3.1 CRUSHING AND TRANSPORTATION

Limestone is the principal raw material required to manufacture cement. Limestone, mined from the site located nearly 9 kms away from the company is crushed into small pieces using primary and secondary crushers. Then the crushed material to the next section is transported from the hopper to the factory with the help of mono cable Ariel ropeway system.

3.2 PREBLENDING AND STORAGE

The materials transported through the ropeway fed into the hopper and the transported to the stockyard through the belt conveyor. Mined material are accumulated in layers one over the other for several days. Each day, from the stockyard reclaimer extracts the materials as cross section wise thereby obtaining the homogeneous material. This is fed to a hopper through a belt conveyor. Limestone and Late rite are also conveyed through a belt conveyor. After crushing into required size the mixture is fed into the respective hopper.

3.3 RAW MATERIAL GRADING, BLENDING AND STORAGE

The above three materials which in separate hoppers are mixed in required ration controlled by master Rate Setter (MRS). This mixture is fed to the row mill.

The raw mill consists of three chambers—a drying chamber and two grinding chambers. In drying chamber the materials dried using hot gas from the kiln, these materials are grinded in the grinding chambers using grinding media balls. The grinded material is centrally discharged through the air slides and bucket elevator is used to transport it to the turbo air separator which separates the material into fine and coarse particles. The coarse particles are again fed to the grinding chamber of the raw mill and fine particles are transported to the Silo through the belt bucket elevator.

The Silo has two sections. In blending section the powered materials are blended for hours using compressed air and analyzed. If any deviation occurred un proportional ratio, a control signal is fed back to the MRS to correct the proportional ratio. The material is then stored in storage section.

The stored powered materials from the Silos are extracted by the pneumatic valves and are fed through the bucket elevator to the weighing hopper which weighs the powered material. From the weighing hopper the
material is fed to the weigh feeder. The weigh feeder feeds the materials to the top part of the pre-heater through the belt bucket elevator.

### 3.4 CLINKERISATION

Materials fed to the pre-heater tower are allowed to pass through a four stage suspension pre-heater which consists of several cyclones. The cyclonic action is generated with the help of suction of pre-heater fan. The hot gases from the kiln are sucked and passed such that the materials are heated to a temperature of about 300 to 400 °C at the top and 900 to 1000 °C at the bottom.

Due to gravitational effect in the material discharged downwards are fed to the kiln. Kiln is a hollow cylinder with refractory lining rotating at variable speed. Inside the kiln the materials undergo various reactions. The process taking place inside the kiln is called calcinations. Inside the kiln the temperature is about 1300 to 1400 °C. The product obtained from the kiln is called clinker. Grate cooler cools the clinker to a temperature of about 100 to 150 °C. The clinker is transported to the stockpile through bucket conveyor and stored there.

### 3.5 COAL GRINDING AND STORAGE

The main fuel used to produce clinker is coal. Coal from the coal stockyard is fed to the crusher with the help of belt conveyors. The crusher reduces the size of the coal and feed to the hopper. This is extracted from the hopper and fed to the coal mill. The grinding media ball inside the coal mill grinds the coal and is fed to the grind separator. It separates the coarse and fine particles. The coarse particles are again fed to the coal mill. The fine coal is then fed into a weigh hopper through a screw feeder. The fine coal from the weigh feeder is pumped to the kiln using a primary fan.

### 3.6 GRINDING AND STORAGE

In MCL three types of cement are manufactured. They are Malabar super OPC 43 grade cement, Malabar Classic PPC (Portland Pozzolona Cement) and Malabar Classic 25-30% fly ash and 50% gypsum is added with clinker to get the mixture. Malabar Aishwarya, which is slag cement used in coastal areas, to resist the corrosion, is not extensively manufactured here. The mixture of fly ash and gypsum is mixed with required quantity and it is grinded using media balls. As a result
temperature is developed inside the cement mill. If the temperature exceeds 120\(^{0}\)C the property of the cement may be changed. To prevent this, a water spraying system is provided using a PID controller and a motorized valve is employed. Then the material from the cement mill is fed to the separator which separates the fine and coarse particles. The fine particles are conveyed using bucket elevator or pneumatic pump to cement Silos. The coarse particles are again fed to the mill inlet for further grinding.

### 3.7 CEMENT PACKING AND LOADING

The cement from the Silos are extracted and fed to the rotary screen through bucket elevators. The screen removes the metal parts in the cement. Cement is then fed to the hopper in the packing section. There are two types of packers in MCL.

- **Electronic Packer**
  
  It employs the cement is weighed using load cell and microprocessor based controllers.

- **Mechanic Packer**
  
  It employs the dead weight weighing. Cement is packed in bags of 50 kg are transported through belt conveyors and loaded in trucks and wagons.
4. PLC(PROGRAMMABLE LOGIC CONTROLLER)

A programmable logic controller (PLC) or programmable controller is 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. 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.

4.1 ADVANTAGES OF PLC

- **Reduced Space**

  PLCs are fully solid state and hence extremely compact as compared to hard-wired controller wherein electromechanical devices are used.

- **Energy Saving**

  Average power consumption is just 1/10th of power consumed by an equivalent Relay logic control.

- **Ease of maintenance**

  Modular replacement

  Easy trouble shooting

  Error diagnostics with programmer

- **Economical**

  Considering one time investment PLC is most economical system. Cost of PLC recovers within a short period low pay back period).

- **Greater life and reliability**

  It is a static device hence lesser number of moving parts reduces wear and tears. In the case of hard-wired logic the control, hardware is either electromechanical or pneumatic and therefore it is more prone to faults due to wear and tear of moving parts resulting in lesser ON TIME of the system.

- **Tremendous Flexibility**
To implement changes in control logic no wiring is required so considerable time is saved.

- **Advanced Computation Supported**

PLC can carry out complex functions such as generation of time delays, counting, comparing arithmetic operations etc.

- **Programming Mode**

“On Line” (i.e. without disturbing the process) as well as” OFF Line” programming is possible.

- **Speed and Flexibility**

It gives high processing speed and great flexibility in the processing of both analog and digital signals.

- **Closed Loop Control Supported**

Suitability for closed loop tasks with several loops and high sampling frequencies.

- **Shorter Project Time**

The hard-wired control system can be constructed only after the task is fully defined. In the PLC, however, the construction of the controller and wiring are independent of control program definition. This means that the total hardware is standard and desired control is achieved through program.

- **Easier Storage Archiving and Documentation.**

This is due to its compatibility with PC/AT, Printer and floppy disk.

**4.2 TYPICAL AREAS OF APPLICATION**

Since its inception, the programmable controller has been successfully applied in virtually every segment of industry including steel mills, paper and pulp plants, food processing, chemical and petroleum plants and automotive and power plants. PLCs perform a great variety of control tasks, from repetitive ON/OFF control of a simple machine to sophisticated manufacturing and process control.

In industry, there are many production tasks, which are of highly repetitive nature. Although repetitive and monotonous, each stage needs careful attention of operator to ensure good quality of final product. Many a times, close supervision of processes cause high fatigue on operator resulting in loss of track of process
control. Sometimes it is hazardous also as in the case of potentially explosive chemical process. Under all such conditions we can use PLCs effectively in totally eliminating the possibilities of human error.

Few examples of industries where PLCs are used for control and automation purpose are listed below;

Tyre Industry, Blender reclaimer, Bulk material handling system at ports, Ship unloader, WAGON LOADERS, Steel plants- Blast furnace charging, Brick molding press in refractory, Galvanizing plant, Dairy automation, Pulp factory, Printing Industry etc.

Today the PLCs are used for control and automation job in a single machine and it increases up to full automation/testing process in a factory.

4.3 PROCESSOR INFORMATION

Processor Type: 1747-L541C 5/04 CPU - 16K Mem. OS401 Series C
Processor Name: COOLER
Total Memory Used: 731 Instruction Words Used - 84 Data Table Words Used
Total Memory Left: 11557 Instruction Words Left
Program Files: 7
Data Files: 9
Program ID: 3081

4.4 I/O CONFIGURATION

0 1747-L541C 5/04 CPU - 16K Mem. OS401 Series C
1 1746-IM16 16-Input 200/240 VAC
2 1746-IM16 16-Input 200/240 VAC
3 1746-OW16 16-Output (RLY) 240 VAC
4 1746-OW16 16-Output (RLY) 240 VAC
5 1746-IM16 16-Input 200/240 VAC
6 1746-NI4 Analog 4 Channel Input Module
4.5 SOFTWARE USED- RSLOGIX 500

Supporting the Allen-Bradley SLC 500 and Micrologix families of processors, RSLogix 500 was the first PLC programming software to offer unbeatable productivity with an industry-leading user interface.

