

Factory Control

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Factory Control

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Applied Programmable Logic Controllers ACDA6000

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Abstract

In this assignment our aim was to make a working a PLC that sorted different sized and weighted boxes into four separate bins. Objectives were to have more than 4 belts, minimum of 2 pushers, conveyor weight scale, 2 diffuse sensors, an emergency button both on the HMI and physical line with sirens, warning lights and stack lights. Students were tasked with creating counters for the number of boxes passed, with a replication of stack lights with working fault light and warning indicators.

The end product should be a working PLC that has countermeasures in place should there be a line error or a clerical error in the system.

Introduction

Literature Review

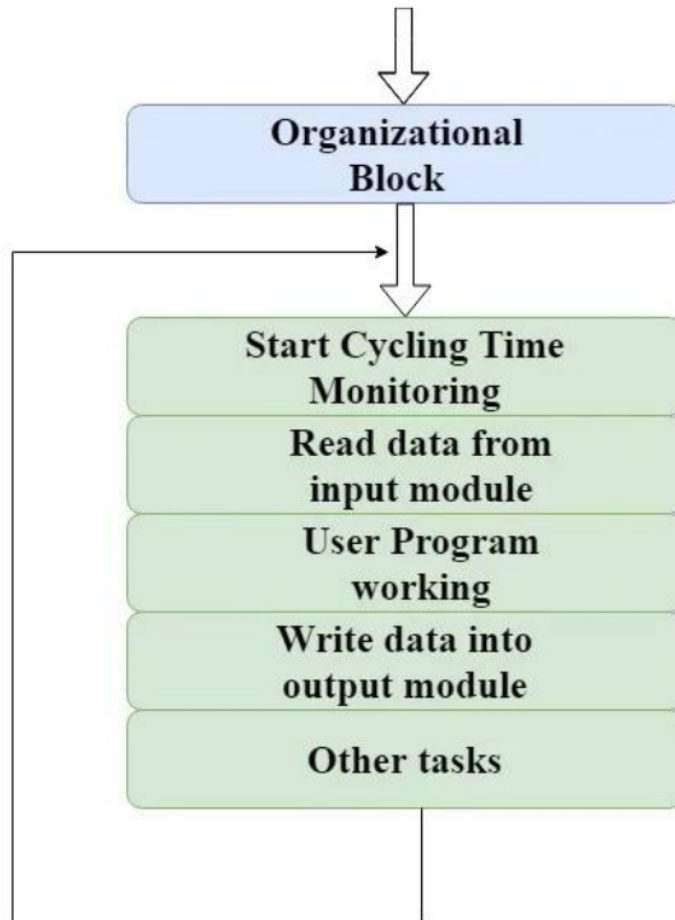
PLC: What is it?

A PLC (Programmable Logic Controller) is a computer specifically designed to operate reliably under harsh, industrial conditions such as extreme temperature changes, wet, dry or dusty conditions.

PLC's are used to automate industrial processes in manufacturing, assembly lines, ore processing plants or wastewater treatment. Depending on the PLC, it is quite versatile and robust and can extend past some of the examples given. [1]

PLC: How does it work?

A PLC can be understood as a cyclic scanning method.



1. <https://www.electrical4u.com/programmable-logic-controllers/>

Block diagram of how PLC functions. [1]

A PLC process includes the following steps:-

- The operating system starts cycling and monitoring the time.

- The CPU starts to read the data from the input modules, and checks the status of said input modules.
- The CPU starts executing the user program or application written ladder logic or other PLC programming languages.
- CPU performs all the internal diagnosis and communication tasks.
- Taking the program results, the PLC writes the data into output modules so all outputs are updated.
- The process continues as long as the PLC is in run mode.

PLC: Application in Industry

As mentioned before, PLC's have a wide range of uses in industry. These include but are not limited to:

Process Automation (e.g. mining, gas and oil) [2]

Automated Water drainage pump monitoring and control [3]

Packing and Labelling Industry [4]

Manufacturing [5]

PLC: History

The first PLCs were introduced in the late 1960s, as an industrial computer capable of aiding in control of manufacturing processes. The first industries to utilise the PLC was the automobile sector. The aim was to replace hardwired relays and timers with programmable and flexible controllers. [6]

The first designed PLCs were being developed in 1968 under the General Motors Company that needed a specialised control system for a 'Standard Machine Controller' and distributed it to vendors for a quote.

Specifications for the system at the time:

- Should use solid state components which should be modular and expandable
- Should contain 16 units that can be expanded to 256
- Should have 16 outputs that can be expanded to 128
- Should offer easy programming and reprogramming
- Should not lose stored programs during power outages, therefore, have at least 1k of memory that can be expanded to 4k
- Richard E. Morley, who worked for Bedford associates, designed a device known as the Modular Digital Controller.

PLCs Today

To support maintenance and reduce size of the operation, the following trends are seen to be:

- **Smaller and faster:** Circuit boards, processors and other electronic components are rapidly shrinking. These influence the PLCs that are being used in industries today.
- **Memory Size:** The cost of utilising declining cost of solid state memory has affected the design of modern PLCs for the better. This allows for enhanced local data storage enabling PLCs to be used in multiple applications that would have otherwise required expensive data acquisition systems.

