Palestine Polytechnic University

College of Engineering & Technology
Electrical & Computer Engineering Department

Graduation Project

Remote control of three dimensions crane

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June 2004

Palestine Polytechnic University

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According to the orientations of the supervisor on the project and the examined committee is by the agreement of a staffers all, sending in this project to the Electrical and computer engineering department are in the college of the engineering and the technology by the requirements of the department for the step of the bachelor's degree.

Project supervisor signature

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Committee signature

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Department head signature

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Dedication

We dedicate this simple labor:

To our Parents

To our Brothers

To our Friends

To our Nation

To any person works hardly…

Acknowledgement

To all whose teach us and he helped us, to whom arrive us for this science step, to the dear supervisor of the project Dr. Sameer khader, to all are faculty that teach us in the department, to us friends and us sweethearts and us relatives, we dedicate this project it may be support other research in the future.

Abstract

Crane is a hoisting machine which used for lifting heavy loads and transferring them from one place to another.

Three-dimensions crane has a wide usage, where 90% of industry application used this type machines, however, as soon as you start to think in solving the problems that faces a worker in a factory, you should consider the work condition so as to suggest optimum solutions for better usage of the crane. That is, the manual crane controlled by heavy cable has many disadvantages to faces the operator and the mechanical process in the factory. Remote control idea is better than traditional crane control and more efficient.

On the other hand, the crane design is hard and should be accurate to realize a powerful, cheaper and reliable crane according to different loads. Also how to make electrical wireless interface between crane motors and remote electronic circuits.

In this project we will design 3-D crane which is control by using programmable logic control technique (PLC). Here we will build remote control circuits, power circuits of three motors which are used to move the load up and down and the mechanical parts which carry the motors and the load. but after building these part of project we see that the remote control circuit dose not work as will as to control from long distance because of the limitation of the hardware device . Also, the motor must run in different speed , whereas , in this project the motor run in one speed .

Index

List of table

List of figure

Chapter 1

Introduction

Chapter 2

Mechanical design

2.1 Introduction

2.2 Classifications of Machine Design

2.3 The main parts of double girder overhead crane fig

2.4 Top running Double Girder Cranes

2.5 Hoisting trolley

2.6 Festoon system

2.7 Girder mechanical Design

2.8 Dynamic stress analysis

2.9 Deflection due to bending

Chapter 3

Electrical Design

3.1 Introduction

3.2 Power distribution unit

3.3 Speed Control Electric of induction motor

3.4 How we can control of Induction motors

3.5 Characteristics of Induction Motors

3.6 Braking of induction motor

3.7 Power electronics circuits

3.8 Power calculates of the motor In hoisting

3.9 power analysis.

Chapter 4

Programmable Logic Controller (PLC)

4.1 Introduction

4.2 PLC History

4.3 The main parts of (PLC) and there functions

4.4 The (PLC) devices

4.5 Programming

Chapter 5

Remote Control

Chapter 6

Protection

Chapter 7

Design Sample

Chapter 8

Conclusion

Reference

Appendix

Appendix A

Appendix B

Appendix A

Appendix B

Chapter 1

Introduction

1.1 About Industrial Cranes

Crane, hoisting machine for lifting heavy loads and transferring them from one place to another, ordinarily over distances of not more than 200 ft (60 m). Old cranes have a long reach and can lift loads to great heights. Powered by manual or animal power, cranes have been in use from early times. Modern cranes are of varied types and sizes; they may be actuated by steam, electricity, diesel, or hydraulic power as well as by manual power, and they are indispensable in industries where heavy materials are handled constantly. The overhead traveling crane, a type of bridge crane, is used inside buildings or in outdoor storage yards. Two or more parallel girders span its working area. Another girder, called the bridge, stretches between them and rolls along them on wheels; this girder, in turn, supports a carriage from which a lifting attachment is lowered by pulleys. On a stacking crane the pulleys are replaced by a stiff, rotating column on which a pair of forks rides up and down. The gantry crane, another type of bridge crane, has a bridge supported by vertical structures that move along tracks. Gantries are used on piers or in shipyards. The jib crane has a horizontal load-supporting boom fastened to a rotating vertical column, either attached to a wall or extending from floor to ceiling; when the column is held only at the bottom it is called a pillar crane.

1.2 Definition:

Crane: is a machine used for lifting or moving heavy weights by means of a movable projecting arm or a horizontal beam traveling on an overhead support. Crane can also be any device with a swinging arm fixed on a vertical axis such as a fireplace crane that holds kettle, or a boom for holding a motion picture or television camera. Industry, the crane is commonly understood to be lifting equipment. However, each type of crane is referred to as crane.

1.3 Main purpose of project:

1. To design an electrical and mechanical crane moving in three dimensions.
2. To change the control system from the traditional method to new method and it is remote control system.
3. To apply this method of control system on the cranes that do in the dangerous places like, an industrial chemicals places, paint workshop, metals liquefaction, and other applications.
4. To apply control on the voltage for control the speed of the induction motor (IM).

1.4 Types of crane:

1. Over head crane:

Overhead crane style in which the horizontal load carrying beam is attached at the end to wall columns (over hung) or the underside of the ceiling (under hung).

This crane available in two basic types' single girder crane and double girder crane each one of this types has a one or two bridge beam that supports a trolley and hoist r multiple trolley-hoist units. At each end of the bridge beam are carriers, also called end trucks and trolleys. End trucks move along a runway structure. These types of cranes are shown in fig.1.1.

These types of crane provide movements in three dimensions and often feature a lower hook with a swivel that rotates the load around the vertical axis.

It can be controlled by many ways like pendant hand or remote radio control or infrared control unit.

And its two types as shown:

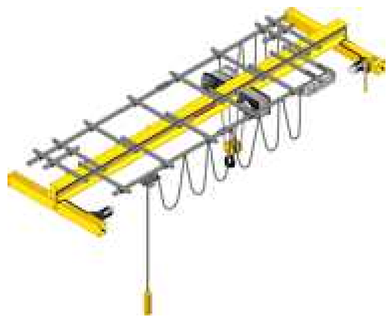
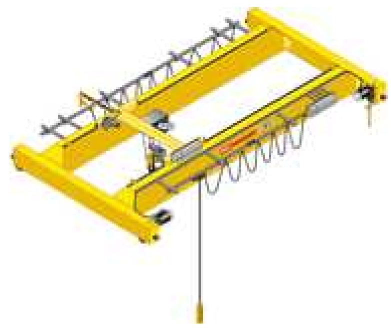
Single Girder Crane	**Double Girder Crane**
	

Fig.1.1 Over head crane

2. Jib Crane its two types:

a- Jib Crane - Wall Mount:

Jib cranes comprise a horizontal beam (jib) upon which a shuttle or hoist is mounted. These are mounted into the side of a wall. Cantilevered jib cranes can incorporate full or partial rotation.Its show in fig.1.2.

Fig.1.2: Jib Crane - Wall Mount

b- Jib Crane - Floor Mount:

Jib cranes comprise a horizontal beam (jib) upon which a shuttle or hoist is mounted. Floor or foundation mounted jib cranes can have higher load ratings than wall-mount cranes. Cantilevered jib cranes can incorporate full or partial rotation. Its show in fig.1.3.

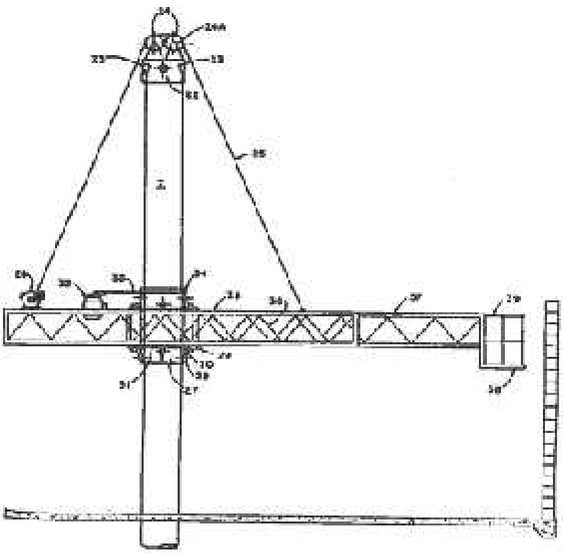


Fig.1.3: Jib Crane-Floor Mount

3. Gantry crane:

Gantry Cranes provide the same strength and durability of Overhead Bridge Cranes. Gantry end trucks ride on rail, or square bar, secured to the factory floor, instead of on the runway structure that supports Bridge Cranes. The gantry crane is raised above the floor by support legs mounted on the end trucks.

Gantry cranes have a horizontal beam supported by end supports or legs. These can vary in size from small workstation cranes to very large, heavy construction cranes. this type is shown in fig.1.4.

Fig.1.4 Gantry crane

Note:

After that we choose the remote control of overhead bridge crane (double girder) to designed it because it's save our life and doing all of the work in the industrial.

1.5 General block diagram overhead bridge crane:

The block diagram shows the all components of the project, and its transmitter, receiver, controller (by programmable logic controller (PLC)), motors, and loads. That we show in fig.1.5.

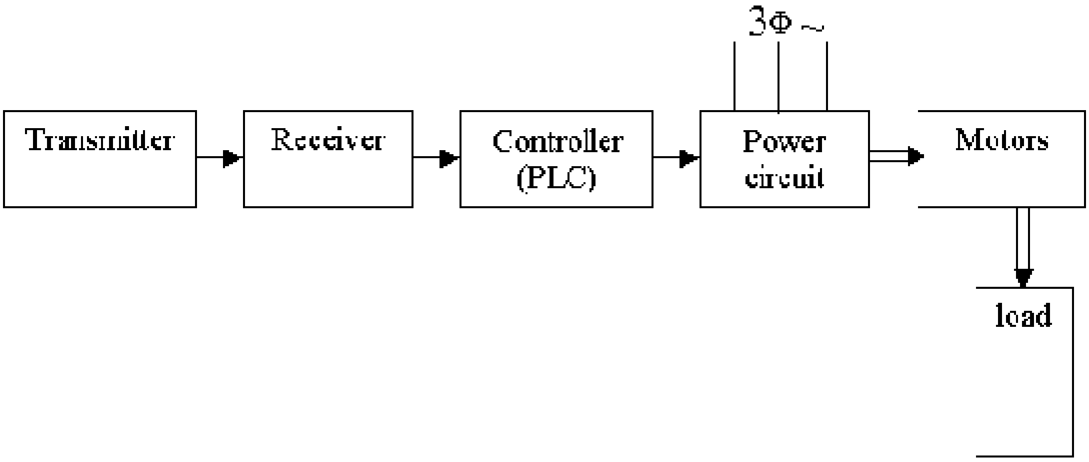


fig.1.5: Block diagram

1.6 Previous Studies:

Many previous studies are complete achievement of the crane project because many shapes and types of crane in industrial lifelong and in our university many student are take this project to fulfill the requirements of bachelor's degree but in another types of crane project.

Three dimension crane control by PLC
By (yousef kharmash & Waseam AL-Qaimary)

Chapter 2

Mechanical design

2.1 Introduction:

The subject Machine Design lathe creation of new and better machines And improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. From the study of existing ideas,’ a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape And form in the form of drawings. In the preparation of these drawings care must be taken of the availability of resources in money, in men and in materials required for the successful completion of the new idea into an actual reality. In designing a machine component, it is necessary to have a good knowledge of Strength of Materials, Theory of Machines and Workshop Processes.

2.2 Classifications of Machine Design

The machine design may be classified as follows:

1. Adaptive design. In most cases, the designer's work is concerned with adaptation of existing designs. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training.'

The designer only makes minor Alternation or modification in the existing designs of the product,

2. Development design. This type of design needs considerable scientific training and design ability in order to modify the existing designs into a new idea by adopting a new material or different method of manufacture. In this case though the designer starts from the existing design, but the final product may differ quite markedly from the original product.

3. New Design. This type of design needs lot of research, technical ability and creative thinking. Only those designers who have personal qualities of a sufficiently high order can take up the work, of a new design.

The designs, depending upon the methods used, way be classified m follows:

a) Rational design. This type of design depends upon mathematical formulae of principle of mechanics.

b) Empirical design. This type of design depends upon empirical formulae based on the practice and ~ experience،

c) Industrial design. This type of design upon the production aspects to manufacture any machine component in the industry.

2.3 The main parts of double girder overhead crane fig.:

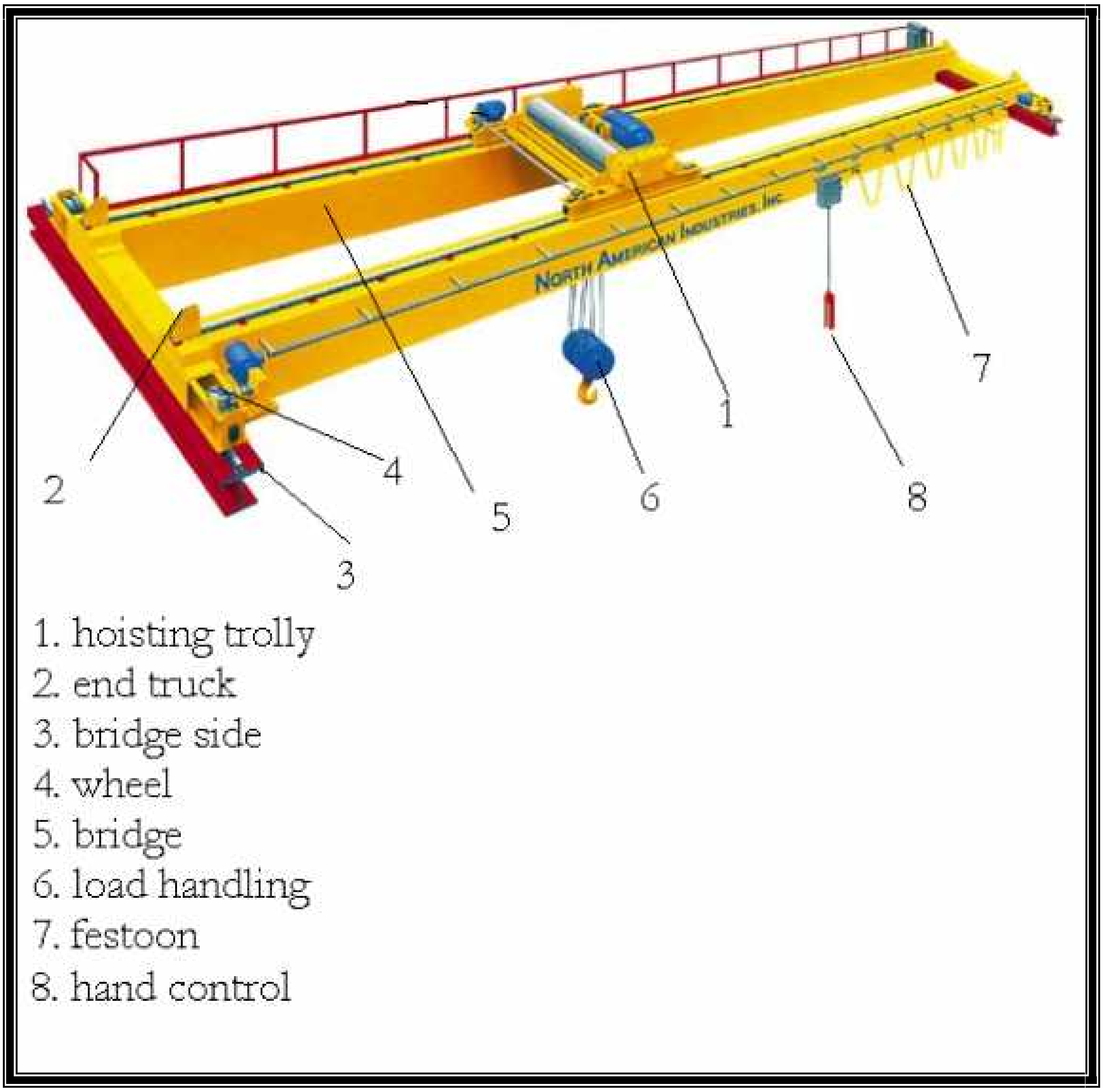


fig.2.1 main parts

The main parts of a crane are:

1. A bridge structure that carries the hoisting trolleys and moves on the runway.

2. A hoisting trolley that hoists and lowers the suspended load using wire rope or chain.

3. Load handling equipment.

2.3.1 Construction of the crane:

Here are the main components of crane:

1. Bridge and outfitting.
2. Hoisting trolley.
3. Traveling mechanisms.
4. Crane electric.
5. Brakes.
6. Load handling equipment.
7. End truck.
8. Festoon.
9. Protections.
10. Accessories.

2.3.2 Main components of crane and their functions:

2.3.2.1. Bridge and outfitting:

1) Bridge:-

The principal parts of the bridge are the main girder(s) and end trucks with wheels. Additional parts include maintenance platforms, also known as walkways, foot walk, and catwalks, and supporting systems for power and control cables as well as for crane electric. These additional parts are often referred to as outfitting. Outfitting varies from crane to crane, depending on the type and the intended use of the crane.

The main purpose of the bridge structures is:

1. To provide sufficient load carrying capacity (strength and stability) for both the vertical and the horizontal loads that originate from hoisting motion, traversing motion of the trolley, and traveling motion of the bridge,

2. To keep the crane aligned thus allowing distortion free movement of the trolley and the whole crane

.

2) Girders:-

A crane usually has one or two main girders that carry the hoisting trolley(s). The main functions of girders are to take the wheel load of the hoisting trolley, distribute these loads across the girder, and transfer them to the end trucks.

The girder bridge is two types:

1. Single Girder Crane:

Single Girder cranes offer the advantages of a low dead weight and lower capital expenses. The larger headroom requirement of a single girder crane is partly compensated by providing a low headroom type monorail hoist.

Single girder cranes are always controlled from the floor. Under running cranes offer the advantage of the maximum area coverage without reducing floor space by using extra columns for support. Usually supported from the ceiling structure, under running cranes are generally limited in capacity to about ten tons.

In special circumstances 12 or even 20 tons are possible. The single girder under running cranes seen here are the most economical means of providing maximum crane coverage with a capacity of two tons.

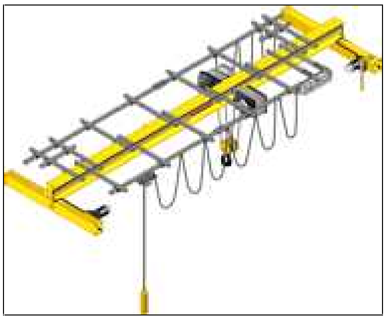


fig. 2.2 single girder

1. Double Girder Crane:

Double Girder cranes in general are available for heavier capacities and wider spans, have greater rigidity and offer improved headroom requirements because in most cases the hook can be raised up between the two crane girders. Double girder cranes can be supplied with walkways and can be operated with any kind of control system Double girder top running cranes up to 50T capacity and 120 ft.

Span with top or under-running trolleys with or without walkways controlled by push button pendant or cab operated Multiple cranes sharing a runway give an economical means of increasing production while minimizing capital expense For higher capacities and longer spans a double girder under running crane is necessary.

The real difference between single and double girder cranes is hook height (how far above the floor your hoist will lift). Double girder cranes provide better hook height, typically 18-36 inches better. Double girder cranes can provide more lift, because on double girder cranes the hoist is placed between the cross girders, not under the cross girder.

You gain the depth of the cross girder. Single girder cranes cost less in many ways: Only 1 cross girder is required, the trolley is simpler, freight costs less, installation is quicker, and your runway beams are lighter due to the reduced crane dead weight. Double Girder Crane Single Girder Crane Maximum Hook Height Reduced Hook Height Double girder cranes provide greater hook height, but are no more durable than single girder cranes.

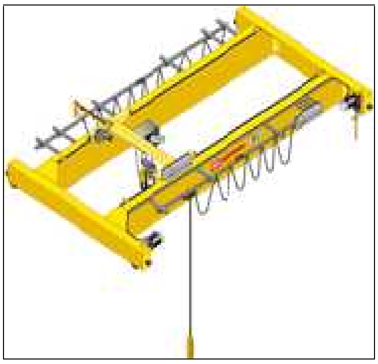


fig.2.3 double girder

3) Outfitting:

Outfitting typically includes mandatory items like buffer stops, supporting structures for control panels (crane electric) and internal cabling (power cables to mechanisms and control cables). Other items, normally required by the user, include maintenance platforms, ladders, and floodlights.

2.3.2.2. Hoisting trolley:

The main types of hoisting motors used in the Cranes are:

1. Squirrel cage motors, normally either single speed motors or two speed motors having two sets of windings (two speed squirrel cage motors are better know as pole-change motors). Some manufacturers offer three speed motors that incorporate three sets of windings in the motor.

2. Slip ring motors (normally single speed motors).

3. DC-motors (normally separately excited).

Typical to all hoisting motors are very high starting torque characteristics and an ability to withstand frequent starts that are required by intermittent duty .The type of hoisting motor depends on the desired performance of the motion (speed control system). These are discussed later in this section under crane electric.

fig 2.4 Hoisting trolley

2.3.2.3. Traveling mechanisms:

Traveling mechanisms consist of an electric motor/a) brake, a gear unit, and couplings. The mechanism is connected to the wheel directly, with a coupling, or with a shaft and coupling(s). In North America, it is common to have one machinery, a motor with or without a gearbox, in the center of the bridge. The torque is transmitted to opposite wheels by long supported shafts. In Europe, it is customary to use independent mechanisms.

The brakes in traveling mechanisms are either conical, disc, or shoe brakes. The brakes function like holding brakes in hoisting motion. The primary function of the traveling mechanism is to move the crane on the runway.

fig2.5 Traveling mechanisms

2.3.2.4. Crane electric:

That is an induction motor and there control circuit by PLC and the power supply three phases (380 V) and the festoon cable.

fig2.6 Crane electric motors

Power Supply Devices:

The power supply devices will bring the needed electric power to the power distribution unit of the crane. The three base systems are:

1. Conductor rail systems with current collectors.

    1. Moving cables (suspended from track), normally festoon type.

2.3.2.5. Cable reel systems.

If power supply line is used only to deliver electric power, all systems are equally competent. In that case, the main purchase criteria are the dimensions and/or cost of the devices. However, if data signals are transferred, the conventional conductor rail systems are not particularly suitable, because of the sparking between the conductor and the collector. The sparking also prevents the use of this system in explosive and corrosive environments.

The power supply system dimensioning is based on maximum continuous and starting currents.

All aforementioned systems must be equipped with a power disconnection switch for the entire crane system, including the power supply conductors or cables. This switch is normally located near the crane on the floor level

2.3.2.6. Brakes:

Working brakes are used to control speed. At present, working brakes are electric. They use either eddy current braking or regenerative braking implemented by the hoisting motor. The holding brake is normally used to stop the movement. In more advanced speed control systems, the holding brakes will only hold the load. Consequently, they are applied only when the hoisting mechanism has been brought to a still stand by a working brake. Regardless of the braking scheme, holding brakes are used to hold the load in case of a power failure or an emergency. The most common types of holding brakes include conical brakes, disc brakes, and shoe brakes.

The load brake is a special brake. Its purpose is to prevent load drop in case of a motor failure, a holding brake failure, and a hoisting gear unit failure.

1) Electro Magnetic Brakes:

Electro magnetic brakes are used when a load must be stopped rapidly to prevent the load from rotating due to the motor automatic control whether it is a question of stopping at a pre-determined time or at selected points of travel or to prevent over traveling. For foolproof and safe operation of machinery, modem methods are necessary, which should not tax the operator very greatly. Any machine which requires its motion to be arrested, whether it is a lifting Crane, Hoist, Winch or Mining Haulage today employs a electro magnetic brake, enabling the operator not only to arrest the motion but also to hold the load at any desired point without danger of falling, merely by release of the starting handle. One cannot possibly disparate the brake. Nothing safer than the electro magnetic brake is available today.

2) Single Phase Electro Magnetic Brake:

Electro magnetic single phase A.C Brake is ruggedly constructed to withstand the effect of mechanical shocks and vibrations. The brake is manufactured to comply with BS Specification

fig2.7 Single Phase Electro Magnetic Brake

The AC Electro magnet is built of high grade, low magnetic steel laminations each insulated from the adjacent one. The entire lot is tightly riveted and machined accurately to eliminate the air gap when the magnet circuit is closed. The coils are wound on bakelite bobbin and are thoroughly insulated.

3) Electro Hydraulic Thruster Operated Brake

Electro hydraulic thruster brake is a heavy-duty brake designed to withstand the severe duty conditions imposed by heavy-duty machinery in various industries. The electro hydraulic thruster transmits useful thrust through the levers onto the brake shoe thereby releasing the brake. When the power is switched off, the brake is smoothly applied because the hydraulic thrust acting against the spring pressure is gradually reduced.

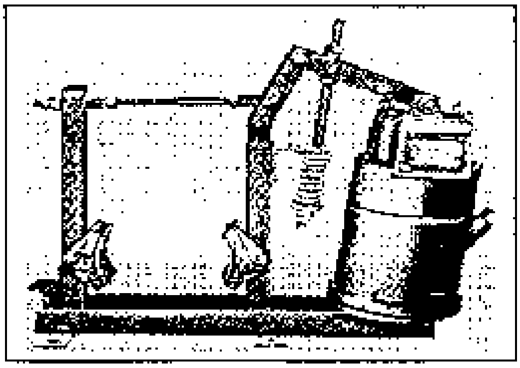


fig2.8 Electro Hydraulic Thruster Operated Brake

4) Steel Mill Duty DC Electro Magnetic Brake:

DC electro magnetic shunt brake is designed to withstand a large number of switching operations per hour. The minimum number of pivots ensures minimum wear and tear of moving parts. The brakes are manufactured for different voltages and are supplied if necessary with Transformer Rectifier Panels

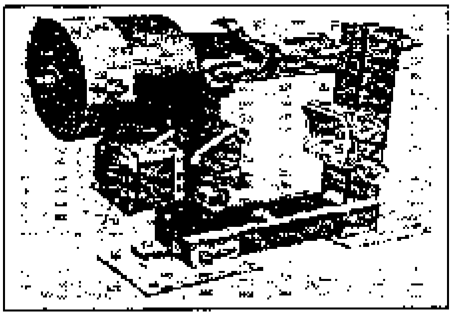


fig2.9 DC Electro Magnetic Brake

All types of brakes are normally applied when in OFF position and the brake is released when power is connected.

5) Disc Brakes:

Flange-mounted Disc Brakes with single or double disc. Brake torques up to1400Nm.

fig.2.10 Disc Brakes

2.3.2.7. Load handling equipment:

The Load Handling Equipment, LHE, has three major functions; to ensure safe attachment of the load to the lifting system, to speed-up the attachment procedure, and to increase the utilization of warehouse area.

The most commonly used LHE is the hook. For more sophisticated load attachment, there is a wide variety of LHEs available, including different type of hooks, lifting magnets, hydraulic container spreaders, vacuum based devices, just to mention a few. The use of these LHEs largely depends on the required degree of efficiency (increased automation in attachment), type and shape of load, and on the money available.

Based on the product catalogues of several manufacturers, the majority of LHEs are operated by the crane driver. In process type industry and container handling, the LHEs are automated. After the LHE is activated, it will attach itself to the load, indicate when the attachment is complete. Then lifting can begin.

