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Implementation of Home Automation Safety Control Using Programmable Logic Controller

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Abstract: This paper deals with the ladder diagram for a system to monitor and control the ON/OFF status of the electrical appliances. In this modern world accurate and reliable operation of relay based industrial automation is not practically possible, hence switching to PLC based automation is one of the better solutions which make the process simple and more reliable. In this project programming is simple when compared to other control systems and trouble shooting is also easy, since we have used PLC. Here we have built the ladder diagram to control the ON/OFF status of the electrical appliances present in various locations from the control room by the use of PLC and HMI.

Key words: Ladder diagram · Monitor and control the ON/OFF · Reliable operation · Used PLC.

INTRODUCTION

In olden days everything was manual. Of course we all know that it has too many difficulties to control. By the use of relays we overcome the above difficulties but this too has few disadvantages such as bulky wire arrangement and troubleshooting is also difficult. These difficulties are then overcome by using electronic circuit control (microprocessor & micro controller). Even this has few disadvantages such as expansion of input and output is not possible and program modification is also difficult. To overcome these above difficulties we are going for Programmable logic controller (PLC) [1].

A normal relay based automation control panel comes in formation of low pressure, high pressure, low temperature, high temperature, over voltage, under voltage, over current, under current, short circuit and earth fault. The control signals have to be interfaced with sequence controller for appropriate control action. This project deals with the implementation of ladder diagram to control the ON/OFF status of various rooms from the control room. Here the programming and the implementation of hardware is simple and easy. In this project we have controlled the ON/OFF status of the electrical appliances of three rooms from the control room by the use of PLC and HMI.

A Home Automation System Controlled by a Programmable Logic Controller (PLC): A normal relay based automation control panel comes in formation of low pressure, high pressure, low temperature, high temperature, over voltage, under voltage, over current, under current, short circuit and earth fault [2]. The control signals have to be interfaced with sequence controller for appropriate control action. This project deals with the implementation of ladder diagram to control the ON/OFF status of various rooms from the control room. Here the programming and the implementation of hardware is simple and easy. In this project we have controlled the ON/OFF status of the electrical appliances of three rooms from the control room by the use of PLC and HMI A home automation system controlled by a Programmable Logic Controller (PLC) was designed. The designed control module comprised of software and hardware. The control module provides multilevel component fault detection, tolerance, switch on or switch off in critical-areas such as gas sensing, voltage control of power socket and valve control circuits. The system is easy to build, service, modify and it provides reliable communication identified as an opportunity to reduce of home automation costs. The proposed system is easily programmable to demand adding different home appliances in short time for home automation and the results show that system yields to efficient use of energy [3].

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Basic Block Diagram: The simplified following block diagram for the implementation of PLC in Home Automation is given in Fig. 1.1.

In this block diagram AC supply given to SMPS, which is used to convert 230V AC into 24V DC, 24V DC supplied to HMI. Then AC supply given to MCB, from MCB to PLC. Now input signal given to PLC. The output of the PLC goes to eight channel relay driver. Using relay driver 24V DC switched to 230V AC, this output of the relay driver supplied to load [4].

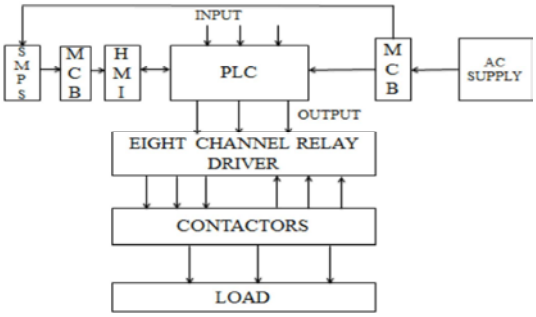

Fig. 1.1: Basic Block Diagram

Plc Basics: A Programmable Logic Controller PLC for short is simply a special computer devices used for industrial control systems. They are used in many industries such as oil refineries, manufacturing lines, conveyor systems and so on.

Where ever there is a need to control devices the PLC provides a flexible way to ¯software□ the components together.

The basic units have a CPU (a computer processor) that is dedicated to run one program that monitors a series of different inputs and logically manipulates the outputs for the desired control [5]. They are meant to be very flexible in how they can be programmed while also providing the advantages of high reliability (no program crashes or mechanical failures), compact and economical over traditional systems. Here the block diagram of PLC is shown in Fig. 2.1.

