A REPORT ON

AUTOMATIC PALLET CHANGE SYSTEM CONFIGURATION IN CNC SMC

By

2014A3PS387H	METTA SAI SIDDHARTHA	EEE
2014AAPS267H	ABHILASH RAMA KRISHNA KALAPATAPU	ECE
2014B4A3807P	ADITYA SUNDARLAL DARAK	Maths+EEE

At

HMT MACHINE TOOLS LIMITED, HYDERABAD

A Practice School – 1 Station of

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

(June, 2016)

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Prepared in partial fulfilment of the

Practice School – I

(COURSE NO: BITS F221)

At

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ACKNOWLEDGEMENTS

We would like to express our gratitude to the following people for their help in the work leading to this report:

- Mr. Lakshman Rao, Joint General Manager, Training and Development Centre, for his useful comments and suggestions on the subject matter.
- Mr. B. Prasad, Joint General Manager, Designs Department and our Coordinator for organizing, coordinating projects and for his valuable support.
- Mr. Raja Babu, Electrical Designs, for giving valuable information about electrical assembly.
- Mr. Balaiah, Training Head, for his guidance and other arrangements in the factory.
- Dr. I. Sreedhar, Instructor In-charge for his encouragement, support and valuable advice during our project selection.
- Particular thanks are conveyed to Practice School Division, BITS-PILANI, for conducting this Program.

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJASTHAN)

Practice School Division

Station: HMT MACHINE TOOLS LIMITED **Centre:** Hyderabad

Duration: 24-05-2016 to 15-07-2016(52 days)

Date of Start: 24-05-2016

Date of Submission: 15-07-2016

Title of project: A REPORT ON AUTO PALLET CHANGE SYSTEM CONFIGURATION IN CNC SMC

ID NOs. /Names of students/ Disciplines of the students:

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Key Words: Machining Center, Pallet, Automatic Pallet Changer, Workpiece

Abstract

With a view of shortening the auxiliary times regarding tool and workpiece changing, conventional machine tools are equipped with automatic tool changers and automatic pallet changers, thus becoming machining centers. Reducing the time consumed with the change of the workpiece to follow in machining implies the existence of another table – i.e. the pallet – on which the workpiece is positioned and clamped, while on the working area of the machine another part is manufactured. This report is presenting a new automatic pallet changer mechanism which is hydraulically driven, along with its guiding and transmission systems.

Signature of Students **Signature of PS Faculty**

Date:

Date:

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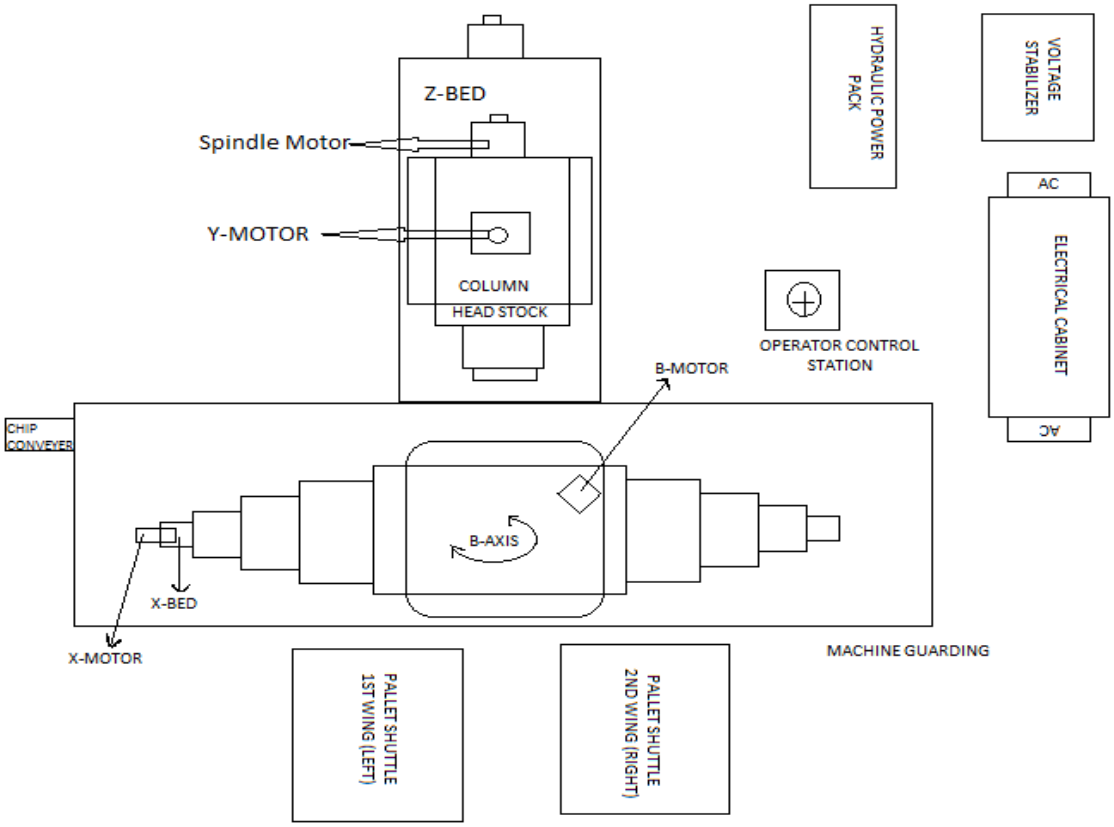
1. SMC Machine Layout



2. MACHINE SPECIFICATIONS

The specification relates to the horizontal machining center (SMC) with horizontal spindle having the following technical features:

2.1. Co-ordinate System:

The Co-ordinate system and axis direction of the machine are as follows.

2.2. Axis Traverse:

X-Axis : 1300mm

Y-Axis : 1000mm

Z-Axis : 1000mm

B-Axis : 0-360° (Continuous)

2.3. Spindle:

a) Speed Range (CW/CCW) : 2-3000 rpm

b) Spindle Power : 37 KW

3. Programmable Logic Controllers

A programmable Logic Controllers (PLC) is a specified computer used to control machines and processes. It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing, counting, sequencing, arithmetic and data handling.

Basically, the PLC is an assembly of solid state digital logic elements designed to make logical decisions and provide outputs. Programmable logic controller is used for the control and operation of manufacturing process equipment and machinery.

The programmable logic controller is, then, basically a computer designed for use in machine control. Unlike an office computer, it has been designed to operate in the industrial environment and is equipped with special input/output interfaces and a control programming language.

Initially the PLC was used to replace relay logic, but its ever increasing range of functions means that it is found in many and more complex applications. Because the structure of a PLC is based on the same principles as those employed in computer architecture, it is capable not only of performing relay switching tasks but also of performing other applications such as counting, calculating, comparing and the processing of analog signals.

Programmable controllers offer several advantages over a conventional relay type of control. Relays have to be hardwired to perform a specific function. When the system requirement change, the relay writing has to be changed or modified. In extreme cases, such as in the auto industry, complete control panels had to be replaced since it was not economically feasible to rewire the old panels with each model changeover. The programmable controller has eliminated much of hardwiring associated with conventional relay control circuits. It is small and inexpensive compared to equivalent relay-based process control systems.

In addition to cost savings, PLCs provide many other benefits including:

1) **Increased Reliability:**

   Once a program has been written and tested, it can be easily downloaded to other PLCs. Since all the logic is contained in the PLCs memory, there is no chance of making a logic writing error. The program takes the place of much of the external wiring that would normally be required for control of a process. Hand wiring though still required to connect field devices, is less intensive. PLCs also offer the reliability associated with solid-state components.

2) **More Flexibility:**

   It is easier to create and change a program in PLC than to wire and rewire a circuit. Original equipment manufacturers can provide system updates by simply sending out a new program. End users can modify the program in the field, or if desired security can be provided by hardware features such as key locks and by software features such as passwords.

3) **Lower cost:**

   PLCs were originally designed to replace relay control logic, and the cost savings have been so significant that relay control is becoming obsolete except for power applications. Generally, if an application has more than about a half-dozen control relays, it will probably be less expensive to install a PLC.

4) **Communication Capability:**

   A PLC can communicate with other controllers or computer equipment to perform such functions as supervisory control, data gathering, monitoring devices and process parameters, and download and upload of programs.

5) **Faster Response Time:**

PLCs are designed for high-speed and real time applications. The programmable controllers operate in real time, which means that an event taking place in the field will result in execution of an operation or output. Machine that process thousands of items per second and objects that spend only a fraction of a second in front of a sensor require the PLCs quick response capability.

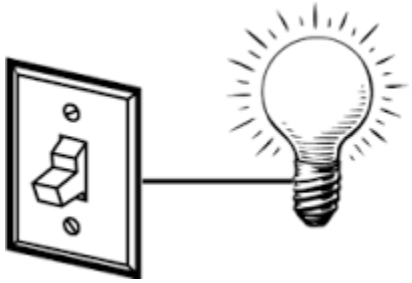
6) **Easier Troubleshoot:**

PLCs have resident diagnostics and override functions that allow users to easily trace and correct software and hardware problems. To find and fix problems, users can display the control program on a monitor and watch it in real time as it executes.

