International Journal of Computational Research and Development (IJCRD)
Impact Factor: 5.015, ISSN (Online): 2456 - 3137
(www.dvpublication.com) Volume 8, Issue 1, 2023

MD INTEGRATED ILMS CONTROL USING PROGRAMMABLE LOGIC CONTROLLER

R. Surendar*, R. Ranjitha, V. Prabath** & S. Santhosh Kumar****

* Assistant Professor, Department of Electrical and Electronics Engineering, M.A.M College of Engineering and Technology, Siruganur, Trichy, Tamilnadu

** UG Student, Department of Electrical and Electronics Engineering, M.A.M College of Engineering and Technology, Siruganur, Trichy, Tamilnadu

Cite This Article: R. Surendar, R. Ranjitha, V. Prabath & S. Santhosh Kumar, "MD Integrated ILMS Control Using Programmable Logic Controller", International Journal of Computational Research and Development, Volume 8, Issue 1, Page Number 28-40, 2023.

Abstract:

Magnetic separators are installed to catch and separate ferrous materials that might come along with lignite. We aim to integrate MD (Metal Detector) with MS (Magnetic Separator). Metal detector will be installed 15-20m apart from MS system. The Enhanced operational performance will be exhibited by MD-integrated MS systems. Electrically operated Magnetic Separators (shortly MS systems) are the main bones of LHS systems incorporated in Receiving and Transfer of lignite. The major aims of such systems are to "Remove Ferrous materials (maximum size to 50 kg) of any shape".

Introduction:

Magnetic Separator:

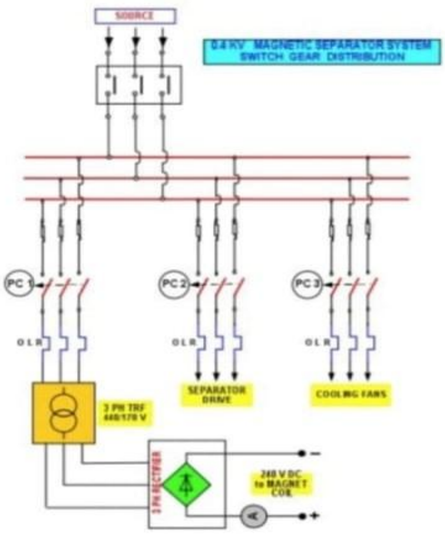
Magnetic separation is the process of using magnetic force to remove metallic or ferrous materials from a mixture. Magnetic separation machines consist of a vibratory feeding mechanism, an upper and lower belt and a magnet. The bulk material is fed through the vibrating mechanism on to the lower belt. At this point, the magnet pulls any material susceptible to magnetic attraction on to the upper belt, effectively separating the unwanted metals from the rest of the bulk. In the Lignite transfer system, before crusher house the lignite is free from ferrous materials. So that the damage caused by the material on carrying conveyor system, crushing mechanism may be avoided. The aim of Lignite Handling system is to receive Lignite and store it on stockpiles and to transfer lignite from stockpile to Boiler bunkers for power production. From bunkers the Lignite is being fed into Boiler furnace via Pulverizing Mill system. Hence if there is any escape of ferrous materials after Crusher- It will make significant damage to Mill system also. Hence Magnetic separators Plays vital role in the removal of Ferrous materials that would cause damage in the above discussed Conveyors, Crusher and Mill systems. The length of the magnet is designed such that the magnetic material is in the magnetic field for a period of 0.4 to 0.5 seconds. Strontium ferrite permanent blocks are used in the magnet assembly to achieve a surface gauss of 2500. The gap between the magnet and conveyor is adjustable. Lower the gap, better the separation efficiency. We can supply belt type separators for a belt width of 650mm to 1600mm.

Functions of Magnetic Separator System:

Magnetic Separators Builds up Strong magnetic field – There by attracts Ferrous materials effectively. The same material will be separated by the conveyor system called Separator and collected at a chute. Our MS (Magnetic Separator) system is designed to lift a material of 50 kg.

Magnetic Separator Power System & Control:

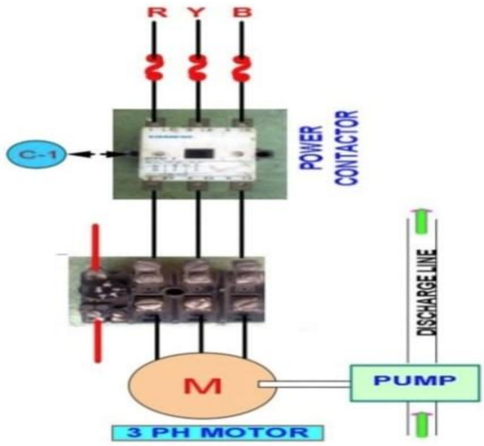
Power Distribution Scheme:



PC - 1 Power contactor for Magnetic Circuit

PC - 2 Power contactor for Separator (3 phase) drive PC - 3 Power contactor for cooling fans (magnet coil)

Power Circuit Concept - Industrial Control:



The above figure shows the industrial drive control arrangement. The three-phase motor which is in the pumping application being powered-up through 3 phase supply, fuses, Power contactor and Overload relay protection. The power contactor in industrial application would energize on 110v ac supply. This is the control supply for the switch gear. Overload relay connected here will be set at the current called over-current or overload.

Operating Principle:

The mixture of char and sponge is passed under the magnetic separator by a conveyor. The mixture is fed on to the conveyor evenly by the help of a feeder. The coal(char) is carried by the bottom conveyor and discharged in the non-magnet chute.

