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Automatic Control of Electrical overhead Smart Trolley Crane AEOSTC Based Programmable Logic Controller (PLC)

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ABSTRACT: *This paper describes the automatic control of electrical overhead smarttrolley craneAEOSTC. An overhead travelling crane, also known as a bridge crane, is a type of crane where the hook-and-line mechanism runs along a horizontal beam that it runs along two widely separated rails. The advantage of the box girder type configuration results in a system that has a lower deadweight yet a stronger overall system integrity. Also included would be a hoist to lift the items, the bridge, which spans the area covered by the crane, and a trolley to move along the bridge. The operation of overhead travelling crane is completely controlled by using Programmable Logic Controller (PLC) which is used for automation of real-world processes, such as control of machinery on factory assembly lines. The system sequence of operation is designed by ladder diagram and PLC programming software. In this paper, we are using sensors that are used to sense the overhead travelling crane motion. By implementing this paper, man power can be decreased and the production of the industry can be increased. Finally forefficient operation, an induction motor with DC in industrial applications. The relay logic in AEOSTC control is implemented using PLC . The model sequence of operation is designed by ladder diagram and PLC programming software WPL for DELTA company . In this paper , using magnetic sensors that are used to sense the overhead travelling crane AEOSTC motion and supplied by 220 AC and DC 12 V.*

Keywords: *PLC based overhead crane, Overhead Travelling Crane Automation, Programmable Logic Controller (PLC), magnetic Sensors.*

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I. INTRODUCTION

A crane is the type of machine mainly used for handling heavy loads in different industry branches: metallurgy, paper and cement industry. By the construction, cranes are divided into overhead cranes and gantry cranes. Overhead and gantry cranes are typically used for moving containers, loading trucks or material storage. This crane AEOSTC type usually consists of three separate motions for transporting material. The first motion is the hoist, which raises and lowers the material. The second is the trolley (cross travel), which allows the hoist to be positioned directly above the material for placement. The third is the gantry or bridge motion (long travel), which allows the entire crane to be moved along the working area[1]. Electrical technology for EOSTC crane control has undergone a significant change during the last few decades. The shift fromThe standard crane comprises a welded steel frame, liberally rated crane-type motors, high-carbon steel gears, precision ball bearings, oil-sealed gear-boxes, robust electro-mechanism brake, automatic over winding prevention and centralized lubrication. In this paper, Programmable Logic Controller (PLC) is used to control the overhead travelling crane movements. This paper mainly presents the programming and operation of an Overhead Travelling Crane in Automobile Production Factory. It can pick up the container which included an automobile to a desired place. PLC can control operation sequence of a large system surveying special module such as link, analog and position control. The controlled program is developed by using ladder diagram and necessary mnemonics codes are also provided [1-5][9].

Ward Leonard system to DC drive technology and the advent of powerful Insulated Gate Bipolar Transistors (IGBTs) during the 1990s enabled the introduction of the AC drive [2]. The standard crane comprises a welded steel frame, liberally rated crane-type motors, high-carbon steel gears, precision ball bearings, oil-sealed gear-boxes, robust electro-mechanism brake, automatic over winding prevention and centralized lubrication. In this paper, Programmable Logic Controller (PLC) is used to control the overhead travelling crane movements. This paper mainly presents the programming and operation of an Overhead Travelling AEOSTC Crane in Automobile Production Factory. It can pick up the container which included an automobile to a desired place. PLC can control operation sequence of a large system surveying special module such as link, analog and position control. The controlled program is developed by using ladder diagram andnecessary mnemonics codes are also provided[3].

II. WHAT IS PLC?

A Programmable Logic Controller is a solid state control system that continuously monitors the status of devices connected as inputs. Based upon a user written program, stored in memory, it controls the status of devices connected as outputs.

