Graduation Project

Design and Control of Product Defect Detection Machine

Supervised By:

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INTRODUCTION

Project Idea

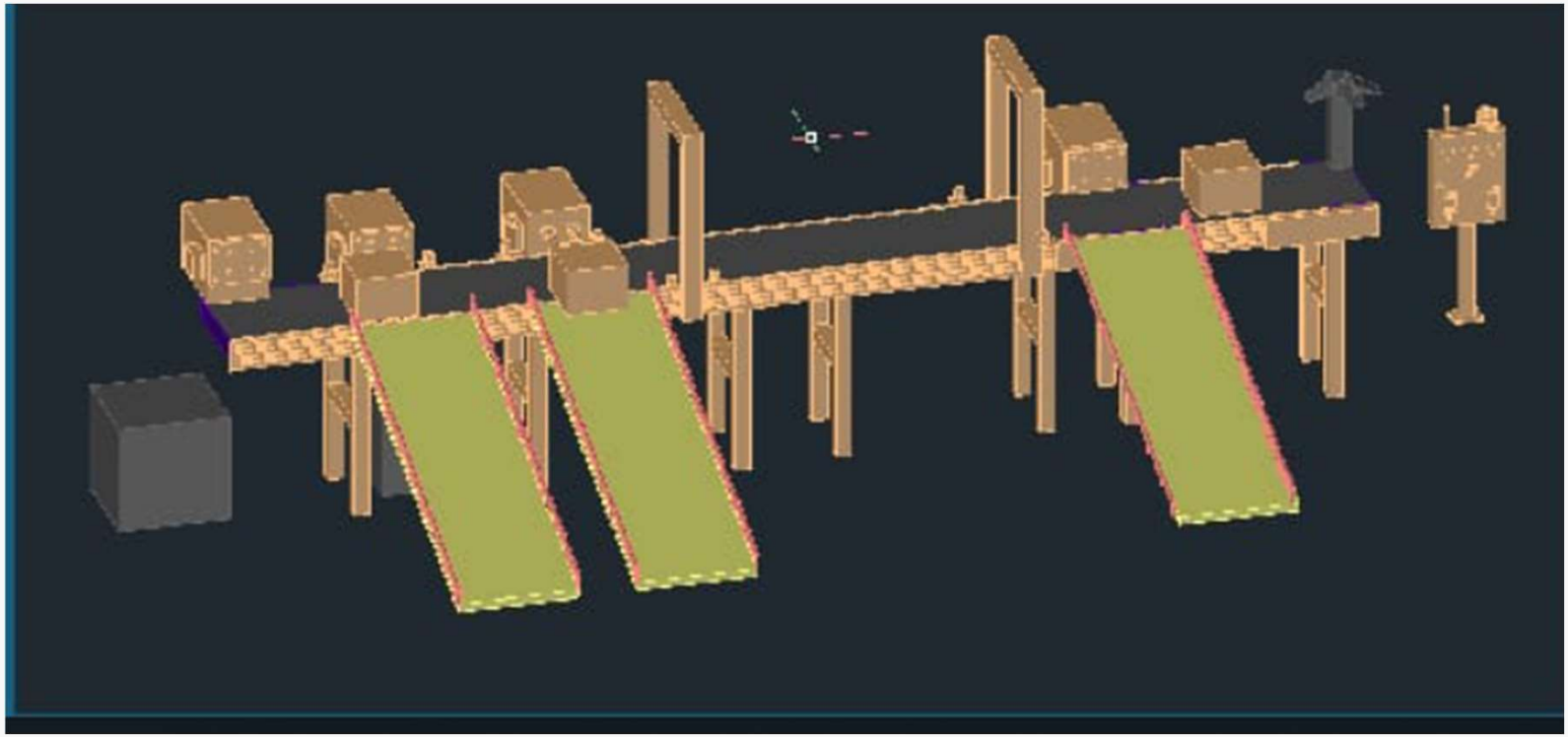
- This project proposes the development of a product defect detection machine designed to identify defects in products during the manufacturing process.

Objectives

- Controller Design
- System Simulation
- Design and Components selection
- Experimental Work

Prespective for the Whole Project

AutoCAD design



Project Steps

- Research and Development
- Prototype Development
- Testing and Calibration
- System Design
- Software Development
- Monitoring and Optimization

Expected Outcomes

- Increase Detection Accuracy
- Reduced Waste
- Cost Savings
- Real-Time Monitoring

Previous Developments in this Field

- Manual Inspection
- Basic Automated Inspection Systems
- Computer Vision Systems
- Machine Learning and AI Integration

COMPONENTS

1-Induction motor:

we use a three-phase induction motor of :

- 4 Poles
- Output: 1 hp, 0.75KW.
- Volts: 220/380
- Amps: 3.68/2.13
- RPM: 1395/1700

Advantages:

- High Efficiency
- Improved Torque Characteristics
- Smooth Operation
- Durability and Low Maintenance

2-Gear box

- A gearbox is a mechanical device used to transmit power and control the speed and torque of motors. It consists of a set of gears that mesh together to transfer torque from a power source to an output device.
- In this project, we use a gearbox of ratio 1:5.

3- Packaging pole:

• Consists of 3 connected fixed parts and one movable part .

• When the open box move at belt this rod is responsible for closing this box after the product been added in it.

4-Belt conveyors:

- The project consists of two belt conveyors
- The first one is the main belt which the box on it be moved through all processes .
- The second belt is mounted on load cell to weigh the box weight and print the accepted box.

5-Photo sensors:

- Their main objectives is to sense the box approaching.
- The box cuts the sensor signal.
- This signal is sent to the plc and then be decided what to do with this signal whether been accepted or been refused.

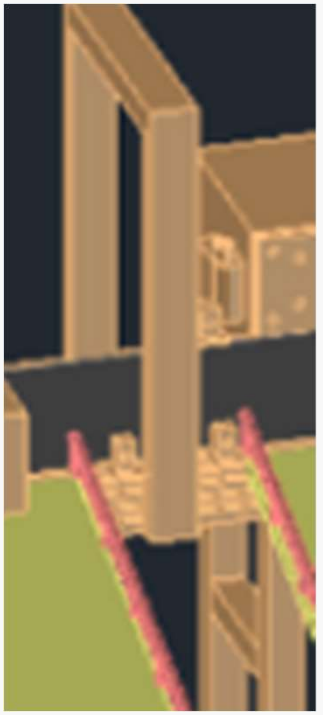
6-Piston:

- It’s forward backward type of pressure piston.
- It’s responsible for rejection of the unwanted boxes.
- The rejection is due to (weight – size – unpacked box).

7-Size Gate:

- First gate is the size and shape gate. Its main function is to measure the volume of the box.

- there is a photosensor before and after the gate to measure the size of the box .



8-Metal Detector

- second gate is metal gate to detect the impurities in the boxes from metals such as bolts or any other unwanted objects.

9- Rejection area:

At the end of each piston there is one rejection area in which the unwanted or incomplete boxes are been found

10- Control unit:-

It’s a control board which contains several push buttons and switches to control the whole program.

11- Load cell :

- It’s a weighing module or can be considered to be weighing sensor.

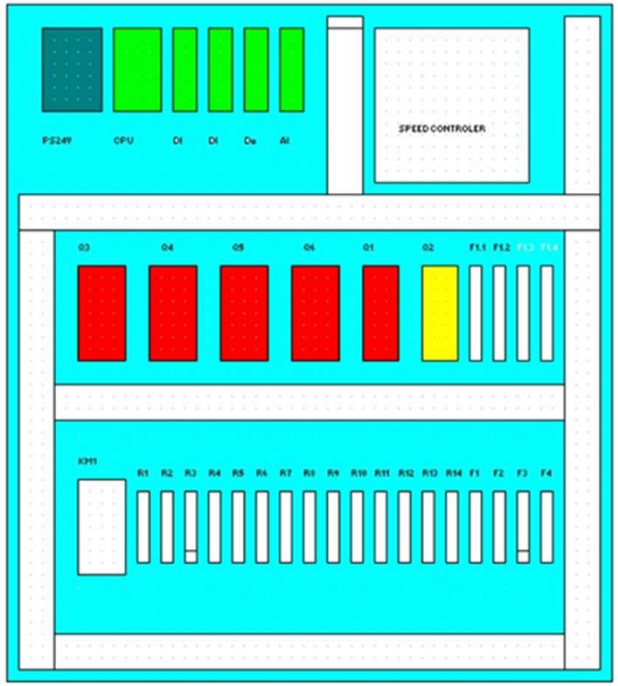
- Its main function is to measure the weight of the box at the end of the process.

12-Acception printer:

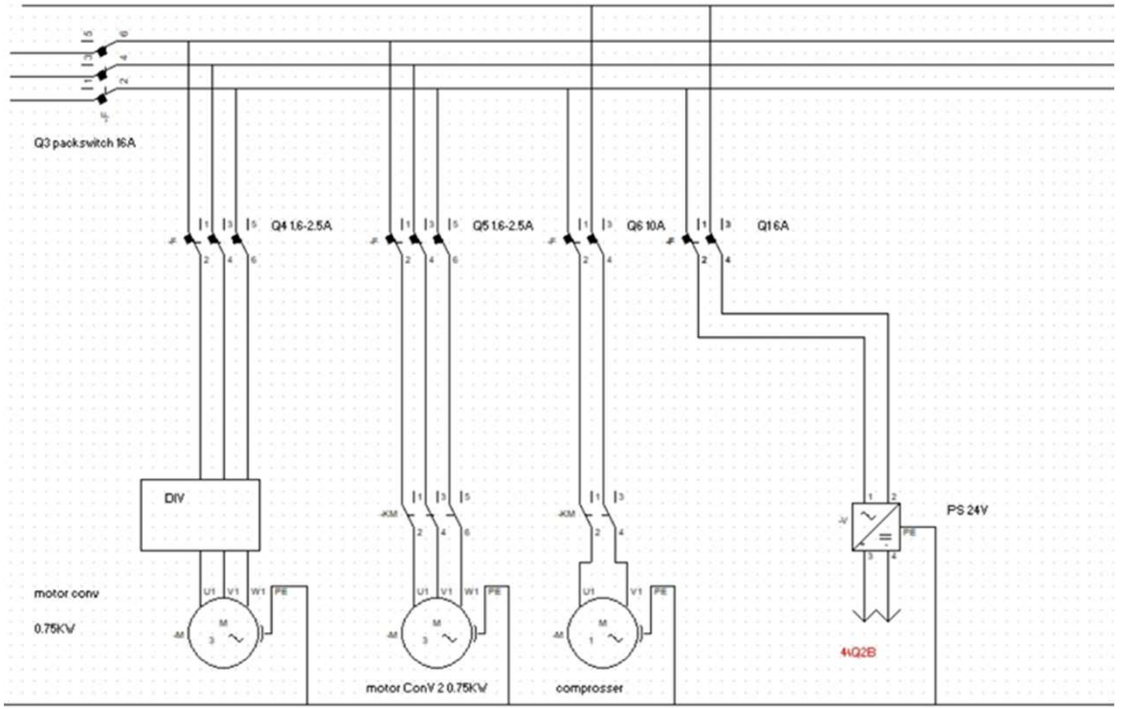
- At the end of the second belt conveyor there is located a small printer module
- Consists of Photo sensor and piston with smaller rod to ensure smaller force
- It prints the acceptio code or sticker at the accepted box

