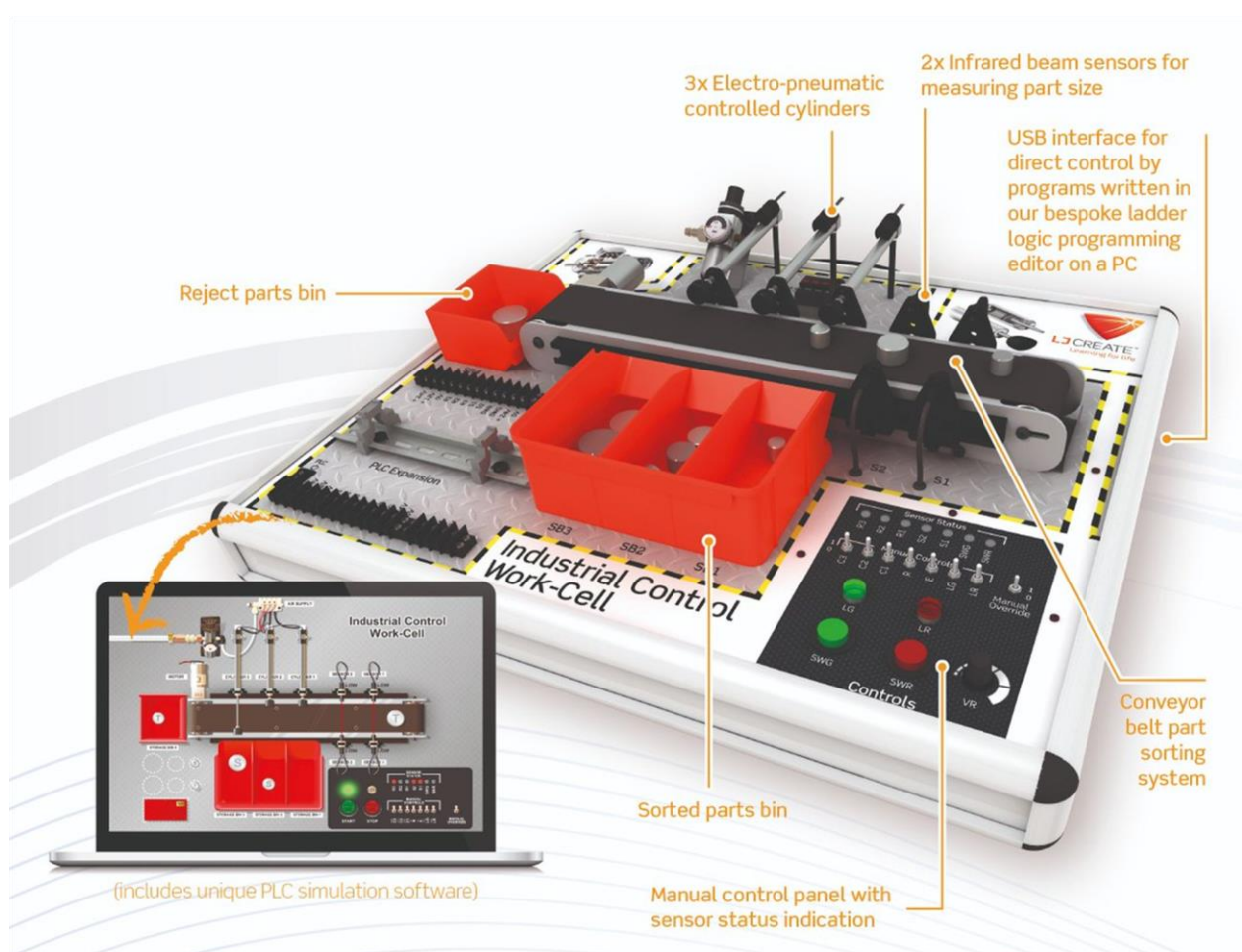


Siemens PLC Control System



Chris Stonelake
PLC Assignment

Contents

Introduction.....	Page 02
Brief Review potential warning & errors.....	Page 03
Operational Flow Chart.....	Page 04
Operator Error & Warning Procedure's.....	Page 5 to 8
Operator Error & Warning Check Procedure.....	Page 8 to 9
Operator Warning procedure.....	Page 09
Operator Error Procedure.....	Page 09
PLC Timing Diagrams.....	Page 10 to 30
System Block Diagram (Hardware).....	Page 31
Improvement Review.....	Page 32

Introduction

This document outlines the requirements as detailed by 'PLC assignment Rev 0', this will take the user through the design concept to the build and final product.

From the client specification as detailed in document 'PLC assignment Rev 0', a clear functional operational scenario is detailed;

You are required to design a PLC control system that differentiates between the diameter and height of a set of aluminium pucks. To achieve this you will utilise the PLC trainer.

The pucks come in three diameters and two heights. You must sort the pucks into different bins, the narrow pucks both tall and short are to be ejected into the bin which captures pucks pushed by cylinder 1. The medium diameter short pucks are to be ejected into the bin which captures pucks pushed by cylinder 2. The medium diameter tall pucks are to be allowed to traverse the conveyor without ejection to fall into bin 4 at the end of the conveyor. The large diameter short pucks are to be ejected into the bin which captures pucks that are pushed by cylinder 3. The large diameter tall pucks are to be sorted into the bin located at the start of the conveyor, this is to be achieved by reversing the conveyor until the puck has been ejected from the conveyor.

Additionally, you are to provide a HMI display which gives visual indication that the system is running, the number of pucks of each type that has been sorted, the speed of the conveyor belt and implement warnings for faults or erroneous operation.

Your main screen should include an emergency stop button and the facility to display alternate screens which can interrogate any warnings or errors that occurs. Should an error occur then the system must stop immediately and should not be able to be re-started until the error has been removed and a manual reset of the master error flag.(REF1)

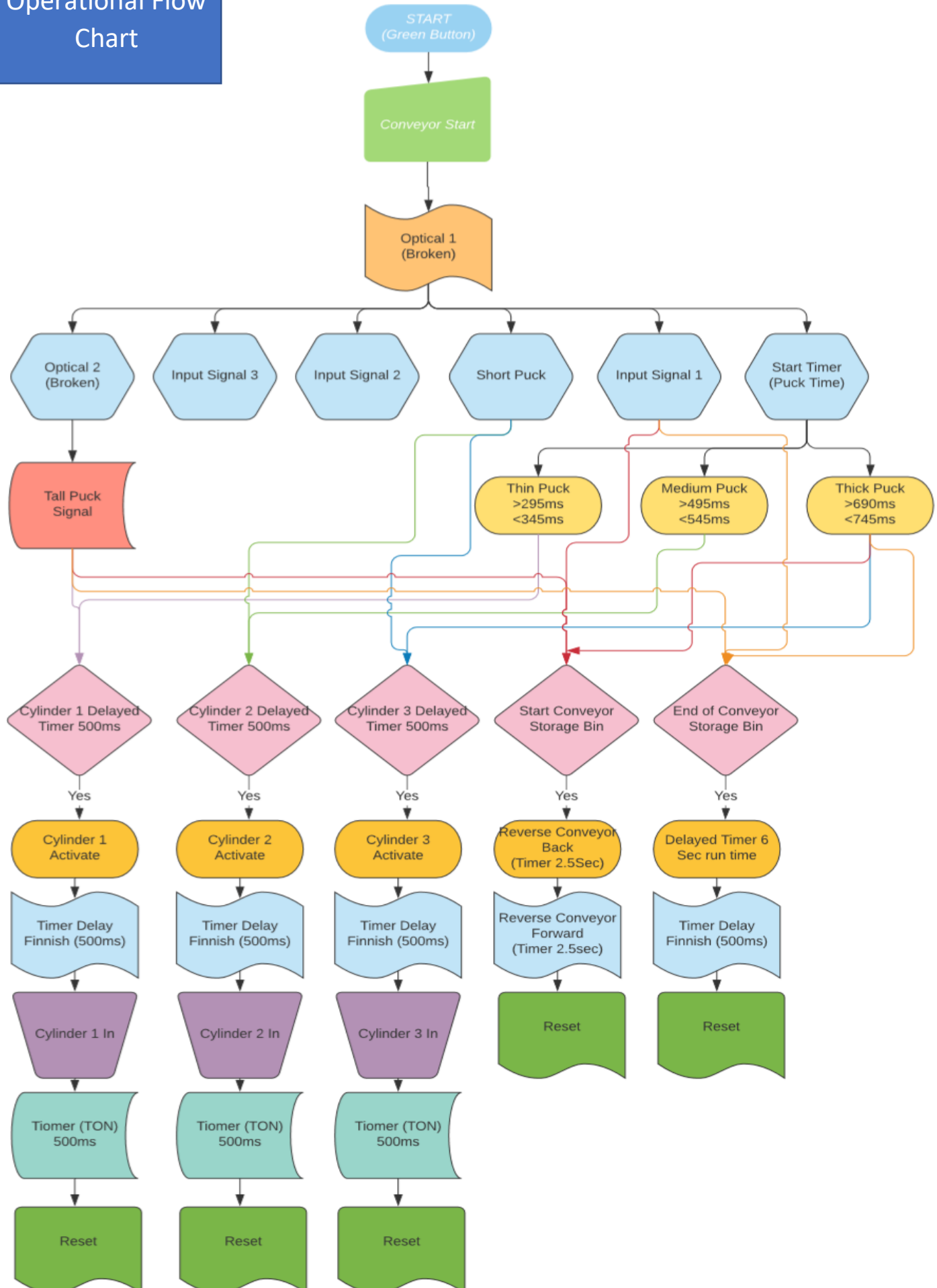
Taking the detailed specification requirement as per the above, this was processed and developed into the engineered solutions presented as this submission document.

Review of Brief – Potential Warnings/Error's that could case operational issues.

Having revised the brief in detail and initial concept over view of what is required, the following potential errors and warning which could case operational issues;

- Cylinders not firing, this would cause the pucks to fall into the wrong bin (end of conveyor), upon a period of time set out by a timer if the cylinder does not fire this will generate a warning to stop the process. > System action > error flag raised > system stop > operator intervention > when fault resolved operator re-fresh system.
- Cylinders stuck in the out position, this would cause the belt to be obstructed and would also not allow the system to reset to enable a new puck to enter the line. > System Action > Error Flag raised > system stop > operator intervention > when fault resolved operator re-fresh system.
- Low air pressure, low pneumatic air pressure will either not operate the cylinders when required or will operate extremely slow and not give the operation the desired operation. > System Action > warning flag raised > operator check air pressure > if found to be too low and adversely effecting system > stop process red button > rectify air pressure > re-fresh system.
- Belt speed, if the belt speed fluctuates and is not constant this will jeopardise the timing operations for the system process. > System Action > warning flag raised > operator intervention > monitor belt speed > if out of sequence > operator manually stop operation > press re-fresh > check to see if this has rectified the issue.
- Storage boxes too full, warnings or counters to allow the monitoring of the storage box level to indicate to the operator when to empty. > system action > warning flag raised > operator intervention > confirm storage box level > if approaching full level > replace with new box > clear warning.
- No material on belt, if the system is started and optical 1 does not register any pucks after 20sec this will cause an alarm to activate alerting no materials on the belt, operator can either put pucks on belt or stop the process to conserve energy. > system action > after 20sec duration of process start from green button operation > warning flag no material on belt > operator intervention > put puck on belt or stop process.

Operational Flow Chart



Operator Error & Warning Procedure

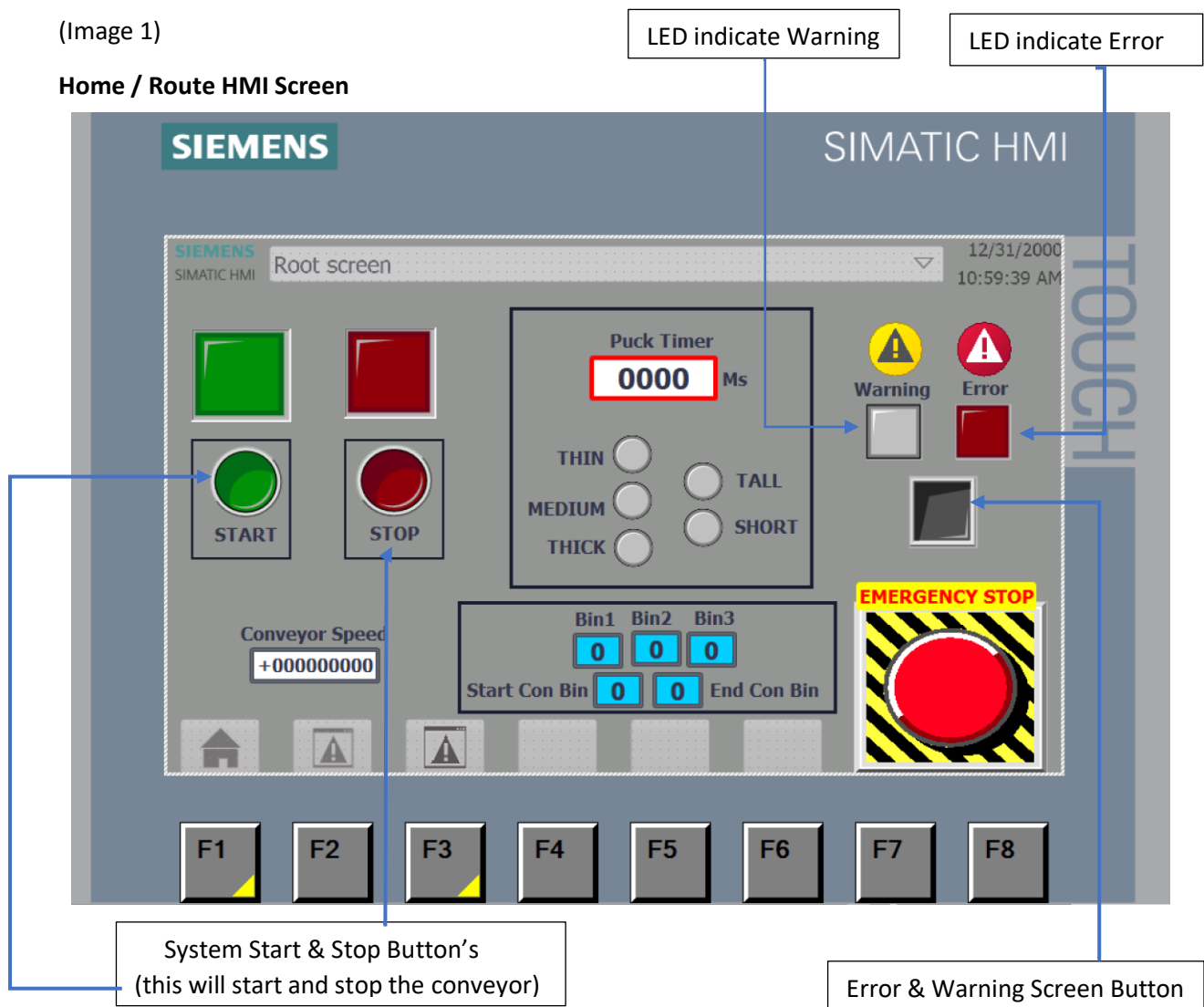
In the event of a system error or warning please follow the below corrective actions;

