# PLC Based Automatic Packaging System

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***Abstract*– A production line is a set of sequential operations established in a factory where components are assembled to make a finished article or where materials are put through a refining process to produce an end-product that is suitable for onward consumption. This project is automatic packaging system, that is the process or procedure of packaging a product without human assistance. It will be a fully automated packaging lines that seal, stack and unitize entire pallets of goods.**

***Keywords*—PLC – Automation – Packaging Systems.**

## I. Introduction

The production line is a complex of machines that are arranged in rows and controlled so that they work together as a cohesive unit. This group of human-operated positions is also organised in accordance with the sequence of tasks performed by technological processes. The needs and technical requirements of the product determine how many positions are needed in the production line. Employees are required to do all tasks given to their position, and every manufactured good must pass through the designated phase in the production process within the designated amount of time. The term "production cycle" refers to this sequence of actions. A production line's final output may be the outcome of processing, handling, transport, packaging, etc.

The production line that we will design is automatic sackaging system, that is the process or procedure of packaging a product without human assistance. It will be a fully automated packaging lines that seal, stack and unitize entire pallets of goods.

This line consists of two conveyors, one for boxes and the other for the product, and two cartesian robot, one for transfer the product to box and the other for unitizing entire pallets of the boxes.

There are three phases for this line,

• First phase is entry the box on the box conveyor and the product on the product conveyor.

• Second phase is transferring the product to the box via the first robot when the product and the box arrived to the appropriate place.

• Third phase is unitizing entire pallets of the boxes via the second robot.

The block diagram, shown in fig 1, shows the packaging system steps.

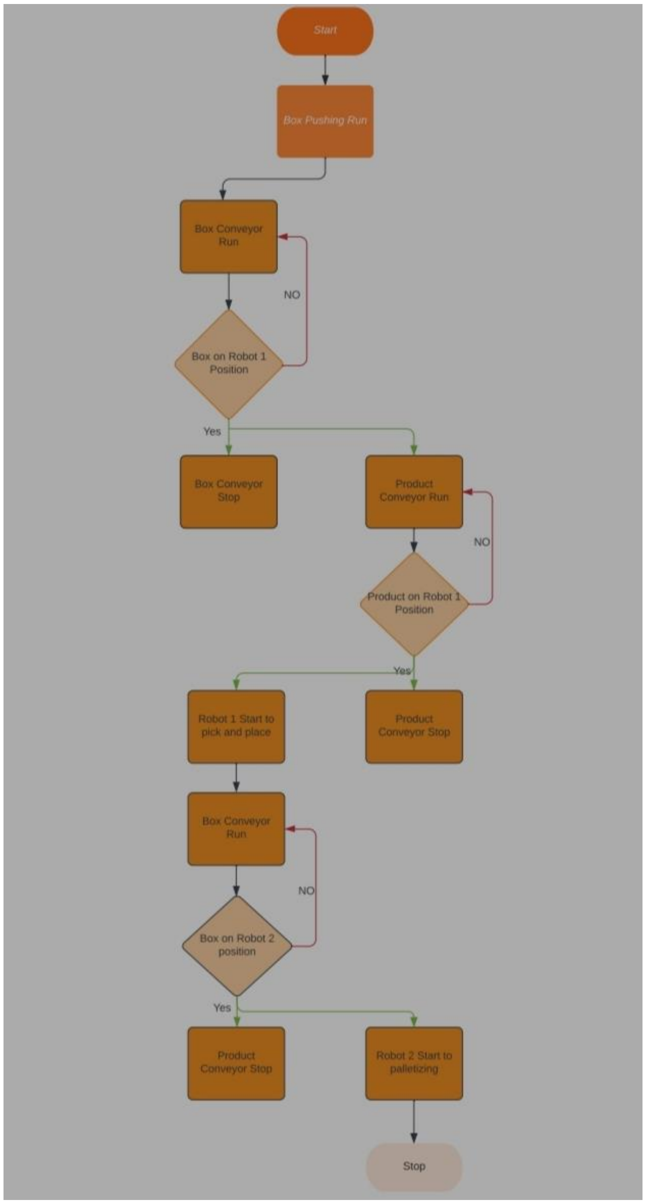



Fig. 1 Packaging system steps.

## II. Conveyor Systems

Conveyor Systems are mechanical devices or assemblies that transport material with minimal effort [1]. Conveyor systems come in a variety of shapes and sizes, but they all typically consist of a frame that holds a belt, wheels, rollers, or some combination of the three. They can be propelled manually, by gravity, or by a motor. These material handling systems are available in a wide range of models to accommodate the various goods or materials that must be transported.

