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# Design and Fabrication of PLC Based Conveyor System with programmable Station

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***Abstract*— The conveyors are the basic primitive component of material handling. There are various types of conveyors used in industry like belt conveyor, chain conveyor, gravity conveyor, etc. The basic features of conveyor systems are not only to convey the objects but also to stop at predefined locations for some operation. The dissertation on conveyor is taken up to design and manufacture a table top model, with programmable number of stations and relevant control panel. The proposed conveyor is 780mm long, capable of conveying the objects of 60 cubic mm size, The number of stations are programmable from 2 to 5, with or without interlocks. The efficient use of timers and counters are incorporated to optimize thei/os. The proposed conveyor is PLC based and with little amendment, it will be coupled with the palletizer. The advanced programming features of PLC with respect to timers and counters and programmable variable inputs are the key operating features which minimizes the input and outputs as required by PLC.***

***Index Terms*—** Programmable conveyer, Palletizer, Programmable PLC, Material Handling

## I. INTRODUCTION

The "Mechatronics" is now being deployed in Flexible Manufacturing System (FMS). The material handling was one of the significant applications of Mechatronics in FMS followed by Robotics. In this dissertation the main focus is to develop a demonstrative setup of conveyor system with programmable workstations and a provision to be interfaced with Pallatizer with see through technology. The conveyer system is selected as it is most commonly used, simple to demonstrate yet it has highly complicated PLC programming aspects. One of the objective was to develop a test bench for the undergraduate students to study PLC programming with all the insights.

The PLC was selected to be a controller for obvious reasons. The most significant is market share of PLC, which is more than 60% in automation industry. The students who are familier with PLC programming have a natural preference while in selection process of the recruitment drives. Simulteneously the post graduate students shall have an opportunity to amend the set up and take it further for the artificially intelligent tasks for PLC programming. The application setup also has a unique feature that it could be interfaced with Pallatizer, which arranges the objects being conveyed with a systematic array. This enables the dissertation work to demonstrate how the independent components are interfaced and linked for the common objective of material handling. Some of the important features and control procedures are inherited from the selective research publications which are summarized as below.

Tsalidis et al. (1998) explained the design phases of belt-conveyor design. Design parameter, design task, design prototype, design state and design rule these are the five steps of designing a product. Yilrnaz et al (1999) configured PLC unit for fuzzy logic to synchronize the speed of two conveyor belts. Sum-min method is used for inference and Center of Gravity method is used for defuzzification. Experimentation is carried out to validate the simulation results. Vallance et al (2003) designed the split-groove kinematic coupling technique for locating the pallets in multi-station assembly systems. The split-groove kinematic couplings are more effective than three-groove couplings when geometric constraints are not feasible.

Xiaohui Cheng and Jie Wan (2013) states in paper that the supply speed of the coal and energy utilization rate of telescopic belt conveyor can be increased upto 150% by implementing PLC based conveyor system. Closed loop motor control system is designed by using frequency convertor. The system regulates the speed of motor along with the on-off control of conveyor power equipment. Kanmani et al. (2014) elaborates in a paper about the need of automation and proposes a SCADA and delta series PLC based automation system which is highly reliable and efficient in operation without delay. The parameters used for monitoring are tearing of belt conveyor, oil level reduction and temperature level of conveyor motor.

## II. PROBLEM STATEMENT

To design and fabricate the demonstrative setup of PLC based conveyor with optimized inputs/ouputs, with minimum two locations as InLoc and OutLoc, along with three intermediate programmable locations interlocked with respective timers, with overall conveyor length of 1 m, with a suitable control panel, with a feature button to interface this conveyer with palletizer.

The basic objective is to develop PLC based conveyor system having centralized control over five stations to minimize total time required for material handling using conveyor.

## III. LAYOUT OF THE SYSTEM

Layout of conveyor system can be classified in following sections:

*Pulley Mounting Sub-assembly*

*Drive and Driven Roller*

It is end portion of assembly. Flat-shaped pulley usedto maintain proper tangency in arrangement of belt drive. The pulley diameters are calculated in belt drive design. they should comply with standard values. There is a relationship between the width of belt and width of pulley,or to be more specific ,width of the rim of the pulley. Pulley's mounted on shaft. It is light duty application hence plastic manufactured pulley's are selected according to the dimensions.

