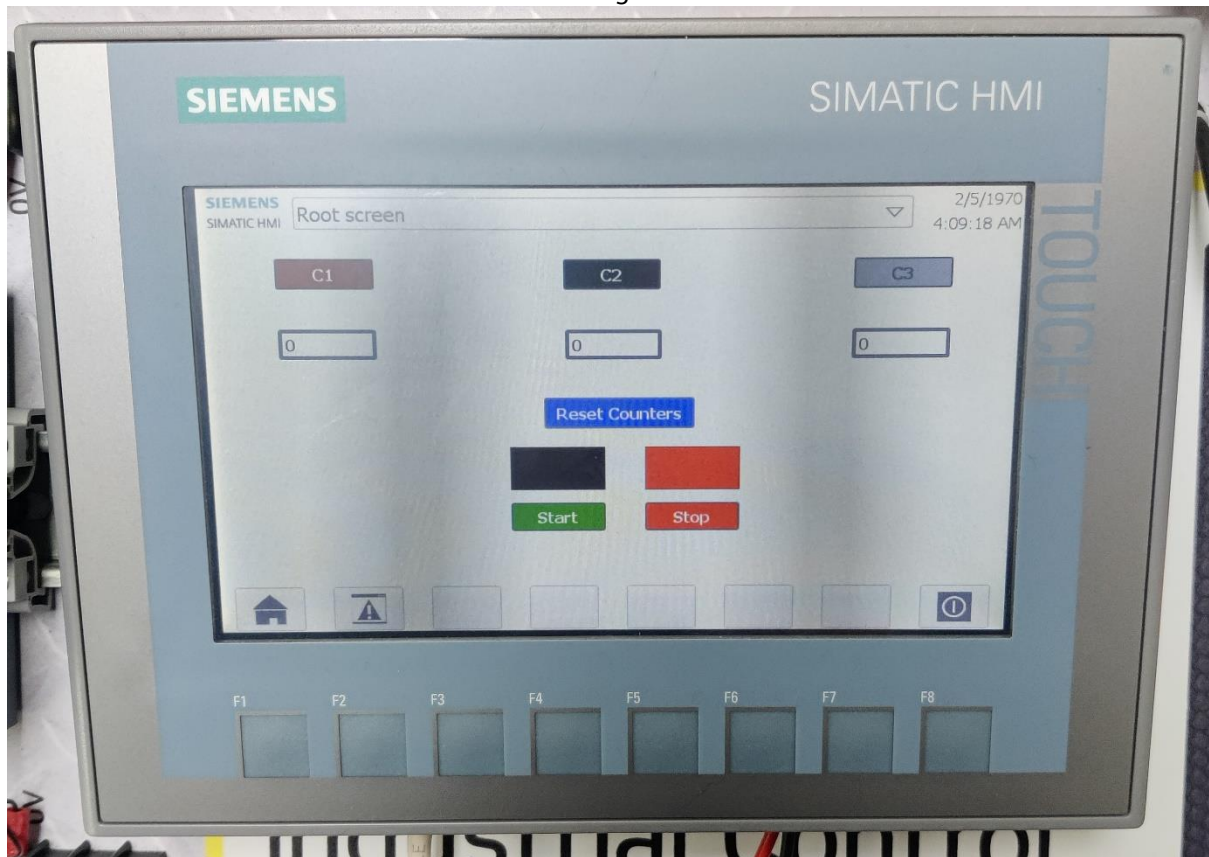
	Name	Tag table	Data type	Address	Retain	Acces...	Writa...	Visibl...
1	C1	Default tag table	Bool	%Q0.0	☐	☒	☒	☒
2	R1	Default tag table	Bool	%I0.0	☐	☒	☒	☒
3	R2	Default tag table	Bool	%I0.1	☐	☒	☒	☒
4	R3	Default tag table	Bool	%I0.2	☐	☒	☒	☒
5	S1	Default tag table	Bool	%I0.3	☐	☒	☒	☒
6	S2	Default tag table	Bool	%I0.4	☐	☒	☒	☒
7	SWR	Default tag table	Bool	%I0.5	☐	☒	☒	☒
8	SWG	Default tag table	Bool	%I0.6	☐	☒	☒	☒
9	ForwardConveyor	Default tag table	Bool	%Q0.3	☐	☒	☒	☒
10	ReverseConveyor (must Stop c...	Default tag table	Bool	%Q0.4	☐	☒	☒	☒
11	LR	Default tag table	Bool	%Q0.5	☐	☒	☒	☒
12	LG	Default tag table	Bool	%Q0.6	☐	☒	☒	☒
13	System_Byte	Default tag table	Byte	%MB1	☐	☒	☒	☒
14	FirstScan	Default tag table	Bool	%M1.0	☐	☒	☒	☒
15	DiagStatusUpdate	Default tag table	Bool	%M1.1	☐	☒	☒	☒
16	AlwaysTRUE	Default tag table	Bool	%M1.2	☐	☒	☒	☒
17	AlwaysFALSE	Default tag table	Bool	%M1.3	☐	☒	☒	☒
18	Clock_Byte	Default tag table	Byte	%MB0	☐	☒	☒	☒
19	Clock_10Hz	Default tag table	Bool	%M0.0	☐	☒	☒	☒
20	Clock_5Hz	Default tag table	Bool	%M0.1	☐	☒	☒	☒
21	Clock_2.5Hz	Default tag table	Bool	%M0.2	☐	☒	☒	☒
22	Clock_2Hz	Default tag table	Bool	%M0.3	☐	☒	☒	☒
23	Clock_1.25Hz	Default tag table	Bool	%M0.4	☐	☒	☒	☒
24	Clock_1Hz	Default tag table	Bool	%M0.5	☐	☒	☒	☒
25	Clock_0.625Hz	Default tag table	Bool	%M0.6	☐	☒	☒	☒
26	Clock_0.5Hz	Default tag table	Bool	%M0.7	☐	☒	☒	☒
27	ResetCounters	Default tag table	Bool	%I2.0	☐	☒	☒	☒
28	StopConveyor	Default tag table	Bool	%Q2.1	☐	☒	☒	☒
29	C2	Default tag table	Bool	%Q0.1	☐	☒	☒	☒
30	C3	Default tag table	Bool	%Q0.2	☐	☒	☒	☒

