

PLC assignment

by Grace Williams

Submission date: 08-Jan-2025 02:30PM (UTC+0000)

Submission ID: 247646629

File name: 49795_Grace_Williams_PLC_assignment_629994_33396069.docx (4.88M)

Word count: 4029

Character count: 19377



Applied Programmable logic controllers – ACDA6000

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Abstract

The aim of this report is to explain the design of a factory IO system that will sort four different types of boxes automatically, including warnings and alarms when the system needs attention.

The control of the system is written in siemens TIA portal V16 and monitored using simulation packages. This report will contain an operational flow chart of the system, and an explanation of the factory IO design along with the control behind it.

Introduction

The Factory IO system is designed to sort four boxes of different sizes; small, medium, large and pallet box. The specification for the system states that the system consists of at least two pushers, 4 conveyors, two push buttons for start and stop, and an Estop. The specification also states that a weigher, two diffuse sensors, two stack lights, a warning light and a siren should also be included. A HMI is required to give the stop and start function, a replication of the stack lights, the counter value of the boxes and a button for resetting them. An Estop is also part of the HMI specification and the HMI should give warning and alarm indications.

In order for the program to be written in TIA, a 1200 series Siemens CPU was chosen. The HMI is a Siemens KTP700 Module. The communication method between these two devices is via the ProfiNet protocol. In order to run it with factory IO, a simulation package was used (siemens PLC sim).

Research

Programmable Logic Controllers (PLCs) have been about since 1968 when general motors came up with a design for a standard machine controller [1]. They work by receiving information from the connected inputs and turning on outputs based on the internal program written within it [2]. There are three different types of PLCs used today; Unitary, Modular and rack mounted.

Table 1 – Comparison of different types of PLCs

Unitary [3]	Modular [4]	Rack mounted [5]
		
This can also sometimes be known as a Brick type PLC. It has an integrated power supply and CPU (central processing unit) and a fixed amount of inputs and outputs (I/O) Unitary PLCs are often seen used in smaller applications. For example, automatic doors and barriers, traffic lights and heating systems. This is usually due the fact they have limited number or I/O so are only used in smaller operations.	Modular PLCs require a power supply, CPU, and I/O modules to be added to it separately. This type of PLC is often seen used in larger processes where it will often control the whole system. It is capable of doing this due to additional I/O modules being able to be easily added to it. The only thing that needs to be involved when adding additional modules is to ensure that they are added to the hardware configuration in the PLC program.	Rack Mounted PLC's are very similar to a Modular PLC and sometimes are referred to as the same, as you will need to add in a power supply, CPU and the required modules. These modules however unlike modular PLCs will need to be fitted within a rack rather than stand alone. Rack mounted PLCs are often used in larger processes just like modular PLCs for the same reasons. Both of these PLCs are capable of operating a whole processes due to the ability that it can have additional modules added to it.
An advantage of this type of PLC is that they are small and compact so can easily fit in panels with limited space. Additionally, they are often the cheapest type of PLC to buy as everything is included within the unit.	The main benefit of a modular PLC is that it can be easily expanded and customised to suit the need of the system, including easily adding to it in the future if required. If a module fails, it can also easily be replaced without the need to replace the whole PLC.	Rack mounted PLCs benefit in a similar manor to a Modular PLC as it can be expanded and customised as required. Multiple racks can be connected together if more modules are required than the size of the rack (backplane).

A disadvantage of this type of PLC is that if one part of the PLC fails then the whole unit will need to be replaced. Furthermore, they can often only be used for small applications due to the limited I/O.	The downside of a modular PLC is that if the system is large and many modules need to be added, then this can be costly.	The fallback of a rack mounted PLC is it is often the most expensive type of PLC out of the three and if more modules are required than what will fit in the rack, then a new rack will need to be purchased for these modules, making it more costly again.
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PLCs can be programmed in any of the 5 IEC 61131-3 standard languages [12]. These five languages consist of Ladder logic (LD), Function block diagrams (FBD), Structured text (ST), sequential Function charts (SFC) and instruction list (IL) [6]. Some manufactures will include their own type of language to be able to be used within their PLCs. For example, siemens will use Structured control languages (SCL) which is a PASCAL based language based on structured text. This is used often to write complex calculations. Siemens Statement list (STL) which is similar to machine code is siemens own version of Instruction list.

Along with some manufacturers creating their own PLC languages, they also usually create their own programming software, communication protocols and also often have their own cable for connecting to and programming the PLC.

Table 2 – Advantages and disadvantages of a selection of PLCs

Brand and type	Advantage	Disadvantage
Siemens - S7 300 [4] 	-I find the Simatic manager software easy to use. It has an easy Goto function that you can type in anything you want to find within the software and it will show you where it is used. It also has a VAT table function (variable table) that makes it easy to monitor values online, force variables and also send in values. -Uses Profibus that is generally very reliable and if any issues occur, a Profibus tester can be used to easily detect any issues with telegrams or modules on the bus. -reliable in most environments - the software has the ability to simulate.	-Require A1 or A2 adapter to connect that is expensive to buy. -Is only available until 2033. [4] -high initial cost -Siemens can be complex and often overcomplicates operations. Especially hard for people new to siemens technology.
Rockwell - SLC 500 [7]	-Logix 500 is user friendly and easy to navigate to people new to PLCs. -Requires DF1 cable for connection which can be purchased cheaply.	- discontinued and parts are hard to find - Can be misleading to detect if I/O cards are faulty as often the LEDs still light up even if there is no voltage at the card.

	- Using RS Linx, connecting is easy and you can see everything in the rack. - Has an easy Goto function for cross referencing parts in the program. And you can quickly see any inputs and outputs that is energised by selecting the input or output selection on the software.	- ports are often blown as they physically look like an ethernet port however use a different protocol of DH485. Because of this, people unfamiliar with this often try and connect with the wrong protocol and cause the ports to blow, making them unusable [7].
Mitsubishi - Q series [9] 	- cheaper compared to Rockwell or Siemens. - the hardware in my experience seems rugged and doesn't seem to fail often. - Good for basic programs.	- GX developer software is quite crude so is not often the best software to write in depth programs. - Requires the specific Q series cable in order to go online that is expensive to buy. - often only has one connection port so if a HMI is connected, you cannot monitor online so can be hard to fault find.
WAGO - Controller PFC200 [10] 	- Tend to be a lot cheaper than most of the bigger manufacturers. - Codesys software is free to use and no licence is required.	- the smaller cost means reduction in total CPU memory. This often means that the total source code won't be downloaded to the controllers. This then means that without the original source code, you won't be able to get online to the PLC to be able to monitor or modify the program.

Flow charts

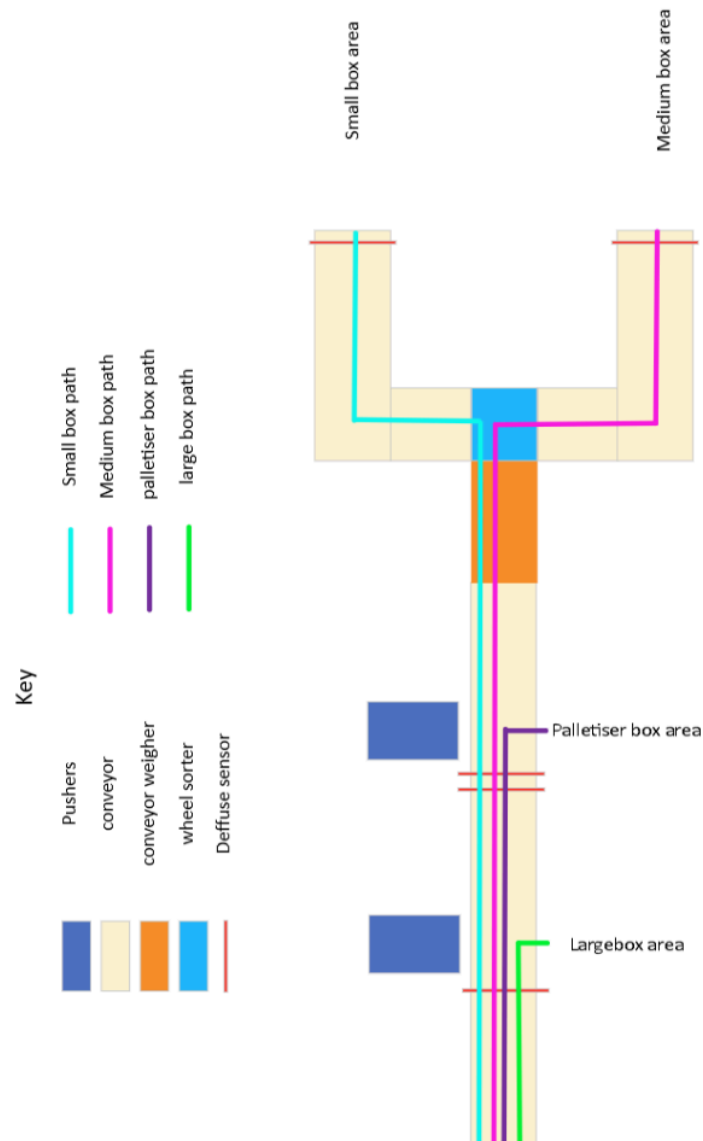


Figure 1 - System organisation flow chart

The system organisation flow chart has been used to refer to when programming. It allows a Visual of the system and the sequence it will operate in. This makes it easier to plan out how the system can be best programmed.

