International Journal of Electrical Engineering.
ISSN 0974-2158 Volume 7, Number 1 (2014), pp. 83-90

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Automated Storage and Retrieval System of Raw Materials Using PLC and SCADA

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Abstract

An Automated Storage and Retrieval System (ASRS) automatically stores and retrieves raw materials as well as finished goods. In this paper a storage system which is dynamic is studied as well as developed by BHEL industries. Because of increasing demand, the industry is facing a rise in complexity of the supply system. To cope with this problem, companies use automated storage and retrieval systems. There has been a transition from human based forklift applications to fast and safe ASRS applications in firm's warehouse systems. This system consists of Aisles, Stacker crane, Storage racks, Pallets etc. To make it automatic the system is integrated with Programmable Logic Controller (PLC). It is an interface between a PLC based system controller and PLC based stacker crane controller. The PLC controls and coordinates the movement and performance of ASRS. In this paper, the design, operation and advantages of new mechanism are presented. This system's implementation is simulated using SCADA.

Keywords: Programmable Logic Controller, Supervisory Control and Data Acquisition, Pick and Deposit platform, Movable Elevator Setup, Storage or retrieval machine.

I. INTRODUCTION

An ASRS provides an appropriate design for the warehouse and material handling systems. The goal of the industry is to move the containers as quickly as possible and at the least possible cost. An ASRS is proposed for automatically shifting loads from specific storage locations which is supported with number of computer techniques. It

allows the load to be shifted quickly, safely and precisely within a warehouse environment. Typically an ASRS consists of several parallel aisles with storage racks, storage and retrieval machine, storage bins, input/output locations, delivery platform and accumulating conveyors [1]. The stacker crane is usually a twin column mobile structure. This stacker crane or S/R machine picks up the load from a station and stores in a location when input is given and also takes the load out from the racks that are they can place or retrieve loads. The crane is integrated with PLC controller. This crane controller is connected to several sensors and limit switches to get physical inputs and is programmed in the PLC. The crane moves alongside the aisle, and it is equipped with a fork which is used to lift the pallets or bins. These bins are stored in the racks for effective utilization of vertical space. The racks are free standing and rigid enough for bearing the load. The weight of the bin along with the materials in it should not exceed the safety working load that is in BHEL industry the crane can withstand 2 metric ton capacity (2000 Kgs). In industrial application AC motors are installed for movement of crane operation, that is dual speed motors for up, down, forward and reverse motion. The end limits of travel in all the axes of movement are detected by heavy duty Limit switches. On reaching any one of such limits, power flow to all the motors is cut off, and the crane stops instantaneously. Unless the sensor gives a signal indicating presence of bin in the P&D platform the system will not accept a store request and will display a warning message on the screen. This similar operation occurs until a bin is detected in the rack for retrieval operation. Main advantages of ASRS are efficient utilization of warehouse space, reduction in damage and loss of goods, increased control upon storage and retrieval of goods and decrease in number of warehouse workers. In this paper the process is controlled using PLC (Programmable Logic Controller) and is monitored using SCADA (Supervisory Control and Data Acquisition).

From the literature, it was clear that the existing Warehouse Management System (WMS), which is a non-intelligent machine and can be operated manually [1]. The system proposed employing of colored petri nets and RF based ASRS and wireless communication [2]–[4]. It occupies manpower and introduces the travel time consumption and sample barcodes have been used in inventory control and for manufacturing of assembly lines [5]-[8]. Design and fabrication techniques for cost effective system [9]

The rest of this paper is organized as follows: Section II describes the proposed ASRS system; while section III explains block diagram. Section IV then details the circuit diagram. Section V gives the simulation results. Section VI gives the result and discussion. Section VII outlines our conclusion.

II. PROPOSED SYSTEM

In our paper we have proposed a small scale system for automatically storing and retrieving of materials in the storage chambers.

The chamber consists of two rows and three columns with IR pairs fixed to its inner wall.

