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Research Article

CONVEYOR CONTROL AND SORTING MODULE CONTROLLED BY PROGRAMMABLE LOGIC CONTROLLER

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ABSTRACT
This paper investigates a conveyor sorting module controlled by programmable logic controller (PLC). Conveyer Sorting Plant module is a full fledged working model of a typical Industrial conveyer plant. It has all the necessary components required for a conveyer sorting. All the necessary control input and outputs are brought out to the front panel to a 4mm sockets. The solenoid valves operate for 24V DC. Infra Red sensors takes 24V DC as input and gives out 24V output when sensed. DC motor run at 12V DC to switch the motors on two relays are used. The Conveyer Sorting system has all the hardware mounted but the system needs a controller to control the process. The controller can be either a PLC, or a microcontroller or a PC based software controller. The control logic for the controller will remain same for any control system. But this paper deals with a conveyer sorting plant controlled by PLC.

Keywords: *Conveyor, PLC, Sensors, DC Geared Motor, IR Sensors, Pneumatic Cylinder, Solenoid Valves*

INTRODUCTION
The process consists of a belt conveyer driven by a small DC geared motor. The belt conveyers are mounted in such a way that the object mounted on the first conveyer will fall on the second conveyer. To sense the object five Infra-Red (IR) sensors are mounted at various points. To the end of the second conveyer a sorting tray with pneumatic actuators is mounted. The object can be sorted based on the height or length to Right or Middle or Left bin. The sorting tray is divided into three paths, Right, Middle and Left. Two wipers are fitted which are actuated by pneumatic cylinders. The Pneumatic cylinders are controlled by solenoid valves. All the inputs and outputs are connected to 4mm sockets through which the whole system can be controlled using PLC or Micro-controller. The system requires 15PSI air pressure to operate. The regulator is provided to adjust 15PSI from air pressure coming from the compressor. The movement of the wipers is controlled using double acting cylinders. These cylinder are controlled using 5/2 solenoid valves. The valves can be actuated using PLC.

MATERIALS AND METHODS
IR Sensors
An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. Infrared waves are not visible to the human eye. In the electromagnetic spectrum, infrared radiation is the region having wavelengths longer than visible light wavelengths, but shorter than microwaves. The infrared region is approximately demarcated from 0.75 to 1000µm. The wavelength region from 0.75 to 3µm is termed as near infrared, the region from 3 to 6µm is termed mid-infrared, and the region higher than 6µm is termed as far infrared (Dwivedi *et.al* 2012). The type of IR sensor used is Quantum infrared sensors. These provide higher detection performance and faster response speed. Their photo sensitivity is dependent on wavelength. Quantum detectors have to be cooled so as to obtain accurate measurements. The only exception is for

detectors that are used in the near infrared region. A typical system for detecting infrared radiation using infrared sensors includes the infrared source such as blackbody radiators, tungsten lamps, and silicon carbide. In case of active IR sensors, the sources are infrared lasers and LEDs of specific IR wavelengths. Next is the transmission medium used for infrared transmission, which includes vacuum, the atmosphere, and optical fibers. Thirdly, optical components such as optical lenses made from quartz, CaF_2, Ge and Si, polyethylene Fresnel lenses, and Al or Au mirrors, are used to converge or focus infrared radiation. Likewise, to limit spectral response, band-pass filters are ideal (Marshall *et al.*,1995). Finally, the infrared detector completes the system for detecting infrared radiation. The output from the detector is usually very small, and hence pre-amplifiers coupled with circuitry are added to further process the received signals.

Specification of Conveyor Control and Sorting Module

INPUTS	:	DC motor 2No., Solenoid valves 2No., Cycle ON LED,
OUTPUTS	:	5 IR sensors, Cycle On switch,
SENSORS		
OBJECT SENSE	:	INFRA RED SENSOR
CONVEYOR	:	Belt conveyer
PRIME MOVER	:	DC Geared motor
SORTING	:	Double acting Pneumatic Cylinder -2 Nos. Stroke : 25mm , 5/2 Solenoid valve 2 No. 24V operated Regulator with Dial Gauge provided
AIR SUPPLY	:	30 to 50 PSI
CONNECTION	:	Via 4mm Patch card Terminal 0r D type sub plugs quick connection to PLC base plate
MEASUREMENTS	:	800 x 450 x 500 (L x B x H mm) approx.
POWER SUPPLY	:	24V DC at 1A (inbuilt)