- **Memory devices:** Portable memory devices such as an SDcard has given PLCs and exorbitant amount of memory that allows for extra memory, which is a further trend that will only continue to improve for designs, going forward.

Allen-Bradley:

Hardware:-

- Needs to connect to Allen-Bradley power supply and rack.
- Needs to install additional cards for safety communication ports.
- Allen-Bradley uses American native protocols e.g. EthernetIP, DeviceNet and ControlNet.

Automation Management:-

- Easy to configure and manage.
- Intuitive interface allows user to easily monitor and manage systems.
- Supports only one safety group, needing to stop the process in order to download program blocks.
- Higher end systems support function blocks and multiple programming techniques.

Support and costs:-

- Allen-Bradley is expensive even at their lower cost systems.
- Technical support is also priced by customer basis which is measured in how much hardware is in use; with the more hardware the higher the price.

Siemens:

Hardware:-

- Works on any 24V DC power supply.
- In-built safety communication ports.
- Uses European protocols e.g. ASI and Profibus

Automation Management:-

- Complex for regular maintenance staff; requires specialised backgrounds.
- Does offer more options to program and customize process.
- Has two safety run-time groups; allows for division of infrastructure, setting controller parameters with different priorities. Allows for download of program blocks without hindrance to processes.
- Has more programmes that it can read e.g. FBD, SCL, STL, LAD etc.

Support and costs:-

- Siemens is relatively cheaper.
- Siemens offers standard technical support for free.

Conclusion:

Their difference lays in the programmable software available to each their hardware. Allen-Bradley easier to manage and use but lacks the versatility that Siemens offers. Siemens needs more technical knowledge by specialists in order to programme which is its drawback. Both are relatively inexpensive but are specialised dependant on needs. Allen-Bradley enjoys a US centred market, whereas Siemens offers an international reach.

1 Equipment

This section should contain a list of the equipment used in the investigation.

- TIAV16
- Factory IO

2 Method

Start Button 1	%I16.0	%Q16.0	Light Indicator (Green) 1
Stop Button 1	%I16.1	%Q16.1	Light Indicator (Red) 2
	%I16.2	%Q16.2	Alarm Siren 1
Diffuse Sensor 1	%I16.3	%Q16.3	Pusher 1
Diffuse Sensor	Diffuse Sensor 1	%Q16.4	Pusher 2
Diffuse Sensor 3	%I16.5	%Q16.5	Pusher 3
Diffuse Sensor 4	%I16.6	%Q16.6	Belt Conveyor (6m) 1
Diffuse Sensor 5	%I16.7	%Q16.7	Belt Conveyor (4m) 1
	%I17.0	%Q17.0	Belt Conveyor (4m) 3
	%I17.1	%Q17.1	Belt Conveyor (2m) 1
	%I17.2	%Q17.2	Belt Conveyor (2m) 2
	%I17.3	%Q17.3	Curved Belt Conveyor 1 CCW
	%I17.4	%Q17.4	Curved Belt Conveyor 2 CW
	%I17.5	%Q17.5	Belt Conveyor (4m) 2
Emergency Stop 0	%I17.6	%Q17.6	
Emergency Stop 1	%I17.7	%Q17.7	Stack Light 0 (Green)
Emergency Stop 2	%I18.0	%Q18.0	Stack Light 1 (Green)
	%I18.1	%Q18.1	Stack Light 2 (Green)
	%I18.2	%Q18.2	Stack Light 3 (Green)
	%I18.3	%Q18.3	Stack Light 0 (Yellow)
	%I18.4	%Q18.4	Stack Light 1 (Yellow)
	%I18.5	%Q18.5	Stack Light 2 (Yellow)
	%I18.6	%Q18.6	Stack Light 3 (Yellow)
	%I18.7	%Q18.7	Stack Light 0 (Red)
	%I19.0	%Q19.0	Stack Light 1 (Red)
	%I19.1	%Q19.1	Stack Light 2 (Red)
	%I19.2	%Q19.2	Stack Light 3 (Red)
	%I19.3	%Q19.3	
	%I19.4	%Q19.4	Pop Up Wheel Sorter 1 (+)
	%I19.5	%Q19.5	Pop Up Wheel Sorter 1 (Left)
	%I19.6	%Q19.6	Pop Up Wheel Sorter 1 (Right)
	%I19.7	%Q19.7	
	%I20.0	%Q20.0	Conveyor Scale 1 (+)
	%I20.1	%Q20.1	
Conveyor Scale 1 Weight (V)	%ID30 (REAL)	(REAL) %QD30	Digital Display 1
	%ID34	%QD34	