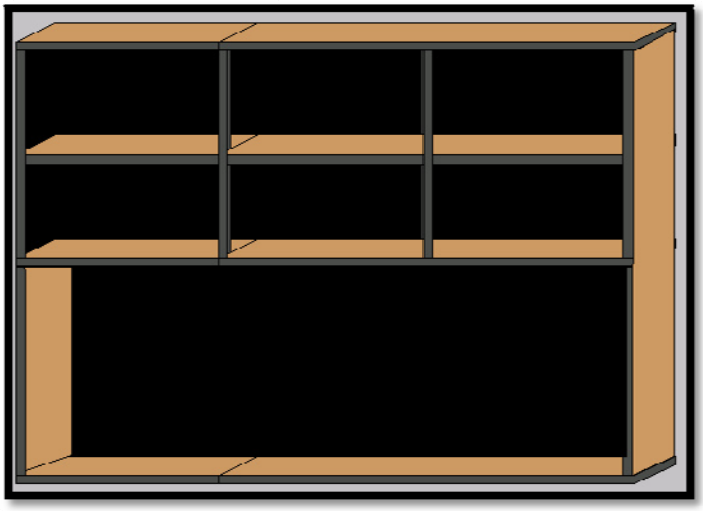


Fig 1: Storage chambers

a) Design of MES

This figure 2 shows the design of the elevator setup which moves in X, Y and Z axes, that is in Horizontal and Vertical directions. At the end of the Z-axis plate an electromagnet is fixed for it to attract the metal piece attached in the bin. Once power supply is cut the electromagnet gets deactivated.

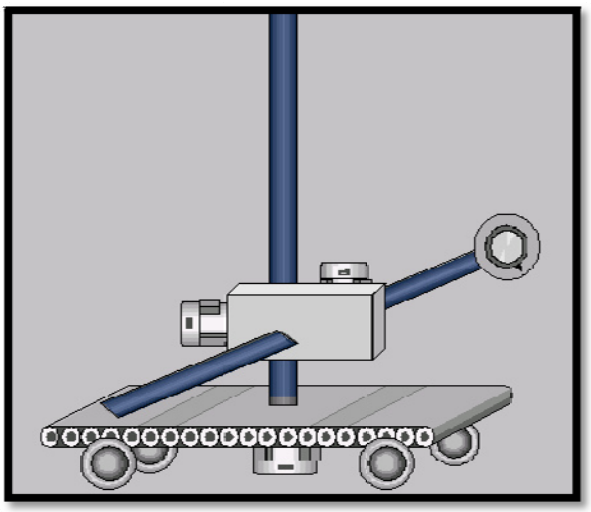


Fig 2: Movable Elevator setup

b) SCADA Design

SCADA screen is developed using Wonderware Intouch software used to give input for the respective operation. The AUTO and START should be in on status before selecting the chamber status. For loading operation the LED glows green in chamber status. And for unloading operation storage chamber's LED glows green.