Section 1.0

In the case of either a system error or warning, this will be indicated via the root (main screen) screen, depending on a error or warning the corresponding LED will illuminated as per below (Image 1)

(Image 1)

Home / Route HMI Screen



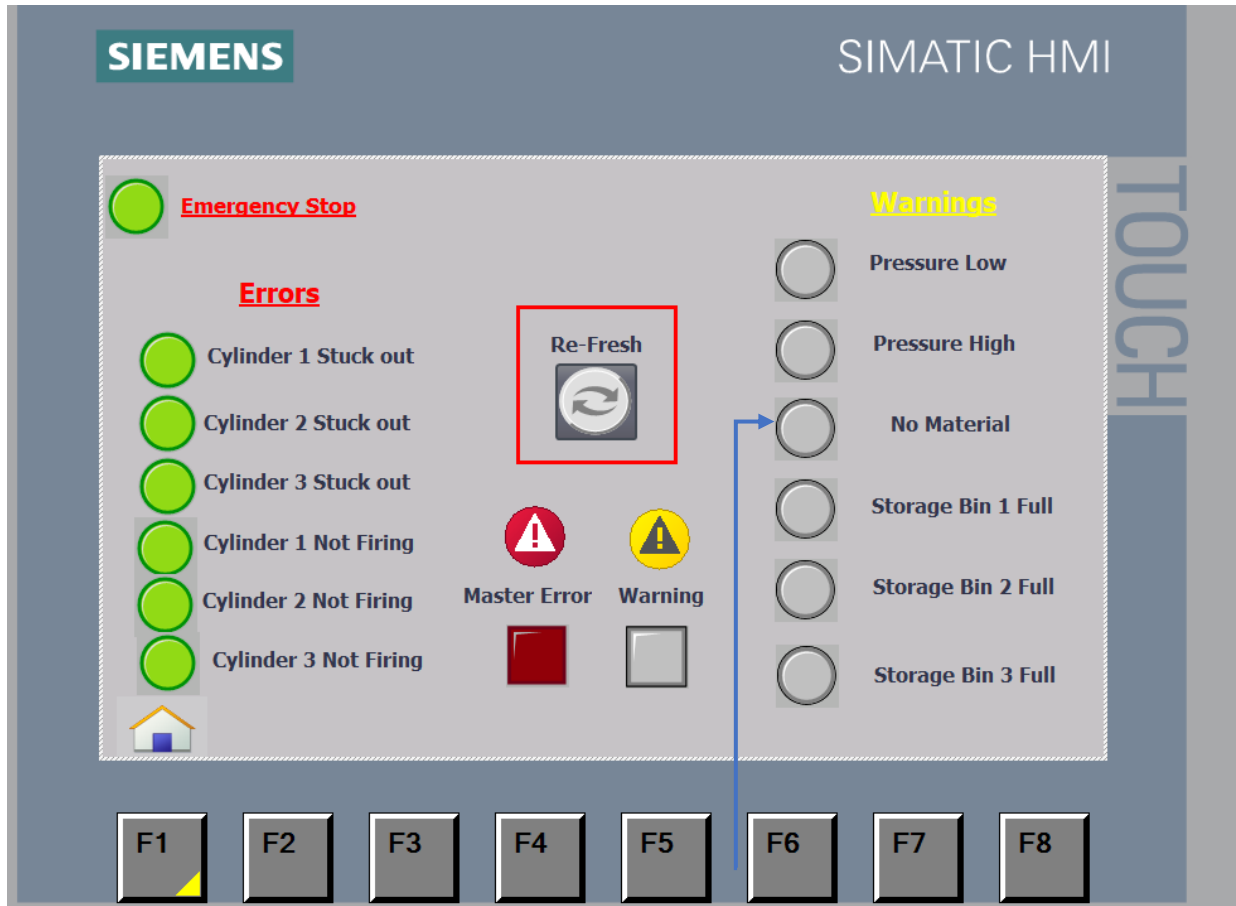
To further diagnose the warning or error press either the [F3] or Error & Warning Screen Button.

Once operator has selected and actioned to proceed to the Error& Warning Screen please proceed to section 2.0

Section 2.0 – Operator Check Procedure

Once the HMI has re-directed the operator to the Error & Warning screen (below image 2 gives representation to what the screen looks like)

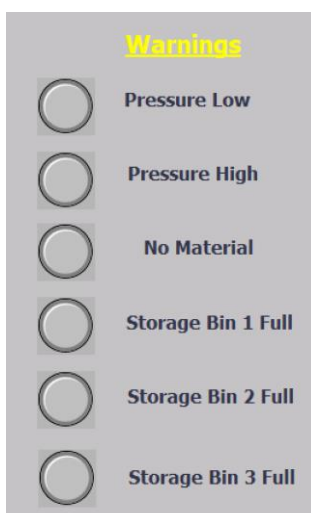
Error & Warning HMI Screen



(Image 2)

Depending on the warning the corresponding LED will illuminate and warning brief description next to it

The above image gives a general lay out of the error & warning screen, in this section 2, will cover the warnings and correct procedures to follow formal warning alarm being activated, section 3 will cover Error's and their corrective actions and procedures.



Warning LED & Description Section (Warning & Errors HMI Screen)

Re-Fresh Button

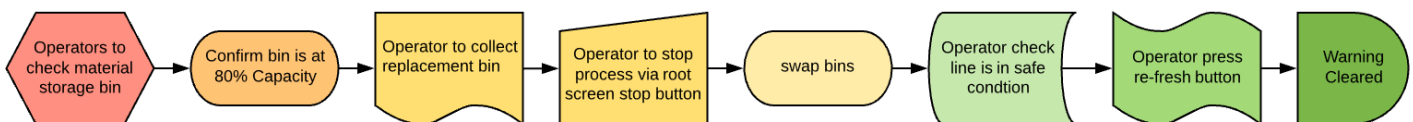


During the event of a System Warning please follow the below corrective actions relevant to the warning.

Pressure Warnings

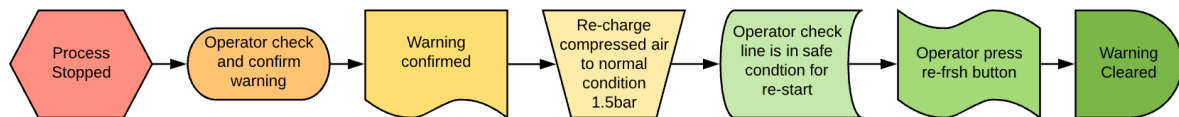
Pressure Low Warning – Pressure low is monitoring the compressed air reservoir storage vessel, if the pneumatic pressure drops below 25% (0.5bar) cylinder operation will be compromised.

Action – Stop process > operator check and confirm error>warning confirmed>re-charge compressed air to nominal working condition (1.5bar) > complete task > ensure line is in safe condition > press the Re-Fresh button > this will clear the warning.



Pressure High Warning – Pressure High is monitoring the compressed air reservoir storage vessel, if the pneumatic pressure goes over 85% (1.8bar) the cylinder operation could potentially operate too quick, missing the timings this will also indicate of early warning of over pressure in the storage vessel.

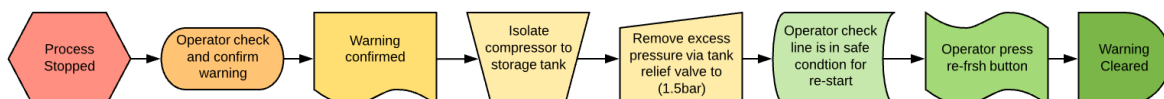
Action – Stop process > turn off compressor to storage tank > remove excess pressure via tank relief valve to (ideally 1.5bar) > ensure line is in safe condition > press the Re-Fresh button > this will clear the warning.



Material Warnings

No Material On Conveyor Warning – once the conveyor start button is pressed to activate the running of the conveyor, a 20 second timer will begin if no other normal operation functions start in this time, a warning will be generated, the purpose of this is to ensure maximum plant efficiency, if the conveyor doesn't need to be operational then it can be switched off to save energy.

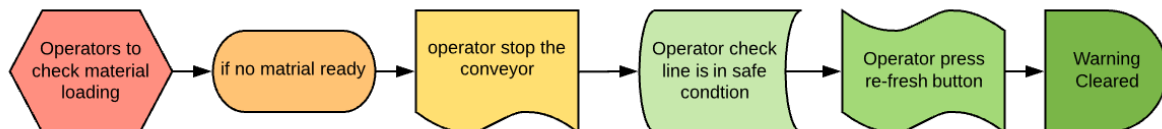
Action – Check with loading operators > if no requirement for the conveyor to be operational > stop the conveyor > ensure line is in safe condition > press the Re-Fresh button > this will clear the warning.



Storage Bin Warnings

Storage Bin 1,2 or 3 full warning – storage bin full warnings will start coming on when the storage bins are nearing their capacity, and giving early warning to operators to replace bin with a new one. The storage bin warning will trigger when the bin is at 80% capacity, so if a bin has a capacity of 10 pucks this will trigger at 8 pucks.

Action – Proceed to check storage bin > confirm if bin is at 80% capacity > collect replacement bin > stop process via root screen stop button > swap bins > ensure line is in safe condition > press the Re-Fresh button > this will clear the warning.

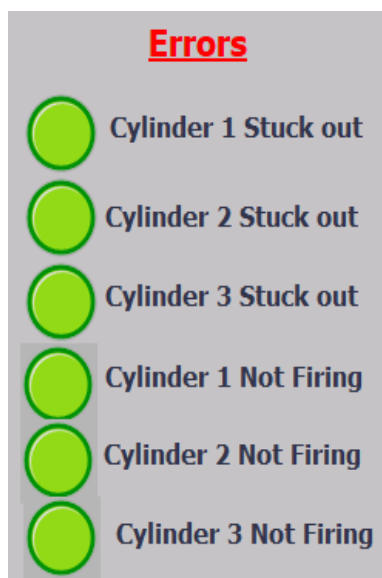


Section 3

Section 3 Covers the operator checks procedures in the event of error's within the system. It should be noted that the system is configure so that in the event of an error the process will stop as a safety intervention.

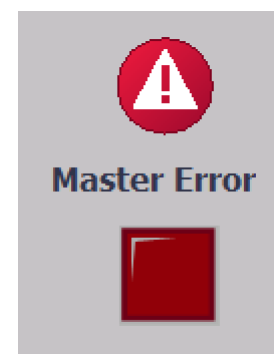
Indication and navigation for errors follows the same process as detailed in section 1.

Once you have navigated to the Error & Warning HMI screen the Errors LED and short description section is on the left as per below (image 3)



Depending on the error the corresponding LED will illuminate.

The master error LED will also be illuminated when any error is activated.

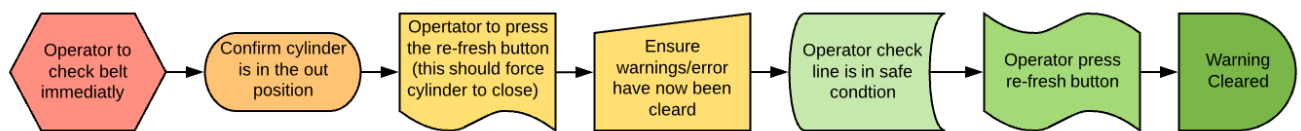


During the event of a System Error please follows the below corrective actions relevant to the warning.

Cylinder Errors

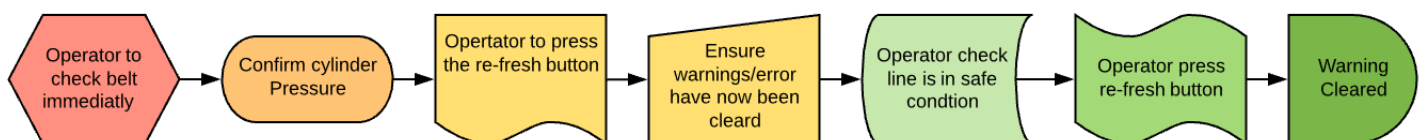
Cylinder 1,2 & 3 Stuck Out - this error will activate when the return cylinder operation does not generate a return signal, indicating the cylinder is in the out position now obstructing the conveyor belt, due to the nature of fault this will automatically stop the conveyor and process.

Actions – operator to immediately check conveyor belt & error indicated cylinder > confirm if the cylinder is in the out position > press the Re-Fresh button (this should now force the cylinder to close > once cylinder is closed ensure no further errors or warnings > press re-fresh for a second time > system ready to restart process.



Cylinder 1,2 & 3 Not Firing – this error will activate when the cylinder's do not fire and the sequence of events or signal triggers that would normally follow does not happen, the error signal generated will stop the process due to the nature of the fault.

Actions – operator to immediately check the conveyor belt & error indicated cylinder > confirm no other warnings (pressure low) > operator to force operate the cylinder > press the Re-fresh button > ensure all errors and warning have cleared > system ready to restart process.