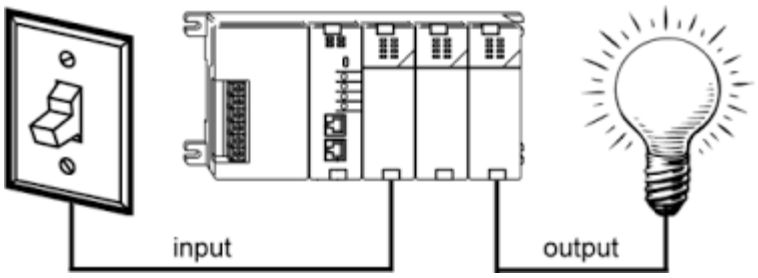
A Simple Example:

Consider something as simple as a switch that turns on a light. In this system with a flick of the switch the light would turn on or off. Beyond that though there is no more control. If the user want that light to turn on thirty seconds after the switch has been flipped, then user would need to buy a timer and do some rewriting. So it is time, labor and money for any little change.

A PLC saves the day



Now with a PLC in the fed as an input into the day consider the same device middle. The switch is the PLC and the light is controlled by a PLC output. Implementing a delay in this system is easy since all that needs to be changed is the program in the PLC to use a delay timer.



This is a rather simple example but in a large system with many switches and lights (and a host of other devices) all interacting with each other. This kind of flexibility is not only nice but imperative.

3.1. PLCs vs Computer

The architecture of a PLC is basically the same as that of a general purpose computer. A personal computer can be made into a programmable logic controller if user provides some way for the computer to receive information from devices such as push buttons or switches. Users also need a program to process the inputs and decide the means of turning load services off and on.

However, some important characteristics distinguish PLCs from general purpose computers. First, unlike computers, the PLC is designed to operate in the industrial environment with wide ranges of ambient temperature and humidity. A well-designed PLC is not usually affected by the electrical noise inherent in most industrial locations. A second distinction between PLCs and computer is that the hardware and the software of PLCs are designed for easy use by plant electricians and technicians. Unlike the computer, the PLC is programmed in relay ladder logic or other easily learned languages. The PLC comes with its program language built into its permanent memory. A PLC has no keyboard, CD drive, monitor, or disk drive. Instead, it has a self-contained box with communication ports and a set of terminals for input and output devices.

Troubleshooting is simplified by the design of most PLCs because they include fault indicators and written fault information displayed on the programmer screen. The modular interfaces for connecting the field devices are actually a part of the PLC and are easily connected and replaced.

Just as it has transformed the way the rest of the world does business, the personal computer has infiltrated the PLC control industry. Software written and run on the PC has changed how people work with PLCs.

Basically, PLC software run on a PC falls into the following two categories:

- PLC software that allows the user to program and document gives the user the tools to write a PLC program using ladder logic or another programming language and document or explain the program in as much detail as is necessary.
- PLC software that allows the user to monitor and control the process is also called man-machine, or operator, interface. It enables the user to view a process-or a graphical representation of a process-on a CRT, determine how the system is running, trend values and receive alarm conditions.

Industrial control technology has evolved from pneumatics to electronic relays to the solid-state PLCs with the relay ladder logic (RLL) programming language of today. Personal computer based control is the latest completion to conventional PLC technology. When functioning as a full-fledged PLC, the computer has to have some way to receive information from sensors and transducers and, in turn, to actuate outputs such as lights, solenoids, relays and motors. Some manufacturers have recently made softwares and interface cards available so that a personal computer can do the work of a PLC. These systems are sometimes referred to as soft logic controllers.

The following are some of the advantages of personal computer based control system:

- Lower initial cost
- Less proprietary hardware and software required.
- Straight forward data exchange with other systems.
- Speedy information processing.
- Easy customization.

4. CNC System

4.1. Evolution of CNC:

With the availability of microprocessors in mid70's the controller technology has made a tremendous progress. The new control systems are termed as computer numerical control (CNC) which are characterized by the availability of a dedicated computer and enhanced memory in the controller. These may also be termed "soft wired numerical control".

These are many advantages which are derived from the use of CNC as compared to NC:

- Part program storage memory.
- Part program editing
- Part program downloading and uploading
- Part program simulation using tool path
- Tool offset data and tool life management
- Additional part programming facilities
- Macros and subroutines
- Background tape preparation, etc.

4.2. Definition of Computer Numerical Control (CNC):

CNC refers to a computer that is joined to the NC machine to make the machine versatile. Information can be stored in a memory bank. The program is read from a storage medium such as the punched tape and retrieved to the memory of the CNC computer. Some CNC machines have a magnetic medium (tape or disk) for storing programs. This gives more flexibility for editing or saving CNC programs. Figure 1 illustrates the general configuration of CNC.

Advantages of CNC:

- Increased productivity
- High accuracy and repeatability
- Reduced production costs
- Reduced indirect operation costs
- Facilitation of complex machining operations
- Greater flexibility
- Improved production planning and control
- Lower operator skill requirement
- Facilitation of flexible automation

Limitation of CNC:

- High initial investment
- High maintenance requirement
- Not cost-effective for low production cost

4.3. Feature of CNC

Computer NC system include additional features beyond what is feasible with conventional hard-wired NC. These, features many of which are standard on most CNC Machine Control units (MCU), include the following:

- **Storage of more than one part program:** With improvements in computer storage technology, newer CNC controllers have sufficient capacity to store multiple programs. Controller manufacturers generally offer one or more memory expansions as options to the MCU.
- **Various forms of program input:** Whereas conventional (hard wired) MCUs are limited to punched tape as the input medium of entering part programs, CNC controllers generally possess multiple data entry capabilities, such as punched

tape, magnetic tape, floppy diskettes, RS-232 communications with external computers, and manual data input (operator entry of program).

- **Program editing at the machine tool:** CNC permits a part program to be edited while it resides in the MCU computer memory. Hence, a part program can be tested and corrected entirely at the machine site, rather than being returned to the programming office for corrections. In addition to part program corrections, editing also permits cutting conditions in the machining cycle to be optimized. After the program has been corrected and optimized, the revised version can be stored on punched tape or other media for future use.
- **Fixed cycles and programming subroutines:** The increased memory capacity and the ability to program the control computer provide the opportunity to store frequently used machining cycles as macros that can be called by the part program. Instead of writing the full instructions for the particular cycle into every program, a programmer includes a call statement in the part program; a programmer includes a call statement in the part program to indicate that the macro cycle should be executed.
- **Interpolation:** Some of the interpolation schemes are normally executed only on a CNC system because of computational requirements. Linear and circular interpolations are sometimes hard-wired into the control unit, but helical, parabolic, and cubic interpolations are usually executed by a stored program algorithm.
- **Positioning features for setup:** Setting up the machine tool for a given workpart involves installing and aligning a fixture on the machine tool table. This must be accomplished so that the machine axes are established with respect to the workpart. The aligning task can be facilitated using certain features made possible by software options in the CNC system. Position set is one of the features. With position set, the operator is not required to locate the fixture on the machine table with extreme accuracy. Instead, the machine tool axes are

referenced to the location of the fixture using a target point or set of target points on the work or fixture.

- **Cutter length and size compensation:** In older style controls, cutter dimensions had to be set precisely to agree with the tool path defined in the part program. Alternative methods for ensuring accurate tool path definition have been incorporated into the CNC controls. One method involves manually entering the actual tool dimensions into the MCU. These actual dimensions may differ from those originally programmed. Compensations are then automatically made in the computed tool path. Another method involves use of a tool length sensor built into the machine. In this technique, the cutter is mounted in the spindle and the sensor measures its length. This measured value is then used to correct the programmed tool path.
- **Acceleration and deceleration calculations:** This feature is applicable when the cutter moves at high feed rates. It is designed to avoid the tool marks on the work surface that would be generated due to machine tool dynamics when the cutter path changes abruptly. Instead, the feed rate is smoothly decelerated in anticipation of a tool path change and then accelerated back up to the programmed feed rate after the direction change.
- **Communication interface:** With the trend toward interfacing and networking in plants today, most modern CNC controllers are equipped with a standard RS-232 or other communications interface to link the machine to other computers and computer driven devices. This is useful for various applications, such as

  1) Downloading part programs from a central data file;

  2) Collecting operational data such as workpiece counts, cycle times, and machine utilization;

  3) Interface with peripheral equipment, such as robots that unload and load parts.

- **Diagnostics:** Many modern CNC systems possess a diagnostics capability that monitors certain aspects of the machine tool to detect malfunctions or signs of

impending malfunctions or signs of impending malfunctions or to diagnose system breakdowns.

4.4. The Machine Control Unit (MCU) for CNC

The MCU is the hardware that distinguishes CNC from conventional NC. The general configuration of the MCU in a CNC system is illustrated in Figure 2. The MCU consists of the following components and subsystems:

1) Central Processing unit
2) Memory
3) Input/output interface
4) Controls for Machine tool axes and spindle speed
5) Sequence controls for other machine tool functions.