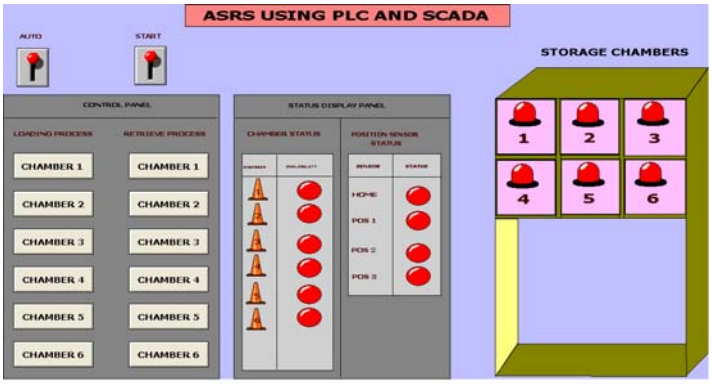


Fig 3: SCADA Screen Designed to Operate ASRS Automatically

III. BLOCK DIAGRAM

The block consists of power supply, IR pair, ULN circuit, relays and PLC. The IR pair sends the signal to the ULN circuit and this ULN activates the relays by giving negative voltage. The relay operates with 24V DC from the PLC. The digital inputs from PLC operate the Movable Elevator Setup (MES) and helps in storing or retrieving the materials in the storage chamber. This MES or Elevator Conveyor Setup moves in three axes. The triaxial motion is X-axis, Y-axis and Z-axis. After every storage or retrieval operation the elevator setup comes to homing position [7].

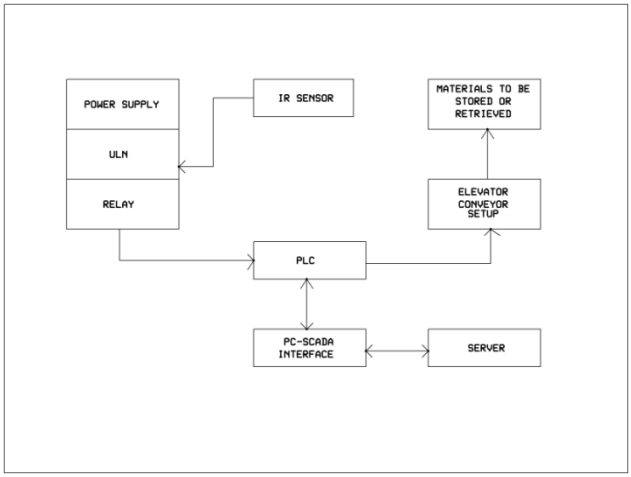


Fig 4: Basic Block Diagram for ASRS

IV. CIRCUIT DIAGRAM

The circuit diagram consists of power supply and programming part. It contains a step down transformer, bridge rectifier, IR pair, ULN circuit, relays and PLC. In the power supply circuit 230 volt 50 Hz AC supply is given to the transformer which acts as a step down transformer. This stepped down AC voltage is given to bridge rectifier

which is converted into DC voltage. The bridge rectifier used here is made of four 1N4007 diodes. Here we use a 1000uf capacitor for filtering the distortions in the converted DC voltage. The PLC operates in unregulated DC supply. This DC supply is given to the IR pair [4].

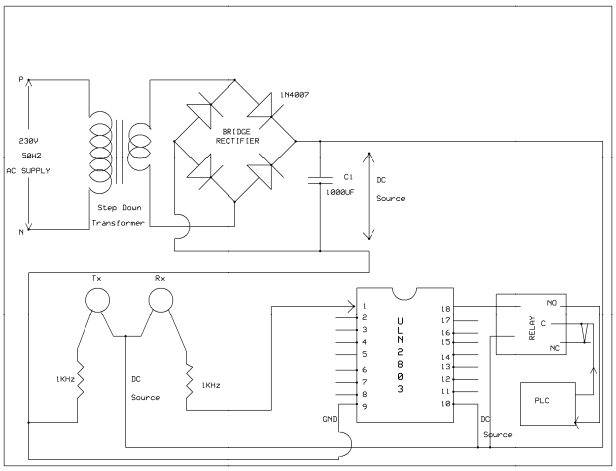
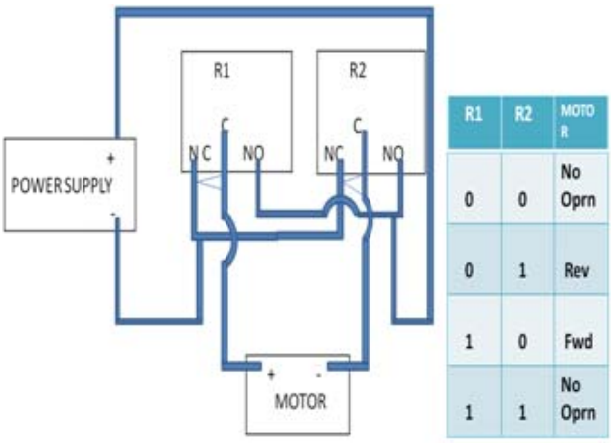