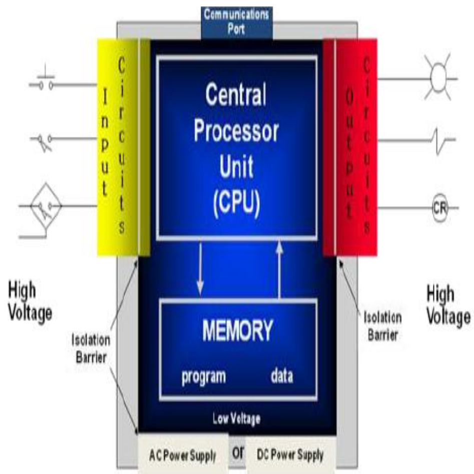


Figure 1. Inside a PLC.

A. Operating cycle of PLC

There are four steps in PLC operations. They are (1) Input scan, (2) Program scan, (3) Output scan, and (4) Housekeeping.
1. Input scan- scan the state of the inputs
2. Program scan- processes the program logic
3. Output scan- energize/de-energize the outputs
4. Housekeeping- this step includes communication, internal diagnostics, etc.
These steps are continuously repeated and processed in a loop.

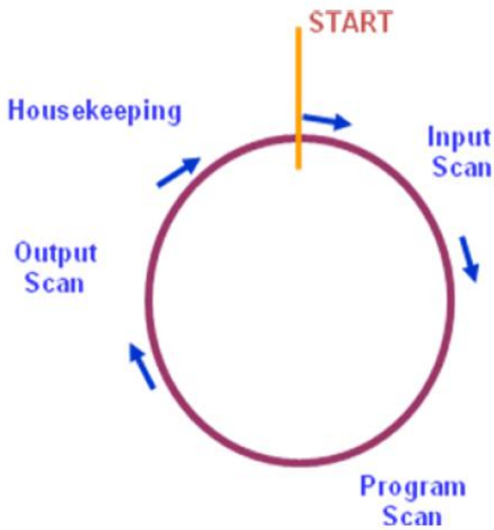


Figure 2. Operating cycle of PLC.

B. Advantages of Programmable Logic Controller(PLC)

Flexibility; In the past, each different electronically controlled production machine required its own controller. Now just one model of a PLC can easily run many machines. Each of the 15 machines under PLC control would have its own distinct program. Implementing Changes and Correcting Errors; A PLC program circuit or sequence can be changed in a matter of minutes. Also, if a programmable error has to be corrected in a PLC control ladder diagram, a change can be done in quickly. Large Quantities of Contacts; The PLC has a large number of contacts for each coil available in its programming.

Lower Cost; Improved technology makes it possible to pact more functions into smaller and less expensive packages.

Pilot Running; A PLC programmed circuit can be pre-run and evaluated in the office or lab. The program can be typed in, tested, observed, and modified if needed, saving valuable factory floor, which can be very time-consuming.

Visual Observation; A PLC circuit's operation can be seen during operation directly on a CRT screen.

Speed of Operation; The speed for the PLC logic operation is determined by time, which is a matter of milliseconds.

Ladder or Boolean Programming Method; The PLC programming can be accomplished in the ladder mode by an election or technician.

Reliability; The PLC is made up of solid state electronic components with high reliability rates.

Documentation; An immediate printout of the true PLC circuit is available in minutes, if required.

Simplicity of Ordering Control System Components; A PLC is one device with one delivery date. When the PLC arrives, all the counters, relays, and other components also arrive.

Security; A PLC program change cannot be made unless the PLC is properly unlocked and programmed.

Ease of Change by Reprogramming; Since the PLC can be reprogrammed quickly, mixed production processing can be accomplished.

C. Disadvantages of Programmable Logic Controller (PLC)

Fixed Program Applications; some applications are single-function applications in the use of drum controller/sequencers for an overall cost advantage.

Environmental Considerations; certain process environments, such as high heat and vibration, interfere with the electronic devices in PLCs, which limits their use.

Fail-save Operation; Auto restart, of course, can be programmed in the PLC; however, in some PLC programs, may have to apply an input voltage to cause a device to stop. These systems are not "fail-save". These disadvantages can be overcome by adding safety relays to a PLC system.