Below is a screenshot of my program blocks list.

RW_Conveyor_Project_V19 ▸ PLC_1 [CPU 1214C DC/DC/DC] ▸ Program blocks ▸ Main_data_1 [DB1]

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	Cylinder 3 Counter	Int	0	☐	☒	☒	☒	☐	
3	Cylinder 2 Counter	Int	0	☐	☒	☒	☒	☐	
4	Cylinder 1 Counter	Int	0	☐	☒	☒	☒	☐	
5	Start_Time	DTL	DTL#2021-10-...	☐	☒	☒	☒	☐	
6	Return_Time	Int	0	☐	☒	☒	☒	☐	
7	Optical_1_Pos	Bool	false	☐	☒	☒	☒	☐	
8	Read_Time_Pos	DTL	DTL#1970-01-01+	☐	☒	☒	☒	☐	
9	Return_Read_Time_Pos	Int	0	☐	☒	☒	☒	☐	
10	Read_Time_Neg	DTL	DTL#1970-01-01+	☐	☒	☒	☒	☐	
11	Return_Read_Time_Neg	Int	0	☐	☒	☒	☒	☐	
12	Optical_1_Neg	Bool	false	☐	☒	☒	☒	☐	
13	Time_Difference	Time	T#0ms	☐	☒	☒	☒	☐	
14	Time_Int	Int	0	☐	☒	☒	☒	☐	
15	Small_Counter	Int	0	☐	☒	☒	☒	☐	
16	Medium_Counter	Int	0	☐	☒	☒	☒	☐	
17	Large_Counter	Int	0	☐	☒	☒	☒	☐	
18	optical2pos	Bool	false	☐	☒	☒	☒	☐	
19	Small Full	Bool	false	☐	☒	☒	☒	☐	
20	Medium Full	Bool	false	☐	☒	☒	☒	☐	
21	Large Full	Bool	false	☐	☒	☒	☒	☐	
22	Static_1	DInt	0	☐	☒	☒	☒	☐	
23	smallone	Int	0	☐	☒	☒	☒	☐	
24	medone	Int	0	☐	☒	☒	☒	☐	
25	largeone	Int	0	☐	☒	☒	☒	☐	
26	cylinder 1 man	Bool	false	☐	☒	☒	☒	☐	
27	cylinder 2 man	Bool	false	☐	☒	☒	☒	☐	
28	cylinder 3 man	Bool	false	☐	☒	☒	☒	☐	
29	SMALL_LIMIT	Int	5	☐	☒	☒	☒	☐	
30	MED_LIMIT	Int	5	☐	☒	☒	☒	☐	
31	LARGE_LIMIT	Int	5	☐	☒	☒	☒	☐	
32	Conveyor Button	Bool	false	☐	☒	☒	☒	☐	

Working HMI



C1 in manual operation for maintenance.



C2 in manual operation for maintenance.



C3 in manual operation for maintenance.



Conclusion

In conclusion, the system I have put together is an efficient and automated solution for sorting items, by size, on a conveyor system. The proposed system is designed to for operational efficiency using intuitive controls. Key elements include optical sensors for size detection, a user-friendly human machine interface (HMI) for controlling operations and monitoring output, and automated sorting mechanisms to ensure correct allocation of items into their designated bins.

The functional requirements of the conveyor control system are met, utilising manual and automatic green and red switches, and HMI buttons. The system's ability to count and display the number of sorted items provides real-time data for users.

The sequence of operations, starting from the detection of item sizes by optical sensors to the final sorting into bins, ensures a seamless workflow. This automated approach minimises the likelihood of errors in item sorting as there are parameters set within the code that prevent overlap of sizes.

Overall, the proposed solution is a robust, user-friendly system that utilises automation to streamline the sorting process. It delivers accuracy, efficiency, and is easy to use.