RSLogix 500 software offers:

- flexible, easy-to-use editors
- diagnostics and troubleshooting tools
- powerful, time saving features & functionality.
- A word class user interface designed for first time power users.
5. CLINKER COOLER

Clinker coolers are classified into different types based on their design and operation. They are:

1. Rotary coolers
   a. Tube coolers
   b. Planetary coolers
2. Grate coolers
   a. Travelling grate coolers
   b. Reciprocating grate coolers
3. Vertical coolers
   a. Gravity coolers

5.1 GRATE COOLER

Grate coolers are extensively used in cement industry to recover heat from hot clinkers coming out of rotary kilns. Heat transfer in coolers indirectly controls the performance of the rotary kiln and is therefore crucial in a cement industry. The outlet temperature of hot clinkers and a part of melt coming out from the rotary kiln is approximately 1673 K. These hot clinkers should be cooled to a temperature around 400 K, by recovering heat from them, which can be used for any other process. In the same time the combustion air required for the burning process should be preheated to a temperature level such that the fuel consumption for clinker formation in the rotary kiln is minimum. So to fulfil both the purposes grate coolers are used in cement industries.

Cooling in a grate cooler is achieved by passing a current of air upwards through a layer of clinker bed lying on the air-permeable grate. So the cooler acts as a pre-heater unit for the air used for coal combustion in rotary kiln and calciner. The energy consumption in the cooler is governed by the energy required to drive the clinker bed and the heat losses to the surroundings from the cooler. The clinker bed can be transported using two types of grates: Travelling grate or Reciprocating grate. In travelling grate coolers a travelling grate transports clinker. On the other hand in reciprocating grate coolers clinker is transported by stepwise pushing of the clinker bed by the front edge of alternate row plates. For a given mechanism in the cooler the energy required for the motion of clinker bed is more or less constant. Therefore, the efficiency of cooler mainly depends on how effectively the heat is recovered from the clinkers and the losses from the cooler surface (conduction, convection, radiation) to surroundings. Clinker temperature variation in the
cooler has an important influence on the quality of the cement produced from the plant. An efficient cooler will be in which outlet temperature of the clinker is minimum with suitable properties. So to improve the efficiency of the cooler used in cement industries we should choose optimum cooling air rate, clinker input rate, Clinker inlet temperature, cooler length, number of openings for air, and grate speed.

5.1.1 TRAVELLING GRATE COOLERS

Clinker transport with this cooler type is by a travelling grate. Cooling air is pressurised by fans discharging into compartments underneath the grate. Advantages of this design are undisturbed clinker layer (no steps) and the possibility of exchanging plates without a kiln stop. Due to mechanical complexity and poor recuperation because of limited bed thickness (caused by difficult sealing between grate and walls), this design was abandoned around 1980.

5.1.2 RECIPROCATING GRATE COOLERS

Material transport in the reciprocating grate cooler takes place by stepwise pushing of the clinker bed by the front edges of each plate row. Relative movement of front edges is generated by hydraulic or mechanical (crankshaft) drives connected to up to every second row. Only the clinker travels from feed end to discharge end, but not the grate. The grate plates are made from heat resistant cast steel and are typically 300 mm wide.
and have holes for the air to pass through them. Cooling air is insufflated from fans at 300 – 1000 mmWG via separate undergratecompartments which are required to maintain the pressure profile. Two cooling zones can be distinguished:

- the recuperation zone, from which the hot cooling air is used for combustion of the main burner fuel (= secondary air) and the precalcer fuel (= tertiary air);
- the after cooling zone, where additional cooling air cools the clinker safely to lower temperatures.

The largest units in operation have about 280 m² active surface and cool 10,000 t/dof clinker. Typical problems with these coolers are segregation and uneven clinker distribution leading to air-clinker imbalance, fluidization of fine clinker (red river) and also build-ups(snowmen) and worse than ideal life of plates.

The essential parts of a reciprocating grate cooler are:-

- Grate plates
- Cooling fans(quenching fan, cooling fan 2,cooling fan 3,cooling fan 4 with variable frequency ac drive)
- Drag chain conveyor
- Clinker crusher
- Spray cooler system

5.1.2.1 GRATE PLATES

The cooler grate is composed of overlapping rows of perforated grate plates. Half of the rows are static, fixed to the casing of the cooler. The alternate rows are carried on a movable frame to which a reciprocating movement is imparted by an eccentric drive or hydraulic rams .The series of grate plates are divided into cooler1 and cooler2 which are driven by corresponding drives.

5.1.2.2 COOLING FANS

- **Cooling fan1:** It is provided at the immediate outlet of the kiln and is otherwise known as the quenching fan since this fan will rapidly reduce the clinker temperature from 1450 °C to about 900 °C. It is driven by DC drive.
- **Cooling fan 2 and 3:** The are ordinary cooling fans run at constant speed(40%) like cooling fan 1 and are also driven by DC motors.
• **Cooling fan 4(VFD):** It is run using a variable frequency drive and its speed can be varied with respect to the load and cooler temperature.

### 5.1.2.3 VARIABLE FREQUENCY DrIVES

Adding a variable frequency drive (VFD) to a motor-driven system can offer potential energy savings in a system in which the loads vary with time. VFDs belong to a group of equipment called adjustable speed drives or variable speed drives. (Variable speed drives can be electrical or mechanical, whereas VFDs are electrical.) The operating speed of a motor connected to a VFD is varied by changing the frequency of the motor supply voltage. This allows continuous process speed control.

Motor-driven systems are often designed to handle peak loads that have a safety factor. This often leads to energy inefficiency in systems that operate for extended periods at reduced load. The ability to adjust motor speed enables closer matching of motor output to load and often results in energy savings.

A variable frequency drive is a device used in a drive system consisting of the following three main sub-systems: AC motor, main drive controller assembly, and drive operator interface.

![Diagram of a variable frequency drive](image)

**FIG 5.2 VARIABLE FREQUENCY DRIVE**

The **AC electric motor** used in a VFD system is usually a three-phase induction motor. Some types of single-phase motors can be used, but three-phase motors are usually preferred. Various types of synchronous motors offer advantages in some situations, but three-phase induction motors are suitable for most purposes and are generally the most economical choice. Motors that are designed for fixed-speed operation are often used.

The **variable frequency drive controller** is a solid state power electronics conversion system consisting of three distinct sub-systems: a rectifier bridge converter, a direct current (DC) link, and an inverter. Voltage-source inverter (VSI) drives are by far the most common type of drives. Most drives are AC-AC drives in...
that they convert AC line input to AC inverter output. However, in some applications such as common DC bus or solar applications, drives are configured as DC-AC drives. The most basic rectifier converter for the VSI drive is configured as a three-phase, six-pulse, full-wave diode bridge. In a VSI drive, the DC link consists of a capacitor which smooth’s out the converter's DC output ripple and provides a stiff input to the inverter. This filtered DC voltage is converted to quasi-sinusoidal AC voltage output using the inverter's active switching elements. VSI drives provide higher power factor and lower harmonic distortion than phase-controlled current-source inverter (CSI) and load-commutated inverter (LCI) drives. The drive controller can also be configured as a phase converter having single-phase converter input and three-phase inverter output.

The operator interface provides a means for an operator to start and stop the motor and adjust the operating speed. Additional operator control functions might include reversing, and switching between manual speed adjustment and automatic control from an external process control signal. The operator interface often includes an alphanumeric display and/or indication lights and meters to provide information about the operation of the drive. An operator interface keypad and display unit is often provided on the front of the VFD controller. The keypad display can often be cable-connected and mounted a short distance from the VFD controller. Most are also provided with input and output (I/O) terminals for connecting pushbuttons, switches and other operator interface devices or control signals. A serial communications port is also often available to allow the VFD to be configured, adjusted, monitored and controlled using a computer.

5.1.2.4 DRAG CHAIN CONVEYOR

Drag chain conveyor is used to transport the fine clinker particles that fall through the grate holes of the grate plates. The drag chain is equipped with a drive/motor to convey the cooled fine particles into the stock pile.
5.1.2.5 CLINKER CRUSHER

The coarse clinker that remain on the grate plates are crushed to fine particles by the clinker crusher. These fine particles are then conveyed to the stock pile.