One pulley on shaft carry the load of the belt whose axis is connected to the shaft of geared motor and another pulley is free to rotate along belt direction to give the support to system are called drive and driven roller respectively. Following figures (1) and (2) show drawings of (i) Drive roller and (ii) Driven roller respectively.

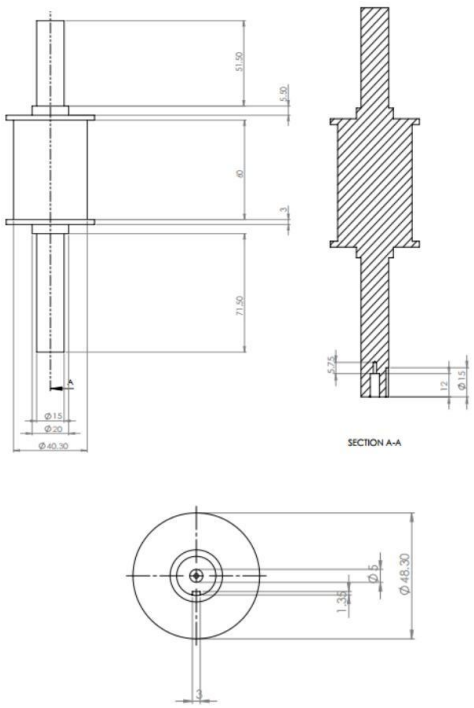


Figure 1: Drive roller

Mounting Bracket for Drive Roller, Mounting Clamp/Bracke for Driven Roller, Bearing Housing Motor Mounting Bracket:

System components such as motor drive and driven roller and bearings require a support that can help to position and lock at the position on the frame. Mountings and brackets are required such a that it can withstand the working forces of the system and maintain position of components.

Following are mounting and bracket designs and their regarding specifications that are uses in conveyor:

Motor bracket: Material: cast iron

Dimension: 40×118.25×3mm

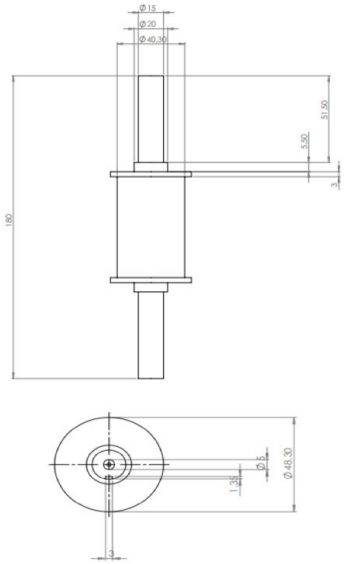

Figure 2: Drive roller

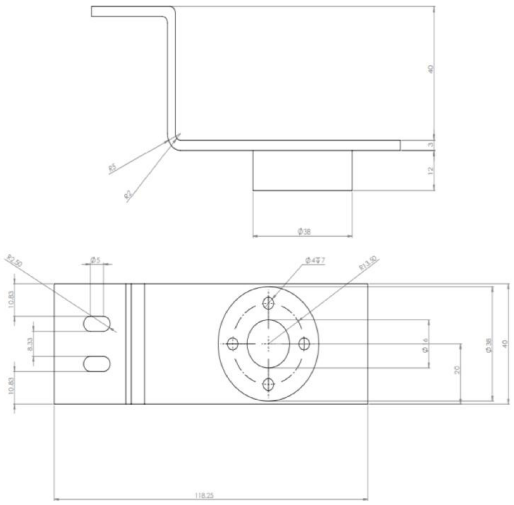

Figure 3: Motor bracket

Driven roller clamp: Material: mild steel

Dimension: 795×75×3mm

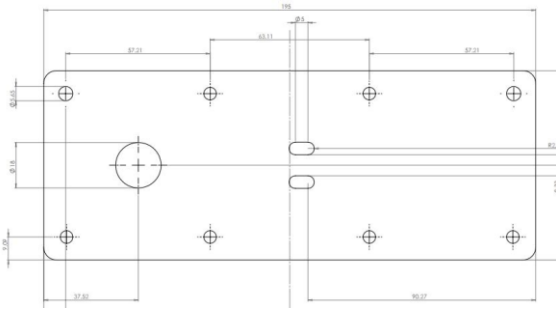

Figure 4: Motor bracket

*A. DC Motor:*

The DC motor used in this system. The DC motor used here is bidirectional in nature but it is restricted to unidirectional. Shaft of motor get engage with shaft of pulley with grub screw on flat surface of motor shaft. Rotation of shaft is completely depends upon rotation of motor direction. the motor is high speed rpm motor .The rpm of the motor is reduced to suitable range through geared box which increases its torque capacity .The geared box is integral part of dc motor assembly.It has reduction ratio for every step by 5. As per signals received from the controlling device motor will react accordingly. The motor used here having operating voltage range from 12V to 30V.

In the system motor is used to rotate only in single direction With given supply voltage of motor 24V. As per signal received from programming logic control unit motor will start to rotate or stop according to the signal.

Dimensions: 1050x120mm.

*B. Sensor Mounting Sub-assembly*

With Inloc and Outloc, also 3 intermediate positions inductive proximity sensors are provided which sense the actual presence of object location. It can sense up to range of 5mm. Due to its inductive property it sense any metallic component. It tells to controller to take further actions as soon as it senses the object.

Sensor mounting plates maintain the constant distance throughout length fromobject. Sensors are fixed to Inloc and Outloc as well as three work stations. Proximity sensor used here are PNP NO in nature. It has sensing range up to 5mm with total length of 35mm. Sensor mounting assembly has overall dimensions are 1050mm x 80mm.

Above all drawings shows detail drawings of manufactured parts of conveyor system. A complete assembly of model of a model for a conveyor system with most important components is shown in the drawing. In following table, all the important technical data listed in an overview.

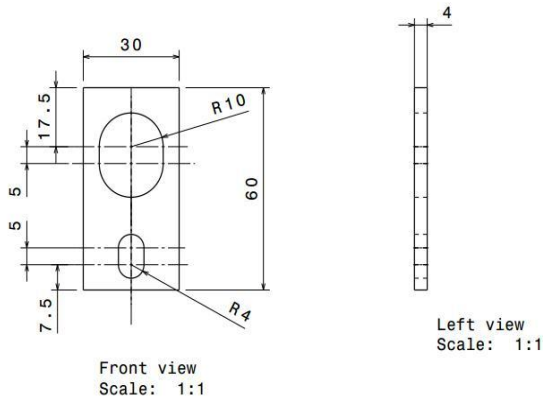


Figure 5: Sensor monitoring

The conveyor has following specifications:

Total Length : 780 mm
Total Width : 150 mm
Total Height : 200 mm
Driving Motor : SM1 Gearbox D.C. Motor
Proximity Sensor : M18 × 35mm, 5mm sensing distance
Power Supply : 24 Volt
Maximum Speed : 10 rpm
Weight of conveyor System : 15kg

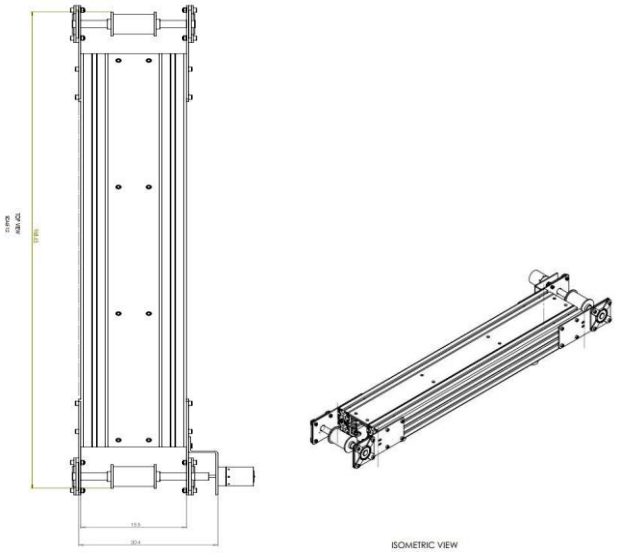


Figure 6: Conveyor final assembly

*C. Wiring and Control Panel:*

Control panel is required to batch controls at one location and monitor the process flow at particular stage. Consist of following components:

[1] Plastic Board: For the mounting of lamps and switches needs to cut profile for required mountings. Dimension of the board is 200×150×50mm.