2 Factory IO: Driver

☒ Auto connect

Model

S7-1200

I/O Config

Numerical Data Type

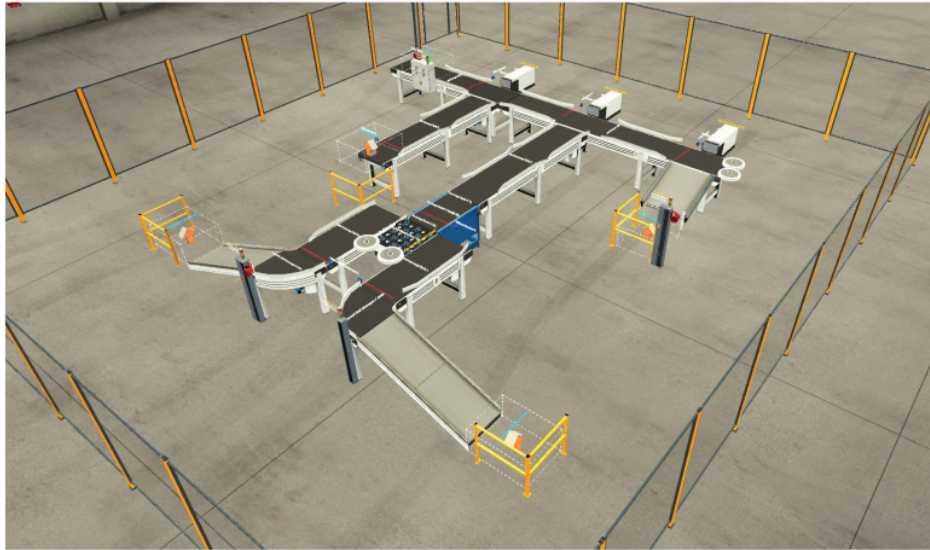
DWORD

I/O Points

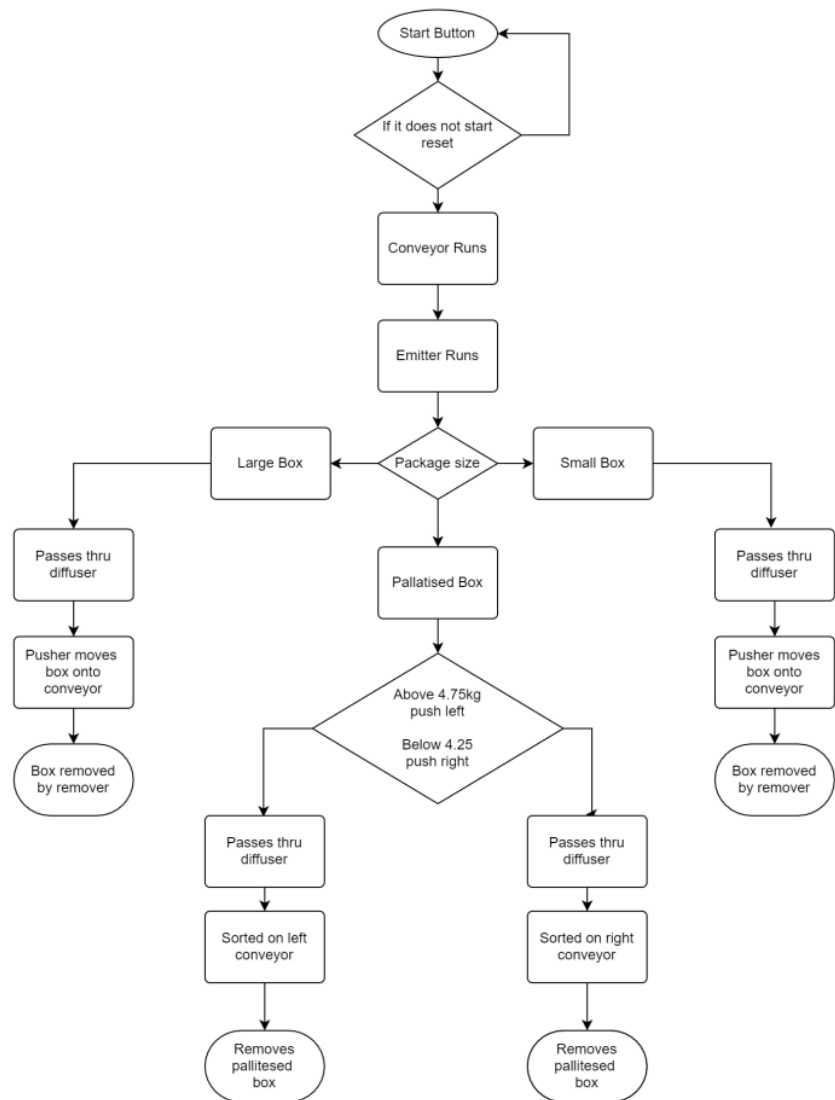
	Offset	Count
Bool Inputs	16	34
Bool Outputs	16	34
DWORD Inputs	30	8
DWORD Outputs	30	8

DEFAULT

3 Factory IO: I/O and model



4 Factory IO: Floor Design



5 Operational Flowchart: Factory Control

TIV16 Program Block Networks

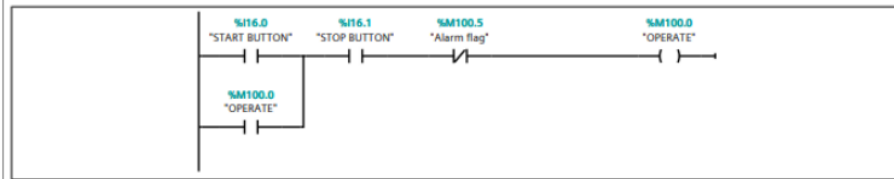
Network 1:



Network 1: To set up the function block and sync up to other program, which is Factory IO.