Electric panel configration

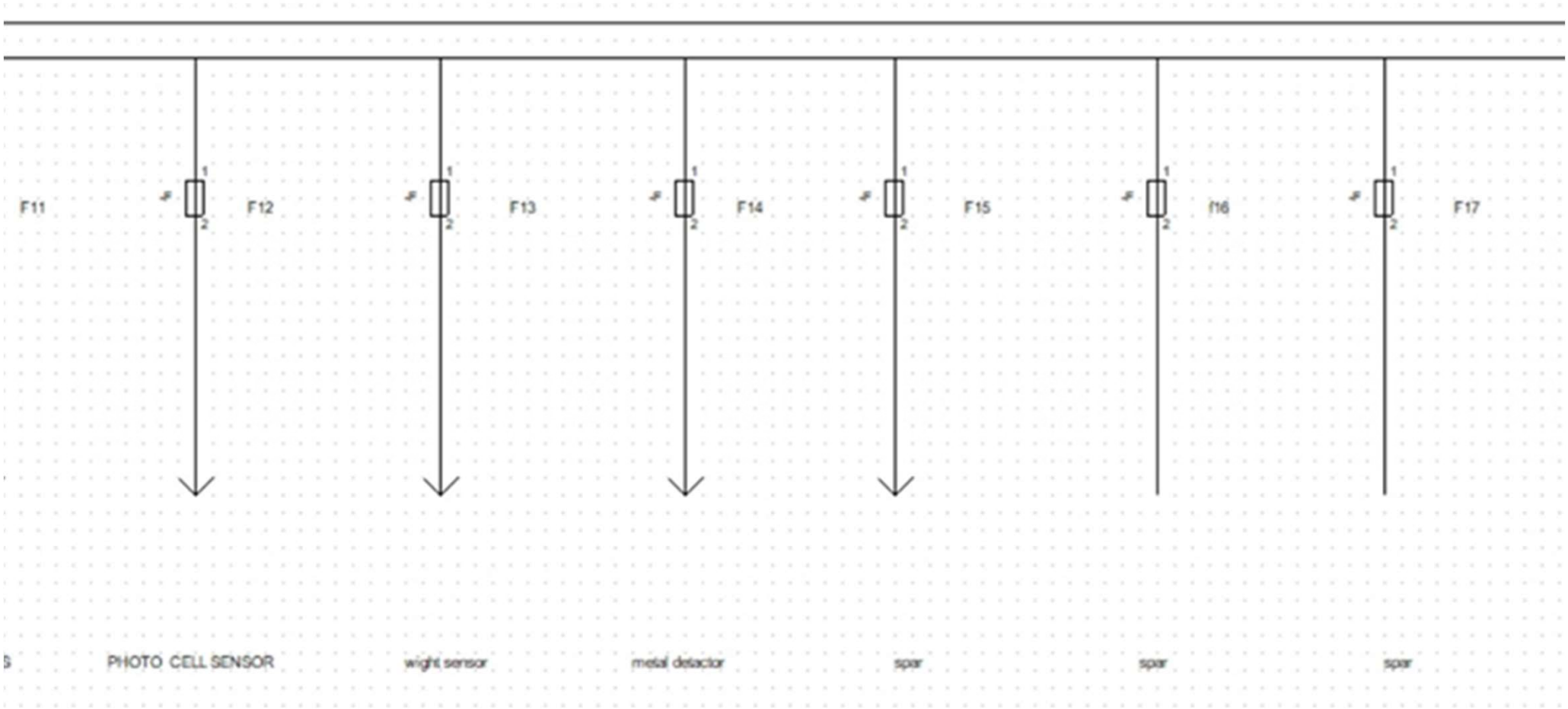
Electrical Panel Components



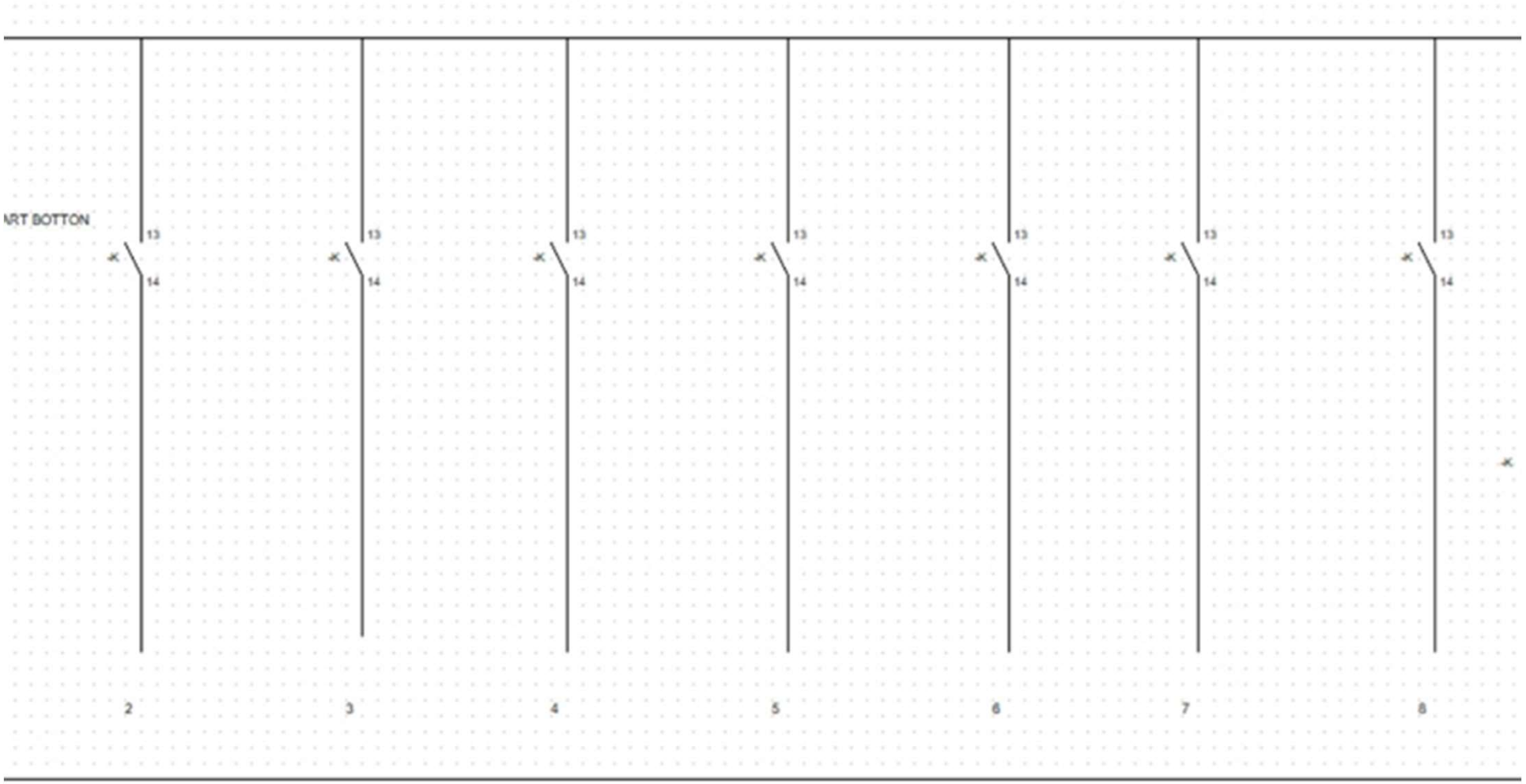
Power Distribution



Sensors Fuses



Relay of Running for Outputs



PLC

Programmable Logic Controller
(PLC)

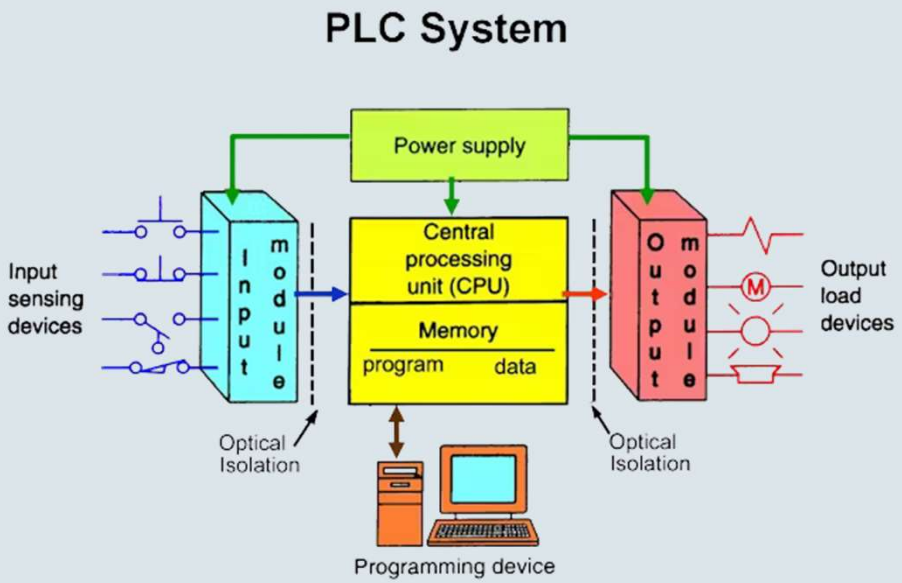
Programmable Logic Controller (PLC)

Programmable Logic Controllers (PLCs) are essential components of modern industrial automation. They play a crucial role in product defect detection machines, offering robust control and monitoring capabilities. PLCs are specifically designed to enhance manufacturing processes by ensuring efficiency, accuracy, and consistency in production.

PLC Components

A typical PLC has:

- Power supply
- Central processing unit (CPU)
- Mounting rack
- Read Only Memory (ROM)
- Random Access Memory (RAM)
- Input/output (I/O) modules
- Programming tool



It is powered by an external power source.

I/O and other specialized modules slip into a PLC rack

thanks to the modular nature of PLCs

PLC Specifications

General Features of PLC used in project :

- Processor: CPU 313C-2DP
- Performance: 32-bit processor with 16-bit instructions
- Integrated: 16-bit Input and 16-bit Output
- Integrated Interfaces:
  - -MPI (Multi-Point Interface)
  - -PROFIBUS DP (Decentralized Peripherals)
- Memory:
  - -Work Memory: 64 KB
  - -Load Memory: Up to 8 MB (via memory card)
- Programming Languages: LAD, FBD, STL, SCL

PLC Specifications

Technical Specifications:

- Digital Inputs: 16 (integrated by PLC)
- Digital Inputs: 16 (added)
- Digital Outputs: 16 (integrated by PLC)
- Analog Inputs: 8 (added)

Communication and Networking:

- Integrated PROFIBUS DP for communication with distributed I/O and other PLCs
- MPI for local networking

PLC Specifications

Power Supply and Physical Attributes:

- Power Supply Voltage: 24 V DC
- Dimensions: 125 x 80 x 130 mm (H x W x D)
- Weight: Approx. 510 g