[2] Switches: start button: 1× push to ON (NO)
18mm diameter switch
Stop button: 1× push to OFF (NC)
18mm diameter switch
Selector Switch: 1× 1Pole and 3
selector position 4mm diameter switch
Reset switch: 1× push to ON (NO)
18mm diameter switch

iii) Lamps: Process Lamp: 1× 24v 12mm
diameter Green Lamp
Emergency Stop Lamp: 1 × 24v 12
mm diameters Red Lamp
Object position indicators: 5 × 24v 12mm
diameter Green Lamp

***Wiring Layout*:**

The wiring is an important phase for installing a conveyor and configuring the sensors and actuators so they can all communicate with each other seamlessly. It is done scientifically to save time and money. The following figure gives more simplified idea about the wiring layout.

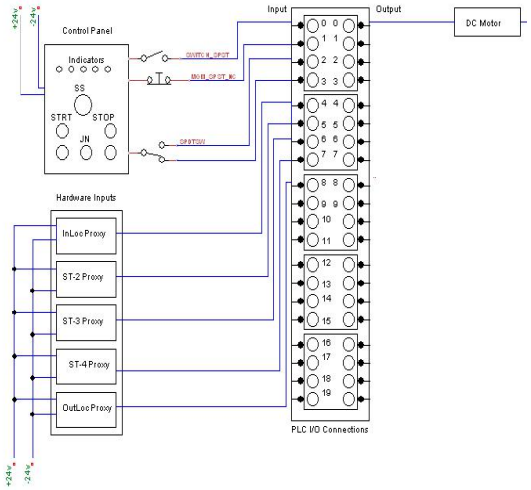


Figure 7: conveyor wiring layout

## V. PROGRAMMING

The main objective of this dissertation is to control motor motion at five stations including three intermediate working and two mandatory stations. This section quickly introduces the PLC Environments with respect to dissertation work carried out. It specifies requirement of the system and its working. This section gives overall working idea and its physical system. Developed logic in the system is in terms of ladder diagrams. All program and inputs of the system developed using Picosoft software in terms of ladder logic.

Following figures shows the algorithm / flow chart which is implemented in the system:

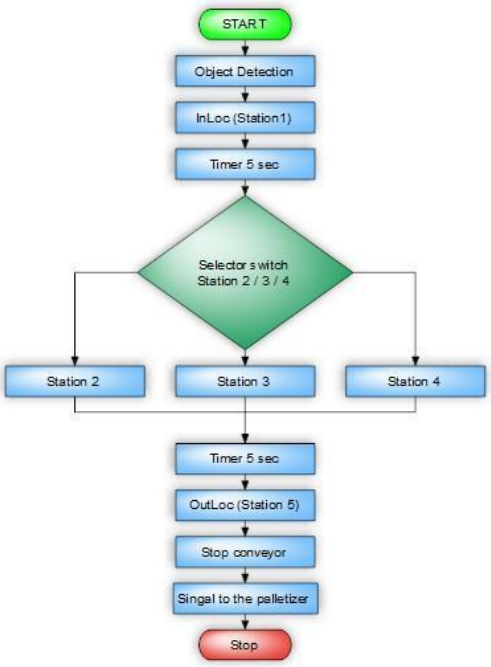


Figure 8: System flow chart

Following are demonstrative diagrams to understand the working of system at different position selection at selector switch.

### *A. Selector Switch at Station 2 (Work Station 1)*

When selector switch is at station 2 position i.e. selection for workstation 1, the object detection at InLoc station will occur and it will set timer of 5 sec for the demonstrative loading purpose and the it will move to station 2 i.e. workstation 1. After successful detection at workstation 1 it will skip station 3 and 4 and will go directly to OutLoc station.