5.1.3 WORKING

Reciprocating grate cooler is one of main equipments for cement production burning system; its function is cooling hot clinker, reclaiming clinker sensible heat and conveying clinker. It works in a condition of high temperature and variability.

The cooler grate is composed of overlapping rows of perforated grate plates. Half of the rows are static, fixed to the casing of the cooler. The alternate rows are carried on a movable frame to which a reciprocating movement is imparted by an eccentric drive or hydraulic rams. The overlying bed of clinker is pushed forward on the forward stroke, and the plates slide beneath the bed on the return stroke. Fine clinker can fall through the grate holes, and so the under-grate chamber contains drag-chain conveyor(s) to move the spillage to the outlet end of the cooler. For most of its history, a crusher, usually in the form of a hammer mill, has been placed at the end of the cooler. Larger clinker lumps, with a low surface area, are less effectively cooled, and having been crushed, the rotary action of the hammer mill hurls the fragments back up the cooler for further cooling.
The under-grate chamber is generally divided into a number of compartments, each with its own fan, which can be separately pressurised. The chamber above the grate is refractory lined. Areas of cold, "dead" clinker are provided at the sides of the grate to protect those areas from over-heating. The hot air emerging from the bed passes out to the kiln, and the hot-end grate pressure is controlled to provide a small negative pressure in the kiln hood. Because, in general, more air passes through the grate than can be used by the kiln, outlet ducts are provided on the side of the cooler parts of the over-grate chamber. The hot air passing out through these may be used productively for process operations - e.g. for fuel or raw material drying - or may simply be run to waste through an exhaust stack. The hot air is inevitably heavily loaded with fine clinker grit, and so some sort of gas cleaning is provided prior to the stack. Both sloping and horizontal grates may be used. The original design had a 12° slope. Since all kilns, irrespective of process, deliver clinker at around 1300°, the size of cooler required is solely related to the expected kiln output, and grates are typically designed for a loading of 30 t/d per m² - i.e. a kiln making 1800 t/d would require a grate area of 60 m².

FIG 5.5 WORKING
FIG 5.6 SCHEMATIC DIAGRAM OF GRATE COOLER

CL1: COOLER 1
CL2: COOLER 2
CF1(QF): COOLING FAN 1/QUENCHING FAN
CF2: COOLING FAN 2
CF3: COOLING FAN 3
CF4(VFD): COOLING FAN 4 WITH VARIABLE FREQUENCY DRIVE
CRSHR: CLINKER CRUSHER
DRG CHN: DRAG CHAIN
5.1.4 SPRAY COOLER

The spray cooler is the emergency cooling system used when the temperature of the clinker exiting the grate cooler is still greater than 600 °C. The temperature at the exit is sensed by a ‘J type THERMOCOUPLE’. The system is equipped with a water tank, spray pump, a level switch to detect when water level in the tank is low, flow switch to check flow of water through the pump, 3 temperature control valves which are opened when clinker temperature exceeds the limit and a flow nozzle to spray water. The flow switch is activated when there is no flow through the pump and generates alarm. Level switch is activated when the water level in the tank is low and generates the corresponding alarm. There is a 3 way valve to provide bypass to the tank which is pneumatically actuated. The other 2 valves are 2 way valves out of which one is pneumatically actuated and the other is electrically actuated. There is a pressure switch used to generate the alarm when the pressure in the compressor is low.

FIG 5.7 SPRAY COOLER
5.1.5 SENSORS

5.1.5.1 THERMOCOUPLE

J type thermocouple is used near to the exit portion of grate cooler system to measure the temperature. The output of thermocouple is used to actuate the spray cooler system under emergency conditions. Type J (iron–constantan) has a more restricted range than type K (−40 to +750 °C), but higher sensitivity of about 55 µV/°C. The Curie point of the iron (770 °C) causes an abrupt change in the characteristic, which determines the upper temperature limit.

5.1.5.2 RF LEVEL DETECTOR

Capacitance level detectors are also referred to as radio frequency (RF) or admittance level sensors. They operate in the low MHz radio frequency range, measuring admittance of an alternating current (ac) circuit that varies with level. Admittance is a measure of the conductivity in an ac circuit, and is the reciprocal of impedance. Admittance and impedance in an ac circuit are similar to conductance and resistance in a direct current (dc) circuit. In this chapter, the term capacitance level sensor will be used instead of RF or admittance. Capacitor consists of two conductors (plates) that are electrically isolated from one another by a nonconductor (dielectric). When the two conductors are at different potentials (voltages), the system is capable of storing an electric charge. The storage capability of a capacitor is measured in farads. As shown in Figure 8-1, the capacitor plates have an area (A) and are separated by a gap (D) filled with a nonconducting material (dielectric) of dielectric constant (K). The dielectric constant of a substance is proportional to its admittance. The lower the dielectric constant, the lower the admittance of the material. Capacitance is calculated as $C = \frac{KA}{D}$

If the area (A) of and the distance (D) between the plates of a capacitor remain constant, capacitance will vary only as a function of the dielectric constant of the substance filling the gap between the plates. If a change in level causes a change in the total dielectric of the capacitance system, because (as illustrated in Figure 8-1B) the lower part of area (A) is exposed to a liquid (dielectric $K_l$) while the upper part is in contact with a vapor (dielectric $K_v$, which is close to 1.0), the capacitance measurement will be proportional to level.
5.1.5.3 BELLOWS TYPE PRESSURE SENSOR

A pressure switch is used to detect the presence of fluid pressure. Most pressure switches use a diaphragm or bellows as the sensing element. The movement of this sensing element is used to actuate one or more switch contacts to indicate an alarm or initiate a control action.

5.1.5.4PADDLE TYPE FLOW SWITCH

Gas or Liquid flow is sensed by the freely suspended disc via bellows-sealed designs which create the movement of Disc against the force. A precision spring guarantees repeatability and high effectiveness of operation. To ensure positive isolation between switch assembly and process fluid, bellows is sealed. Flow Paddle Switches are repeatedly tested for maximum pressure of 10 Bar and are highly suitable for temp. up to 200°C. The process connection for Paddle type is 1" BSP (M) standard and for on-line type is ½" BSP (F) std.
5.1.6 BLOCK DIAGRAM
5.1.7 TABLE OF INPUTS AND OUTPUTS

<table>
<thead>
<tr>
<th>SL NO</th>
<th>DESCRIPTION</th>
<th>TAG NO</th>
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</thead>
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<tr>
<td>1</td>
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<td>2</td>
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<td>M1101_LSP</td>
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<tr>
<td>3</td>
<td>QUENCHING FAN FEEDBACK</td>
<td>M1101_FB</td>
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<tr>
<td>4</td>
<td>QUENCHING OVERLOAD</td>
<td>M1101_Ol</td>
</tr>
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<td>5</td>
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<td>M1103_LST</td>
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<tr>
<td>7</td>
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<td>M1 103_FB</td>
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</tr>
<tr>
<td>36</td>
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<td>M4 111_Ol</td>
</tr>
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<td>37</td>
<td>DRAG CHAIN MOTOR ZERO SPEED</td>
<td>M4 111_ZS</td>
</tr>
<tr>
<td>38</td>
<td>SPRAY COOLER PUMP LOCAL START</td>
<td>M1205_LST</td>
</tr>
<tr>
<td>39</td>
<td>SPRAY COOLER PUMP LOCAL STOP</td>
<td>M1205_LSP</td>
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<td>40</td>
<td>SPRAY COOLER PUMP FEEDBACK</td>
<td>M1205_FB</td>
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<td>41</td>
<td>SPRAY COOLER PUMP OVERLOAD</td>
<td>M1205 OL</td>
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<td>42</td>
<td>AIR PRESSURE SWITCH ON</td>
<td>PS206_ON</td>
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<td>43</td>
<td>FLOW SWITCH ON</td>
<td>FS207_ON</td>
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**ANALOG INPUT**

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<td>1</td>
<td>COOLING FAN 4 SPEED</td>
<td>M2105_SD</td>
</tr>
<tr>
<td>2</td>
<td>COOLER 1 DRIVER SPEED</td>
<td>M3106_SD</td>
</tr>
<tr>
<td>3</td>
<td>COOLER 2 DRIVER SPEED</td>
<td>M3107_SD</td>
</tr>
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<td>4</td>
<td>TEMPERATURE TRANSMITTER</td>
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**DIGITAL OUTPUT**