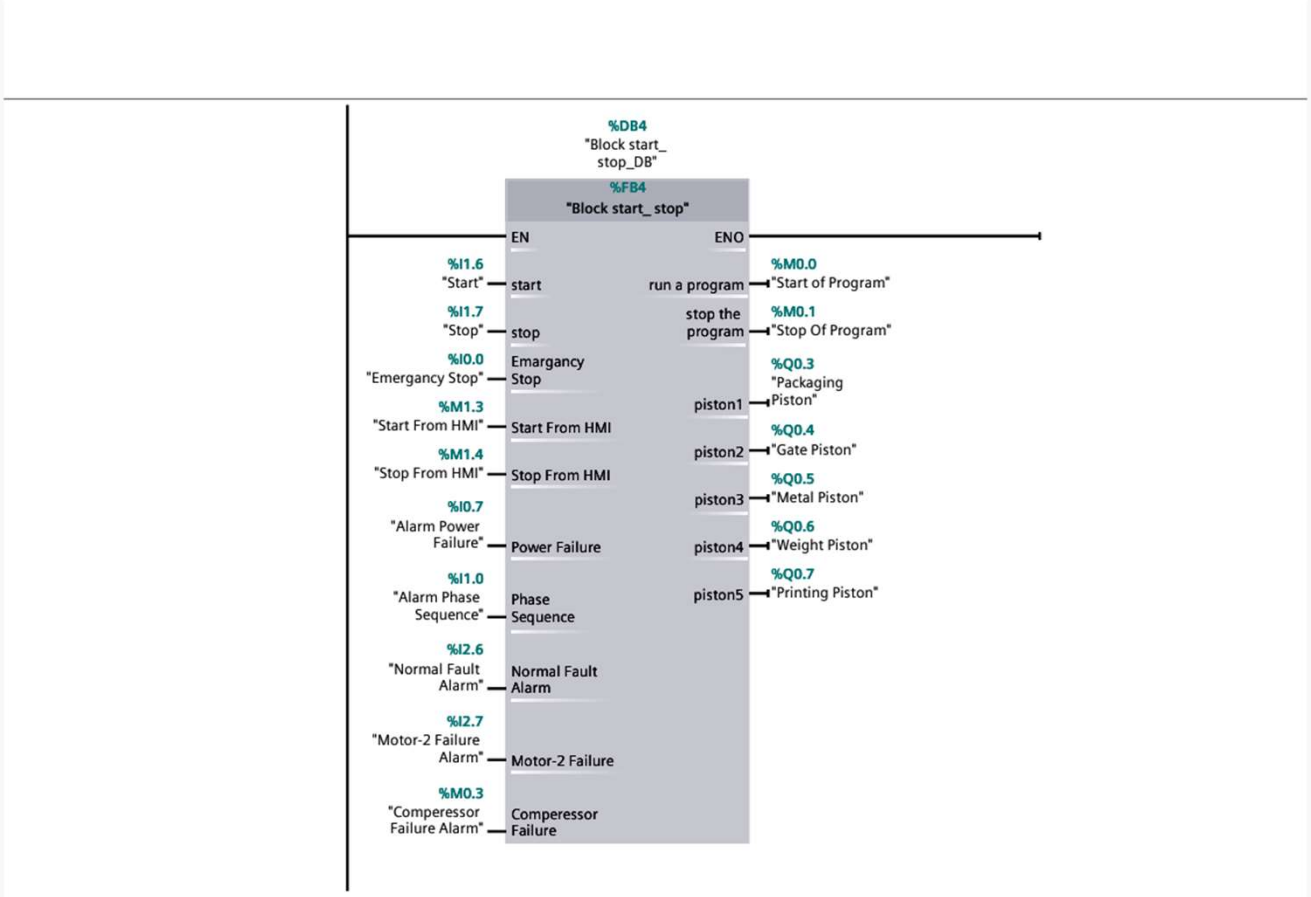
This compact and versatile PLC is ideal for applications requiring moderate performance with integrated communication and I/O capabilities.

PLC CONFIGURATION

PLC Programming

Network1 : Start / Stop Block

This network manages the start and stop operations of the entire program. it ensures that the program can start and stop safely. It handles emergency stops and various alarms, ensuring that the system responds appropriately to different conditions



Notes:

•Stop: Push Button N.C point

•Emergency Stop: Push Button N.C point

•Power Failure : is N.O point from main GV2

•Phase Sequence: is N.O point from phase sequence

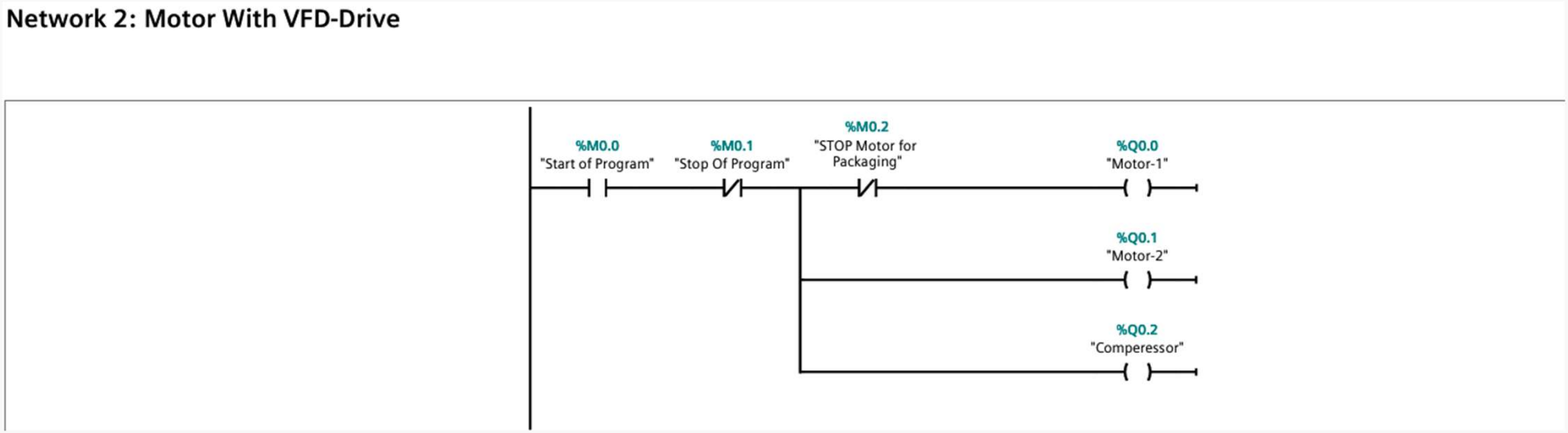
•Normal Fault Alarm: N.O point in Drive, send the signal when the fault occurred

•Motor-2-Failure: N.O from Motor-2 GV2

•Compressor Failure: When the pressure sensor in the compressor reed less than 5 bar the system will be stooped

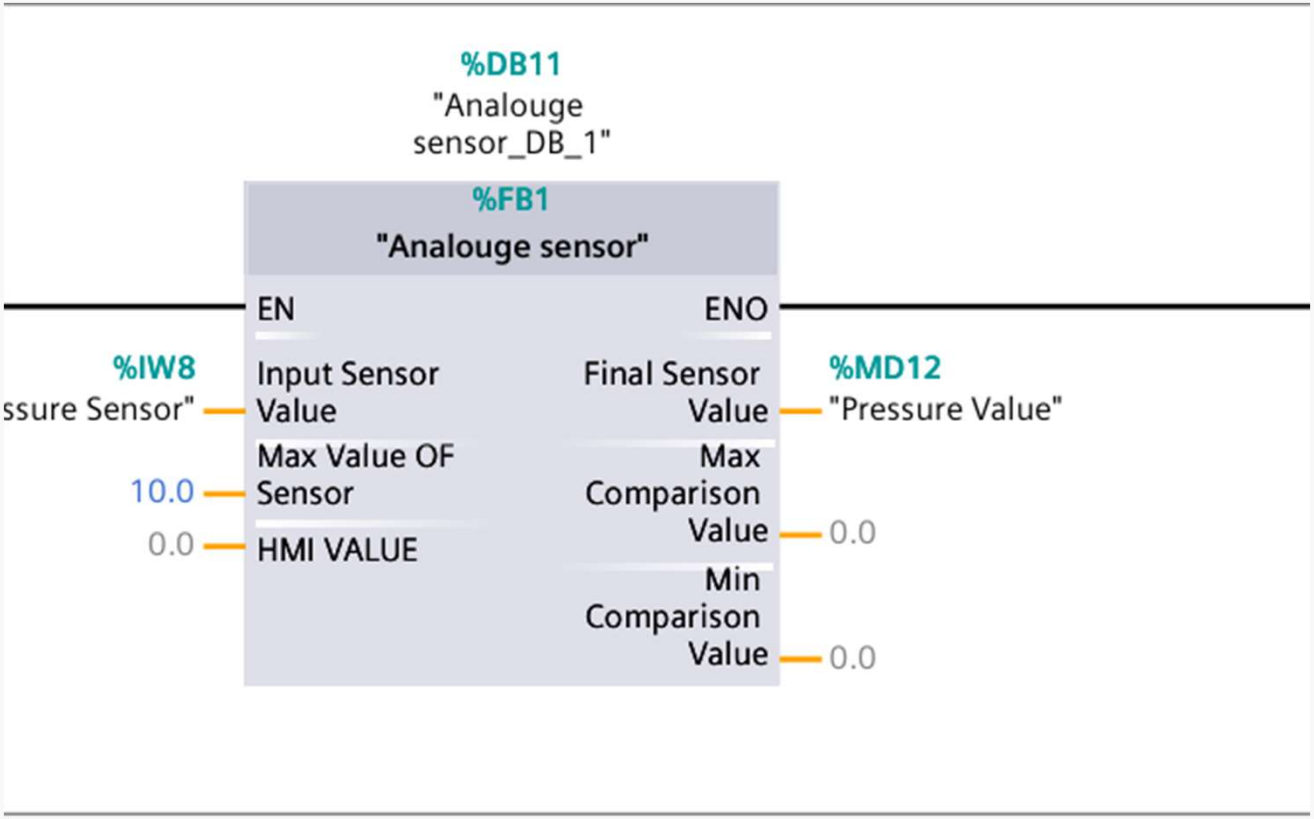
Network 2 : VFD (Variable Frequency Drive)

This network controls motors using Variable Frequency Drive (VFD). It manages the operation of motor and Mechanical Gear Box for second motor and compressors, ensuring they start and stop as required.



Network 3:Analogue Sensor FB

This network reads and processes pressure values from the sensor, compares them with set values to ensure they do not drop below a critical threshold and outputs the final sensor value.

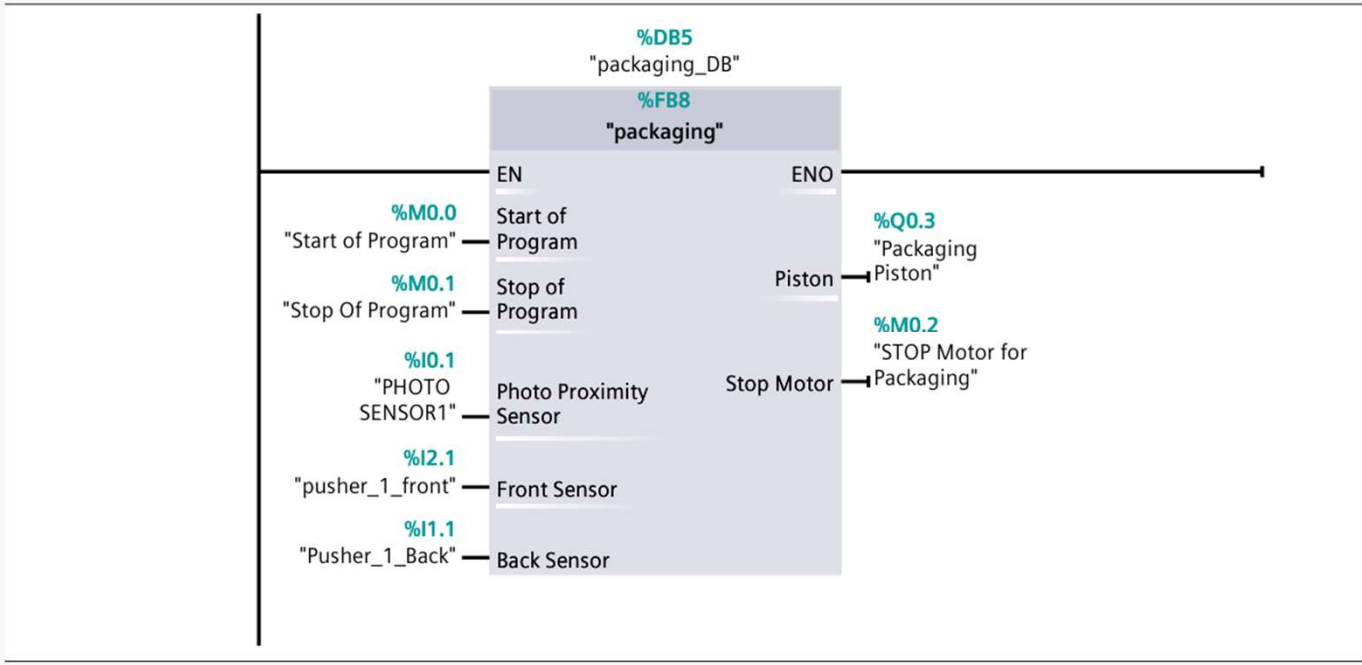


Network 4 : Checking Pressure of pistons

It monitors the pressure level and if it’s lower than 5 Bar; it triggers the Compressor Failure Alarm.