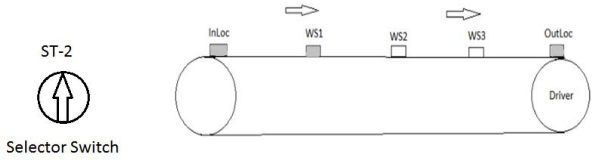


Figure 9: Selector switch at station 2 position

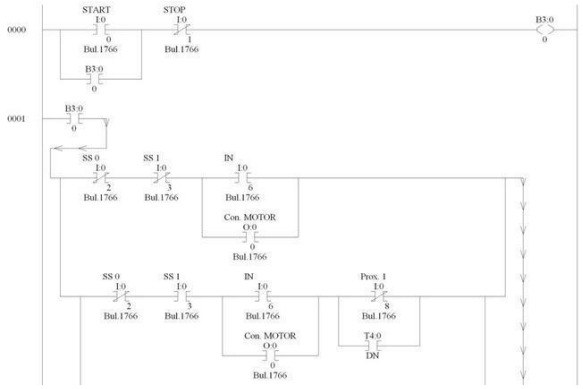


Figure 10: Logic Ladder for Work Station 1

### *B. Selector Switch at Station 3 (Work Station 2)*

When selector switch is at station 3 position i.e. selection for workstation 2, the object detection at InLoc station will occur and it will set timer of 5 sec for the demonstrative loading purpose and the it will move to station 3 i.e. workstation 2, skipping workstation 1. After successful detection at workstation 2 it will skip station 4 and will go directly to OutLoc station.

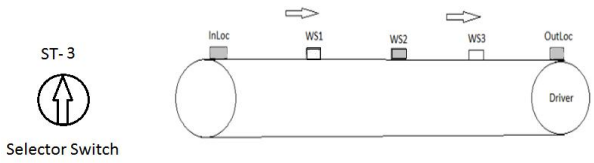


Figure 11: Selector switch at station 3 position

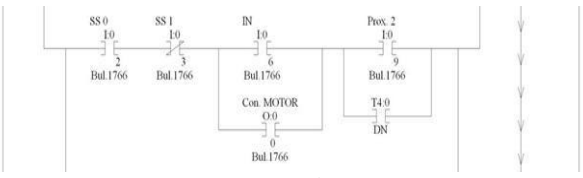


Figure 12: Logic Ladder for Work Station 2

C. *Selector Switch at Station 4 (Work Station 3)*

When selector switch is at station 4 position i.e. selection for workstation 3, the object detection at InLoc station will occur and it will set timer of 5 sec for the demonstrative loading purpose and the it will move to station 4 i.e.workstation 3, skipping workstation 1 and 2. After successful detection at workstation 3 it will go directly to OutLoc station.

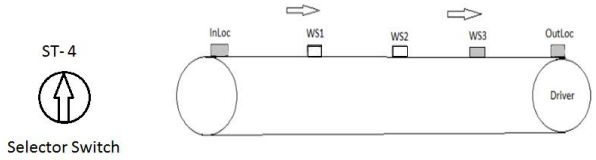


Figure 13: Selector switch at station 4 position

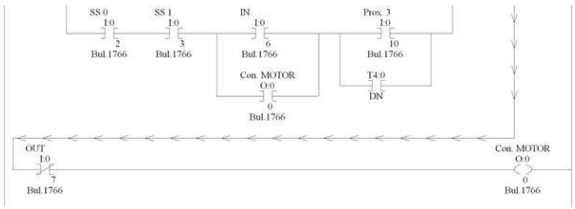


Figure 14: Logic Ladder for Work Station 3

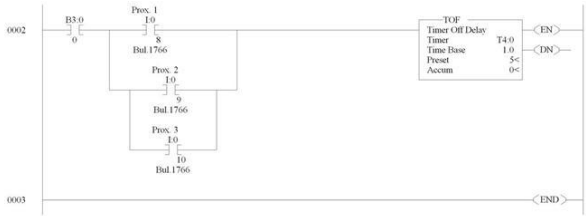


Figure 15: Logic Ladder Common Timer for workstations

D. *I/O Definition and Programming*

I/O definitions plays role of bridge between the plc and physical setup of the system. It allows to system program to communicate with switches, sensors as inputs and actuators as outputs. At first total inputs and outputs of system are identified.