When the crane runs on automatic mode, additional safety regulations apply. These regulations involve safe attachment of load, load drop prevention when crane or trolley moves, allowed transportation routes (no access to space above corridors, etc.), access of the personnel to the area where the crane operates, and so on. These regulations have not yet been harmonized to an international standard, they vary from country to country.

fig.2.11 Load handling equipment

2.3.2.8. End truck:

The main tasks of the end trucks are to support the girders, transfer the loading from girders to crane rails through wheel assemblies, move the crane with the help of traveling mechanisms, keep the crane perpendicular to runway, and protect the crane and load from dropping in case of a wheel or axle breakage.

End trucks consist of steel housing, wheel assemblies, a connection to girders, crane buffers that are also known as bumpers, and a connection for traveling mechanisms. In its simplest form, an end truck has two wheels. In bigger cranes, the end trucks an form a system that has several elementary trucks that are normally pin connected to girders with balancing beams.

Fig.2.12 End truck

2.3.2.8.1 offer the following style End Trucks:

1. Top Running Single Girder - Manual & Powered
2. Top Running Double Girder - Powered
3. Under Running Single Girder - Manual & Powered

fig.2.13 offer the following style End Trucks

2.4 Top running Double Girder Cranes:

Double girder top running cranes up to 50T capacity and 120 ft. span with top or under-running trolleys with or without walkways controlled by push button pendant or cab operated.

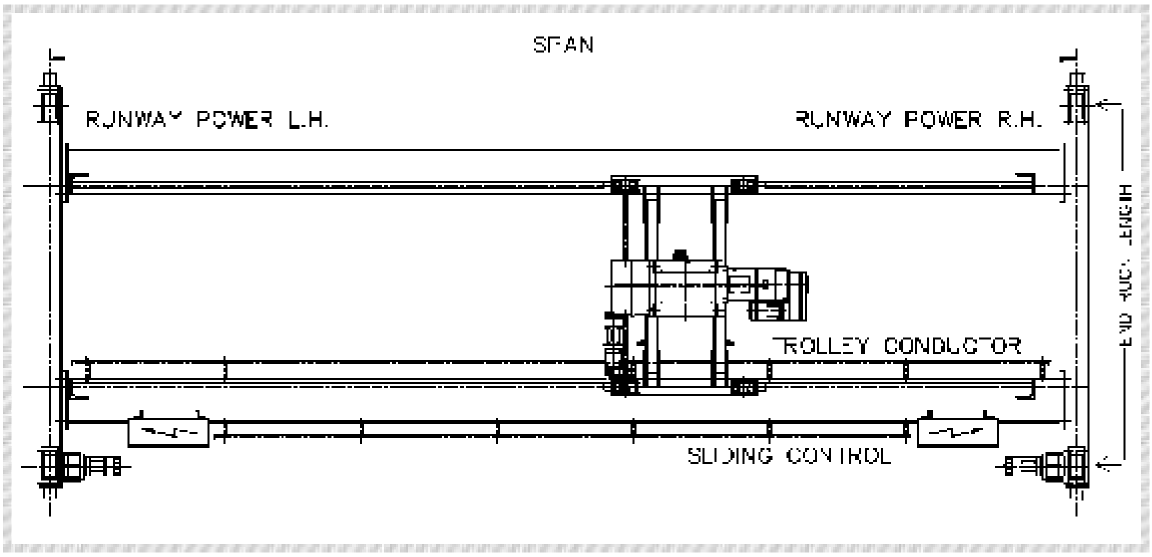


fig.2.14 projection head of overhead crane

Span: is equal 7 meter

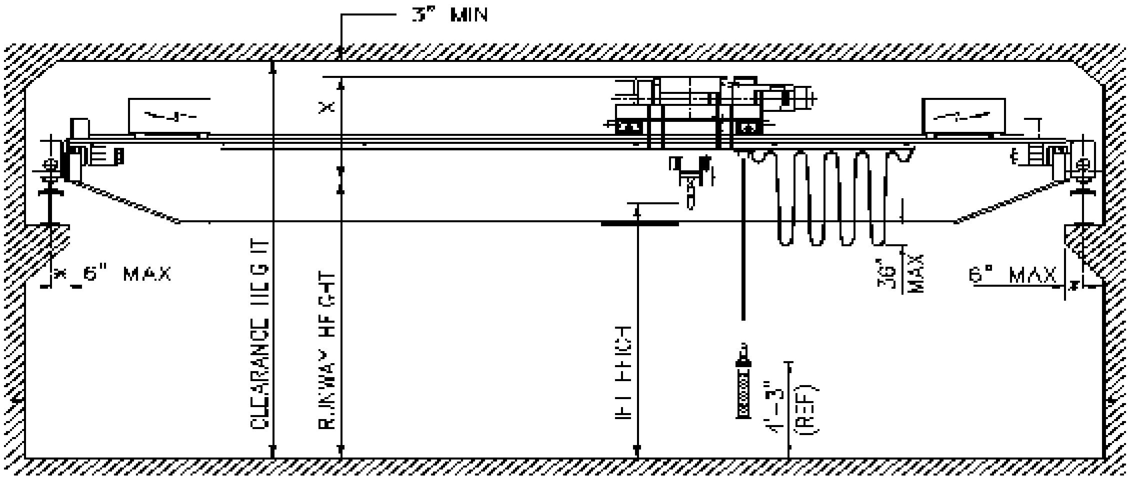


fig.2.15 projection front of overhead crane

Clearance height: is equal 3 meter & The length is 10 meter

2.5 Hoisting trolley:

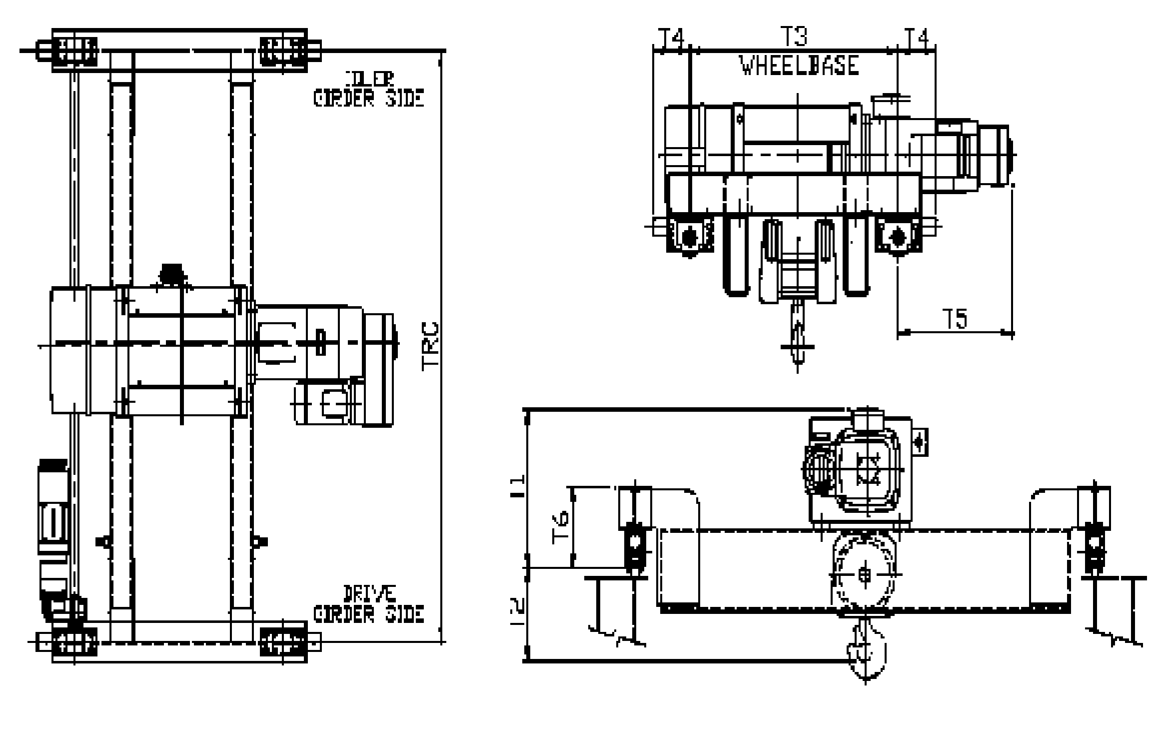


fig.2.16 projection front ,head and side view of overhead crane

We can see all distance of all lengths of T from the table (2.1)

CAPACITY (Ton)	EZLDH HOIST MODEL	TRAVEL WHEEL	T1 (in)	T2 (in)	T3 (in)	T4 (in)	T5 (in)	T6 (in)	WEIGHT by TRC (lbs) 55 12"	88 18'	110 25"
3	DH168H19KV24/1F4	DRS112	15.2	7.3	42	6.5	7.2	11.2	990	1270	1390
5	DH212H19KV24/1F4	DRS112	18.2	10.8	42	6.5	7.2	11.2	1010	1290	1410
5	DH312H12KN34/1F10	DRS112	22.1	13.8	36	6.5	20.3	11.2	1320	1600	1830
5	DH312H20KN34/1F10	DRS112	22.1	13.8	40	6.5	18.4	11.2	1400	1690	1920
7.5	DH320H12KN34/1F10	DRS112	22.1	13.8	36	6.5	20.3	11.2	1330	1610	1850
7.5	DH320H20KN34/1F10	DRS112	22.1	13.8	48	6.5	18.4	11.2	1420	1700	1940
7.5	DH520H12KN34/1F10	DRS112	23.7	15.7	38	6.5	23.0	11.2	1730	2070	2410
7.5	DH520H20KN34/1F10	DRS112	23.7	18.7	50	6.5	21.0	11.2	1810	2150	2500
10	DH425H20KN34/1F10	DRS125	22.8	13.1	50	7.1	17.4	11.9	1570	1930	2280
10	DH525H12KN34/1F10	DRS125	24.4	18.0	40	7.1	22.0	11.9	1920	2360	2700
10	DH525H20KN34/1F10	DRS125	24.4	18.0	52	7.1	20.0	11.9	2000	2450	2780
15	DH640H20KN34/1F10	DRS125	24.4	18.0	56	7.1	18.0	13.6	2280	2720	3160
15	DH1040H16KN34/1F10	DRS125	29.7	24.1	50	7.1	35.3	13.6	3500	3940	4390
15	DH1040H24KN34/1F10	DRS125	29.7	24.1	62	7.1	33.6	13.6	3740	4180	4630

2.6 Festoon system:

They are four types of the festoon wire system :

1. • Stretched wire.
2. • C-track.
3. • Square bar.
4. • I-beam.

2.6.1. Typical stretched wire system:

This is a light-duty festoon system for economical installation where heavy service is not required. Economical and dependable, this wire rope-supported festoon system is designed to provide electrification to small cranes, moving hoists, and other moving machinery where relatively light load conditions are present.

Stretched wire systems can also be used to festoon supply hoses for pneumatic tools, as well as continuous welding machines or flame cutters where oxygen or acetylene gases are used.

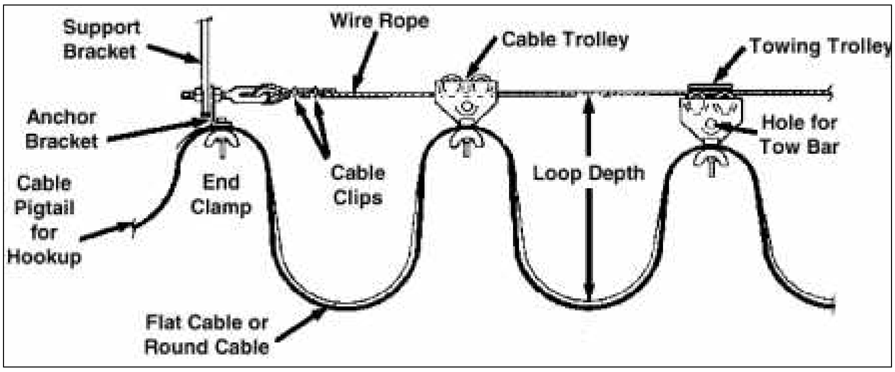


fig.2.17 Typical stretched wire system

2.6.2. Typical C-track system:

The C-track system is one of the most versatile festooning techniques available. It is an all-purpose system suited for either indoor or outdoor use under a broad range of operating conditions.

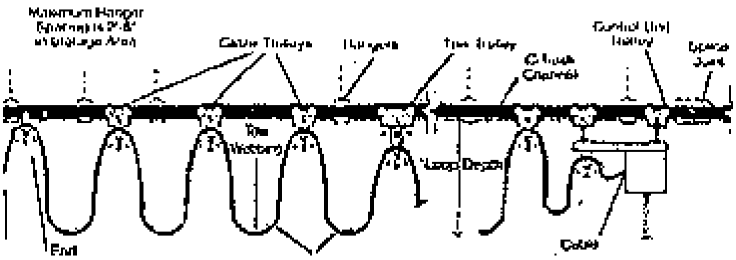


fig.2.18 Typical C-track system

2.6.3. Typical Square Bar System:

Square bar systems provide a rigid and stable support for cable carriers without the weight and greater cost of an I-beam installation. Square bar installations also mean that carriers travel on exposed surfaces and permit easy access to moving parts for maintenance. The carriers have guide wheels that contact all four surfaces of the bar and are less prone to sway from side-to-side.

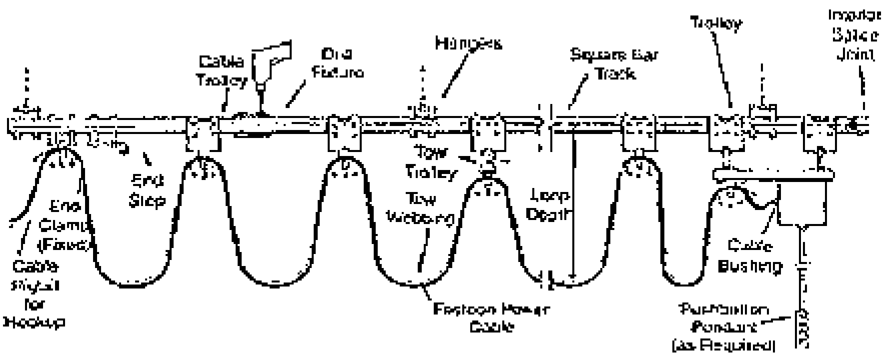


fig2.19 Typical Square Bar System

2.6.4. Typical I-B earn System:

I-beam festoons are for use when needs merit a sophisticated solution.

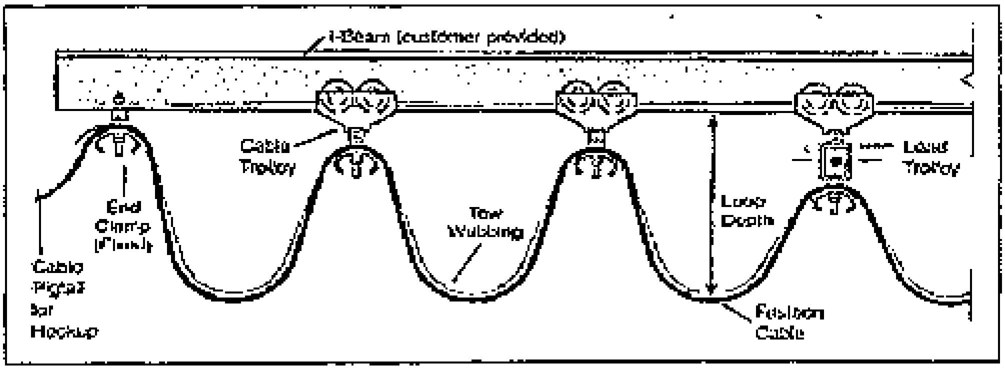


fig.2.20 Typical I-B earn System

2.7 Girder mechanical Design:

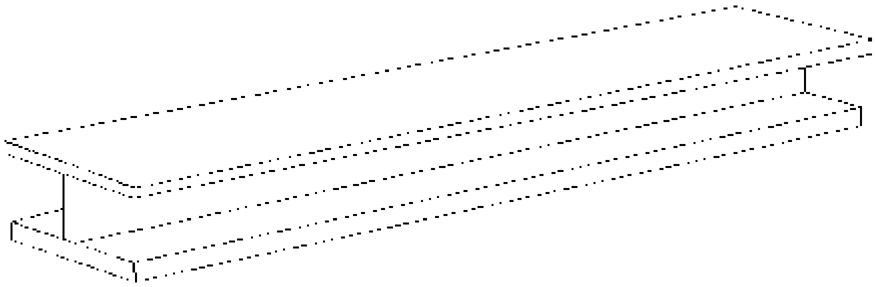


fig.2.21 the beam

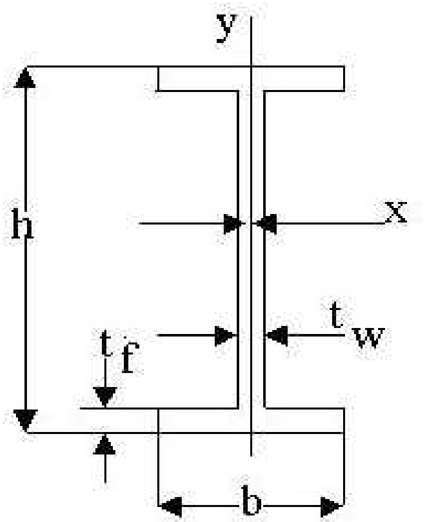


Fig.2.22 the beam distance

The weight of beam:

$m = v * \rho$ ………. (E 2.1)

$V = (2* L*b*t_f)+((h-2*t_f)*L*t_w)$ ………. (E 2.2)

$m = \rho \left[(2* L*b*t_f)+((h-2*t_f)*L*t_w)\right]$ ………. (E 2.3)

W: weight of the beam (N)

ρ : Material density (kg/m^3)

V: beam volume (m^3)

m: mass of the beam (kg)

2.8 Dynamic stress analysis:

Stress: is external system forces or loads on a body and the internal forces (equal and opposite) are set up various section of the body, which resist the external forces. This internal forces per unit area at any section of the body is known as a unit stress or simply stress.

The maximum stress force is applied on the center of the beam

$\sigma = F/A$ ………. (E 2.4)

$F = m_b * g$ ………. (E2.5)

m_c : chain hoist mass (kg)

σ: beam stress(N/m^2)

A: area of the beam (m^2) .

F : applied force on the beam (N)

from table (2.1) that make stand hand for mechanical engineers design of the weights of the hoisting trolley.

$m_c = 197 — 211$ kg ≈220 kg

m_L : looking basined load

m_b: mass on the beam

mb= mc+ mL =220 kg ……….(E2.6)

$F = (1220) * 9.81 = 11968.2$ N

A=L.W .... (E2.7)

$\sigma = F/A$ (N/m^2) .... (E2.8)

$\delta = F.L/A.E$

Where

δ: Is the total deformation of the beam

F: beam force

L: beam length

A: surface Area of the beam

E: modulus of elasticity .

M: Moment.

θ: Slope, tensional deflection.

V: shear force.

(2.1) Table that make stand hand for mechanical engineers design of the weights of the hoisting trolley

Capacity		Lifting speed		Beam to high hook distance		Net weight		motor	
Shoottons		ft/min	m/min	in	mm	Ib	Kg	hp	Kw
½	0.4	60	18	27	686	430	195	4.5	3.36
¾	0.68	37	11	27	686	430	195	4.5	3.36
1	0.91	30	9	25	635	465	211	4.5	3.36
1	0.91	37	11	27	686	435	197	4.5	3.36
1	0.91	60	18	27	686	445	202	4.5	3.36
1½	1.36	18	5.5	25	635	464	211	4.5	3.36
1½	1.36	30	9	25	635	464	211	4.5	3.36
1½	1.36	37	11	27	686	445	202	4.5	3.36
2	1.81	18	5.5	25	635	465	211	4.5	3.36
2	1.81	30	9	25	635	480	218	4.5	3.36
3	2.7	18	5.5	25	635	560	254	4.5	3.36
5	4.5	13	4	30	762	710	322	4.5	3.36
7½	6.8	15	4.6	36	914	1100	499	7.5	5.59
10	9.1	13.5	4.1	40	1016	1785	810	10	7.46
15	13.6	13	4	49	1245	2510	1139	15	11.19

2.9 Deflection due to bending:

The relation involved in the binding of beams are well known and are given here for reference purposes as follows :

$$\frac{q}{EI} = \frac{d^4y}{dx^4} \qquad \text{……….. (E2.9)}$$

$$\frac{V}{EI} = \frac{d^3y}{dx^3} \qquad \text{……….. (E2.10)}$$

$$\frac{M}{EI} = \frac{d^2y}{dx^2} \qquad \text{……….. (E2.11)}$$

$$- \quad = \frac{dy}{dx} \qquad \text{……….. (E2.12)}$$

$$y = f(x) \qquad \text{……….. (E2.13)}$$

These relation are illustrated by the beam of Fig (2.23) .note that the x axis is positive to the right and the y axis is positive upward .All quantities ,loading ,shear force, support reaction, moment, slope, and deflection have the same sense as y ; they are positive if upward ,negative if downward.

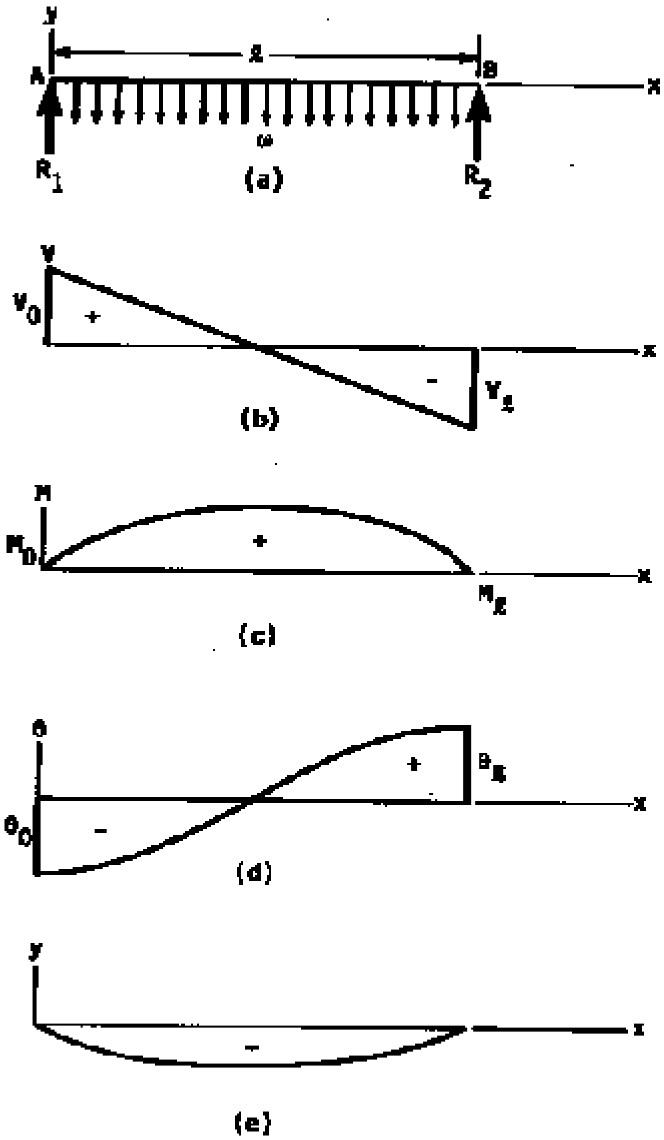


Fig 2.23 (a) loading diagram showing beam supported at A and B with uniform load

W having units of force per unit length, $R_1 = R_2 = wl/2$; (b) shear –force diagram showing end conditions; (c) moment diagram ;(d) slope diagram ; (e) deflection diagram .

Chapter 3

Electrical Design

3.1 Introduction:

The crane electric consists of a power distribution unit, speed control electric for each motion, a controller consisting of a man-machine interface, protective devices, and wiring.

3.2 Power distribution unit:

Electricity for the crane is brought to the power distribution unit. This unit contains the mandatory main switches and fuses or circuit breakers. This unit can also contain protective devices, such as over/under voltage protectors, phase failure detectors, and condition monitoring systems. The electric power is then distributed to crane mechanisms and controllers

Like all electrical components, the dimensioning of their individual parts and functions are strictly controlled by local and international regulations.

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3. Speed control system. In this system, the crane operator gives a speed reference value. This speed reference value is normally a voltage, whose polarity indicates direction of the movement. The control unit adjusts the actual speed requested by using the feedback given by a tachometer or a similar device and then modifying the system parameters so that the equilibrium between the required and the actual speed is reached and kept.

The construction of the speed control system depends on the motor type.

3.4 How we can control of Induction motors:

1. Stator voltage control.
2. Rotor voltage control.
3. Stator voltage and frequency control.
4. Frequency control.
5. Stator current control.

6. Voltage, current and frequency control.

Although all of the above strategies are used in cranes, the most common strategies are the stator voltage control, the rotor voltage control, and the stator voltage and frequency control. The aforementioned classification of the strategies is purely theoretical from the crane maker's point of view. The rotor voltage control is in practice a rotor resistance control.

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III) The torque varies directly with the slip;
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V) The efficiency of an induction motor is inversely proportional to slip.

A motor with a lower value of slip will be more efficient than a motor with a higher slip because of the increased losses in the rotor of the latter. The efficiency of three phase induction motors varies with type, size and load. It ranges from 85% to 99% in the case of squirrel cage motors above 5 HP. It is about 75% for smaller motors. The efficiency is less in the case of slip-ring motors, slow speed motors and motors running at part load.

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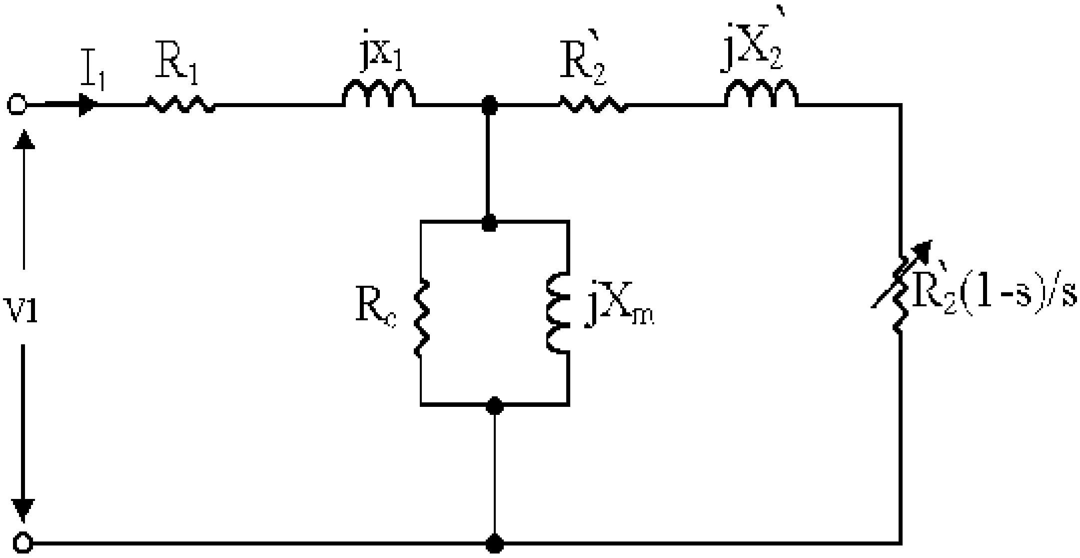

fig.3.1 Equivalent Circuit of an Induction motor

Where:

R1: is the stator resistance per phase.

X1: is the stator reactance per phase.

R2’: is the equivalent rotor resistance referred to stator per phase.

X2’: is the equivalent rotor reactance referred to stator per phase.

Rc: is the resistance representing core losses.

Xm: is the magnetizing reactance per phase .

V1: is the per phase supply voltage to the stator s is the slip of the motor.