MS Operation:

The above circuit shows the operation of magnetic separator system using control relays (named CR 1, 2, 3….) and timers. The circuit that uses the above components are generally named as Relay logic control or Hard-wired logic. Any application can be automated via this logic. But for any automation it requires large number of relays and physical wiring, timers if required. This is logic available for magnetic separator system as per the design. The facilities extended by the circuit are

- Local starting / stopping when required by maintenance people.
- Remote starting by the Control room executives for ferrous material separation during lignite receiving/transfer.

Past / Present Control System:

The past magnetic separator system has “Relay Based Logics”, which is hard wired and very difficult to troubleshoot whenever any problem occurs in the system. It uses number of electromechanical relays and timers for the process requirement. Hence associated internal wiring between them will be a bulkier system design. In odd hours it is very difficult to identify a problem and without drawings it is not all possible to recover the system operation. Thus, the system up gradation is highly required based on the above said drawbacks- the Magnetic separator system is being installed and designed with a 20 I/O micro-PLC of OMRON made. Like all the conveyor system, magnetic separator system is also controlled either from field (LOCAL) or from control room (REMOTE). It is achieved via LOCAL/REMOTE selections. From local Magnet or separator can be started or stopped through command Push Buttons available at field. For this option L/R selection should be in Local. Single start command from control room enables both magnet and separator to pick up ON one by one. The running feedback of MS system is interlocked with feeding system conveyor. Hence if the MS is “not made on” lignite feeding to the bunkers is not possible. In case of severe problem which can’t be recovered in time, a BY-PASS switch is provided at control room premises. This is purely for emergency purpose to carry out the transfer system lignite flow for bunkers. In this case, the ferrous substance in the lignite can’t be filtered. This causes the crusher system mechanism to damage. Thus, the importance of MS system is highly required for the Lignite Handling System to catch and separate any magnetic particles that may present in lignite.

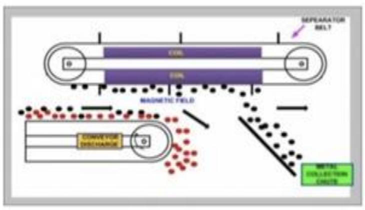


Figure: MS Operation

Accessories of Magnetic Separator System:

- 3 Phase 7.5KW Squirrel Gage Induction Motor as Separator drive
- 3 Phase Bridge Rectifier (200A Diode Each) with filter and Freewheeling diode at DC end (terminal voltage 240 V D.C) for electro magnet.
- 3 Phase 415/170 v ac Transformer as I/P for bridge circuit (170x1.414= 240.38 v D.C)
- 3 wire Speed sensor of 24v dc supply- proximity type.
- Remote command and Local emergency switch, starting/stopping PBs.
- Overload relays for Separator motor, Magnet circuit ac &dc sides.

Recently, the speed monitor application is also eliminated via software and implemented. So, it is one of a Cost-Benefited solution because a speed monitor costs a lot to replace (RS. 15,000). I made an attempt to study and present automation of magnetic separator system via PLC. In addition, I give my physical co-operation during speed monitor elimination and associated quality control (QC) circle activities regarding this project. Further more information on PLC and associated software portions will be discussed in the forthcoming pages.

Metal Detector:

All metal detectors operate based on the same fundamental principle. When electricity passes through a coil contained within a metal detector, a magnetic field or frequency is produced. This magnetic field remains stable unless a metal particle is introduced and disrupts it. In quarry and mine environments metal detectors are usually installed over a conveyor belt when tramp metal comes into the metal detector's magnetic field, the control activates and either stops the conveyor entirely or diverts contaminated product away from the main product flow. Metal Detectors are available in a wide variety of designs. In a quarry or mine, Metal detectors are commonly located underneath or around a conveyor belt. When tramp metal enters the magnetic field of the metal detector, the control either stops the conveyor or can divert the contaminated product flow. During tramp metal detection, solid material passes across a metal detector. When tramp metal is detected, it can either be removed manually or automatically. With manual removal, tramp metal detection triggers an alarm relay and stop belt-this allows a safe manual removal of the tramp metal to prevent it from entering the downstream process. In automatic removal, tramp metal detection activates a bypass chute to automatically reject the tramp without stopping the belt.

Working Principle:

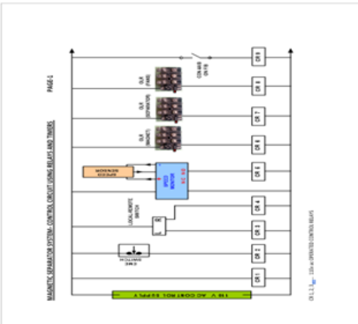
The principle of it is that three coils which are central transmitting coil and two equivalent receiving coils are installed in a probe, and the oscillator emits a high frequency magnetic field through the central transmitting coil connecting with the two receiving coils, but the polarity is opposite. In the mining industry, Metal Detectors are used to protect crushers, belts and other downstream equipment from tramp metal contamination. The metal to be detected varies widely based on the specifics of the equipment being protected. The operation of metal detectors is based on the principle of Electromagnetic Induction - "When electric current passes through a coil, it produces a magnetic field around it" In our circuit, the transistor having series capacitors in parallel with the inductor forms a Colpitts oscillator. First the capacitors get charged and as soon as it gets fully charged, it starts to discharge the energy to the inductor.