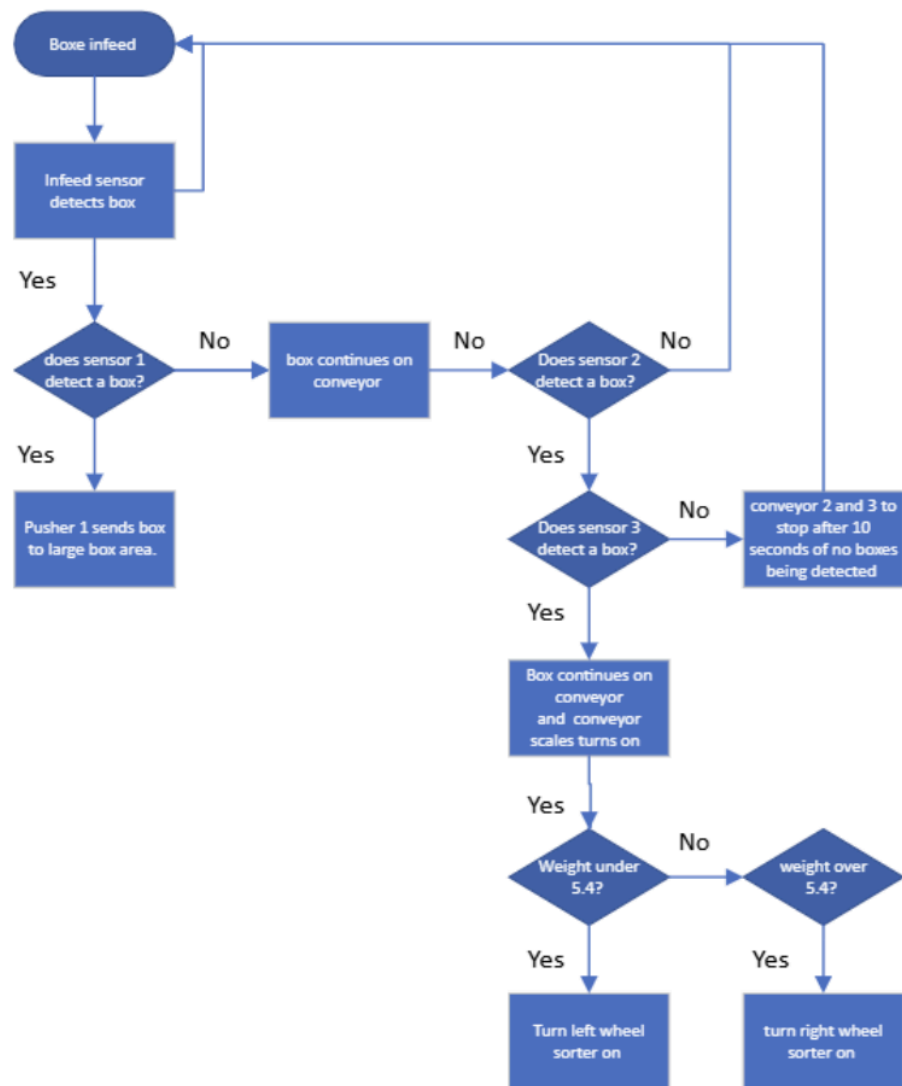


Figure 2 Flow chart for sorting boxes

Figure 2 is the flow chart used for the sorting of the boxes. It shows the process that the boxes should follow in order to be sorted in the correct areas.

Factory IO Design

The Factory IO system composes of 5 conveyor belts, 2 pushers, 1 conveyor scales, 6 diffuse sensors and also a pop up wheel sorter. The process also comprises of an emergency stop, A start and stop button, A siren, a warning light and 2 stack lights for indication. This can be seen in figure 3. These components have been assigned an I/O address to be wired to in the PLC in order for them to be able to work (figure 4).

The process has been designed so that not all the conveyors will be turned on at start up so that the initial current draw to the system will be minimal. It has also been designed so that it is only taking up a minimal amount of room in the factory. This makes it neat and tidy, and keeps it simple to follow the process. The system operates from left to right, making it easy to see where everything will go. The stack lights, warning light and siren are used as indication to how the line is running and if there are any alarms or warnings active.

At the start of the process the green arrow is the infeed system for the boxes. It places an assortment of randomly selected boxes on the conveyor out of the four different chosen sizes (small, medium, large, pallet). The orange arrows placed at the end of each slide is for the package removal. The operation has been designed so that after a set amount of boxes have occurred in each area, the area will need to be emptied before the process can continue. This simulation however has the orange package removers instead of letting it build up to keep the simulation software from developing an error.



Figure 3 – Process overview

Start Button 0	%I16.0	%Q16.0	Conveyor 1
Stop Button 0	%I16.1	%Q16.1	Conveyor Scale 0 (+)
Emergency Stop 0	%I16.2	%Q16.2	Conveyor 2
Sensor 1 (Lrg)	%I16.3	%Q16.3	Conveyor 3
Sensor 2 (Low)	%I16.4	%Q16.4	Conveyor 4
Sensor 3 (Med)	%I16.5	%Q16.5	Pop Up Wheel Sorter 0 (+)
Sensor 4 Small Boxes	%I16.6	%Q16.6	Pop Up Wheel Sorter 0 (Left)
Sensor 5 Medium Boxes	%I16.7	%Q16.7	Pop Up Wheel Sorter 0 (Right)
Pusher 1 (Back Limit)	%I17.0	%Q17.0	Pusher 1
Pusher 2 (Back Limit)	%I17.1	%Q17.1	Pusher 2
Infeed Count	%I17.2	%Q17.2	Conveyor 5
	%I17.3	%Q17.3	Stack Light 0 (Green)
	%I17.4	%Q17.4	Stack Light 0 (Red)
	%I17.5	%Q17.5	Stack Light 0 (Yellow)
	%I17.6	%Q17.6	Warning Light 0
	%I17.7	%Q17.7	Alarm Siren 0
Conveyor Scale 0 Weight (V)	%ID30 (REAL)	%Q18.0	Start conveyor
	%ID34	%Q18.1	Stack Light 1 (Green)
	%ID38	%Q18.2	Stack Light 1 (Red)
	%ID42	%Q18.3	Stack Light 1 (Yellow)
		%Q18.4	
		%Q18.5	
		%Q18.6	
		%Q18.7	
	(REAL) %Q00		Digital Display 0
	%Q04		
	%Q08		
	%Q12		

Figure 4 - Factory IO simulation PLC 1200 I/O configuration

Figure 5 shows the start of the production process. When the boxes are first emitted onto the conveyor, a sensor is mounted low on the conveyor in order to detect all the boxes and count the amount that is fed into the system. The next part of the process is the large box area. It has a diffuse sensor positioned so that it only detects large size boxes. When the beam is broken, the pusher will be energised after a set amount of time. This will then push the large box down the correct slide. The extend position of the pusher is used in order to count how many large boxes has been sorted.

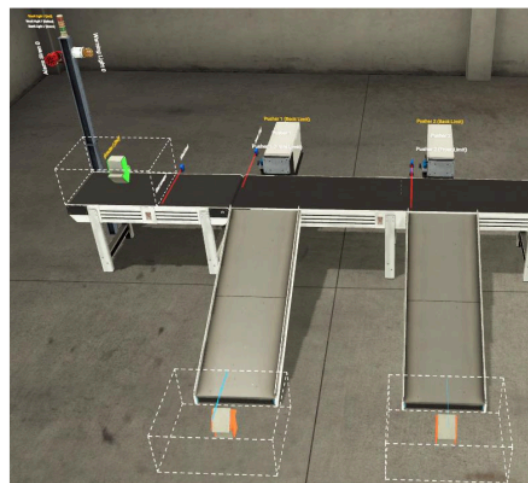


Figure 5 – Pallet and Large size box area

The next step of the process is the palletiser box sorter. This has two diffuse sensors parallel to each other for them to be able to detect two different size boxes. If the beam of the bottom sensor is broken and not the top, it means that a palletiser size box has arrived and the pusher will be energised after a set amount of time. If both beams are broken however, then the pusher will not energise and the box will pass onto the next part in the process. The extend of the pusher is also the count for the amount of palletiser size boxes sorted.