S: is the slip of the motor

3.5.3 Power flow in an Induction motor :

$$P_g = 3 \times I_2^{'2} \times [R_2^{'} + R_2^{'} \times (1-s)/s]$$ …………………….....………. (3.1)

The equation can be split into two part as follows-

$$P_g = 3 \times I_2^{'2} \times R_2^{'} + 3 \times I_2^{'2} \times R_2^{'} \times (1-s)/s$$ ……………………….....……..…. (3.2)

Such that $P_g = P_{rc} + P_m$ ……………………………………… ………. (3.3)

such that $P_g = P_{rc} + P_m$ ………………………………………………...………. (3.4)

and $P_m = 3 \times I_2^{'2} \times R_2^{'} \times (1-s)/s$ ……………….....……...………. (3.5)

from the equivalent circuit can be see that the equivalent resistance $R_2^1(1\text{-}s)/s$ is variable resistance and is equivalent to the mechanical power developed thus the part P_m corresponds to the mechanical power developed to meet the load .

From the circuit, we see that the total power input to the rotor P_g is

The power flow diagram is-

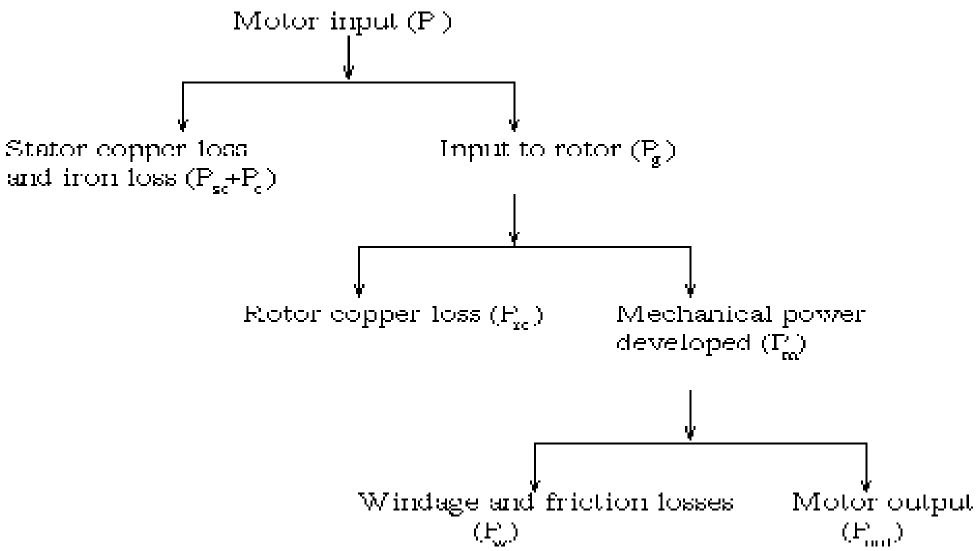

fig3.2 The power flow diagram

3.5.4 Soft Starters for Induction Motors:

Definition:

A soft starter is another form of reduced voltage starter for A.C. induction motors. The soft starter is similar to a primary resistance or primary reactance starter in that it is in series with the supply to the motor. The current into the starter equals the current out. The soft starter employs solid state devices to control the current flow and therefore the voltage applied to the motor. In theory, soft starters can be connected in series with the line voltage applied to the motor, or can be connected inside the delta loop of a delta connected motor, controlling the voltage applied to each winding.

The starting current of an AC motor can vary from 3 to 7 times the nominal current.

This is because a large amount of energy is required to magnetize the motor enough to overcome the inertia the system has at standstill. The high current drawn from the network can cause problems such as voltage drop, high transients and, in some cases, uncontrolled shutdown. High starting current also causes great mechanical stress on the motor's rotor bars and windings, and can affect the driven equipment and the Foundations. Several starting methods exist, all aiming to reduce these stresses.

The load, the motor and the supply network determine the most appropriate starting Method. When selecting and dimensioning the starting equipment and any protective

Devices, the following factors must be taken into account:

- The voltage drop in the supply network when starting the motor
- The required load torque during start
- The required starting time

3.5.5 How does a motor start in the first place?

Motors convert electrical energy drawn from the power supply into a mechanical form, usually as a shaft rotating at a speed fixed by the frequency of the supply. The power available from the shaft is equal to the torque (moment) multiplied by the shaft speed (rpm). From an initial value at standstill, the torque alters, up or down, as the machine accelerates, reaching a peak at about two-thirds full speed, finally to become zero at synchronous speed. This characteristic means that induction motors always run at slightly less than synchronous speed in order to develop power the 'slip speed' and, hence the term asynchronous. The (fig) below, which shows an induction motor torque/speed curve, illustrates this most important characteristic.

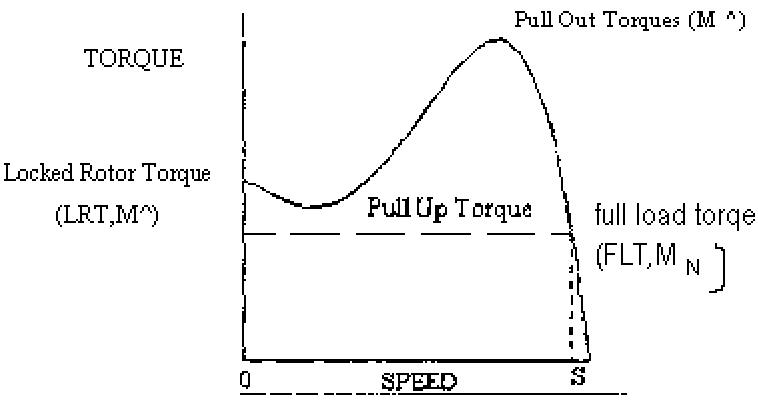

fig3.3 Induction motor torque/speed curve

3.6 Braking of induction motor:

Braking occurs by the methods:

3.6.1 Regenerative braking

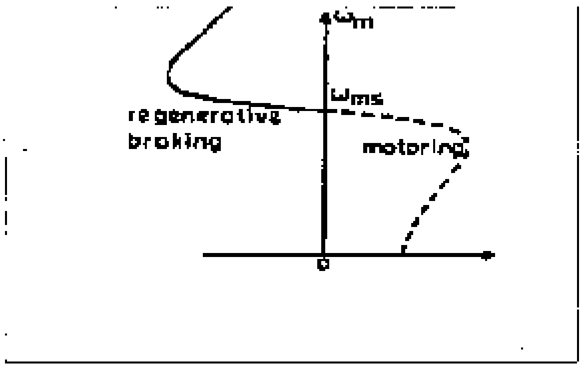

fig3.4 Regenerative braking

When regenerative braking is employed for holding motor-speed against an active load, stable operation is generally possible between synchronous speed and the speed for which braking torque is maximum.

Main advantage of regenerative braking is that generated power is usefully employed and main drawback being that when fed from a constant frequency source, it cannot be employed below synchronous speed.

3.6.2 Plugging or reverse voltage braking

In this method, mechanical energy supplied to the rotor, either by active load or form kinetic energy stored in motor and load inertia, is covered into electrical energy and wasted in rotor resistance.

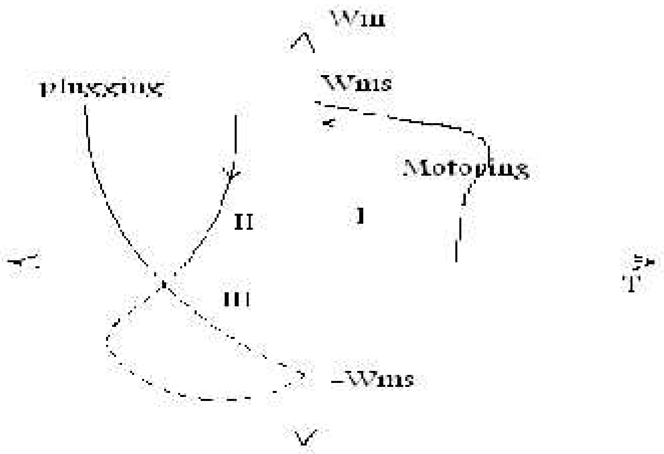

fig3.5 Plugging or reverse voltage braking

3.6.3 Dynamic braking:

ac dynamic braking is obtained when the motor is run on a single phase supply by disconnecting one phase from the source and either leaving it open as in last fig. (b) or connecting it with another machine phase as in the last fig (c) . the two connection of the last fig. in (b)&(c) are respectively known as two and three lead connections.

When connected to a 1-phase supply, the motor can be considered to be fed by positive and negative sequence three phase set of voltage. Net torque produced by the machine is sum of torques due to positive and negative sequence voltages. When rotor has a high resistance, the net torque is negative and braking operation is obtained.

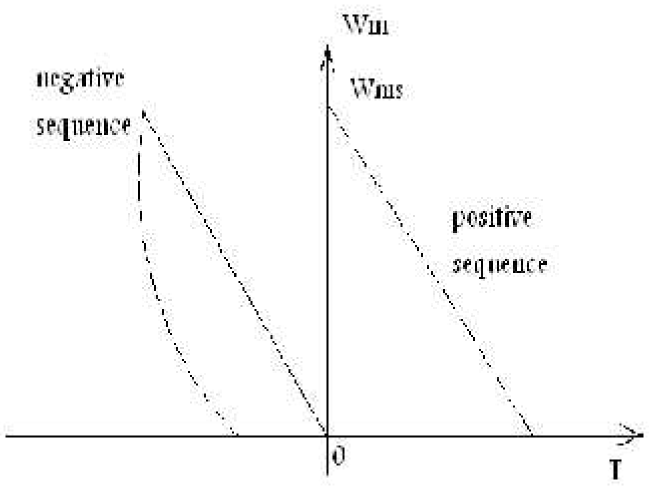

Fig3.6   Dynamic braking

3.7   Power electronics circuits:

That have a two circuits

1.triggering circuit.

This circuit to give trigger to triac in the power circuit.

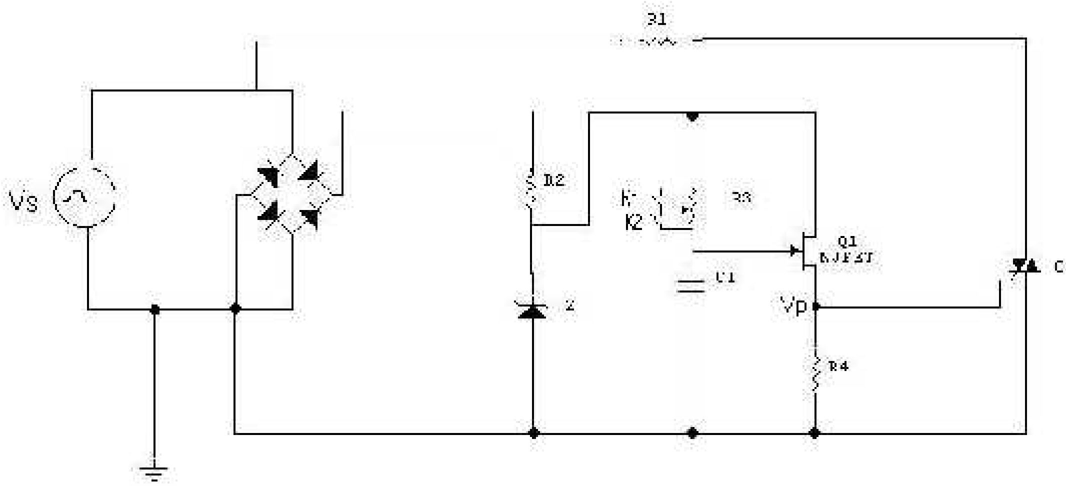

fig3.7 triggering circuit

2. power circuit.

It’s take the trigger pulses to operate the triac.

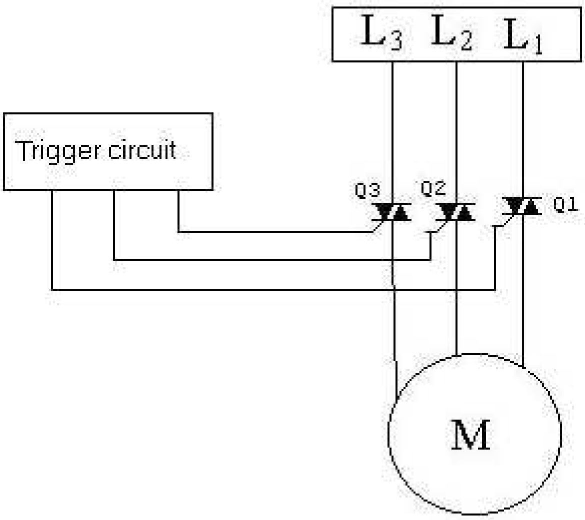

fig3.8power circuit

3.8 Power calculates of the motor In hoisting:

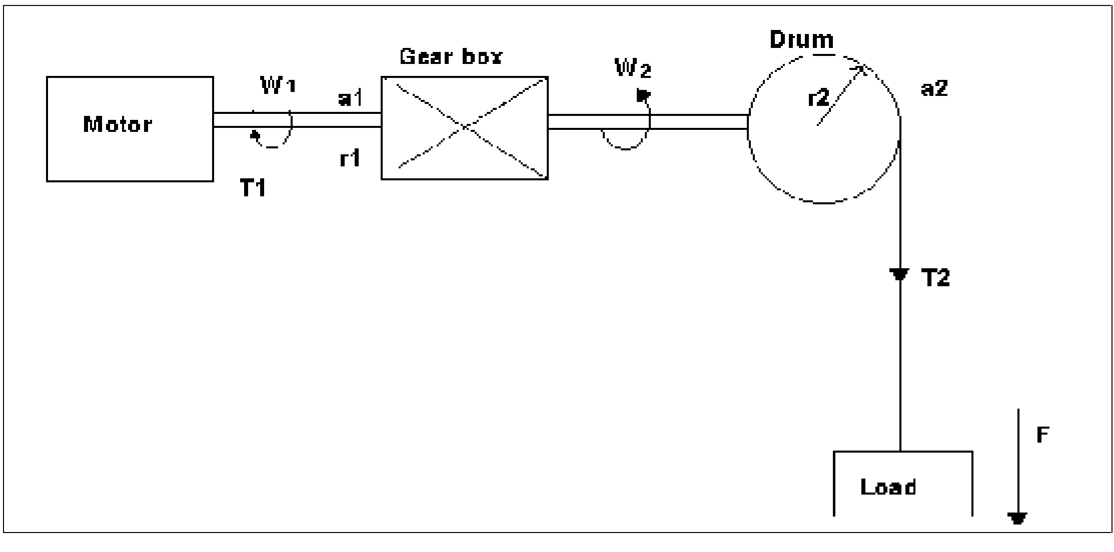

fig3.7 motor In hoisting

3.9 power analysis:

3.9.1 Analysis of the required power of the lifting motor:

The power requirement of the motor to safety carry the loads be found by using the maximum torque theory, using the following equation

$$T1 \times \omega1 = T2 \times \omega2 \quad \text{...}(3.6)$$

Where:

T1: Torque of motor, N.m.

ω1: Angular velocity of the motor, rad/s.

T2: Torque produced from the loads, N.m.

ω2: Angular velocity of lifting wheel, rad/s.

The torque produced from the loads can be found using the following equation:

$$T2 = N \times F \times r \quad \text{...}(3.7)$$

Where:

N: Factor of safety corresponding dynamic loads.

F: Force produced by loads, N.

r: Radius of the lifting wheel, m

3.9.2 Analysis of the power required for bridge movement:

After selecting the dimensions of the train for bridge in this section we will cheek weather the selection satisfies the power requirement for moving the bridge, that is, If the reduction train suggested can move the crane when it is fully loaded.

The power requirement for the bridge movement can be represented by the following equation:

$$P = (F \times v) \div (1000 \times \eta) \quad \text{...} (3.8)$$

Where:

P: Power required, Kw.

F: Resistance force resulting from loads, N.

V: Lifting speed, m/s.

η: Efficiency of drives belts.

$$F=(W_o + W_1) \times g \times B \times ((f \times d + 2 \times k) / D) \quad \text{(3.9)}$$

Where:

F:Resistance force resulting from friction, N.

W0: Weight of the crane, Kg.

W1: Maximum weight lifted, Kg.

G: Standard acceleration of gravity, m/s2.

B: Correction factor for the friction between wheels and the path.

f.: Friction factor for the bearings. Diameter of shaft, mm.

K: Rolling correction factor.

D: Diameter of wheel, mm.

3.9.3 Analysis of the power required for trolley movement:

The power required to move the trolley when fully loaded is found by:

$$P= (F \times v) \div (1000 \times \eta) \quad \text{(9.10)}$$

Where:

P: Power required, Kw.

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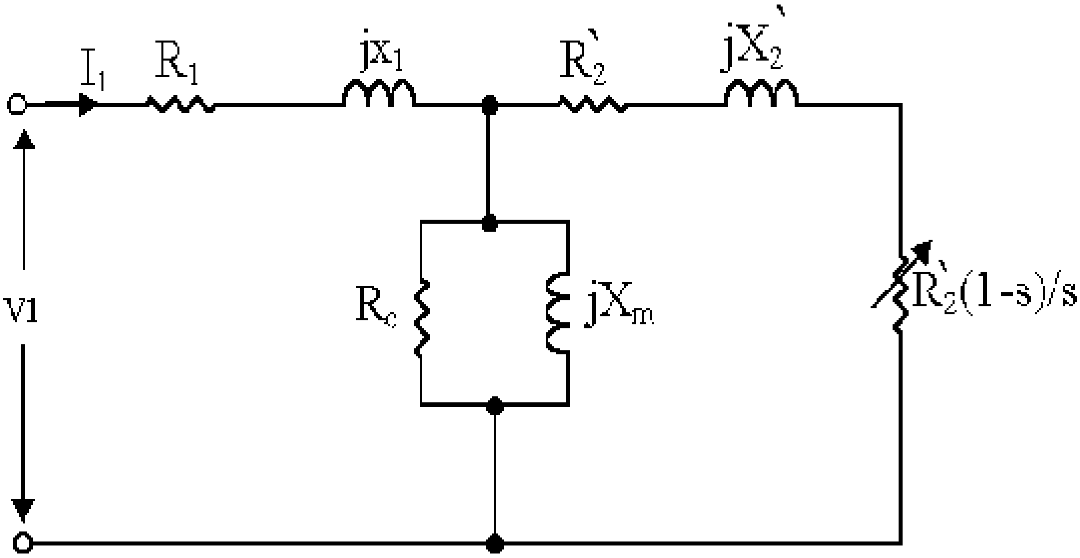

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Such that $P_g = P_{rc} + P_m$ ……………………………………… ………. (3.3)

$$\text{such that } P_g = P_{rc} + P_m$$ ………………………………………………...………. (3.4)

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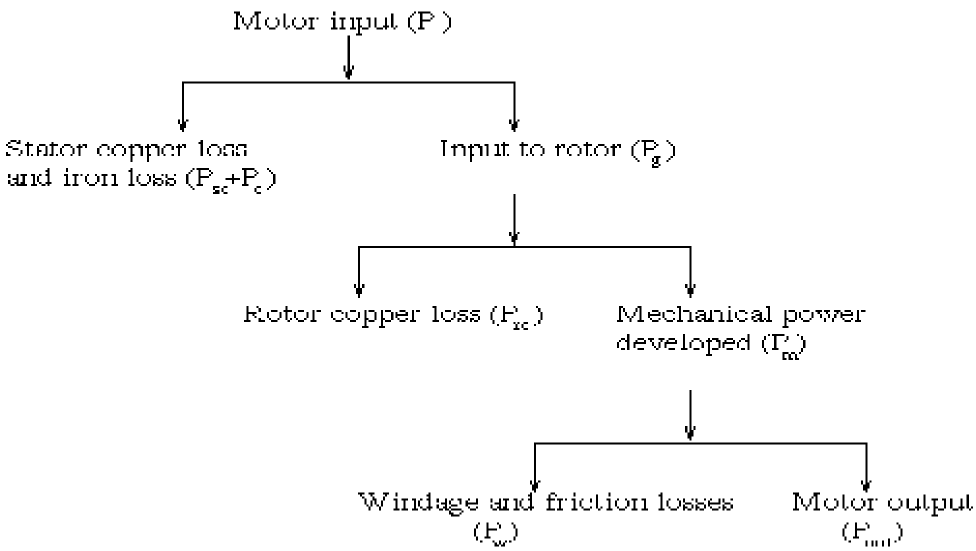


fig3.2 The power flow diagram

3.5.4 Soft Starters for Induction Motors:

Definition:

A soft starter is another form of reduced voltage starter for A.C. induction motors. The soft starter is similar to a primary resistance or primary reactance starter in that it is in series with the supply to the motor. The current into the starter equals the current out. The soft starter employs solid state devices to control the current flow and therefore the voltage applied to the motor. In theory, soft starters can be connected in series with the line voltage applied to the motor, or can be connected inside the delta loop of a delta connected motor, controlling the voltage applied to each winding.

The starting current of an AC motor can vary from 3 to 7 times the nominal current.

This is because a large amount of energy is required to magnetize the motor enough to overcome the inertia the system has at standstill. The high current drawn from the network can cause problems such as voltage drop, high transients and, in some cases, uncontrolled shutdown. High starting current also causes great mechanical stress on the motor’s rotor bars and windings, and can affect the driven equipment and the Foundations. Several starting methods exist, all aiming to reduce these stresses.

The load, the motor and the supply network determine the most appropriate starting Method. When selecting and dimensioning the starting equipment and any protective

Devices, the following factors must be taken into account:

• The voltage drop in the supply network when starting the motor

• The required load torque during start

• The required starting time

3.5.5 How does a motor start in the first place?

Motors convert electrical energy drawn from the power supply into a mechanical form, usually as a shaft rotating at a speed fixed by the frequency of the supply. The power available from the shaft is equal to the torque (moment) multiplied by the shaft speed (rpm). From an initial value at standstill, the torque alters, up or down, as the machine accelerates, reaching a peak at about two-thirds full speed, finally to become zero at synchronous speed. This characteristic means that induction motors always run at slightly less than synchronous speed in order to develop power the 'slip speed' and, hence the term asynchronous. The (fig) below, which shows an induction motor torque/speed curve, illustrates this most important characteristic.

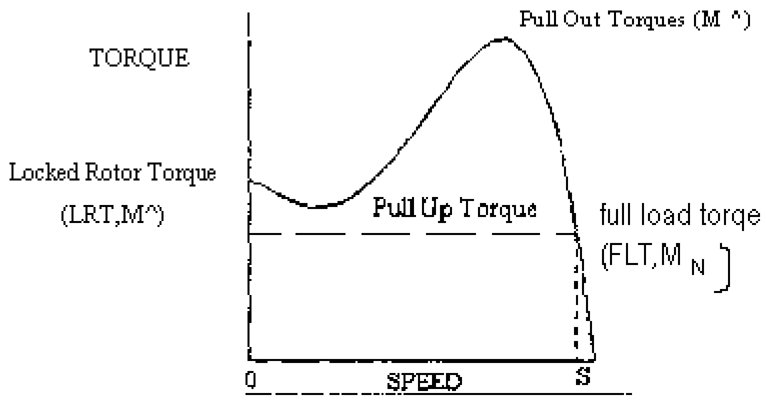


fig3.3 Induction motor torque/speed curve

3.6 Braking of induction motor:

Braking occurs by the methods:

3.6.1 Regenerative braking

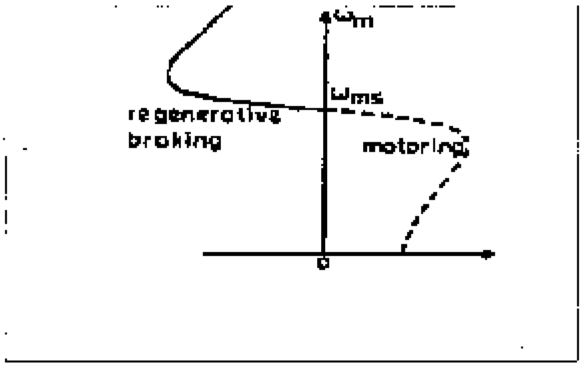


fig3.4 Regenerative braking

When regenerative braking is employed for holding motor-speed against an active load, stable operation is generally possible between synchronous speed and the speed for which braking torque is maximum.

Main advantage of regenerative braking is that generated power is usefully employed and main drawback being that when fed from a constant frequency source, it cannot be employed below synchronous speed.

3.6.2 Plugging or reverse voltage braking

In this method, mechanical energy supplied to the rotor, either by active load or form kinetic energy stored in motor and load inertia, is covered into electrical energy and wasted in rotor resistance.

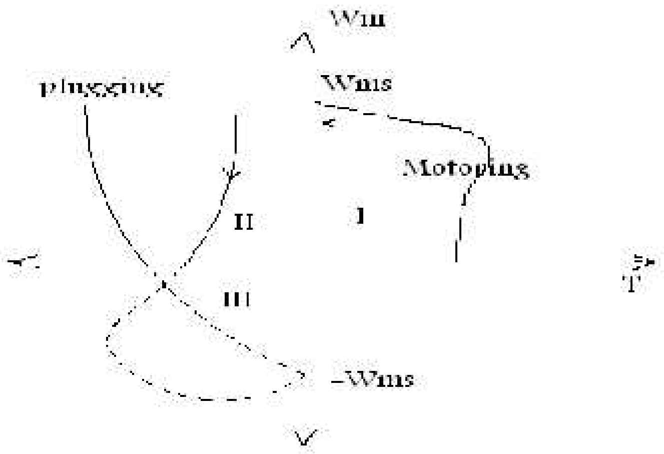


fig3.5 Plugging or reverse voltage braking

3.6.3 Dynamic braking:

ac dynamic braking is obtained when the motor is run on a single phase supply by disconnecting one phase from the source and either leaving it open as in last fig. (b) or connecting it with another machine phase as in the last fig (c) . the two connection of the last fig. in (b)&(c) are respectively known as two and three lead connections.

When connected to a 1-phase supply, the motor can be considered to be fed by positive and negative sequence three phase set of voltage. Net torque produced by the machine is sum of torques due to positive and negative sequence voltages. When rotor has a high resistance, the net torque is negative and braking operation is obtained.

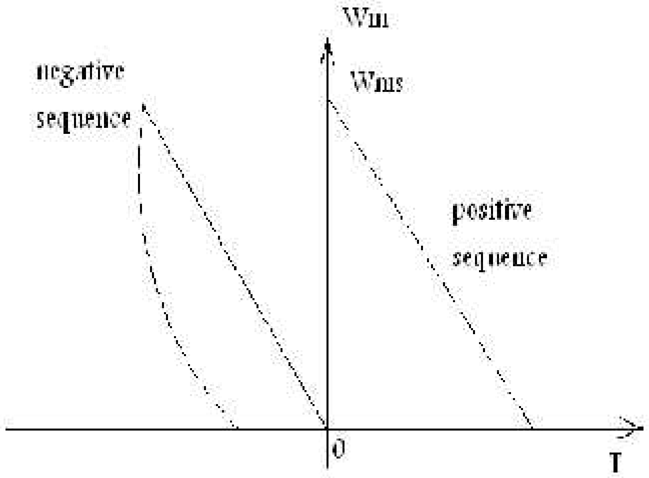


Fig3.6 Dynamic braking

3.7 Power electronics circuits:

That have a two circuits

1.triggering circuit.

This circuit to give trigger to triac in the power circuit.