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<tr>
<td>1</td>
<td>QUENCHING FAN COIL OUTPUT</td>
<td>M101_CO</td>
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<tr>
<td>2</td>
<td>COOLING FAN2 COIL OUTPUT</td>
<td>M1103_CO</td>
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<td>3</td>
<td>COOLING FAN3 COIL OUTPUT</td>
<td>M1104_CO</td>
</tr>
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<td>4</td>
<td>COOLING FAN4 COIL OUTPUT</td>
<td>M1105_CO</td>
</tr>
<tr>
<td>5</td>
<td>COOLING FAN4 INCREASING SPEED</td>
<td>M2105_IS</td>
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<td>6</td>
<td>COOLING FAN4 DECREASING SPEED</td>
<td>M2105_DS</td>
</tr>
<tr>
<td>7</td>
<td>COOLER 1 DRIVER COIL OUTPUT</td>
<td>M3106_CO</td>
</tr>
<tr>
<td>8</td>
<td>COOLER 1 DRIVER INCREASING SPEED</td>
<td>M3106_IS</td>
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<td>9</td>
<td>COOLER 1 DRIVER DECREASING SPEED</td>
<td>M3106_DS</td>
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<td>10</td>
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<td>M3107_CO</td>
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<td>11</td>
<td>COOLER 2 DRIVER INCREASING SPEED</td>
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<td>12</td>
<td>COOLER 2 DRIVER DECREASING SPEED</td>
<td>M3107_DS</td>
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<td>CLINKER CRUSHER COIL OUTPUT</td>
<td>M4109_CO</td>
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<td>TEMPERATURE CONTROL VALVE(3 WAY) ON</td>
<td>TCV202_ON</td>
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<td>15</td>
<td>TEMPERATURE CONTROL VALVE1(2 WAY) ON</td>
<td>TCV1203_ON</td>
</tr>
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<td>16</td>
<td>TEMPERATURE CONTROL VALVE2(2 WAY)ON</td>
<td>TCV2204_ON</td>
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<td>17</td>
<td>DRAG CHAIN MOTOR COIL OUTPUT</td>
<td>M4111_CO</td>
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<td>18</td>
<td>SPRAY COOLER PUMP COIL OUTPUT</td>
<td>M1205_CO</td>
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</table>
5.1.8 FLOWCHART

start

Level switch=1(low)

YES

Alarm on

NO

Pressure switch=1(low)

YES

Alarm on

NO

Spray pump on

Flow switch=1(low)

YES

Alarm on

NO

Overload=1 or stop=1(quenching fan and 2 cooling fans)

YES

Stop quenching fan and 2 cooling fans

NO

Quenching fans on, 2 cooling fans on

Overload=1 or stop=1(drag chain, crusher, cooler1, cooler 2, 3rd cooling fan)

YES

Stop all motors

1
Run 3$^{rd}$ cooling fan at 40% speed

Feedback = 1

Cooling fan speed = sp

Speed > sp

Cooler 2 speed = sp

Speed > sp

Cooler 1 speed = sp

Speed > sp

Cooler temperature > sp

Temperature control valves off

end
5.1.8.1 EXPLANATION OF FLOWCHART

- The level is checked. If it is low, the alarm turns on.
- The pressure is checked. If it is low, the alarm turns on.
- The spray pump is turned on.
- The flow is checked. If the flow is low, the alarm turns on.
- The running sequence of cooler parts are fixed as cooling fan1,2,3&4, drag chain, clinker crusher, cooler1 & cooler2. The stopping sequence is in the reverse order. This is so that the motion of the parts are not obstructed by the clinker remains if any.
- The overload and stop criteria of the quenching fan and two cooling fans are checked. If both are on the quenching fan and the two cooling fans are turned off. Otherwise it is turned on.
- The overload and stop criteria of the drag chain, crusher, cooler1, cooler2, and the third cooling fan are checked. If both are on the drag chain, crusher, cooler1, cooler2, and the third cooling fan are turned off. Otherwise it is turned on.
- Drag chain is turned on. Zero speed is checked. If it is on, the drag chain is turned off. If zero speed is off, a feedback is given and then delay is given.
- Clinker crusher is turned on. Zero speed is checked. If it is on, the drag chain is turned off. If zero speed is off, a feedback is given and then delay is given.
- Cooler 2 is turned on. Zero speed is checked. If it is on, the drag chain is turned off. If zero speed is off, a feedback is given and then delay is given. Similarly, cooler 1 is turned on.
- Run the third cooling fan at 40% speed. Then a feedback is given and then the cooling fan is turned off.
- The cooling fan is given the set point speed. If the speed is greater than the set point speed then a decreasing speed is given otherwise an increasing speed is given.
- Cooler 2 is given the set point speed. If the speed is greater than the set point speed then a decreasing speed is given otherwise an increasing speed is given. The same check is done for cooler 1 also.
- If the cooler temperature is greater than the set point, temperature control valves are open otherwise it is closed.
6. LADDER DIAGRAM

FIG 6.1 MAIN PROGRAM 1
FIG 6.2 MAIN PROGRAM 2
FIG 6.3 CONTROL 1
FIG 6.4 CONTROL 2
FIG 6.5 ALARM SEQUENCE1
FIG 6.6 ALARM SEQUENCE2
FIG 6.7 ALARM SEQUENCE3
FIG 6.8 ALARM SEQUENCE4
FIG 6.9 ALARM SEQUENCE5
FIG 6.10 ALARM SEQUENCE 6
FIG 6.11 ALARM SEQUENCE 7
FIG 6.12 ALARM SEQUENCE 8
FIG 6.13 ALARM SEQUENCE 9
FIG 6.14 ALARM SEQUENCE 10
FIG 6.15 ALARM SEQUENCE 11
FIG 6.16 ALARM SEQUENCE 12
FIG 6.17 ALARM SEQUENCE13
FIG 6.18 ALARM SEQUENCE14
**FIG 6.19 ALARM SEQUENCE 15**
FIG 6.20  ALARM SEQUENCE 16
FIG 6.21 ALARM SEQUENCE 17
FIG 6.22 ALARM SEQUENCE 18
FIG 6.23 ALARM SEQUENCE 19
FIG 6.24 ALARM SEQUENCE 20
FIG 6.25 ALARM SEQUENCE 21
FIG 6.26 ALARM SEQUENCE 22
FIG 6.27 RUNNING SEQUENCE 1
FIG 6.28 RUNNING SEQUENCE 3
FIG 6.29 RUNNING SEQUENCE 4
FIG 6.30 RUNNING SEQUENCE 5
FIG 6.31 RUNNING SEQUENCE 6
FIG 6.32 RUNNING SEQUENCE 7
FIG6.33 RUNNING SEQUENCE 8
FIG 6.34 RUNNING SEQUENCE 9
FIG 6.35 RUNNING SEQUENCE 10
FIG 6.36 RUNNING SEQUENCE 11
FIG 6.37 RUNNING SEQUENCE 12
FIG 6.38 RUNNING SEQUENCE 13
FIG 6.39 RUNNING SEQUENCE 14
### FIG 6.40 SCALING 1

#### SCALED SPEED CF1

<table>
<thead>
<tr>
<th>SCP CP</th>
<th>Scale w/ Parameters</th>
<th>Input</th>
<th>1:6.0</th>
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<tbody>
<tr>
<td></td>
<td>Input Min.</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input Max.</td>
<td>21000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scaled Min.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scaled Max.</td>
<td>100</td>
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<td></td>
<td>Output</td>
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#### SCALED SPEED CL1

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<th>1:6.1</th>
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<td></td>
</tr>
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<td>Input Max.</td>
<td>21000</td>
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</tr>
<tr>
<td></td>
<td>Scaled Min.</td>
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<td>Scaled Max.</td>
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#### SCALED SPEED CL2

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<td>Input Min.</td>
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<td></td>
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<td></td>
<td>Input Max.</td>
<td>21000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scaled Min.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scaled Max.</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output</td>
<td>N7.2</td>
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FIG 6.41 SCALING 2
A PLC (i.e. Programmable Logic Controller) is a device that was invented to replace the necessary sequential relay circuits for machine control. The PLC works by looking at its inputs and depending upon their state, turning on/off its outputs. The user enters a program, usually via software, that gives the desired results.

PLCs are used in many "real world" applications. If there is industry present, chances are good that there is a plc present. If you are involved in machining, packaging, material handling, automated assembly or countless other industries you are probably already using them. If you are not, you are wasting money and time. Almost any application that needs some type of electrical control has a need for a plc.