### A. Belt Conveyors

Belt Conveyors, as shown in fig 2, are material handling systems that use continuous belts to convey products or material. In between two end-pulleys, the belt is stretched out in an endless loop. Usually, there is a roll underneath one or both ends. For mild weights when no friction would be applied to the belt to generate drag, the conveyor belting is either supported by a metal slider or on rollers. Power is provided by motors that use either variable or constant speed reduction gears [1].

Fig. 2 Belt conveyor.

Numerous materials can be utilized for belt construction, and the material used should be appropriate for the

environment in which the belt will be used. Rubber, plastic, leather, fabric, and metal are all typical materials for conveyor belting. A thicker and more durable conveyor belting construction is needed to transport heavier loads. Depending on the throughput needed, belt conveyors can run at a variety of speeds and are often powered. The conveyors can run vertically or horizontally, or both. Troughed belt conveyors can handle huge or bulky items.

### B. Conveyor Systems Specifications

1- Load Capacity per Unit Length

When a conveyor will be built to a specific length, the manufacturer will offer this feature to allow customers to choose loading margins.

2- Maximum Load Capacity

Associated with load capacity per unit length, this value can be stated for fixed length, purpose-built conveyors. Also, this can be known as flow rate.

3- Conveyor Belt System Speed/Rated Speed

While powered roller conveyors express the linear velocity in terms of a package, carton, etc. moving over the powered rollers, belt conveyors are commonly rated in terms of belt speed in feet per minute. Both drag/chain/tow conveyors and apron/slat conveyors operate at their rated speed.

4- Throughput

Throughput measures the capacity of conveyors that handle powdered materials and similar bulk products. It is frequently expressed as a volume per unit of time, such cubic feet per minute. This attribute applies to screw, bucket, vacuum/pneumatic, vibrating, and walking beam conveyors.

5- Frame Configuration

The conveyor frame's configuration, or "frame," refers to its shape. The shapes of the frames can be straight, curved, z-frames, or other.

6- Drive Location

On conveyor systems, drives can be placed in various locations. The most typical kind of drive is a head or end drive, which is located on the conveyor's discharge side. Center drives are not always at the actual center of the conveyor, but somewhere along its length, and are mounted underneath the system. They're used for reversing the conveyor direction.

## III. Robotic Arms

Robotic arms are specialised forms of jointed robot manipulators that let machines communicate with their surroundings. Although they can be managed directly or in a variety of other ways, many have inbuilt controllers or translators to make communication easier. Because of this, standalone arms are frequently categorised as full robots.

### A. Cartesian Robot Arm

Taking its name from the Cartesian plane, the Cartesian robots are also called gantry robots or rectilinear or arms. These robotic arms have three prismatic joints – the X, Y, and Z joints –, as shown in fig 3, whose linear motions are delivered along each axis. In order to allow rotational movement, they might additionally feature a wrist-like attachment on one end. Cartesian robots are popular in arc welding, assembly operations, and pick and place (P&P) machines [2].

Fig. 3 Cartesian Robot Arm.

### B. Parameters of Robotic Arms

There are normally fourteen different factors that describe arms.

1- Number of Axes: Any point in a plane can be reached using two axes. To get to a point in space, you need three. To fully control the end manipulator, roll, pitch, and yaw control are necessary.

2- Degrees of Freedom: The number of points that a robot can be directed around. A human arm has seven degrees; articulated arms typically have up to 6.

3- Working Envelope: Region of space a robot can encompass.

4- Working Space: the area of space that a robot can interact with completely.

5- Kinematics: Arrangement and types of joints (Cartesian, Cylindrical, Spherical, SCARA, Articulated, Parallel).

6- Payload: Amount that can be lifted and carried.

7- Speed: May be defined by total angular or individual or linear movement speed.

8- Acceleration: limits the maximum possible speed over short distances. In terms of each degree of freedom or by axis, acceleration is given.

9- Accuracy: Given as a best case with modifications dependent on position and movement speed relative to the ideal inside the envelope.

10- Repeatability: More closely related to precision than accuracy. Robots with a low repeatability factor and high accuracy often need only to be recalibrated.

11- Motion Control: Arms may only need to move to specific locations in the working area depending on the application. They could also need to communicate with every potential point.

12- Power Source: Although new techniques are developing and being tested, electric motors or hydraulics are commonly used.