These subsystems are interconnected by means of a system bus, which communicates data and signals among the components of a network.

- **Central processing unit:** The central processing unit (CPU) is the brain of the MCU. It manages the other components in the MCU based on software contained in main memory. The CPU can be divided into three sections:
  1) Control section, 2) arithmetic-logic unit, and 3) immediate access memory.

  The control section retrieves command and data from memory and generates signals to activate other components in the MCU. In short, it sequences, coordinates, and regulates all the activities of the MCU computer. The arithmetic logic unit (ALU) consists of the circuitry to perform various calculations (addition, subtraction, and multiplication), counting, and logical functions required by software residing in memory. The immediate access memory provides a temporary storage of data

being processed by the CPU. It is connected to main memory of the system data bus.

- **Memory:** The immediate access memory in the CPU is not intended for storing CNC software. A much greater storage capacity is required for the various programs and data needed to operate the CNC system. As with most other computer systems, CNC memory can be divided into two categories:

  1) Primary memory and 2) second memory.

  Main memory (also known as primary storage) consists of ROM (read only memory) and RAM (random access memory) devices. Operating system software and machine interface programs are generally stored in ROM. These programs are usually installed by the manufacturer of the MCU. Numeric control part programs are stored in RAM devices. Current programs in RAM can be erased and replaced by new programs as jobs are changed.

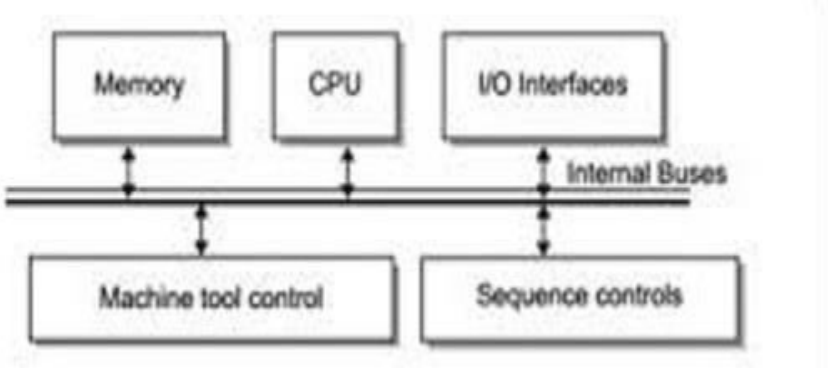


Figure 2 Configuration of CNC machine control unit

High capacity secondary memory (also called auxiliary storage or secondary storage) devices are used to store large programs and data files, which are transferred to main memory as needed. Common among the secondary memory devices are hard disk and portable devices that

have replaced most of the punched paper tape traditionally used to store data programs. Hard disks are high capacity storage devices that are permanently installed in the CNC machine control unit. CNC secondary memory is used to store data programs, macros, and other software.

- **Input/output interface:** The I/O interface provides communication software between the various components of the CNC system, other computer systems, and the machine operator. As its name suggests, the I/O transmits and receives data and signal to and from external devices, several of which are illustrated in figure 2. The operator control panel is the basic interface by which the machine operator communicates to the CNC system. This is used to enter commands related to part program editing, MCU operating mode (e.g., program control vs. manual control), speeds and feeds, cutting fluid pump on/off, and similar functions. Either an alphanumeric keypad or keyboard is usually included in the operator control panel. The I/O interface also includes a display (CRT or LED) for communication of data and information from the MCU to the machine operator. The display is used to indicate the current status of the program as it is being executed and to warn the operator of any malfunctions in the CNC system. Also included in the I/O interface are one or more means of entering the part program into storage. As indicated previously, NC part programs are stored in a variety of ways. Programs can also be entered manually by the machine operator or stored at a central computer site and transmitted via local area network (LAN) to the CNC system. Whichever means is employed by the plant, a suitable device must be included in the I/O interface to allow input to the program into MCU memory.

- **Controls for Machine Tool Axes and Spindle Speed:** These are hardware components that control the position and velocity (feed rate) of each

machine axis as well as the rotational speed of the machine tool spindle. The control signals generated by MCU must be converted to a form and power level suited to the particular position control systems used to drive the machine axes. Positioning systems can be classified as open loop or closed loop, and different hardware components are required in each case.

Depending on the type of machine tool, the spindle is used to drive either1) workpiece or 2) rotating cutter. Turning exemplifies the first case, whereas milling and drilling exemplify the second. Spindle speed is a programmed parameter for most CNC machine tools. Spindle speed components in the MCU usually consist of a drive control circuit and a feedback sensor interface. The particular hardware components depend on the type of spindle drive.

5. HARDWARE REQUIREMENTS

5.1 Proximity Sensor:

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation, and looks for changes in the field or return signal. The object being sensed in often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target.

The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

Proximity sensors are commonly used on smartphones to detect (and skip) accidental touchscreen taps when held to the ear during a call. They are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings.

International Electro-technical Commission (IEC) 60947-5-2 defines the technical details of proximity sensors. A proximity sensor adjusted to a very short range is often used as a touch switch.

5.2 Solenoid Valve:

A solenoid valve is an electromechanical device used for controlling liquid or gas flow. The solenoid valve is controlled by an electrical current, which runs through a coil. When the coil is energized, a magnetic field is created, causing a plunger inside the coil to move. Depending on the design of the valve, the plunger will either open or close the valve. When electrical current is removed from the coil, the valve will return to its de-energized state.

In direct-acting solenoid valves, the plunger directly opens and closes an orifice inside the valve. In pilot-operated valves (also called the servo-type), the plunger opens and closes a pilot orifice. The inlet line pressure, which is fed through the orifice, opens and closes the valve seal.

The most common solenoid valve has two ports: an inlet port and an outlet port. Advanced designs may have three or more ports. Some designs utilize a manifold-type design. Solenoid valves make automation of fluid and gas control possible. Modern solenoid valve offer fast operation, high reliability, long service life, and compact design.

5.3 Voltage Regulator:

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

5.4 MCCB:

All circuit breaker systems have common features in their operation. The details vary substantially depending on the voltage class, current rating and type of the circuit breaker. The circuit breaker must detect a fault condition; in low voltage circuit breakers this is usually done within the breaker enclosure. Circuit breakers for large currents or high voltages are usually arranged with protective relay pilot devices to sense a fault condition and to operate the trip opening mechanism. The trip solenoid that releases the latch is usually energized by a separate battery, although some high-voltage circuit breakers are self-contained with current transformers, protective relays, and an internal control power source.

Once a fault is detected, the circuit breaker contacts must open to interrupt the circuit; some mechanically stored energy (using something such as springs or compressed air) contained within the breaker is used to separate the contacts, although some of the energy required may be obtained from the fault current itself. Small circuit breakers may be manually operated; larger units have solenoids to trip the mechanism, and electric motors to restore energy to the springs.

The circuit breaker contacts must carry the load current without excessive heating, and must also withstand the heat of the arc produced when interrupting (opening) the circuit. Contacts are made of copper or copper alloys, silver alloys and other highly conductive materials. Service life of the contacts is limited by the erosion of contact material due to arcing while interrupting the current. Miniature and molded-case circuit breakers are usually discarded when the contacts have worn, but power circuit breakers and high-voltage circuit breakers have replaceable contacts.

When a current is interrupted, an arc is generated. This arc must be contained, cooled and extinguished in a controlled way, so that the gap between the contacts can again withstand the voltage in the circuit. Different circuit breakers use vacuum, air, insulating gas, or oil as the medium the arc forms in. Different techniques are used to extinguish the arc including:

- Lengthening or deflecting the arc
- Intensive cooling (in jet chambers)
- Division into partial arcs
- Zero point quenching (contacts open at the zero current time crossing of the AC waveform, effectively breaking no load current at the time of opening. The zero crossing occurs at twice the line frequency; i.e., 100 times per second for 50 Hz and 120 times per second for 60 Hz AC.)
- Connecting capacitors in parallel with contacts in DC circuits.

Finally, once the fault condition has been cleared, the contacts must again be closed to restore power to the interrupted circuit.

5.5 Hydraulic Motor:

A hydraulic motor is a mechanical actuator that converts hydraulic pressure and flow into torque and angular displacement (rotation). The hydraulic motor is the rotary counterpart of the hydraulic cylinder.

Conceptually, a hydraulic motor should be interchangeable with a hydraulic pump because it performs the opposite function - similar to the way a DC electric motor is theoretically interchangeable with a DC electrical generator. However, most hydraulic pumps cannot be used as hydraulic motors because they cannot be back-driven. Also, a hydraulic motor is usually designed for working pressure at both sides of the motor

Hydraulic pumps, motors, and cylinders can be combined into hydraulic drive systems. One or more hydraulic pumps, coupled to one or more hydraulic motors, constitute a hydraulic transmission

One of the first rotary hydraulic motors to be developed was that constructed by William Armstrong for his Swing Bridge over the River Tyne. Two motors were provided, for reliability. Each one was a three-cylinder single-acting oscillating engine. Armstrong developed a wide range of hydraulic motors, linear and rotary, that were used for a wide range of industrial and civil engineering tasks, particularly for docks and moving bridges.