For example, let's assume that when a switch turns on we want to turn a solenoid on for 5 seconds and then turn it off regardless of how long the switch is on for. We can do this with a simple external timer. But what if the process included 10 switches and solenoids? We would need 10 external timers. What if the process also needed to count how many times the switches individually turned on? We need a lot of external counters.

As you can see the bigger the process the more of a need we have for a PLC. We can simply program the PLC to count its inputs and turn the solenoids on for the specified time.

This site gives you enough information to be able to write programs far more complicated than the simple one above. We will take a look at what is considered to be the "top 20" PLC instructions. It can be safely estimated that with a firm understanding of these instructions one can solve more than 80% of the applications in existence. That's right, more than 80%! Of course we'll learn more than just these instructions to help you solve almost ALL your potential PLC applications.
The PLC is an assembly of solid-state digital logic elements designed to make logical decisions and provide outputs.

- Sequential logic solver
- PID Calculations.
- Advanced Subroutines
- BIT Operations.
- Data Transfer.
- Text Handling.

A.1.1 APPLICATIONS

Machine controls, Packaging, Palletizing, Material handling, similar Sequential task as well as Process control Advantages of PLC: They are fast and designed for the rugged industrial environment.

They are attractive on Cost-Per-Point Basis.

These Devices are less Proprietary (E.g. Using Open Bus Interface.)

These Systems are upgraded to add more Intelligence and Capabilities with dedicated PID and Ethernet Modules. Disadvantages of PLC: PLC was designed for Relay Logic Ladder and has Difficulty with some Smart Devices.

To maximize PLC performance and Flexibility, a number of Optional Modules must be added

A1.2 PLC TYPES

- Nano (Small)
- Micro (Medium)
- Large

A1.3 BASIC CRITERIA FOR PLC TYPES:

- Memory Capacity
- I/O Range
- Packaging and Cost per Point
• Central Processing Unit (CPU)
• Input Output Modules
• Power Supply
• Bus system
• Programming Device

A1.4 BASICS OF PLC

With the coming of microprocessor and associated peripheral chips, the whole process of control and automation underwent a radical change.

Instead of achieving the desired control or automation through physical wiring of control devices, in the PLC it is achieved through a program or say software.

As desired logic control is achieved through a “program”, these controllers are referred to as Programmable Logic Controllers.

The Programmable Logic Controllers have in recent years experienced an unexpected growth as universal element in industrial automation. It can be effectively used in applications ranging from simple control like replacing small number of relays to complex automation problems.

A1.5 BASIC ARCHITECTURE OF PLC SYSTEM

The PLC mainly consists of a CPU, memory areas, and appropriate circuits to receive input/output data. We can actually consider the PLC to be a box full of hundreds or thousands of separate relays, counters, timers and data storage locations. Do these counters, timers, etc. really exist? No, they don't "physically" exist but rather they are simulated and can be considered software counters, timers, etc. These internal relays are simulated through bit locations in registers. (More on that later)

Fig. A1.2 Architecture of PLC system
A1.6 WHAT DOES EACH PART DO?

A1.6.1 INPUT RELAYS (CONTACTS)-These are connected to the outside world. They physically exist and receive signals from switches, sensors, etc. Typically they are not relays but rather they are transistors.

A1.6.2 INTERNAL UTILITY RELAYS-(contacts) These do not receive signals from the outside world nor do they physically exist. They are simulated relays and are what enables a PLC to eliminate external relays. There are also some special relays that are dedicated to performing only one task. Some are always on while some are always off. Some are on only once during power-on and are typically used for initializing data that was stored.

A1.6.3 COUNTERS-These again do not physically exist. They are simulated counters and they can be programmed to count pulses. Typically these counters can count up, down or both up and down. Since they are simulated they are limited in their counting speed. Some manufacturers also include high-speed counters that are hardware based. We can think of these as physically existing. Most times these counters can count up, down or up and down.

A1.6.4 TIMERS-These also do not physically exist. They come in many varieties and increments. The most common type is an on-delay type. Others include off-delay and both retentive and non-retentive types. Increments vary from 1ms through 1s.

A1.6.5 OUTPUT RELAYS (COILS) -These are connected to the outside world. They physically exist and send on/off signals to solenoids, lights, etc. They can be transistors, relays, or triacs depending upon the model chosen.

A1.6.6 DATA STORAGE-Typically there are registers assigned to simply store data. They are usually used as temporary storage for math or data manipulation. They can also typically be used to store data when power is removed from the PLC. Upon power-up they will still have the same contents as before power was removed. Very convenient and necessary!!

The PLC is basically a programmed interface between the field input elements like limit switches, sensors, transducers, push-buttons etc., and the final control elements like actuators, solenoid valves, dampers, drives, LEDs, hooters etc.

This interface called as Programmable Logic Controllers consist of the following:

- CPU with processor and program memory
- Input modules
- Output modules
- Bus system
- Power supply

The user program directs and controls the CPU’s working. This program is prepared (by the user) based on the control logic required or the control and automation task.

**A1.6.7 CENTRAL PROCESSING UNIT**

The central processing unit or CPU consists of the following blocks:

- Arithmetic Logic Unit (ALU)
- Program Memory
- Process Image Memory (i.e. internal memory of CPU)
- Internal timers and counters
- Flags

The heart of CPU is its microprocessor / microcontroller chip. The working of CPU is fully controlled by the instruction/programs stored in “user program memory”.

The user program directs and controls the CPU’s working. This program is(prepared by the user)based on the control logic required for the control and automation task.

**A1.6.8 POWER SUPPLY**

The power supply generates the voltage required for the electronic modules of the PLC from the mains supply.

**A1.6.9 INPUT MODULES**

The input module acts as an interface between the field control inputs and the CPU. The voltage or current signals generated by the sensors, transducers, limit switches, push buttons etc. are applied to the terminals of the input module.

The input module helps in the following way:

It converts the field signal into a standard control signal for processing by PLC. The standard control signal delivered by input module could be 5V or 9V whereas the field signal received by it could be 24V DC, 110V AC or 230V AC.
If required, it isolates the field signal from the CPU.

It sends one input at a time to CPU by multiplexing action.

Depending upon the nature of input signal coming from the field, the input module could be

- Analog Input module
- Digital Input Module.

The typical analog current input modules are 4+-20Ma, 0+-20Ma and analog voltage input modules are 0+-50Mv, 0+-500Mv and 0+-10v. The typical digital input modules are 24V DC, 115V AC and 230V AC.

**A1.6.10 OUTPUT MODULE**

The output module acts as a link between the CPU and the output devices located in the field. The field devices could be relays, contactors, lamps, motorized potentiometers, actuators, solenoid valves, dampers etc. These devices actually control the process. The output module converts the output signal delivered by the CPU into an appropriate voltage level suitable for the output field device. The voltage signal provide by CPU could be 5v or 9V, but the output module converts this voltage level into say 24V DC or 115V AC or 230V AC etc. Thus the output module on receiving signal from the processor switches voltage to the respective output terminals. This makes the actuators(i.e. contactors, relays etc.)Or indicating lights etc.connected to the terminal to come ON or OFF. Like input module, an output module could be an analog or digital.

The selection is based on the voltage rating of the field output devices. If the output device is analog, then analog output module is required and if it is digital like contactors coil or a lamp then a digital output module is required.

Typical analog modules have the ratings of 4+-20mA or 0+-10V and the signal output modules have 24V DC, 115v AC, and 230V AC or relay output.

**A1.6.11 BUS SYSTEMS**

Bus system is the path for the transmission of signals. In the programming controllers, it is responsible for signal exchange between processor and input/output modules. The bus comprises of several single lines i.e. wires/tracks.

There are three buses in a PLC.
Address bus, which enables the selection of a memory location or module.

Data bus, which carries the data from modules to processor and vice versa.

Control bus, which transfers control and timing signals for the synchronization of the CPU’s active within the programmable controller.

**A1.6.12 OTHER MODULES**

In addition to the above listed modules, the other frequently used modules for special function that go with PLCs are interfacing Module, Communication processor and Counter module.

**A1.7 PLC OPERATION**

A PLC works by continually **scanning** a program. We can think of this scan cycle as consisting of 3 important steps. There are typically more than 3 but we can focus on the important parts and not worry about the others. Typically the others are checking the system and updating the current internal counter and timer values.

![Fig.A1.3 PLC Operation](image)

**STEP 1- CHECK INPUT STATUS**- First the PLC takes a look at each input to determine if it is on or off. In other words, is the sensor connected to the first input on? How about the second input? How about the third... It records this data into its memory to be used during the next step.