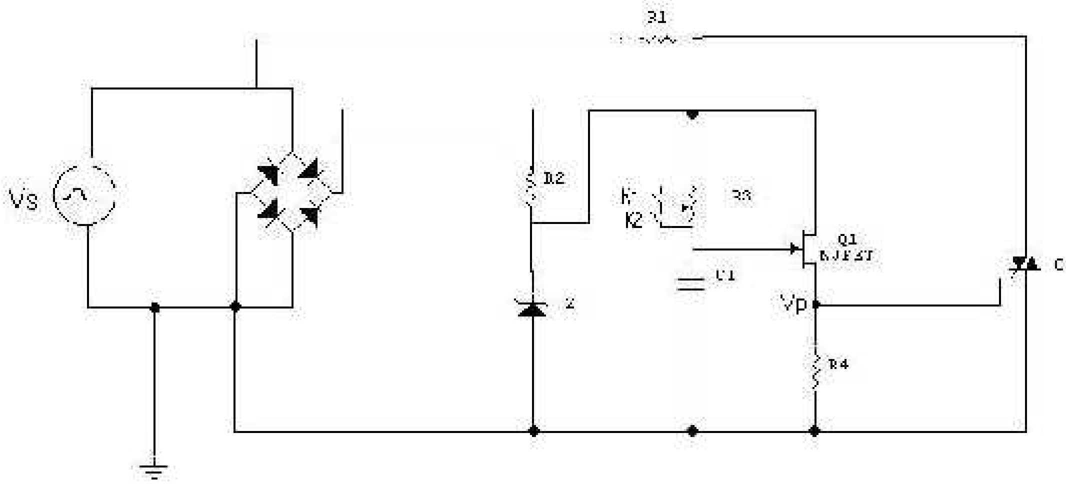


fig3.7 triggering circuit

2. power circuit.

It's take the trigger pulses to operate the triac.

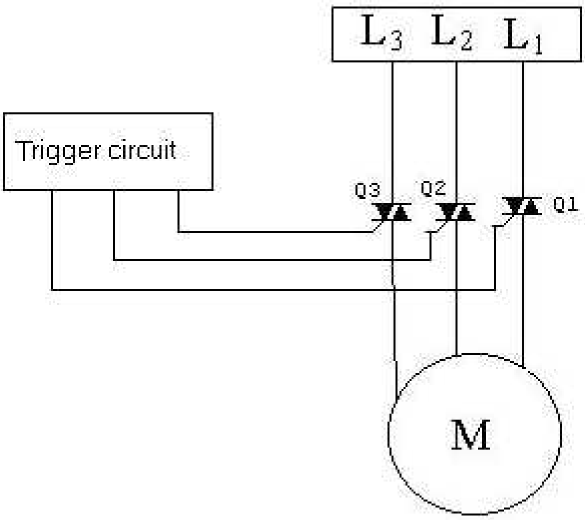


fig3.8power circuit

3.8 Power calculates of the motor In hoisting:

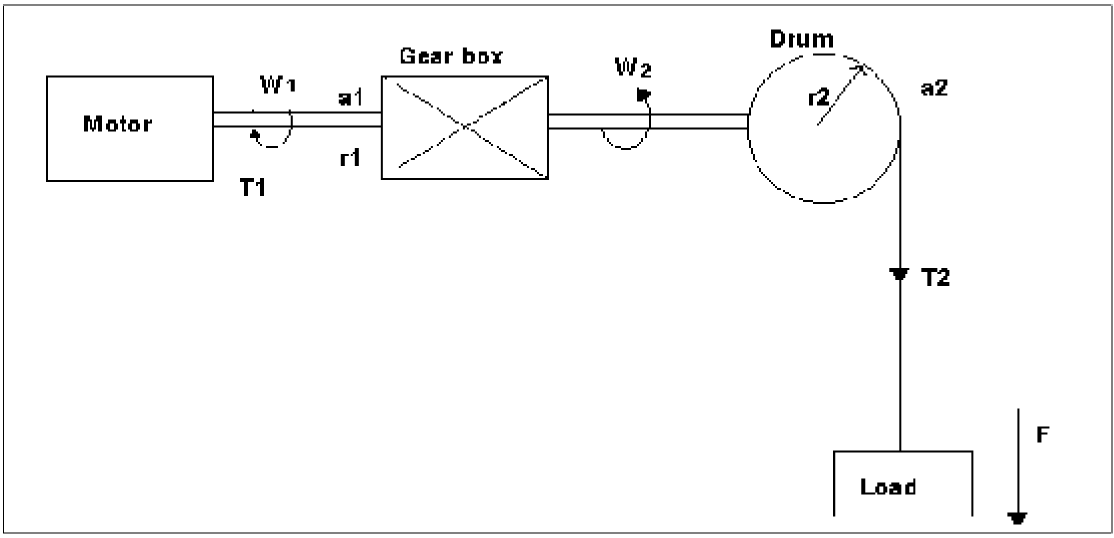


fig3.7 motor In hoisting

3.9 power analysis:

3.9.1 Analysis of the required power of the lifting motor:

The power requirement of the motor to safety carry the loads be found by using the maximum torque theory, using the following equation

$$\mathbf{T1 \times \omega 1 = T2 \times \omega 2} \quad \text{...(3.6)}$$

Where:

T1: Torque of motor, N.m.

ω1: Angular velocity of the motor, rad/s.

T2: Torque produced from the loads, N.m.

ω2: Angular velocity of lifting wheel, rad/s.

The torque produced from the loads can be found using the following equation:

$$\mathbf{T2 = N \times F \times r} \quad \text{…..……………………………………………..(3.7)}$$

Where:

N: Factor of safety corresponding dynamic loads.

F: Force produced by loads, N.

r: Radius of the lifting wheel, m

3.9.2 Analysis of the power required for bridge movement:

After selecting the dimensions of the train for bridge in this section we will cheek weather the selection satisfies the power requirement for moving the bridge, that is, If the reduction train suggested can move the crane when it is fully loaded.

The power requirement for the bridge movement can be represented by the following equation:

P= (F × v) ÷ (1000 ×η) …………………………..…………………… (3.8)

Where:

P: Power required, Kw.

F: Resistance force resulting from loads, N.

V: Lifting speed, m/s.

η: Efficiency of drives belts.

F=(Wo + W1) × g × B × ((f × d + 2 × k) / D) ………..……..………….(3.9)

Where:

F:Resistance force resulting from friction, N.

W0: Weight of the crane, Kg.

W1: Maximum weight lifted, Kg.

G: Standard acceleration of gravity, m/s2.

B: Correction factor for the friction between wheels and the path.

f.: Friction factor for the bearings. Diameter of shaft, mm.

K: Rolling correction factor.

D: Diameter of wheel, mm.

3.9.3 Analysis of the power required for trolley movement:

The power required to move the trolley when fully loaded is found by:

P= (F × v) ÷ (1000 ×η) ………………………………………………….(9.10)

Where:

P: Power required, Kw.

F: Resistance force resulting from loads, N.

V: Lifting speed, m/s.

η: Efficiency of drives belts.

$$F=(W_o + W_1) \times g \times B \times ((f \times d + 2 \times k) / D) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.11)$$

Where:

F: Resistance force resulting from friction, N.

W0: Weight of the trolley, Kg.

W1: Maximum weight lifted, Kg.

G: Standard acceleration of gravity, m/s2.

B: Correction factor for the friction between wheels and the path.

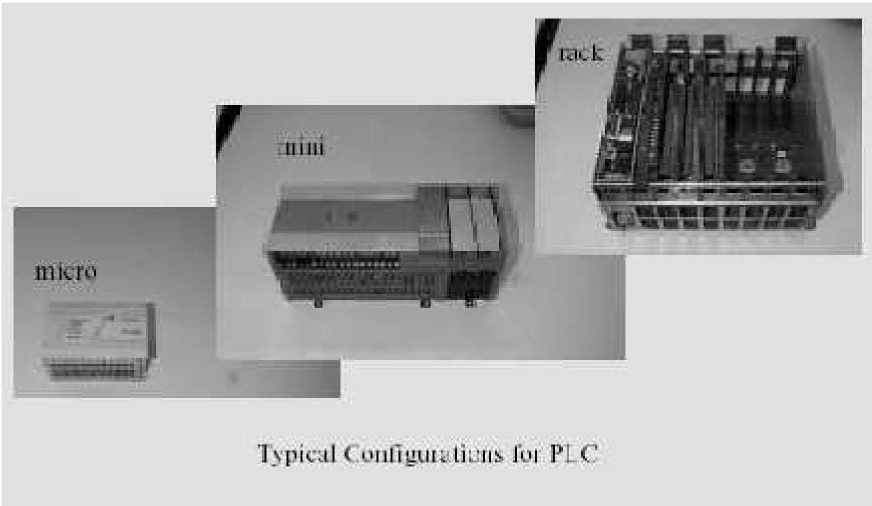
f.: Friction factor for the bearings. Diameter of shaft, mm.

K: Rolling correction factor.

D: Diameter of wheel, mm.

Chapter 4

Programmable Logic Controller (PLC)



4.1 the (PLC) devices

4.1 Introduction:

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 pie 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 pie.

4.2 PLC History:

Control engineering has evolved over time. In the past humans were the main method for controlling a system. More recently electricity has been used for control and early electrical control was based on relays. These relays allow power to be switched on and off without a mechanical switch. It is common to use relays to make simple logical control decisions. The development of low cost computer has brought the most recent revolution, the Programmable Logic Controller (PLC). The advent of the PLC began in the 1970s, and has become the most common choice for manufacturing controls.

PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come. Most of this is because of the advantages they offer.

- Cost effective for controlling complex systems.
- Flexible and can be reapplied to control other systems quickly and easily.
- Computational abilities allow more sophisticated control.
- Trouble shooting aids make programming easier and reduce downtime.
- Reliable components make these likely to operate for years before failure.

4.3 The main parts of (PLC) and there functions:

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.
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.
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.
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 Is.
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.
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.

4.4 The (PLC) devices:

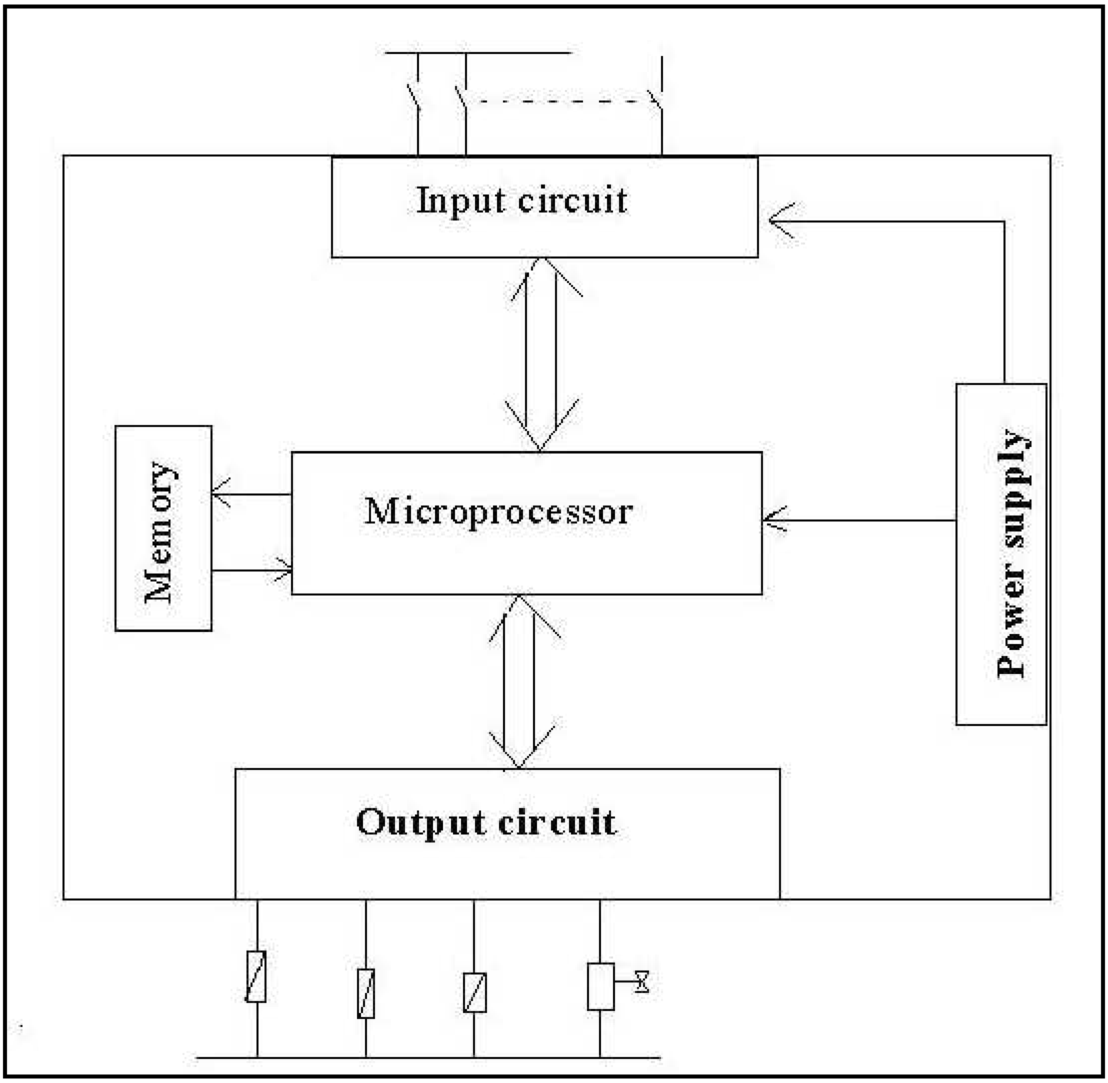


fig 4.2 The (PLC) devices

4.4.1 Microprocessor devices:

For simple programming the relay model of the PLC is sufficient. As more complex functions are used the more complex VonNeuman model of the PLC must be used. A VonNeuman computer processes one instruction at a time. Most computers operate this way, although they appear to be doing many things at once. Consider the computer components shown last block diagram:

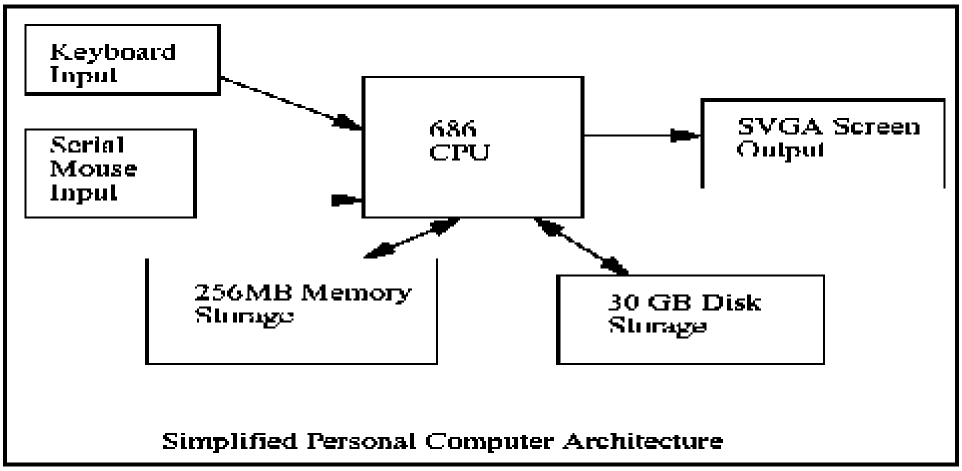


fig4.3 Simplified Personal Computer Architecture

Input is obtained from the keyboard and mouse, output is sent to the screen, and the disk and memory are used for both input and output for storage. (Note: the directions of these arrows are very important to engineers, always pay attention to indicate where information is flowing.) This figure can be redrawn as fig.(4.3) clarify the role of inputs and outputs.

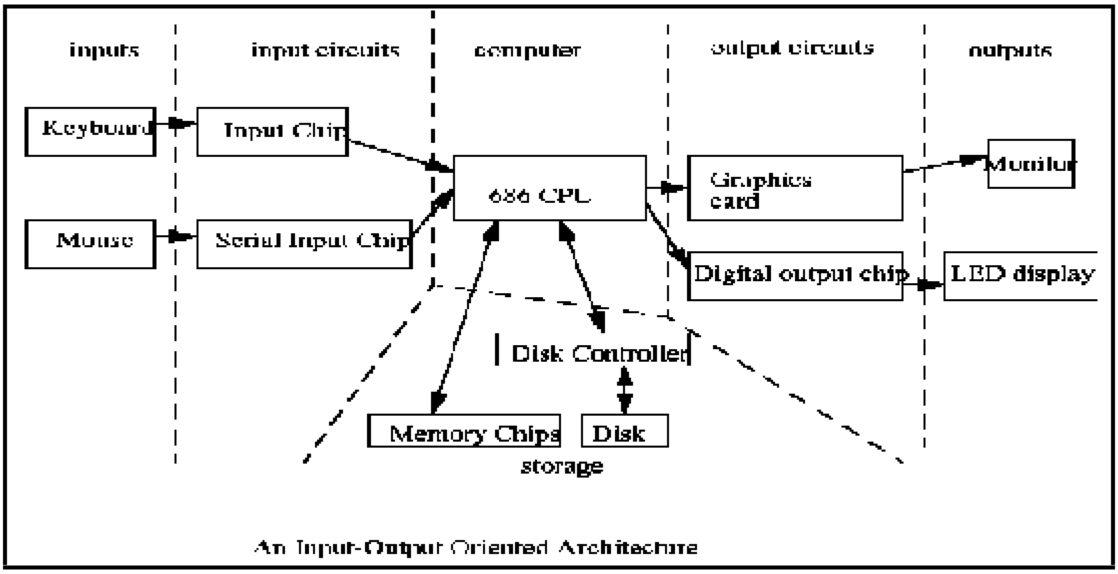


fig4.4 An input-output oriented architecture

In the figure(4.4) the data enters the left side through the inputs. (Note: most engineering diagrams have inputs on the left and outputs on the right.) It travels through buffering circuits before it enters the CPU. The CPU outputs data through other circuits. Memory and disks are used for storage of data that is not destined for output. If we look at a personal computer as a controller, it is controlling the user by outputting stimuli on the screen, and inputting responses from the mouse and the keyboard.

A PLC is also a computer controlling a process. When fully integrated into an application the analogies become; Inputs - the keyboard is analogous to a proximity switch Input circuits - the serial input chip is like a 24Vdc input card Computer - the 686 CPU is like a PLC CPU unit Output circuits - a graphics card is like a triac output card Outputs - a monitor is like a light Storage - memory in PLCs is similar to memories in personal computers It is also possible to implement a PLC using a normal Personal Computer, although this is not advisable. In the case of a PLC the inputs and outputs are designed to be more reliable and rugged for harsh production environments.

4.4.2 Input and Out put of PLC device:

Inputs to, and outputs from, a PLC are necessary to monitor and control a process. Both inputs and outputs can be categorized into two basic types:

- Logical.
- Continuous.

4.4.2.1 Input devices:

In smaller PLCs the inputs are normally built in and are specified when purchasing the PLC. For larger PLCs the inputs are purchased as modules, or cards, with 8 or 16 inputs of the same type on each card. For discussion purposes we will discuss all inputs as if they have been purchased as cards. The list below shows typical ranges for input voltages, and is roughly in order of popularity.

1. 12-24 Vdc
2. 100-120 Vac
3. 10-60 Vdc
4. 12-24 Vac/dc
5. 5 Vdc (TTL)
6. 200-240 Vac
7. 48 Vdc
8. 24 Vac

PLC input cards rarely supply power, this means that an external power supply is needed to supply power for the inputs and sensors. The next Figure is shows how to connect an AC input card.

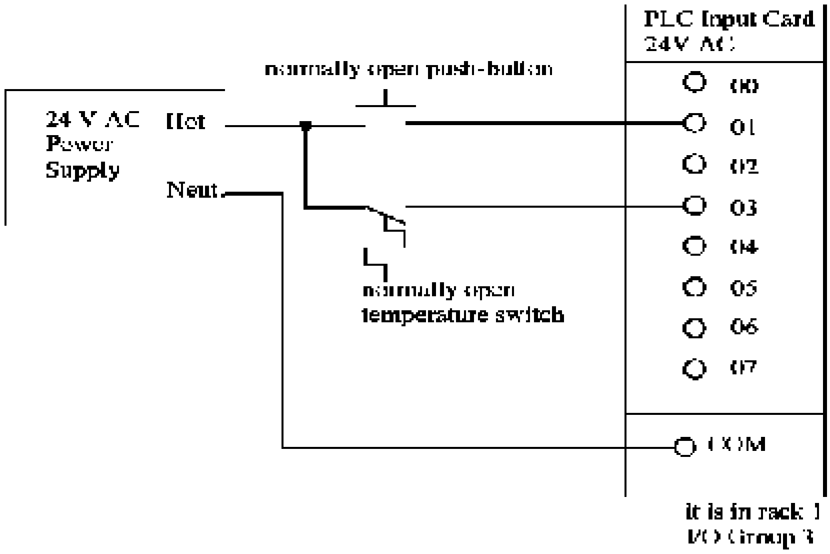


fig4.5 input devices

In the last fig. there are two inputs, one is a normally open push button, and the second is a temperature switch, or thermal relay. Both of the switches are powered by the hot output of the 24Vac power supply - this is like the positive terminal on a DC supply. Power is supplied to the left side of both of the switches. When the switches are open there is no voltage passed to the input card. If either of the switches is closed power will be supplied to the input card. In this case inputs 1 and 3 are used - notice that the inputs start at 0.

The input card compares these voltages to the common. If the input voltage is within a given tolerance range the inputs will switch on. Ladder logic is shown in the figure for the inputs.

Here it uses Allen Bradley notation for PLC-5 racks. At the top is the location of the input card I: 013 which indicate that the card is an Input card in rack 01 in slot 3. The input number on the card is shown below the contact as 01 and 03.

Many beginners become confused about where connections are needed in the circuit above. The key word to remember is circuit, which means that there is a full loop that the voltage must be able to follow. In the last Figure we can start following the circuit (loop) at the power supply. The path goes through the switches, through the input card, and back to the power supply where it flows back through to the start. In a full PLC implementation there will be many circuits that must each be complete.

A second important concept is the common. Here the neutral on the power supply is the common, or reference voltage. In effect we have chosen this to be our 0V reference, and all other voltages are measured relative to it. If we had a second power supply, we would also need to connect the neutral so that both neutrals would be connected to the same common. Often common and ground will be confused. The common is a reference, or datum voltage that is used for 0V, but the ground is used to prevent shocks and damage to equipment. The ground is connected under a building to a metal pipe or grid in the ground. This is connected to the electrical system of a building, to the power outlets, where the metal cases of electrical equipment are connected. When power flows through the ground it is bad. Unfortunately many engineers and manufacturers mix up ground and common. It is very common to find a power supply with the ground and common mislabeled.

One final concept that tends to trap beginners is that each input card is isolated.

This means that if you have connected a common to only one card, then the other cards are not connected. When this happens the other cards will not work properly. You must connect a common for each of the output cards.

There are many trade-offs when deciding which type of input cards to use.

- DC voltages are usually lower and therefore safer (i.e., 12-24V).
- DC inputs are very fast, AC inputs require a longer on-time. For example, a 60Hz wave may require up to 1/60sec for reasonable recognition.
- DC voltages can be connected to larger variety of electrical systems.
- AC signals are more immune to noise than DC, so they are suited to long distances, and noisy (magnetic) environments.
- AC power is easier and less expensive to supply to equipment.

- AC signals are very common in many existing automation devices.

4.4.2.2 Output devices:

As with input modules, output modules rarely supply any power, but instead act as switches. External power supplies are connected to the output card and the card will switch the power on or off for each output. Typical output voltages are listed below, and roughly ordered by popularity.

- 120 Vac
- 24 Vdc
- 12-48 Vac
- 12-48 Vdc
- 5Vdc (TTL)
- 230 Vac

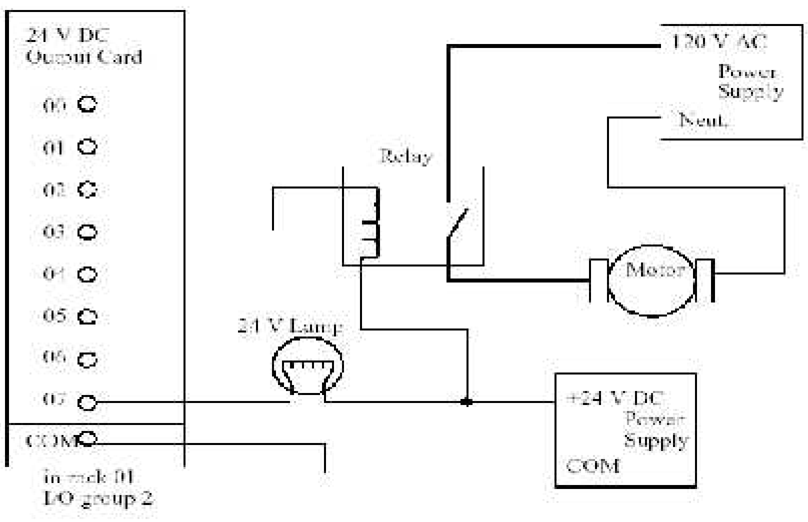


fig 4.6 Output devices

These cards typically have 8 to 16 outputs of the same type and can be purchased with different current ratings. A common choice when purchasing output cards is relays, transistors or triacs. Relays are the most flexible output devices. They are capable of switching both AC and DC outputs. But, they are slower (about 10ms switching is typical), they are bulkier, they cost more, and they will wear out after millions of cycles. Relay outputs are often called dry contacts. Transistors are limited to DC outputs, and Triacs are limited to AC outputs. Transistor and triac outputs are called switched outputs.

1- Dry contacts - a separate relay is dedicated to each output. This allows mixed voltages (AC or DC and voltage levels up to the maximum), as well as isolated outputs to protect other outputs and the PLC. Response times are often greater than 10ms. This method is the least sensitive to voltage variations and spikes.

2 - Switched outputs - a voltage is supplied to the PLC card, and the card switches it to different outputs using solid state circuitry (transistors, triacs, etc.) Triacs are well suited to AC devices requiring less than 1A. Transistor outputs use NPN or PNP transistors up to 1A typically. Their response time is well under 1ms.

Accidentally connected to a DC transistor output it will only be on for the positive half of the cycle, and appear to be working with a diminished voltage. If DC is connected to an AC triac output it will turn on and appear to work, but you will not be able to turn it off without turning off the entire PLC.

4.5 Programming:

After definition the program logic control (PLC) and who it is programmable, and what is the software and the hardware of the PLC, now we can write the program, which is, describe the crane work.

Table of PLC program:

Table here is describing the input and the output of the PLC.