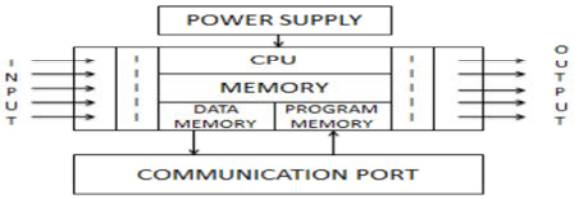

Fig. 2.1: Basic Block Diagram of PLC

Programmable Logic Controller: A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many industries and machines [6]. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a hard real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result. The following Fig. 2.2 shows the Siemens PLC

Fig. 2.2: Siemens Simatic S7-400 at Rack 7

Features of PLC: The main difference from other computers is that PLCs are armored for severe conditions (such as dust, moisture, heat, cold) and have the facility for extensive input/output (I/O) arrangements. These connect the PLC to sensors and actuators. PLCs read limit switches, analog process variables (such as temperature and pressure) and the positions of complex positioning systems. Some use machine vision. On the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays, solenoids, or analog outputs. The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC [7].

Scanning time of PLC: A PLC program is generally executed repeatedly as long as the controlled system is running. The status of physical input points is copied to an area of memory accessible to the processor, sometimes called the "I/O Image Table". The program is then run from its first instruction rung down to the last rung. It takes some time for the processor of the PLC to evaluate

all the ladders and update the I/O image table with the status of outputs. This scan time may be a few milliseconds for a small program or on a fast processor, but older PLCs running very large programs could take much longer (say, up to 100 MS) to execute the program. If the scan time was too long, the response of the PLC to process conditions would be too slow to be useful [8].

As PLCs became more advanced, methods were developed to change the sequence of ladder execution and subroutines were implemented. This simplified programming and could also be used to save scan time for high-speed processes; for example, parts of the program used only for setting up the machine could be segregated from those parts required to operate at higher speed.

Special-purpose I/O modules, such as timer modules or counter modules, could be used where the scan time of the processor was too long to reliably pick up, for example, counting pulses from a shaft encoder. The relatively slow PLC could still interpret the counted values to control a machine, but the accumulation of pulses was done by a dedicated module that was unaffected by the speed of the program execution

System Scale: A small PLC will have a fixed number of connections built in for inputs and outputs. Typically, expansions are available if the base model has insufficient I/O.

Modular PLCs have a chassis (also called a rack) into which are placed modules with different functions [9]. The processor and selection of I/O modules is customized for the particular application. Several racks can be administered by a single processor and may have thousands of inputs and outputs. A special high speed serial I/O link is used so that racks can be distributed away from the processor, reducing the wiring costs for large plants.

User Interface: PLCs may need to interact with people for the purpose of configuration, alarm reporting or everyday control. A human-machine interface (HMI) is employed for this purpose. HMIs are also referred to as man-machine interfaces (MMIs) and graphical user interface (GUIs). A simple system may use buttons and lights to interact with the user. Text displays are available as well as graphical touch screens. More complex systems use programming and monitoring software installed on a computer, with the PLC connected via a communication interface.

Communications: PLCs have built in communications ports, usually 9-pin RS-232, but optionally EIA-485 or Ethernet. Modbus, BACnet or DF1 is usually included as one of the communications protocols. Other options include various fieldbuses such as Device Net or Profibus. Other communications protocols that may be used are listed in the List of automation protocols.

Most modern PLCs can communicate over a network to some other system, such as a computer running a SCADA (Supervisory Control and Data Acquisition) system or web browser.

PLCs used in larger I/O systems may have peer-to-peer (P2P) communication between processors. This allows separate parts of a complex process to have individual control while allowing the subsystems to co-ordinate over the communication link. These communication links are also often used for HMI devices such as keypads or PC-type workstations [10].

Conventional Control Panel: At the outset industrial revolution, especially during sixties and seventies, relays were used to operate automated machines and these were interconnected using wires inside the control panel. In some cases a control panel covered an entire wall. To discover an error in the system much time was needed especially with 19 more complex process control systems. On top of everything, a lifetime of relay contacts was limited, so some relays had to be replaced. If replacement was required, machine had to be stopped and production too. Also, it could happen that there was not enough room for necessary changes [11].

Control panel was used only for one particular process and it wasn't easy to the requirements of a new system. As far as maintenance, electricians had to be very skillful in finding errors. In short, conventional control panel is shown in Fig. 2.4.