Figure 6 – Control panel and conveyor weigher

The conveyor weigher is the next part of the process, seen in figure 3. If boxes have passed onto this section, then they will be weighed on the scales. The weight of the boxes will then be used to sort the boxes further. If the scales measures greater than 5.4kg then it will give the instruction to the pop up wheel sorter to go right and if it is less than this it will go left. This pop-up wheel sorter can be seen below in figure 7. Depending on what way the pop-up sorter goes will depend on what conveyors will activate. The diffuse sensors placed at the end of the conveyors are to count the amount of boxes that have been sorted for each size.

A physical emergency stop (Estop) button is placed on the control panel along with a physical start and stop button. The Estop will be wired as a normally closed contact (N/C) for safety. This is so that if a wire was to break the line will no longer work as it will act as though an estop is pressed. The start and stop buttons however can be normally open contacts (N/O). The control panel also has a display for the weight of the conveyor going to it. This has been done so that operators will be able to monitor the weight on the scales themselves if required.

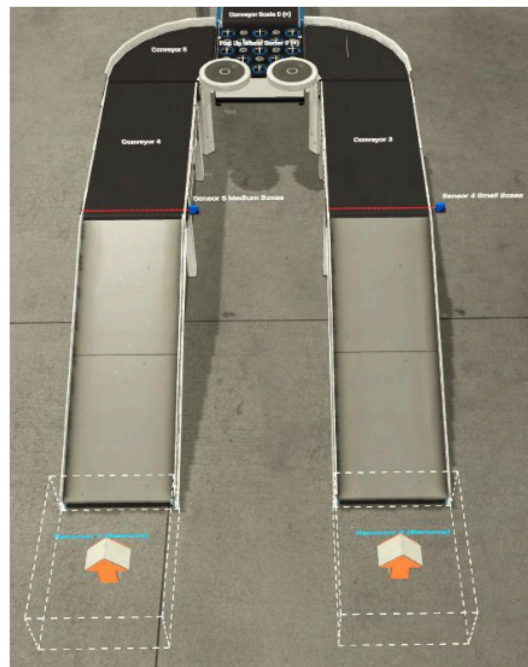


Figure 7 – Small and medium size box area

PLC Program

The PLC program was written in Organisation block OB1 and has a total of 13 rungs that can be seen titled in figure 8. All of the I/O is identified in the tag table in figure 22 as well as the flags/ memory bits used throughout the program.

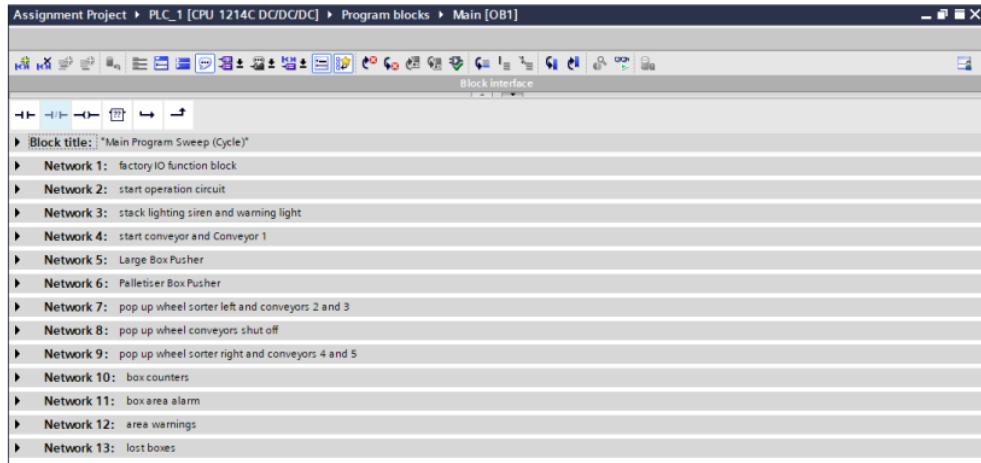


Figure 8 - OB1 network titles



Figure 9 - Network 1

Network 1 calls function call FC9000. This FC is how the communication is carried out to the factory IO software so that simulations can take place.

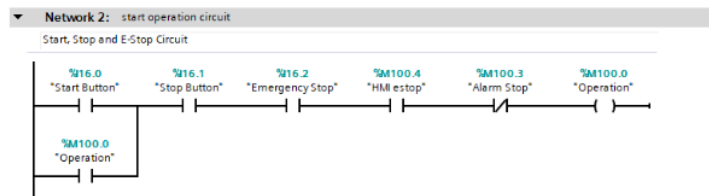


Figure 10 - Network 2

Figure 10 shows the start circuit for the operation. Without this circuit being healthy, the process will not work. This is where the safety is written into the circuit. It has been written like this so that the Operation flag can be used throughout the program instead of needing to re write the start and stop functions multiple of times.

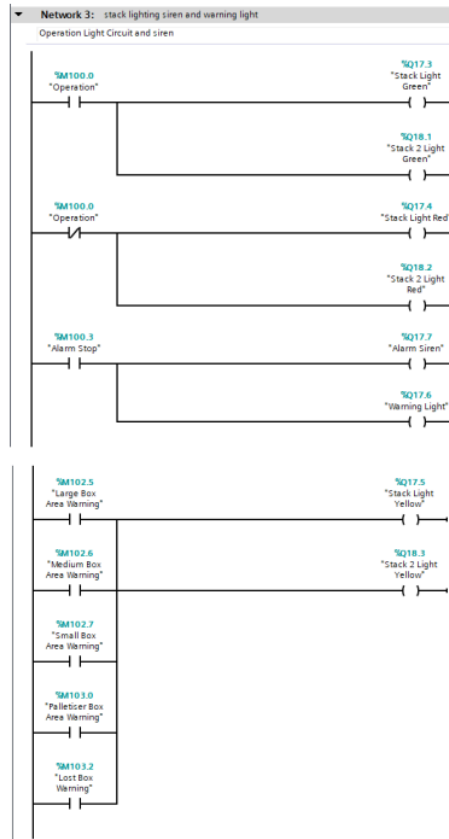


Figure 11 - Network 3

If the line is running healthy, then both the green stack lights will be on and likewise if it is not running then both red stack lights will be on. If an alarm occurs then the alarm siren will sound as well as the warning light giving indication. The yellow stack lights will only be lit if a warning is present on the line.

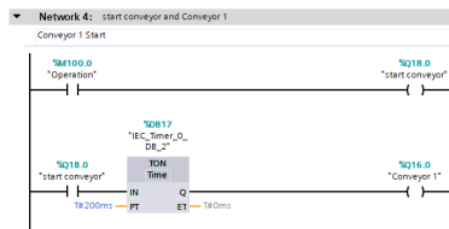


Figure 12 - Network 4

The start conveyor will operate as soon as the start operation is healthy. In order to stop an in-rush of current caused by all the conveyors starting at the same time, conveyor 1 is delayed to start 200ms after the start conveyor. This on delay timer was only set for a small amount of time in order to prevent a box build up on the start conveyor. This is because if the time is set to high it may cause a queue of boxes.

value of the weight will be moved so that it can be displayed on the control panel. Alongside this, conveyor 2 and 3 will also energise for 10s. Providing the wheel direction is not being changed, if the weight is more than or equal to 1kg on the scale, then the left wheel sorter will energise. It is set at a value of greater than or equal to 1kg as there is minor discrepancies with the weigher prior to boxes being placed on it due to movement and vibrations so therefore it was best to set it to this value as a minimum as no boxes will be below this value and it will stop errors occurring.

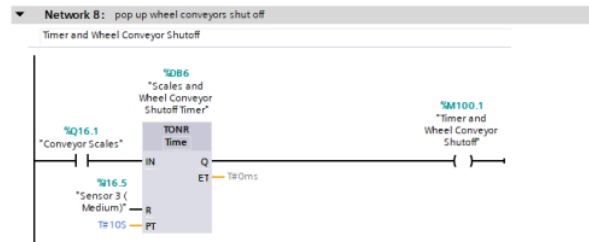


Figure 16 - Network 8

Network 8, shown in figure 16 is to stop the conveyor scale, wheel sorter and conveyor 2 and 3 from operating as M100.1 is cross referenced to be read in network 7. This is done by having a time accumulator giving the shut off output when the conveyor scale gives the timer the input. The sensor 3 is used as a reset so that the 10 seconds will start again every time sensor 3 detects an object. The program has been written this way so that it saves energy by stopping conveyors when they are not required to be running.