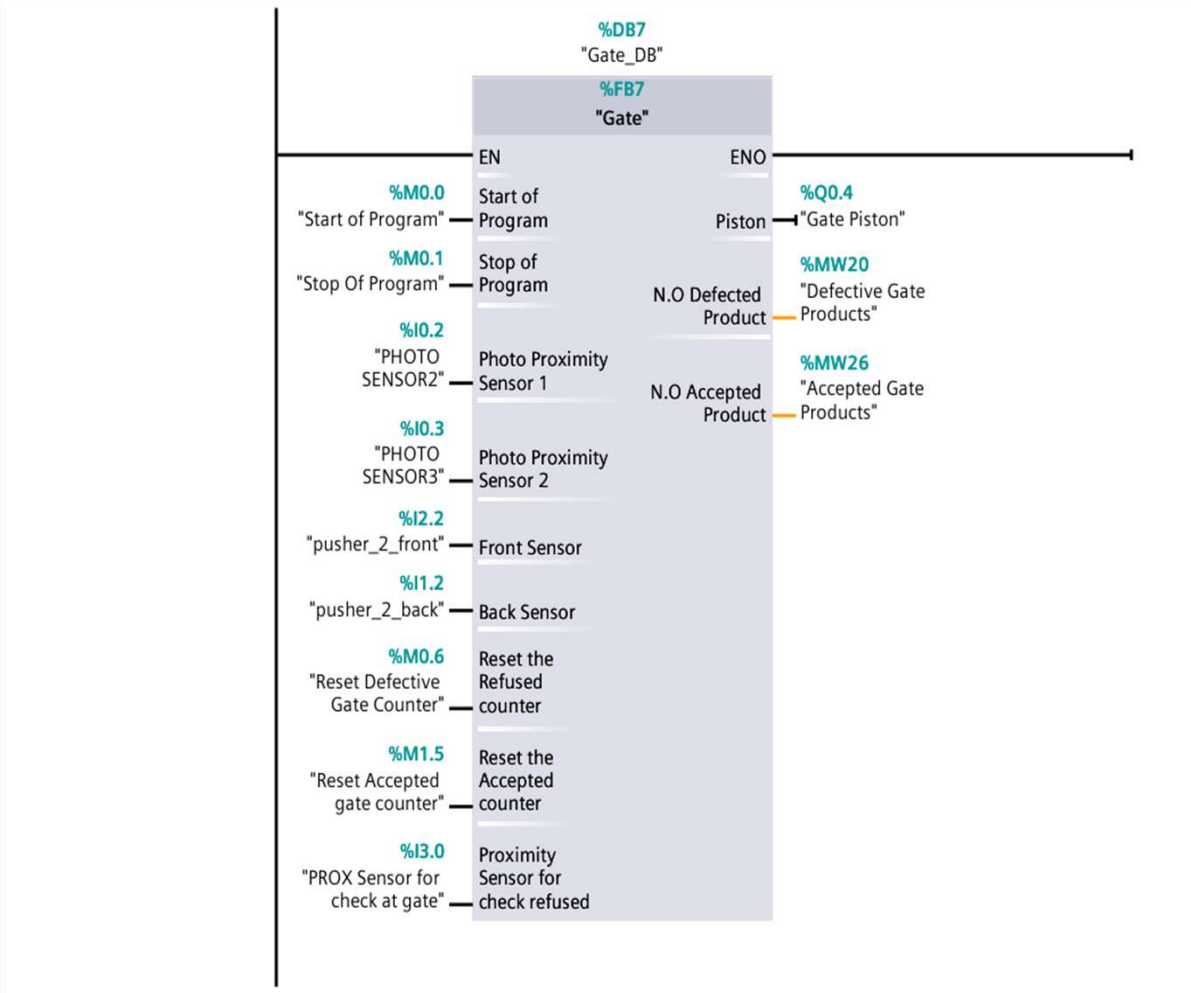
Network 5: Packaging

This network controls the packaging piston and stops the motor when necessary.



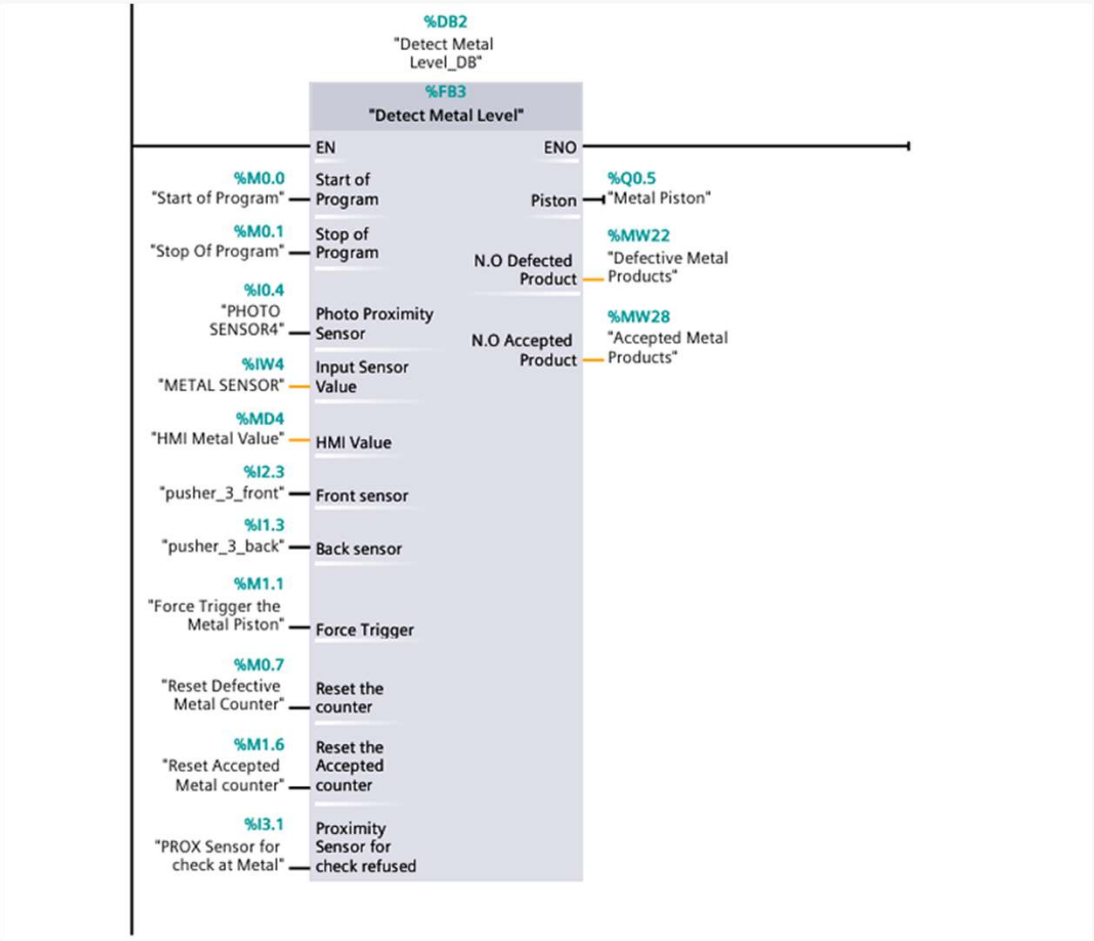
Network 6: Gate Stage

This network is responsible for controlling the gate mechanism in the system.



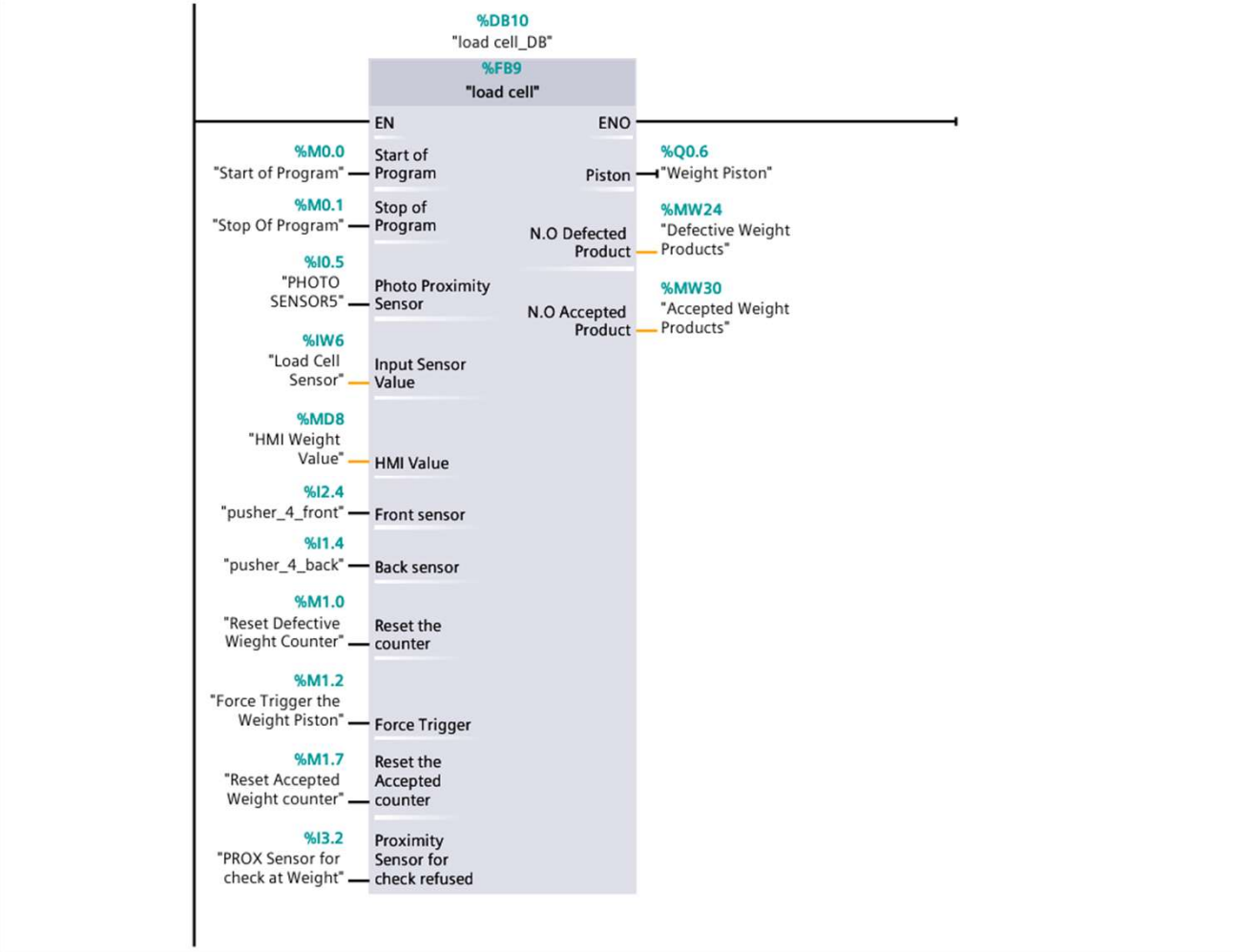
Network 7 : Metal Detection

This network involves detecting the metal level and managing the operation of the metal piston.