Fig 5: Circuit Diagram of Power supply and Programming part

IR pair consists of a transmitter and a receiver which is protected by means of resistors. IR pair is connected to the ULN circuit and this is connected to the relays and further to PLC. Whenever the IR pair will sense an object it sends signal to the ULN circuit. The ULN is an IC chip which will be acting as a NOT operation. Therefore a negative supply is given to the relay which activates it. Normally the common terminal of the relay will be in contact with normally closed terminal. Whenever the relay gets activated by the negative supply the common terminal comes in contact with the normally open terminal. Thus the relay operates and it transmits the signals to the PLC. Hence the operation is performed.



R1	R2	MOTOR
0	0	No Oprn
0	1	Rev
1	0	Fwd
1	1	No Oprn

Fig 6: Motor operation and its truth table

The motor operation is performed using PLC and relays. Triaxial operation is performed here that is, here we use four DC gear motors to perform the operation [1]. Here we have two relays for each axis. If we consider the X axis operation, common terminal of R1 is connected to the positive terminal of the motor and common terminal of R2 is connected to negative of the motor. The NC terminals of both relays are short circuited and the NO terminals are also short circuited. The positive terminal of the power supply from the PLC is given to the NO of the relay and the negative terminal of the power supply is given to the NC of the relay.

TRUTH TABLE OPERATION

When 0 and 0 or 1 and 1 is given to both the relays there will not be any operation performed as the common terminal will be in contact with normally closed terminal.

When 0 is given to R1 and 1 is given to R2, the common terminal of R2 will come in contact to normally open terminal and since the common terminal is connected to negative of the motor, the motor will rotate in reverse direction.

When 1 is given to R1 and 0 is given to R2, the common terminal of R1 will come in contact to normally open terminal and since the common terminal is connected to positive of the motor, the motor will rotate in forward direction.

Likewise the same operation is done for Y axis and Z axis.

V. SIMULATION RESULTS:

a) Loading

This ladder logic programming for PLC is done in the software, CX programmer. Figure 7 shows the logic before feeding the input in the SCADA screen. Here the SCADA_START, SCADA_AUTO and SCADA_C1 are not activated.

Figure 8 shows the activation of SCADA_START, AUTO and C1. This gets activated once when the input is given in the SCADA screen. Now the crane is being operated automatically. Here Timers are added just to give a delay for each operation.

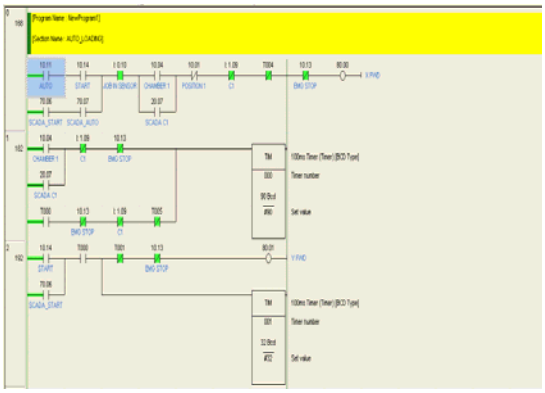


Fig 7: Chamber 1 Loading before Auto is activated

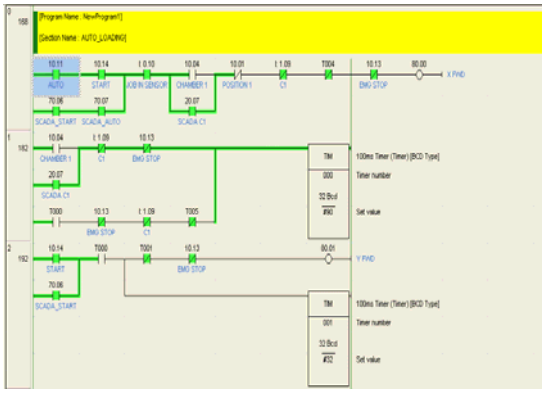


Fig 8: Chamber 1 Loading after Auto is activated

b) Unloading

Just like loading operation figure 9 shows the status of the logic before input command is fed by the server.