5.6 Servo Motor:

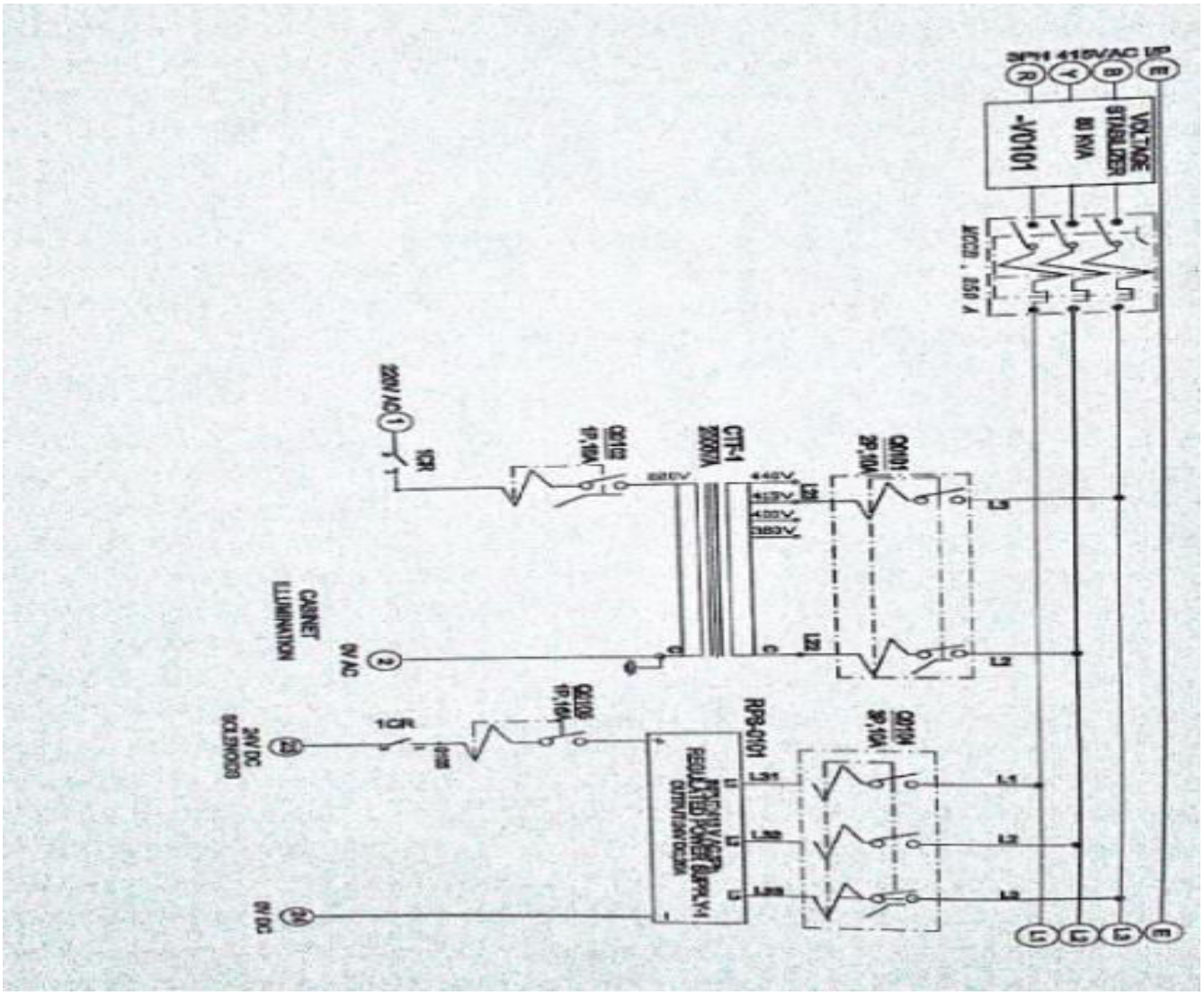
A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term *servomotor* is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

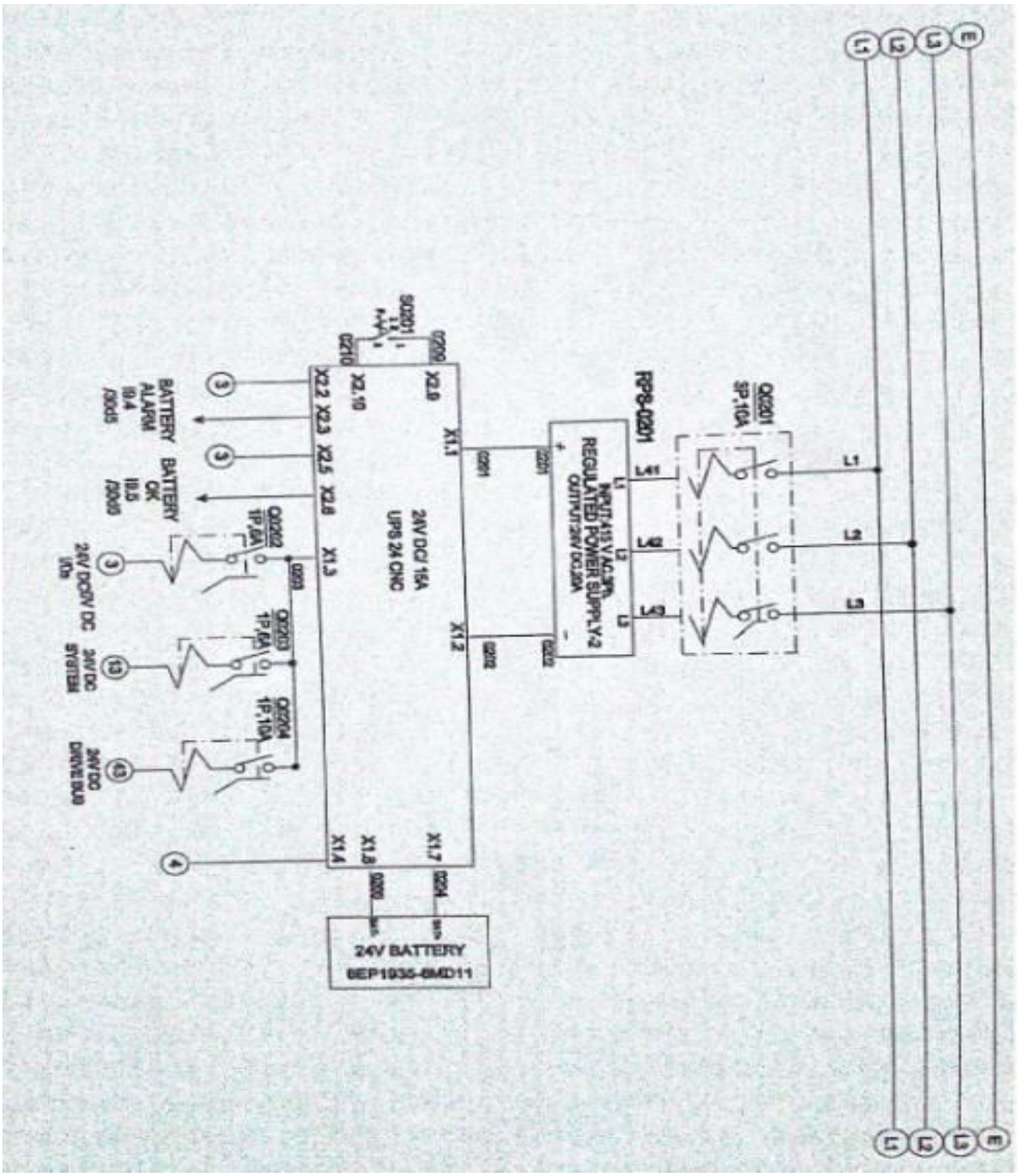
A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is some signal, either analogue or digital,

representing the position commanded for the output shaft. The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

The very simplest servomotors use position-only sensing via a potentiometer and bang-bang control of their motor; the motor always rotates at full speed (or is stopped). This type of servomotor is not widely used in industrial motion control, but it forms the basis of the simple and cheap servos used for radio-controlled models. More sophisticated servomotors use optical rotary encoders to measure the speed of the output shaft and a variable-speed drive to control the motor speed. Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.