Network 2:

START OPERATIONS

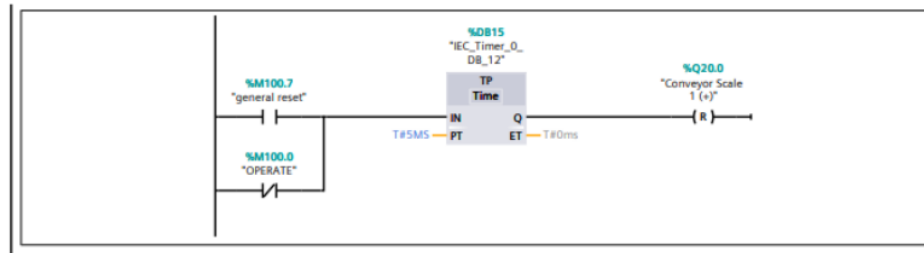


Network 2: Input 16.0 is directly correlated to the chip we were using which was the S7-1200 and is in input channel for a real button on the factory floor.

I16.1 is a stop button for the factory floor

M100.5 is allocated memory which is an "Alarm flag" which if triggered still allows for operation, however will let end user know there is a problem somewhere down the line.

"Operate" is another memory allocation to start up conveyors and is a switch type function, to let the CPU know to run script.

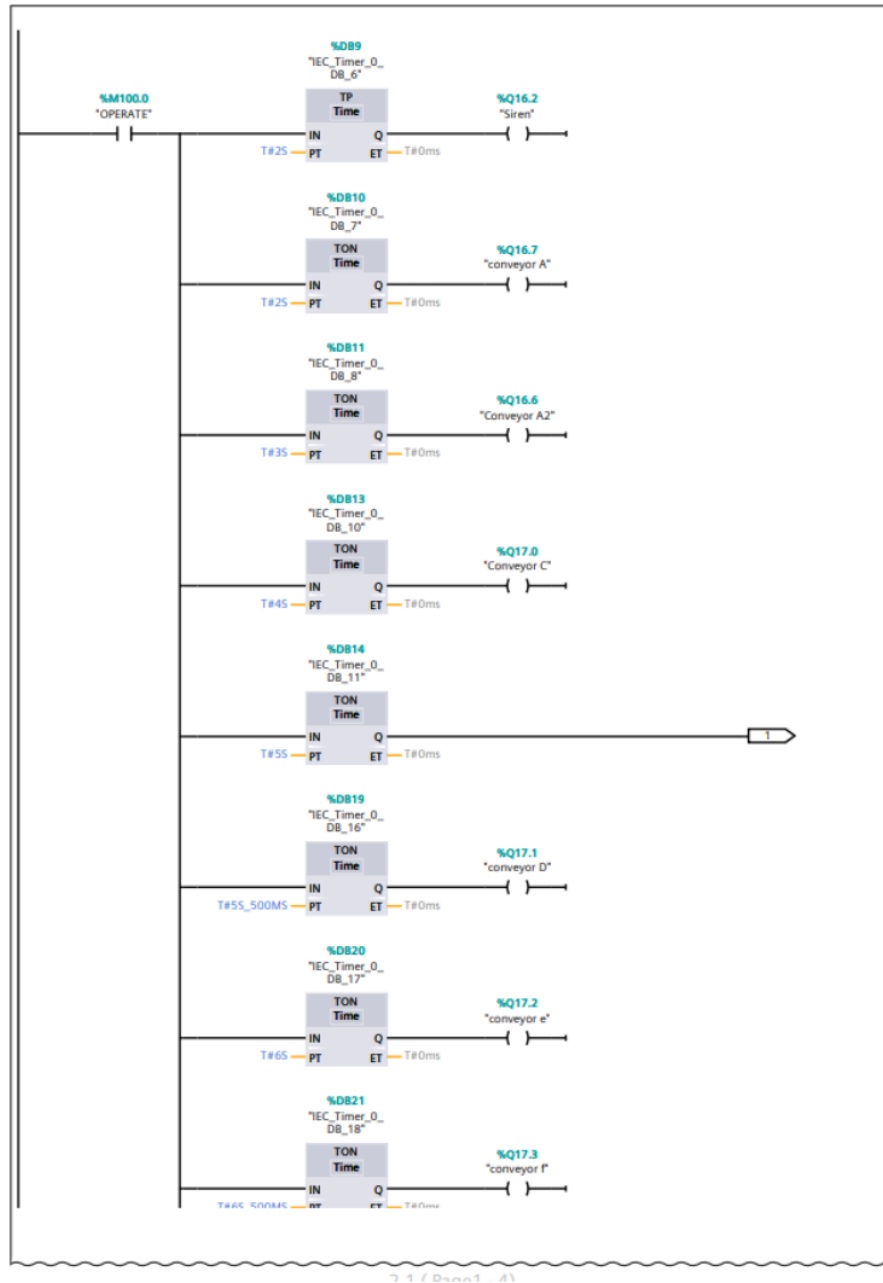


Network 3: Memory allocated for a general reset pulse in the program “general reset” is to allow for the reset of counters, and alarms.