Fixed-circuit Operation; If the circuit in operation is never altered, a fixed control system might be less costly than PLC. The PLC is most effective when periodic changes in operation are made [7][10].

D. Structure of PLC

A PLC consists, like any computer, of a control and an arithmetic unit as well as a program and a data memory (memory marker). In addition a PLC has timers, an interface to the so-called programming device and input/output units, which cover one or more groups of input/outputs depending on the size and level of expansion of the controller.

Input Unit: The input unit conduce the acquisition of analog and digital input signals. Additionally it offers a decoder to allow the control a targeted access to the relevant module via a gate circuit.

Output Unit: Even with the output unit there can be differences between analog and digital modules. The storage of the binary output values on the respective output card is necessary to generate a continuous output signal from the pulse-shaped output values from the controller. The output modules can still possibly include means for monitoring the outputs for short circuit and to switch off the outputs in case of failure.

Timers: The timers make it possible the formation of the necessary times for control engineering tasks in the range from 0.01 s to 1000 min.

Memory Markers: Memory Markers are memory parts of the PLC in which the controller saves (marks) the signal states.

Program Memory: The program memory contains the instructions of the user program in machine code (e.g. 16-bit words at consecutive address). For this purpose buffered write-read memory is normally used.

Control Unit: The control unit reads the instructions of the automation program in the order of the addresses from the program memory and runs the specified operations.

Bus System: A backplane bus called bus connects program memory, control unit, and I/O units (inputs and outputs) in the PLC [11].

E. Programming of a PLC

Control tasks are recorded by the user in a program. By the use of a set of language elements, the program for specific tasks is created. Since tasks for the processing of binary signals are handled, the language elements for these functions are interrupted. From such limited requirements, five programming languages were developed for practical use:

Ladder diagram (LD)

- Function block diagram (FBD)
- Instruction list (IL)
- Flow languages (AS)
- StructuredText(ST)

Among them, the programming language of PLC that is used in this paper is Ladder diagram (LD).

III. THE HISTORY OF CRANE AUTOMATION

PLCs have been in use in container cranes for about 25 years. Neither the PLCs nor the digital DC drives introduced in the mid-eighties did result in any significantimprovement of functionality of the container cranes. The PLCs and drives could not solve any of the three key crane processes:

1. Measurement and control of load sway.
2. Communication between crane and terminal control.
3. Obstacle and target identification.

These technological obstacles did delay the introduction of automation and centralized control by decades compared with other industry applications. The last step in the process towards fully automated container cranes can now be taken using laser transducers as the eyes of the crane and using high speed communication networks for transmissions of video signals. The development of automation for cranes is now faster than in other industry areas and the ports industry is quickly catching up with the paper, chemical and metals industries [12]. The fuzzy logic implementation requires high expertise here ladder logic is implemented. The PLC has 16 ports inputs , and which 8 ports in output. Shown in fig 3