6. Circuit Diagrams

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L3
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3P,10A
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24V DC/ 16A
UPS 24 CNC
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X1.3
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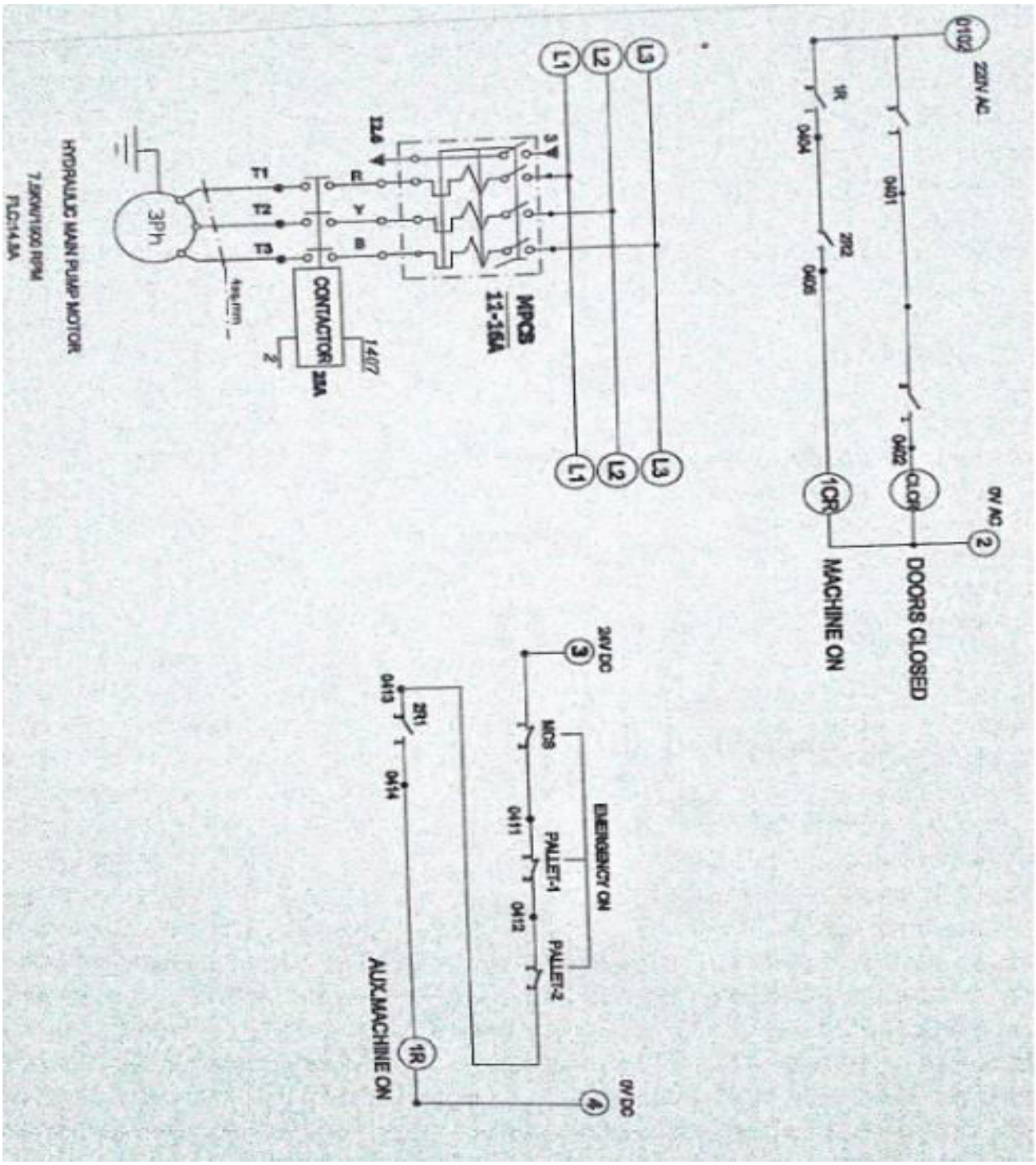
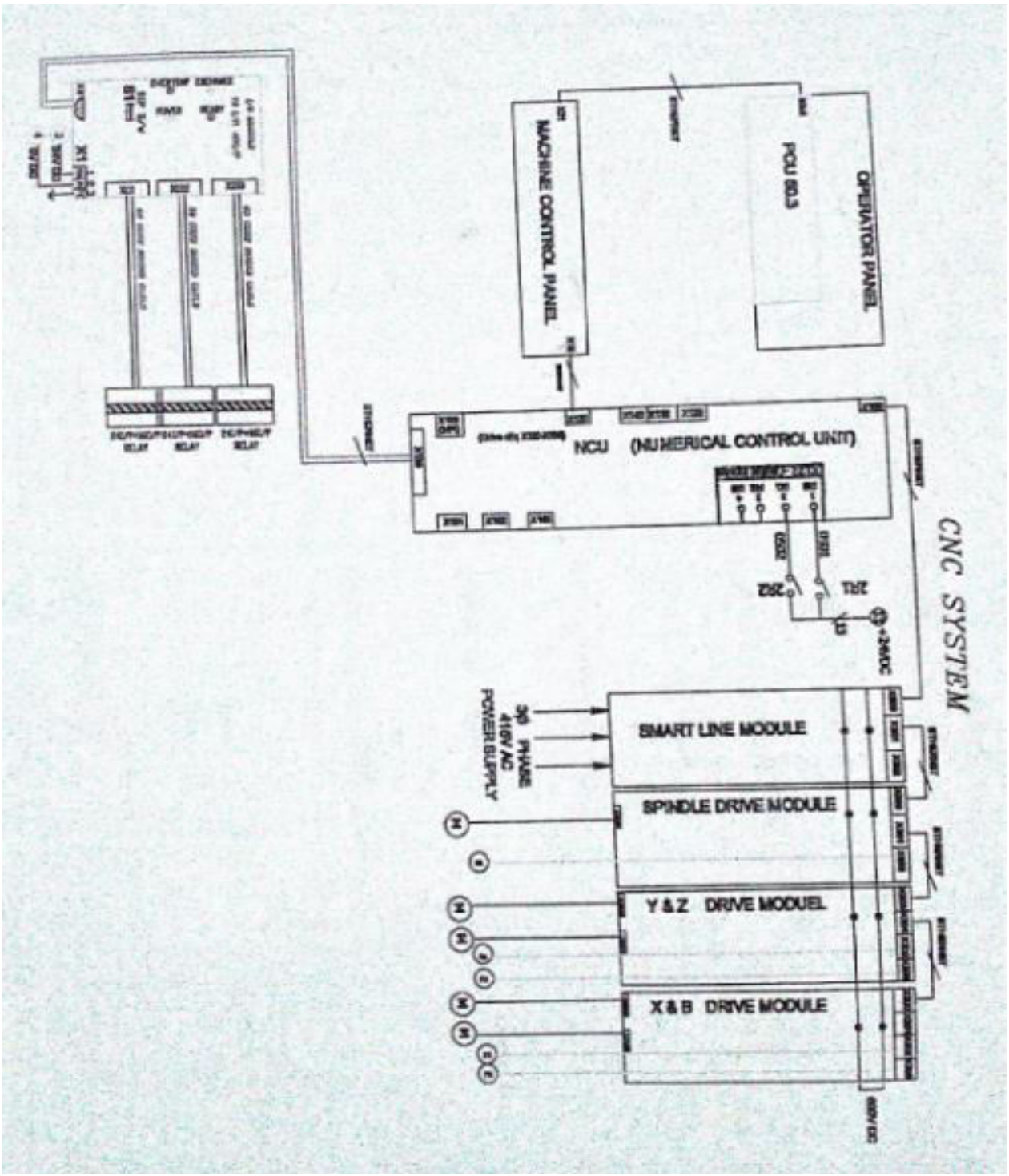
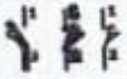
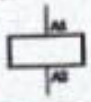
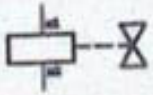
1P,6A
Q0204
1P,10A
24V DC/0V DC
I/Os
24V DC
SYSTEM
24V DC
DRIVE BUS
0203
0204
24V BATTERY
6EP1935-6MD11


220V AC
0102
0401
0402
CLCR
0V AC
2
DOORS CLOSED
1R
0404
2R2
0406
1CR
MACHINE ON
L1
L2
L3
MPCB
11-16A
3 Y
12.5
E
Y
B
F1
F2
F3
3Ph
CONTACTOR
25A
1407
24V DC
3
MCB
0411
PALLET-1
0412
PALLET-2
EMERGENCY ON
0V DC
4
2R1
0413
0414
1R
AUX.MACHINE ON
HYDRAULIC MAIN PUMP MOTOR
7.5KW/1500 RPM
FLC=14.8A


MACHINE CONTROL PANEL
PCU 50.3
OPERATOR PANEL
NCU (NUMERICAL CONTROL UNIT)
SMART LINE MODULE
SPINDLE DRIVE MODULE
Y & Z DRIVE MODUEL
X & B DRIVE MODULE
3Ø PHASE 415V AC POWER SUPPLY
CNC SYSTEM

SR.NO	SYMBOL	DESCRIPTION
1		EMERGENCY STOP
2		PUSH BUTTON
3		ILLUMINATED PUSH BUTTON
4		HOME, +VE, -VE LIMET SWITCHER
5		CIRCUIT BREAKER
6		PROXIMITY SWITCH
7		LAMP (INDICATION LAMP)
8		LED
9		CONTACTOR
10		SOLENOID

6.1 Machine Elements

Elements' number	Specifications	Location
CTF- 1	2000 VA	CABINET
CTF- 2	2500 VA	CABINET
CTF- 3	2500 VA	CABINET
VOLTAGE STABILIZER- V0101	80 VA	NEAR CABINET