In this photo you can notice a large number of electrical wires, time relays, timers and other elements of automation typical for that period. Pictured control panel is not one of the more ¯complicated□ ones, so you can imagine what complex ones looked like.

- Most frequently mentioned disadvantages of a classic control panel are.
- Too much work required in connecting wires.
- Difficulty with changes or replacements.
- Difficulty in finding errors; requiring skillful work here.

Fig. 2.5: PLC with Control Panel

- When a problem occurs, hold-up time is indefinite, usually long.

Control Panel with PLC: With invention of programmable controllers, much has changed in how a process control system is designed. Many advantages appeared. Typical example of control panel with a PLC controller is shown in Fig. 2.3.

Advantages of control panel that is based on a PLC controller can be presented in few basic points:

- Compared to a conventional process control system, number of wires needed for connections is reduced by 80%.
- Consumption is greatly reduced because of PLC consumes less than a bunch of relays.
- Diagnostic functions of a PLC controller allow for fast and easy error detection.
- Change in operating sequence or application of a PLC controller to a different operating process can easily be accomplished by replacing a program through a console or using a PC software (not requiring changes in wiring, unless addition of some input or output device is required).
- Needs fewer spare parts.
- It is much cheaper compared to a conventional system, especially in cases where a large number of I/O instruments are needed and when operational functions are complex.
- Reliability of a PLC is greater than that of an electro-mechanical relay or a timer.

Sequence and Logic Control: Many control applications do not involve analog process variables, that is, the ones which can assume a continuous range of values, but instead variables that are set valued, that is they only assume values belonging to a finite set. The simplest examples of such variables are binary variables that can have either of two possible values, (such as 1 or 0, on or off, open or closed etc.). These control systems operate by turning on and off switches, motors, values and other devices in response to operating conditions and as a function of time. Such systems are referred to as sequence/logic control systems [12].

Advantages of Plc Based Automation: The PLC based automation has some advantages, these are mentioned below

- All the rooms can be controlled by in a single room i.e. called control room.
- Maintenance easy.
- Easy to trouble shooting.
- The wiring of the system usually reduced.
- Reliability is more.
- The power consumption is greatly reduced.

Applications of PLC: The PLC can support some of the industrial applications, these are mentioned below

- Sugar manufacturing plant
- Palm oil manufacturing plant
- Air conditioner control
- TVs manufacturing plant
- Power station plant
- Process monitoring control
- Electrical and electronics appliances
- Conveyor system
- Packaging machine
- Pick and place control robot control
- Pump control
- Swimming pool
- Water treatment
- Chemical processing plant
- Paper and pulp industries
- Pre-cast concrete industries
- Cement manufacturing
- Printing industries
- Electro-plating plants
- Food processing
- Machine tools
- Tobacco industries
- Plastic molding machine

- Semiconductor manufacturing
- Car manufacturing plant
- Iron and steel plant
- Lift control system
- Security control system
- Generator control system

RESULTS

Input and Output List of Plc Using Ladder Logic Diagram: The following Fig.3.1. Shows the input and output flow diagram of LC using ladder logic diagram.

Hmi Screen Input and Output List of Plc Using Ladder Logic Diagram: The following Figure 3.2 shows the HMI screen Input and Output list of PLC using Ladder Logic Diagram

Hardware Implementation: This chapter deals with hardware implementation of the project. It includes input and output of PLC, peripheral connections, relay control circuit, advantages and disadvantages of PLC and components used in the hardware.

Plc Input and Output Type

Dc Inputs: Typically, DC input modules are available that work with 5, 12, 24 and 48 volts. DC input modules allow us to connect either PNP (sourcing) or NPN (sinking) transistor type devices to them. If we are using a regular switch (i.e. toggle or push button, etc.)

AC Inputs: An AC voltage is non-polarized. Put simply, this means that there is no positive or negative. However, AC voltage can be quite dangerous to work with if we are careless. Typically, ac input modules are available that will work with 24, 48,110 and 220 volts. Be sure to purchase the one that fits your needs based up to the input devices (voltage) you will use. AC input modules are less common these days than DC input modules. The reason being that today's sensors typically have transistor outputs. A transistor will not work with an AC voltage. Most commonly, the AC voltage is being switched through a limit switch or other switch type. If your application is using a sensor it probably is operating on a DC voltage.

Relay Outputs: Once of the most common type of outputs available is the relay output. A relay can be used with both AC and DC loads. A load is simply a fancy word for whatever is connected to our outputs.