4.1 table of describe the input and the output of the PLC

Tools	Condition	Works	Symbols
F0	Nc	Over load m1	I0.0
F1	Nc	Over load m2	I0.1
F2	Nc	Over load m3	10.2
F3	Nc	Over load m4	I2.4
Em	Nc	Emergency	I0.3
S0	No	Stop	I0.4
S1	No	Start	I0.5
S2	No	Quickly	I0.6
S3	No	Slow	I0.7
S4	No	Lifting up	I1.0
S5	No	Down	I1.1
S6	No	Left	I1.2
S7	No	Right	I1.3
S8	No	Forward	I1.4
S9	No	Backward	I1.5
L1	NO	Max right	I1.6
L2	NO	Max lift	I1.7

L3	NO	Max Forward	I2.0
L4	NO	Max Backward	I2.1
L5	NO	Max up	I2.2
L6	NO	Max down	I2.3
K1	---	Quickly	Q3.0
K2	---	Slow	Q3.1
K3	---	Lifting up	Q3.2
K4	---	Down	Q3.3
K5	---	Left	Q3.4
K6	---	Right	Q3.5
K7	---	Forward	Q3.6
K8	---	Backward	Q3.7

Programming:

The PLC need program in hardware to control to machine , the program is saved in the memory of the PLC box ,the program her is control the work of the crane by changing the input to give the output . the program is by (STL) programming

Program:

A I0.0

A I0.1

A I0.2

AI2.4

A I0.3

A I0.4

A I0.5

S F0.0

AN I0.0

AN I0.1

AN I0.2

AN I0.3

AN I0.4

R F0.0

.... **Quickly**

A F0.0

A I0.6

S Q2.0

AN F0.0

A I0.7

R Q3.0

.... **Slow**

A F0.0

A I0.7

S Q2.1

A NF0.0

A I0.6

R Q3.1

.... **Lifting up**

A F0.0

A I1.0

ANI2.2

AN Q2.3

= Q3.2

.... **Down**

A F0.0

A I1.1

ANI2.3

AN Q2.2

= Q3.3

.... **Left**

A F0.0

A I1.2

ANI1.7

AN Q2.5

= Q3.4

.... **Right**

A F0.0

A I1.3

ANI1.6

AN Q2.4

= Q3.5

.... **Forward**

A F0.0

A I1.4

ANI2.0

AN Q2.7

= Q3.6

.... **Backward**

A F0.0

A I1.5

ANI2.1

AN Q2.6

= Q3.7

4.5.3 The (PLC) Connection:

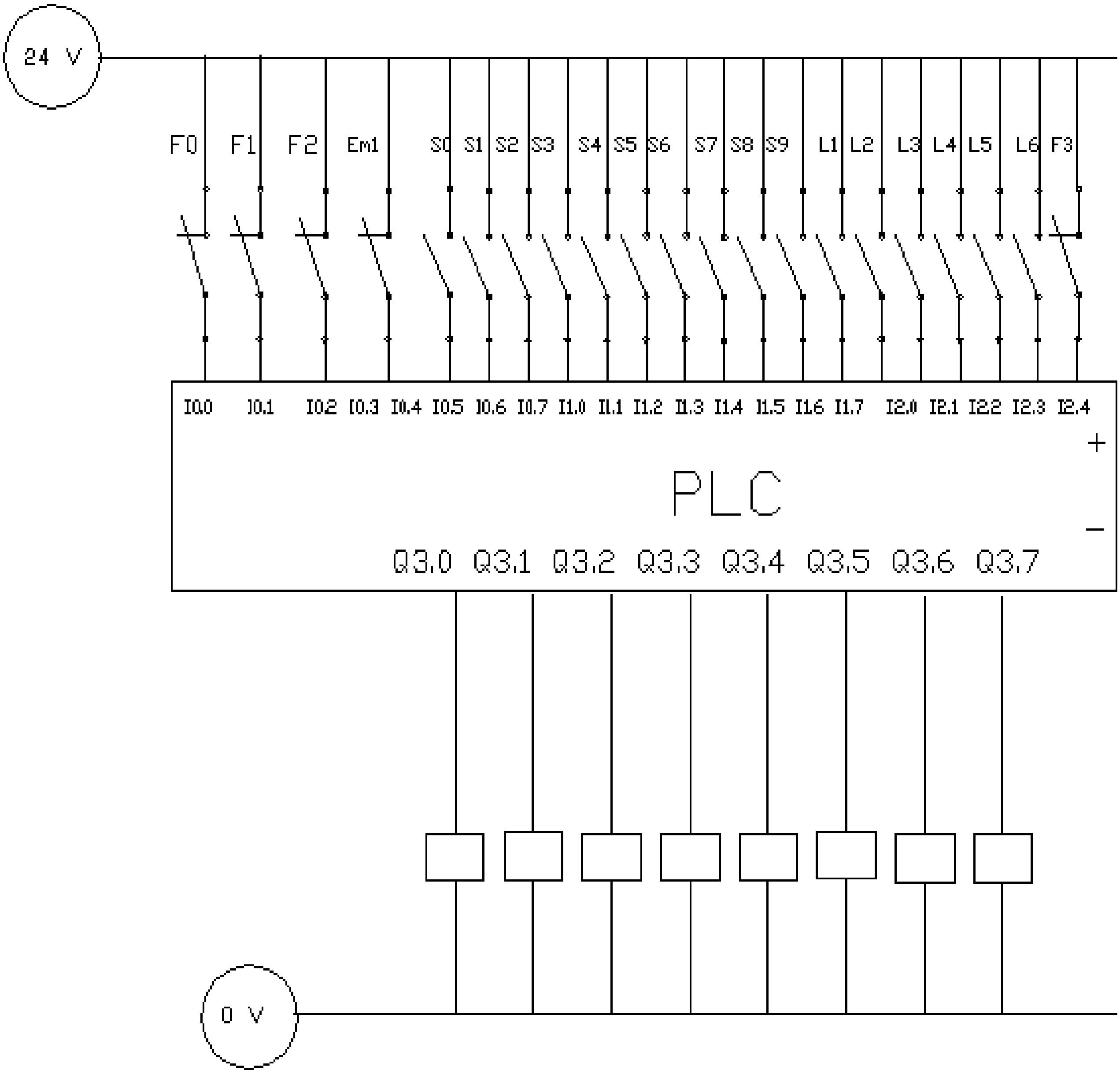


fig4.7 The (PLC) Connection

Chapter 5

Remote Control

5.1 Introduction:

Nowadays, it is common practice in industrial environments to use remote control equipment to operate load-lifting machinery. The advantages that the use of this equipment offers are as follows:

• Increased productivity: as the cranes are no longer operated from the cabin but rather from the surrounding area, the operator is also able to hook up and unhook the load.

• Maneuverability is improved, particularly high precision maneuvers as the operator is no longer obliged to remain in the cabin and becomes free to position himself in the best possible vantage point. In addition, the operator no longer depends on a second person to signal him, which sometimes leads to confusion.

• Safety and work conditions are improved for the crane operator as he can choose the safest and most convenient spot from which to work, away from dangerous areas and unpleasant environmental conditions, (heat, smoke, noise, etc...).

The choice of remote control equipment will depend on the nature of the machine maneuvers to be carried out. Similarly, the receiver will need to have a certain number of outputs to control the machine properly, receivers with from 6 to 60 relays are available as well as up to 6 analog outputs. With these characteristics it is possible to cover all imaginable requirements .The transmitter will depend on the type of electric control used by the crane and falls into two categories: Pendant controller and cabins.

5.2 Pendant Controllers:

The configuration of the remote control transmitter for overhead cranes is quite similar to the pendant controller it is replacing. The commands are dual effect buttons, which enable the control of maneuvers at up to two speeds. The buttons have been designed in such a way that other types of commands, such as spring-return and maintained 1-0-1 toggle switches or rotary switches can easily substitute them. These offers great flexibility in the configuration of our equipment so it may be adapted to all kinds of machinery .All equipment comes fitted with an emergency stop button.

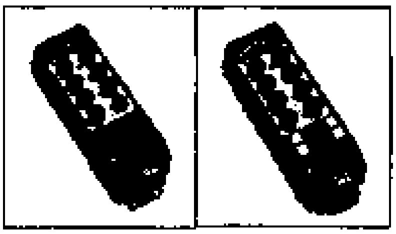


*Fig.5.1: Pendent Controlle*r

5.3 Cabins controllers :

For cabin cranes, multi-step joysticks are used to control the main maneuvers. The remote control equipment for this type of crane is a portable console with small joysticks similar to those found in the crane cabin .The joysticks use optical reading, which offers optimum reliability, as they do not have electrical contacts. In addition, this enables the simultaneous control of two maneuvers at up to 5 different speed steps or steeples .As well as the optical joy sticks and emergency stop button, the transmitters may come with other control fittings for other functions such as the selection of trolley or hook, crab, magnets, over-riding limit switches, lights, horns etc.

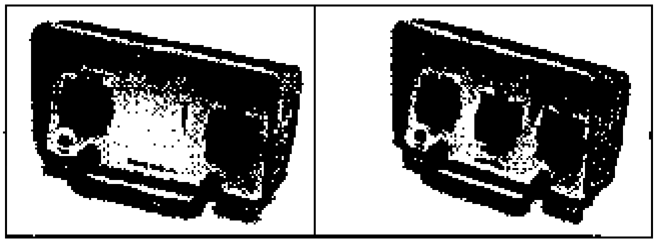


Fig.5.2: Cabins

5.4 Types Of Remote Control:

5.4.1 Radio Remote Control:

Radio remote control for cranes and other equipment eliminates the need to rely on crane (or locomotive, etc.) cab control and pendant control as the only means of operation. The addition of radio remote controls allows you to convert from a two-person operation to a single-Person operation, since you no longer need that extra person providing hand signals at ground level. (Occasionally you convert from a three-person to a two-person operation but the effect is the same in terms of saving one person's labor.).

Load positioning and damage control are improved too, because a radio operator can better judge crane load or rail car clearance. Placing the operator on the floor avoids the health hazards of high humidity, vapors, smoke, radiation, high voltage, etc.

With radio control, one person can control several cranes or other material handling vehicles, one at a time, from a single transmit. Maintenance is simple and can be handled by your in-plant personnel. A pendant control forces the operator to walk with the load, which often translates as running an obstacle course. As well, the swinging pendant is clumsy and a hazard in its own right. Radio control eliminates these problems. Radio controls have available options to provide adjustable controlled range (typically 75 to 100 feet), with the crane automatically stopping or not being able to start when the operator can no longer safely see the load. In the case of signal failure, all motion comes to a safe stop. Magnets and vacuum lifts, for example, retain their last commanded state with the option of latching circuits.

To move a crane, for example, the operator activates a lever or button to send a radio signal, which is picked up by the receiving antenna mounted on the crane. The antenna passes the signal to the receiver unit, also on the crane. This unit transforms the signal into electrical energy and passes it on to the intermediate relay unit on the crane, and the appropriate contact is activated. The operator, from floor level,' can not only control forward, backward and other crane and hoist motions, but also the speed at which things happen. There are optional safeguards to prevent moves that the operator cannot see and to prevent collisions with other equipment.

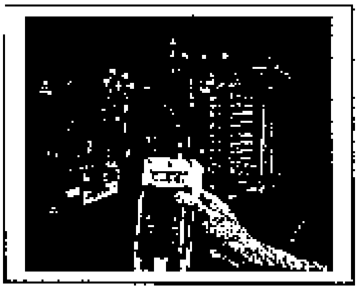


Fig.5.3: Radio Remote Control

5.4.2 Infra Red Remote Control*:*

Problems of pendent for hoist and cable control for machinery have become a thing of the past. Now, the highly cost-effective fail-safe remote control system offers an economical alternative to previous cable-limited controls.

We can forget the inconvenience-and danger-associated with struggling around obstacles with cable control. A crane operator may now move freely in high area, controlling the crane remotely from wherever he chooses. Unrestricted freedom of movement decreases the time to complete the job, benefiting profitability while increasing safety.

The innovative engineering results in:

- Wide range of application.
- 100% fail-safe operation.
- No need for a license.

5.5 The transmitter

The transmitter is designed to transmit 14 universal commands. The individual keys can be linked into function groups via the coding circuit. Depending on the specific application the following mode is available:

- 3 drives each 2 stage (3X2-0-2) & 2 individual function.
- 2 drives each 2 stage (2X2-0-2) & 6 individual function.
- 1 drive, 2 stage.
- 14 individual function.

Labeling of the keyboard may be changed to accommodate specific requirements. Unauthorized use of the transmitter is prevented by mean of an electronic lock for which various switch-on key codes can be reselected.

5.6 The receiver

The receiver is designed for universal applications on a number of operating voltages. Control output is via industrial relays a (415/16A). The electronic circuit and the relays are all on a single PCB, housed in a robust metal case. The infra-red sensor is external and positioned for optimum reception. To extend the range a second infra red sensor can be added.

5.7 Technical data

- Infra-red wavelength: approx. 950 nm.
- Transmission rate: 9,600 bits per second.

- Range: max. 30m (100 feet).
- Transmitter power: 4X1.5V miniature (AA) batteries or 4X1.2 V(AA) NiCades cells.
- Transmitter dimension: 240x70x59 mm.
- Transmitter weight: approx. 480g including battery.
- Protection: IP 54.
- Operating temperature range: -15 deg. Centigrade to +60 deg. Centigrade.
- Receiver relays: Output relays: 415V AC/8A main protection 415V AC/6A (positively driven fail safe relay).
- Receiver dimensions: 110x270x220 mm.
- Receiver power: 48V, 62V, 110V, 220V, 245V 50/60Hz, or 24V DC.

5.8 Transmitter circuit:

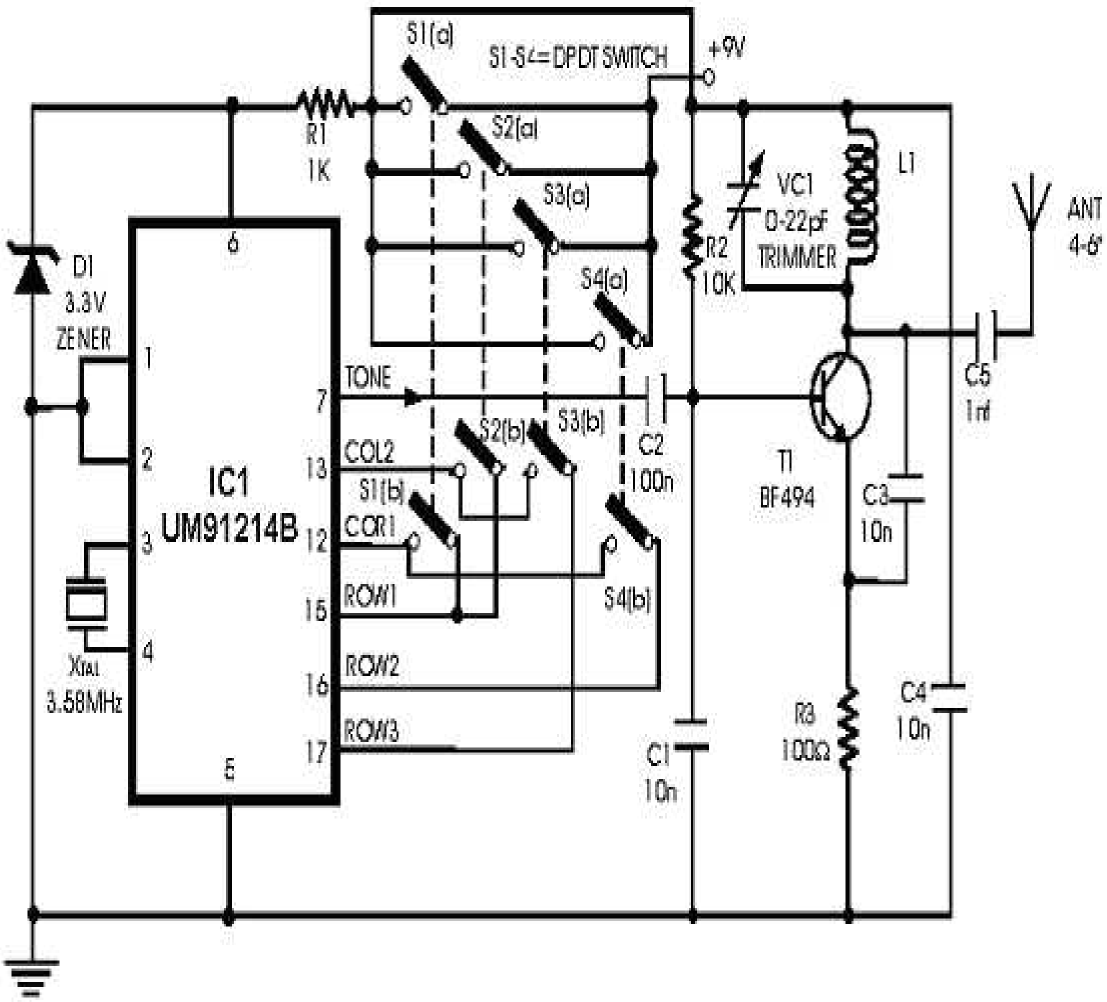


fig5.4 Transmitter circuit

We use two transmitter circuit for our case that inside the remote control.

5.9 The receiver circuit:

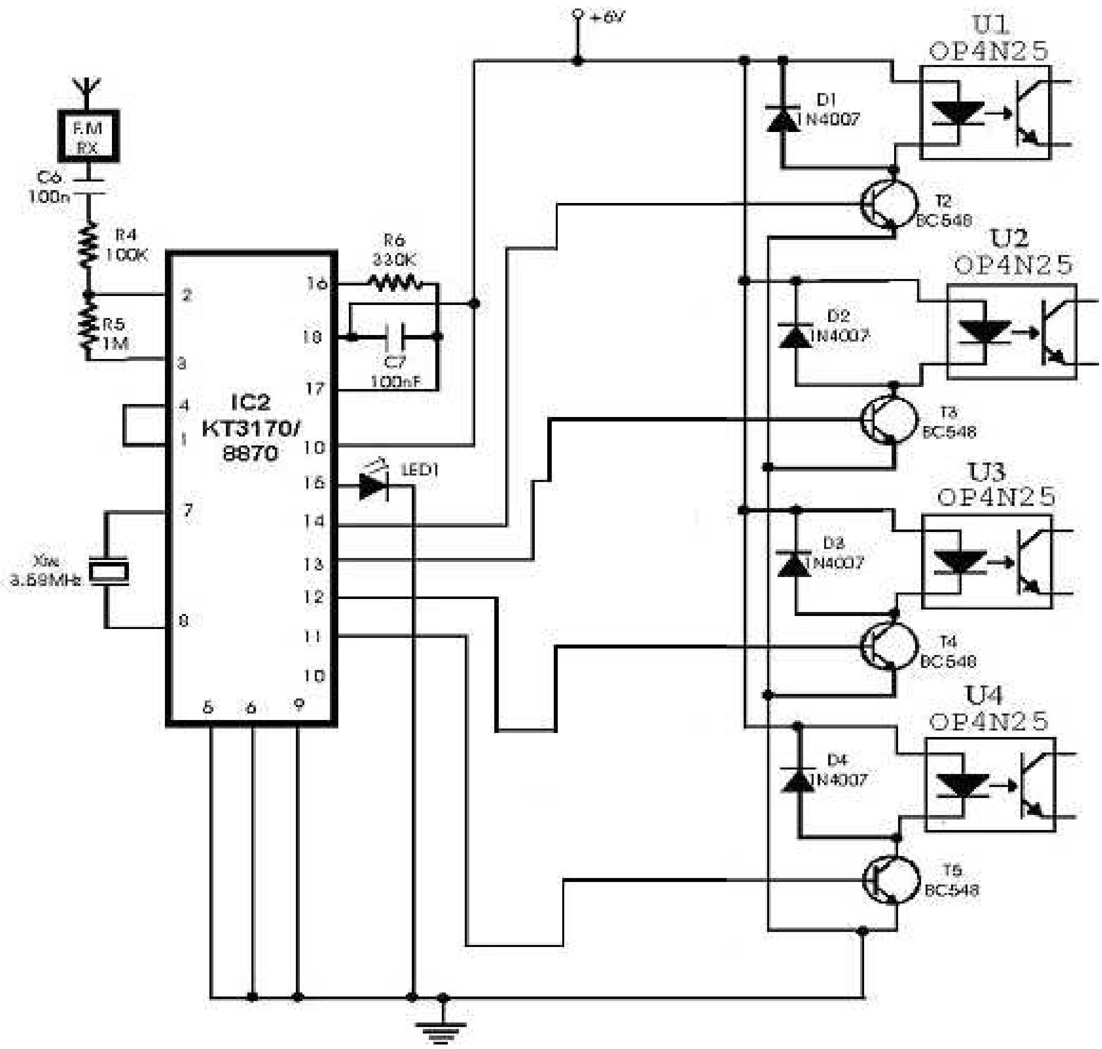


fig 5.5 The receiver circuit:

We use two receiver circuit for our case that inside the receiver block.

Chapter 6

Protection

6.1 Definition

What is electrical protection?

Electrical protection it is the protect the electrical system from dangerous that happened from fault in the electrical system. From that the electrical protection not prevent occur the electrical fault but it is prevent the dangerous which is damage the system.

So the electrical protection is the science solve the electrical fault an the effect of it with small speed to make continuity in the system.

6.2 Requirements of the electrical protection system:

1. Reliability: it must operate in unnatural condition.
2. Speed :the time of the operate must less than or equal three Cycles.
4. Selectivity: it must keep the continuity of the power with less Number times of cutting the current.
4. Simplicity and economy.

6.3 Protection against over current:

An over current is the current grater than the rated current of the circuit it may occur in tow ways:

1. As an overload current.
2. As short-circuit of fault current**.**

These conditions need to be protecting against in order to avoid damage to circuit conductors and equipment. In practice, fuses and circuit breakers will fulfil both is this needs.

6.4 Overload:

Overheads are over current occurring in healthy circuit they may be caused, for example, and faulty appliances or by surges due to motors starting.

The current that we limit the overload is equal or less of the max. Full load current.

6.5 Short circuit:

A short circuit current that will flow when a" dead short " occurs between life conductors (phase to neutral for single phase; phase to phase for three phase). Prospective short circuit current is the same,, But the term is usually used to signify the value of short circuit at fuse or circuit breaker position.

6.6 fuse and circuit breaker:

fuse in the weak link in a circuit which will break when too much current flows, those protecting the circuit conductors from damage. There are many different types and sizes of fuse, all designed to perform a cretin function .

6.6.1 There conditions of select the fuse:

1. Construction and dimension wire of fuse.
2. The operation current and voltage.
3. Porcelain housing of the fuse.

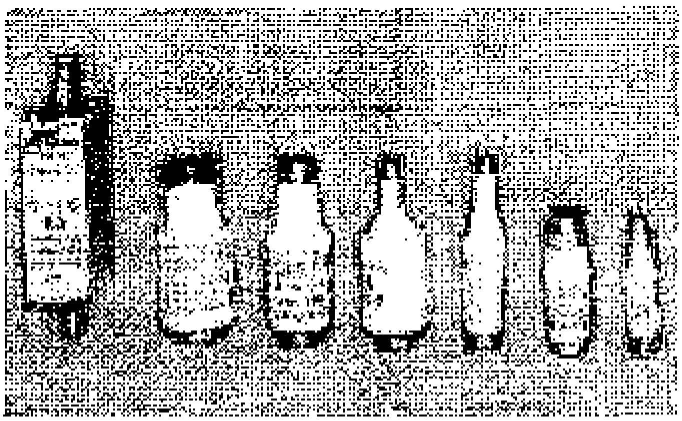


fig 6.1 shape of fuses

6.6.2 Type fuses:

1. Open or link fuse.
2. Enclosed fuse.
3. Expulsion fuse.

6.6.3 Circuit breaker:

The on off of the circuit is consider the basic operation in any electrical system, this operation occur by means of circuit breaker.

But the circuit barker very important used of the circuit breaker in order to open the circuit if any unnatural condition occur.

6.7 Cable and wiring for power circuit:

A great number of types of cable are available ranging from the very smallest signal-core wire used in the electric circuit , we discuss the cable in the low voltage only. A cable comprises two parts: the conductor or conductors and the Sheathing and insulation.

And from table (6.1) we can see the motor power ,nominal current ,thickness of cable ,maximum length of the cable ,over load current and the fuse current.

6.8 reverse diode:

This type of diodes is use to protect darlington transistor from the reverse current in the power circuit

6.9 Optocoplure :

1. We use the Optocupler as switch .
2. Also we used Optocupler to isolation the power circuit from the control circuit .

6.10 Heat sink:

Its use to keep the transistor temperature at safety level ; also it 's used to absorb the transistor temperature

table (6.1)motor power ,nominal current ,thickness of cable ,maximum length of the cable ,over load current and the fuse current.

Motor power (kw)	Nominal Current In (A)	Thickness of the cable q^N (mm)	Maximum Length of the cable (m)	Over load Current (A)	Fuse current (A)
0.06	0.22	1.5	2800	0.2-0.3	1
0.09	0.33	1.5	1890	0.3-0.5	1
0.12	0.42	1.5	1400	0.3-0.50	2
0.18	0.64	1.5	950	0.45-0.75	2
0.25	0.88	1.5	700	0.7-1.1	2
0.37	1.22	1.5	510	1-1.6	4
0.55	1.5	1.5	410	1-1.6	4
0.75	2.00	1.5	310	1.4 -2.2	4
1.1	2.6	1.5	240	2-3.2	4
1.5	3.5	1.5	170	3-5	6
2.2	5.00	1.5	120	4.5-7.52	10
3.00	6.6	1.5	90	4.5-7.5	16
4.00	8.5	1.5	70	7-12	16
5.5	11.5	1.5	50	7-12	20
7.5	15.5	2.5	65	11-18	25
11	22	4	75	16-25	35
15	30	4	55	20-32	50
18.5	37	6	65	30-45	63
22	44	6	55	30-45	63
30	60	10	65	40-63	80
37	72	16	90	60-90	100
45	85	16	75	60-90	125
55	105	25	95	80-130	160
75	140	35	100	100-160	200
90	170	50	120	130-210	250
110	205	70	140	160-210	250
132	245	95	160	160-250	315
160	295	120	165	200-400	400
200	370	185	205	200-400	500

Chapter 7

Design sample

7.1 Introduction:

In this chapter we will talk about the sample of our project (three dimension crane) that we designed, in this sample or model we explain the main parts of the crane explained in previous chapters.

These figures show the model, which we designed, when we see the all crane constructs parts and the dimensions of the crane.