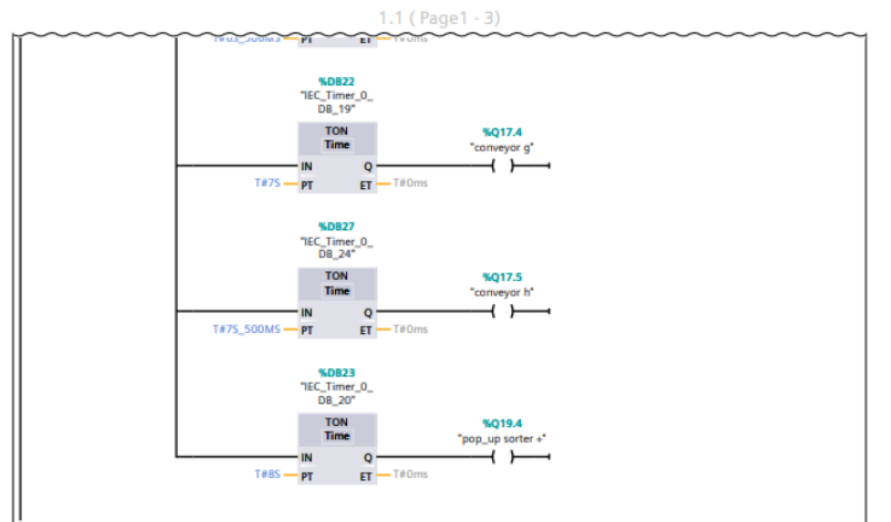
The timer is for when the pulse hits DB15, the conveyor scale then runs.

“Operate” is to allow for a stop in or reset in operation and wouldn’t affect the conveyor, bar the counter and alarm systems.

Q20.0 is an output for the conveyor scale used. The (+) is to indicate which way the conveyor is running, making it reversible is needed.

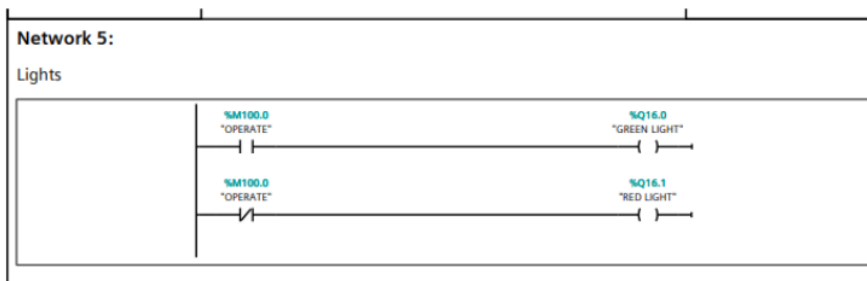


3 / 3 Down 1 - A1



Network 4: General operation of the several conveyors on the factory floor as well as the pop up sorter and siren to indicate operation or warning.

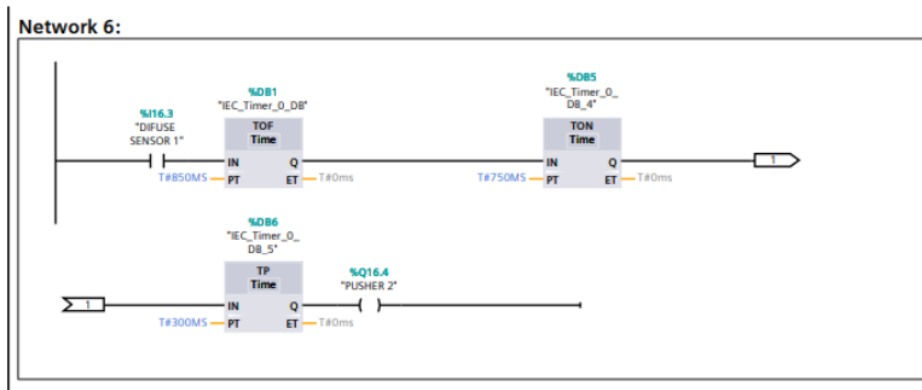
The timers seen are the start times for each operating conveyor in the system, and how long the pop sorter is meant to hold, to switch to left or right, depending on weight of the palletised box. Weights below 4.25 are pushed right, and weights above 4.75 are pushed left. Weight exceeding 5kg, the weight conveyor stops and alarm pulse is sent to the end user. Depending on number of allowing lost packages, the system sends a warning and ceases operation.



Network 5: To allow a start and stop light indicating to the user when machine is in operation and the PLC is running.

“Operate” in the open configuration, there is a greenlight. This indicates that machine is operable/

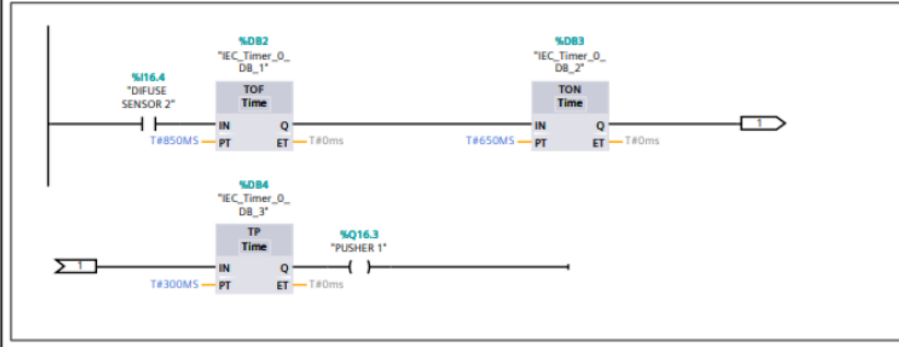
“Operate in the closed configuration is a red light. This indicates that machine is inoperable.