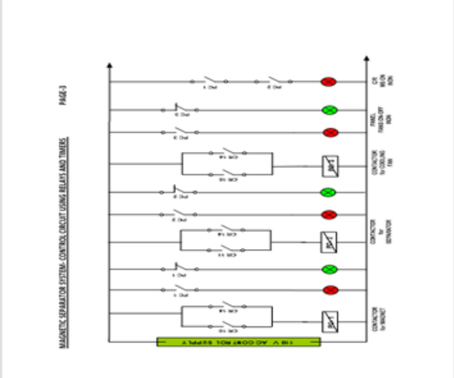
Figure: Metal Detector

Control Logic for Fixed Excitation:

Control circuit of MS System Using Traditional relays / Timers:

The control circuit for MS system with control relays - as follows: -





All the above user inputs, protective relay feedback was used in the relay logic circuit to avail our application requirement. The panel receives 3 phase supply form LHS common switchgear system allotted for Magnetic separator system. The control room start command will be recognized only when the Local /Remote selector switch is in Remote. The local starting/stopping of magnet will be enabled only when L/R selector is selected in Local.

- CR1 control supply supervision relay (will be energized on110v ac)
- CR2 control relay for emergency switch monitoring
- CR3 relay for Local selection
- CR4 relay for Remote selection
- CR5 relay for speed monitoring
- CR6 control relay for magnet Overload
- CR7 control relay for separator overload
- CR8 control relay for cooling fans overload
- CR9 con 4A/4B Running feedback for MS operation
- CR10 Local magnet on/off relay
- CR11 Local separator on/off relay
- CR12 MS system control components healthiness check relay
- CR14 relay for
- Remote operation (control room)
- CR15 MS f/b to con 4A/4B
- CR16 Relay for cooling fan on/off
- TR1 On delay timer (10 sec) for acceleration delay
- TR2 off delay timer (3 min) for MS stopping

Hence the above circuit uses more number of relays from CR1…….CR16 and timers TR1, TR2 for the MS operation requirement. The internal wiring is being a complicated one with interlocks. The reasons were tabulated as follows,

- Life of OEM design (Original Equipment Manufacturer)
- Uses traditional relays, timers' control
- Physical wiring complications between control relays
- Frequent Speed monitor failure due to dusty location
- Non-availability of fault indication at control room (On/Off available)

On further discussions it was concluded to designuser-friendly relays free control technology using Programmable Logic Controller applications. Based on the efforts made by the maintenance team with a month of time all the MS systems were automated with PLC systems (Omron make 20 I/O).

Drawbacks of Relays:

- Physical wiring of system is complicated and difficult.
- The panel board arrangement occupies more space. The arrangements also require proper ventilations. The arrangement is not simple and neat.
- This can result in mal-operation and false trips.
- Using more number of relays.
- Timers' usage.
- Fault finding is fed ions and without circuit diagram it is not possible.
- Chance of relay/timer's mis-behaviour is there because of that expected operation is not possible.
- Maintenance is to be regular and periodical.
- Power consumption is more.
- Once in 4 years we need to change relay/timers.

Based on the above issues, the need of user-friendly control logic up gradation is highly required – PLC is highly reliable control logic.

Role of MS System:

In Lignite chance of Ferrous material mix up is more casual. To avoid such materials Magnetic Separators are installed in the conveyor system network. Hence the role of MS in LHS system is playing a vital role in removing Ferrous materials – that might cause significant damage on

- Crusher Mechanism
- Conveyor System
- Mill Drives

Fixed Excitation:

In general MS system is having "Separator system driven by a 3 Ph motor" and a "Coil for Magnetisation" excited by DC supply. The present way of Excitation is Fixed Mode with 220v dc. In this type MS will work for fixed excitation always. On observation, if 100 materials are crossing through the conveyor (where MS is suspended over that) 80 of them will be catched and separated effectively by MS. Remaining 20 number of materials shall escape through lignite. The average work performance of MS is nearly 80% in this fixed mode excitation. The escape materials through lignite definitely would cause damage on the above systems. According to the size and shape the depth of damage will be more. In case if one of the Mill system damages happens, it has to be stopped immediately and attended for restoration (requiring 2 to 3 days). One mill system is responsible for 40 MW of power production. Absence of one mill leads to reduction in power production

Variable Excitation:

To overcome other system damages, It is a good idea to improve Magnetic strength of the MS system. Thereby we shall encounter the Escaping ferrous materials. In more technical, we shall introduce one Metal detector device ahead of MS system. Hence with MD integrated MS system will functions as Variable Excitation concept. In this mode, the MS system will start and run in "Under Excitation Mode (110 v dc)" there by creating a base magnetic field under the region. Whenever a Metal deduction pulse came from MD, the control logic immediately commands to energize "Over Excitation Mode (330 v dc)" and held in the state for 20 sec. Thus, the ferrous material(s) effectively attracted by the strong magnetic field and separated. After 20 sec the excitation will revert back to Under Excitation Mode, by the Control logic. For doing this kind of Variable excitation methodology we need

- Three phase transformer with tapings to enable three modes of excitations namely, Under Excitation, Medium Excitation and Over Excitation.
- Metal Detector
- Control Mode / Non-Control Mode Selector switch

All the above three things are easily possible to carryout enhanced MS System modification

MS Operation Logic with MD:

- If the Selection of CM/NC Selector is in CM (Control mode)- and- L/R Selector switch in R (Remote) Only Remote (from control room) will be accepted and Local commands will be ignored.

If MS Start command is coming, PLC will issue start command for Separator motor and Magnet coil (in Under Excitation mode -110 dc). The Metal detector which is installed 20 m apart from MS, searching for any ferrous material in the passing lignite. If any material is crossing through the MD, it will initiate a signal to PLC. Accordingly as per our instruction, PLC will command for Over Excitation mode (330 v dc) and reside in OE mode for 15/20 sec. Then PLC will command again for Under Excitation mode. Thus, on material entry, time being the excitation mode is changed thereby magnetic strength is higher to catch and separate the ferrous material effectively and on other times the coil resides in Under excitation. Thereby we minimize power loss in normal times.