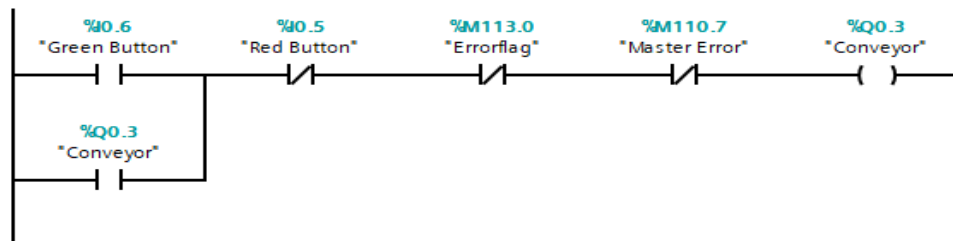


PLC Timing Diagrams

Network 1

Network 1: Start / Stop Conveyor

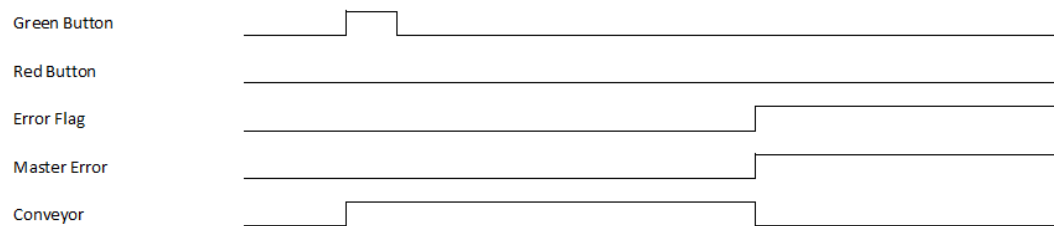
▼ Function start / stop conveyor cycle (so long as E-Stop and Errorflag status have not been broken)



Timing Diagram for Network 1 (Manual switching of conveyor)



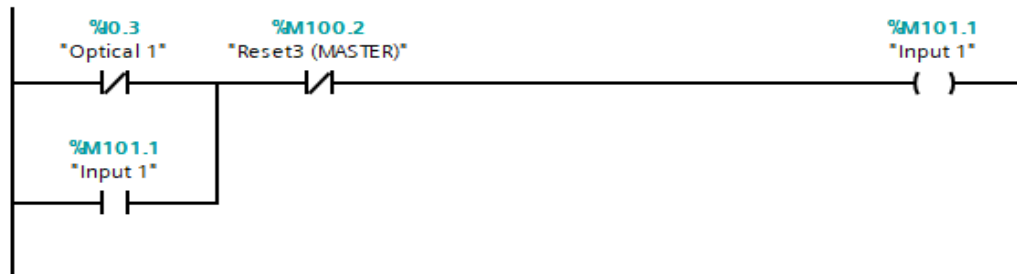
Timing Diagram for Network 1 (Error Operation)



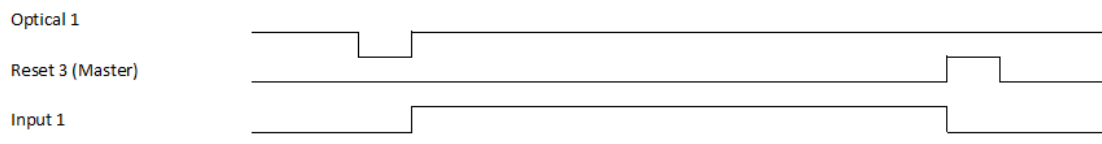
Network 2

Network 2: Optical 1 broken _ triggers Input 1

Comment



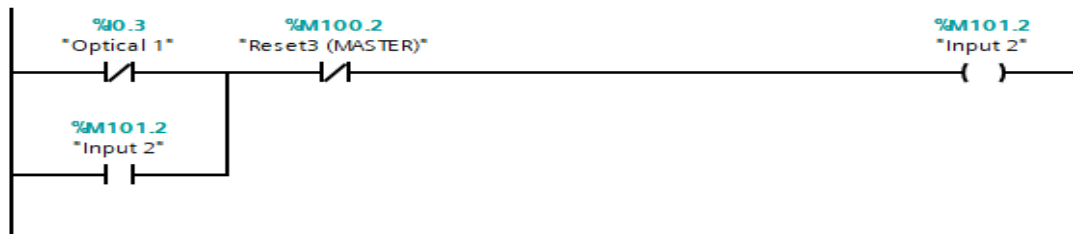
Timing Diagram for Network 2 (Normal operation)



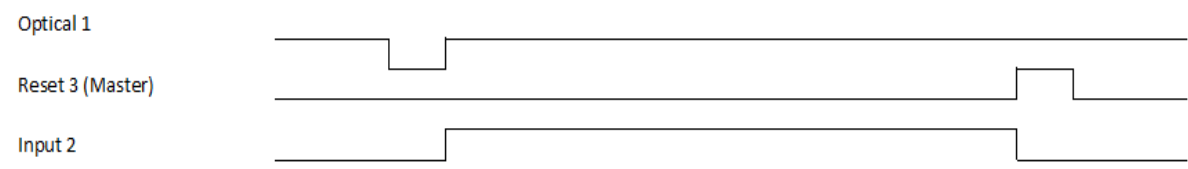
Network 3

Network 3: Optical 1 Broken _ Triggers Input 2

Comment



Timing Diagram for Network 3 (Normal operation)



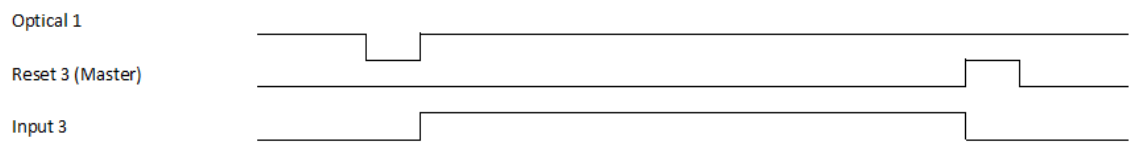
Network 4

Network 4: Optical 1 Broken _ Triggers Input 3

Comment



Timing Diagram for Network 4 (Normal operation)



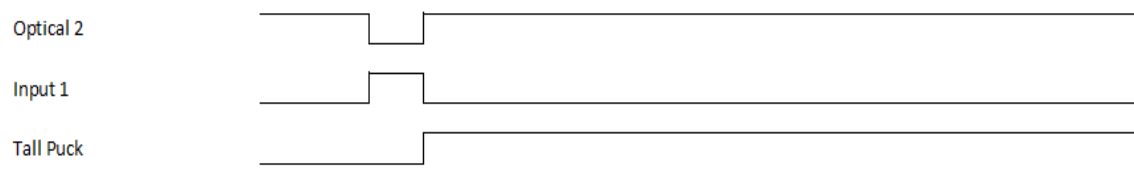
Network 5

Network 5: Optical 2 & Optical 1 beam broken _ Tall Puck

Comment



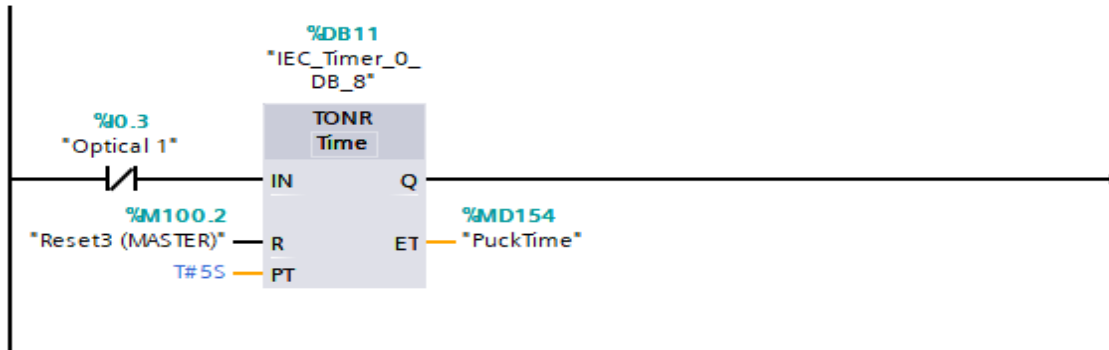
Timing Diagram for Network 5 (Normal operation)



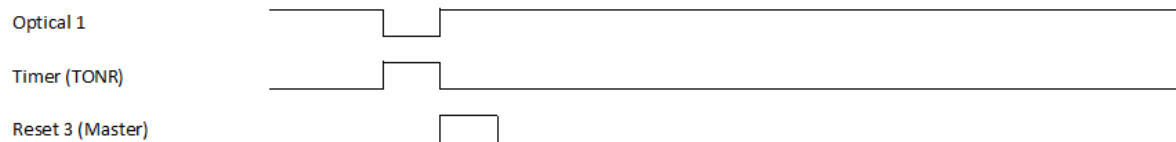
Network 6

Network 6: Puck Timer via optical 1 _ Puck width measurement

- Width Puck Time's
 - Thin - 295-345mS
 - Med - 495-545mS
 - Wide - 690-745mS



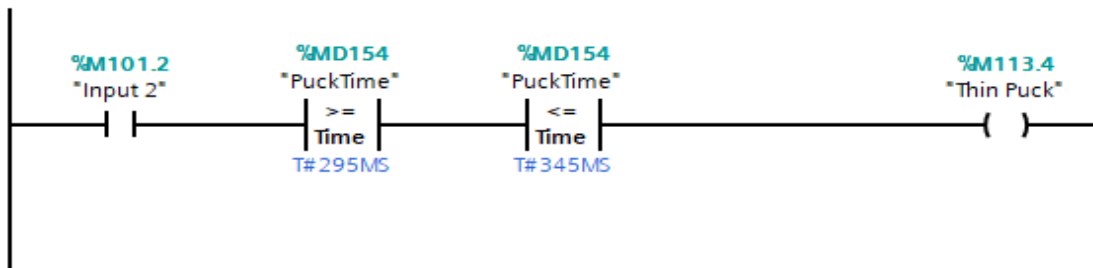
Timing Diagram for Network 6 (Normal operation)



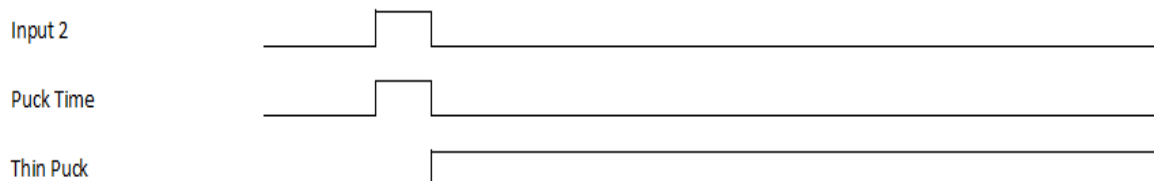
Network 7

Network 7: Create Thin Puck Output _ validating checking times

Comment

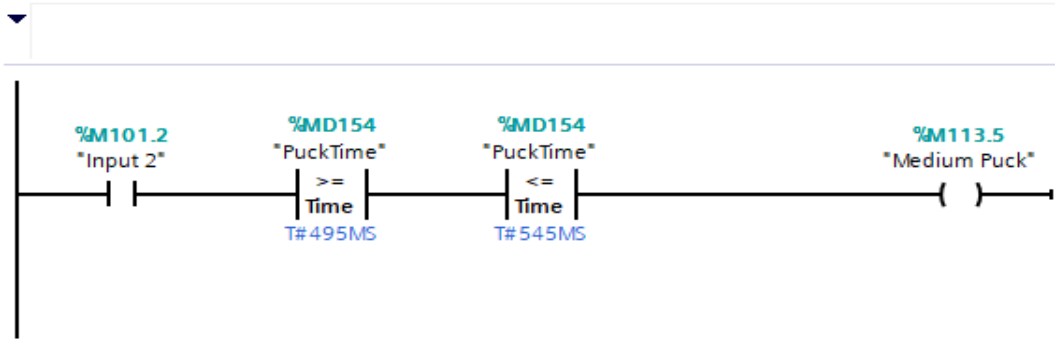


Timing Diagram for Network 7 (Normal operation)

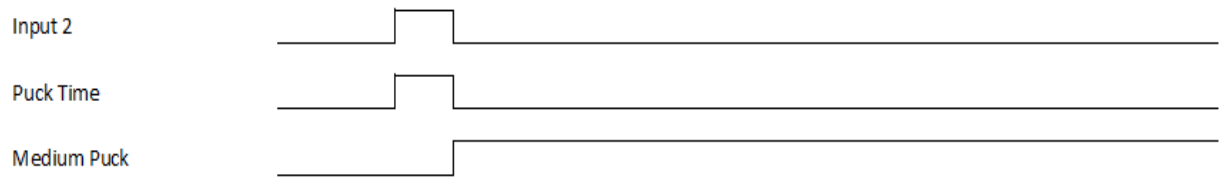


Network 8

Network 8: Create Medium Width Puck Output _ validating checking times



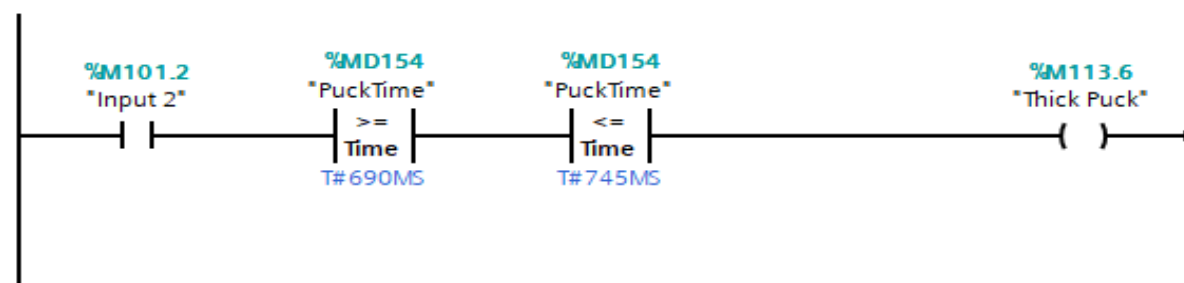
Timing Diagram for Network 8 (Normal operation)