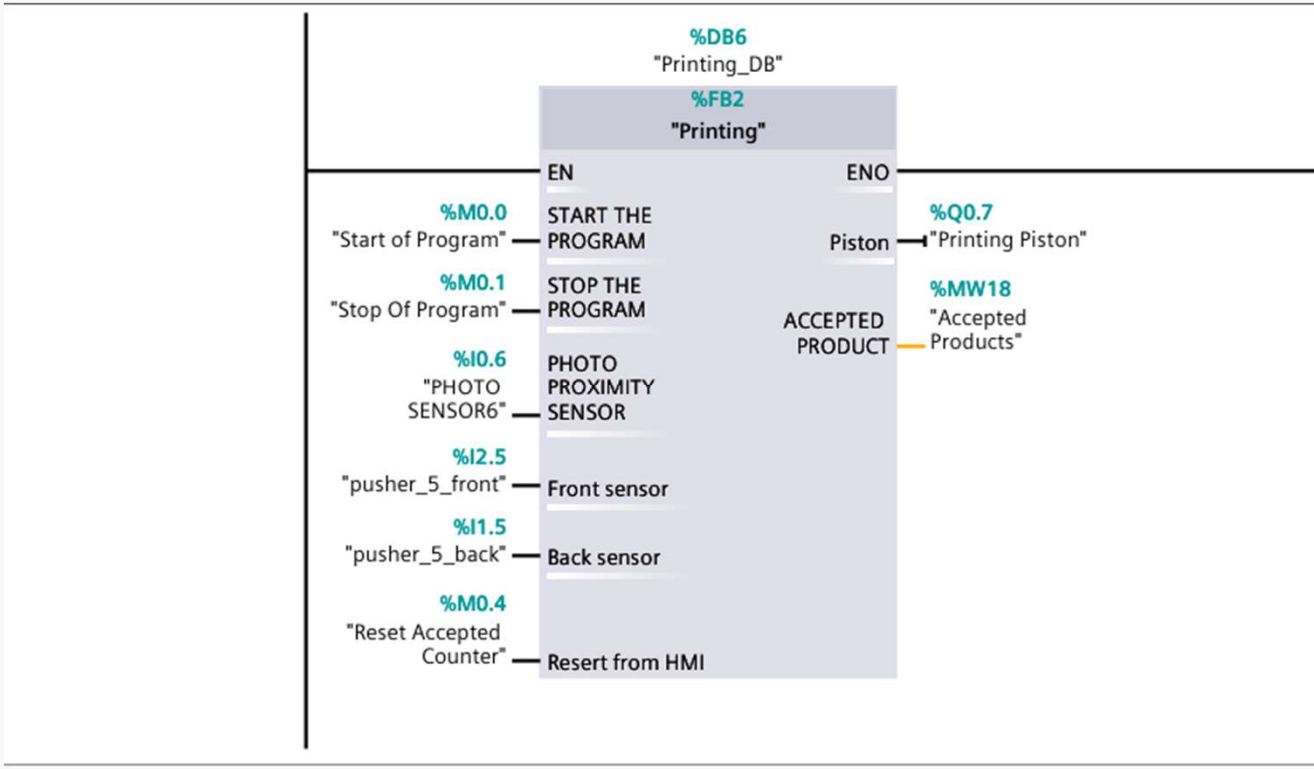
Network 8 : Load cell Stage

This network ensures that the load cell sensor's data is accurately processed and that any defective products are tracked and managed.



Network 9: Printing Stage

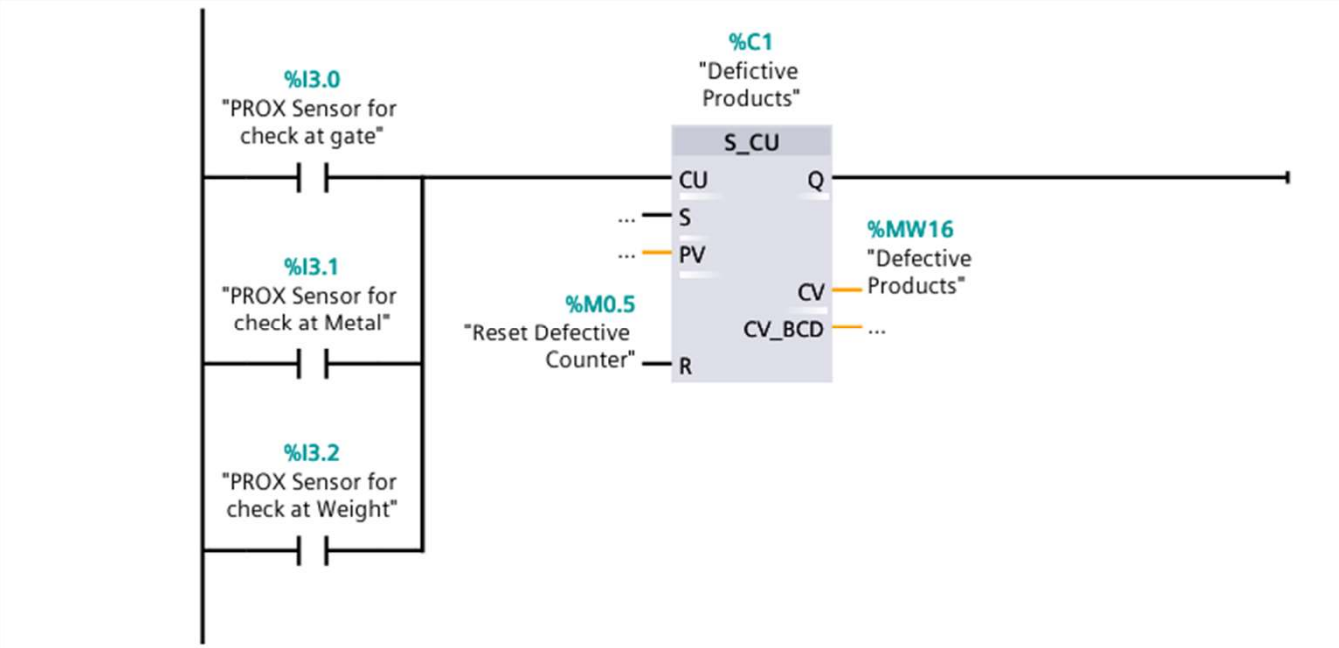
This network ensures that the printing process is automated and accurately tracks the number of accepted products.



Network 10 : Counting defective products

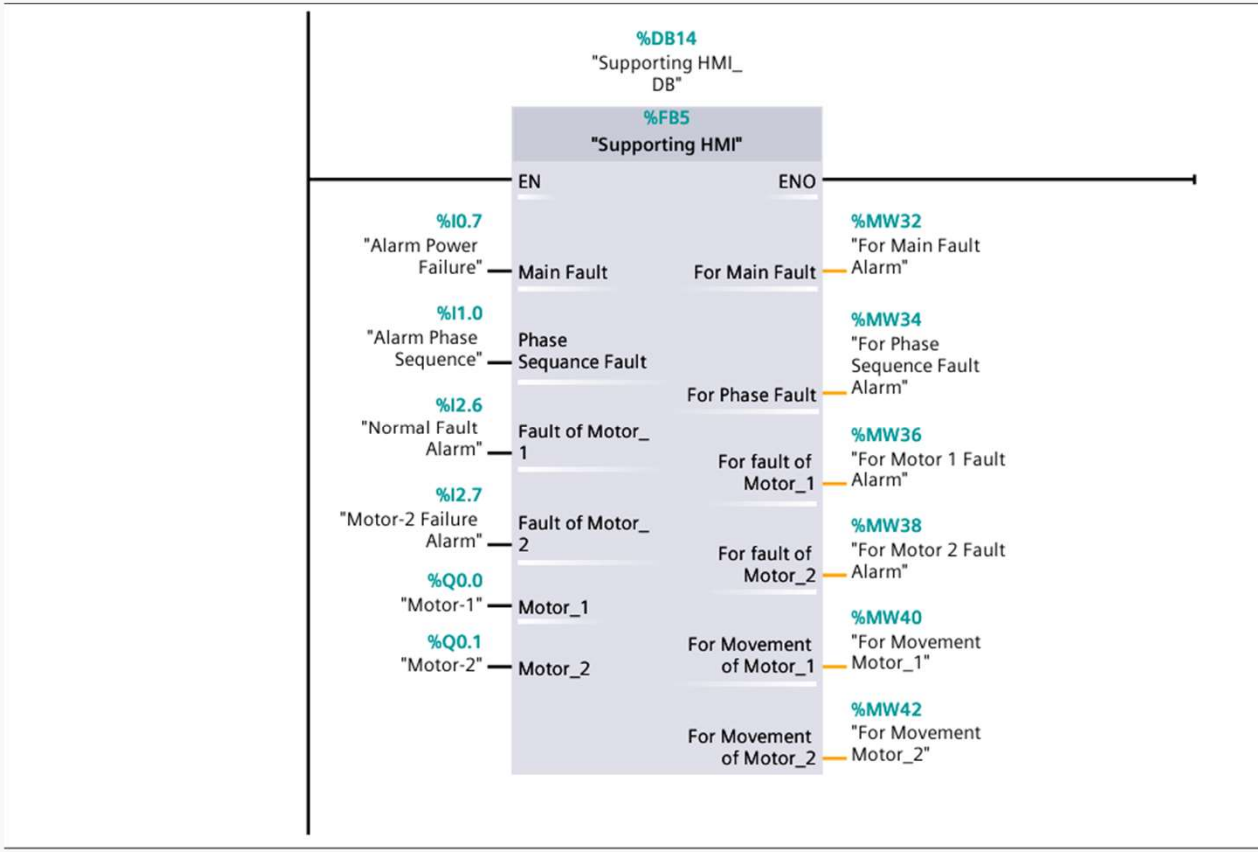
When one of the following is set, the counter "Defective Products" increments by one:

- Gate piston is done.
- Metal piston is done.
- Weight piston is done.



Network 11 : Supporting HMI

This network focused on supporting the Human-Machine Interface (HMI) and handling various alarms and motor controls.



HMI CONFIGUARTION

Human-Machine Interfaces (HMIs)

Human-Machine Interfaces (HMIs) are critical components in modern industrial automation, especially in product defect detection machines. They serve as the bridge between operators and machines, facilitating effective interaction and control of automated systems.

HMI specifications

In this project ,we use a HMI Siemens TP900 Comfort Panel according to its Technical Specifications.

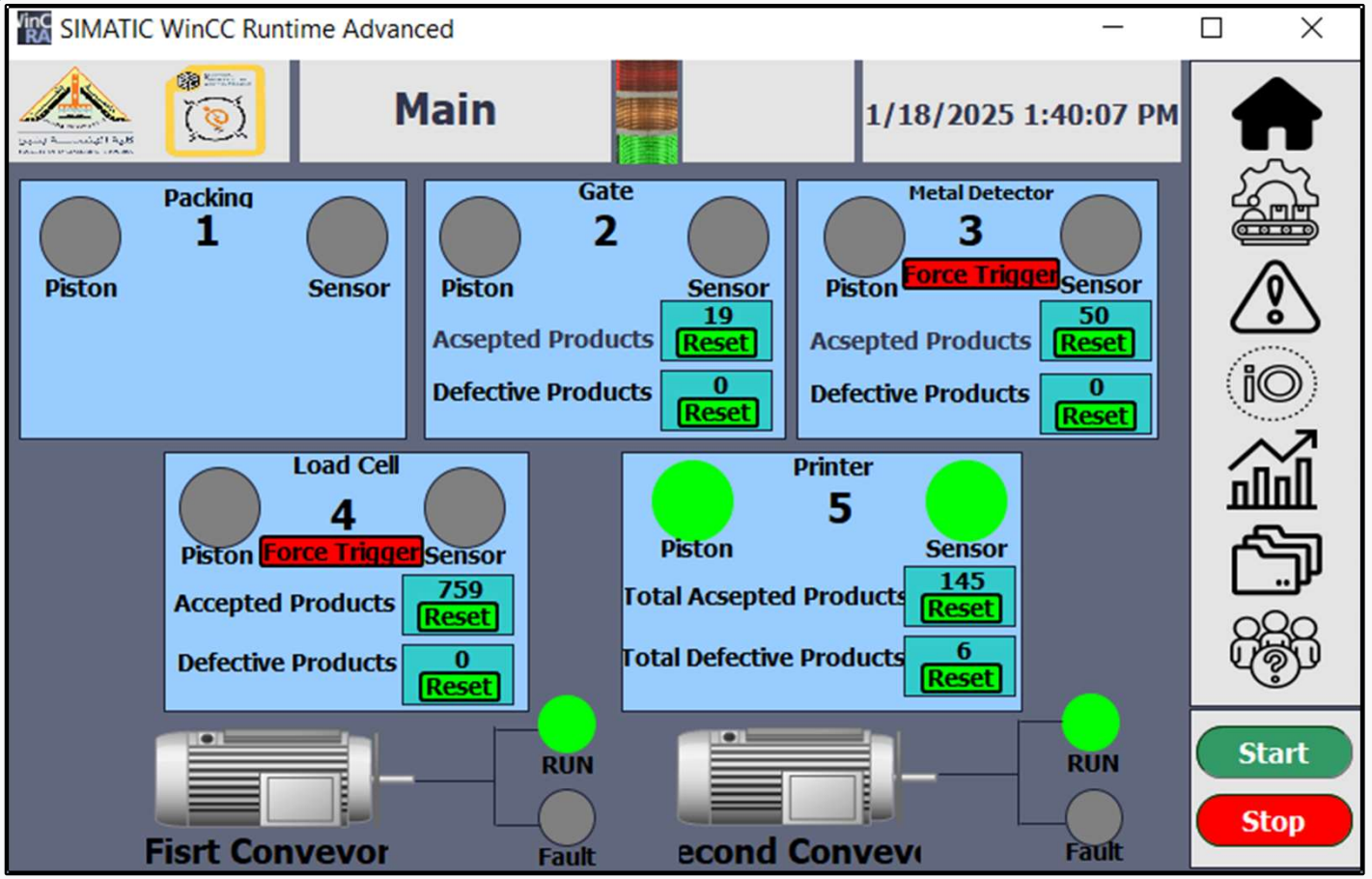
Specifications	Details
Screen Size	9 inches
Resolution	800 * 480 pixels
Touch Type	Capacitive
Communication Protocols	MPI/Profibus DP ,Profinet Ehernet,USB
Ports	DP, Ethernet,USB, Sd card
Power Supply	24V