TABLE I
INPUT DEFINITIONS OF SYSTEM

| Sr No | Input | Description | Address |
|---|---|---|---|
| 1 | Start | | |
| | Btn | Start switch | **I**:0.0/1 |
| 2 | Stop | | |
| | Btn | Emergency Stop | **I**:0.0/2 |
| 3 | SS 2 | Selector S/W Station 2 | **I**:0.0/3 |
| 4 | SS 3 | Selector S/W Station 3 | **I**:0.0/4 |
| 5 | SS 4 | Selector S/W Station 4 | **I**:0.0/5 |
| 6 | InLoc | InLoc Proximity Sensor | **I**:0.0/6 |
| 7 | | Station 2 Proximity | |
| | ST-2 | Sensor | **I**:0.0/7 |
| 8 | | Station 3 Proximity | |
| | ST-3 | Sensor | **I**:0.0/8 |
| 9 | | Station 4 Proximity | |
| | ST-4 | Sensor | **I**:0.0/9 |
| 10 | OutLoc | OurLoc Proximity Sensor | **I**:0.0/10 |
| 11 | | Reserved for Palletizer | **I**:0.0/11 |
| 12 | | Reserved for Palletizer | **I**:0.0/12 |
| 13 | | Reserved for Palletizer | **I**:0.0/13 |
| 14 | | Reserved for Palletizer | **I**:0.0/14 |
| 15 | | Reserved for Palletizer | **I**:0.0/15 |
| 16 | | Reserved for Palletizer | **I**:0.0/16 |
| 17 | | Reserved for Palletizer | **I**:0.0/17 |
| 18 | | Reserved for Palletizer | **I**:0.0/18 |

Once physical address is acquired we can start programming due to the wrong addressing. As shown in table bellow, purposefully physical blank addresses are kept in order to further connections of subsystem like conveyor.

RSlogix 500 software is used for the programming purpose which is capable of offline logic failure detection.

TABLE II
OUTPUT DEFINITIONS OF SYSTEM

| Sr. No. | Output | Description | Address |
|---|---|---|---|
| 1 | | Reserved for Palletizer | **O:**0.0/1 |
| 2 | | Reserved for Palletizer | **O:**0.0/2 |
| 3 | | Reserved for Palletizer | **O:**0.0/3 |
| 4 | | Reserved for Palletizer | **O:**0.0/4 |
| 5 | | Reserved for Palletizer | **O:**0.0/5 |
| 6 | | Reserved for Palletizer | **O:**0.0/6 |
| 7 | | Reserved for Palletizer | **O:**0.0/7 |
| 8 | Motor | DC Motor | **O:**0.0/8 |

## VI. CONCLUSION

The important deductions of the dissertation work are as follows:

(a) The PLC based Conveyor system with programmable locations, of 1 m span is ready in the laboratory for undergraduate and post graduate students.
(b) The installed control panel has start, stop, selector switch, reset switch and indicator lamps.
(c) The Conveyor has InLoc, OutLoc and 3 processing stations.
(d) Each intermediate location has a 5 sec timer to process the specified operation.
(e) The speed of conveyor is synchronized with palletizer.

System setup, wiring connections and programming is accomplished. Mentioned objectives are achieved.

In RSlogix 500 logic ladder and sensor inputs are checked and errors are eliminated. The system is ready for experimentation, bug fixings as well as upgrades.

## VII. FUTURE SCOPE

The conveyor object are picked by an at loading point of its path and are delivered to palletizing mechanism at unloading station this is entirely planned by PLC control in modular way this will not only expose the student to programming environment but also open an aspect of PLC program planning and execution and also operation plan to be introduced with RFID. The RFID identifier shall be fixed on the object to be stored on pallet racks and PLC

shall store the IDs and respective location the IDs shall be categorized so that similar group shall be stored nearby.

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