Working Details

Two DC motors are used as prime movers to drive the belt conveyor. 5 IR sensors (IR1 to IR5) are used sensing the object on the conveyor. Two IR sensors are used to sense the object placed on the conveyor belt. IR1 is placed at the loading end and IR2 at the sorting end. 2 IR sensors (IR3 and IR4) are mounted in the centre place of the conveyor one over the other. These 2 sensors are used to differentiate the heights of the objects moving on the conveyor belt. IR5 sensor is mounted at the end to sense whether the object is moved out of the conveyor for sorting. Sorting tray is divided in to three ways. The objects based on the size are sorted and moved towards right, centre and left by means of wipers. These wipers are controlled by the solenoid valves. The wipers are mounted to the 2 pneumatic cylinders which are driven by the 2 solenoid valves.

Programmable Logic Controller

The Programmable logic controller used is ABB Model AC500eco series. Basic units 500eco offer ample configuration range. Each basic unit incorporates a specific number of binary inputs/outputs. It is possible, depending on the basic unit, to increase the number of inputs /outputs, to add as 6 extensions connected directly to the basic units or remote input / output units via the CS 31 twisted pair. 110 binary inputs/ outputs or 48 analog inputs / outputs for series 40 basic unit or remote unit can be configured. The PLC used has 8 inputs and 6 outputs (Transistor type). The PLC is configured for 128 KB of user program memory and 10KB of Data memory. It uses PS501 control builder as programming software. The execution time for 1000 instruction for a binary word is 0.3ms and for floating point is 0.6ms (Sowmiya, 2013).

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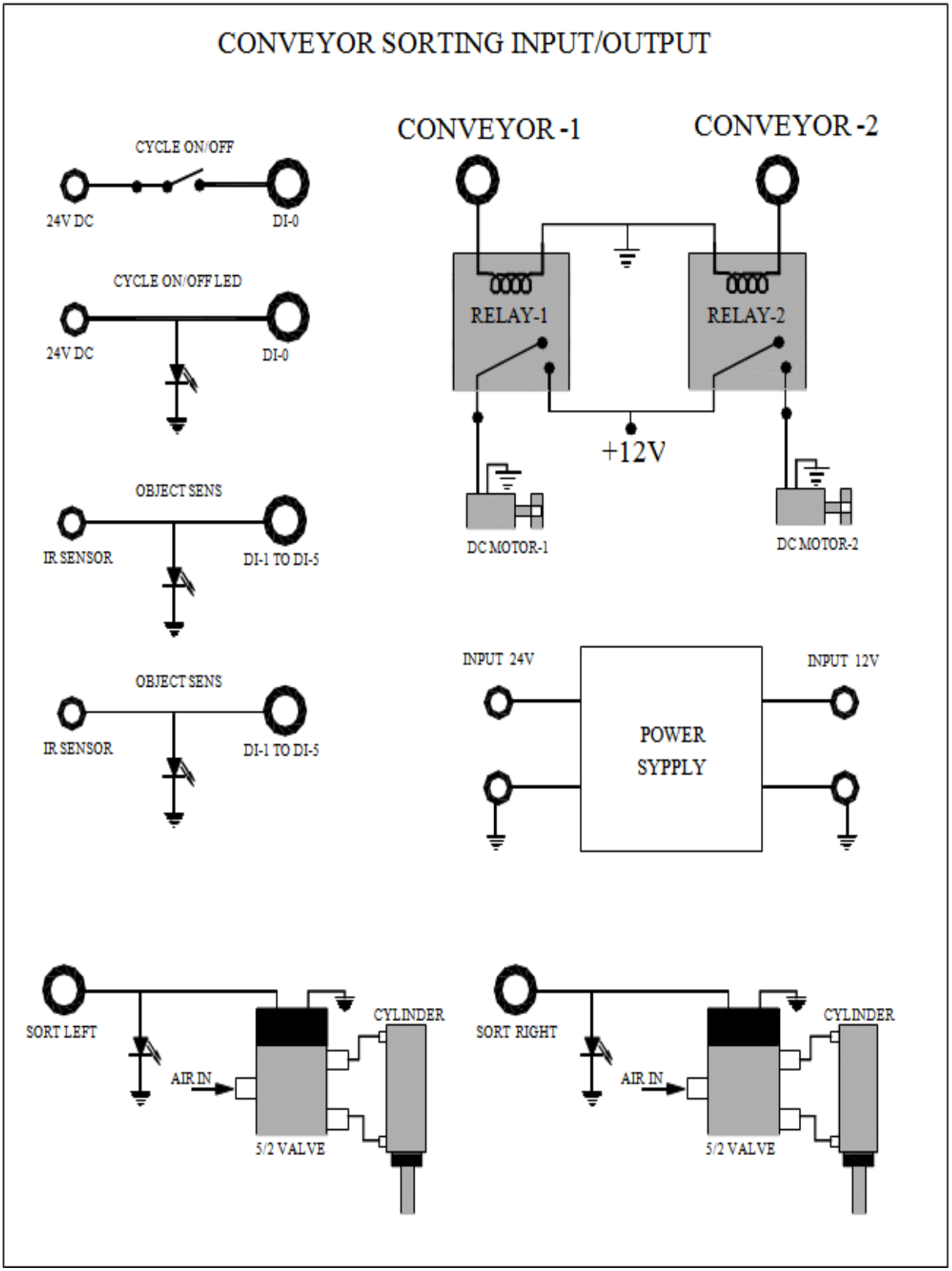
Connection Circuit