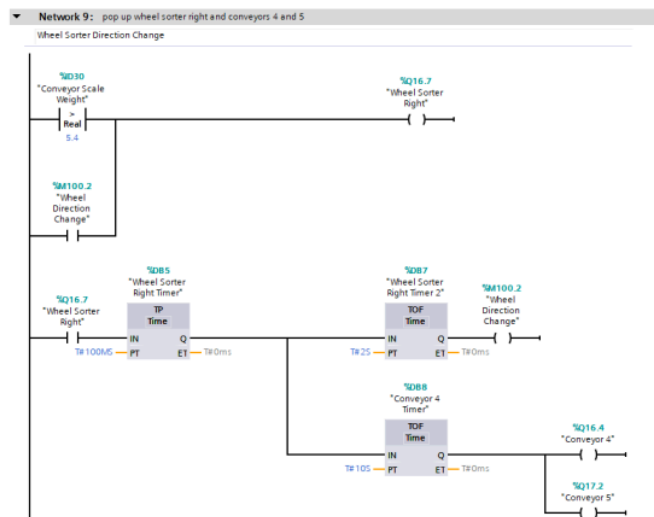
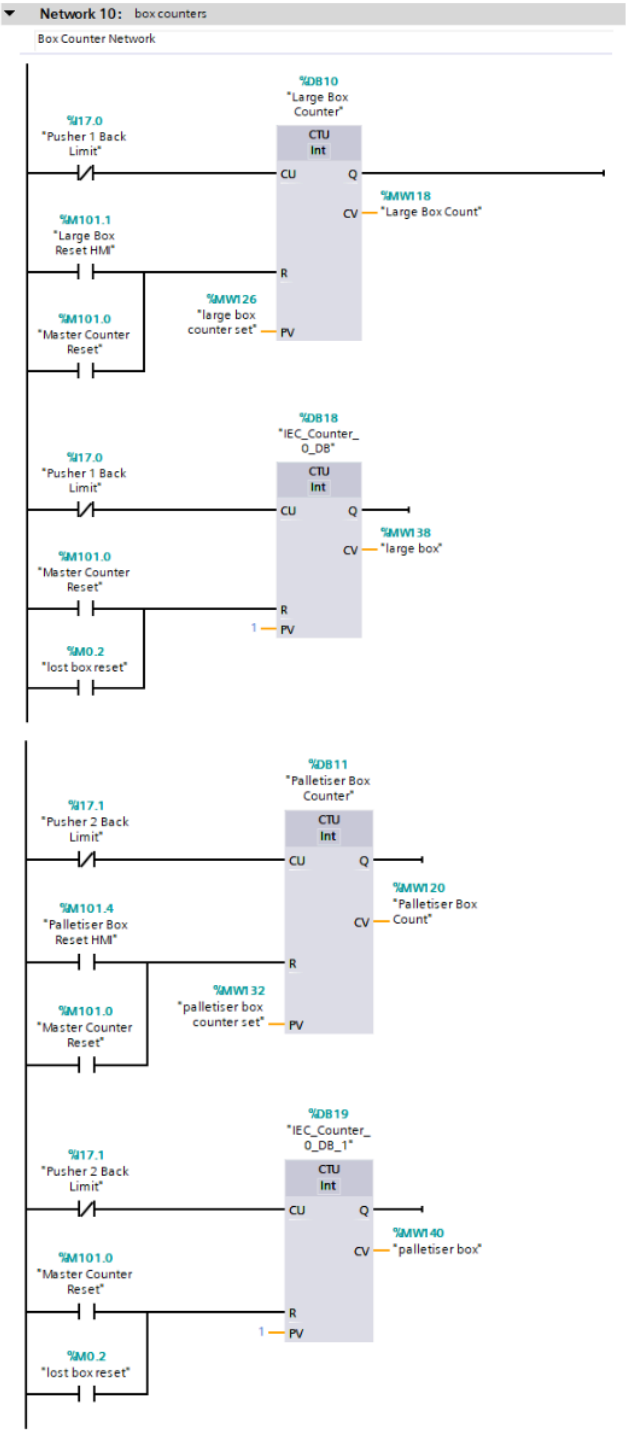


Figure 17 - Network 9

If the weight on the scales is more than 5.4kg then the wheel sorter right will energise. Once this energises, it will give a pulse for 100ms to two on delay timers. One of the on-delay timers is for the direction change memory bit and the other delay timer is for conveyor 4 and 5. Similar to network 8, this has been done so that energy will not be wasted needlessly

and therefore the conveyors won't keep running after 10 seconds if a weight over 5.4kg hasn't been detected.



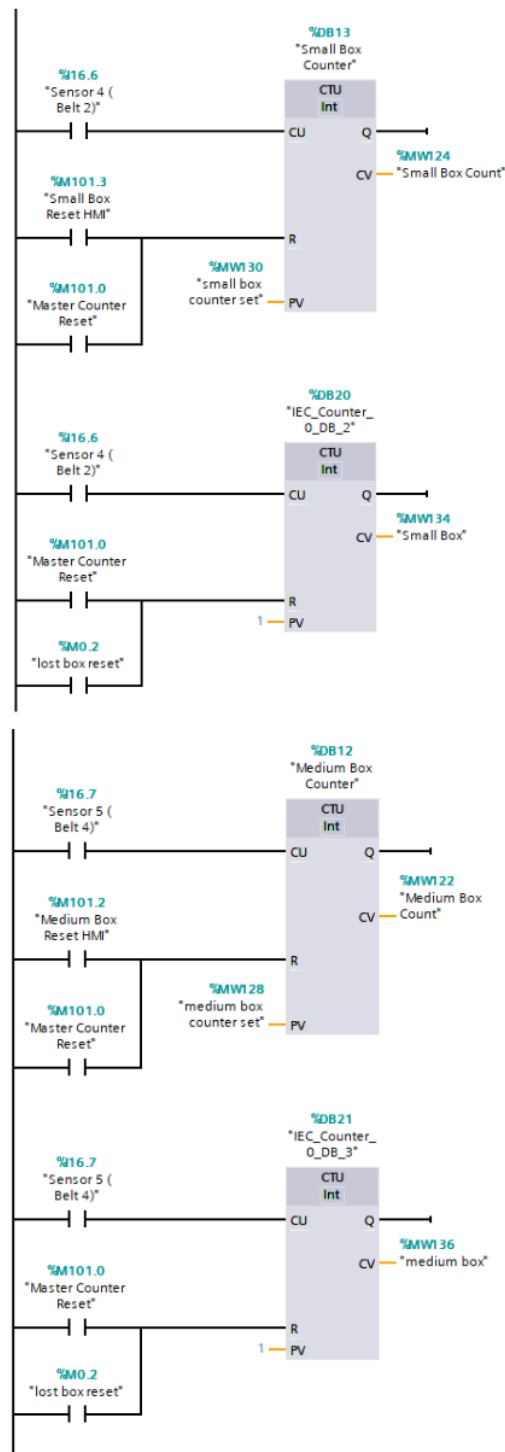


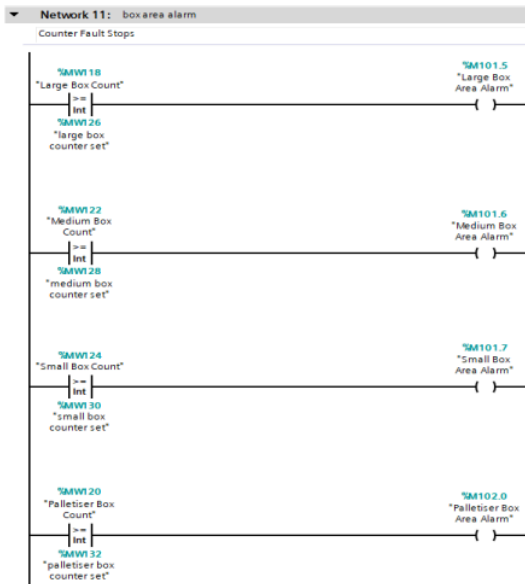
Figure 18 - Network 10

DB10 and DB18 are both counters for the large boxes and count when the pusher has extended. Two counters have been used to do this, one will reset individually for the area or with the master reset and the other by the master reset or lost box reset. This has been done so that the one counter can continue to count the total boxes gone through for that area even when the area reset has been pressed due to the area being full. This counter can then be compared with the infeed counter in order to discover any lost boxes.

Two counters needed to be used to do this as when only one counter was used, the boxes appeared lost when the area was reset at the HMI, causing a false lost box alarm.

The counters increase with the extension of the pushers, as if it was done off the sensor, the counter would increase even if the pusher wasn't working, giving false counts.