Table 6.1 List of transformers

Elements' number	Function	KW	RPM	FLC A
M1	HYDRAULIC MAIN PUMP MOTOR	7.5 KW	1500	14.8

Table 6.2 3-Phase Induction Motor Details

Elements' number	Function	Output Number	Connected to
1CR	MACHINE ON	Q2.1	220V SOLENOID CIRCUIT

Table 6.3 List of auxiliary contactors

Elements' number	Function	Output Number	Location

C1	HYDRAULIC PUMP MOTOR ON	Q 3.6	CABINET

Table 6.4 List of power contactors

Element Number	**Rating**	**No. of Pole**	**Location**
Q0101	10A	2-POLE	CTF-1/2000 VA
Q0102	10A	1-POLE	CONTROL CIRCUIT
Q0104	10A	3-POLE	24V DC REGULATED POWER SUPPLY-1
Q0105	16A	1-POLE	24V DC SOLENOIDS
Q0201	10A	3-POLE	24V DC REGULATED POWER SUPPLY-2
Q0202	6A	1-POLE	24V DC I/OS
Q0203	6A	1-POLE	24V DC SYSTEM
Q0204	10A	1-POLE	24V DC DRIVE BUS
Q0301	10A	2-POLE	CTF-2/2500A
Q0302	10A	1-POLE	AIR CONDITIONER-1
Q0303	10A	2-POLE	CTF-3/2500A
Q0304	10A	1-POLE	AIR CONDITIONER-2

Table 6.5 List of Miniature Circuit Breakers

Element Number	Rating	Input Serial No.	Location
MPCB	11-16 A	12.6	HYDRAULIC MAIN PUMP MOTOR

Table 6.6 List of Motor Circuit Breakers

Element No.	Function	Output No.	Location
LAMP 1	LOCKED PALLET-1	Q1.0	PALLET
LAMP 2	UNLOCKED PALLET-1	Q1.1	PALLET
LAMP 3	READY PALLET-1	Q1.2	PALLET
LAMP 4	LOCKED PALLET-2	Q1.3	PALLET
LAMP 5	UNLOCKED PALLET-2	Q1.4	PALLET
LAMP 6	READY PALLET-2	Q1.5	PALLET

Table 6.7 List of Lamps

Function	Input No.	Output No.	Location
MACHINE ON	127.7	Q 25.7	MCP, Control Station
FAULT RESET	126.3	Q 24.3	MCP, Control Station

Table 6.8 List of User Keys

Elements No.	Function	Input No.	Location

PB- 1	OPEN GATE-1	10.4	PALLET STATION-1
PB- 2	CLOSE GATE-1	10.5	PALLET STATION-1
PB- 3	OPEN GATE-2	12.3	PALLET STATION-2
PB- 4	CLOSE GATE-2	12.4	PALLET STATION-2

Table 6.9 List of Push Buttons

Element No. (Push Button)	**Element No. (Lamp)**	**Function**	**Input No.**	**Output No.**	**Location**
LPB-1	LAMP 1	LOCK PALLET-1	10.2	Q1.0	PALLET STATION-1
LPB-2	LAMP 2	UNLOCK PALLET-1	10.3	Q1.1	PALLET STATION-1
LPB-3	LAMP 3	READY PALLET-1	10.6	Q1.2	PALLET STATION-1
LPB-4	LAMP 4	LOCK PALLET-2	12.1	Q1.3	PALLET STATION-2
LPB-5	LAMP 5	UNLOCK PALLET-2	12.2	Q1.4	PALLET STATION-2
LPB-6	LAMP 6	READY PALLET-2	12.5	Q1.5	PALLET STATION-2

Table 6.10 List of Illuminated Push Buttons

Element no	Function	Input no.	Output no.
S0201	UPS ON/OFF	-	ON CABINET

Table 6.11 List of Selector Switch

Element No.	Function	Output No.	Connected to
1R	AUX MACHINE ON	HARDWARE	1CR
1R1	EMERGENCY STOP	Q0.0	LED 1
1R2	X-AXIS IN PALLET-1 TRANSFER POSITION	Q0.1	LED 2
1R3	X-AXIS IN PALLET-2 TRANSFER POSITION	Q0.2	LED 3
1R4	PALLET-1 ON TABLE	Q0.3	LED 4
1R5	PALLET-2 ON TABLE	Q0.4	LED 5
1R6	HYDRAULIC OIL LOW LEVEL	Q0.5	LED 6
1R7	PALLET CHANGE SEQ. ACTIVE	Q0.6	LED 7
1R9	LOCKED PALLET-1	Q1.0	LAMP 1
1R10	UNLOCKED PALLET-1	Q1.2	LAMP 2
1R11	READY PALLET-1	Q1.3	LAMP 3
1R12	LOCKED PALLET-2	Q1.4	LAMP 4

1R13	UNLOCKED PALLET-2	Q1.5	LAMP 5
1R14	READY PALLET-2	Q1.6	LAMP 6
2R1	MACHINE HEALTHY	Q2.0	1R
2R2	MACHINE ON	Q2.1	1CR
2R3	NCU ENABLE	Q2.2	NCU
2R4	DRIVE ENABLE	Q2.3	NCU
2R5	OPEN GATE-1	Q2.4	SOLENOID S1
2R6	CLOSE GATE-1	Q2.5	SOLENOID S2
2R7	OPEN GATE-2	Q2.6	SOLENOID S3
2R8	CLOSE GATE-2	Q2.7	SOLENOID S4
2R9	PALLET UP UNCLAMPED	Q3.0	SOLENOID S5
2R10	PALLET DOWN UNCLAMPED	Q3.1	SOLENOID S6
2R11	LOAD PALLET-1	Q3.2	SOLENOID S7
2R12	UNLOAD PALLET-1	Q3.3	SOLENOID S8
2R13	LOAD PALLET-2	Q3.4	SOLENOID S9
2R14	UNLOAD PALLET-2	Q3.5	SOLENOID S10

2R15	HYDRAULIC MAIN PUMP MOTOR ON	Q3.6	POWER CONTACTOR C1

Table 6.12 List of DC relays

Element no.	**Function**	**Output no.**	**Location**
S1	OPEN GATE-1	Q2.4	PNEUMATIC CABINET
S2	CLOSE GATE-1	Q2.5	PNEUMATIC CABINET
S3	OPEN GATE-2	Q2.6	PNEUMATIC CABINET
S4	CLOSE GATE-2	Q2.7	PNEUMATIC CABINET
S5	PALLET UP	Q3.0	B-AXIS TABLE
S6	PALLET DOWN UNCLAMPED	Q3.1	B-AXIS TABLE
S7	LOAD PALLET-1	Q3.2	PALLET STTATION
S8	UNLOAD PALLET-1	Q3.3	PALLET STTATION
S9	LOAD PALLET-2	Q3.4	PALLET STTATION
S10	UNLOAD PALLET-2	Q3.5	PALLET STTATION

Table 6.13 List of solenoid valves

Element no.	Function	Input no.	Location
PRX-1	FORWARD PALLET-1	11.0	PALLET STATION-1
PRX-2	BACKWARD PALLET-1	11.2	PALLET STATION-1
PRX-3	LOCK PALLET-1	11.3	PALLET STATION-1
PRX-4	UNLOCK PALLET-1	11.4	PALLET STATION-1
PRX-5	FORWARD PALLET-2	13.1	PALLET STATION-2
PRX-6	BACKWARD PALLET-1	13.2	PALLET STATION-2
PRX-7	LOCK PALLET-2	13.3	PALLET STATION-1
PRX-8	UNLOCK PALLET-2	13.4	PALLET STATION-1
PRX- 9	B-AXIS HOME	13.5	B-AXIS TABLE
PRX-10	PALLET UP	13.6	B-AXIS TABLE
PRX-11	PALLET DOWN	13.7	B-AXIS TABLE

Table 6.14 list of proximity switches used

Element no.	Function	Input no.	Location
LS-6	GATE-1 OPENED	14.0	MACHINE GUARD
LS-7	GATE-1 CLOSED	14.1	MACHINE GUARD
LS-8	GATE-2 OPENED	14.3	MACHINE GUARD

LS-9	GATE-2 CLOSED	14.4	MACHINE GUARD
LS-1	X-AXIS HOME	11.4	X-BED
LS-2	X-AXIS NEGATIVE END SAFETY	11.5	X-BED
LS-3	X-AXIS POSITIVE END SAFETY	11.6	X-BED
LS-4	TRANSFER POSITION PALLET-1	11.7	X-BED
LS-5	TRANSFER POSITION PALLET-2	12.0	X-BED

Table 6.15 List of limit switches used

S.no	**Input**	**Description**
1	10.0	EMERGENCY STOP ON MCP PRESSED
2	10.1	CONTROL ON
3	10.2	LOCK PALLET-1
4	10.3	UNLOCK PALLET-1
5	10.4	OPEN GATE-1
6	10.5	CLOSE GATE-1
7	10.6	READY PALLET-1