Screen1: Welcome screen

In HMIs used in industrial environments, the welcome screen is essential for providing clear and direct information

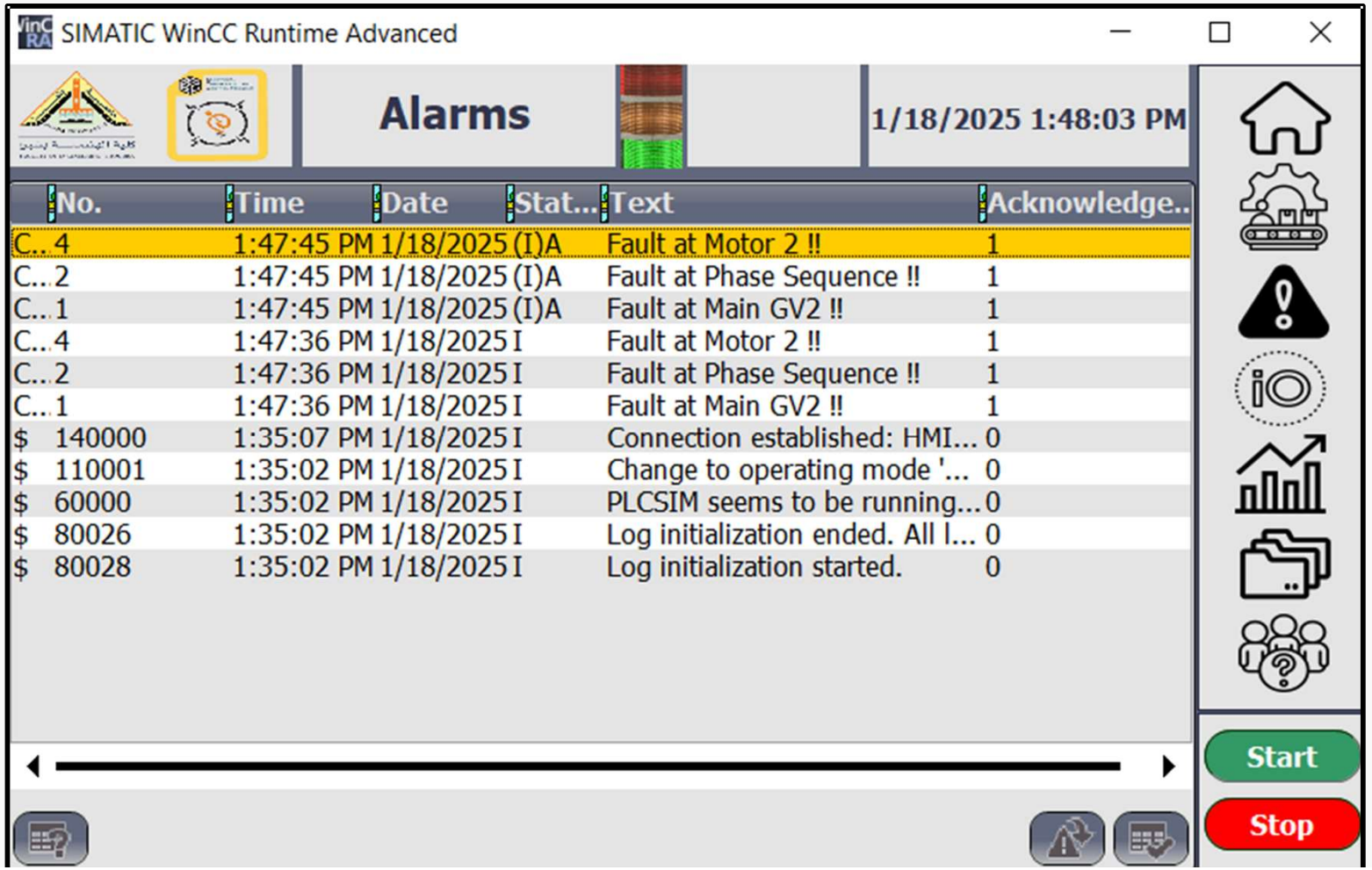
Main screen :

The system is monitoring production processes, The green light indicates The conveyor is running normally.



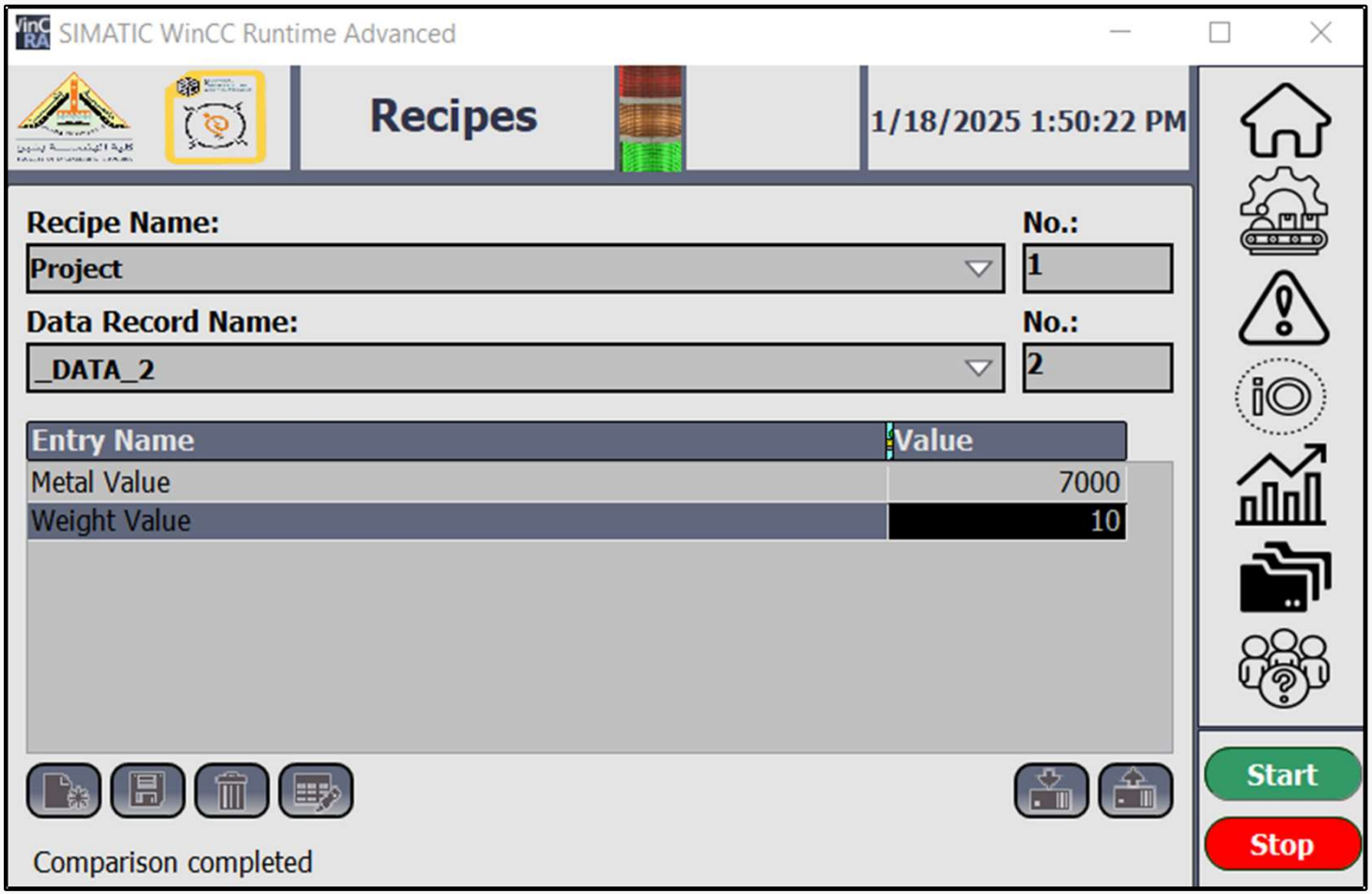
Alarm in main screen:

Critical alarm in a HMI system indicates a serious error or issue.



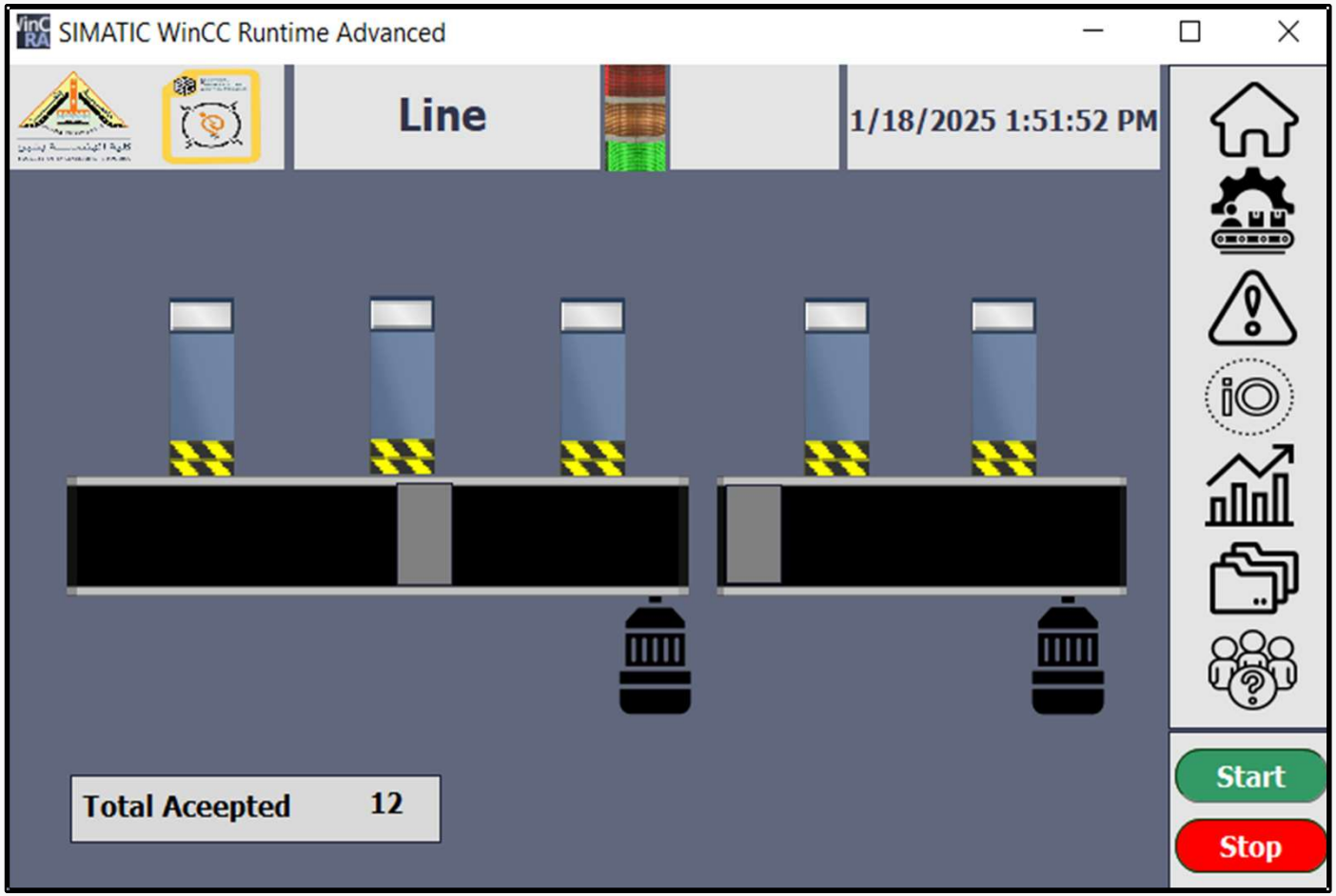
Screen 3: Recipe

Using the recipe to enter values that were compared with the PLC for the number of rejected products in the metal detector and load cell.