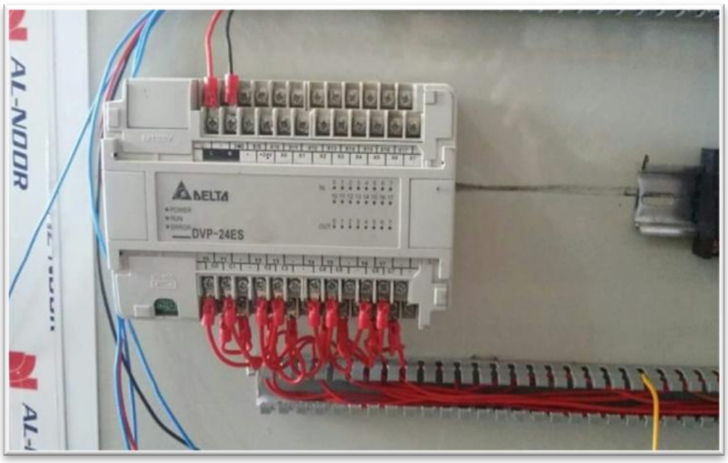


Figure 3 DELTA PLC

IV. INTEGRATED CRANE CONTROL CONCEPT

The first integrated crane control concept is designed for handling of the complete control and automation of an industrial crane. The total functions are built up of a number of distinct building blocks which can be installed from the beginning or added on after the delivery of the crane. Many of the building blocks are tightly connected to each other and requires as system designed and built with the total functionality to achieve the right performance. Already the basic drive and control package has to be designed to handle the real time and communication requirements of the automation functions.

V. DRIVE AND CONTROL

A number of features are needed in the basic drive and control package of the crane to enable the addition of automation and information system functions.

1. Powerful process controller with advanced multitasking, capable of handling several time critical control loops simultaneously.

2. High speed communication links between drives, transducers and controls.
3. Accurate measurement and fast transmission of drive positions and speeds.
4. Communication interfaces for all necessary drive, transducer, remote control and information system equipment. Centralized interface for diagnostics of the complete system.

VI. AUTOMATED CRANE COTROL

A crane with electronic load control is well prepared for automatic, unmanned operation. To realize the unmanned operation the crane must be equipped with “eyes” to be able to identify obstacles and the position of targets like vehicles and stacks of containers. The automated control sequence is the brain of the unmanned crane. The sequence control is built up to handle various types of motions with and withoutload and with different combinations of hoist, trolley and gantry motions.

VII. OPERATION OF OVERHEAD TRAVELLING CRANE USING PROGRAMMABLE LOGIC CONTROLLE (PLC)

The girder of a crane moves in the travelling axis, the trolley moves in the traversing axis and the object transferred by the crane goes up and down. Their movements are described with positions and velocities in the X-Y-Z coordinates, as shown in figure 4. The travelling axis is described with X axis, the traversing axis with Y axis and movement of the object in up and down direction with Z axis. Firstly, the hook is in the up-condition. When switch or input is ON, the hook moves down by running motor No.3. Sensor No.1 is the down-condition sensor . When it signals, motor No.3 stops and then Timer No.1 operates.

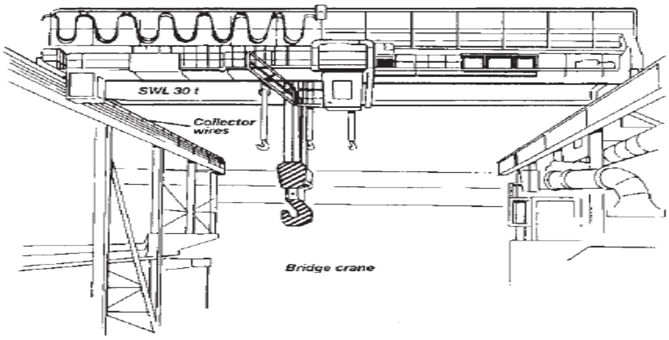


Figure 4 Overhead travelling Crane structure

VIII. LADDER DIAGRAM FOR OVERHEAD TRAVELLING CRANE USING DELTA PLC BY WPL SOFTWARE

MODEL DESIGNATION OF DELTA PLC

Shown in figure 5 below the model of DELTA PLC of 16 PORTS INPUT and 12 port output.