- If the Selection of CM/NC Selector is in NC (Non- Control mode)- and- L/R Selector switch in R (Remote)

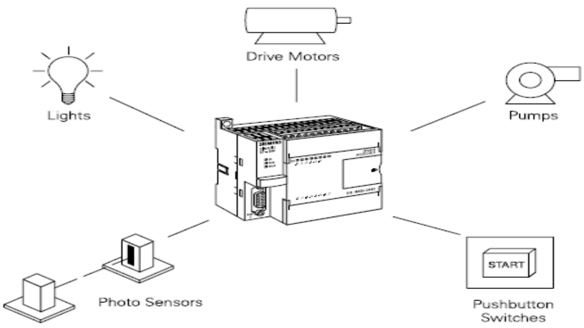
Only Remote (from control room) will be accepted and Local commands will be ignored. In this mode the system always will run in Normal Excitation (220 v dc)

- If the Selection of CM/NC Selector is in NC (Non-Control mode)- and- L/R Selector switch in Local (Local)

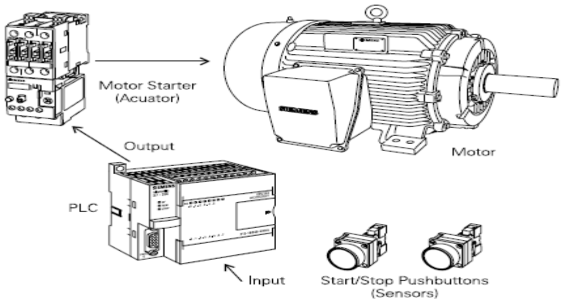
Only Local commands (from Field) will be accepted and Remote commands will be ignored. In this mode the system always will run in Normal Excitation (220 v dc). Now we will discuss about Programmable Logic Controllers in detail.

Programmable Logic Controllers:

Programmable Logic Controllers (PLCs), also referred to as programmable controllers, are in the computer family. They are used in commercial and industrial applications. A PLC monitors inputs, makes decisions based on its program, and controls outputs to automate a process or machine.



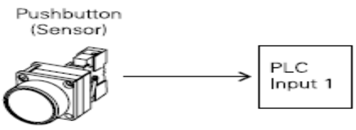
PLCs consist of input modules or points, a Central Processing Unit (CPU), and output modules or points. An input accepts a variety of digital or analog signals from various field devices (sensors) and converts them into a logic signal that can be used by the CPU. The CPU makes decisions and executes control instructions based on program instructions in memory. Output modules convert control instructions from the CPU into a digital or analog signal that can be used to control various field devices (actuators).



PLCs The same, as well as more complex tasks, can be done with a PLC. Wiring between devices and relay contacts is done in the PLC program. Hard-wiring, though still required to connect field devices, is less intensive. Modifying the application and correcting errors are easier to handle. It is easier to create and change a program in a PLC than it is to wire and rewire a circuit.

Terminology:

The language of PLCs consists of a commonly used set of terms; many of which are unique to PLCs. In order to understand the ideas and concepts of PLCs, an understanding of these terms is necessary. Sensor A sensor is a device that converts a physical condition into an electrical signal for use by the PLC. Sensors are connected to the input of a PLC. An electrical signal is sent from the pushbutton to the PLC indicating the condition (open/closed) of the pushbutton contacts.

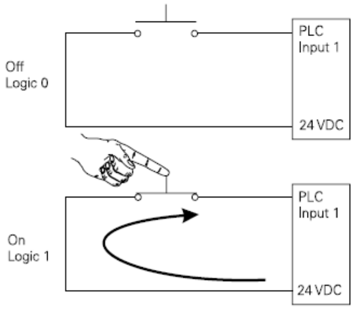


Actuators (Power Contactors):

Actuators convert an electrical signal from the PLC into a physical condition. Actuators are connected to the PLC output. A motor starter is one example of an actuator that is connected to the PLC output. Depending on the output PLC signal the motor starter will either start or stop the motor.

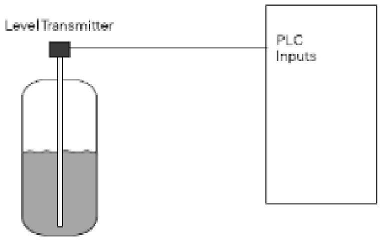
Discrete Input (DI):

A discrete input, also referred to as a digital input, is an input that is either in an ON or OFF condition. Pushbuttons, toggle switches, limit switches, proximity switches, and contact closures are examples of discrete sensors which are connected to the PLCs discrete or digital inputs. In the ON condition a discrete input may be referred to as a logic 1 or a logic high. In the OFF condition a discrete input may be referred to as a logic 0 or a logic low. A Normally Open (NO) pushbutton is used in the following example. One side of the push button is connected to the first PLC input. The other side of the pushbutton is connected to an internal 24 V DC power supply. Many PLCs require a separate power supply to power the inputs. In the open state, no voltage is present at the PLC input. This is the OFF condition. When the pushbutton is depressed, 24 V DC is applied to the PLC input. This is the ON condition.



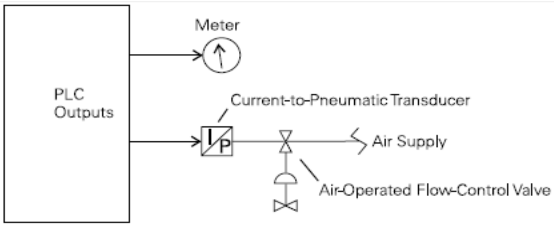
Discrete Outputs (DO):

A discrete output is an output that is either in an ON or OFF condition. Solenoids, contactor coils, and lamps are examples of actuator devices connected to discrete outputs. Discrete outputs may also be referred to as digital outputs. In the following example, a lamp can be turned on or off by the PLC output it is connected to.