**STEP 2- EXECUTE PROGRAM**- Next the PLC executes your program one instruction at a time. Maybe your program said that if the first input was on then it should turn on the first output. Since it already knows which inputs are on/off from the previous step it will be able to decide whether the first
output should be turned on based on the state of the first input. It will store the execution results for use later during the next step.

STEP 3 - UPDATE OUTPUT STATUS - Finally the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step. Based on the example in step 2 it would now turn on the first output because the first input was on and your program said to turn on the first output when this condition is true.

After the third step the PLC goes back to step one and repeats the steps continuously.
A1.8 INSTRUCTION SET USED IN PLC LADDER PROGRAMMING

AB PLCs have a variety of instructions for efficient programming of various problems. The instructions are broadly grouped under certain types.

A1.8.1 RELAY TYPE INSTRUCTIONS

These instructions are used to monitor and control the status of bits in the data table such as input bits or timer control-word bits. With these instructions we can address bits in all sections of data storage. Some are

- **Examine If Open (XIO):**

  ![Fig.A1.4.Examine if Open](image)

  The XIO instruction is used in ladder program to determine if a bit is OFF. When the instruction is executed, if the bit addressed is off (0), then the instruction is evaluated as true. When the instruction is executed, if the bit addressed in ON (1), then the instruction is evaluated as false.

- **Examine If Closed (XIC)**

  ![Fig A1.5 Examine if closed](image)

  The XIC instruction is used in ladder program to determine if a bit is ON. When the instruction is executed, if the bit addressed is ON (1), then the instruction is evaluated as true. When the instruction is executed, if the bit addressed in OFF (0), then the instruction is evaluated as false.

- **Output Energize (OTE)**

  ![Fig. A1.6 Output energize](image)

  OTE instruction is used in ladder program to turn ON a bit in memory or output terminal when rung conditions are evaluated as true. OTE instructions are reset when we enter or return to the REM Run or REM Test mode or power is restored or the OTE is programmed within an inactive or false Master Control Reset zone.

- **OUTPUT LATCH (OTL) AND OUTPUT UNLATCH (OUT)**

  ![Fig.A1.7 Output latch and Output unlatch](image)
OTL and OUT are retentive output instructions. OTL can only turn ON a bit, while OUT can only turn OFF a bit. These instructions are usually used in pairs, with both instructions addressing the same bit. When rung conditions become false (after being true), the bit remains set (for OTL) or reset (for OUT) and the corresponding output device remains energized or de-energized until it is reversed by the other instruction.

### A1.8.2 TIMER INSTRUCTIONS

Timers are used to control operations based on time or number of events. The length of time between the moment the processor enables a timer instruction and the moment the processor completes the timed interval is known as Timer Accuracy. Common timer instructions are

- **Timer On-Delay (TON)**

  ![Fig. A1.8 Timer On-Delay](image)

  TON instruction delays the turning ON or OFF of an output. The TON instruction begins to count base intervals when rung conditions become true. As long as rung conditions remain true, the timer increments its accumulated value (ACC) for each scan, until it reaches the present value (PRE). The accumulated value is reset when rung conditions go false, regardless of whether the timer has timed out. TimerDone bit (DN) is set when accumulated value is equal to or greater than the present value. Timer Enable bit (EN) is set when accumulated value is less than the present value.

- **Timer Off-Delay (TOF):**

  ![Fig. A1.9 Timer Off-Delay](image)

  ACCUMULATOR 00.00

  Timer Off-Delay
The TOF instruction delays turning ON or OFF an output. The TOF instruction begins to count time base intervals when the rung makes a true-to-false transition. As long as rung conditions remain false, the timer increments its accumulated value (ACC) for each scan until it reaches the preset value (PRE). The controller resets the accumulated value when rung conditions go true regardless of whether the timer has timed out. Timer Done Bit (DN) is set when rung conditions are true and remains set until rung conditions go false and the accumulated value is greater than or equal to the preset value. Timer Timing Bit (TT) is set when rung conditions are false and the accumulated value is less than the preset value. Timer enable Bit (EN) is set when rung conditions are true.

A1.8.3 COUNTER INSTRUCTIONS:

Counters are used to count a specific number of events. Some counter related Instructions are:

- **Count Up (CTU):**

  The CTU is an instruction that counts false-to-true transitions. Rung transitions can be caused by events occurring in the program (from internal logic or by external filed devices) such as parts travelling past a detector or actuating a limit switch. When rung conditions for a CTU instruction have made a false-to-true transition, the accumulated value is incremented by one count, provided that the rung containing the CTU instruction is evaluated between these transitions. This depends on the speed (frequency) of the incoming signal. The accumulated value is retained when the rung conditions again become false and remains until cleared by a reset (RES) instruction even when power is gone. The Done Bit (DN) is set when accumulated value is equal to or greater than the preset value. The Count Up Enable bit (CU) remains set whenever rung conditions are true or a reset instruction disables it.

![Fig. A1.10 Counter Up](image-url)
• Count down (CTD):

CTD

COUNT DOWN

Counter C5:2
Preset 10
Accumulator 0

( ) ______ ) DN

Fig. A1.11 Counter Down

This instruction also counts false-to-true rung transitions. When rung conditions for a CTD instruction have made a false-to-true transition, the accumulated value is determined by one count, provided that the rung containing the CTD instruction is evaluated between these transitions. The accumulated counts are retained when the rung conditions again become false and remain until cleared by a reset (RES) instruction even when the power is gone. The Done bit (DN) is set when accumulated value is equal to or greater than the preset value. The Count Enable bit (CD) is set when rung conditions are true and remains set until rung conditions go false or a reset instruction disables it.

• Reset (RES)

Fig. A1.12 Reset

A RES instruction is used to reset a timer or counter. When the RES instruction is executed, it resets the data having the same address as the RES instruction.

A1.8.4 COMPARE INSTRUCTIONS

Compare instructions are used to test pairs of values to conditions the logical continuity of a rung. They let us compare values using an expression or a specific comparison instruction. Data of various data types could be compared. Parameters may be program constants, or logical addresses of values to be compared. Some of compare instructions are

• Compare (CMP)
This is an input instruction which perform a comparison on given expression. If the instruction is true the rung goes true. Operators like =, >, <=, >=, +, -, *, /, <>, - (negate), SQR, ** (exponent) etc. could be used. Conversions like FRD (BCD to binary) and TOD (binary to BCD) are also available.

- Equal to (EQU)

```
EQUAL
Source A T4:1Acc
Source B 30.0
```

fig A1.14 Equal To

The EQU instruction is used to test whether two values are equal. If source A and source B are equal, the instruction is logically true. If these values are not equal, the instruction is logically false.

Limit Test (LIM)

```
LIM
LIMIT TEST (CTRC)
Low Limit 15
TEST T4:2 ACC
High Limit 100
```

fig A1.15 Limit Test

The LIM instruction is used to test for values within or outside a specified range, depending on how the limits are set. The low Limit, Test, and High Limit values can be word addresses or constants. If the Low Limit has a value equal to or less than the High Limit, the Instruction is true when the Test value is between the limits or is equal to either limit. If the test value is outside the limits, the instruction is false. If the Low Limit has a value greater than the High Limit, the instruction is false for given conditions.
A2. RSLOGIX 500

A2.1 OVER VIEW

It includes the screen elements described below:

- **LADDER VIEW**: In this part of the application window you can view several program files at the same time. This is where you edit your ladder logic.

- **RESULT WINDOW**: Displays the result of a Find All search or a verification procedure. You can hide this window view or drag it from the application window and place it anywhere on your screen.

- **MENU BAR**: Select functionality from the menus that appear as you click each selection on this bar.

- **STANDARD TOOLBAR**: the standard toolbar (also referred as the main toolbar) contain many functions that you will use repeatedly as you develop and test your logic program. If you want to know what any of the icon is used for.

- **ONLINE BAR**: learn the operational mode and see whether you have online edits or forces installed at a glance. You can even view the driver and node number.

- **INSTRUCTION TOOLBAR**: Displays instruction mnemonics in tabbed categories. When you click on the category tab the instruction toolbar just above it changes to show that category of instructions. Click an instruction to put it in your ladder program.

- **STATUS BAR**: look here for on going status information or prompts, as you use the software.

- **PROJECT TREE**: Displays all the files and folders contained in your project.

A2.2 TO CREATE A NEW PROJECT OR OPEN AN EXISTING PROJECT

- RSLogix is based on a projects. A project is the complete set of files associated with your program logic. To create a new project, select file. New.