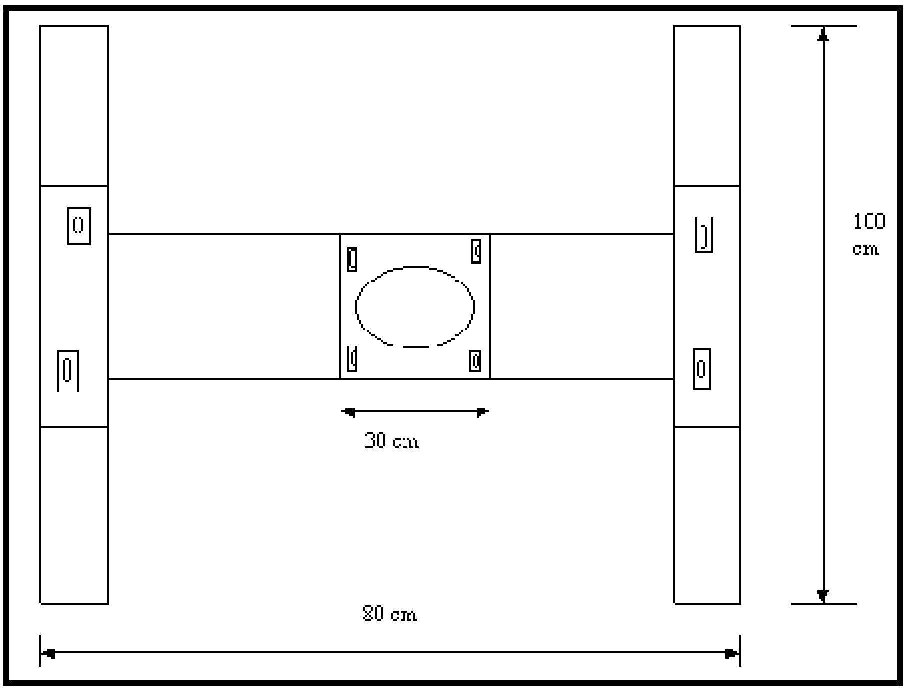


fig 7.1 lengths of the model

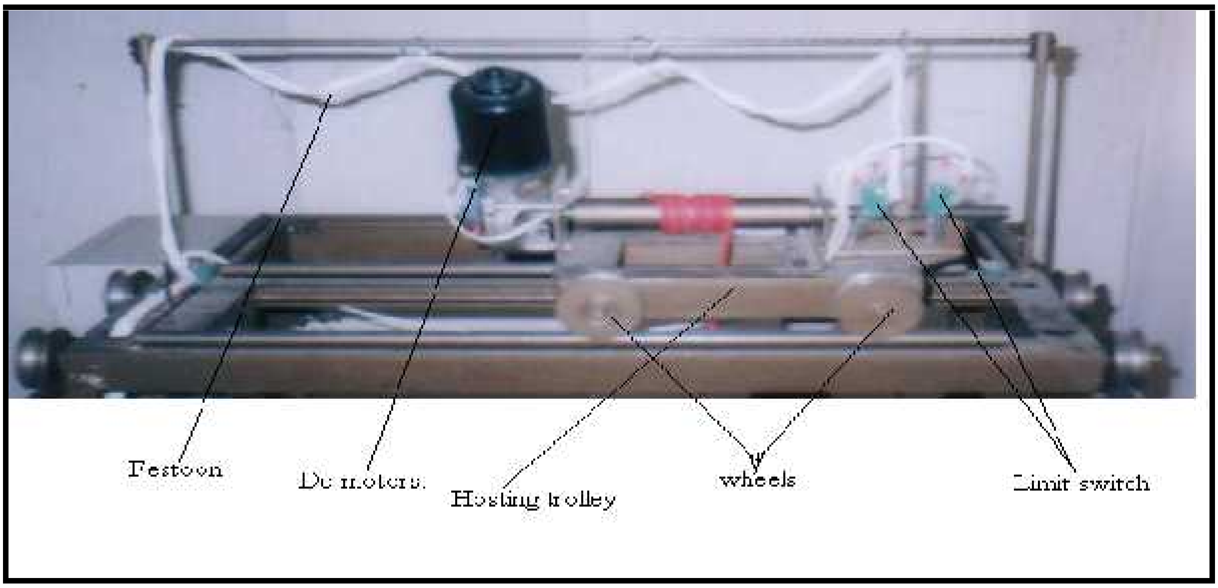


fig 7.2 parts of the models

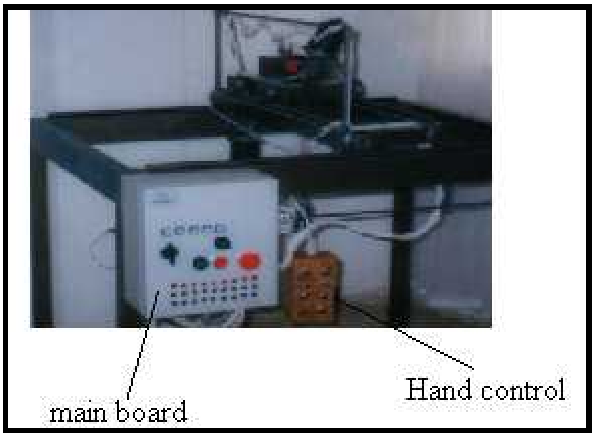


Fig7.3 parts of the model.

7.2 The designed sample consists of the following element:

1. Dc motors (3 P.M motors)
2. Hosting trolley .(80 cm active movement distance)
3. End truck. (limit switch).

4. Festoon. (connecting cable)
5. Main board

7.3 DC motors:

This section contains information about implementing dc motors in a mechanical system, such as those that are typically encountered in ME 3110. Although there is some limited information on stepper and other, specialized types of motors; primary emphasis is placed on DC permanent magnet motors, since these motors are the most common, least expensive, and lightest type of motors.

7.3.1 Types of motors:

There are several different types of dc (direct current) motors that are available. Their advantages, disadvantages, and other basic information are listed below in tabular form.

Tabe7.1 Different between the type of the dc motors

Type	Advantages	Disadvantages
Stepper Motor	Very precise speed and position control. High Torque at low speed	Expensive and hard to find. Require a switching control circuit

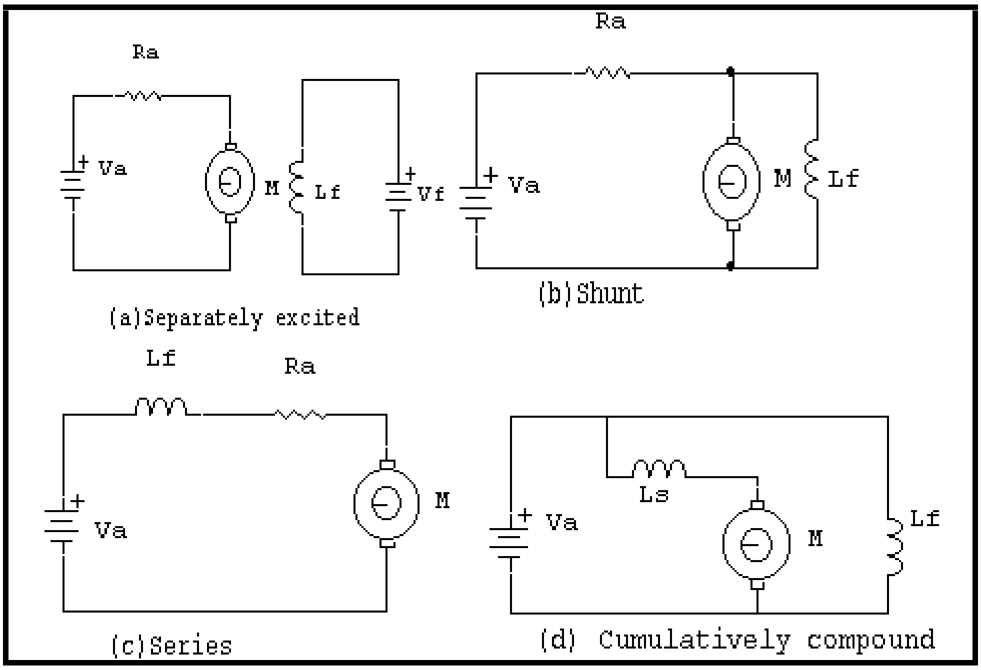
DC Motor w/field coil	Wide range of speeds and torques. More powerful than permanent magnet motors	Require more current than permanent magnet motors, since field coil must be energized. Generally heavier than permanent magnet motors. More difficult to obtain.
DC permanent magnet motor	Small, compact, and easy to find. Very inexpensive	Generally small. Cannot vary magnetic field strength.

Almost without exception, dc permanent magnet motors are by far the best choice projects. Their small size, compactness, and common availability make them a good choice on almost any machine that doesn't require a huge amount of power output.

7.3.2 Dc motors and their performance:

Commonly used dc motor is shown in (fig 7.4). In a separately exited motor, field and armature can be controlled independent of each other.

In a shunt motor , field and armature are connected to common source . In case of a series motor , field current is same as armature current ,and therefore field flux is function of armature current . In a cumulatively compound motor , the magneto-motive force of the series field is a function of armature current and is in same direction as mmf of the shunt field .



.fig7.4 commonly used dc motors

7.3.3 Elementary Theory of DC Permanent Magnet Motors:

Since this type of motor uses a permanent magnet to generate the magnetic field in which the armature rotates, the motor can be modeled by the electrical circuit in the armature alone. If we further simplify the circuit by ignoring the inductance of the armature coil, we arrive with the following circuit diagram for a simple motor:

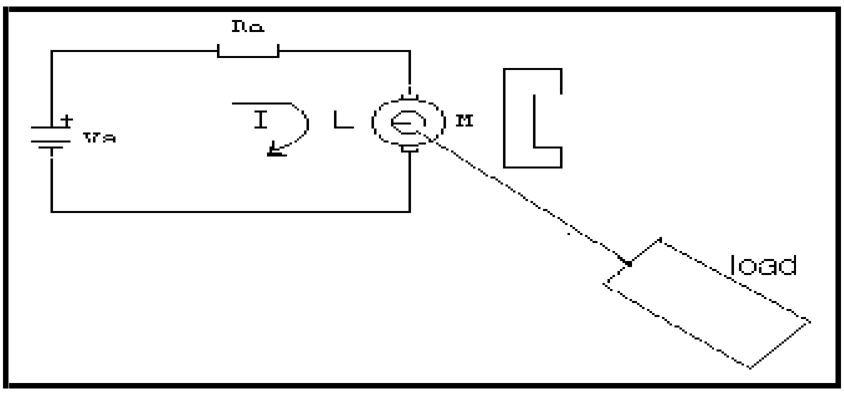


Fig7.5 pm dc motor

V is the voltage supplied by the power source (usually a battery), and R is the resistance of the motor's armature coil. This resistance cannot be measured at rest, since it changes as speed increases towards the steady state speed. Kerchief's voltage law leads to the following equation:

$$V=I_a R_a+E \quad \text{..........(7.1)}$$

Where:

Va : Armature DC supply.

E : Induced voltage in armature windings.

Ra: armature circuit resistance.

Ia : armature current.

$$E = C\Phi\omega \quad \text{..........(7.2)}$$

Where:

C : armature constant.

Φ : Flux.

ω : The angular velocity of the Rotor.

$$\omega=(2\pi/60)\times n \quad \text{..........(7.3)}$$

n : The rotor speed.

$$T=C\Phi\, Ia \quad \text{..........(7.4)}$$

T : Developed electrical torque.

$$\omega=(Va/C\Phi) - (Ra/C\Phi) * Ia \quad \text{..........(7.5)}$$

ω=(Va/CΦ) – (Ra/CΦ^2)*T …………………………………………………….…….(7.6)

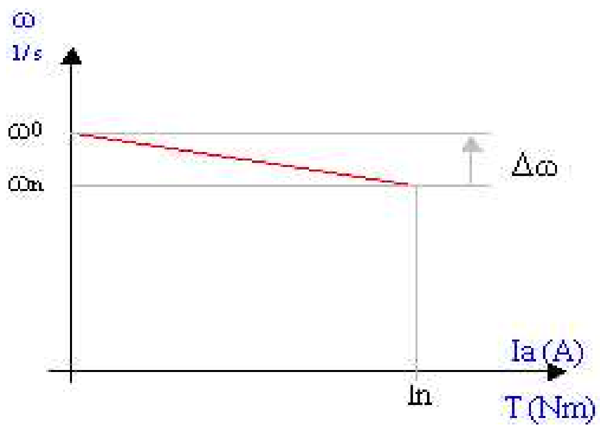


fig 7.6 Natural mechanicl Characteristic

7.3.4 Speed control:

The purpose of speed control is to determine new-rated speeds at the same load depending on the technology process.

Sep. DC motor has the following characteristic equation:

$$\omega = \frac{Va}{C\Phi} - \frac{Ra}{(C\Phi)^2} \quad \text{………………………………………………..(7.7)}$$

According to last equation; speed can be controlled by any of the following methods:

1- Armature voltage control.

2- Field flux control.

3- Armature resistance control.

7.4 Power calculation

the main lifting motor choose light power PM dc motor with purpose to lift : The load which we need to left is 5kg , and the current of the motor is Ia =1.8A, and Va= 12v . and the radius r =0.02 cm

$$\mathbf{P_{in}=Ia * Va} \quad \text{……………………………………………………………….}(7.8)$$

P_{in}= 1.80 *12 = 21.6 watt

$$\mathbf{P_{out}= \omega * T} \quad \text{………………………………………………………………..}(7.9)$$

$$\mathbf{T_{out}= F *} r \quad \text{……..…………………………………………………………..}(7.10)$$

$$\mathbf{F= W * g} \quad \text{……………………………………………….…………………}(7.11)$$

F= 5* 9.81 =49.05 N

T = 49.05 * 0.02 = 0.981 N. m

$$\mathbf{\omega= P_{out}/T_{out}} \quad \text{……………………………………………..……………..}(7.12)$$

ω = 21.6/ 0.981 =2 2 rad /sec

$$\mathbf{V= \omega * r} \quad \text{…………………………………………………………………….}(7.13)$$

V= 22 * 0.02 = 0.24 m/s

where:

p : power of the motor .

ω : the angular velocity

T : the torque of the motor .

W: the weight of the load .

g: gravitational acceleration .

7.5 Gears:

Inside the dc motor box from the (fig 7.2) have Worm Gear gears .the advantages of this gear is to reduce the speed of the motor, and to increase the torque of the dc motor, the another advantages is to braking the motor. We see the fig of the Worm Gear from fig 7.7.

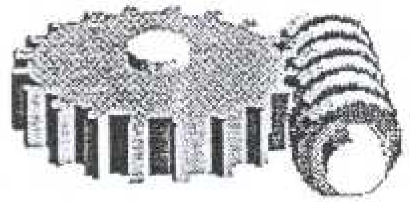


Fig 7.7 Worm Gear

7.6 Festoon:

From the figures we see how we connected the wire to the electrical parts on the crane, motors, limit switch, and bell.

7.7 Limit switch:

In the crane we have six limit switch's or end truck switch's , and this switch s stop the motion of the motors in the end of the allowed distance, by sending a signal to the PLC machine , to stop the motors motions.

7.8 The main board:

This board is responsible for providing the crane with the power to produce the required motion. It is supplied by 220 V AC. This board contains the all-electrical parts that realize the electrical protection and the required motion.

The main board contains the following parts:

7.8.1 On the cover of the board:

1. Emergency switch.
2. Start switch.
3. Stop switch.
4. Power switch.
5. Fuses.
6. Plugs for PLC device

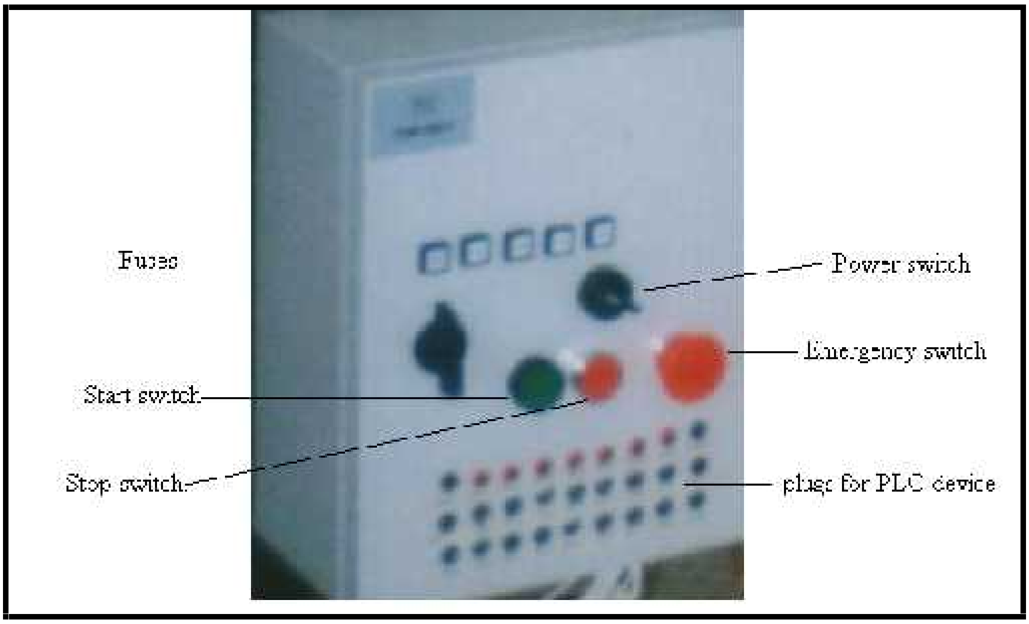


Fig 7.8 cover of the board

7.8.2 Inside of the main board :

1. Transformer (220v ac to 12v dc)
2. Receiver of the remote circuit
3. Motor control circuit
4. Clemens
5. Fan

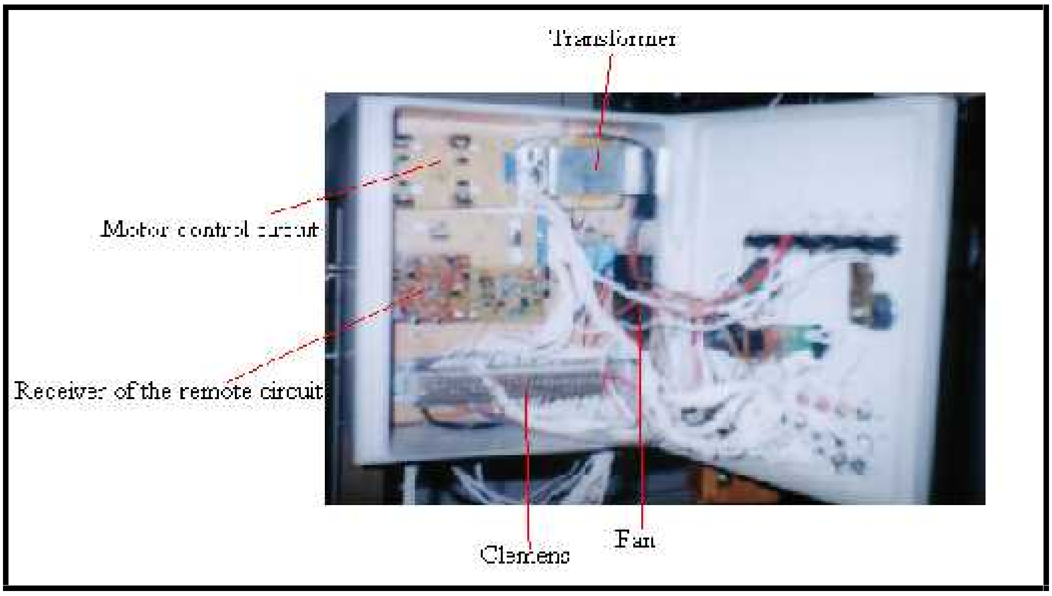


Fig7.9 Inside of the main board

7.9 Power circuit of the motor:

To run the motor we build the power electronic circuit as shown in figure (7.14). By this circuit we can control of the motor by using the signals from the PLC device to run every motor in two diminutions; left or right and up or down.

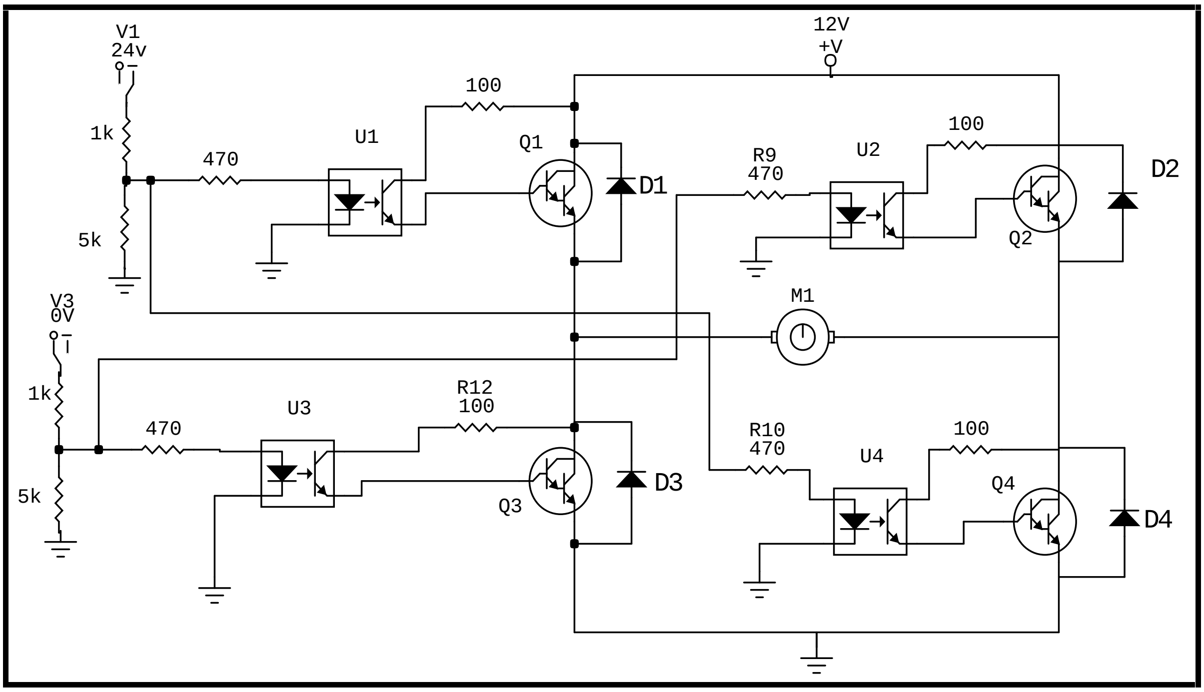


Fig 7.10 Power circuit of the motor

The power circuit contains :

1. Darlington transistor.

2. Optocoupler

3. Diode

4. Resistances

5. Power supplies

7.9.1 Darlington transistor:

Bipolar Transistor: NPN

This device operates as a current amplifier. It consists of three terminals, the Base, Emitter and Collector. Its circuit symbol is shown below.

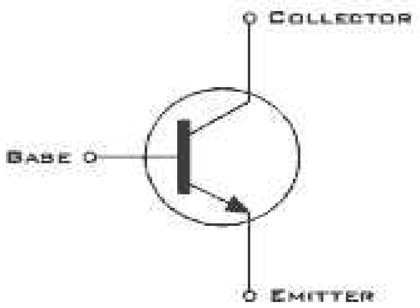


fig 7.11 figure of transistor

The device amplifies the current into the base terminal by allowing a much larger current to pass from the collector to the emitter. This gain varies between transistor types ranging from several hundred for small signal transistors to a few tens for high current power transistors. When used as a switching device the bipolar transistor is operated in saturation mode as shown below.

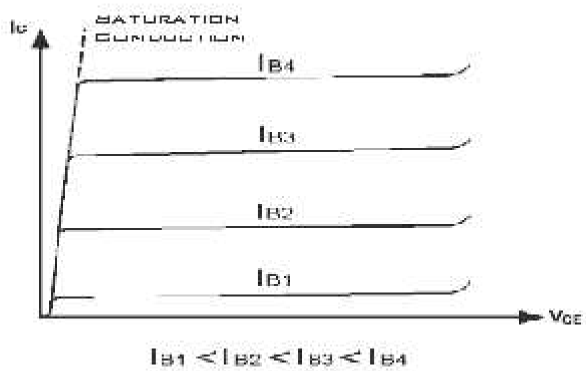


fig 7.12 Characteristic of Bipolar Transis

When the device is saturated the voltage drop across the collector and emitter is minimized, and consequently so are the conduction losses You need to supply a large enough base current to ensure the device will be saturated at the required collector current.

While bipolar power transistors offer high current capacity they require substantial base drive current (as much as 10% of the collector current in some cases) and this requires additional signal processing from the control system.

$$\mathbf{I_E = I_B + I_C} \quad \text{……(7.14)}$$

$$\boldsymbol{\beta} \mathbf{= I_C/I_B} \quad \text{……(7.15)}$$

$$\mathbf{I_B = (V_B - V_{BE})/R_B} \quad \text{……(7.16)}$$

$$\mathbf{V_C = V_{CE}} \quad \text{……(7.17)}$$

$$\mathbf{V_{CE} = V_{CB} + V_{BE}} \quad \text{……(7.18)}$$

Where:

I_E: the emitter current .

I_C: Base current

I_C : the collector current

β: the current gain

The Darlington pair:

The higher the β, the higher the input impedance of the base. Many transistors have βs up to 300. With a *Darlington pair*, we can get much higher βs. From the figure …… Darlington pair. The collectors are connected, and emitter of the first transistor drives the base of the second. Because of this the over β is.

β= β1 β2

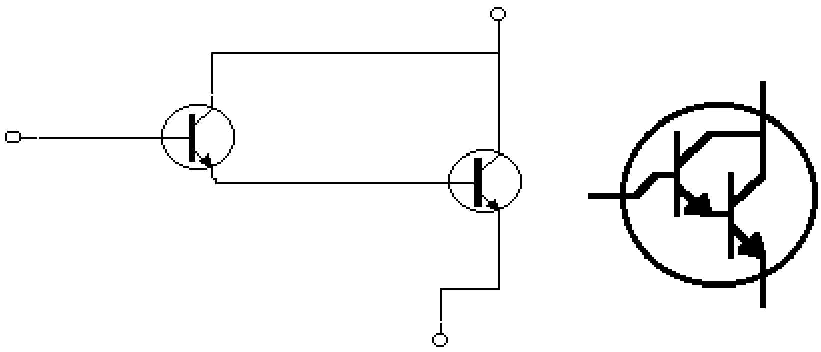


Fig 7.13 Darlington NPN transistor.

7.9.2 Optocoupler :

Here we use the Optocoupler as a switch

And we use it to isolation the power circuit from the control circu.

7.9.3 Diode:

The diode is used to pass the current in one way only

7.10 Programming (PLC):

After designed the model we programming the motion of it buy the PLC .
The program of the model is written (STL) programming for S5 SEMMENS

Table here is discretion the input and the out put of the PLC device.

Table7.1 discretion the input and the out put of the PLC device.

Tools	Condition	Works	Symbols
EM1	NC	Emergency	I0.0
EM2	NO	Emergency	I0.1
S0	NO	Start	I0.2
S1	NO	Stop	I0.3
S2	NO	Right	I0.4
S3	NO	Lift	I0.5
S4	NO	Forward	I0.6
S5	NO	Backward	I0.7
S6	NO	Lifting up	I1.0
S7	NO	Down	I1.1
S8	NO	Warning bell	I1.2
L1	NO	Max right	I1.3
L2	NO	Max lift	I1.4
L3	NO	Max Forward	I1.5
L4	NO	Max Backward	I1.6
L5	NO	Max up	I1.7
L6	NO	Max down	I2.0
G1	———	Right	Q3.0
G2	———	Left	Q3.1
G3	———	Forward	Q3.2

G4	———	Backward	Q3.3
G5	———	Lifting up	Q3.4
G6	———	Down	Q3.5
G7	———	Warning bell	Q3.6

7.10.1 The program:

AI0.0

ANI0.1

AI0.2

ANI0.3

SF0.0

———

ANI0.0

OI0.1

OI0.3

RF0.0

——— **RIGHT**

AF0.0

AI0.4

ANI1.3

ANQ3.1

SQ3.0

———

ANF0.0

ONI0.4

OI1.3

OQ3.1

RQ3.0

LEFT

AF0.0

AI0.5

ANI1.4

ANQ3.0

SQ3.1

ANF0.0

ONI0.5

OI1.4

OQ3.0

RQ3.1

FORWARD

AF0.0

AI0.6

ANI1.5

ANQ3.3

SQ3.2

ANF0.0

ONI0.6

OI1.5

OQ3.3

RQ3.2

---- **BACKWARD**

AF0.0

AI0.7

ANI1.6

ANQ3.2

SQ3.3

ANF0.0

ONI0.7

OI1.6

OQ3.3

RQ3.3

---- **LIFTING UP**

AF0.0

AI1.0

ANI1.7

ANQ3.5

SQ3.4

ANF0.0

ONI1.0

OI1.7

OQ3.5

RQ3.4

---- **DOWN**

AF0.0

AI1.1

ANI2.0

ANQ3.4

SQ3.5

ANF0.0

ONI1.1

OI2.0

OQ3.4

RQ3.5

WARNING BELL

AF0.0

AI1.2

=Q3.6

the end.