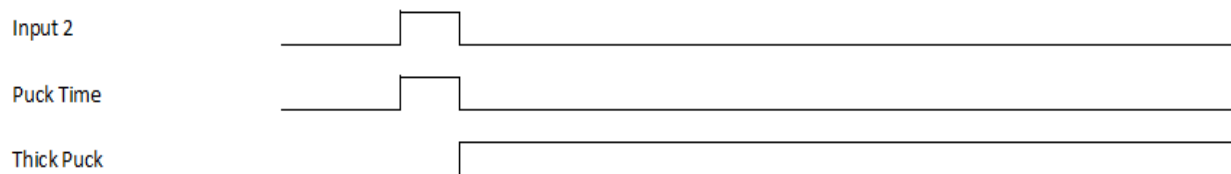
Network 9

Network 9: Create Thick Puck Output _ validating checking times

Comment

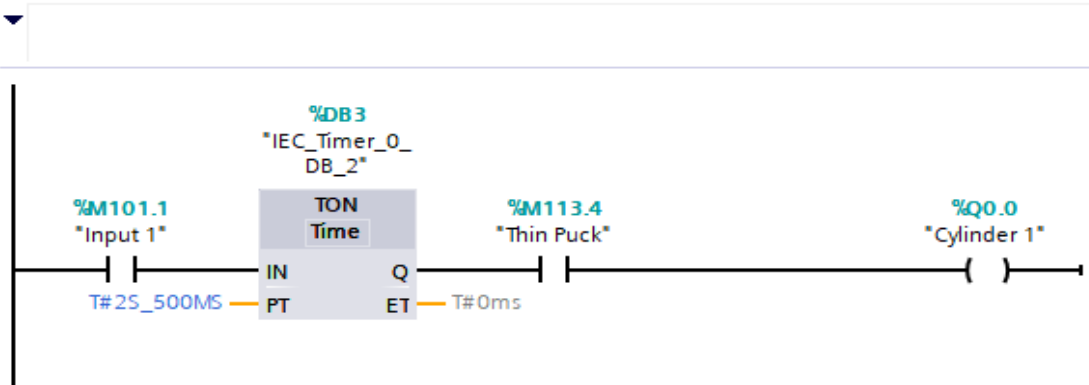


Timing Diagram for Network 9 (Normal operation)

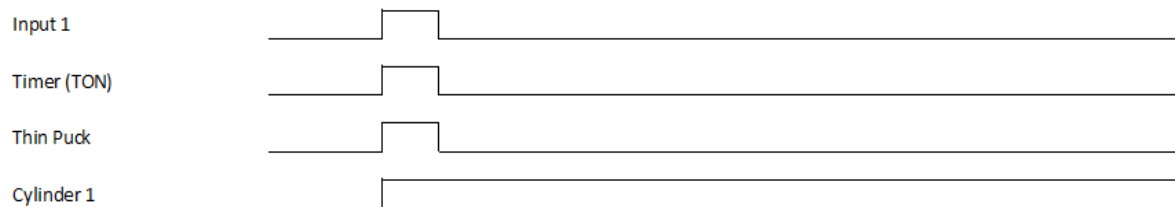


Network 10

Network 10: Cylinder 1 Tuck into Bin 1 - Short & Tall Pucks (THIN Width)



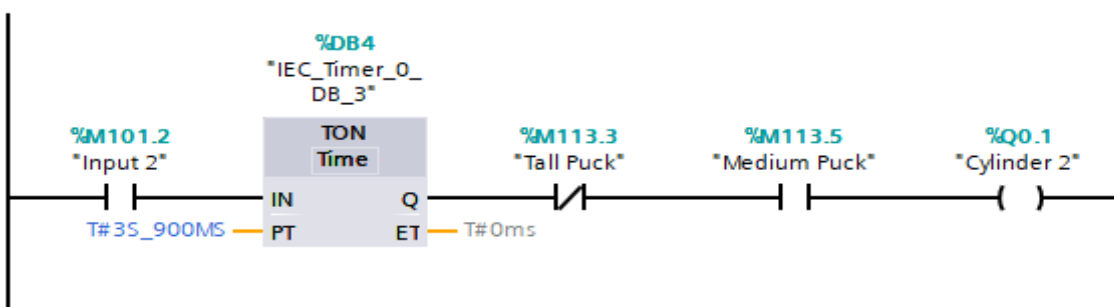
Timing Diagram for Network10 (Normal operation)



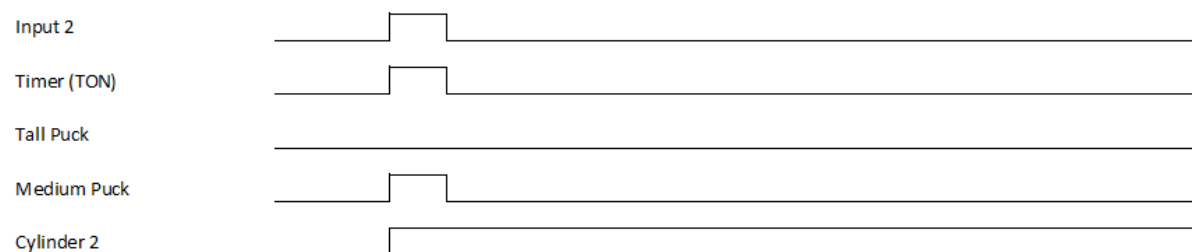
Network 11

Network 11: Cylinder 2 operate into Bin2 _ Short pucks (Medium Width)

Comment



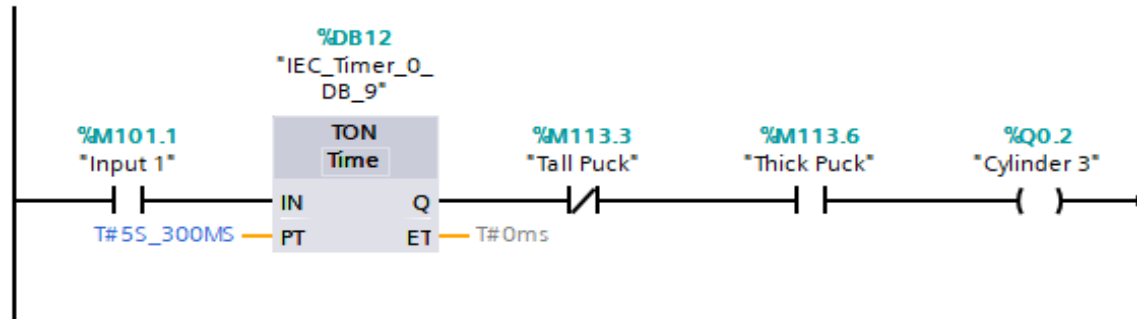
Timing Diagram for Network11 (Normal operation)



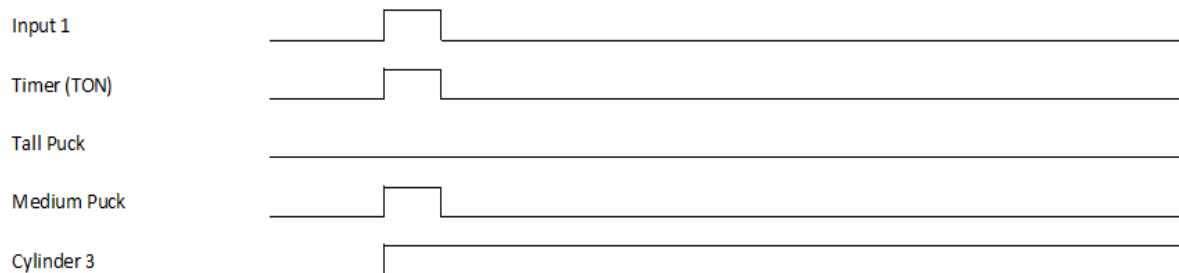
Network 12

Network 12: Cylinder 3 Operate into Bin3 _ Short Pucks (Thick Width)

Comment



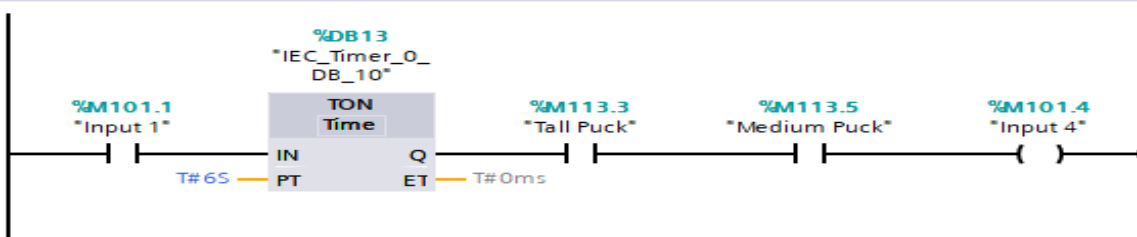
Timing Diagram for Network12 (Normal operation)



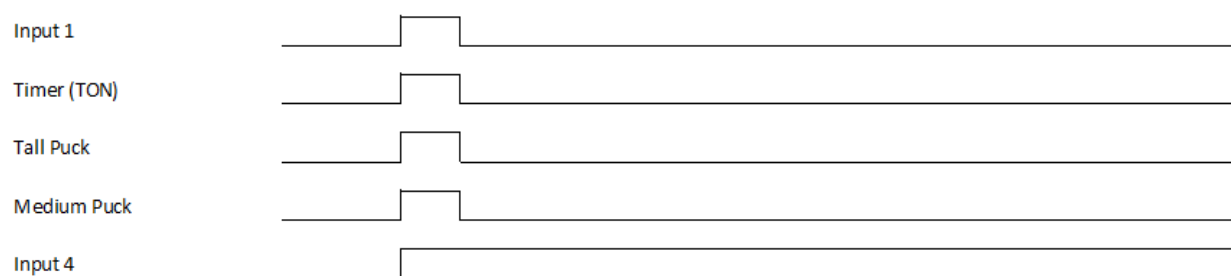
Network 13

Network 13: End of conveyor Box _ Tall Pucks (Medium Thickness)

end of conveyor storage bin _ no cylinder operations long time dealy 6sec rest after 6sec



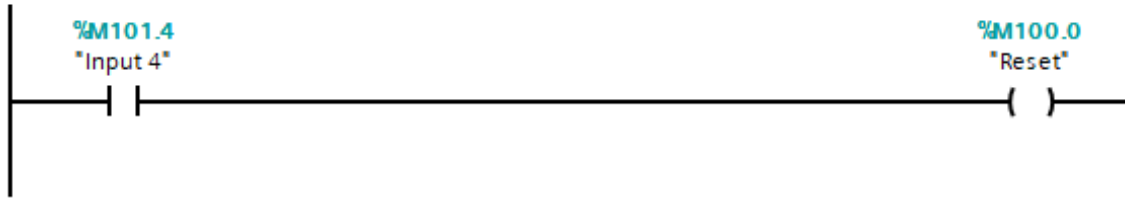
Timing Diagram for Network 13 (Normal operation)



Network 14

Network 14: Network 13 Reset

Comment



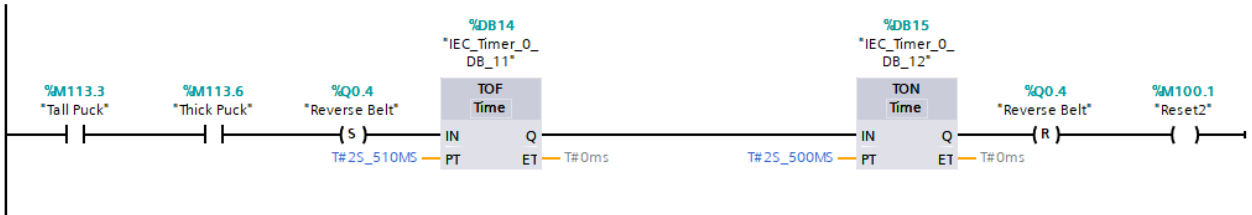
Timing Diagram for Network 14 (Normal operation)



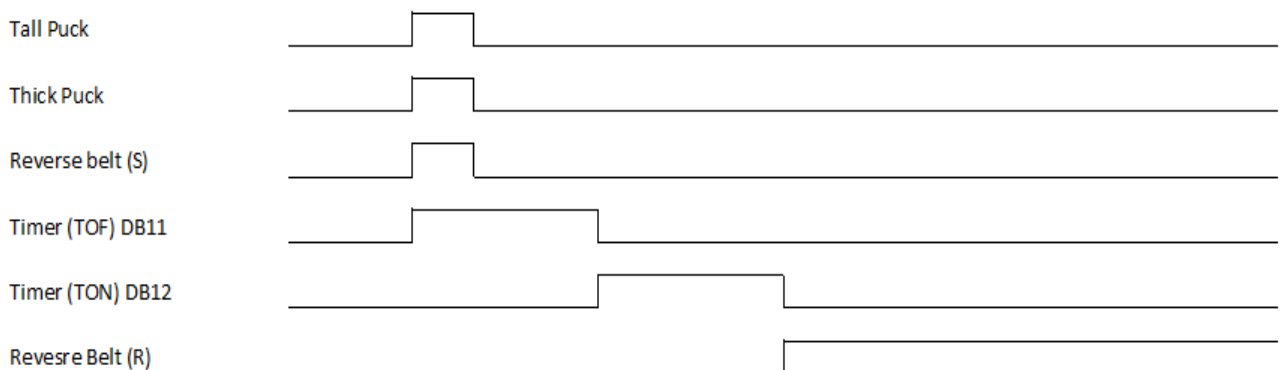
Network 15

Network 15: Start of Conveyor Belt Storage Bin (REVERSE CONVEYOR) Tall Pucks (Thick Width)

Comment



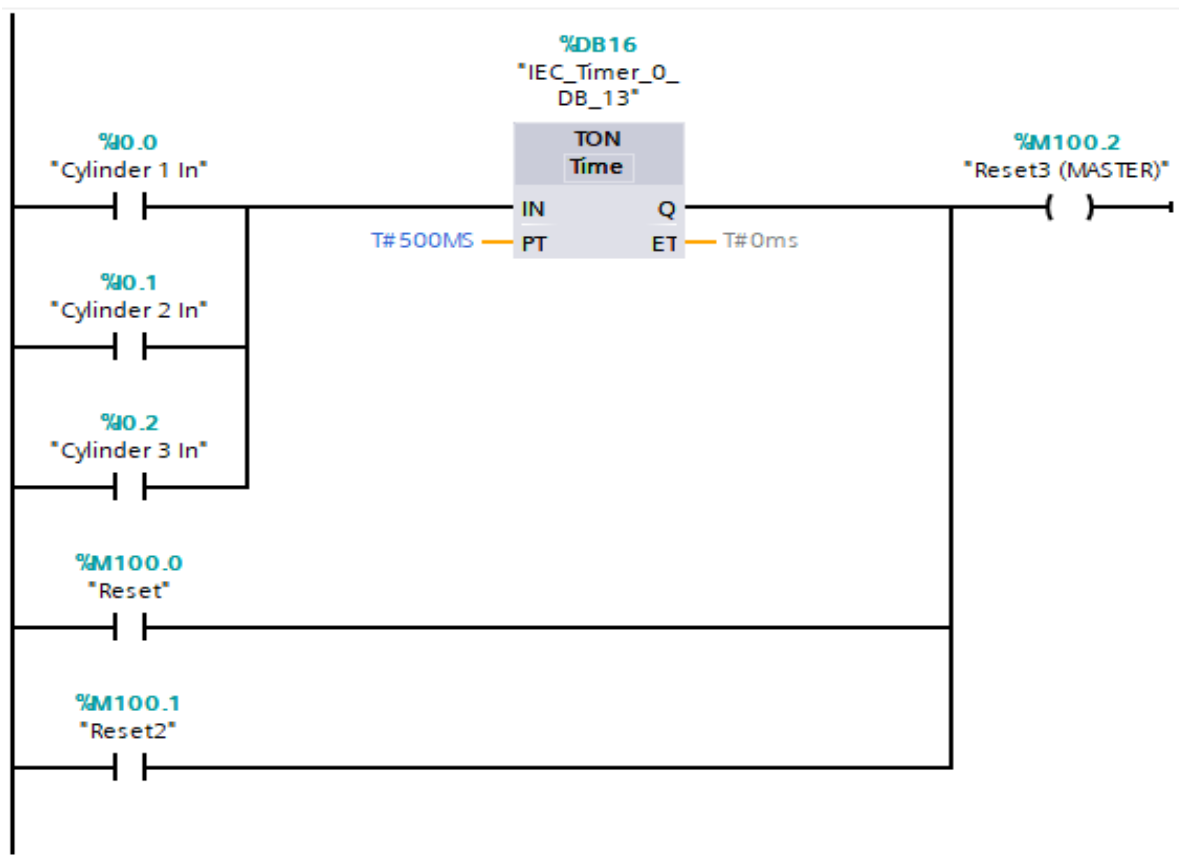
Timing Diagram for Network 15 (Normal operation)