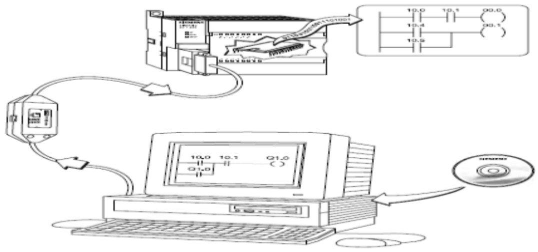
Analog Inputs (AI):

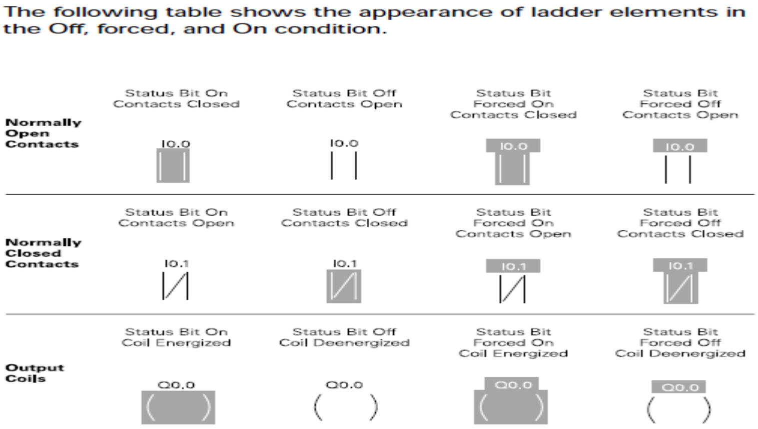
An analog input is an input signal that has a continuous signal. Typical analog inputs may vary from 0 to 20 milliamps, 4 to 20 milliamps, or 0 to 10 volts. In the following example, a level transmitter monitors the level of liquid in a tank. Depending on the level transmitter, the signal to the PLC can either increase or decrease as the level increases or decreases.



Analog Outputs (AO):

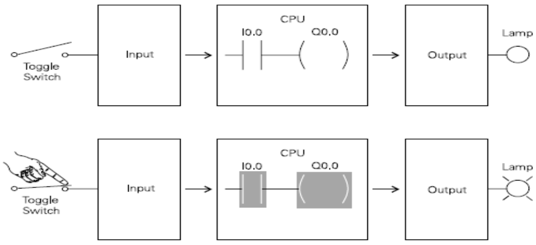
An analog output is an output signal that has a continuous signal. The output may be as simple as a 0-10 VDC level that drives an analog meter. Examples of analog meter outputs are speed, weight, and temperature. The output signal may also be used on more complex applications such as a current-to pneumatic transducer that controls an air-operated flow-control valve.





CPU:

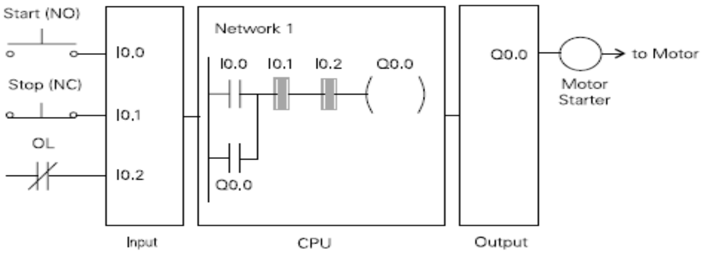
The central processor unit (CPU) is a microprocessor system that contains the system memory and is the PLC decision making unit. The CPU monitors the inputs and makes decisions based on instructions held in the program memory. The CPU performs relay, counting, timing, data comparison, and sequential operations.



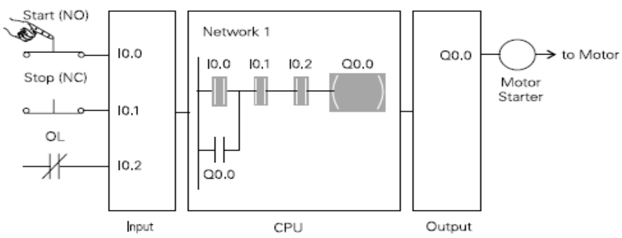
The following drawing illustrates the sequence of events. A switch is wired to the input module of the PLC. A lamp is wired to the output module. The program is in the CPU. The CPU scans the inputs. When it finds the switch open I0.0 receives a binary 0. This instructs Q0.0 to send a binary 0 to the output module. The lamp is off. When it finds the switch closed I0.0 receives a binary 1. This instructs Q0.0 to send a binary 1 to the output module, turning on the lamp.

Program Instruction (for 3 ph Motor Starting):

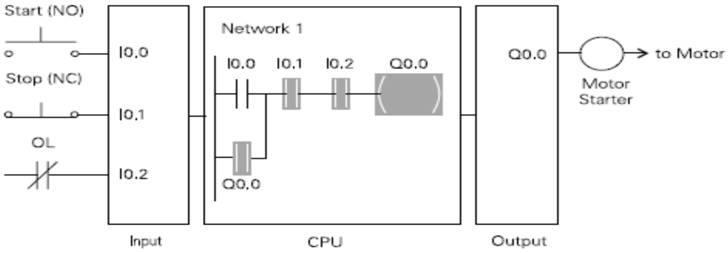
A normally open Start pushbutton is wired to the first input (I0.0), a normally closed Stop pushbutton is wired to the second input (I0.1), and normally closed overload relay contacts (part of the motor starter) are connected to the third input (I0.2).In addition, a normally open set of contacts associated with Q0.0 is programmed on Network 1 to form an OR circuit. A motor starter is connected to output Q 0.0.