8	10.7	EMERGENCY STOP ON PALLET-1
9	11.0	FORWARD PALLET-1
10	11.1	BACKWARD PALLET-1
11	11.2	LOCKED PALLET-1
12	11.3	UNLOCKED PALLET-1
13	11.4	X AXIS HOME
14	11.5	X AXIS –VE END SAFETY
15	11.6	X AXIS +VE END SAFETY
16	11.7	TRANSFER POSITION PALLET-1
17	12.0	TRANSFER POSITION PALLET-2
18	12.1	LOCK PALLET-2
19	12.2	UNLOCK PALLET-2
20	12.3	OPEN GATE-2
21	12.4	CLOSE GATE-2
22	12.5	READY PALLET-2
23	12.6	MAIN HYDRAULIC PUMP MOTOR MPCB ON

24	13.0	EMERGENCY STOP ON PALLET-2
25	13.1	FORWARD PALLET-2
26	13.2	REVERSE PALLET-2
27	13.3	LOCK PALLET-2
28	13.4	UNLOCK PALLET-2
29	13.5	B-AXIS HOME
30	13.6	PALLET IP
31	13.7	PALLET DOWN
32	14.0	GATE-1 OPEN
33	14.1	GATE-1 CLOSE
34	14.2	GATE-2 OPEN
35	14.3	GATE-2 CLOSE

S.NO	**Output**	**Description**
1	Q0.0	EMERGENCY STOP
2	Q0.1	X-AXIS IN PALLET-1 TRANSFER POSITION
3	Q0.2	X-AXIS IN PALLET-2

		TRANSFER POSITION
4	Q0.3	PALLET-1 ON TABLE
5	Q0.4	PALLET-2 ON TABLE
6	Q0.5	HYDRAULIC OIL LOW LEVEL
7	Q0.6	PALLET CHANGE SEQ. ACTIVE
8	Q1.0	LOCKED PALLET-1
9	Q1.1	UNLOCKED PALLET-1
10	Q1.2	READY PALLET-1
11	Q1.3	LOCKED PALLET-1
12	Q1.4	UNLOCKED PALLET-2
13	Q1.5	READY PALLET-2
14	Q2.0	MACHINE HEALTHY
15	Q2.1	MACHINE ON
16	Q2.2	NCU ENABLE
17	Q2.3	DRIVE ENBLE
18	Q2.4	GATE-1 OPEN
19	Q2.5	GATE-1 CLOSE
20	Q2.6	GATE-2 OPEN

21	Q2.7	GATE-2 CLOSE
22	Q3.0	PALLET UP UNCLAMPED
23	Q3.1	PALLET DOWN CLAMPED
24	Q3.2	LOAD PALLET-1
25	Q3.3	UNLOAD PALLET-1
26	Q3.4	LOAD PALLET-2
27	Q3.5	UNLOAD PALLET-2
28	Q3.6	HYDRAULIC PUMP MOTOR ON

7. WORKING MECHANISM

7.1 SWITCHING ON MACHINE:

Switch "ON" Main Voltage Stabilizer. Display gets power and loads the software and checks for the communications with PCU50, NC, & PLC. After loading system software “8” will be displayed on PCU50 module and "6" will be displayed on NCU module.

IMPORTANT: It is recommended that all personnel associated with this machine should study SINUMERIK 840DSL "Operating and programming' Manual prior to switching on the machine.

- Ensure that latching type EMERGENCY SWITCH on CNC Operator panel is pressed. This is to avoid any inadvertent machine start-up and Axis movement.
- As soon as the display is switched "ON", 'MACHINE OFF' message will appear on the screen.
- Release latching type emergency switch on CNC machine operator panel or any other. if pressed. Press 'MACHINE ON' user key and then press “RESET” key on MCP and machine will be on and after 5 seconds drives will be powered-up, displaying `MACHINE HOLD' led on the MCP.
- Press 'FAULT RESET' key on MCP to reset the machine hold conditions. If it fails to reset, follow operator messages. If any fault is present call maintenance personnel for corrective action.

7.2. DESCRIPTION OF KEYS ON MACHINE CONTROL PANEL:

7.2.1 AXIS MOVEMENT IN JOG MODE:

• Select JOG mode on the machine control panel (MCP) ascertains the direction of motion of the selected Axis to bring it to approximatel middle point. Center point of axis is selected for referencing, to avoid accidental movement of the Axis up to the end limit switch in case the axis position is very close to the hard ware limit switch.

CAUTION: It is very important that Axes and traverse direction is carefulh selected in jog mode to avoid accident and axes movement in wrong direction. Always starts with “Low feed” rate and then increase in steps.

• If 'Axis Disable message’ (feed stop) is displayed on screen, indicating feed hold while pressing "+" OR “-” Direction Key. Select "DIAGNOSIS- from menu bar and then press “Message/Alarm" soft key to know about the cause of feed hold.

• Select "REF" mode and press '+' Direction for Y and Z Axes and ‘-’Direction for B and X axes to reference the Axes.

Note: Z-Axis must be Reference First to avoid Tool collision.

• When axis stops at reference position, point reached indication for the particular axis displayed on the CNC operator panel.

7.2.2 FEED START / STOP:

MCP Key for feed “start” and "stop” remain active in all operating modes and can be operated as and when required. "Feed Stop" MCP Key generates 'Axis Disable message' and stops axes movement & spindle running. It is reset by “Feed Start" MCP Key.

7.2.3 SPINDLE START/STOP:

Spindle "Start and Stop” MCP Key are also active in all operating mode and can be operated as and when required. Spindle Stop MCP key generates spindle stop and reset by the Spindle Start MCP Key.

7.3 AXIS MOVEMENTS

7.3.1 JOG MODE:

Axis can move in manually in JOG mode. Select particular axis which want to move in manual mode on MCP axis selection. Press (+) ve OR (-)ve direction movement key to move the axis & release reed override.

7.3.2 MDA MODE:

Axis can move in SEMI-AUTO MODE(MDA mode). Select MDA mode on MCP. Enter the command for linear motion of axis (G01 OR G0) press cycle start button & release reed override.

G01 X500 F1000

(OR)

G0 X500

NOTE: MOVEMENT OF AXIS IN MDA MODE AXIS REFERENCE IS MUST.

7.3.3 AUTO MODE:

Select part programmed from part programmed folder & execute in auto mode.

NOTE: MOVEMENT OF AXIS IN AUTO MODE AXIS REFERENCE IS MUST

7.4 SPINDLE CW/CCW ROTATION:

7.4.1 SPINDLE JOG ROTATION:

Select Spindle on MCP & press (+) direction key to rotate spindle in clockwise direction & (-) direction key to rotate in counterclockwise direction.

7.4.2 SPINDLE MDA ROTATION:

Automatic gear change will be taken place depending on the programmed spindle speed.

• Spindle running in clock wise direction

M3 S 100

• Spindle running in counter clock wise direction

M4 S 100

7.5 DESCRIPTION OF USER KEYS ON MCP

MACHINE ON: By pressing this user key pushbutton machine will be on depending on the healthy condition of the machine after RESET key on the MCP.

FAULT RESET: By actuating this user key push button, resets the machine hold condition.

7.6. DESCRIPTION OF LED's ON OPERATOR PANEL

EMERGENCY STOP (LED1):

This LED glows when an emergency stop is pressed.

X-AXIS IN PALLET 1 TRANSFER POSITION (LED2):

This LED glows when X-Axis is at pallet-1 transfer position i.e., X=0 during the execution of L951 subroutine.

X-AXIS IN PALLET 2 TRANSFER POSITION (LED3):

This LED glows when X-Axis is at pallet-2 transfer position i.e., X=1300 during the execution of L951 subroutine.

PALLET-1 ON TABLE (LED4): This LED glows when pallet-1 is on the table.

PALLET-2 ON TABLE (LED5): This LED glows when pallet-2 is on the table.

PALLET CHANGE SEQ. ACTIVE (LED7): This LED glows when any of the pallet loading or unloading sequence is active.

7.7. DESCRIPTION OF SELECTOR SWITCHES

UPS ON/OFF (S0201): This is a selector switch kept on cabinet. Machine has provided UPS only for CNC SYSTEM kept on during power failure. Machine display will be live after power failure. Operator must shutdown system by EXIT mode & waits till system is safe to turn off message on control panel, after only keep this switch in OFF mode. Power resume again keep this switch in ON position to prevent CNC system to live in case of power failure.

7.8 DESCRIPTION OF PUSH BUTTON SWITCHES

OPEN GATE-1(PB1): This push button is kept on pallet station. This switch is use to open the gate-1.

CLOSE GATE-1(PB2): This push button is kept on pallet station. This switch is use to close the gate-1.

OPEN GATE-2(PB3): This push button is kept on pallet station. This switch is use to open the gate-2.

CLOSE GATE-2(PB4): This push button is kept on pallet station. This switch is use to close the gate-2.

READY PALLET-1: This push button is kept on pallet station. This switch is use to make pallet ready for the pallet changing. Press the pallet-1 ready push button to make pallet-1 ready. When the pallet is ready then only pallet loading or unloading will take place.