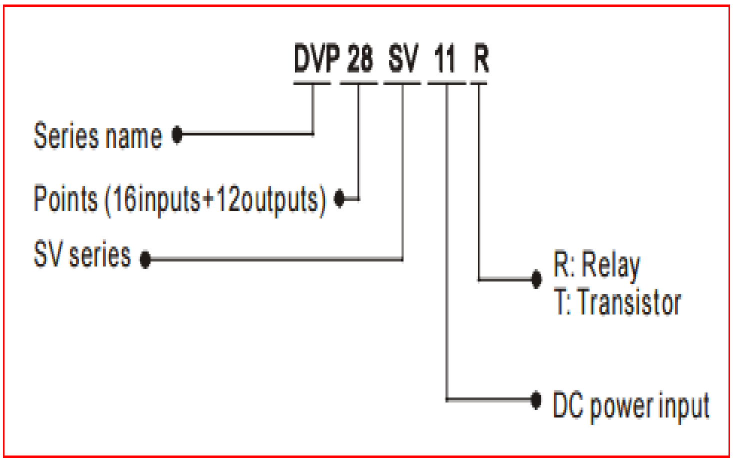


Figure 5 Designation of delta plc

IX. LADDER DIAGRAM FOR OVERHEAD TRAVELLING CRANE USING DELTA PLC BY WPL SOFTWARE

Using ladder diagram of WPL software because cheep, free instillation , and very easy to changing of control. shown in figure 6.