Transistor Outputs: It is important to note that a transistor can only switch a DC current. For this reason it cannot be used with an AC voltage.

Peripheral Connections:

RS-232 Communication (Hardware): RS-232 communication is the most popular method of PLC to external device communication. RS-232 is an asynchronous (a marching band must be ¯in sync□ with each other so that when one steps they all step. They are asynchronous in that they follow the band leader to keep their timing) communications method.

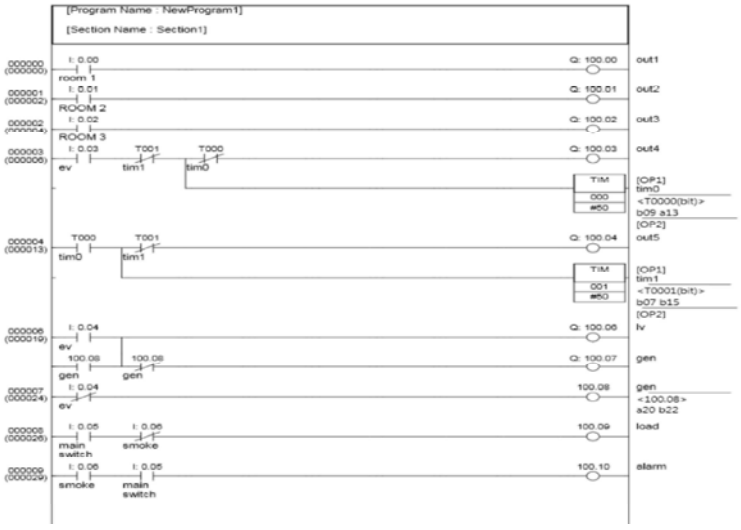

Fig. 3.1: Input and Output list of PLC using Ladder Logic Diagram

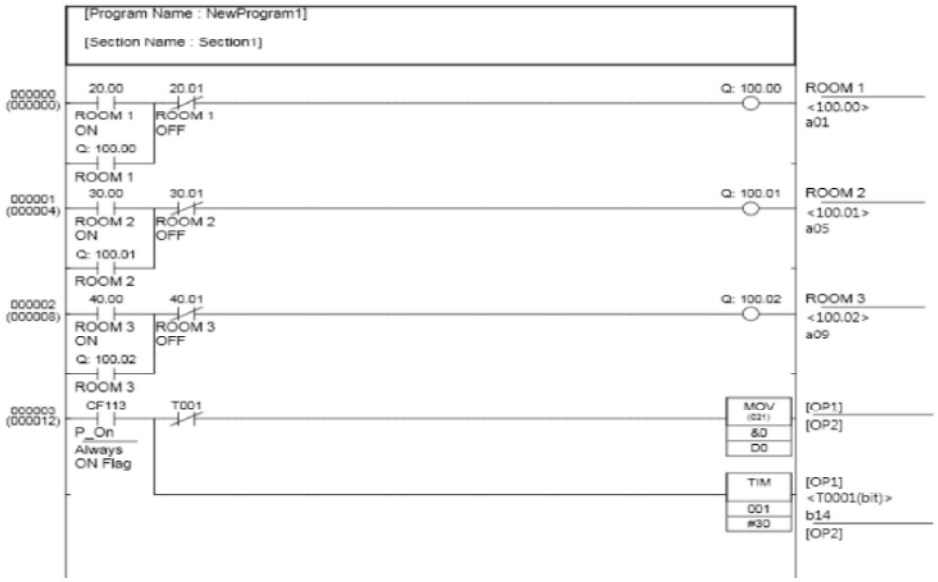

Fig. 3.2: HMI Screen Input and Output list of PLC using Ladder Logic Diagram

Using RS-232 with Ladder Logic: Some manufacturers include RS-232 communication capability in the main processor. Some use the ¯programming port□ for this

We assign memory locations DM100 through DM102 to be where we'll put our data before we send it out the serial port. Note –Many PLCs have dedicated areas of memory for this and only this purpose.

We'll assign internal relay 1000 to be our send relay. In other words, when we turn on 1000 the PLC will send the data in DM100-DM102 out the serial port to our external device.

Relay Control Circuit: The following Figure 5.1 shows the Relay control circuit of Manual mode operation.