READY PALLET-2: This push button is kept on pallet station. This switch is use to make pallet ready for the pallet changing. Press the pallet-2 ready push button to make pallet-2 ready. When the pallet is ready then only pallet loading or unloading will take place.

EMERGENCY: All machine operations including hydraulics will be "OFF" when this push button is actuated. This is pressed to stop the machine in the event of any emergency.

7.9 PALLET CHANGE [LOAD/UNLOAD] OPERATION

7.9.1 PALLET CHANGE SEQUENCE

To facilitate the initial conditions necessary to initiate auto pallet change operation, emergency panel is provided with different phases for pallet-1 and pallet-2 loading and unloading. The operations that can be performed from the emergency panel along with the necessary preconditions are listed below.

Activation of emergency control panel :- Emergency control panel can be activated if the following conditions are satisfied

1) Machine is on.
2) Jog mode is selected [CNC machine control panel]
3) Emergency panel ON/OFF selector switch is in 'ON' condition.

When all the above three conditions are full filled then the emergency panel light will glow and machine hold lamp will glow

Axes X, Y, Z & B should be at pallet change position. Using thumb wheel switch select required phase and press execute phase till phase completed lamp glows.

CAUTION*:* If pallet is loaded or unloaded through emergency panel. CNC will not update the data in CNC memory; operator has to appropriately up to date after completion of the sequence in MDA mode in the following manner.

NOTE: M86 has to be executed after using of emergency panel to acknowledge the tools pallet status.

DESCRIPTION	**OUTPUT**	**INPUT**
PALLET UP	Q3.0, S5	I3.6, PRX-10
GATE-1 OPEN	Q2.4, S1	I4.0, LS-6
PALLET-1 LOAD	Q3.2, S7	I1.0, PRX-1
PALLET DOWN	Q3.1, S6	I3.7, PRX-11
GATE-1 CLOSE	Q2.5, S2	I4.1, LS-7

Table 7.1 pallet 1 loading sequence

DESCRIPTION	OUTPUT	INPUT
GATE-1 OPEN	Q2.4, S1	I4.0, LS-6
PALLET UP	Q3.0, S5	I3.6, PRX-10
PALLET-1 UNLOAD	Q3.3, S8	I1.1, PRX-2
GATE-1 CLOSE	Q2.5, S2	I4.1, LS-7
PALLET DOWN	Q3.1, S6	I3.7, PRX-11

Table 7.2 pallet 1 unloading sequence

DESCRIPTION	OUTPUT	INPUT
PALLET UP	Q3.0, S5	I3.6, PRX-10
GATE-2 OPEN	Q2.6, S3	I4.2, LS-8
PALLET-2 LOAD	Q3.4, S9	I3.1, PRX-5
PALLET DOWN	Q3.1, S6	I3.7, PRX-11
GATE-2 CLOSE	Q2.7, S4	I4.3, LS-9

Table 7.3 Pallet 2 Loading sequence

DESCRIPTION	OUTPUT	INPUT
GATE-2 OPEN	Q2.6, S3	I4.2, LS-8
PALLET UP	Q3.0, S5	I3.6, PRX-10
PALLET-2 UNLOAD	Q3.5, S10	I3.2, PRX-6
GATE-2 CLOSE	Q2.7, S4	I4.3, LS-9
PALLET DOWN	Q3.1, S6	I3.7, PRX-11

Table 7.4 Pallet 2 Unloading sequence

7.10. CONTROLS ON PALLET 1 & 2 [WING BASE]:

PALLET READY: When the pallet is ready with component mounted condition and locked. This button is to be operated to enable pallet transfer. When it is pressed, pallet ready lamp glows.

OPEN GATE: It is to be pressed for opening the gates when the machine is in JOG mode only.

CLOSED GATE: It is to be pressed for closing the gates when the machine is in JOG mode only.

LOCK PALLET: It is to be operated to lock the pallet when the pallet is in unlocked condition. Pallet locked lamp glows when the pallet is in locked condition.

UNLOCK PALLET: It is to be operated to unlock the pallet when the pallet is in locked condition. Pallet locked lamp glows when the pallet is in locked condition.

7.11. AUTO PALLET CHANGER

The pallets can be transferred in auto mode or MDA mode by execution of the subroutine L951. The initial conditions required to start auto pallet change cycle are listed below.

- All axes should be homed
- B-axis (table) should be clamped
- Doors should be closed
- Pallet ready push button to be pressed. Pallet ready function is explained below.

PALLET READY:

Pallet ready push button is provided on pallet operator control stations to ensure that JOB loaded on the pallet is ready for machining this light can be switched on & off only in

auto/MDA mode using pallet ready push button to make pallet ready or pallet inhibit. Before giving L951, command pallet ready light should be glowing, otherwise "**NO PALLET READY"** message is displayed on the monitor. By pressing the pallet ready push button message disappears and pallet changes cycle starts.

Pallet ready indication light should glow. If any of the above conditions are not met, auto pallet changer does not take place and appropriate message will be displayed on the monitor.

For pallet changer cycle special part program "L951" is made for any pallet load/unload this to be programmed in part program. L951 is the subroutine, which brings X, Y, Z & B Axes of the machine to pallet changer position depending on the operator's request and starts pallet changer cycle. L951 consists of the following sequence of operation.

L951:

```
N10 M9 G90 D0 G0 G53 Y500 Z1000
   N15 STOPRE
   N20 IF (R87==1) GOTOF UNLD1
   N21 IF (R87==2) GOTOF UNLD2
   N22 IF (R87==0) GOTOF END1
   N25 STOPRE
   N30 UNLD1: G53 G0 X0
   G01 B0 F360
   N35 GOTOF UNLD
   N40 UNLD2: G0 G53 X1300
      G01 B0 F360
   N45 UNLD: MSG ("UNLOADING SEQ IS ACTIVE)
   N50 M951
   N55 M62
```

```
N60 MSG ()
N65 STOPRE
N70 MSG (“PRESS PALLET READY PB OF PALLET TO BE LOADED”)
N75 STOPRE
N80 END1: GO4 F5
N85 STOPRE
N86 IF (R89==1) GOTOF LD1
N87 IF (R89==2) GOTOF LD2
N88 IF (R89==0) GOTOF END
N90 LD1: G0 G53 X0
   G01 B0 F360
N95 GOTOF LD
N100 STOPRE
N105 LD2: G0 G53 X1300
   G01 B0 F360
N110 LD: MSG (“LOADING SEQ IS ACTIVE”)
N115 STOPRE
N120 M951
N125 M61
N130 STOPRE
N135 GO4 F1
N140 GO4 F3
N145 MSG ()
N150 END: M17
LD0: MSG (“PRESS PALLET READY PB OF PALLET TO BE LOADED”)
G04 F2
M17
```

SEQUENCE OF OPERATIONS:

→ Y and Z move to their respective pallet changer positions.

→ X and B move to pallet changer positions (X = 0 OR X =1300)

→ B=0,000 Degrees

→ Pallet raise

→ Gate opened

→Pallet load/unload takes place.

→ Pallet down

→ Gate closed

7.12 LIST OF M-CODES AND ITS DESCRIPTION

M00 PROGRAM STOP: M00 will stop axis movement, spindle running and with cycle start or rest art continuous the program.

M01 OPTIONAL PROGRAM STOP: M01 is also used similar to M00, and continues the program with cycle start or restart if optional stop is activated in the program modifications display

M02 END OF PROGRAM: M02 terminates the program in auto mode. All axes movements, spindle rotation, magazine rotation stop and reset is initiated. M02 is to be programmed at the end of the program

M03 SPINDLE ON CLOCKWISE (CW) ROTATION: By programming M03 with the spindle speed, spindle will rotate in clockwise direction with the programmed speed.

M04 SPINDLE ON COUNTER- CLOCKWISE (CCW) ROTATION: By programming M04 with the spindle speed, spindle will rotate in counter clockwise direction with the programmed speed.

M05 SPINDLE STOP: It stops the spindle with rated braking torque irrespective of its direction of rotation it cancels M03, M04 AND M10.

M17 END OF SUBROUTINE: M17 is end of subroutine, which must be programmed at the end of the subroutine.

M30 END OF PROGRAM: It is similar to M02, programmed at the end of the program to terminate the program.

8. CONCLUSION

The automatic pallet changer mechanism presented in this paper can be attached to almost any conventional machine tool along its travel axis. This mechanism is hydraulically driven, being supplied from the machining centre's main hydraulic unit, and can be used in handling weights up to 800 kg. The main advantage of an automatic pallet changer is the small setup time of the workpiece to follow in the machining chamber, which is resumed, practically, to the total time taken to complete the given sequence. Besides this advantage, the automatic pallet changer presented in this paper binds together the drives of the two main movements (up/down translation and clockwise/counter-clockwise rotation) into one double hydraulic piston. This solution reduces the space occupied by an extra motor used to perform one of the main movements, and also the manufacturing cost of the automatic pallet changer mechanism is reduced. This mechanism is designed for long life and low maintenance and it's virtually contamination free. As a future development of the automatic pallet changer, it can be integrated in the structure of a pallet magazine, thus, the machining centre becomes a flexible manufacturing cell.

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