The same method has been used for the palletiser boxes (with the extend of the pusher) for the same reason, however, the small and medium boxes was done off sensors as the sensors are positioned at the end of the conveyor so wouldn't have any opportunity to give false counts.



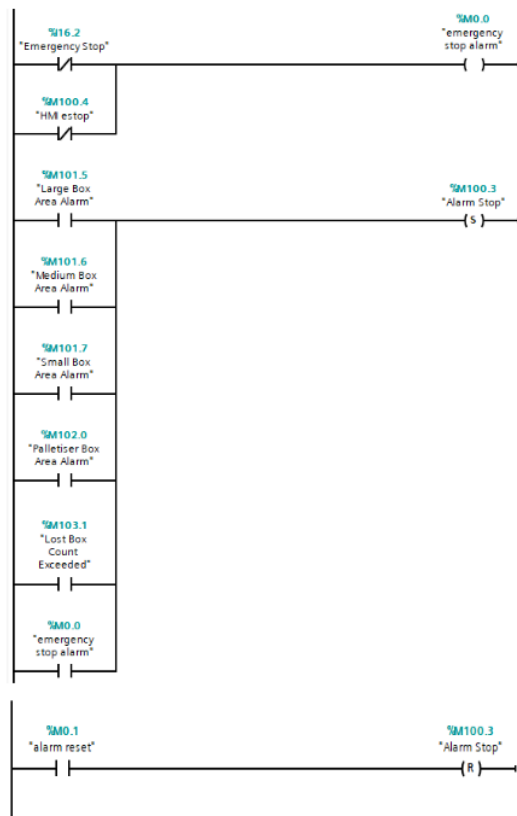
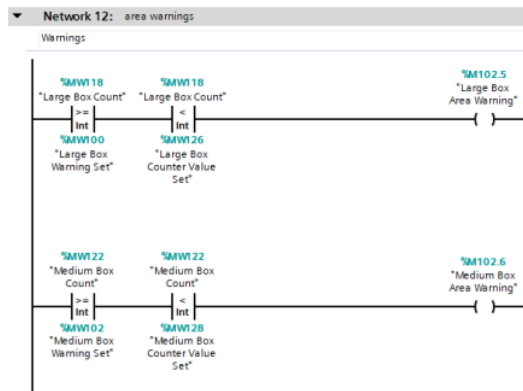


Figure 19 - Network 11

Network 11 is for the alarms. If the amount of boxes are more than or equal to the amount set in the HMI, then the alarm will go off. Likewise if an Estop is pushed it will also set off an alarm. If any of these alarms have been activated, they will need to be reset by correcting the error, and also by pressing the alarm reset in order for the alarm to fully clear and the process to be able to run again. This alarm reset will only be able to be pressed by an engineer in order to make sure that the alarm has been fully cleared before the line can run again.



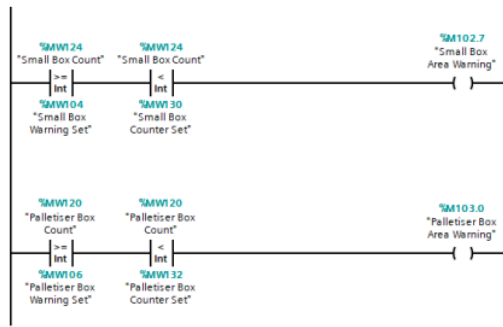
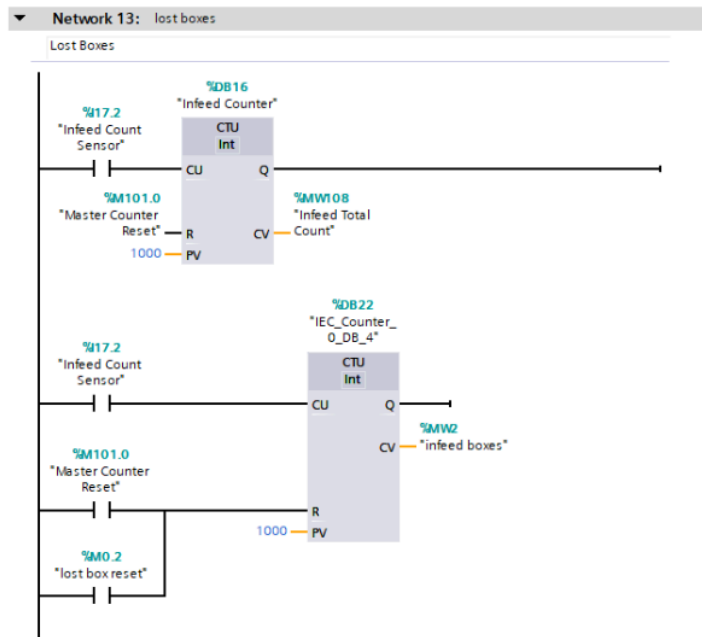


Figure 20 - Network 12

Figure 20 is where the warnings are set. If the value is more than or equal to the value entered in the HMI but less than the alarm value then the warning will go off. It has been written like this as the design means that the warning will go off when the alarm goes on. This is important in my design so that the warning and alarm page will not be too confusing to look at.



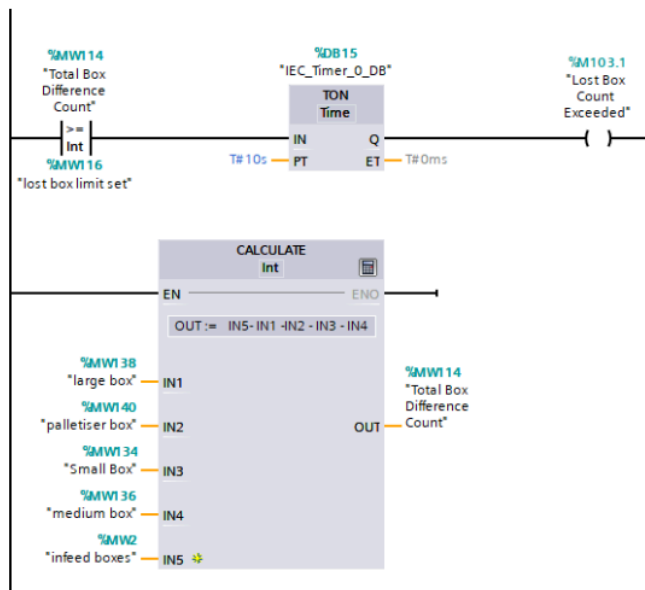


Figure 21 - Network 13

Network 13 is where the lost boxes are calculated. The infeed count sensor is the count input for DB16 and DB22. This means the counter will count up every time the sensor detects an item at the beginning of the process. The master counter reset on the HMI will be able to reset the counter DB16 and DB22 when required, as well as the lost box reset also being able to reset DB22. The calculate block takes the values from the area up counters in network 10 and also the value from the infeed box counter DB22 and subtracts them from each other. This value is then used in order to detect if any boxes are missing. Any difference calculated between the infeed total and outfeed is compared to a value stated on the HMI and if it is equal to or more than this value, an alarm will go off. Before the alarm output can be energised, an on delay timer has been used in order to account for any possible boxes that may still be travelling on the conveyor that hasn't been able to be accounted for in the box area, causing a false lost box.