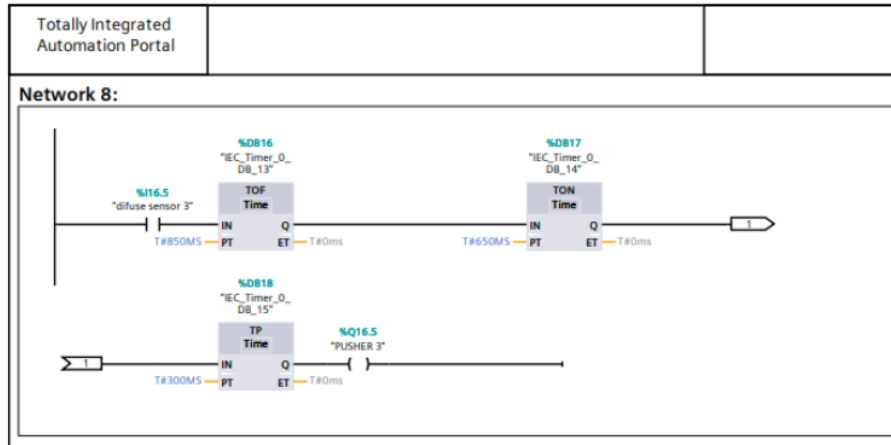
Network 6: I16.3 is an input to the diffuser on the factory floor and is timed to push the ‘pusher’ when a box has passed the diffuser. Timings can change whether or not the box is sorted in the correct bins/Removers.

This network is sorting for the large boxes in the system and in the floor design, you can see a noticeable height difference in the diffuser to allow the smaller height boxes to pass through.

Network 7:

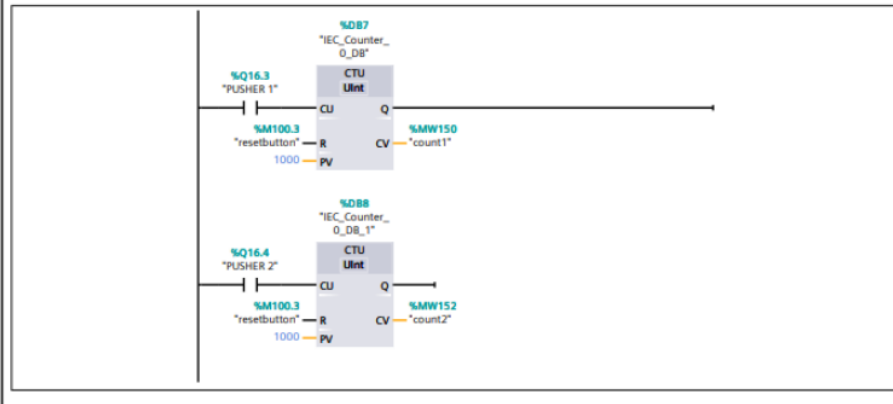


Network 7: This network functions ion the same operation above, but pushes the palletised medium sized boxes into this sorting bin.



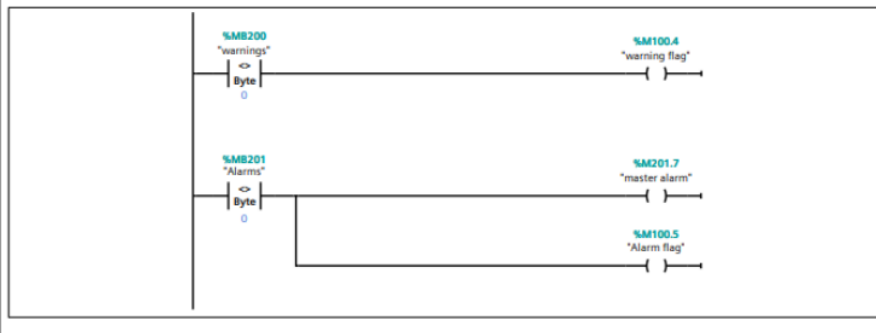
Network 8: Functions in similar principal to Networks, 6 and 7 but has a noticeable height difference and only pushes the lower height, small boxes into the correct bin/remover.

Network 9:



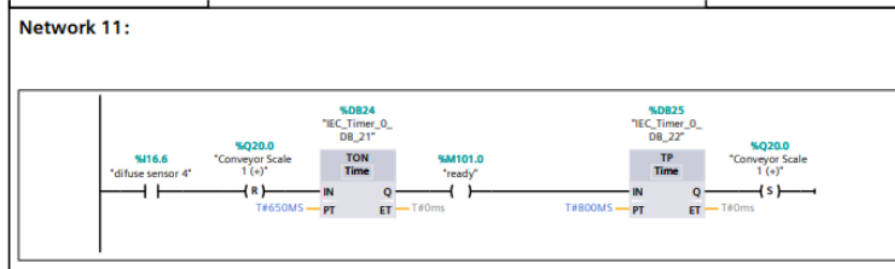
Network 9: This is a counter set in order to indicate how many boxes ‘pusher’s’ 1 and 2 have sorted. Every time it’s pushed, it clocks 1 unit up.