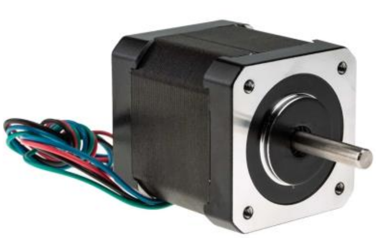
13- Drive: Motors may be hooked directly to segments for direct drive. In a harmonic drive system or using gears, they can also be connected.

14- Compliance: Measure of the distance or angle a robot joint will move under a force [3].

## IV. Stepper Motors

Stepper motor, as shown in fig 4, is a special type of synchronous motor which is designed to rotate a specific number of degrees for every electric pulse received by its control unit. Typical steps are 15 or 7.5 degree per pulse.

Fig.4 Stepper Motor



It is a motor that has the ability to rotate in both directions, can change angles precisely, can maintain a holding torque at zero speed, and can be controlled by digital circuits. It moves in accurate angular increments known as steps, in response to the application of digital pulses to the electric drive circuit. Generally, these motors are typically produced with steps per revolution.

Depending on the source of its electrical power, it:

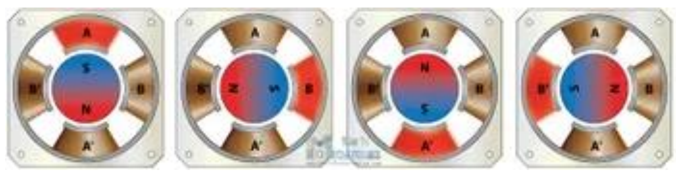
A- Unipolar: It only needs one power source, hence the term unipolar, if its coils are always supplied by a single voltage in the same direction.

B- Bipolar: It needs two power sources when the coils are sometimes fed in one direction and sometimes in the other. The term "bipolar" refers to the fact that they sometimes produce south pole and sometimes produce north pole.

Stepper motors can divide a full 360° into a huge number of steps, like 200, and are brushless, unlike regular DC motors.

### A. *Operating principles*

Fig. 5 Stepper Motor Operating Principles



Stepper motors operate, as shown in fig 5, differently from normal DC motors, which rotate when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. An external control circuit, such as a microcontroller, powers the electromagnets. One electromagnet is powered first to turn the motor shaft, which causes the gear's teeth to be magnetically drawn to the electromagnet's teeth. When the teeth of gear are thus aligned to the first electromagnet, they are somewhat offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates somewhat to align with the next one, and the process is repeated. Each of those slight rotations is called a "step," making a full rotation with an integer number of steps. In that way, the motor can be turned by an accurate angle [4].

### B. *Advantages*

1- Cheap price.

2- works well in open loops (no feedback required).

3- Great holding torque (eliminated brakes/clutches).

4- Great torque at low speeds.

5- Low maintenance (brushless).

6- Very rugged - any environment.

7- Great for accurate positioning control.

### C. *Disadvantages*

Following are some disadvantages of stepper motors in compared to servo motors.:

1- Rough performance at low speeds except if you use micro-stepping.
2- Consume current regardless of load.
3- Limited sizes available.
4- Noisy.
5- Speed causes torque to decrease (you need an oversized motor for higher torque at higher speeds).
6- Without a control loop, stepper motors might stall or lose position.

## V. Programmable Logic Controller (PLC)

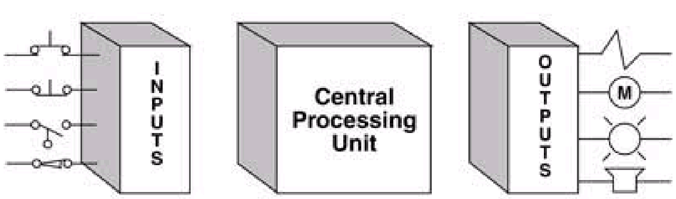
A Programmable Logic Controller (PLC), as shown in fig 6, is an industrial computer control system that continuously assesses the status of input devices and decides how to regulate the state of output devices based on a custom program. This kind of control system can considerably improve almost any production line, machine operation, or process. However, the biggest benefit in using a PLC is the ability to change and replicate the process or operation while collecting and communicating vital information.

Fig. 6 Programmable Logic Controller (PLC)

A PLC system also has the benefit of being modular. To best suit your application, you can combine and match different types of input and output devices.

### A. *Inside of PLC*

Fig. 7 Inside of PLC




The CPU, or central processing unit, has an internal programme that instructs the PLC how to carry out the following tasks:

• Execute the Control Instructions contained in the Programs of user. This program is stored in "non-volatile" memory, meaning that the program will not be lost if power is removed.