Assignment Project ▶ PLC_1 [CPU 1214C-2 DC/DC/DC] ▶ PLC tags										
Tags User constants System constants										
PLC tags										
	Name	Tag table	Data type	Address	Retain	Access	Write	Visible	Comment	
1	Start Button	Default tag table	Bool	%I16.0						
2	Stop Button	Default tag table	Bool	%I16.1						
3	Emergency Stop	Default tag table	Bool	%I16.2						
4	Sensor 1 (Large)	Default tag table	Bool	%I16.3						
5	Sensor 2 (Low)	Default tag table	Bool	%I16.4						
6	Sensor 3 (Medium)	Default tag table	Bool	%I16.5						
7	Sensor 4 (Belt 2)	Default tag table	Bool	%I16.6						
8	Sensor 5 (Belt 4)	Default tag table	Bool	%I16.7						
9	Pusher 1 Back Limit	Default tag table	Bool	%I17.0						
10	Pusher 2 Back Limit	Default tag table	Bool	%I17.1						
11	Infeed Count Sensor	Default tag table	Bool	%I17.2						
12	Conveyor Scale Weight	Default tag table	Real	%D30						
13	weight display	Default tag table	Real	%QD0						
14	Conveyor 1	Default tag table	Bool	%Q16.0						
15	Conveyor Scales	Default tag table	Bool	%Q16.1						
16	Conveyor 2	Default tag table	Bool	%Q16.2						
17	Conveyor 3	Default tag table	Bool	%Q16.3						
18	Conveyor 4	Default tag table	Bool	%Q16.4						
19	Wheel Sorter Activate	Default tag table	Bool	%Q16.5						
20	Wheel Sorter Left	Default tag table	Bool	%Q16.6						
21	Wheel Sorter Right	Default tag table	Bool	%Q16.7						
22	Pusher 1	Default tag table	Bool	%Q17.0						
23	Pusher 2	Default tag table	Bool	%Q17.1						
24	Conveyor 5	Default tag table	Bool	%Q17.2						
25	Stack Light Green	Default tag table	Bool	%Q17.3						
26	Stack Light Red	Default tag table	Bool	%Q17.4						
27	Stack Light Yellow	Default tag table	Bool	%Q17.5						
28	Warning Light	Default tag table	Bool	%Q17.6						
29	Alarm Siren	Default tag table	Bool	%Q17.7						
30	start conveyor	Default tag table	Bool	%Q18.0						
31	Stack 2 Light Green	Default tag table	Bool	%Q18.1						
32	Stack 2 Light Red	Default tag table	Bool	%Q18.2						
33	Stack 2 Light Yellow	Default tag table	Bool	%Q18.3						
34	Operation	Default tag table	Bool	%M100.0						
35	Timer and Wheel Conveyor Shu...	Default tag table	Bool	%M100.1						
36	Wheel Direction Change	Default tag table	Bool	%M100.2						
37	Alarm Stop	Default tag table	Bool	%M100.3						
38	HMI stop	Default tag table	Bool	%M100.4						
39	Master Counter Reset	Default tag table	Bool	%M101.0						
40	Large Box Reset HMI	Default tag table	Bool	%M101.1						
41	Medium Box Reset HMI	Default tag table	Bool	%M101.2						
42	Small Box Reset HMI	Default tag table	Bool	%M101.3						
43	Palletiser Box Reset HMI	Default tag table	Bool	%M101.4						
44	Large Box Area Alarm	Default tag table	Bool	%M101.5						
45	Medium Box Area Alarm	Default tag table	Bool	%M101.6						
46	Small Box Area Alarm	Default tag table	Bool	%M101.7						
47	Palletiser Box Area Alarm	Default tag table	Bool	%M102.0						
48	Large Box Area Warning	Default tag table	Bool	%M102.5						
49	Medium Box Area Warning	Default tag table	Bool	%M102.6						
50	Small Box Area Warning	Default tag table	Bool	%M102.7						
51	Palletiser Box Area Warning	Default tag table	Bool	%M103.0						
52	Lost Box Count Exceeded	Default tag table	Bool	%M103.1						
53	Lost Box Warning	Default tag table	Bool	%M103.2						
54	reset lost boxes	Default tag table	Bool	%M103.3						
55	Large Box Warning Set	Default tag table	Int	%MW100						
56	Medium Box Warning Set	Default tag table	Int	%MW102						
57	Small Box Warning Set	Default tag table	Int	%MW104						
58	Palletiser Box Warning Set	Default tag table	Int	%MW106						
59	Infeed Total Count	Default tag table	Int	%MW108						
60	Lost Box Warning Limit Set	Default tag table	Int	%MW110						
61	Total Box Difference Count	Default tag table	Int	%MW114						
62	lost box limit set	Default tag table	Int	%MW116						
63	Large Box Count	Default tag table	Int	%MW118						
64	Palletiser Box Count	Default tag table	Int	%MW120						
65	Medium Box Count	Default tag table	Int	%MW122						
66	Small Box Count	Default tag table	Int	%MW124						
67	Large Box Counter Value Set	Default tag table	Int	%MW126						
68	Medium Box Counter Value Set	Default tag table	Int	%MW128						
69	Small Box Counter Set	Default tag table	Int	%MW130						
70	Palletiser Box Counter Set	Default tag table	Int	%MW132						
71	small box	Default tag table	Int	%MW134						
72	medium box	Default tag table	Int	%MW136						
73	large box	Default tag table	Int	%MW138						
74	palletiser box	Default tag table	Int	%MW140						
78	emergency stop alarm	Default tag table	Bool	%M0.0						
79	alarm reset	Default tag table	Bool	%M0.1						

Figure 22 - PLC Tag table

HMI Design

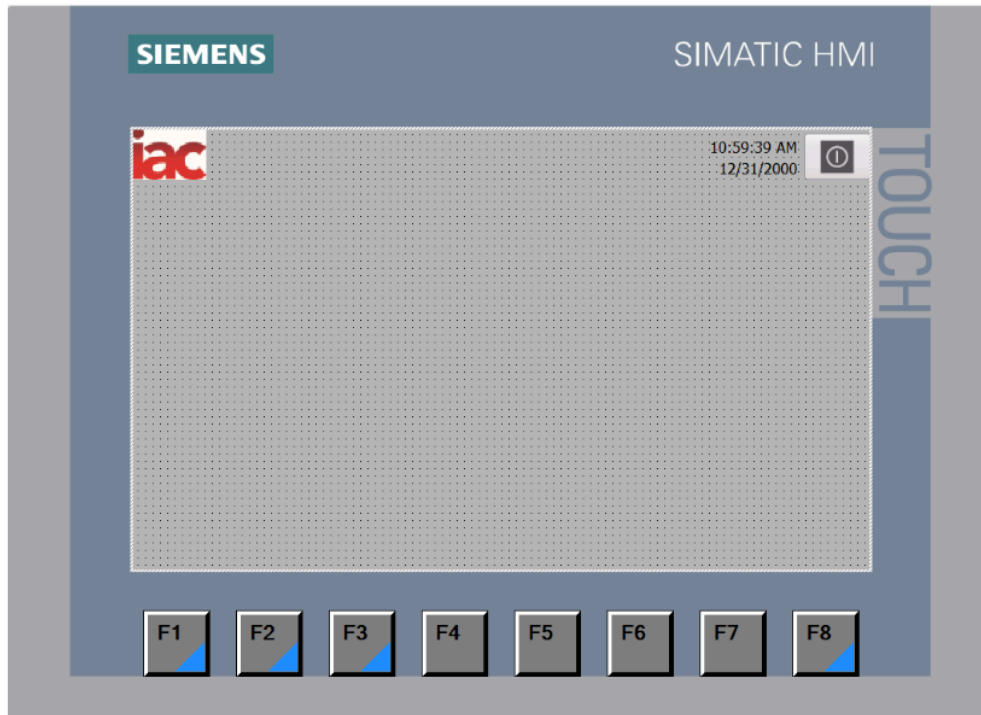


Figure 23 - Screen Template

This screen is the template screen used as the base for every screen. It contains the company logo which is standard procedure for any HMIs put in by my company and has the date and time along with a power button for safe power down. The buttons at the bottom of the screen have also been programmed to change pages. This was done as the buttons are already in place and less screen space would have then be needed to be taken up needlessly.

The F1 button makes the page go to the root screen, the F2 button to the counter reset screen and the F3 button to the engineer screen. This screen however is password protected as in real life usage, you wouldn't want the operators to be able to change the count set value or reset the overall alarm. The F8 button is then the log out button that the engineers can use once they have finished their task.

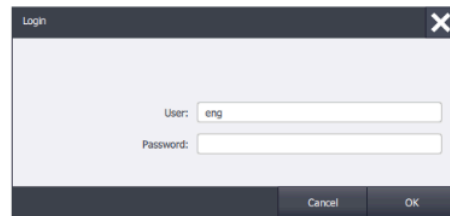


Figure 24 - Login popup

Figure 24 is displaying the POP up that appears when trying to go into the engineer screen when pressing F3. Once it has been logged into, the F3 button will work to transfer you to the counter set page.