Network 10: check for warnings or alarms

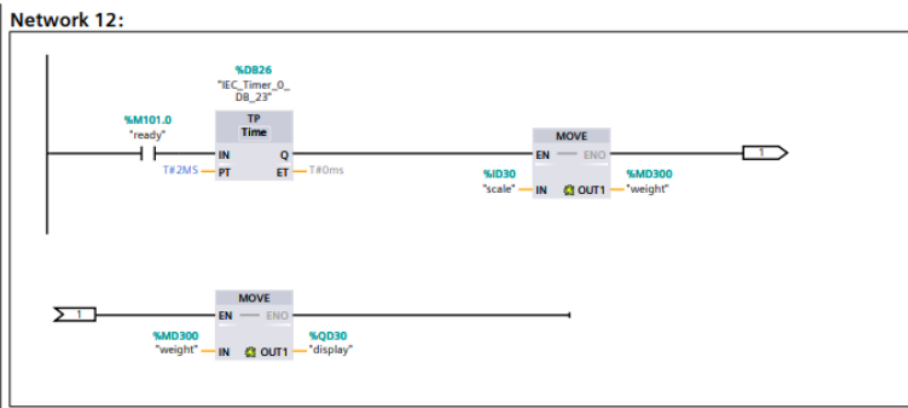


Network 10: directly indicates and directs which ‘warning’ signals are being pulsed by the system, and ‘warning flag’, flags the warning and indicates it to the rest of the system, which is attached to the other network nodes and ceases the operation of the PLC or notifies the end user, requiring an engineer to reset the system.

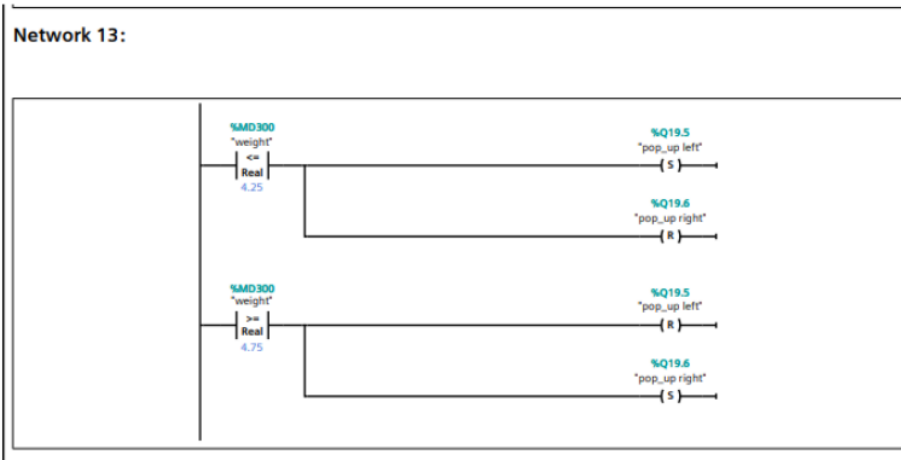
The alarm functions in the same way, but only notifies the engineer that there is a problem somewhere on the factory line, but does not stop the operation of the PLC.



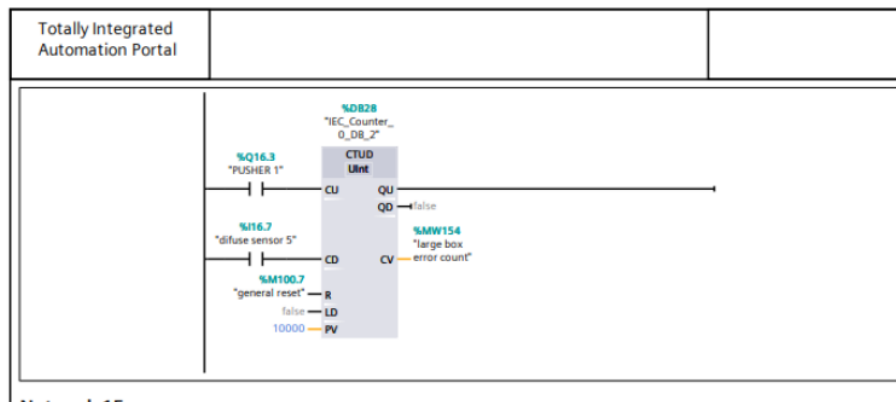
Network 11: This is similar to networks 8,7 & 6 but has the added function of a the conveyor scale. This is to indicate to the conveyor to stop, and weigh the package, to get an accurate measurement and allow the popper to switch between left and right.



Network 12: Allows end user to see the weight being displayed on the scale.



Network 13: Displays weight, anything below 4.25 is popped left, and above 4.75 popped right.