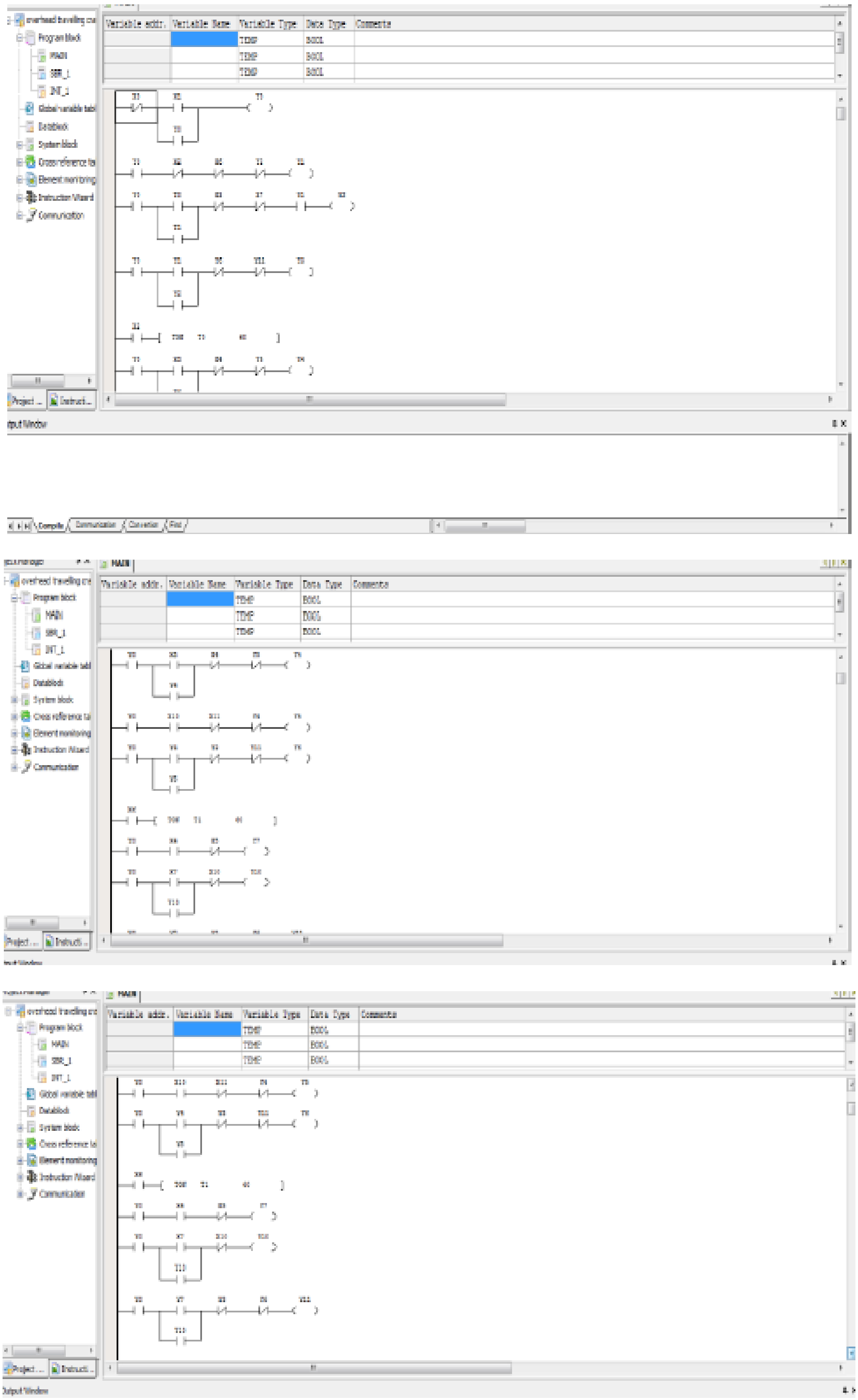


Figure 6. Ladder Diagrams for Overhead Travelling Crane AEOSTC

X. LIST OF SYMBOL MEANING FROM LADDER DIAGRAM

X0 – System stop

X1 – System start
X2 – Sensor No.1
X3 – Sensor No.2 (3' above the ground & Motor No.1 operates in forward direction)
X4 – Sensor No.3 (end of X direction & start of Y direction)
X5 – Sensor No.4 (end of Y direction & start of –Z direction)
X6 – Sensor No.5 (Load reaches at the ground)
X7 – Sensor No.6 (The hook reaches to the original position & Motor No.2 operates in reverse direction)
X10– Sensor No.7 (end of Y direction & Motor No.1 operates in reverse direction)
X11- Sensor No.8 (Motor No.1 stops & the hook reaches to the original position)
Y0 – Master Control Relay
Y1 - Motor No.3 (forward direction)
Y2 – Motor No.3 (reverse direction)
Y3 – Motor No.3 for Z direction
T0 – Timing Solenoid No.1
Y4 – Motor No.1 (forward direction)
Y5 – Motor No.1 (reverse direction)
Y6 – Motor No.1 for X direction
Y7 – Motor No.2 (forward direction)
Y10 – Motor No.2 (reverse direction)
Y11 – Motor No.2 for Y direction
T1 – Timing Solenoid No.2

XI. POWER CALCULATION FOR MOTOR

The motor used here is a DCMotorsthrough the practical experimental to determine the parameters & characteristics for steady-state of this type of motors .The most important conclusions in this paper are :-
1. This type of motors have Efficiency higher than Electromagnetic D.C motors .
2. The damping coefficient (Bm) have negative effect on characteristics of motor especially at no-load steady state in spit of smallness value .The equivalent circuit for PMDC shown in fique 7.

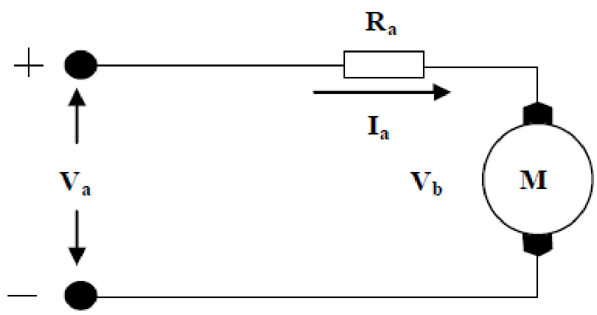


Fig.7 equivalent circuit for PMDC

XII. MATHEMATICAL MODEL OF PMDC

In ideal case the mechanical power equal to electrical power shown the equations below
$Tm * \omega m= Vb * Ia$........................(2)
Tm= 9.55*Po/N........................(3)
$Tm * \omega m= TL*\omega L$........................(4)
$Va=Eb- IaRa$...................... .. ..(5)
$W= 2\pi N/60$...................... ……...(6)
Where **Tm** mechanical torque
ωmThe angular speed of motor.
Vb the back e.m.f
*Ia*armature current
Based on the design specification the output power and the output torque of the motor are calculated by a simple calculation.
Power and torque calculation .the gear ratio 1:20
Weight of cabin=2 k.g*9.8= 20 N
Ra=0.8 ohm, Ia=4 A, Va=12 V ,Ea= 8.8 V, F= 0.2 m/s , Pi= 36 watt ,Po= 36 watt , eff= 70%, Kt=Kv=0.07
Tm=9.55*36/1200=0.28 N.m