- Provide information about your processor on the select processor type dialog and click ok. To open an existing project, select file>open.

- Click the file you want to open and click open

- The project tree is your point-of-entry for creating new files or accessing existing files. To create a new file, right click the program or data file icon and then select new. A dialog appears for you to provide information about the file.

- A program file may contain controller information, the main ladder program, or a subroutine program. Data table files contain the status information associated with external I/O and all other instructions you use in your main and subroutine ladder program files.
A2.3 ENTER A LOGIC PROGRAM

Click on the end rung and then select the new rung icon on the user tab of the instruction toolbar.

To place an instruction on a rung, click its icon on the instruction toolbar.

You can place several instructions on a rung in sequence by clicking the icons one after another. Rslogix place instructions from left to right.

Assign an address to each instruction. Double click an instruction, type the address in the empty field that appears above the instruction, then press the enter key. You can drag drop addresses from a data table file onto instructions in your ladder logic.

After adding rungs, save the file periodically with FILE>SAVE.

A2.4 FEATURES

- **Flexible, Easy-to-use Editing Features**

  Create application programs without worrying about getting the syntax correct. A Project Verifier builds a list of errors that you can navigate through to make corrections at your convenience.

  Powerful online editors allow you to modify your application program while the process is still operating. The Test Edits feature tests the operation of your modification before it becomes a permanent part of the application program. Online and offline editing sessions are limited only by the amount of available RAM.

  Drag-and-drop editing lets you quickly move or copy instructions from rung to rung within a project, rungs from one subroutine or project to another, or data table elements from one data file to another.

  Context menus for common software tools are quickly accessible by clicking the right mouse button on addresses, symbols, instructions, rungs, or other application objects.

  This convenience provides you with all the necessary functionality to accomplish a task within a single menu. This is a time-saving feature because you don’t have to remember the placement of functionality options in the menu bar.

  The RSLogix 500 ladder logic programming package was the first PLC programming software to offer unbeatable productivity with an industry-leading user interface.

  RSLogix 500 is compatible with programs created using Rockwell Software’s DOS-based programming packages for the SLC 500 and MicroLogix families of processors, making program maintenance across hardware platforms convenient and easy.

  RSLogix 500 may be used with Windows 2000, Windows XP, or Windows Vista.
• **Point-and-Click I/O Configuration**

The easy-to-use I/O Configurator lets you click or drag-and-drop a module from an all-inclusive list to assign it to a slot in your configuration. Advanced configuration, required for specialty and analog modules, is easily accessible. Convenient forms speed entry of configuration data. An I/O auto configuration feature is also available.

• **Powerful Database Editor**

Use the Symbol Group Editor to build and classify groups of symbols so that you can easily select portions of your recorded documentation for use across multiple projects. The Symbol Picker list allows you to assign addresses or symbols to your ladder logic instructions simply by clicking on them. Export your database to Comma-Separated-Value (CSV) format to use or manipulate the data in your favourite spreadsheet program. When finished, simply import the CSV file into RSLogix 500.

• **Diagnostics and Troubleshooting Tools**

Quickly locate the specific area in the application that is causing a problem with Advanced Diagnostics. Diagnose the interaction of output instructions within a section of your program by viewing them at the same time. Simultaneously examine the status of bits, timers, counters, inputs and outputs all in one window with the Custom Data Monitor. Each application project you create can have its own Custom Data Monitor window. Use the tabbed Status displays to easily review status bit settings specific to your application programming, including Scan Time and Math Register information, Interrupt settings, and more.

• **Assistance on Demand**

Comprehensive online help provides an instruction reference as well as step by step instructions for common tasks.
The Allen-Bradley SLC 500 System is a modular, small chassis-based class of programmable controllers integrating discrete, analog, and specialty I/O and peripheral devices in stand-alone electronics cabinets.

The System has become the choice of manufacturing engineers worldwide because it is the industry standard for reliability and cost effectiveness. Consider these features that make the SLC 500 System the option you should consider:

- **Powerful** - the SLC 500 System offers programmable controllers that are well equipped to handle a broad range of applications from small, one machine processes to high speed assembly operations, and all points in between.
- **Modular** – the System can be configured to your precise needs today, yet is totally expandable and adaptable to future changes. Power supplies, memory capabilities, the number and type of input and output points, and the various communication links required are all easily included in the System to satisfy virtually every situation.
• **Advanced Instruction Capability** – indirect addressing, high level math capabilities, and compute instructions are a feature of the System.

• **Communication versatility** – options include on-board Ethernet, DH+, DH-485, Control Net, Device Net, and Remote Input/output.

• **Numerous I/O Options** – modules are available to fulfil every conceivable need, from both discrete and analog I/O to temperature signals to a wide array of third-party specialty modules compatible with the System.

• **Industrial Use Design** – the SLC 500 System is engineered to withstand the extremes encountered in industrial environments, such as excessive vibration, temperature fluctuations, and even electrical noise and interference.

• **Windows Software** – RSLogix 500 programming software is an Allen-Bradley/Rockwell Automation exclusive product designed to maximize productivity by simplifying program development and/or troubleshooting. The RSLogix 500 ladder logic programming includes flexible editors, point-and-click I/O configuration, and a powerful database editor.

The SLC 500 System can be configured with up to 64 K of data/program memory and literally 100s of types of both discrete and analog I/O modules, making it the system of choice for everything from very basic to extremely intricate industrial applications. Minimum SLC 500 Systems require a processor module, and I/O modules in a single chassis with a power supply. Advanced local Systems can be created, using from one to three local chassis and up to 30 I/O and/or communication modules. More complex Systems are created using I/O across networks distributed in remote locations and connected via multiple I/O links.

Creating a SLC 500 System may seem to be a daunting task at first, but it is really a very straightforward proposition. The first step is to examine the manufacturing blueprints, and all related machine and electrical functions requiring an input /output. Plot the entire operation in a spreadsheet to determine the exact number of I/O points that will be required as well as the amount of memory needed to complete the operations. Once you have determined the number of I/O points, and all specialty applications, such as temperature controllers, you are ready to select the various elements of the SLC 500. Here are some ideas on selecting the appropriate hardware, and accompanying tables identifying the various components and their capabilities.

To create an SLC 500 System there are a few basic steps to take. The following checklist will guide you through the various steps required:

**A2.5.1 ALLEN BRADLEY SLC 500 I/O MODULES**
Allen-Bradley offers both discrete (digital) and analog Input and Output modules of various capabilities. The digital Input/output modules feature a discrete signal that is either on or off, such as the input of limit switches or the output signal to a relay. Conversely, analog Input/output modules convert voltage or current to point-in-time values via the processor, such as the input received by a thermocouple or the output signal of a pressure regulator. Virtually all SLC 500 Systems will incorporate the use of both discrete and analog Input and Output modules.

The SLC 500 System delineates between the various discrete modules by sorting them into two categories: Sinking and Sourcing. As an engineer designing your own system it will help you to understand the difference between these two options. Here is the definition as given by Allen-Bradley:

"Sinking and Sourcing are terms used to describe a current signal flow relationship between field input and output devices in a control system and their power supply.

- Field devices connected to the positive side (+V) of the field power supply are sourcing field devices.
- Field devices connected to the negative side (DC Common) of the field power supply are called sinking field devices.

To maintain electrical compatibility between field devices and the programmable controller system, this definition is extended to the input/output circuits on the discrete I/O modules.

- Sourcing I/O circuits supply (source) current to the sinking field devices.
- Sinking I/O circuits receive (sink) current from sourcing field devices.