Network 14: Same function as networks 7,6,8 & 11

Network 15:

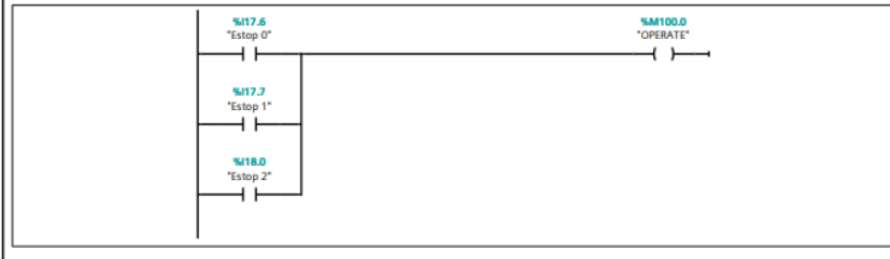
large box error warn/alarm



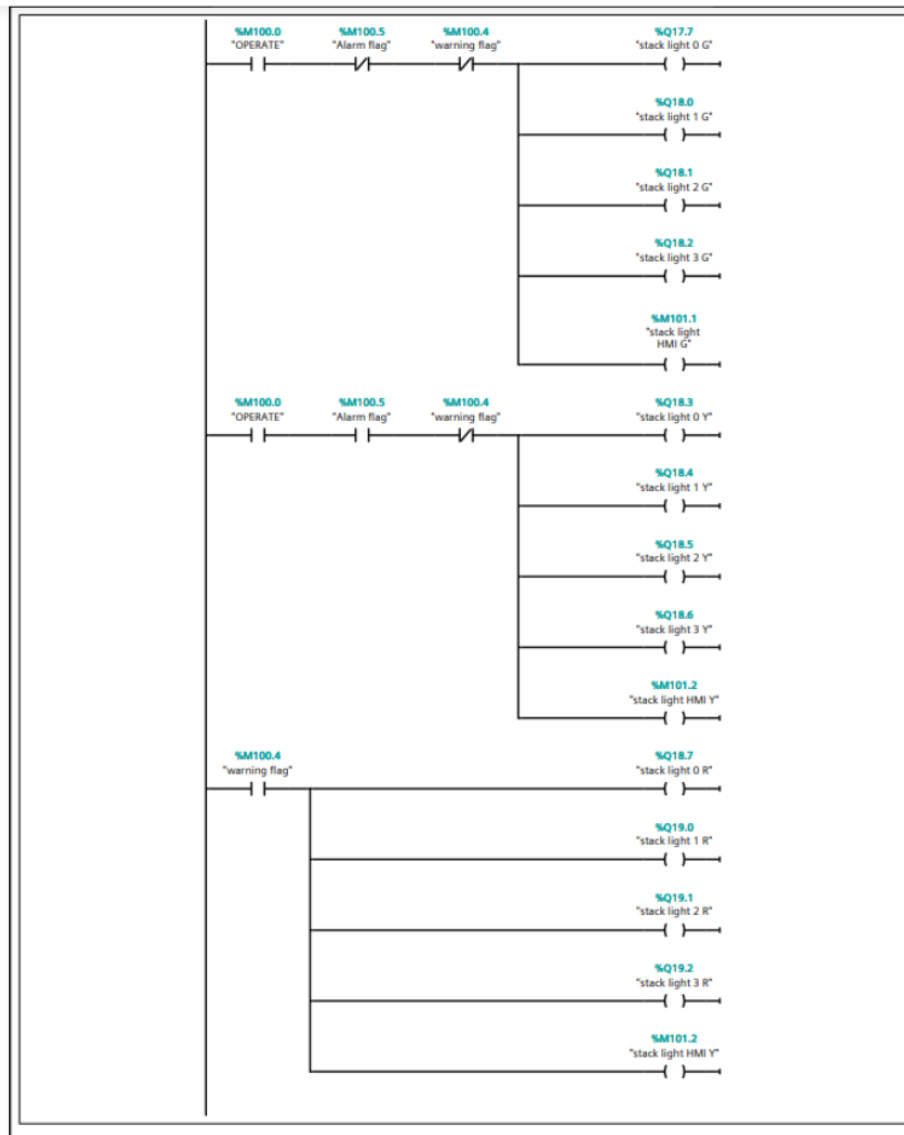
Network 15: error counters

Network 16: Real Stop

Real emergency stop on panel, in factory floor



Network 16: Estops on the factory floor



Network 17: Stack lights and HMI stack lights

3 References

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4 Appendices

Factory Control

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

66/100

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GRADING FORM: SMU GENERIC_GJ

KEEFE MONTEBON

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RESEARCH-INFORMED LITERATURE



Reasonable literature review of PLCs on the market, could have been improved with some images and a bit more time. 55%

KNOWLEDGE AND UNDERSTANDING



The factory looks good with all of the required components included. Your factory operates well and demos very well except your box counters are a little confusing. 65%

ANALYSIS



Your ladder logic program is reasonably well documented throughout with an alarm strategy. 68%

PRACTICAL APPLICATION AND DEP.



Your HMI screens are well laid out and intuitive for the operator. 68%

SKILLS FOR PROFESSIONAL PRAC.



The report is reasonably presented. The illustrations are good and clear. A limited selection of references. 65%