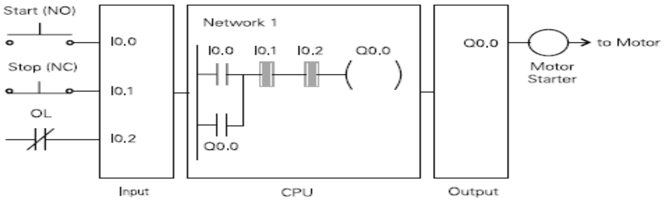
When the Start pushbutton is depressed the CPU receives a logic 1 from input I0.0. This causes the I0.0 contact to close. All three inputs are now a logic 1. The CPU sends a logic 1 to output Q0.0. The motor starter is energized and the motor starts.



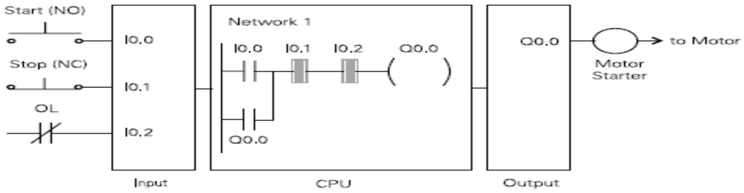
When the Start pushbutton is pressed, output Q0.0 is now true and on the next scan, when normally open contact Q0.0 is solved, the contact will close and output Q0.0 will stay on even if the Start pushbutton has been released.



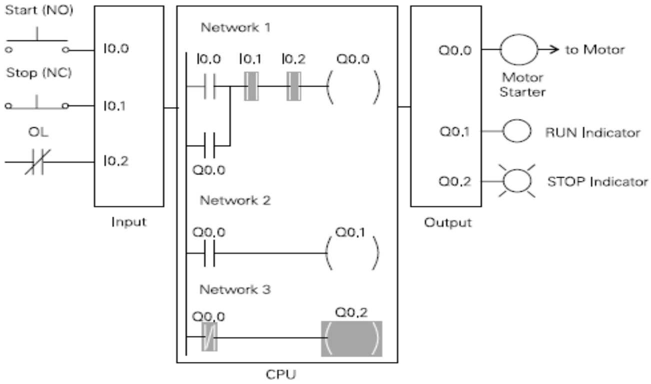
The motor will continue to run until the Stop pushbutton is depressed. Input I0.1 will now be a logic 0 (false). The CPU will send a binary 0 to output Q0.0. The motor will turn off.



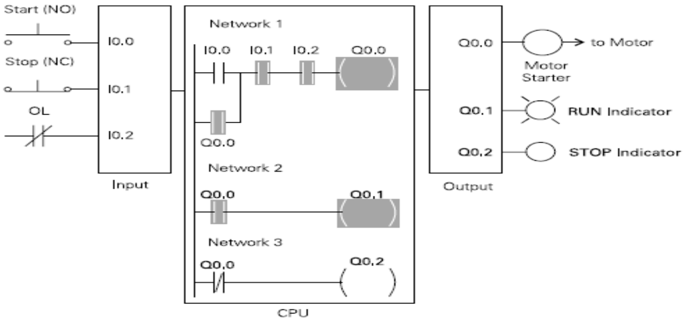
When the Stop pushbutton is released I0.1 logic function will again be true and the program ready for the next time the Start pushbutton is pressed.



It can be seen from the ladder logic that a normally open output Q0.0 is connected on Network 2 to output Q0.1 and a normally closed Q0.0 contact is connected to output Q0.2 on network 3. In a stopped condition output Q0.0 is off. The normally open Q0.0 contacts on Network 2 are open and the RUN indicator, connected to output Q0.1 light is off. The normally closed Q0.1 on Network 3 lights are closed and the STOP indicator light, connected to output Q0.2 is on.

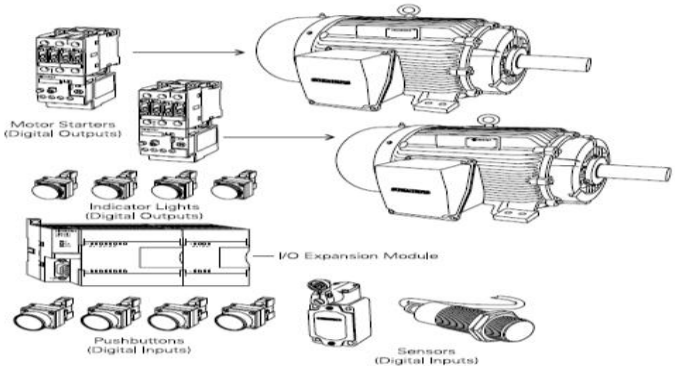


When the PLC starts the motor output Q0.0 is now a logic high (On). The normally open Q0.0 contacts on Network 2 now switch to a logic 1 (closed) and output Q0.1 turns the RUN indicator on. The normally closed Q0.0 contacts on Network 3 switch to a logic 0 (open) and the STOP indicator light connected to output Q0.2 is now off.



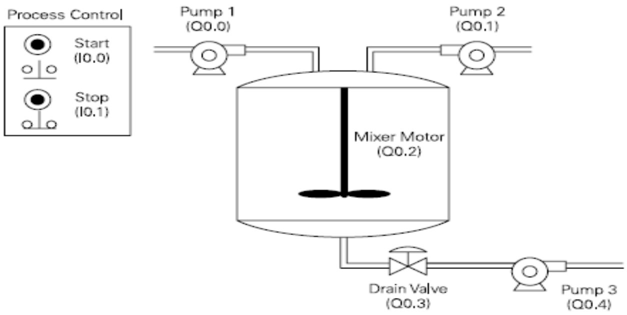
Expansion:

The PLC program can be expanded to accommodate many commercial and industrial applications. Additional Start/Stop pushbuttons and indicator lights can be added for remote operation, or control of a second motor starter and motor. Over travel limit switches can be added along with proximity switches for sensing object position. In addition, expansion modules can be added to further increase the I/O capability. The applications are only limited by the number of I/O's and amount of memory available on the PLC.