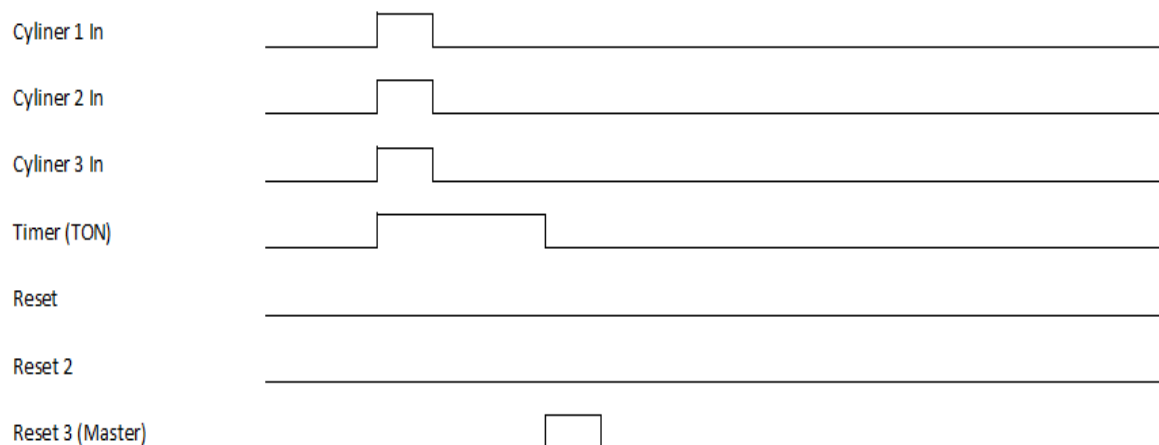
Network 16

Network 16: Cylinder 1,2 & 3 retract after operation @ 500ms

Comment



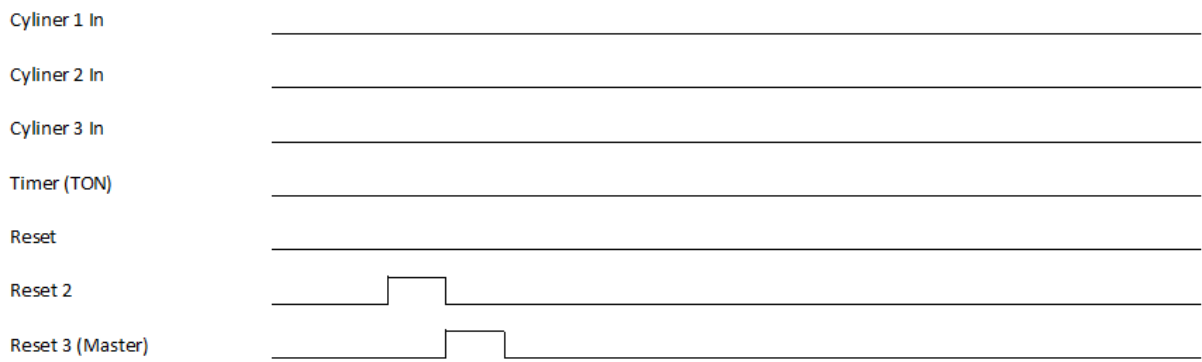
Timing Diagram for Network 16 (Cylinder 1,2,3 Inputs Only) 1 of 3



Timing Diagram for Network 16 (Reset Input Only) 2 of 3



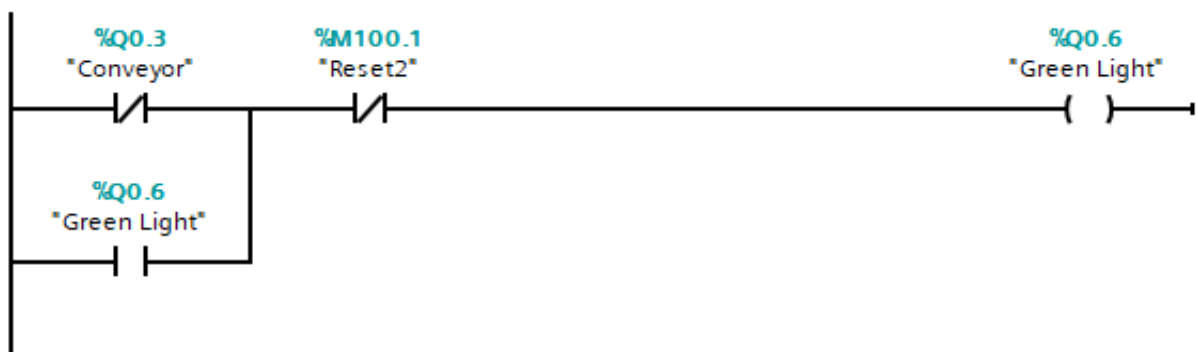
Timing Diagram for Network 16 (Reset 2 Input Only) 3 of 3



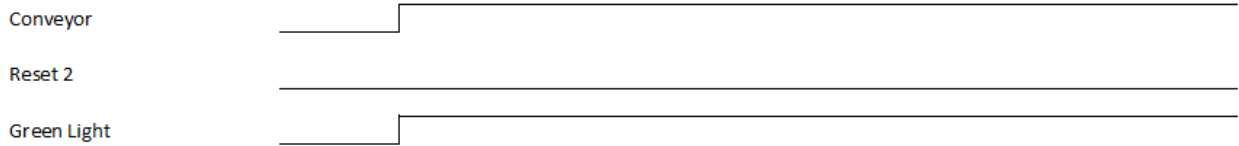
Network 17

Network 17: Green Light Operation

▼ The green LED light will only operate when the conveyor is in running mode



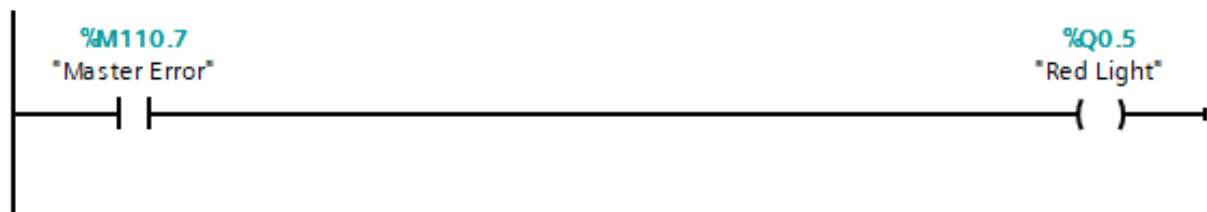
Timing Diagram for Network 17 (Normal Operation)



Network 18

Network 18: Red Light Operation

Red light will only operate when master error is triggered



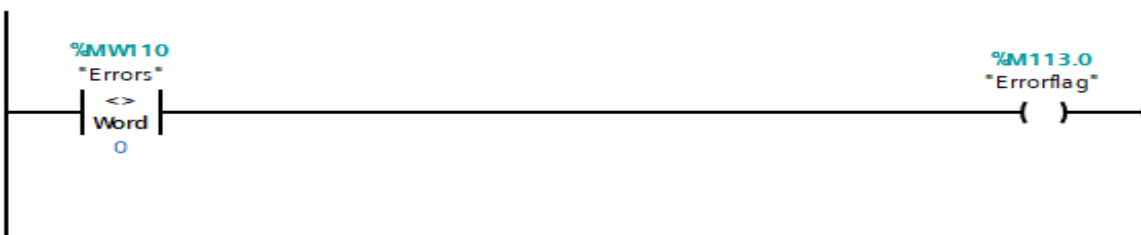
Timing Diagram for Network 18 (Normal Operation)



Network 19

Network 19: Error Flag

When any error word triggers _ error flag



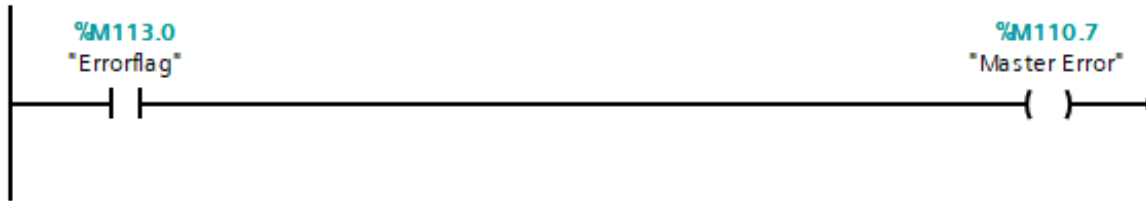
Timing Diagram for Network 19 (Normal Operation)



Network 20

Network 20: Error Flag _ Master Error

▼ When Error Flag triggers _ this will then also trigger Master Error



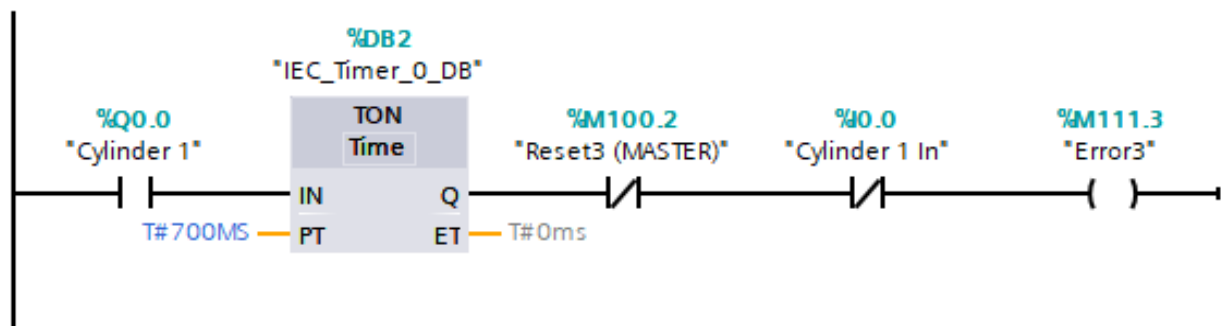
Timing Diagram for Network 20 (Normal Operation)



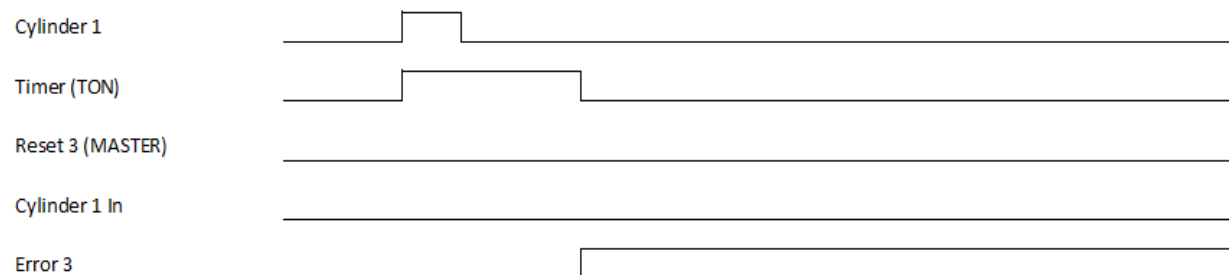
Network 21

Network 21: cylinder 1 stuck out

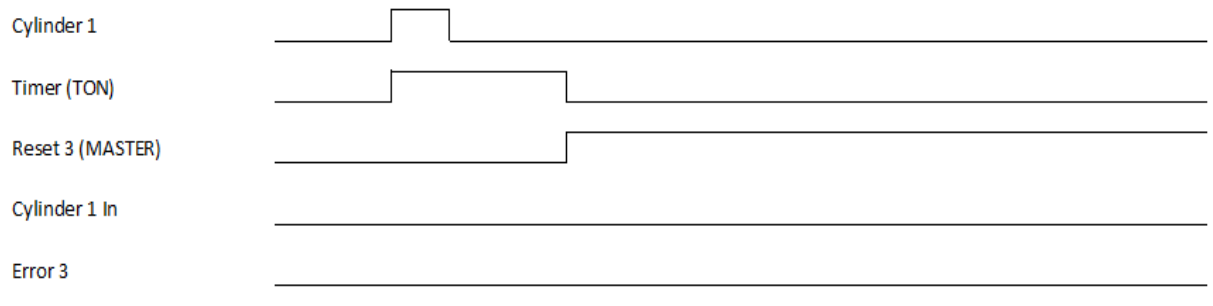
Comment



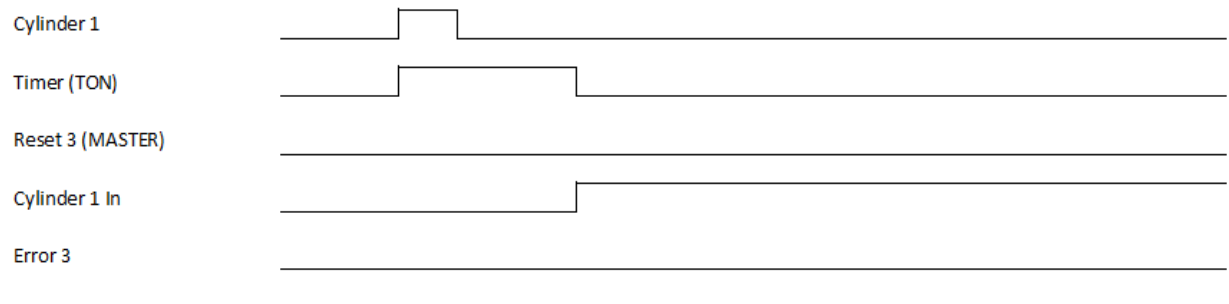
Timing Diagram for Network 21 (Normal Operation) 1 of 3