• Communicate with other devices, which can include Programming Devices, I/O Devices, Networks, and even other PLCs.

• Perform Housekeeping activities such as Communications, Internal Diagnostics, etc [5].

### B. *The Operate of PLC*

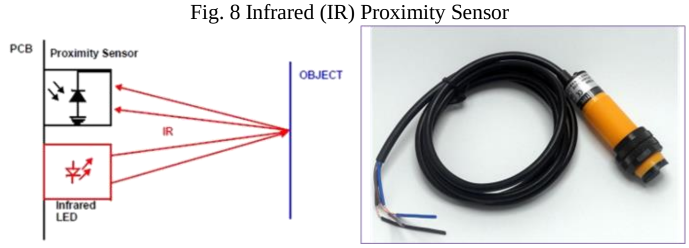
All PLCs operate in accordance with the same four fundamental steps: input scan, program scan, output scan, and housekeeping. These actions are repeated repeatedly in a loop. Operation of the PLC in four steps:

1- Input Scan: Detects the state of each input device linked to the PLC.
2- Program Scan: Executes the program logic created by user.
3- Output Scan: Energizes or de-energize all output devices that are attached to the PLC.
4- Housekeeping: This step includes communications with internal diagnostics, programming terminals, etc...

## VI. Infrared (IR) Proximity Sensor

The SN-E18-B03N1, shown in fig 8, contains infrared sensor for use as reflection of IR signal barriers. It makes use of a particular sensor to find the modulated IR signal that is reflected back from the object, whether it is close by or far away. The light intensity of the digital infrared sensor can be changed between the transmitter and receiver for the purpose of current changes in order to achieve the detection. As an NPN output, the digital infrared sensor's output signal must be pulled high. If an object is detected, the module will output a low , else a high.

Fig. 8 Infrared (IR) Proximity Sensor




### A. *Sensitivity*

For an object that is white or bright, the digital infrared sensor has a detection range of around 0 cm to 30 m. The Digital Infrared Sensor's detection range for dark or black objects is approximately 2 cm to 25 cm. It demonstrates that a white surface will reflect the sensor's light more than a black one. The sensing range of the sensor can be adjusted.

When user adjust the white preset (at the bottom of Digital Infrared Sensor, the range of object detected also change. If the user adjusts the preset to counter-clockwise, the detected range will be less than 30cm. The digital infrared sensor can identify objects for longer distances the more counterclockwise the user turns the preset.

## VII. Final Form of the PACKAGING SYSTEM

Fig. 9 Final Form of The Packaging System

The final form of the packaging system, shown in fig 9, consists of:

- Box container,
- Box conveyor,
- Product conveyor,
- Pick and place robot,
- Palletizing robot,
- Electrical panel.

## VIII. Electrical panel

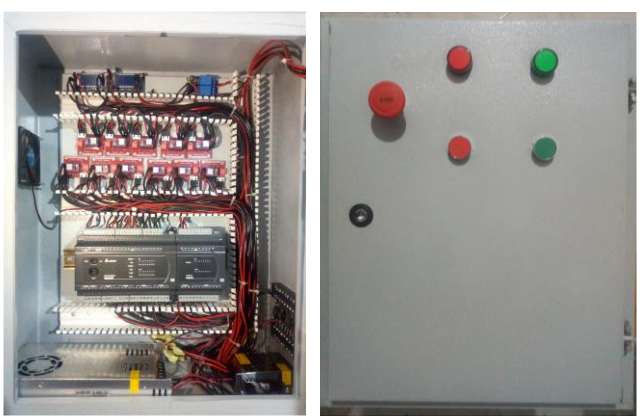


Fig. 10 Electrical Panel

Electrical panel, shown in fig 10, consists of:

- Programmable logic controller (16 digital input/ 16 digital output),
- Extension module (8 digital input/ 8 digital output),
- 11 stepper motor driver (DRV8825),
- 2 Pulse width generator,
- Cooling fan,
- 12V Power supply,
- 5V power supply,
- 12V to 24V converter.
- 2 LED indicator lights (green/red),
- 2 Push button(start/stop),
- 1 Emergency button.

## IX. Software

In this project, we used ISP soft programming software to program it by ladder diagram (LD) method.

ISPSoft is Delta's most latest programme development tool for PLCs that complies with the IEC 61131-3 standard and integrates several project management tasks.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