The username and password is set as;

username: Eng

Password: eng123

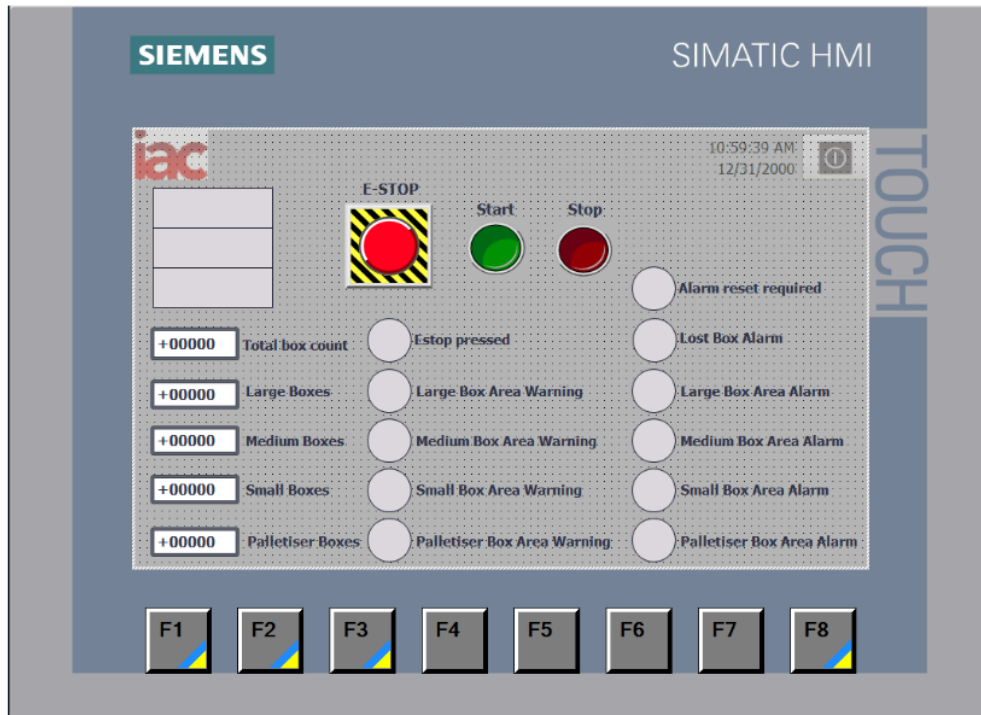


Figure 25 - Root screen

The root screen is shown in figure 25 above. This screen is the main screen shown on startup. Only when setting up the machine or clearing warnings and alarms will the page need to be changed. It contains the warning and alarm notifications, a representation of the stack lights, the box count values for each area as well as the overall count and also the start, stop and Estop button.

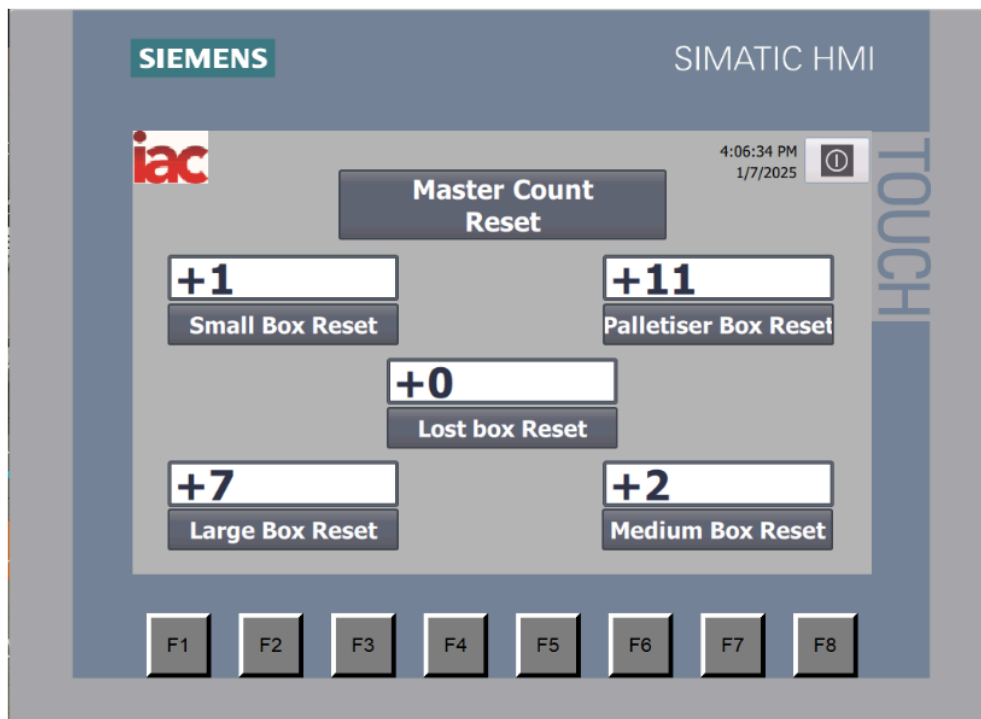


Figure 26 - counter reset screen

The counter reset screen shows the amount of boxes in each section and the amount of lost boxes. Once the value chosen has been reached, the warning light will come on shown in the root screen and the operators will need to remove the boxes. Once the boxes are removed, the area will need to be reset so the count can begin again. If the boxes are not removed or the count is not reset, then the line will continue to run until the alarm set amount where the line will then stop. If this happens then the boxes will need to be removed, the count reset and then also the alarm rest button will need to be pressed on the engineering screen in order for the line to start again.

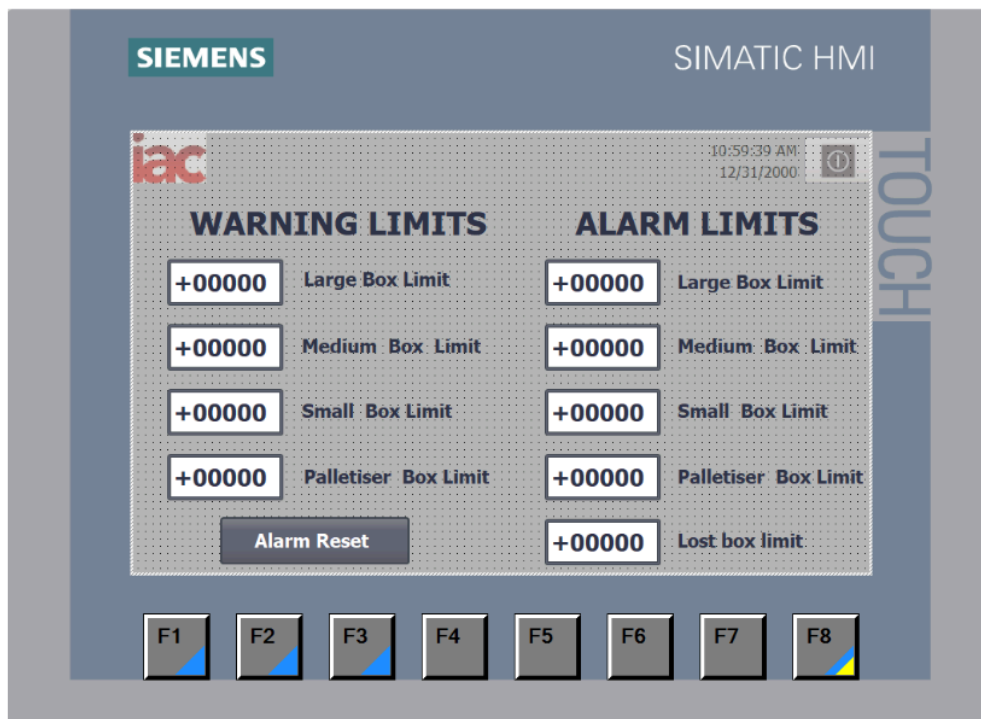


Figure 27 - Engineer screen

The engineer screen should be accessed only by the engineers and is password protected because of this. This screen is where the warning amount for the count of each size boxes will need to be entered as well as the alarm amount. This will need to be done on start-up of the machine in order for it to be able to run. This screen is also where the alarm reset button is placed so that an engineer will need to come and reset it if any alarms was to go off in order for the machine to be able to run again.