Timing Diagram for Network 21 (If Reset 3 (Master) is activated) 2 of 3



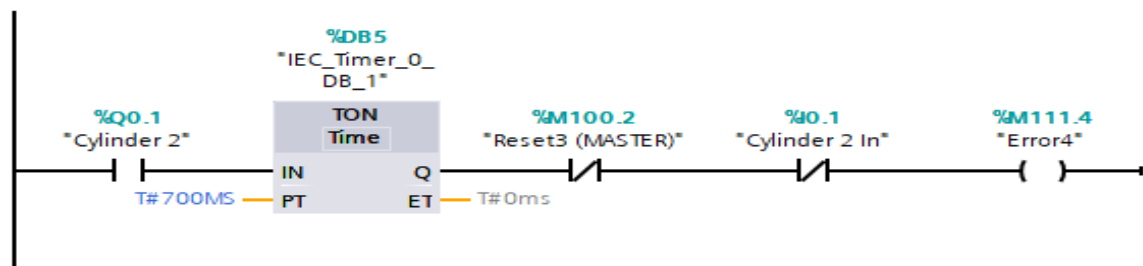
Timing Diagram for Network 21 (If Cylinder 1 In is activated) 3 of 3



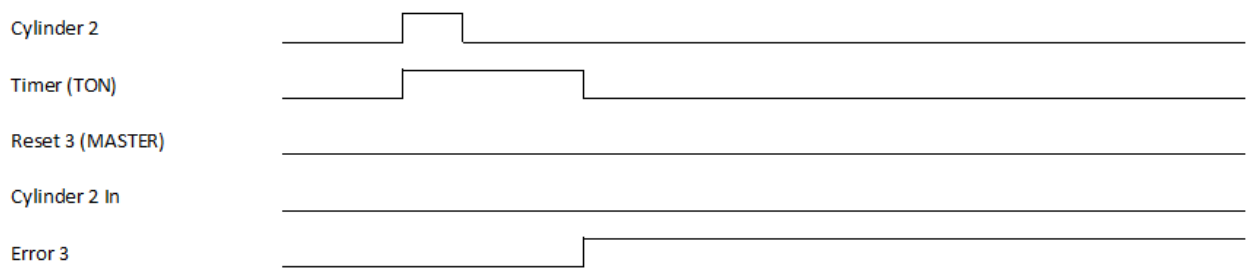
Network 22

Network 22: cylinder 2 stuck out

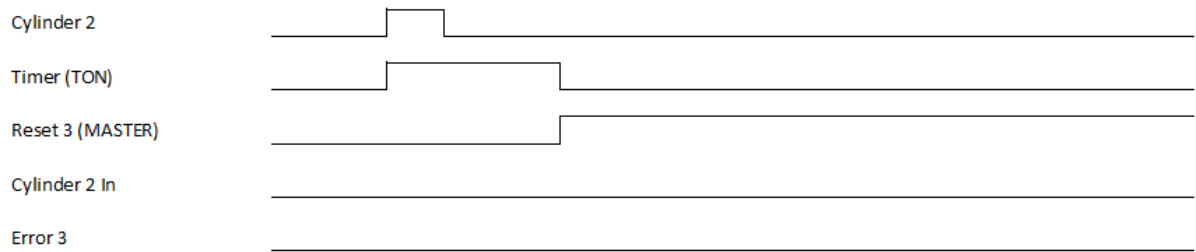
Comment



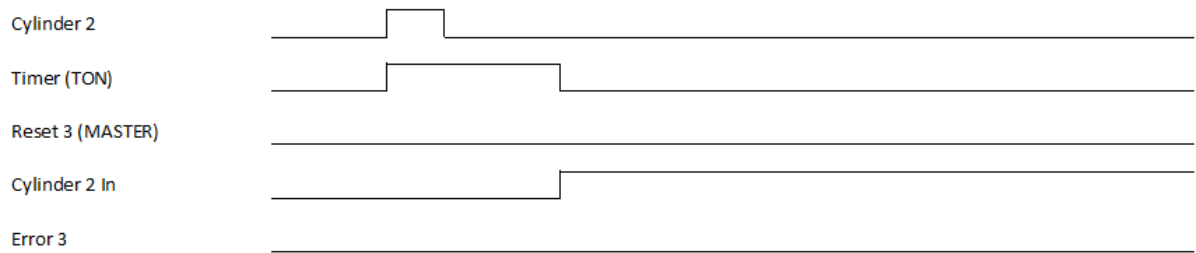
Timing Diagram for Network 22 (Normal Operation) 1 of 3



Timing Diagram for Network 22 (If Reset 3 (Master) is activated) 2 of 3



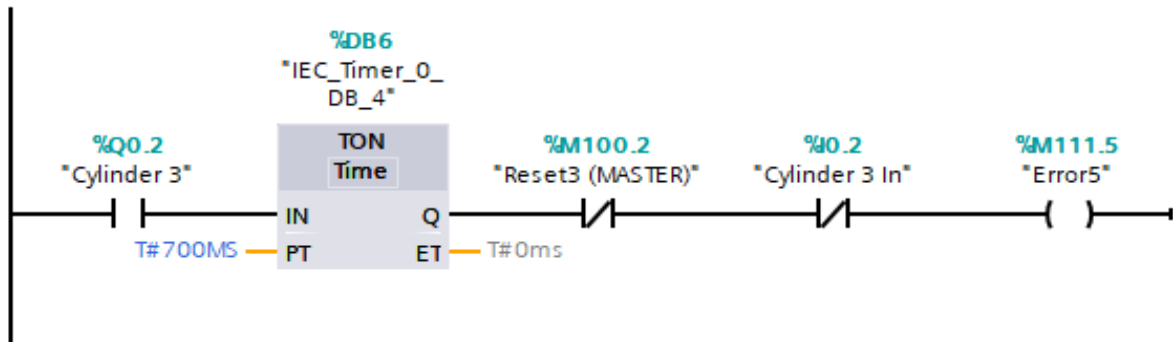
Timing Diagram for Network 22 (If Cylinder 1 In is activated) 3 of 3



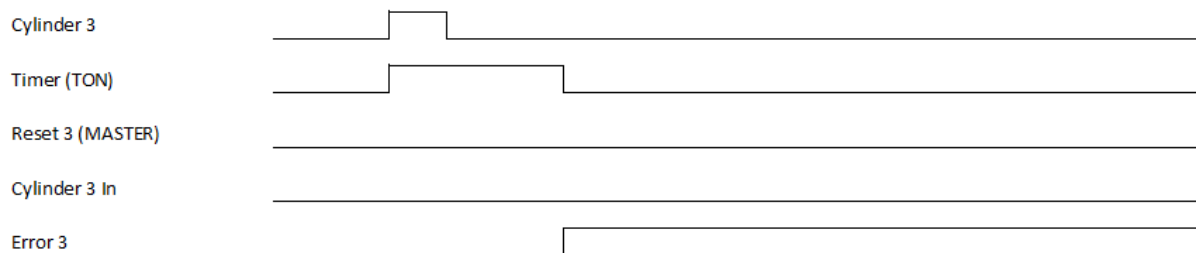
Network 23

Network 23: cylinder 3 stuck out

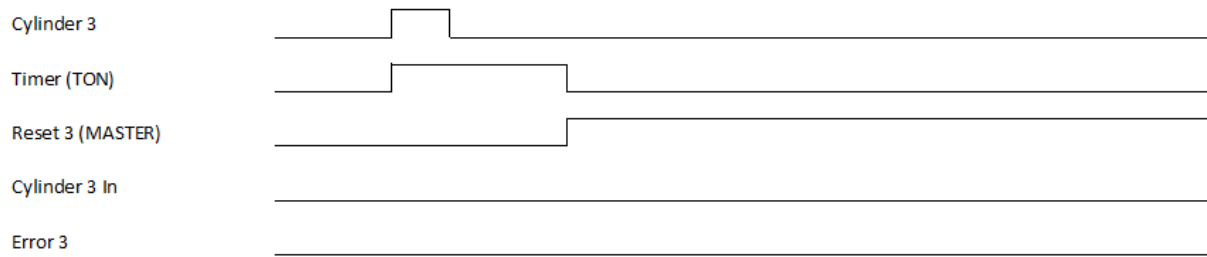
Comment



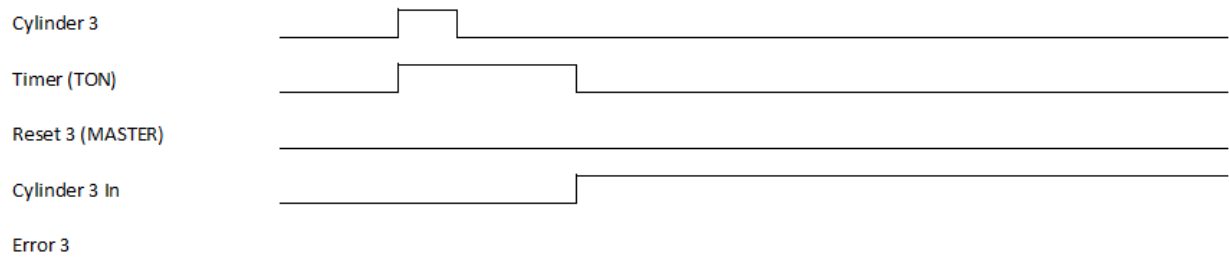
Timing Diagram for Network 23 (Normal Operation) 1 of 3



Timing Diagram for Network 23 (If Reset 3 (Master) is activated) 2 of 3



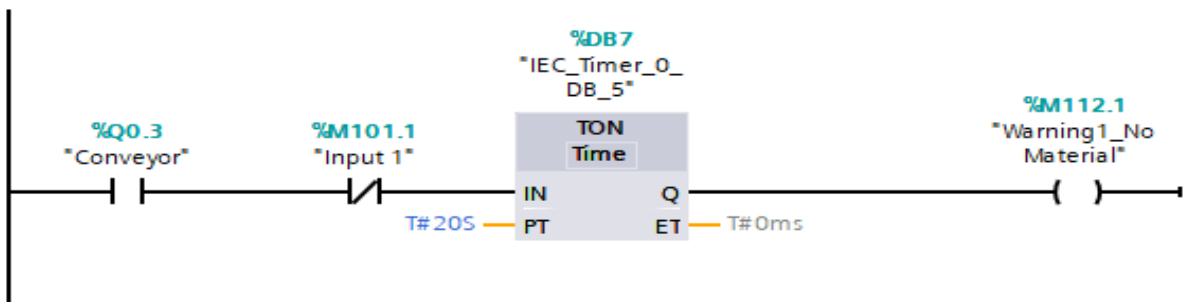
Timing Diagram for Network 23 (If Cylinder 1 In is activated) 3 of 3



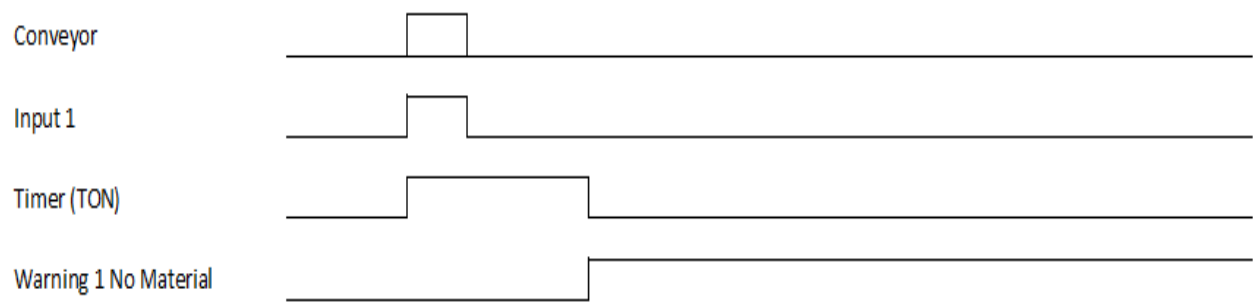
Network 24

Network 24: No Material Running On Conveyor

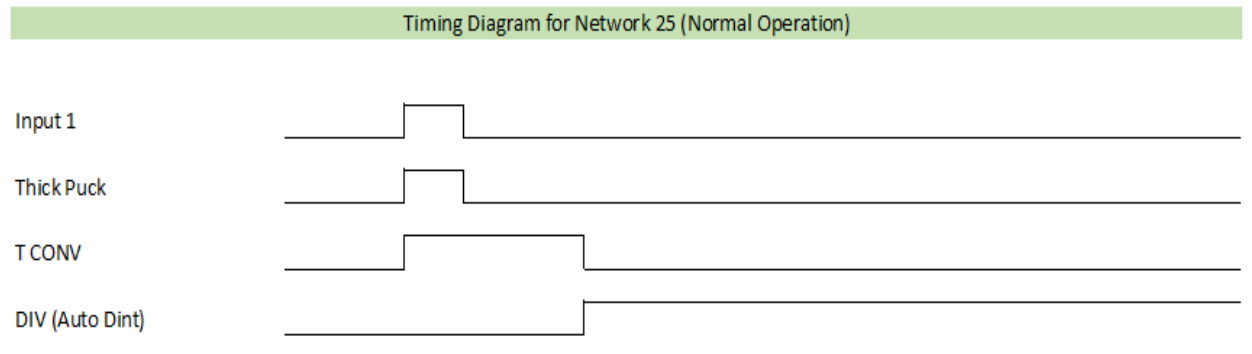
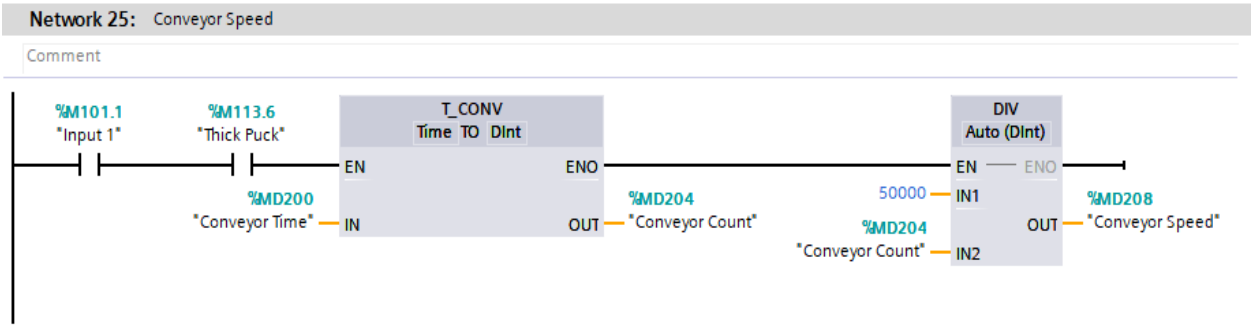
Comment