Wm=wL=1:20 where TL=5.6 N.m
Nm=1200r.p.m
NL=60 r,p.m
Wm=43raq/sec
wL=6.28

XIII. WIRING OF DLTA PLC.

Figure 8 depicts the wiring of PLC IC200UDR010. The terminals from C1 to C4 in the input side and terminal from C1 to C7 in the output side describes the common points where any one of the terminals of either the load or the source has to be connected.

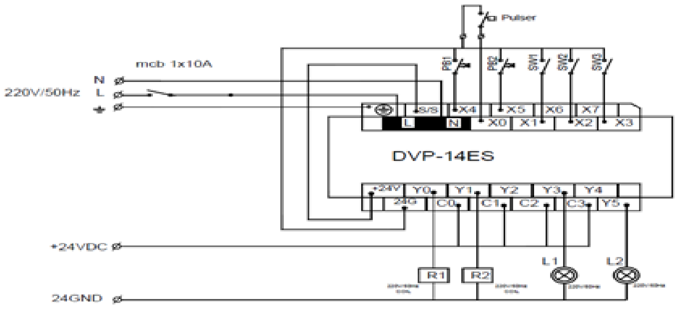
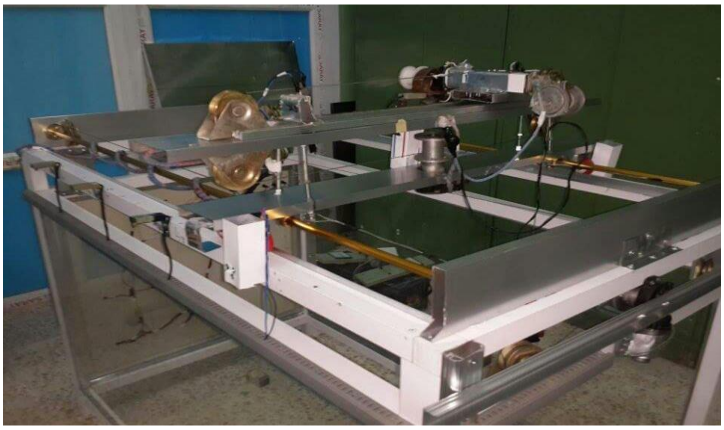


Figure 8

XIV. CONCLUSION

In this paper, Programmable Logic Controller (PLC) applying in industrial AEOSTC work shop is one of the most important features of PLCs. Besides, it makes changes in the control system easy and cheap. In future definitely PLC is dominated on all other controlling methods. The operation of overhead travelling crane is successfully done with the use of PLC. Nowadays, the factory automation and control processes are more and more complicated. Again, control field is expanding to include the complete factory and total control systems combined with feedback control, data processing and centralized monitoring systems. The advantages of PLC are reduced overall manufacturing costs, environmental safety for operating personnel, promptemergency recognition and reaction and general convenience. The objective of controlling Overhead travelling crane is for lifting the industrial field. This crane is mainly used to lift and transport goods and assembling plant, metal working shop, mechanical maintenance shop and warehouses, also for equipment erection and maintenance such as gate for power station, etc. The program (PLC) controlled motor is got more benefit the operation of crane. Motors are controlled by PLC which in overhead travelling cranes is applied in factory.A robust crane control system is designed by using PLC and operated using manual and computerizing control experimental as shown in figure9(a,b).You can view the deviceAEOSTC in the following link
https://www.youtube.com/watch?v=Dsb0uFwnu4A



(a)

(b)

figure 7 a,B) ExperimentalWorks

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