Assignment Project ▶ HMI_1 [KTP700 Basic PN] ▶ HMI tags

Name	Tag table	Data type	Connection	PLC name	PLC tag
Alarm Light HMI	Default tag table	Bool	HMI_Connection...	PLC_1	"Stack Light Red"
HMI Estop	Default tag table	Bool	HMI_Connection...	PLC_1	"HMI estop"
Large Box Area Alarm	Default tag table	Bool	HMI_Connection...	PLC_1	"Large Box Area Alarm"
Large Box Area Warning	Default tag table	Bool	HMI_Connection...	PLC_1	"Large Box Area Warni..."
Large Box Count	Default tag table	Int	HMI_Connection...	PLC_1	"Large Box Count"
Large Box Counter Reset	Default tag table	Bool	HMI_Connection...	PLC_1	"Large Box Reset HMI"
Large Box Counter Set	Default tag table	Int	HMI_Connection...	PLC_1	"Large Box Counter Va..."
Large Box Warning Set	Default tag table	Int	HMI_Connection...	PLC_1	"Large Box Warning Set"
lost box limit set	Default tag table	Int	HMI_Connection...	PLC_1	"lost box limit set"
lost box warning limit set	Default tag table	Int	HMI_Connection...	PLC_1	"Lost Box Warning Li..."
lost boxes count	Default tag table	Int	HMI_Connection...	PLC_1	"Total Box Difference ..."
Master Counter Reset Button	Default tag table	Bool	HMI_Connection...	PLC_1	"Master Counter Reset"
Medium Box Area Alarm	Default tag table	Bool	HMI_Connection...	PLC_1	"Medium Box Area Ala..."
Medium Box Area Warning	Default tag table	Bool	HMI_Connection...	PLC_1	"Medium Box Area Wa..."
Medium Box Count	Default tag table	Int	HMI_Connection...	PLC_1	"Medium Box Count"
Medium Box Counter Reset	Default tag table	Bool	HMI_Connection...	PLC_1	"Medium Box Reset H..."
Medium Box Counter Set	Default tag table	Int	HMI_Connection...	PLC_1	"Medium Box Counter..."
Medium Box Warning Set	Default tag table	Int	HMI_Connection...	PLC_1	"Medium Box Warning..."
Operate	Default tag table	Bool	HMI_Connection...	PLC_1	Operation
package weight	Default tag table	Real	HMI_Connection...	PLC_1	"weight display"
Palletiser Box Area Alarm	Default tag table	Bool	HMI_Connection...	PLC_1	"Palletiser Box Area AL..."
Palletiser Box Area Warning	Default tag table	Bool	HMI_Connection...	PLC_1	"Palletiser Box Area W..."
Palletiser Box Count	Default tag table	Int	HMI_Connection...	PLC_1	"Palletiser Box Count"
Palletiser Box Counter Reset	Default tag table	Bool	HMI_Connection...	PLC_1	"Palletiser Box Reset H..."
Palletiser Box Counter Set	Default tag table	Int	HMI_Connection...	PLC_1	"Palletiser Box Counter..."
Palletiser Box Warning Set	Default tag table	Int	HMI_Connection...	PLC_1	"Palletiser Box Warnin..."
reset lost boxes	Default tag table	Bool	HMI_Connection...	PLC_1	"reset lost boxes"
Small Box Area Alarm	Default tag table	Bool	HMI_Connection...	PLC_1	"Small Box Area Alarm"
Small Box Area Warning	Default tag table	Bool	HMI_Connection...	PLC_1	"Small Box Area Warni..."
Small Box Count	Default tag table	Int	HMI_Connection...	PLC_1	"Small Box Count"
Small Box Counter Reset	Default tag table	Bool	HMI_Connection...	PLC_1	"Small Box Reset HMI"
Small Box Counter Set	Default tag table	Int	HMI_Connection...	PLC_1	"Small Box Counter Set"
Small Box Warning Set	Default tag table	Int	HMI_Connection...	PLC_1	"Small Box Warning Set"
Stack Light Green	Default tag table	Bool	HMI_Connection...	PLC_1	"Stack Light Green"
Stack Light Red	Default tag table	Bool	HMI_Connection...	PLC_1	"Stack Light Red"
Stack Light Yellow	Default tag table	Bool	HMI_Connection...	PLC_1	"Stack Light Yellow"
Tag_ScreenNumber	Default tag table	Int	<Internal tag>		<Undefined>
Total Box Count	Default tag table	Int	HMI_Connection...	PLC_1	"Infeed Total Count"
Total Lost Box Alarm	Default tag table	Bool	HMI_Connection...	PLC_1	"Lost Box Count Exceeded"
Total Lost Box Warning	Default tag table	Bool	HMI_Connection...	PLC_1	"Lost Box Warning"
Total Lost Box Warning Set	Default tag table	Int	HMI_Connection...	PLC_1	"Lost Box Warning Limit ..."
Warning Light HMI	Default tag table	Bool	HMI_Connection...	PLC_1	"Warning Light"

Figure 28 - HMI tag table

The HMI tag table is used for all the functions on the HMI. It corresponds to the tags used in the PLC.

Commissioning checklist

Operation	Checked
Warning limits have been entered for each box area and remain in place once exited the screen?	Yes
Alarm limits have been entered for each box area and remain in place once exited the screen?	Yes
Alarm limits have been entered for lost box limit and remain in place once exited the screen?	Yes
Does physical start work?	Yes
Does physical Estop work?	Yes
Does HMI start work?	Yes
Does HMI Estop work?	Yes
Does Physical stop work?	Yes
Does HMI stop work?	Yes
Does the Estop alarm go off when estop is pressed and off when rectified?	Yes
Checked the system won't start before alarm reset has been pressed after alarm has activated?	Yes
Does physical Red stack lights light up when system is stopped?	Yes
Does HMI Red stack lights light up when system is stopped?	Yes
Does physical green stack lights light up when system running healthy?	Yes
Does HMI green stack lights light up when system running healthy?	Yes
Does physical yellow stack lights light up when warning is present?	Yes
Does HMI yellow stack lights light up when warning is present?	Yes
Does small box area warning go off when over value entered?	Yes
Does Large box area warning go off when over value entered?	Yes
Does palletiser box area warning go off when over value entered?	Yes
Does medium box area warning go off when over value entered?	Yes
Does small box area alarm go off when over value entered?	Yes
Does large box area alarm go off when over value entered?	Yes
Does Palletiser box area alarm go off when over value entered?	Yes
Does medium box area alarm go off when over value entered?	Yes
Does siren go off when alarm is present	Yes
Does alarm light go off when alarm is present?	Yes
Checked that the system doesn't start when any alarm is present	Yes
Is the total number of boxes being displayed?	Yes
Does the weight display work on the control panel	Yes
Can you individually reset the small box area?	Yes
Can you individually reset the Large box area?	Yes
Can you individually reset the Palletiser box area?	Yes
Can you individually reset the Medium box area?	Yes
Does the master count reset button reset everything?	Yes
Does F8 log you off?	Yes
Does the date and time work on the HMI?	Yes

Conclusion and Improvements

According to the specification given, the system works as required and meets the specification. All relevant features work as intended, and the system allows for the operator to reset the box counters and an engineer to adjust the count value required. A password protected page on the HMI was created in order to stop the operators being able to modify the count value so that the alarms wouldn't sound. As with any system, improvements can be made. This includes improvements with the program, the operation and also the HMI display.

An improvement I would make with the program is to structure it so that it is not all written in OB1. This is because this is a Siemens PLC and Siemens uses OB1 (organisation block 1) in order to call all the other functions within the program in a specific order. Other functions can then be named specifically for the operation for easy fault finding in the future. For example, Figure 29 is one method of structured programming written for a customer.

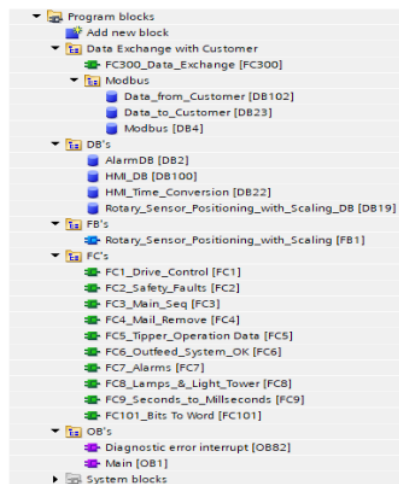


Figure 29 – Structured program blocks for a Parcel sorting machine at royal mail.

The system can be improved in future by stopping the weigher conveyor for a brief second so that the weight can be taken more accurately and then once finished weighing the conveyor can move again. If this was done, the weight can be established more accurately and errors in sorting can be reduced.

Improving the HMI can be done by making the main screen less busy as it can be overwhelming to look at. This could be done by putting some alarms or counters on a different page. Also the warning and alarm limits need to be entered each time the PLC has been downloaded. This can cause an issue as it means the machine starts up on fault. A way to overcome this issue can be by entering the value into a DB and initialised it so that the set value will always be used upon start up.

Lastly, a change I would make to the specification is to remove the Estop from the HMI. This is because a HMI isn't fail safe as it could freeze or crash in a time that the Estop needs to be pressed, making it unreliable. If an additional physical Estop is placed in the system instead then it makes the system safer.

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PLC assignment

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FINAL GRADE

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GRADING FORM: SMU GENERIC_GJ

GRACE WILLIAMS

72

RESEARCH-INFORMED LITERATURE



Good literature review of PLCs on the market, with images and explanations. 78%

KNOWLEDGE AND UNDERSTANDING

- 
- The factory looks good with all of the required components included plus a few others. Your factory operates well and demos well, except the wight sorting seems to be a little flaky, incorrectly sending boxes of the same size and weight to different shoots. 70%

21

ANALYSIS

- 
- Your ladder logic program is comprehensive and well documented throughout with an alarm strategy. Although the alarm strategy does function as expected 72%

21.6

PRACTICAL APPLICATION AND DEP.

- 
- Your HMI screens are reasonably laid out and informative for the operator, but the password entry was not needed at this time. 70%

14

SKILLS FOR PROFESSIONAL PRAC.

- 
- The report is well presented with the network operations described at each level. The illustrations are good and clear. A good selection of references. 76%

7.6