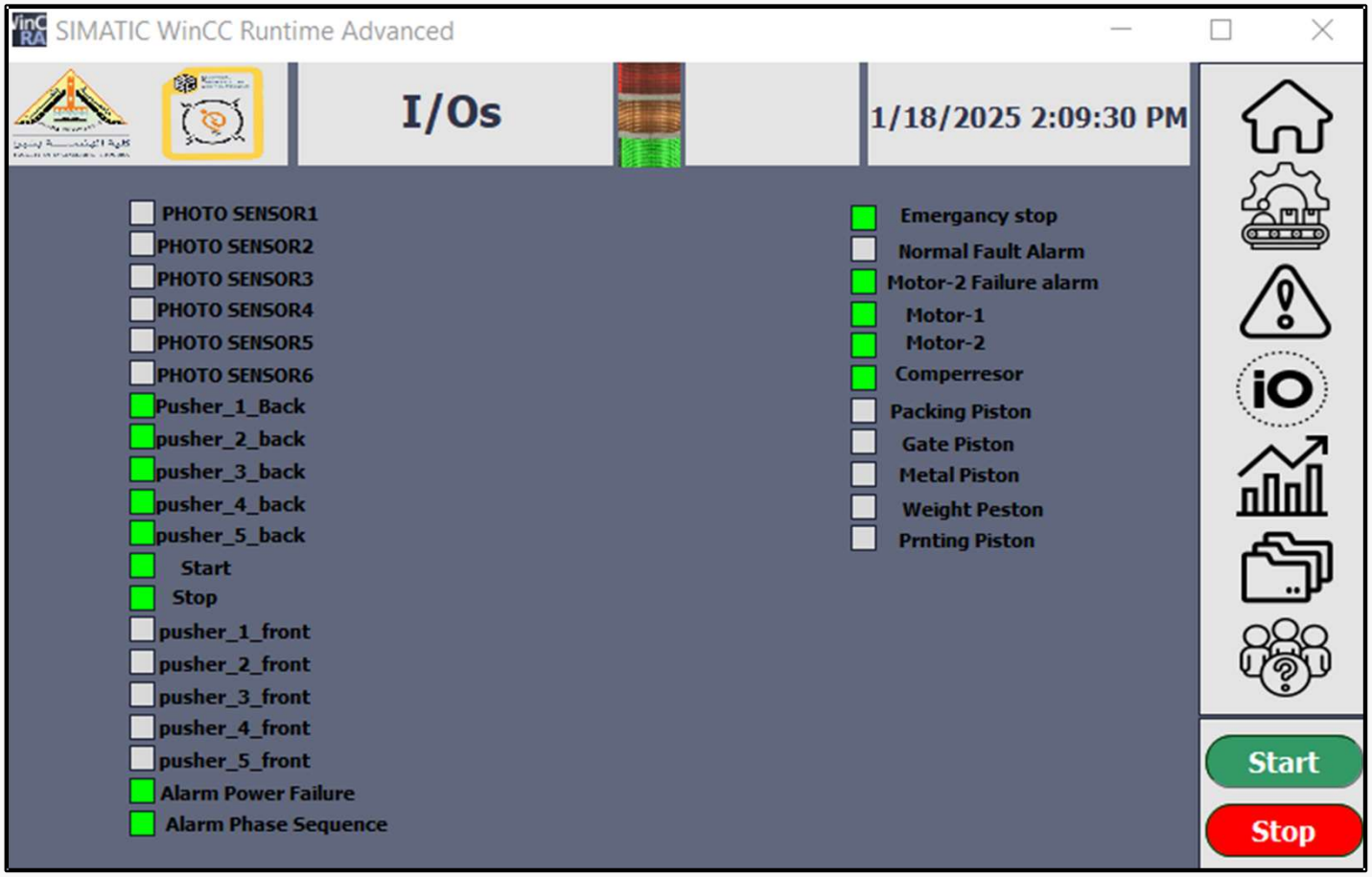
Screen 4: Line

This screen plays a crucial role in monitoring and controlling the workflow effectively.



Screen 5 : I/O Field

Interaction with the system: This field provides a direct interface for the user to interact with the connected device.



Screen 6: Trends

It’s primarily used to monitor and analyze time-based data collected from industrial processes. This screen displays changes in values (such as temperature, pressure and Total Accepted Products).

screen 7 : Information

The presence of an Information Screen in HMI (Human-Machine Interface) systems is crucial as it enhances user.

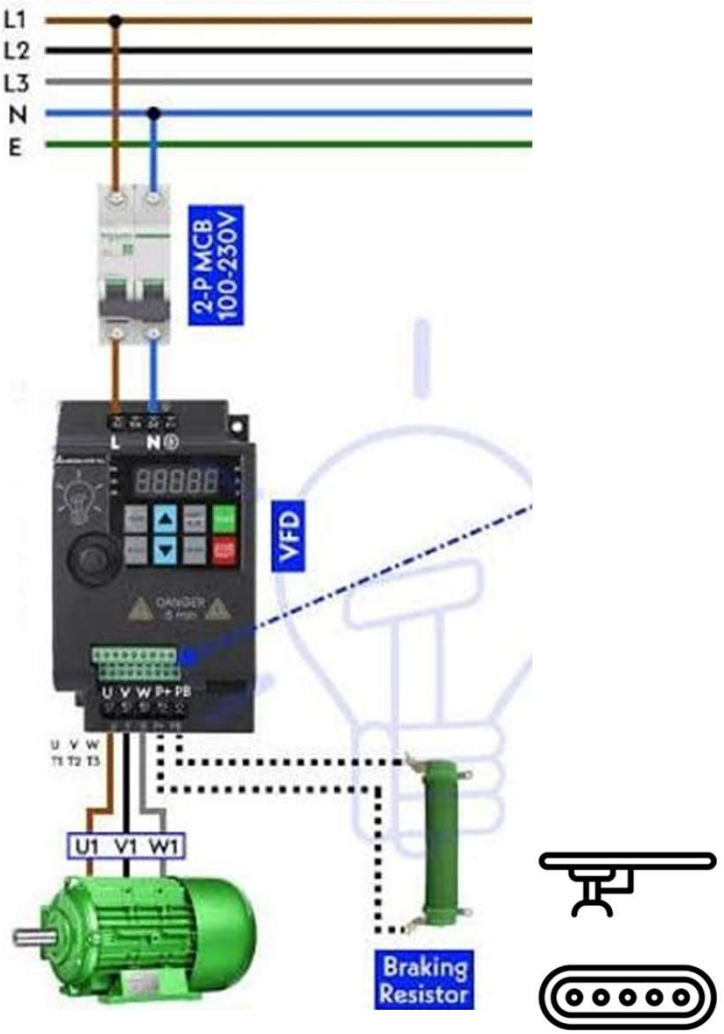
MOTOR DRIVE

AC DRIVE

AC drives control the speed and torque of AC motors using techniques like Pulse Width Modulation (PWM). They are widely used in HVAC systems and industrial machines.

Advantages of (VFD)

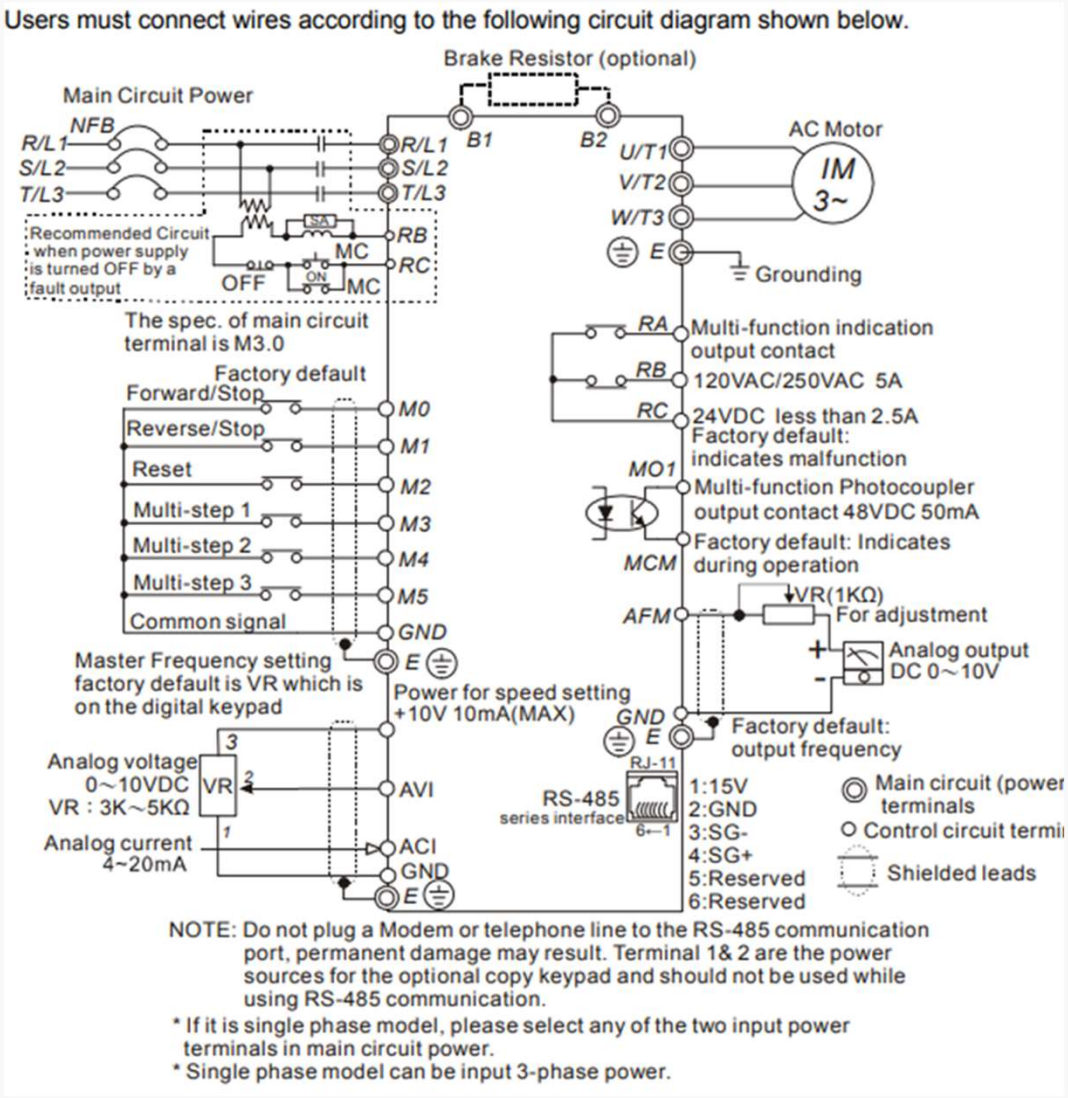
- Reduce Energy Consumption and Energy Costs.
- Extend Equipment Life and Reduce Maintenance.
- Match the speed of the drive to the process requirements.