Disadvantages of Relay Based Control Panel:

- There is too much wiring in the panel.
- Modification can be quite difficult.
- Troubleshooting can be quite troublesome as you may require.
- Power consumption can be quite high as the coil consumes power skillful person.
- Machine downtime is usually long when problems occur; as it takes longer time to troubleshoot the control panel.
- Drawings are no updated over the years due to changes. It causes downtime in maintenance and modification.
- Cost is higher compare to PLC panel.

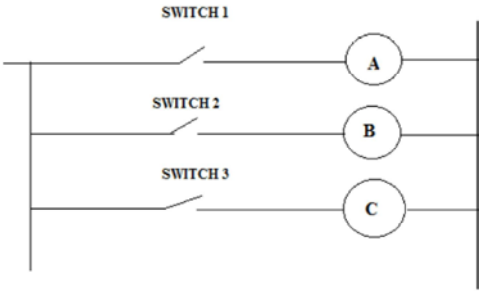

Fig. 5.2.1: Manual Mode Operation

Components Used: The below mentioned components we used in our project hardware, these are

- PLC-CP1E-N20DR-A
- HMI-NV3WMR20
- Power supply
- 8 channel relay model
- Toggle switch
- Wire Ducts
- Tin channel
- Mounting plate
- EL-MAX connector
- Panel box
- Selector switch
- Miniature circuit breaker
- Indication lamp

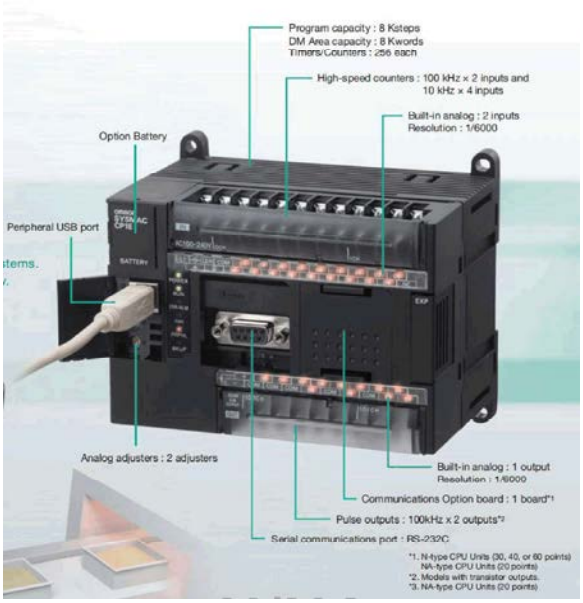

Fig. 5.2: PLC Module CP1E-N20DR-A

The Configuration of PLC is:

- POWER SUPPLY: 100 to 240 VACINPUT, 24 VDC Output
- INPUTS: 12
- OUTPUTS: 8
- OUTPUT TYPE: Relay
- PROGRAM (CAP) :8K Steps
- DATAMEMORY(C) :8K Words

Human Machine Interface (HMI)

Definition: The Human-Machine Interface is quite literally where the human and the machine meet. It is the area of the human and the area of the machine that interact during a given task. The HMI shows in Fig.5.3 and wiring configuration is clearly shows in Fig 5.4.

Toggle Switch: A toggle switch is a device having a plurality of terminals and means operated by a lever for making and breaking electrical connections between pair s of those terminals.Toggle switches of various type have long been used to control Ac power in domestic, commercial and industrial application for operating various electrical devices.

Toggle switch are typically used in application that require the mounting of the toggle switches to panels such that the toggle levers of the toggle switches protrude from a first side of the panels and extend through

Fig. 5.3: Front view of HMI module

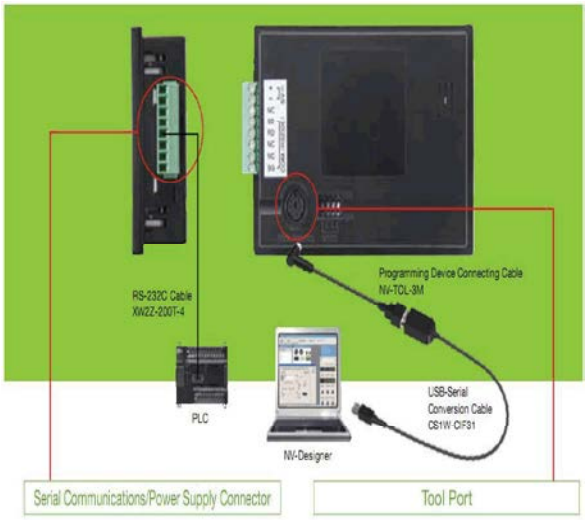

Fig. 5.4: Interfacing of HMI to PLC, Interfacing and downloading programs to HMI

the panels to operate lever that is pivoted about a pin in order to control the position of one or more switch contacts.The pin passes through a bushing and the toggle lever so as to support the toggle lever in one or more stable position,in addition to maintaining or assisting in the maintenance of a force on electrical contacts that are being switched into contact. Here the typical view of toggle switch shows in Fig. 5.5.