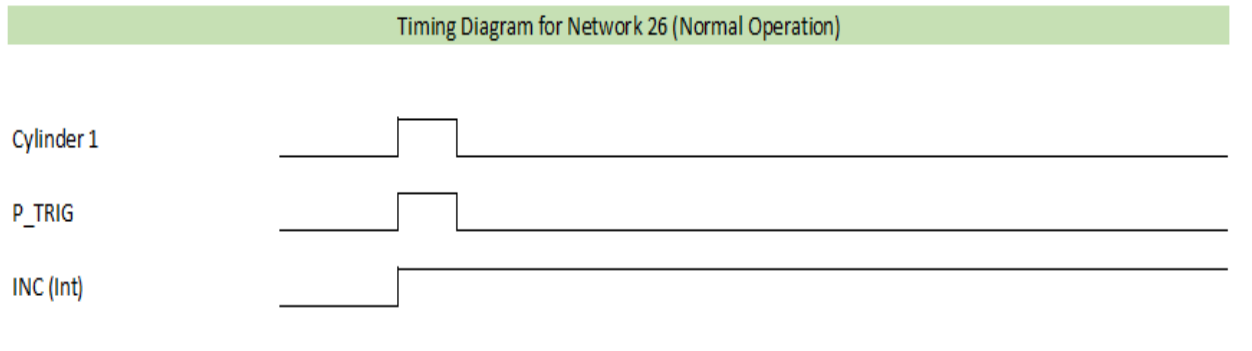
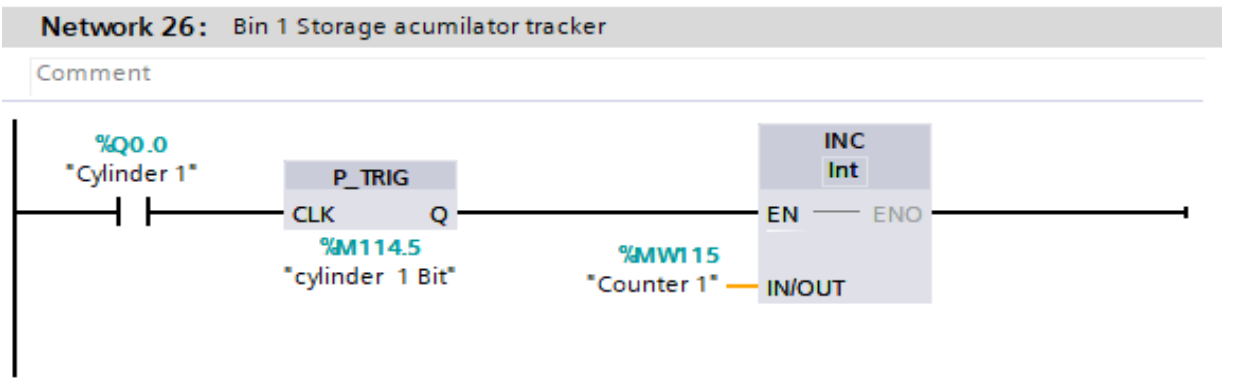
Timing Diagram for Network 24 (Normal Operation)



Network 25



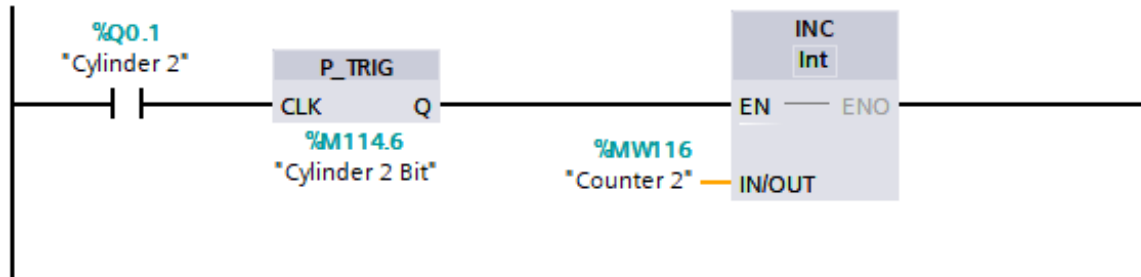
Network 26



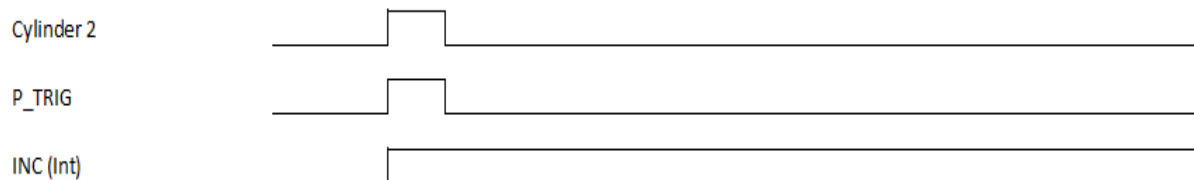
Network 27

Network 27: Bin 2 Storage accumulator tracker

Comment



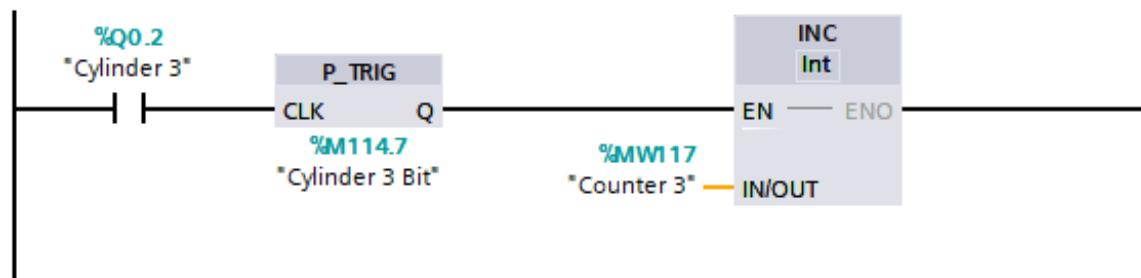
Timing Diagram for Network 27 (Normal Operation)



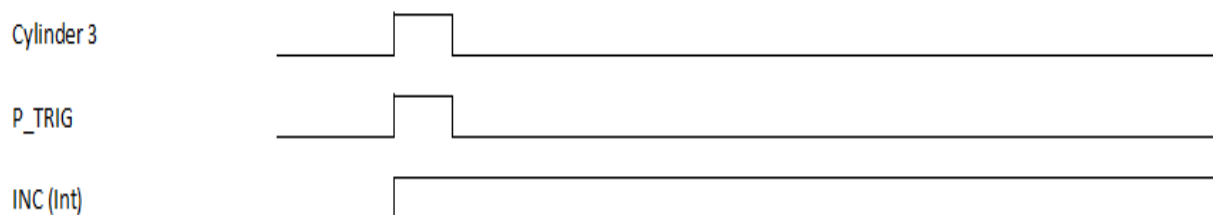
Network 28

Network 28: Bin 3 storage accumulator tracker

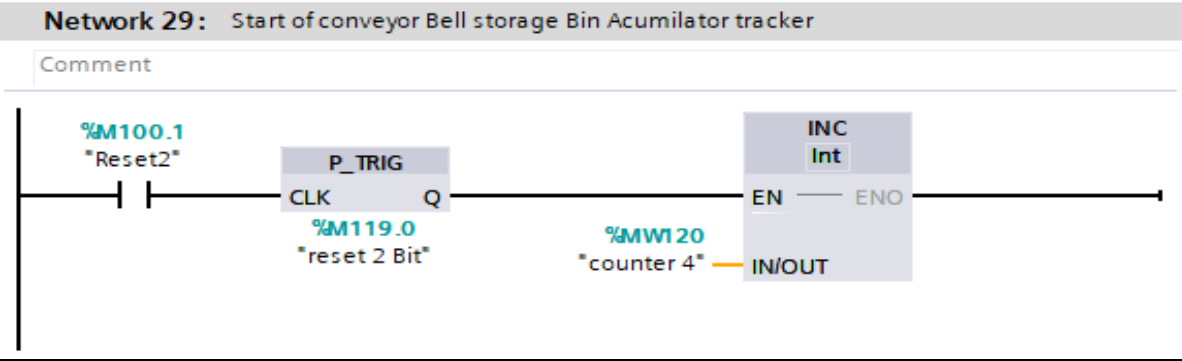
Comment



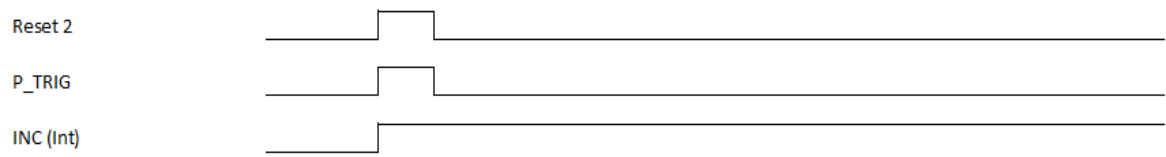
Timing Diagram for Network 28 (Normal Operation)



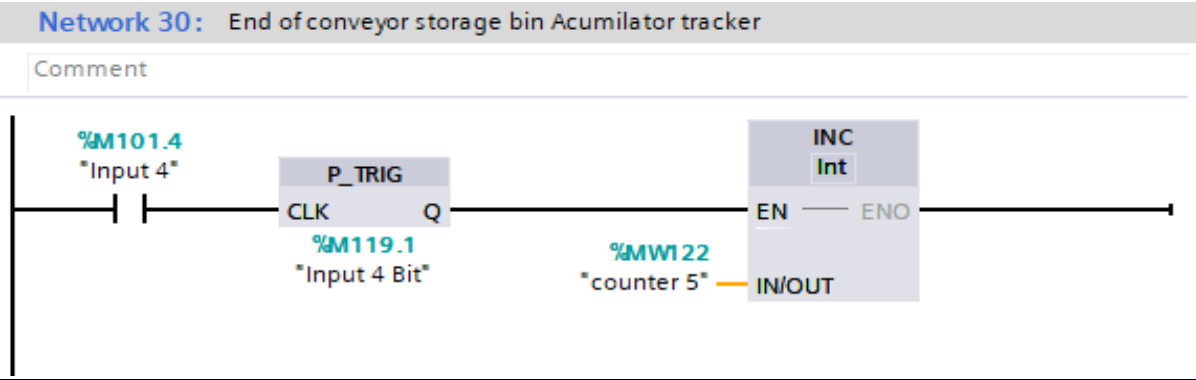
Network 29



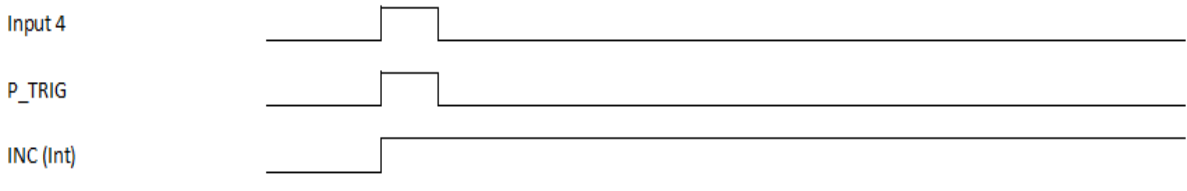
Timing Diagram for Network 29 (Normal Operation)



Network 30



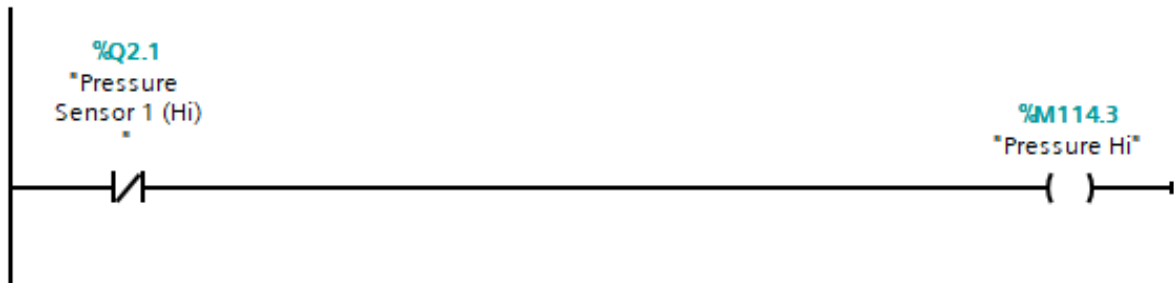
Timing Diagram for Network 30 (Normal Operation)



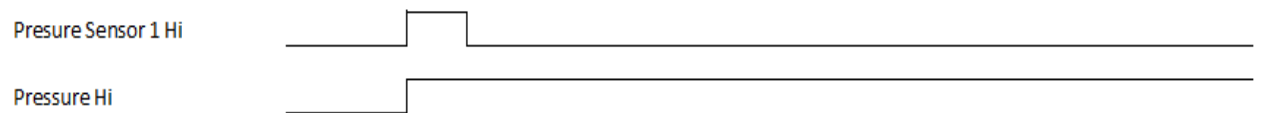
Network 31

Network 31: Pressure Hi

Comment



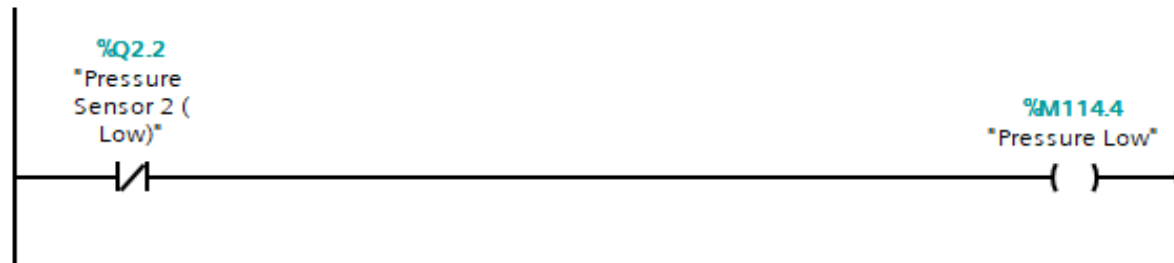
Timing Diagram for Network 31 (Normal Operation)