Connection of VFD

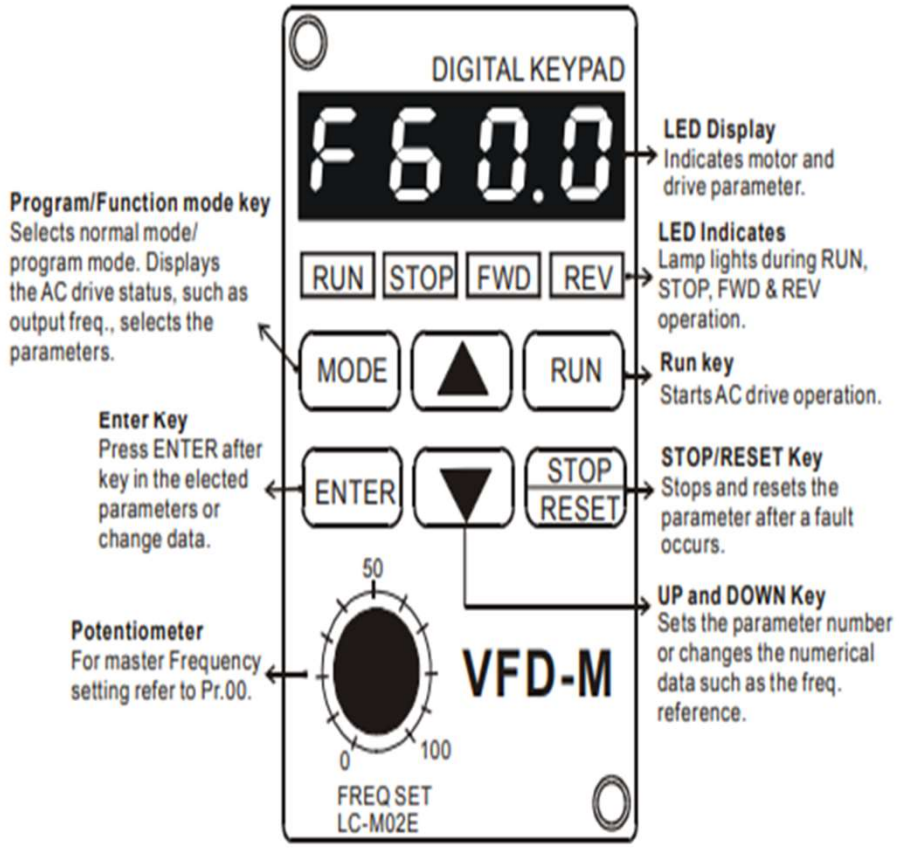
Delta VFD

- Power:0.75 KW
- Input Power: 3-Phase 380V AC
- Output Power:3-Phase 380V AC



Basic Wiring Diagram

The digital keypad includes two parts: Display panel and keypad. The display panel provides the parameter display and shows the operation status of the AC drive and the keypad provides programming and control interface.



Description of the Digital Keypad

4.1 Summary of Parameter Settings

↗: The parameter can be set during operation.

Parameter	Explanation	Settings	Factory Setting	Customer
↗ Pr.00	Source of Frequency Command	00: Master frequency determined by digital keypad (LC-M02E) 01: Master frequency determined by 0 to +10 V input on AVI terminal with jumpers 02: Master frequency determined by 4 to 20mA input on ACI terminal with jumpers 03: Master frequency determined by RS-485 Communication port 04: Master frequency determined by potentiometer on digital keypad	00	
↗ Pr.01	Source of Operation command	00: Operation determined by digital keypad 01: Operation determined by external control terminals, keypad STOP is effective 02: Operation determined by external control terminals, keypad STOP is ineffective 03: Operation determined by RS-485 communication port, keypad STOP is effective 04: Operation determined by RS-485 communication port, keypad STOP is ineffective	00	
Pr.02	Stop Method	00: Ramp stop 01: Coast Stop	00	
Pr.03	Maximum Output Frequency	50.00 to 400.0 Hz	60.00	

Some Parameters Settings

Pr.10	↯ Acceleration Time 1
Pr.11	↯ Deceleration Time 1
Pr.12	↯ Acceleration Time 2
Pr.13	↯ Deceleration Time 2

Settings 0.1 to 600.0 sec or 0.01 to 600.0 sec

Some Parameters Settings

Pr.38 Multi-function Input Terminal (M0, M1)

Factory Setting: 00

Settings	00	M0: FWD/STOP, M1: REV/STOP
	01	M0: RUN/STOP, M1: REV/FWD
	02	M0, M1, M2: 3-wire operation control mode

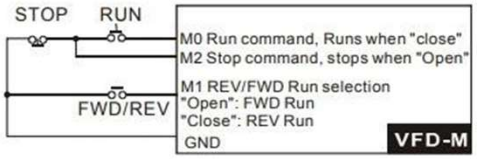
Explanations:

00: Two wire operation: Only Pr.38 can be set to "0".

01: Two wire operation: Only Pr.38 can be set to "1".

Note: Multi-function Input Terminal M0 does not have its own parameter designation. M0 must be used in conjunction with M1 to operate two and three wire control.

02 Three Wire Control: Only Pr.38 can be set to "2".



Note: When the "2" setting is selected for Pr.38, the value in Pr.39 will be ignored.

Some Parameters Settings

Parameter	Setting	Explanation
Pr.00	00	Frequency reference is set to the keypad, meaning the drive receives its frequency control commands directly from the keypad.
Pr.01	02	Both external control and keypad inputs are active, allowing flexibility in controlling the drive.
Pr.02	00	Stop method is set to "ramp to stop," which smoothly reduces the motor speed instead of an abrupt stop.
Pr.03	50.00	Maximum frequency the drive can output to the motor, set to 50 Hz in this case. This aligns with standard motor requirements.
Pr.05	380V	Maximum voltage the drive can output, ensuring it matches the motor's rated voltage.

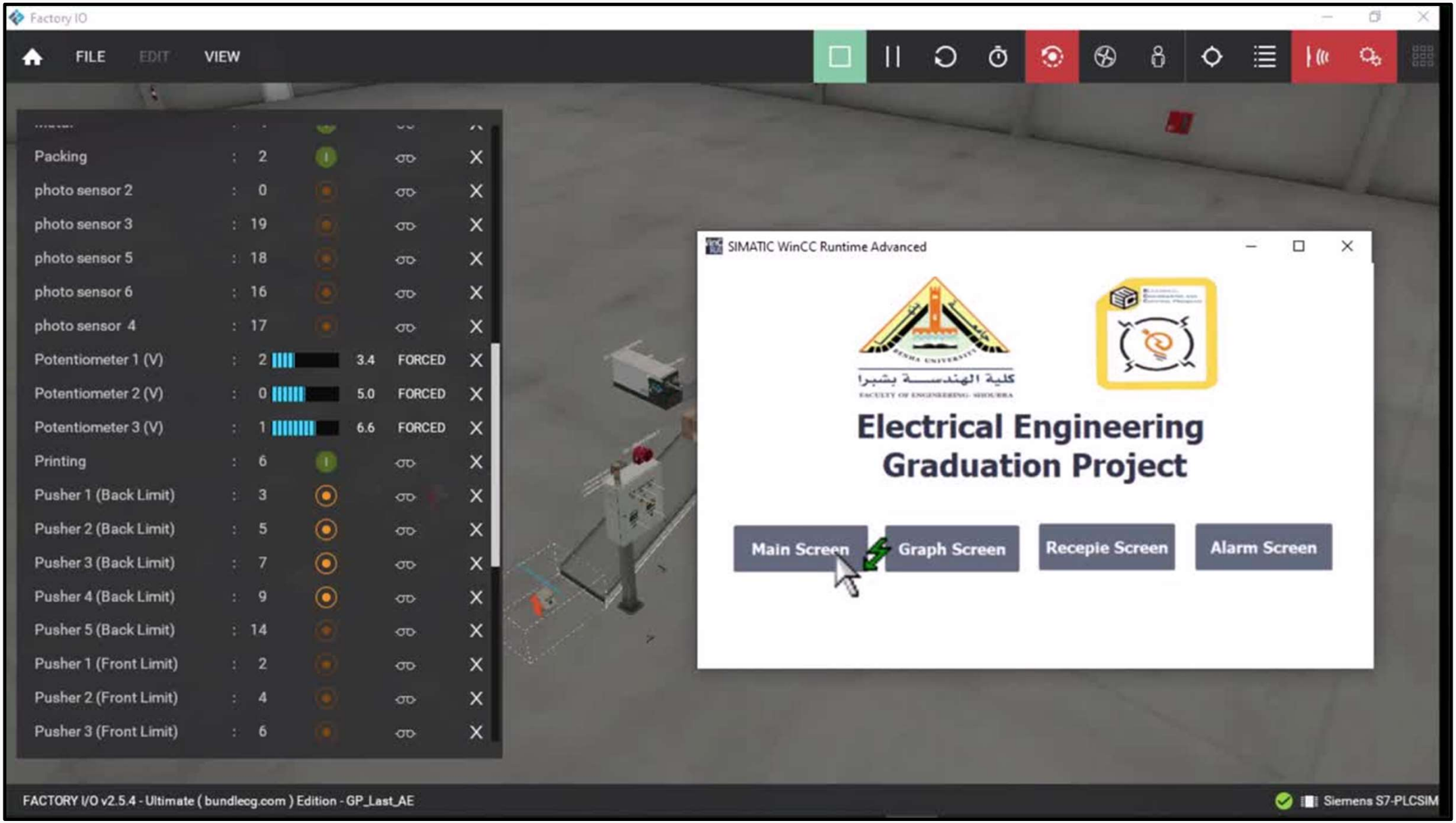
Drive Setup

Pr.08	1HZ	Minimum output frequency, ensuring the motor does not operate below this frequency to prevent stalling or insufficient torque.
Pr.09	10 v	Minimum output voltage, preventing motor operation at too low a voltage, which might lead to inefficiency.
Pr.10	3sec	Acceleration time, which defines how quickly the drive reaches the set speed. A smooth acceleration minimizes mechanical stress on the system.
Pr.11	0sec	Deceleration time, set to zero here, meaning the motor stops as soon as the drive command is deactivated. If set higher, it would ramp down the speed.
Pr.24	01	Reverse direction is disabled, ensuring the motor operates only in the forward direction to meet system requirements.
Pr.25	300 V	Over-voltage stall prevention is enabled to protect the drive from voltage spikes.

Drive Setup

Pr.26	5A	Over-current stall prevention during acceleration (20% to 200%), limiting current to prevent damage to the drive or motor.
Pr.27	6A	Over-current stall prevention during normal operation, ensuring system safety under consistent loads.
Pr.38	00	Multifunction input terminal is set to mode 0, likely a default or specific function required by the system.
Pr.76	01	All parameters are read-only, preventing accidental or unauthorized changes to the drive settings.

Drive Setup


Factory IO
FILE
EDIT
VIEW
Packing : 2
photo sensor 2 : 0
photo sensor 3 : 19
photo sensor 5 : 18
photo sensor 6 : 16
photo sensor 4 : 17
Potentiometer 1 (V) : 2 3.4 FORCED
Potentiometer 2 (V) : 0 5.0 FORCED
Potentiometer 3 (V) : 1 6.6 FORCED
Printing : 6
Pusher 1 (Back Limit) : 3
Pusher 2 (Back Limit) : 5
Pusher 3 (Back Limit) : 7
Pusher 4 (Back Limit) : 9
Pusher 5 (Back Limit) : 14
Pusher 1 (Front Limit) : 2
Pusher 2 (Front Limit) : 4
Pusher 3 (Front Limit) : 6
SIMATIC WinCC Runtime Advanced
كلية الهندسة بشبرا
Electrical Engineering
Graduation Project
Main Screen
Graph Screen
Recepie Screen
Alarm Screen
FACTORY I/O v2.5.4 - Ultimate (bundlecg.com) Edition - GP_Last_AE
Siemens S7-PLCSIM

Thanks for your attention,

Any questions ?