Timer Example:

In the following example a tank will be filled with two chemicals, mixed, and then drained. When the Start Button is pressed at input I0.0, the program starts pump 1 controlled by output Q0.0. Pump 1 runs for 5 seconds, filling the tank with the first chemical, then shuts off.

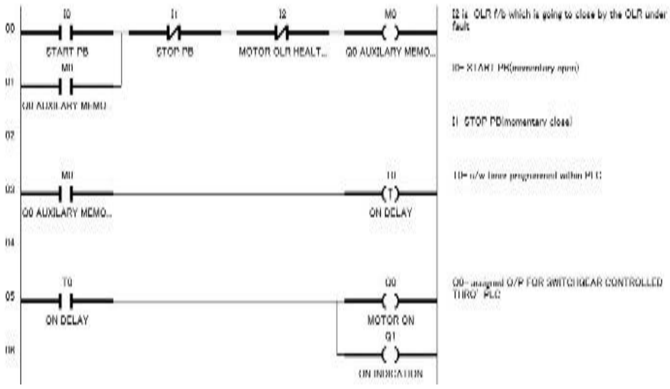


The program then starts pump 2, controlled by output Q0.1. Pump 2 runs for 3 seconds filling the tank with the second chemical. After 3 seconds pump 2 shuts off. The program starts the mixer motor, connected to output Q0.2 and mixes the two chemicals for 60 seconds. The program then opens the drain valve controlled by output Q0.3, and starts pump 3 controlled by output Q0.4. Pump 3 shuts off after 8 seconds and the process stops. A manual Stop switch is also provided at input I0.1. The upcoming pages will be discussed about the software part of AUTOMATION part of Magnetic Separator system

Software of PLC:

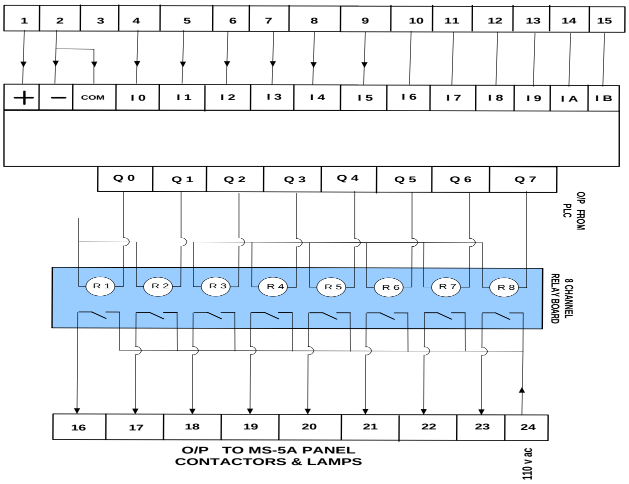
OMRON Make ZEN MODEL:

The below program shows the software part of 3-phase drive control using start/stop and protection inputs. It is being done by a timer operation via inbuilt timer T0 and the output for switch gear is taken from output Q0. The below program is simulated and tested.



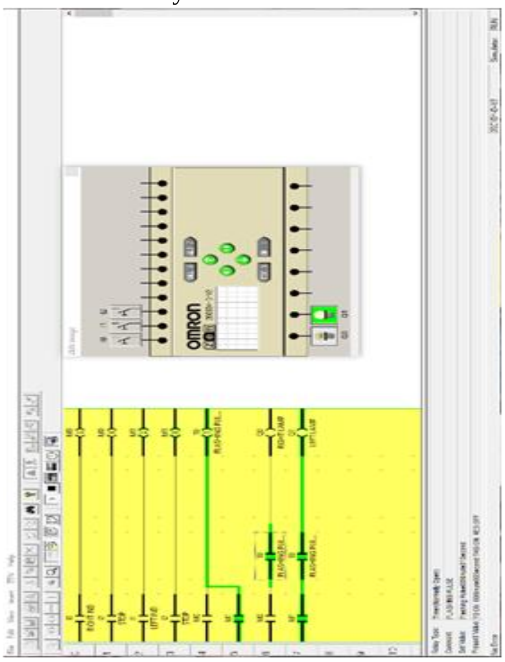
This shows how PLC control is simple. We can go for edit on above software to make changes on I/O's and timers via dedicated buttons in PLC top or through PC. In the following pages we will discuss about the automation of MS system with all assigned actual I/O's implemented practically.

PLC Interfacing:

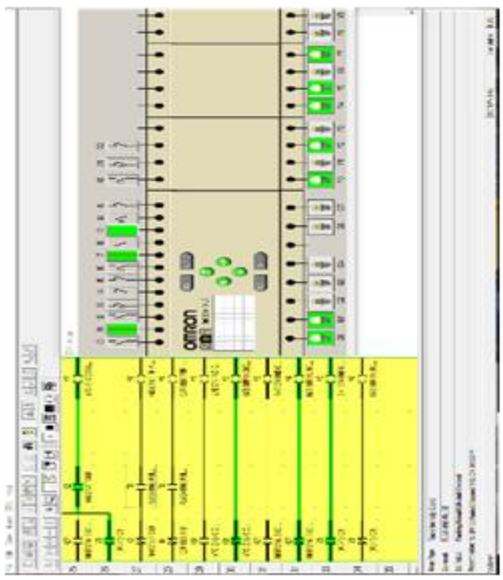


Ladder Diagram:

The following pages will be discussed by the Software of PLC



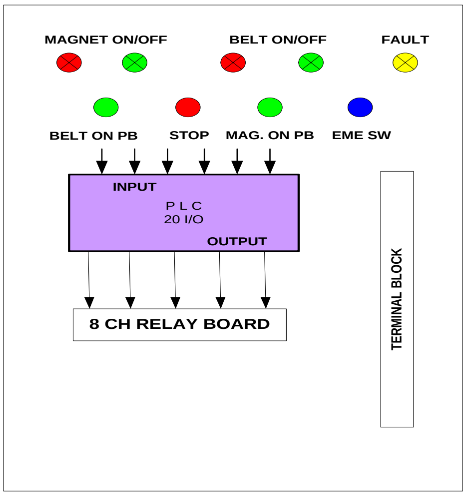
Star Delta Connection:



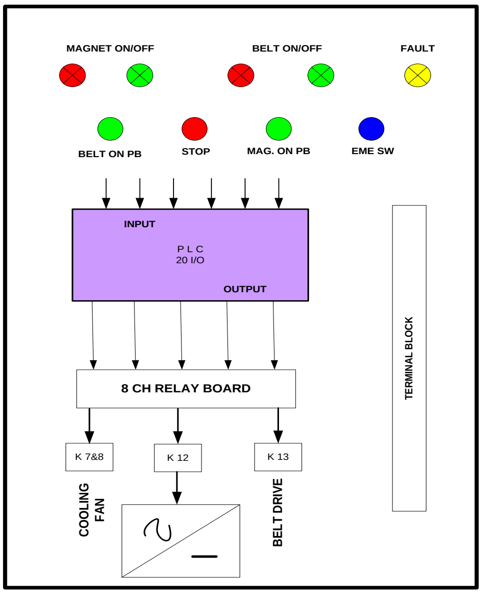
Input / Output:

MD Integrated ILMS Control Using PLC:-

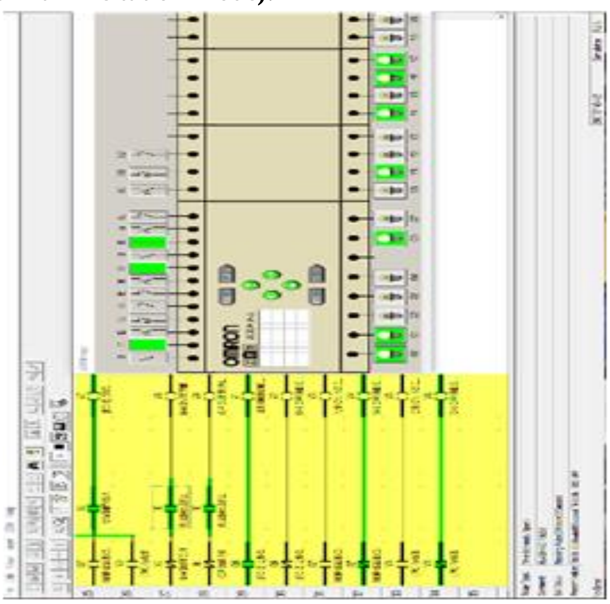
Automation of MS System Via Omron PLC:



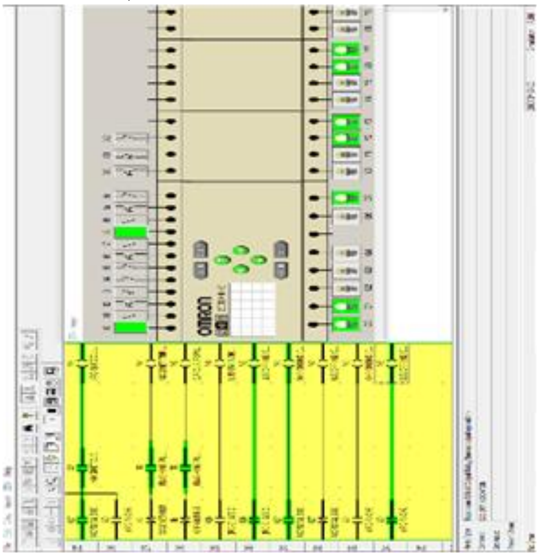
M S - 5A LOCAL PANEL



Local Fixed Excitation (Normal Excitation Mode):



Remote Variable (Over Excitation Mode):



Conclusion:

A detailed study on lignite handling system of TPS-II and the ms control system in lhs have been made through this project. This project has developed our knowledge in the areas of lignite handling through a system of conveyors, magnetic separator control in lignite handling plant. We had a very good opportunity to work at Neyveli lignite corporation India ltd. we had a brief idea about plc based control for ms system operation and control for process requirement-to have better ferrous metal separation. We had more clarity on power station operation basics and maintenance activities. Everything that we had planned went smoothly during the project development span. Also, we had a limited amount of time for its completion. So, we were under a certain amount pressure as well. We do our project to improvise "MD integrated ILMS control using programmable logic controller"; thereby we suggest an enhanced improved performance of ms control via plc. Due to the superior communication facility with pc, system monitoring via computer is possible. We thank the Neyveli lignite corporation India ltd for giving us a very good opportunity work, which gave us an exposure to industrial atmosphere.

References:

1. L. A. Bryan and E. A. Bryan., "Programmable Controllers Theory and Implementation" (Second Edition).
2. Hugh Jack., "Automating Manufacturing System with PLCs" (Version 5.0).
3. Course Book in STEP 2000 Series, Siemens Technical Educational Program.
4. Rehg J., Muller, B., "Teaching PLCs with the IEC 61131 Standard Languages", ASEE Annual Conference & Exposition, 2000.
5. Guo, L., Pecen, R., "Design Projects in a Programmable Logic Controller (PLC) Course in Electrical Engineering Technology", ASEE Annual Conference & Exposition.
6. NLC profile from www.nlcindia.com website.