Connection Details between Working Model to PLC

Each working model requires Digital input and Digital output. In the Main Panel of PLC the digital I/O's are brought out to the panels and clearly designated for Eg. Digital Input as DI-0, DI-1, DI-2, DI-3, DI-4……..DI-11. Digital Output as DO-0, DO-1, DO-2, DO-3, DO-4……DO-9. On all the working models required input and output are brought out to the terminals and designated accordingly (Sreesha *et al.,* 2013). Match the inputs to inputs and outputs to outputs.

Table

Sl. No.	Particulars (Connections)	Input / Output devices	Notation on DI/O
1	Cycle ON/OFF	Toggle switch	DI - 0
2	Sense Object - 1	Infra red sensor	DI – 1
3	Sense Object - 2	Infra red sensor	DI – 2
4	Sense Height - 1	Infra red sensor	DI – 3
5	Sense Height - 2	Infra red sensor	DI – 4
6	Sense Object - 3	Infra red sensor	DI – 5
7	Cycle on LED	LED	DO – 0
8	Conveyor – 1 ON	Relay/ DC Motor	DO – 1
9	Conveyor – 2 ON	Relay/ DC Motor	DO – 2
10	Sort - L	Solenoid Valve	DO – 3
11	Sort - R	Solenoid Valve	DO – 4

Algorithm

STEP – 1: Cycle starts if DI-0 goes high. Digital output DO-0 is on to glow the Power on LED. Object loaded on the conveyer-1 is sensed using object sensor -1 (DI-1). If DI-1 goes high then the object is loaded on the Conveyer-1.

STEP – 2: Conveyer-1 is started by making CONVEYER-1 ON (DO-1) high. The relay-1 is switched and the Conveyer-1 starts moving long with the object loaded.

STEP – 3: Object will be loaded on to the conveyer-2. It is sensed by object sensor-2 (DI-2). Once the object sensor DI-2 goes high, stop conveyer-1 by making DO-1 low and start Conveyer-2 by making conveyer-2 ON (DO-2) high. This will switch the Relay-2 and the Conveyer-2 will start moving.

STEP – 4: As the object keeps moving sense the height of the object using object Hohigh-1 (DI-2) and 2 (DI-3) sensors. - If both the sensors are not sensed then the object is small.

If the Object Height-1 (DI-2) is sensed then the object is medium.

If both Object Height-1(DI-2) and Object Height-2 (DI-3) goes high at a time then the Object is big.

STEP – 5: Once the object height is sensed then accordingly objects are sorted by switching on Sort-L Solenoid (DO-2) or Sort-R Solenoid (DO-3). After Object sensor-3 (DI-4) senses stop the Conveyer -2 by switching DO-3 Low after a time delay