In figure 10 the switches get activated which is represented in green as the server enter the input in SCADA screen and the elevator setup operates and retrieves the bin from the chamber.

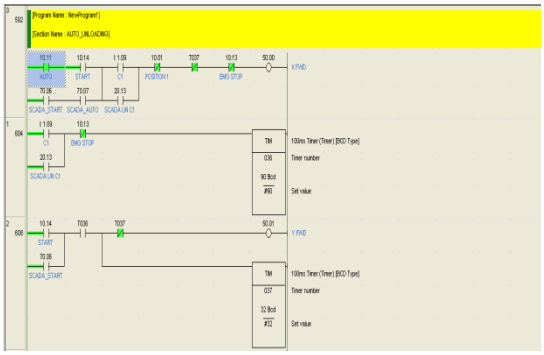


Fig 9: Unloading of chamber 1 before activation of Auto

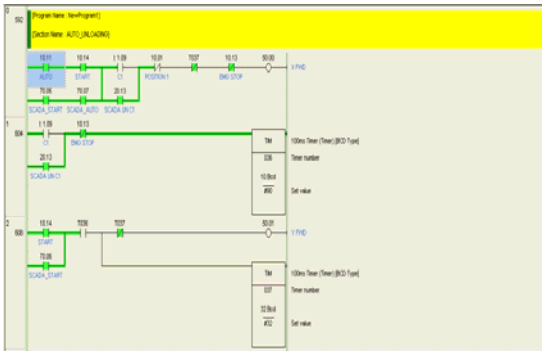


Fig 10: Unloading of chamber 1 after auto is activated

VI. RESULTS AND DISCUSSION

In figure 11, the hardware assembly is represented. The power supply used here is unregulated. The supply is given to ULN 2803 and it is connected to relays. Since only eight outputs can be taken from one ULN, here we are using two ULN chip board as we are using 11 relays.

This elevator conveyor setup is nothing but the Movable Elevator Setup which moves in triaxial direction. This is the crane which moves in X-axis, Y-axis and Z-axis. The operation goes in the sequence like,

X fwd → Y fwd → Z fwd → Z rev → Y rev → X rev

Fig 11: Hardware setup of ASRS

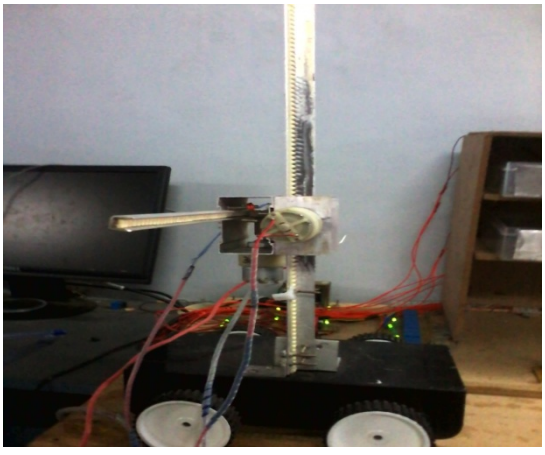


Fig 12: Developed Elevator setup

VII. CONCLUSION

Automated warehouses are very expensive and should therefore be carefully designed. The proposed system provides the industrial and manufacturing environment with automated operation. So that production can be increased with decreasing the time of selecting an appropriate material. Also the accuracy of the material and expensive damages can be avoided. Hence the system is expected to provide flexibility and secure environment.

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