Power Supply: Conservation of one from of electrical power to another desired from and voltage, typically involving converting AC line voltage to a well-regulated lower –voltage DC for electronic devices.

Fig. 5.5: Typical view of toggle switch

Fig. 5.6: Typical view of power supply

Fig. 5.7: Typical view of Miniature Circuit Breaker

Low voltage, low power DC power supply units are commonly integrated with the devices they supply. Here the typical view of power supply shows in Fig. 5.6.

Miniature Circuit Breakers (MCB): A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual house hold appliance Up to large switchgear designed to protect high voltage circuits feeding an entire city.

Here the typical view of Miniature circuit breaker is shown in Fig. 5.7.

Fig. 5.8: The typical view of Rotary Switch

Rotary Switch: A Rotary switch is a type of switch that is used on devices which have two or more different ¯states or modes of operation, such as a three-speed fan or a CB radio with multiple reception of reception or ¯channels.

Three –deck rotary switch allows controlling three different circuit functions. A rotary switch consists of a spindle or ¯rotor that has a contact arm or ¯spoke which projects from its surface like a cam. It has an array of terminals, arranged in a circle around the rotor, each of which serves as a contact for the ¯spoke through which any one of a number of different electrical circuits can be connected to the rotor. The switch is layered to allow the use of multiple poles:

Each layer is equivalent to one pole. Usually such a switch has a decent mechanism so it ¯clicks from one active position to another rather than stalls in an intermediate position. Thus a rotary switch provides greater pole and throw capabilities than simpler switches do. Here the typical view of rotary switch shown in Fig. 5.8.

Eight Channel Relay Module: A relay channel is a model on the communication between a sender and a receiver aided by one or more intermediate relay nodes. It is a

Fig. 5.9: Typical view of Eight Channel Relay Module

Fig. 5.10: Typical views of wire ducts

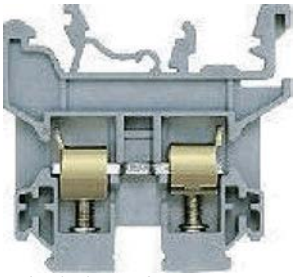

Fig. 5.11: Typical view of ELMAX contactor 70

combination of then broadcast channel (from sender to receiver) and multiple access channels (from sender and relays to receiver). Here the typical view of eight channel relay module shows in Fig. 5.9.

Wire Ducts: Cable duct systems are used to route, protect and conceal data, voice, video, fiber optic or power cabling of building structures for distribution of electric power generally requires specially insulated wires and/or passing of the insulated wires through suitable wires through a suitable protective conduct.

The wiring system is generally enclosed within the wall structure between suitable outlet and power connections. Wire ducts allow custom installation and can be provided within walls or more preferably provide on external surfaces, allowing ready access for reconfiguration, repair, or installation of additional. A wide variety of wiring duct and raceway systems are known for routing various types of wiresand cables. A typical wire duct system includes a plurality of raceway runs. Here the typical view of wire ducts shown in Fig. 5.10.

ELMAX Connector: An ELMAX connecter is a connecting device for joining electrical components together. The connection may be temporary, as for portable equipment, or may require a tool for assembly and removal, or may be a permanent electrical joint between two wires or devices.In computing, an electrical connector can also be known as physical interface.Connectors may joint two lengths of flexible wire or cable, or may connect a wire or cable to an electrical terminal. Here the typical view of ELMAX connector can be shown in Fig. 5.11.

CONCLUSION

PLC is much better when compared to relay based automation. PLC uses, simple program. The major advantage is that, it consumes less power, low maintenance cost, can be programmed. Also, it self-diagnostic functions enables easy and fast troubleshooting of the system. The machine cycle time is improved tremendously due to the speed of PLC operation is a matter of milliseconds. Thus, productivity increases. Modification of control sequence or application can easily be done by programming through the console or computer software without changing of I/O wiring, if no additional input or output device are required.

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