7.10.2 The PLC connection:

The input and output are connect to the PLC device as shown in fig 7.19

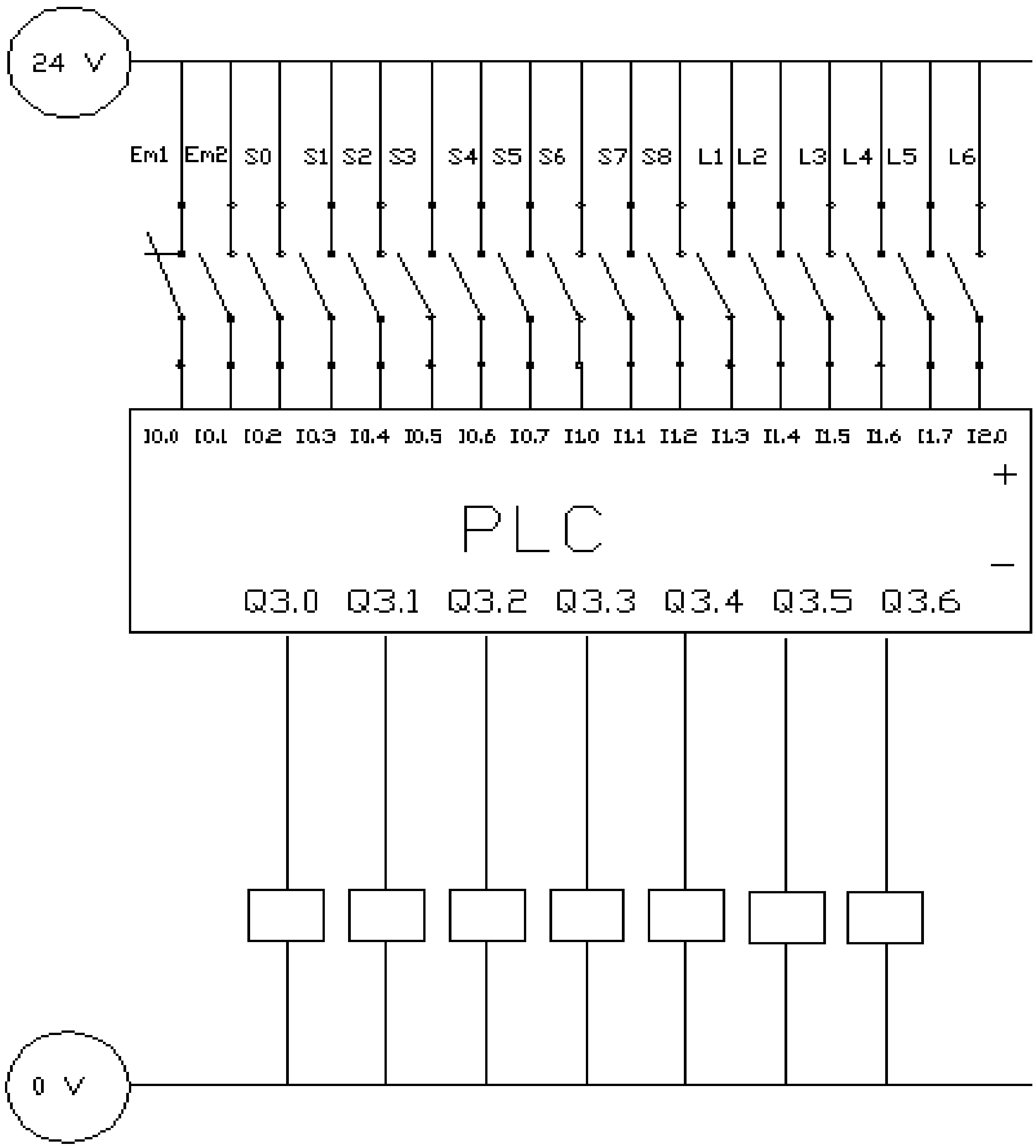


fig 7.14 the connection of PLC device

7.11 Plane of the electrical wire of the crane :

7.12 The samble economic cost.

Table (7.3) the project economic cost

type	number	Piece cost (N.I.S)	Total cost (N.I.S)
Motor	3	50	150
Board	50 cm	50	50
Darlington	14	8	112
Optocouplors	14	5	110
Diodes	14	1	14
Control box	1	50	50
Cooling fan	1	5	5
Em. Switch	1	35	35
Wires	50 m	0.6	30
Plugs	30	1	30
Resistances	50	0.33	16.5
Fuse house	5	3	15
Fuses	10	.35	3.5
Receiver	1	130	130
Transmitter	1	130	130
Control hands	2	10	20
Control hands switches	16	4	60
Bell	1	25	25
Turning	________	________	2000
Transformer	1	60	60

Chapter 8

Conclusion

- In all of the factories nearly it’s important to use the crane that determine by the condition of industrial work .

- After analysis the mechanical design with increase the load on the crane that give curvature on the iron of the girder. And we choose the type of the iron by the load of the crane. We see the curvature of the iron on the fig (2.23).

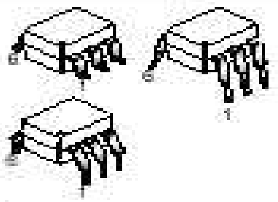
- The motor which use to lifting, it’s have a large power than others motors in the crane where used to moving the crane left right front and back.

- The (PLC) programming is use to definition and description the work of the machine . And we can change the program of PLC with the requirements and additional on machine work.

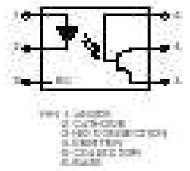
- The devise which use in protections is different by the employee way is in the protection and the element is protected.

4N25	4N26	4N27	4N28	4N35	4N36
4N37	H11A1	H11A2	H11A3	H11A4	H11A5

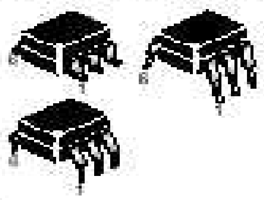
WHITE PACKAGE (-M SUFFIX)



SCHEMATIC



BLACK PACKAGE (NO -M SUFFIX)



DESCRIPTION

The general purpose optocouplers consist of a gallium arsenide infrared emitting diode driving a silicon phototransistor in a 6-pin dual in-line package.

FEATURES

• Also available in white package by specifying -M suffix, eg. 4N25-M
• UL recognized (File # E90700)
• VDE recognized (File # 94766)
- Add option V for white package (e.g., 4N25V-M)
- Add option 300 for black package (e.g., 4N25.300)

APPLICATIONS

• Power supply regulators
• Digital logic inputs
• Microprocessor inputs

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

INDIVIDUAL COMPONENT CHARACTERISTICS

Parameter	Test Conditions	Symbol	Min	Typ*	Max	Unit
EMITTER						
Input Forward Voltage	(I_F = 10 mA)	V_F		1.18	1.50	V
Reverse Leakage Current	(V_R = 6.0 V)	I_R		0.001	10	µA
DETECTOR						
Collector-Emitter Breakdown Voltage	(I_C = 1.0 mA, I_F = 0)	BV_{CEO}	30	100		V
Collector-Base Breakdown Voltage	(I_C = 100 µA, I_F = 0)	BV_{CBO}	70	120		V
Emitter-Collector Breakdown Voltage	(I_E = 100 µA, I_F = 0)	BV_{ECO}	7	10		V
Collector-Emitter Dark Current	(V_{CE} = 10 V, I_F = 0)	I_{CEO}		1	50	nA
Collector-Base Dark Current	(V_{CB} = 10 V)	I_{CBO}			20	nA
Capacitance	(V_{CE} = 0 V, f = 1 MHz)	C_{CE}		8		pF

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise specified)			
Parameter	**Symbol**	**Value**	**Units**
TOTAL DEVICE			
Storage Temperature	T_{STG}	-55 to +150	°C
Operating Temperature	T_{OPR}	-55 to +100	°C
Wave solder temperature (see page 14 for reflow solder profiles)	T_{SOL}	260 for 10 sec	°C
Total Device Power Dissipation @ T_A = 25°C	P_D	250	mW
Derate above 25°C		3.3 (non-M), 2.94 (-M)	
EMITTER			
DC/Average Forward Input Current	I_F	100 (non-M), 60 (-M)	mA
Reverse Input Voltage	V_R	6	V
Forward Current - Peak (300µs, 2% Duty Cycle)	I_F(pk)	3	A
LED Power Dissipation @ T_A = 25°C	P_D	150 (non-M), 120 (-M)	mW
Derate above 25°C		2.0 (non-M), 1.41 (-M)	mW/°C
DETECTOR			
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	70	V
Emitter-Collector Voltage	V_{ECO}	7	V
Detector Power Dissipation @ T_A = 25°C	P_D	150	mW
Derate above 25°C		2.0 (non-M), 1.76 (-M)	mW/°C

ISOLATION CHARACTERISTICS						
Characteristic	**Test Conditions**	**Symbol**	**Min**	**Typ***	**Max**	**Units**
Input-Output Isolation Voltage	(Non '-M', Black Package) (f = 60 Hz, t = 1 min)	V_{ISO}	5300			Vac(rms)
	('-M', White Package) (f = 60 Hz, t = 1 sec)		7500			Vac(pk)
Isolation Resistance	(V_{I-O} = 500 VDC)	R_{ISO}	10^{11}			Ω
Isolation Capacitance	(V_{I-O} = 0, f = 1 MHz)	C_{ISO}		0.5		pF
	('-M' White Package)			0.2	2	pF

Note
* Typical values at T_A = 25°C

BDX53B / BDX53C
BDX54B / BDX54C

COMPLEMENTARY SILICON POWER DARLINGTON TRANSISTORS

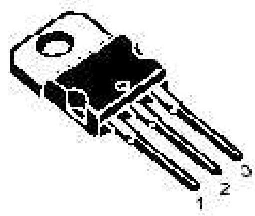
- STMicroelectronics PREFERRED SALESTYPES

APPLICATIONS
- AUDIO AMPLIFIERS
- LINEAR AND SWITCHING INDUSTRIAL EQUIPMENT

DESCRIPTION

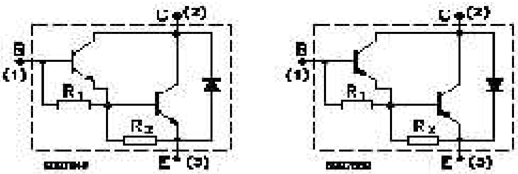
The BDX53B and BDX53C are silicon Epitaxial-Base NPN power transistors in monolithic Darlington configuration mounted in Jedec TO-220 plastic package. They are intented for use in hammer drivers, audio amplifiers and other medium power linear and switching applications.

The complementary PNP types are BDX54B and BDX54C respectively.



TO-220

INTERNAL SCHEMATIC DIAGRAM



R_1 Typ. = 10 KΩ R_2 Typ. = 150 Ω

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value		Unit
		NPN	BDX53B	BDX53C	
		PNP	BDX54B	BDX54C	
V_{CBO}	Collector-Base Voltage (I_E = 0)		80	100	V
V_{CEO}	Collector-Emitter Voltage (I_B = 0)		80	100	V
V_{EBO}	Emitter-base Voltage (I_C = 0)		5		V
I_C	Collector Current		8		A
I_{CM}	Collector Peak Current (repetitive)		12		A
I_B	Base Current		0.2		A
P_{tot}	Total Dissipation at $T_c \leq 25$ °C		60		W
T_{stg}	Storage Temperature		-65 to 150		°C
T_j	Max. Operating Junction Temperature		150		°C

For PNP types voltage and current values are negative.

THERMAL DATA

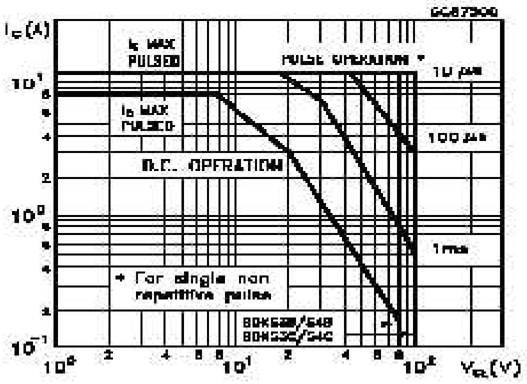
$R_{thj-case}$	Thermal Resistance Junction-case	Max	2.08	°C/W
$R_{thj-amb}$	Thermal Resistance Junction-ambient	Max	70	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

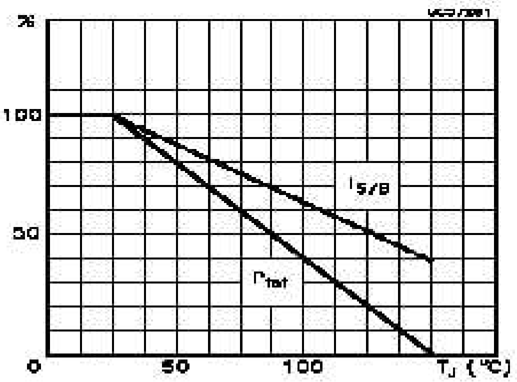
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector Cut-off Current (I_E = 0)	for **BDX53B/54B** V_{CB} = 80 V for **BDX53C/54C** V_{CB} = 100V			0.2 0.2	mA mA
I_{CEO}	Collector Cut-off Current (I_B = 0)	for **BDX53B/54B** V_{CE} = 40 V for **BDX53C/54C** V_{CE} = 50V			0.5 0.5	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage (I_B = 0)	I_C = 100 mA for **BDX53B/54B** for **BDX53C/54C**	80 100			V V
$V_{CE(sat)}$*	Collector-emitter Saturation Voltage	I_C = 3 A I_B = 12 mA			2	V
$V_{BE(sat)}$*	Base-emitter Saturation Voltage	I_C = 3 A I_B = 12 mA			2.5	V
h_{FE}*	DC Current Gain	I_C = 3 A V_{CE} = 3 V	750			
V_F*	Parallel-diode Forward Voltage	I_F = 3 A I_F = 8 A		1.8 2.5	2.5	V V

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %
For PNP types voltage and current values are negative.

Safe Operating Area

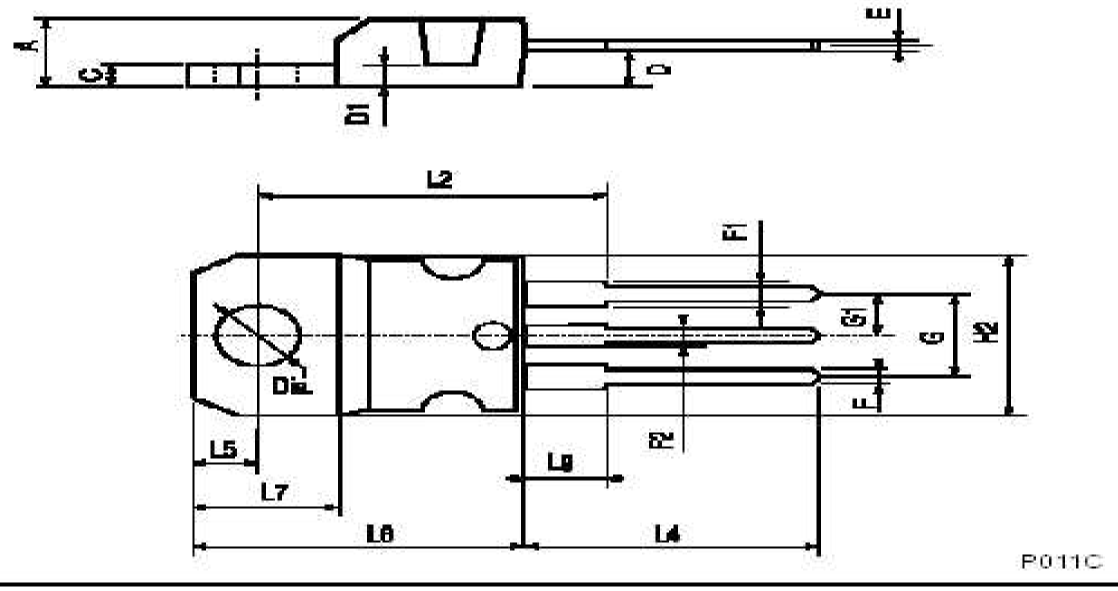


Derating Curve



TO-220 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
C	1.23		1.32	0.048		0.051
D	2.40		2.72	0.094		0.107
D1		1.27			0.050	
E	0.49		0.70	0.019		0.027
F	0.61		0.88	0.024		0.034
F1	1.14		1.70	0.044		0.067
F2	1.14		1.70	0.044		0.067
G	4.95		5.15	0.194		0.203
G1	2.4		2.7	0.094		0.106
H2	10.0		10.40	0.393		0.409
L2		16.4			0.645	
L4	13.0		14.0	0.511		0.551
L5	2.65		2.95	0.104		0.116
L6	15.25		15.75	0.600		0.620
L7	6.2		6.6	0.244		0.260
L9	3.5		3.93	0.137		0.154
DIA.	3.75		3.85	0.147		0.151



Reference:

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- Fundamentals of electrical drives

(Narosa Publishing House).

- Standard handbook of machine design

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- Machine design

(R. S.Khurmi &J. K. Gupta)

- www.yahoo\search.com
- www.google\search.com

Chapter 1

Introduction

1.1 About Industrial Cranes

Crane, hoisting machine for lifting heavy loads and transferring them from one place to another, ordinarily over distances of not more than 200 ft (60 m). Old cranes have a long reach and can lift loads to great heights. Powered by manual or animal power, cranes have been in use from early times. Modern cranes are of varied types and sizes; they may be actuated by steam, electricity, diesel, or hydraulic power as well as by manual power, and they are indispensable in industries where heavy materials are handled constantly. The overhead traveling crane, a type of bridge crane, is used inside buildings or in outdoor storage yards. Two or more parallel girders span its working area. Another girder, called the bridge, stretches between them and rolls along them on wheels; this girder, in turn, supports a carriage from which a lifting attachment is lowered by pulleys. On a stacking crane the pulleys are replaced by a stiff, rotating column on which a pair of forks rides up and down. The gantry crane, another type of bridge crane, has a bridge supported by vertical structures that move along tracks. Gantries are used on piers or in shipyards. The jib crane has a horizontal load-supporting boom fastened to a rotating vertical column, either attached to a wall or extending from floor to ceiling; when the column is held only at the bottom it is called a pillar crane.

1.2 Definition:

Crane: is a machine used for lifting or moving heavy weights by means of a movable projecting arm or a horizontal beam traveling on an overhead support. Crane can also be any device with a swinging arm fixed on a vertical axis such as a fireplace crane that holds kettle, or a boom for holding a motion picture or television camera. Industry, the crane is commonly understood to be lifting equipment. However, each type of crane is referred to as crane.

1.3 Main purpose of project:

1. To design an electrical and mechanical crane moving in three dimensions.
2. To change the control system from the traditional method to new method and it is remote control system.
3. To apply this method of control system on the cranes that do in the dangerous places like, an industrial chemicals places, paint workshop, metals liquefaction, and other applications.
4. To apply control on the voltage for control the speed of the induction motor (IM).

1.4 Types of crane:

1. Over head crane:

Overhead crane style in which the horizontal load carrying beam is attached at the end to wall columns (over hung) or the underside of the ceiling (under hung).

This crane available in two basic types' single girder crane and double girder crane each one of this types has a one or two bridge beam that supports a trolley and hoist are multiple trolley-hoist units. At each end of the bridge beam are carriers, also called end trucks and trolleys. End trucks move along a runway structure. These types of cranes are shown in fig.1.1.

These types of crane provide movements in three dimensions and often feature a lower hook with a swivel that rotates the load around the vertical axis.

It can be controlled by many ways like pendant hand or remote radio control or infrared control unit.

And its two types as shown:

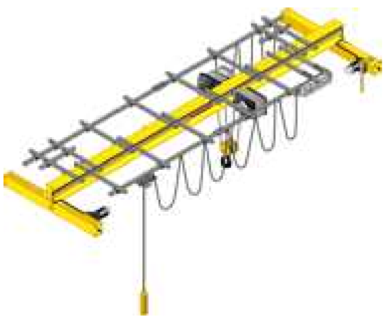
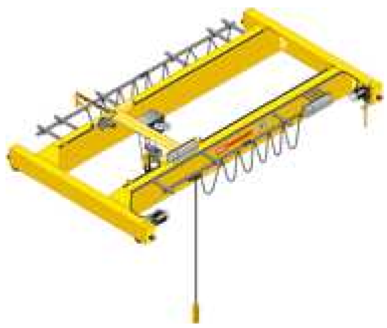
Single Girder Crane	**Double Girder Crane**
	

Fig.1.1 Over head crane

2. Jib Crane its two types:

a- Jib Crane - Wall Mount:

Jib cranes comprise a horizontal beam (jib) upon which a shuttle or hoist is mounted. These are mounted into the side of a wall. Cantilevered jib cranes can incorporate full or partial rotation.Its show in fig.1.2.

Fig.1.2: Jib Crane - Wall Mount

b- Jib Crane - Floor Mount:

Jib cranes comprise a horizontal beam (jib) upon which a shuttle or hoist is mounted. Floor or foundation mounted jib cranes can have higher load ratings than wall-mount cranes. Cantilevered jib cranes can incorporate full or partial rotation. Its show in fig.1.3.

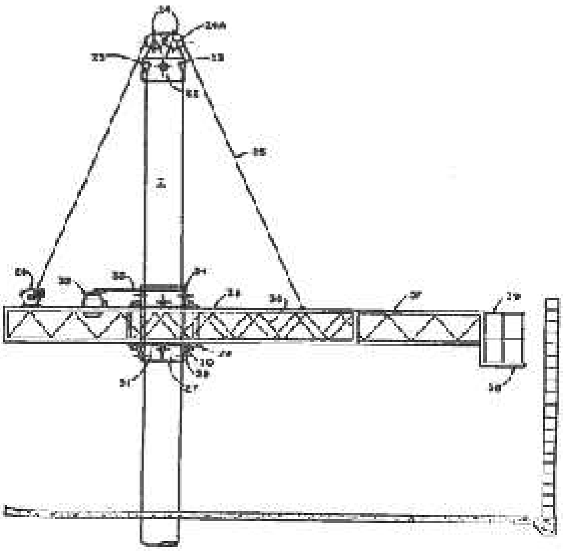


Fig.1.3: Jib Crane-Floor Mount

3. Gantry crane:

Gantry Cranes provide the same strength and durability of Overhead Bridge Cranes. Gantry end trucks ride on rail, or square bar, secured to the factory floor, instead of on the runway structure that supports Bridge Cranes. The gantry crane is raised above the floor by support legs mounted on the end trucks.

Gantry cranes have a horizontal beam supported by end supports or legs. These can vary in size from small workstation cranes to very large, heavy construction cranes. this type is shown in fig.1.4.

Fig.1.4 Gantry crane

Note:

After that we choose the remote control of overhead bridge crane (double girder) to designed it because it's save our life and doing all of the work in the industrial.

1.5 General block diagram overhead bridge crane:

The block diagram shows the all components of the project, and its transmitter, receiver, controller (by programmable logic controller (PLC)), motors, and loads. That we show in fig.1.5.

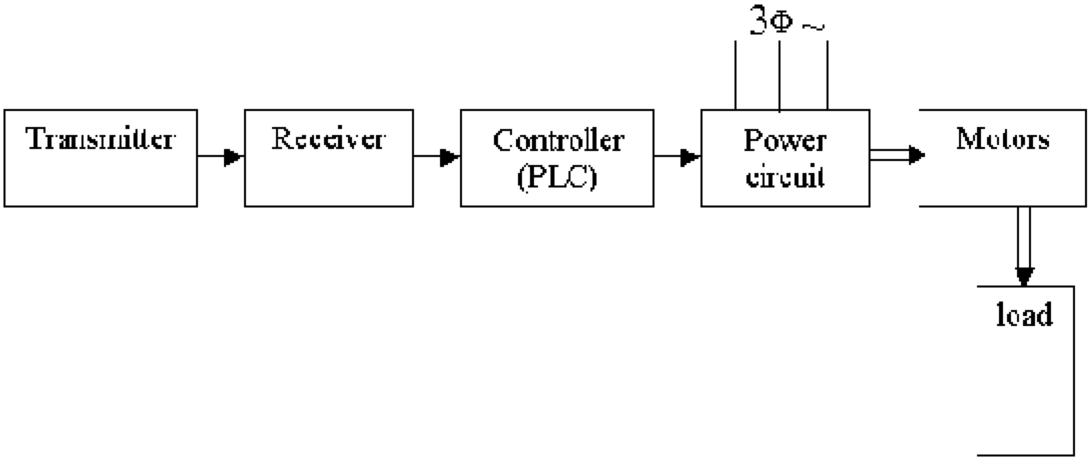


fig.1.5: Block diagram

1.6 Previous Studies:

Many previous studies are complete achievement of the crane project because many shapes and types of crane in industrial lifelong and in our university many student are take this project to fulfill the requirements of bachelor’s degree but in another types of crane project.

Chapter 2

Mechanical design

2.1 Introduction:

The subject Machine Design lathe creation of new and better machines And improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. From the study of existing ideas,’ a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape And form in the form of drawings. In the preparation of these drawings care must be taken of the availability of resources in money, in men and in materials required for the successful completion of the new idea into an actual reality. In designing a machine component, it is necessary to have a good knowledge of Strength of Materials, Theory of Machines and Workshop Processes.

2.2 Classifications of Machine Design

The machine design may be classified as follows:

1. Adaptive design. In most cases, the designer's work is concerned with adaptation of existing designs. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training.'

The designer only makes minor Alternation or modification in the existing designs of the product,

2. Development design. This type of design needs considerable scientific training and design ability in order to modify the existing designs into a new idea by adopting a new material or different method of manufacture. In this case though the designer starts from the existing design, but the final product may differ quite markedly from the original product.

3. New Design. This type of design needs lot of research, technical ability and creative thinking. Only those designers who have personal qualities of a sufficiently high order can take up the work, of a new design.

The designs, depending upon the methods used, way be classified m follows:

a) Rational design. This type of design depends upon mathematical formulae of principle of mechanics.

b) Empirical design. This type of design depends upon empirical formulae based on the practice and ~ experience،

c) Industrial design. This type of design upon the production aspects to manufacture any machine component in the industry.