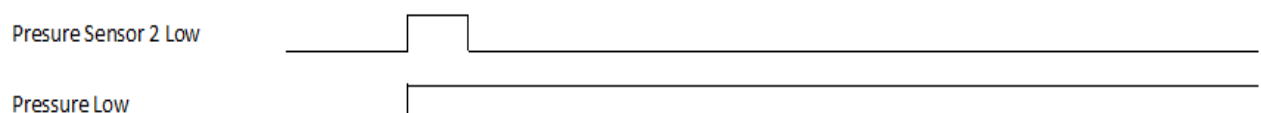
Network 32

Network 32: Pressure Low

Comment

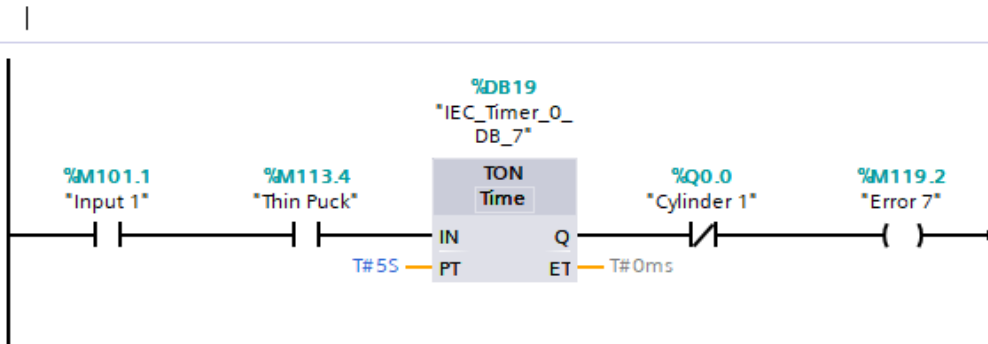


Timing Diagram for Network 32 (Normal Operation)

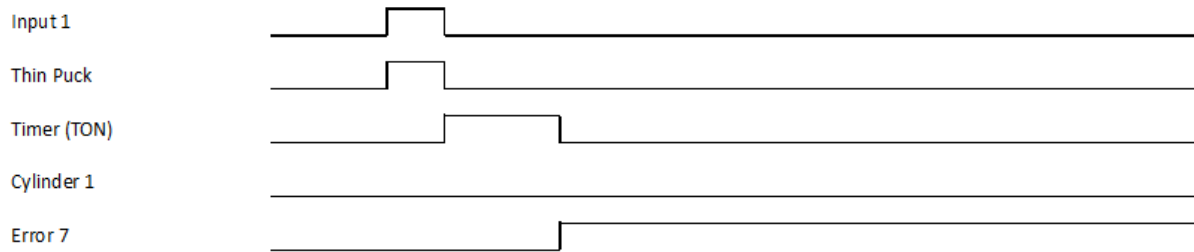


Network 33

Network 33: Cylinder 1 Not Firing



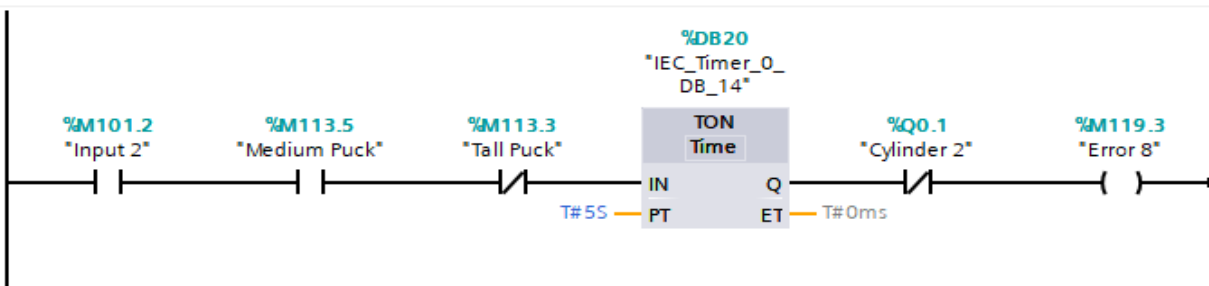
Timing Diagram for Network 33 (Normal Operation)



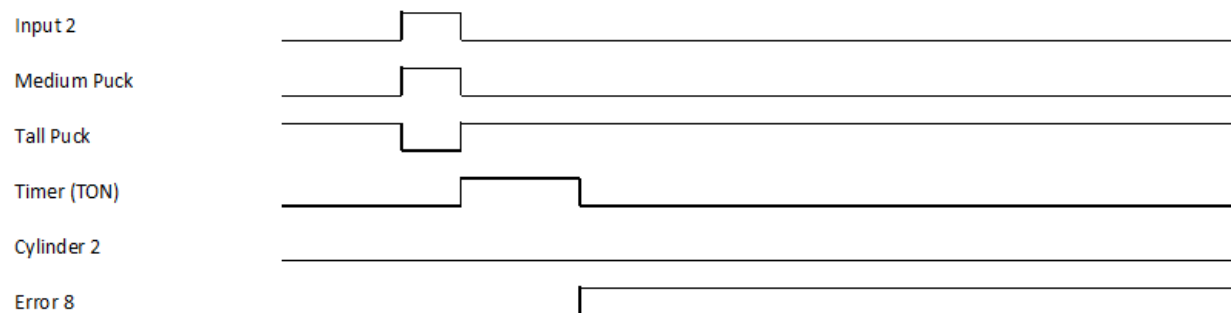
Network 34

Network 34: Cylinder 2 Not Firing

Comment

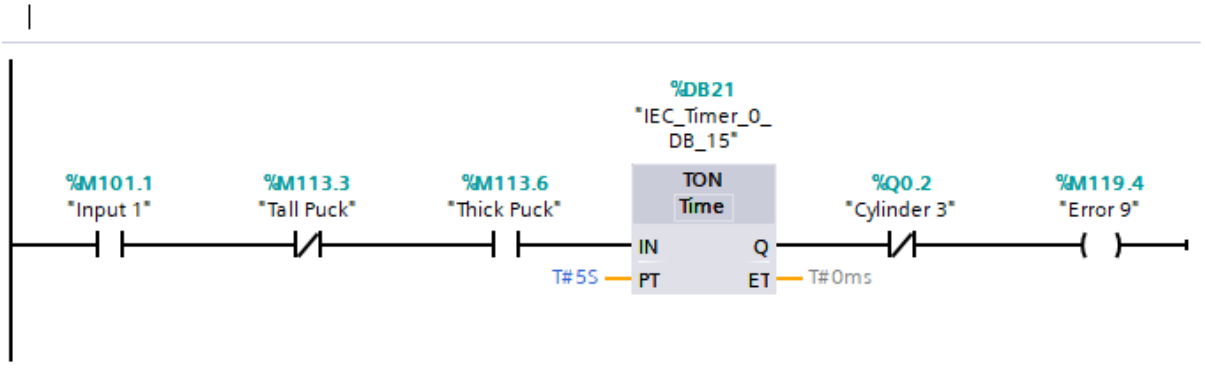


Timing Diagram for Network 34 (Normal Operation)

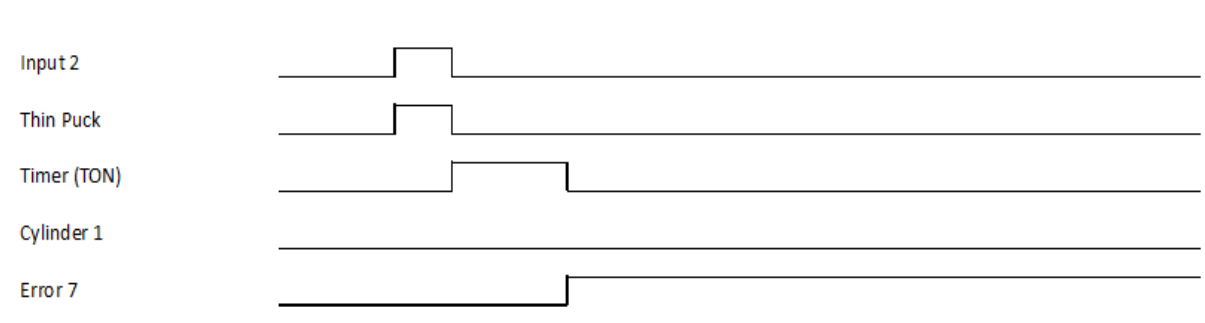


Network 35

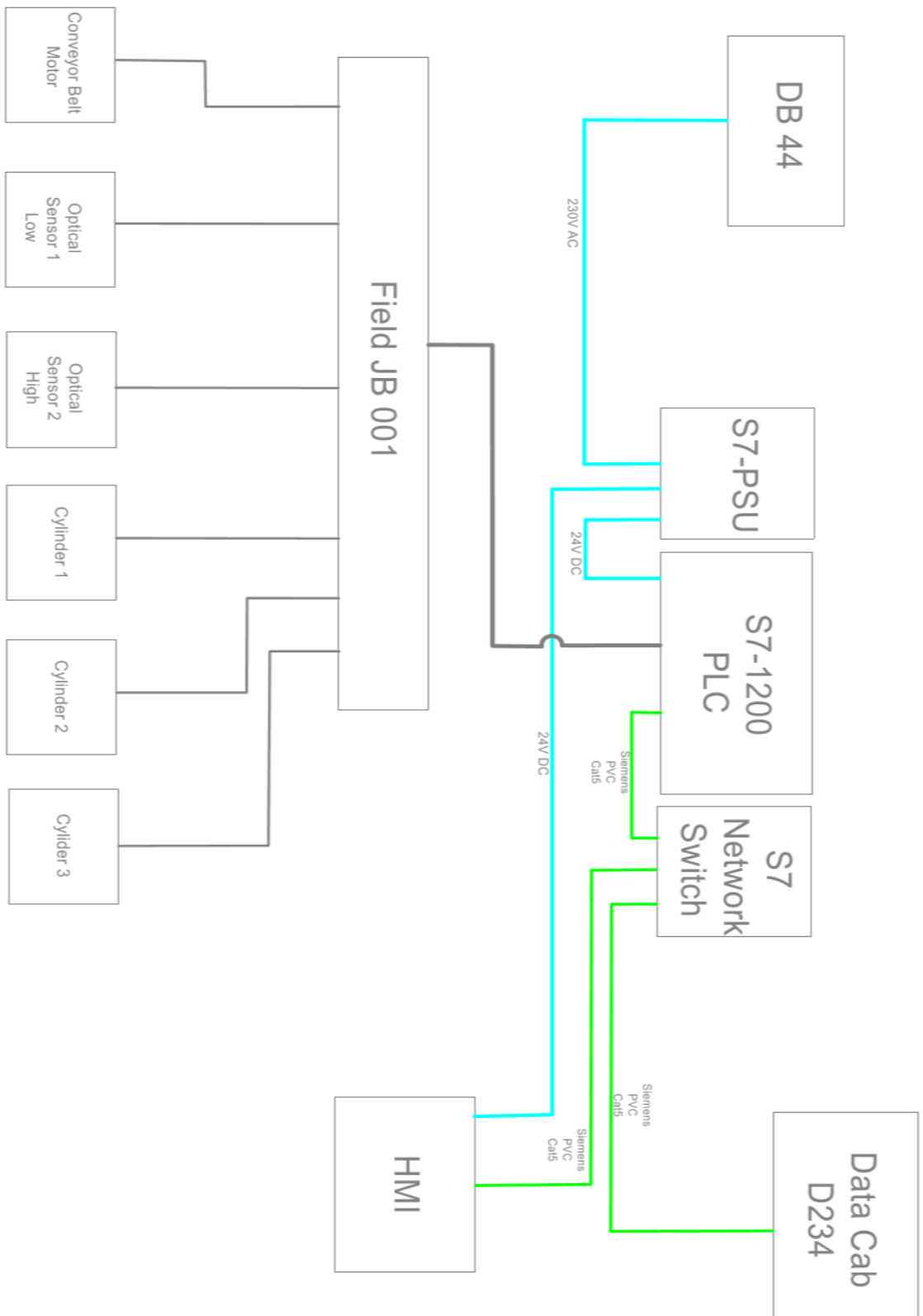
Network 35: Cylinder 3 Not Firing



Timing Diagram for Network 35 (Normal Operation)



System Block Diagram



Improvement Review

Improvement section review

For the development and next iteration below are some of the suggested improvements;

- 1 – Bin Storage Interlocks; the purpose to introduce interlocks for the bins, would ensure that the system does not operate and put pucks onto the floor without the collection bins present.
- 2 – Belt Speed; the current set up for recording belt speed on the PLC program, is quite complicated and intermittent as it requires a tall puck to break optical 2. If we add an encoder to the belt motor or a roller we can accurately monitor the speed continuously.
- 3 – Second Low Level Optic; the second low level optic would ensure greater system stability, as the whole process relies on the operation of optic 1 if this were to fail the entire process would stop having a second optic would ensure reliability with built in redundancy, this would also allow to improve the belt speed tracking more precisely.
- 4 – HMI system over view replication, for future operator ease and to help improve response time to faults within the system, would be to have a visual graphic of the process and for this to show what components are in operation in real time simulation.
- 5 – Introduction of cameras to the conveyor belt area, this would allow operators to have full visibility of the production process and be able to intervene before an error or warning has a chance to develop.
- 6 – operator station pressure mat, this would ensure that an operator must be in the operator station at all times, if the operator is not at his post the system cannot operate.
- 7 – system interlocks, this would be a formal set of checks the operator has to tick off the HMI before the system will allow the operation via the green start button.
- 8 – belt tensioner, this will allow the system to recognise when there is load (pucks) on the conveyor belt.