Europe: DC sinking input and sourcing output module circuits are the commonly used options “The following tables will help you to compare the Discrete Input/output modules available in the Allen-Bradley SLC 500 System as well as the Analog Input/output modules:

### A2.5.2 DISCRETE AC INPUT MODULES

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>1746-IM16</th>
</tr>
</thead>
<tbody>
<tr>
<td># OF OUTPUTS</td>
<td>16</td>
</tr>
<tr>
<td>POINTS/COMMON</td>
<td>16</td>
</tr>
<tr>
<td>VOLTAGE</td>
<td>200/240VAC</td>
</tr>
<tr>
<td>OPERATING VOLTAGE RANGE</td>
<td>170-265 V @ 47-63 HZ</td>
</tr>
<tr>
<td>CURRENT @ 5V</td>
<td>85 mA</td>
</tr>
<tr>
<td>CURRENT @ 24V</td>
<td>0 mA</td>
</tr>
<tr>
<td>VOLTAGE, OFF-STATE INPUT, MAX.</td>
<td>50 VAC</td>
</tr>
<tr>
<td>NOMINAL INPUT CURRENT</td>
<td>12 mA @</td>
</tr>
<tr>
<td>CURRENT, OFF-STATE INPUT, MAX.</td>
<td>2 mA</td>
</tr>
<tr>
<td>INRUSH CURRENT, MAX.</td>
<td>1.6 A</td>
</tr>
<tr>
<td>INRUSH CURRENT TIME DURATION MAX.-</td>
<td>0.5 ms</td>
</tr>
<tr>
<td>SIGNAL ON DELAY, MAX.</td>
<td>35 ms</td>
</tr>
<tr>
<td>SIGNAL OFF DELAY, MAX.</td>
<td>45 ms</td>
</tr>
</tbody>
</table>

Table. A2.1 Discrete ac input modules

### A2.5.3 ANALOG INPUT/OUTPUT MODULES

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>FUNCTION</th>
<th>CURRENT/VOLTAGE</th>
<th>I/O CHANNELS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1746-NI4</td>
<td>INPUT</td>
<td>-10 TO +10 VDC</td>
<td>4</td>
<td>HIGH RESOLUTION INPUT CURRENT/VOLTAGE</td>
</tr>
</tbody>
</table>

Table. A2.2 Analog I/O modules

### A2.5.4 ALLEN BRADLEY SLC 500 COMMUNICATION MODULES

You will need to ascertain what your communication requirements are going to be, which will help you to select the proper communication modules for your system. Processors used in the SLC 500 PLC system communicate across the 1746 backplane, contained in the chassis, to the various Input/output modules in the system. The different processors have a variety of communication ports on board for communication with other processors and computers. These varied communication ports will be part of the criteria you will use in selecting the right processors for your system. Every processor in the SLC 500 series has one or two built-in ports for direct communication with Ethernet/IP, DH+, DH-485, or RS-232 (DFI, ASCII, or DH-485 protocols).

Additionally, separate modules can be incorporated into the system's design to provide other communication ports within the system. Modules for Control Net and Universal Remote Input/output links are an option, as well as I/O adapter modules to interface I/O modules with scanner ports in remote locations. The Communication Modules available are denoted in the following table. Here in this project there was no any communication module configured.

### A2.5.5 ALLEN BRADLEY SLC 500 PROCESSOR

Selecting a processor is the next step in designing your system. After taking all the steps above, it is possible to determine your processor needs. You will choose the processor needed based on memory,
number of Input/output modules, speed, communications, and programming requirements of your system. Here are the basic features of the SLC 500 Processors by type of processor:

- **SLC 5/01** - A basic set of 52 instructions with 1 K or 4 K options. This processor supports up to three chassis for a maximum of 30 slots and from 4 to 3940 Input/output points.

- **SLC 5/02** - For more complex applications, communications, faster scan times, and extensive diagnostics. Maximum 3 chassis (30 slots) and 4 to 4096 Input/output points.

- **SLC 5/03** - Available with 8 K, 16 K, and 32 K memory. Built-in RS-232 allows connection to external devices without added modules. Maximum 3 chassis (30 slots) and 4 to 4096 Input/output points.

- **SLC 5/04** - Incorporates a DH+ port for high-speed communications between processors and controllers. Available memory options of 16 K, 32 K, and 64 K. Maximum 3 chassis (30 slots) and 4 to 4096 I/O points. SLC 5/04P contains ERC2 algorithms especially for Plastics Machinery Control.

- **SLC 5/05** - Same functions as SLC 5/04 but with Ethernet rather than DH+ communications. Ethernet communicates at 10 Mbps or 100 Mbps for high performance upload/download, online editing, and peer-to-peer communications. Maximum 3 chassis (30 slots) and 4 to 4096 I/O points.

The following table further delineates the features available in the SLC 500 processors.

### A2.5.6 SLC 500 PROCESSOR

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SLC 5/04</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART # (1747-)</td>
<td>L541</td>
</tr>
<tr>
<td>MEMORY</td>
<td>16 K</td>
</tr>
<tr>
<td>CURRENT/5 VDC</td>
<td>1000 mA</td>
</tr>
<tr>
<td>CURRENT/24 VDC</td>
<td>200 Ma</td>
</tr>
<tr>
<td>DISCRETE I/O MAX.</td>
<td>8192</td>
</tr>
<tr>
<td>CHASSIS/SLOTS</td>
<td>3/30</td>
</tr>
<tr>
<td>COMM. ON-BOARD</td>
<td>DH+ &amp; RS-232</td>
</tr>
</tbody>
</table>

Table. A2.3 slc 500 processor
A2.5.7 ALLEN BRADLEY SLC 500 CHASSIS

Available in four different sizes, the SLC 500 chassis offers maximum flexibility as you configure your system. The chassis come in 4-slot, 7-slot, 10-slot, and 13-slot options to allow you to design the perfect system for your application. The chassis accepts the SLC 500 processor module or the SLC 500 adapter module and the various Input/Output modules. Every chassis will need its own power supply, which installs on the left side of the chassis. You can connect a maximum of three chassis with the available chassis interconnect cables. The following table delineates the chassis and cable options available for the SLC 500 system.

A.2.5.8 SLC 500 CHASSIS

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1746-A7</td>
<td>7 SLOT CHASSIS</td>
</tr>
</tbody>
</table>

Table. A2.4 SLC 500 chassis

A2.5.9 ALLEN BRADLEY SLC 500 POWER SUPPLY

Each chassis in the SLC 500 system requires its own power supply. You will need to analyze your system requirements thoroughly to ascertain the power supply requirements for each chassis. Overloading a power supply can result in system shutdown and/or premature failure of the power supply or other system components. This is not the place to underrate system needs. As you calculate your system's power needs, don't forget to include possible future enhancements to the system. When configuring your system, it is always safer to provide excess power than to be borderline on your system's requirements.

The SLC 500 system has three AC and four DC power supply options. Mounting on the left side of the chassis, the power supply requires just two screws. The AC options are 120/240 volt selectable. All the power supplies have an LED indicating it is working normally. Each power supply can withstand brief power losses, which enables the system to continue normal functioning. All SLC 500 power supplies operate at 0 to 60°C (32 to 140° f) and use #14 AWG wiring. The power supply options for the SLC 500 are specified in the following table.

A2.5.10 SLC 500 POWER SUPPLIES

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>LINE VOLTAGE</th>
<th>CURRENT @ 5 VDC</th>
<th>CURRENT @ 24 VDC</th>
<th>USER CURRENT</th>
<th>INRUSH CURRENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1746-P1</td>
<td>85-265 VAC 47-63 Hz</td>
<td>2 A</td>
<td>0.46 A</td>
<td>0.2 A @ 24 VDC</td>
<td>20 A</td>
</tr>
</tbody>
</table>

Table. A2.5 SLC 500 power supply module
A2.5.11 ALLEN BRADLEY SLC 500 SOFTWARE

The SLC 500 system uses RSLogix 500 ladder logic programming. This software package offers an industry leading user interface and is compatible with Rockwell Software's DOS-based programming packages and MicroLogix processors. RSLogix 500 correlates with Windows software, such as Windows 2000, Windows XP, and Windows Vista.

RSLogix 500 incorporates easy-to-use editing, such as drag-and-drop, Test Edits, and even online or offline editing. Context menus are quickly available with a right mouse button click. Input/Output configuration is easily carried out with both point-and-click and drag-and drop capabilities. Database editors, diagnostics and troubleshooting tools are also available at your fingertips. Online help is readily available, including step by step guidance for common programming functions. The RSLogix 500 programming packages described in the following table are compatible with Windows 2000, XP, and Vista. The English versions are provided on CD-ROM so that you always have the original copy available for present or future needs.

A2.5.12 RSLOGIX 500 PROGRAMMING PACKAGES

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>9324-RL0300ENE</td>
<td>RSLOGIX 500 PROGRAMMING FOR SLC 500 &amp; MICROLOGIX</td>
</tr>
<tr>
<td>9324-RL0100ENE</td>
<td>RSLOGIX 500 STARTER PROGRAMMING PACKAGE</td>
</tr>
<tr>
<td>9324-RL0700NXENE</td>
<td>RSLOGIX 500 PROFESSIONAL PROGRAMMING PACKAGE</td>
</tr>
</tbody>
</table>

Table. A2.6 Rslogix 500 programming packages
10. REFERENCES


3) www.rockwellautomation.com