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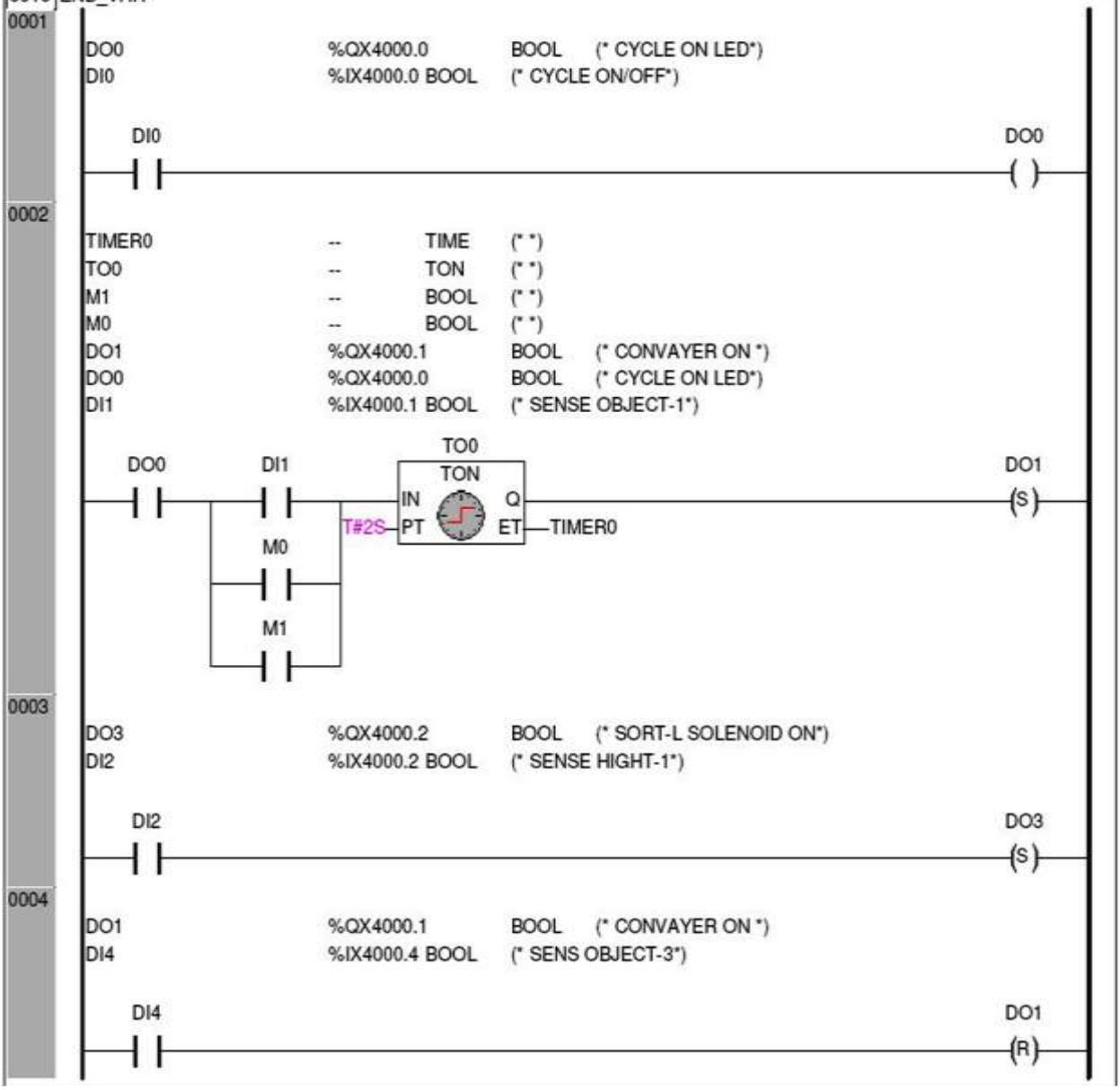
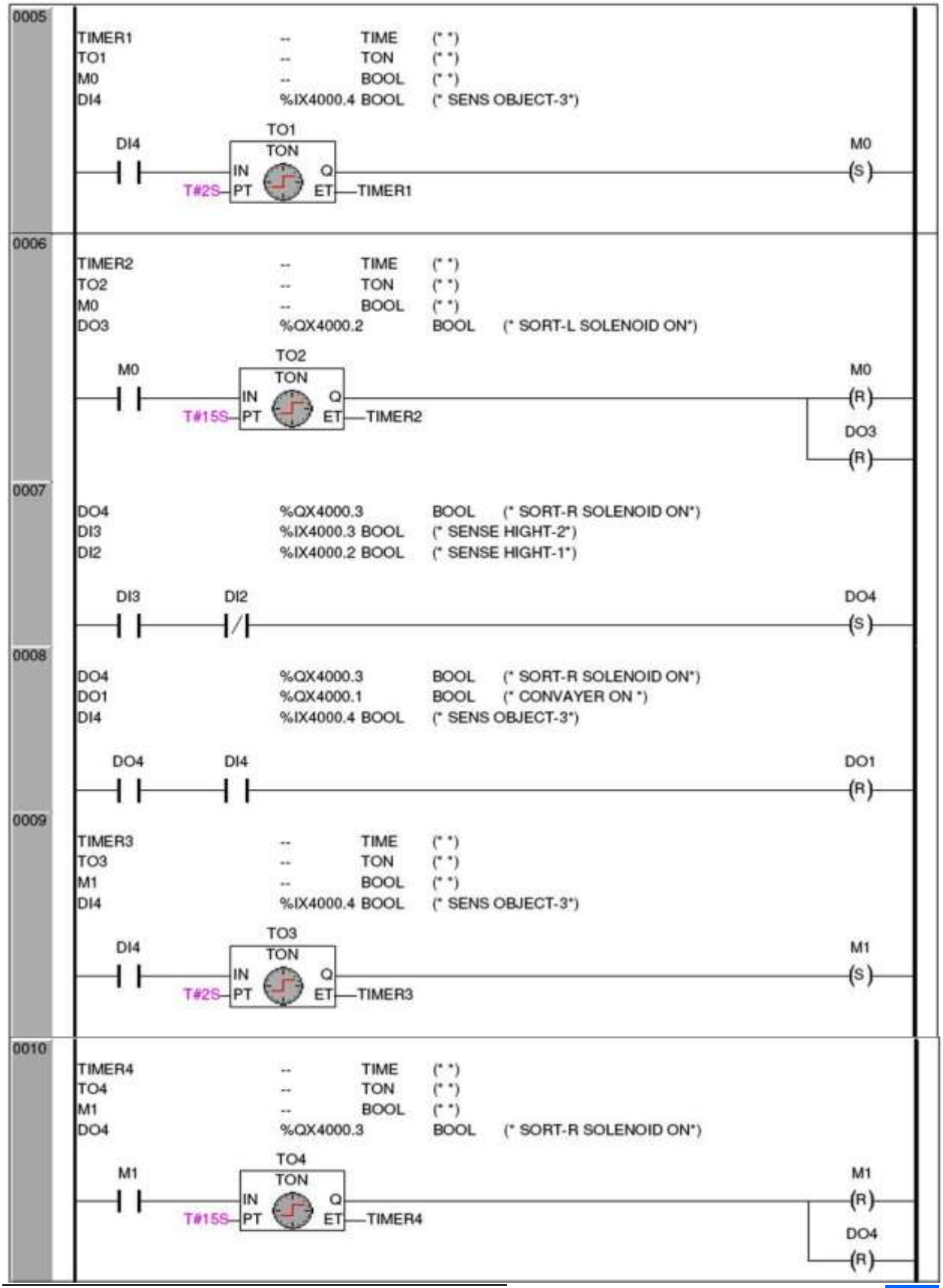
Program

```
0001 PROGRAM PLC_PRG
0002 VAR
0003     TO0: TON;
0004     TIMER0: TIME;
0005     TO1: TON;
0006     TIMER1: TIME;
0007     M0: BOOL;
0008     TOF3: TOF;
0009     TIMER3: TIME;
0010     TO2: TON;
0011     TIMER2: TIME;
0012     TO3: TON;
0013     M1: BOOL;
0014     TO4: TON;
0015     TIMER4: TIME;
0016 END_VAR
```





RESULTS AND DISCUSSION

The designed conveyor sorting module can be used for different logics that can be applied in conveyer sorting

✓To sense the object and sort the small one to Right bin, Large one to middle bin and Medium one to center bin.

✓To sense the object only the medium size object to center or left or right bin and if small or big object is sensed stop conveyer-2 immediately and blink Cycle on LED DO-0 at interval. Once the object is removed from the conveyer, stop blinking and wait to accept the Object loading again.

✓To sort only Small and Medium height Object so that once the big object is sensed stop the conveyer.

✓To sort the Small object 4 nos, Medium object 4 nos. and Big object 4 no. to the bin and stop sensing till reset button is sensed.

✓To sort the objects in ascending order according to the size and stop the conveyer if the sequence is wrong.

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