2.3 The main parts of double girder overhead crane :

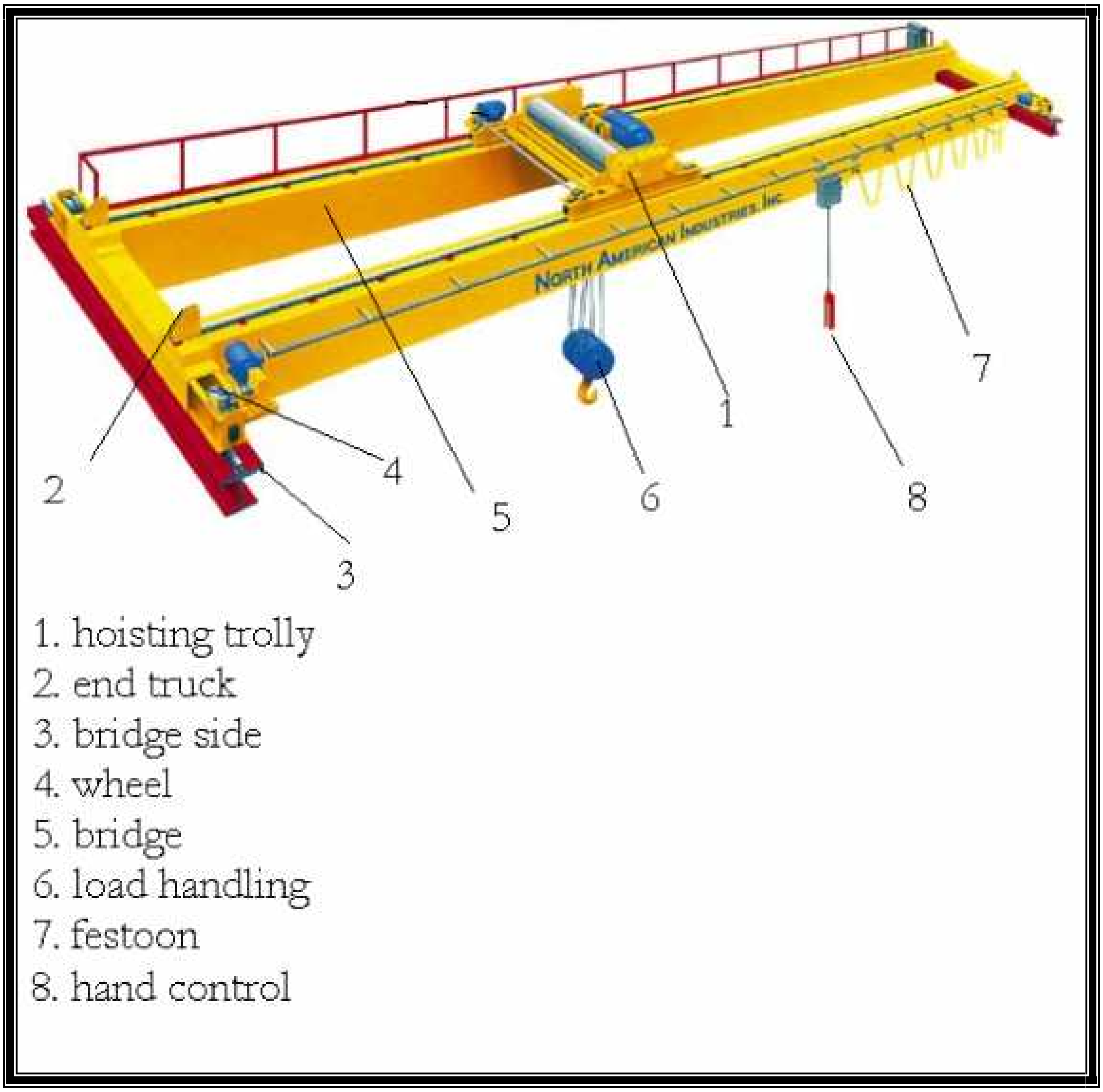


fig.2.1 main parts

The main parts of a crane are:

1. A bridge structure that carries the hoisting trolleys and moves on the runway.

2. A hoisting trolley that hoists and lowers the suspended load using wire rope or chain.

3. Load handling equipment.

2.3.1 Construction of the crane:

Here are the main components of crane:

1. Bridge and outfitting.
2. Hoisting trolley.
3. Traveling mechanisms.
4. Crane electric.
5. Brakes.
6. Load handling equipment.
7. End truck.
8. Festoon.
9. Protections.
10. Accessories.

2.3.2 Main components of crane and their functions:

2.3.2.1 Bridge and outfitting:

1) Bridg**e:-**

The principal parts of the bridge are the main girder(s) and end trucks with wheels. Additional parts include maintenance platforms, also known as walkways, foot walk, and catwalks, and supporting systems for power and control cables as well as for crane electric. These additional parts are often referred to as outfitting. Outfitting varies from crane to crane, depending on the type and the intended use of the crane.

The main purpose of the bridge structures is:

1. To provide sufficient load carrying capacity (strength and stability) for both the vertical and the horizontal loads that originate from hoisting motion, traversing motion of the trolley, and traveling motion of the bridge,

2. To keep the crane aligned thus allowing distortion free movement of the trolley and the whole crane

.

2) Girders:-

A crane usually has one or two main girders that carry the hoisting trolley(s). The main functions of girders are to take the wheel load of the hoisting trolley, distribute these loads across the girder, and transfer them to the end trucks.

The girder bridge is two types:

1. Single Girder Crane:

Single Girder cranes offer the advantages of a low dead weight and lower capital expenses. The larger headroom requirement of a single girder crane is partly compensated by providing a low headroom type monorail hoist.

Single girder cranes are always controlled from the floor. Under running cranes offer the advantage of the maximum area coverage without reducing floor space by using extra columns for support. Usually supported from the ceiling structure, under running cranes are generally limited in capacity to about ten tons.

In special circumstances 12 or even 20 tons are possible. The single girder under running cranes seen here are the most economical means of providing maximum crane coverage with a capacity of two tons.

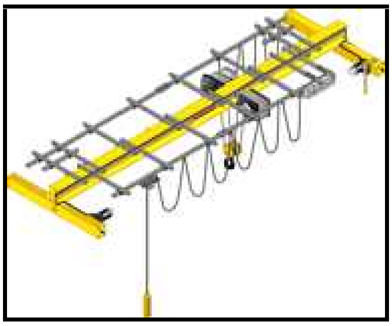


fig. 2.2 single girder

1. Double Girder Crane:

Double Girder cranes in general are available for heavier capacities and wider spans, have greater rigidity and offer improved headroom requirements because in most cases the hook can be raised up between the two crane girders. Double girder cranes can be supplied with walkways and can be operated with any kind of control system Double girder top running cranes up to 50T capacity and 120 ft.

Span with top or under-running trolleys with or without walkways controlled by push button pendant or cab operated Multiple cranes sharing a runway give an economical means of increasing production while minimizing capital expense For higher capacities and longer spans a double girder under running crane is necessary.

The real difference between single and double girder cranes is hook height (how far above the floor your hoist will lift). Double girder cranes provide better hook height, typically 18-36 inches better. Double girder cranes can provide more lift, because on double girder cranes the hoist is placed between the cross girders, not under the cross girder.

You gain the depth of the cross girder. Single girder cranes cost less in many ways: Only 1 cross girder is required, the trolley is simpler, freight costs less, installation is quicker, and your runway beams are lighter due to the reduced crane dead weight. Double Girder Crane Single Girder Crane Maximum Hook Height Reduced Hook Height Double girder cranes provide greater hook height, but are no more durable than single girder cranes.

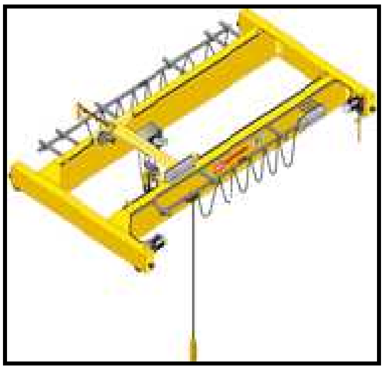


fig.2.3 double girder

3) Outfitting:

Outfitting typically includes mandatory items like buffer stops, supporting structures for control panels (crane electric) and internal cabling (power cables to mechanisms and control cables). Other items, normally required by the user, include maintenance platforms, ladders, and floodlights.

2.3.2.2 Hoisting trolley:

The main types of hoisting motors used in the Cranes are:

1. Squirrel cage motors, normally either single speed motors or two speed motors having two sets of windings (two speed squirrel cage motors are better know as pole-change motors). Some manufacturers offer three speed motors that incorporate three sets of windings in the motor.

2. Slip ring motors (normally single speed motors).

3. DC-motors (normally separately excited).

Typical to all hoisting motors are very high starting torque characteristics and an ability to withstand frequent starts that are required by intermittent duty .The type of hoisting motor depends on the desired performance of the motion (speed control system). These are discussed later in this section under crane electric.

fig 2.4 Hoisting trolley

2.3.2.3 Traveling Mechanisms:

Traveling mechanisms consist of an electric motor/a) brake, a gear unit, and couplings. The mechanism is connected to the wheel directly, with a coupling, or with a shaft and coupling(s). In North America, it is common to have one machinery, a motor with or without a gearbox, in the center of the bridge. The torque is transmitted to opposite wheels by long supported shafts. In Europe, it is customary to use independent mechanisms.

The brakes in traveling mechanisms are either conical, disc, or shoe brakes. The brakes function like holding brakes in hoisting motion. The primary function of the traveling mechanism is to move the crane on the runway.

fig2.5 Traveling mechanisms

2.3.2.4 Crane electric:

That is an induction motor and there control circuit by PLC and the power supply three phases (380 V) and the festoon cable.

fig2.6 Crane electric motors

Power Supply Devices:

The power supply devices will bring the needed electric power to the power distribution unit of the crane. The three base systems are:

1. Conductor rail systems with current collectors.
2. Moving cables (suspended from track), normally festoon type.

2.3.2.5 Cable reel systems.

If power supply line is used only to deliver electric power, all systems are equally competent. In that case, the main purchase criteria are the dimensions and/or cost of the devices. However, if data signals are transferred, the conventional conductor rail systems are not particularly suitable, because of the sparking between the conductor and the collector. The sparking also prevents the use of this system in explosive and corrosive environments.

The power supply system dimensioning is based on maximum continuous and starting currents.

All aforementioned systems must be equipped with a power disconnection switch for the entire crane system, including the power supply conductors or cables. This switch is normally located near the crane on the floor level

2.3.2.6 Brakes:

Working brakes are used to control speed. At present, working brakes are electric. They use either eddy current braking or regenerative braking implemented by the hoisting motor. The holding brake is normally used to stop the movement. In more advanced speed control systems, the holding brakes will only hold the load. Consequently, they are applied only when the hoisting mechanism has been brought to a still stand by a working brake. Regardless of the braking scheme, holding brakes are used to hold the load in case of a power failure or an emergency. The most common types of holding brakes include conical brakes, disc brakes, and shoe brakes.

The load brake is a special brake. Its purpose is to prevent load drop in case of a motor failure, a holding brake failure, and a hoisting gear unit failure.

1) Electro Magnetic Brakes:

Electro magnetic brakes are used when a load must be stopped rapidly to prevent the load from rotating due to the motor automatic control whether it is a question of stopping at a pre-determined time or at selected points of travel or to prevent over traveling. For foolproof and safe operation of machinery, modem methods are necessary, which should not tax the operator very greatly. Any machine which requires its motion to be arrested, whether it is a lifting Crane, Hoist, Winch or Mining Haulage today employs a electro magnetic brake, enabling the operator not only to arrest the motion but also to hold the load at any desired point without danger of falling, merely by release of the starting handle. One cannot possibly disparate the brake. Nothing safer than the electro magnetic brake is available today.

2) Single Phase Electro Magnetic Brake:

Electro magnetic single phase A.C Brake is ruggedly constructed to withstand the effect of mechanical shocks and vibrations. The brake is manufactured to comply with BS Specification

fig2.7 Single Phase Electro Magnetic Brake

The AC Electro magnet is built of high grade, low magnetic steel laminations each insulated from the adjacent one. The entire lot is tightly riveted and machined accurately to eliminate the air gap when the magnet circuit is closed. The coils are wound on bakelite bobbin and are thoroughly insulated.

3) Electro Hydraulic Thruster Operated Brake

Electro hydraulic thruster brake is a heavy-duty brake designed to withstand the severe duty conditions imposed by heavy-duty machinery in various industries. The electro hydraulic thruster transmits useful thrust through the levers onto the brake shoe thereby releasing the brake. When the power is switched off, the brake is smoothly applied because the hydraulic thrust acting against the spring pressure is gradually reduced.

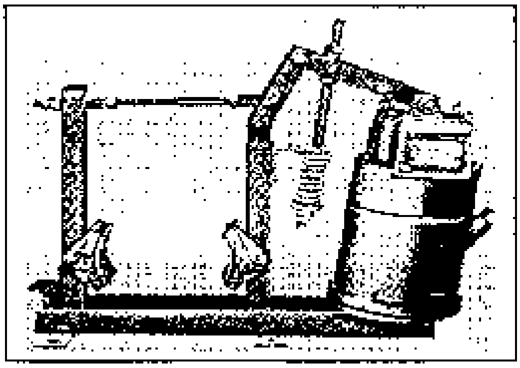


fig2.8 Electro Hydraulic Thruster Operated Brake

4) Steel Mill Duty DC Electro Magnetic Brake:

DC electro magnetic shunt brake is designed to withstand a large number of switching operations per hour. The minimum number of pivots ensures minimum wear and tear of moving parts. The brakes are manufactured for different voltages and are supplied if necessary with Transformer Rectifier Panels

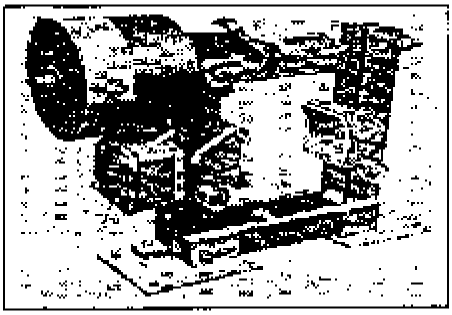


fig2.9 DC Electro Magnetic Brake

All types of brakes are normally applied when in OFF position and the brake is released when power is connected.

5) Disc Brakes:

Flange-mounted Disc Brakes with single or double disc. Brake torques up to1400Nm.

fig.2.10 Disc Brakes

2.3.2.7 Load handling equipment:

The Load Handling Equipment, LHE, has three major functions; to ensure safe attachment of the load to the lifting system, to speed-up the attachment procedure, and to increase the utilization of warehouse area.

The most commonly used LHE is the hook. For more sophisticated load attachment, there is a wide variety of LHEs available, including different type of hooks, lifting magnets, hydraulic container spreaders, vacuum based devices, just to mention a few. The use of these LHEs largely depends on the required degree of efficiency (increased automation in attachment), type and shape of load, and on the money available.

Based on the product catalogues of several manufacturers, the majority of LHEs are operated by the crane driver. In process type industry and container handling, the LHEs are automated. After the LHE is activated, it will attach itself to the load, indicate when the attachment is complete. Then lifting can begin.

When the crane runs on automatic mode, additional safety regulations apply. These regulations involve safe attachment of load, load drop prevention when crane or trolley moves, allowed transportation routes (no access to space above corridors, etc.), access of the personnel to the area where the crane operates, and so on. These regulations have not yet been harmonized to an international standard, they vary from country to country.

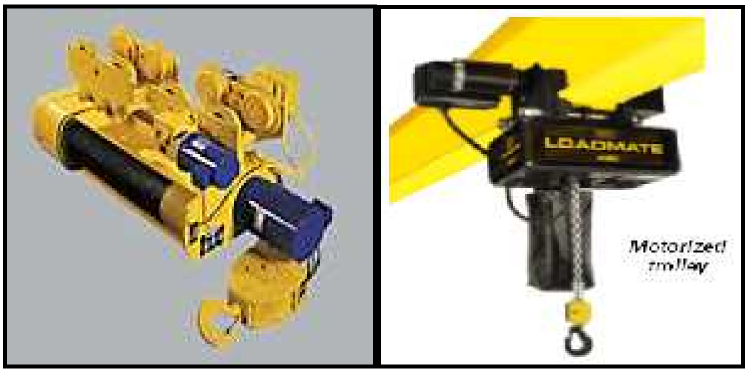


fig.2.11 Load handling equipment

2.3.2.8 End truck:

The main tasks of the end trucks are to support the girders, transfer the loading from girders to crane rails through wheel assemblies, move the crane with the help of traveling mechanisms, keep the crane perpendicular to runway, and protect the crane and load from dropping in case of a wheel or axle breakage.

End trucks consist of steel housing, wheel assemblies, a connection to girders, crane buffers that are also known as bumpers, and a connection for traveling mechanisms. In its simplest form, an end truck has two wheels. In bigger cranes, the end trucks an form a system that has several elementary trucks that are normally pin connected to girders with balancing beams.

Fig.2.12 End truck

2.3.2.8.1 Offer the following style End Trucks:

1. Top Running Single Girder - Manual & Powered
2. Top Running Double Girder - Powered
3. Under Running Single Girder - Manual & Powered

fig.2.13 offer the following style End Trucks

2.4 Top running Double Girder Cranes:

Double girder top running cranes up to 50T capacity and 120 ft. span with top or under-running trolleys with or without walkways controlled by push button pendant or cab operated.

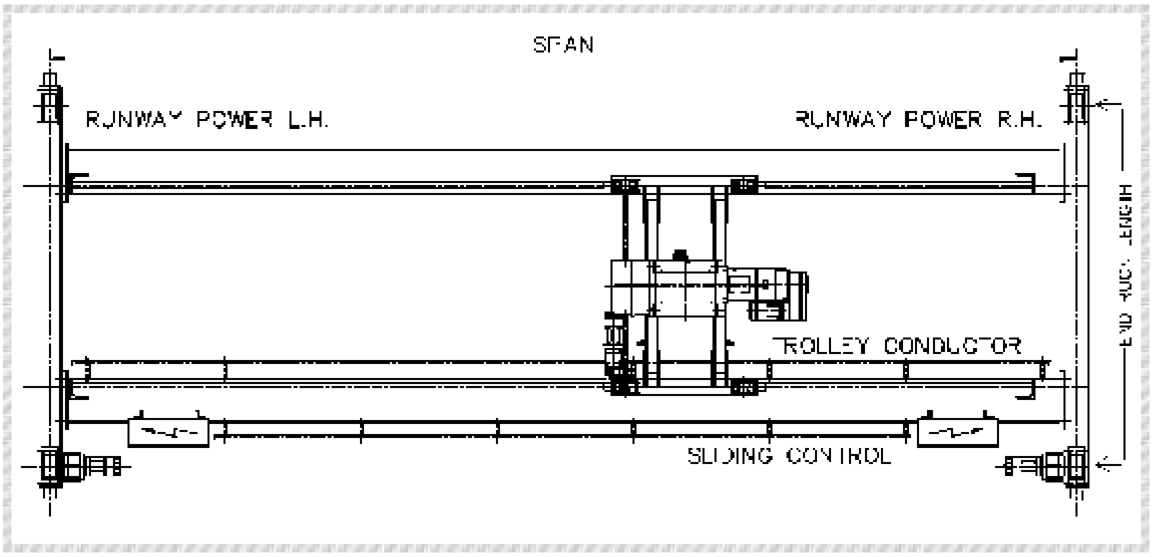


fig.2.14 projection head of overhead crane

Span: is equal 7 meter

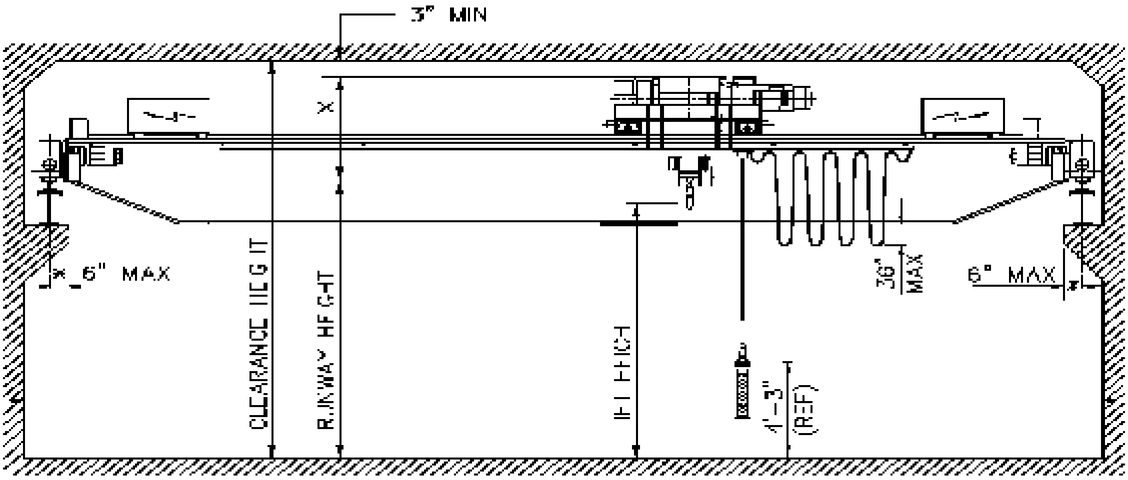


fig.2.15 projection front of overhead crane

Clearance height: is equal 3 meter & The length is 10 meter

2.5 Hoisting trolley:

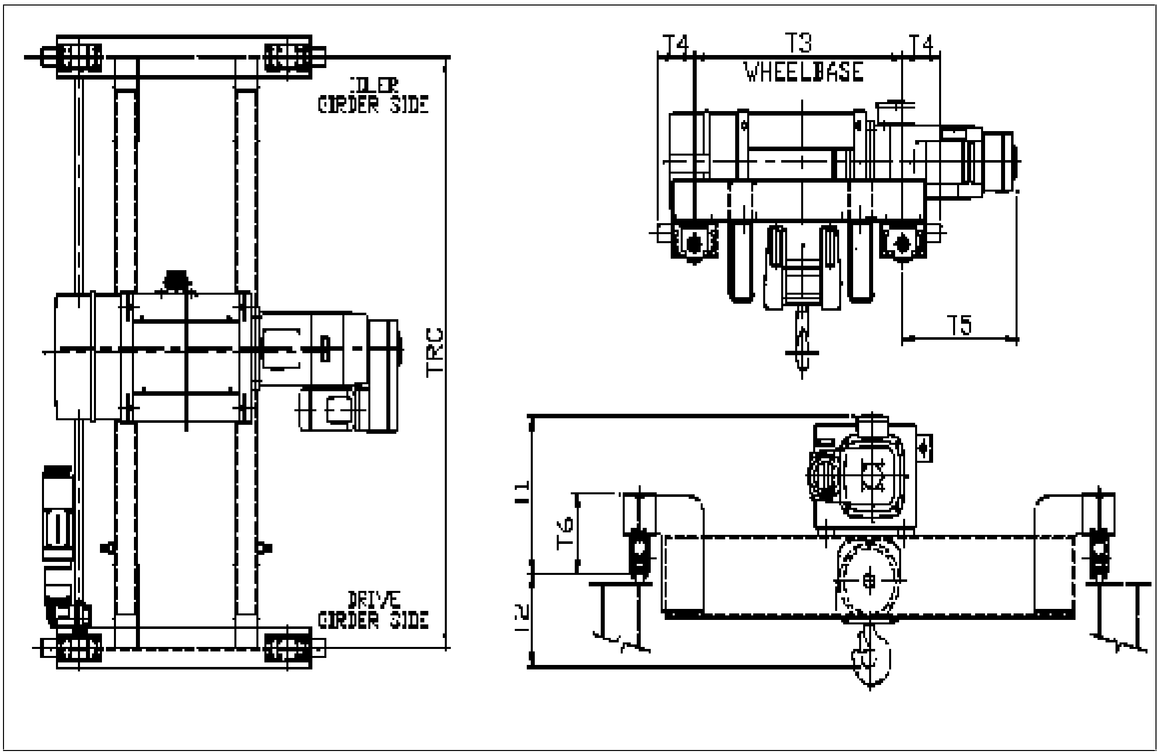


fig.2.16 projection front ,head and side view of overhead crane

We can see all distance of all lengths of T from the table (2.1)

Table (2.1) the *distance of all lengths of T.*

CAPACITY (Ton)	EZLDH HOIST MODEL	TRAVEL WHEEL	T1 (in)	T2 (in)	T3 (in)	T4 (in)	T5 (in)	T6 (in)	WEIGHT by TRC (lbs) 55.12"	88.18"	110.25"
3	DH168H19KV24/1F4	DRS112	18.2	7.3	42	6.5	7.2	11.2	990	1270	1390
5	DH212H16KV24/1F4	DRS112	18.2	10.8	42	6.5	7.2	11.2	1010	1290	1410
5	DH312H12KN34/1F10	DRS112	22.1	13.8	36	6.5	20.3	11.2	1320	1600	1830
5	DH312H20KN34/1F10	DRS112	22.1	13.8	48	6.5	18.4	11.2	1400	1680	1920
7.5	DH320H12KN34/1F10	DRS112	22.1	13.8	36	6.5	20.3	11.2	1330	1610	1850
7.5	DH320H20KN34/1F10	DRS112	22.1	13.8	48	6.5	18.4	11.2	1420	1700	1940
7.5	DH520H12KN34/1F10	DRS112	23.7	16.7	38	6.5	23.0	11.2	1730	2070	2410
7.5	DH520H20KN34/1F10	DRS112	23.7	16.7	50	6.5	21.0	11.2	1810	2150	2500
10	DH425H20KN34/1F10	DRS125	22.8	13.1	50	7.1	17.4	11.9	1670	1930	2280
10	DH525H12KN34/1F10	DRS125	24.4	16.0	40	7.1	22.0	11.9	1920	2360	2700
10	DH525H20KN34/1F10	DRS125	24.4	16.0	52	7.1	20.0	11.9	2000	2450	2780
15	DH640H20KN34/1F10	DRS125	24.4	16.0	56	7.1	18.0	13.8	2280	2720	3160
15	DH1040H16KN34/1F10	DRS125	29.7	24.1	50	7.1	35.3	13.8	3500	3940	4380
15	DH1040H24KN34/1F10	DRS125	29.7	24.1	62	7.1	33.6	13.8	3740	4180	4630

2.6 Festoon system:

They are four types of the festoon wire system :

1. • Stretched wire.
2. • C-track.
3. • Square bar.
4. • I-beam.

2.6.1 Typical stretched wire system:

This is a light-duty festoon system for economical installation where heavy service is not required. Economical and dependable, this wire rope-supported festoon system is designed to provide electrification to small cranes, moving hoists, and other moving machinery where relatively light load conditions are present.

Stretched wire systems can also be used to festoon supply hoses for pneumatic tools, as well as continuous welding machines or flame cutters where oxygen or acetylene gases are used.

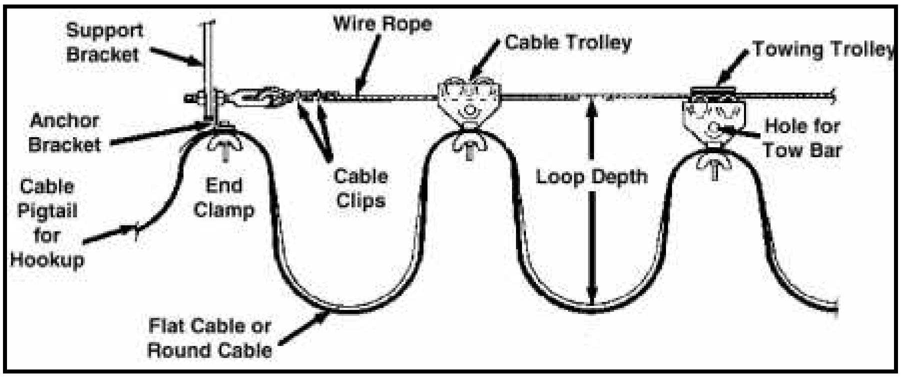


fig.2.17 Typical stretched wire system

2.6.2 Typical C-track system:

The C-track system is one of the most versatile festooning techniques available. It is an all-purpose system suited for either indoor or outdoor use under a broad range of operating conditions.

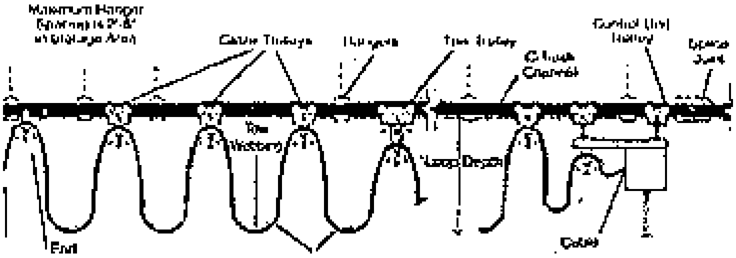


fig.2.18 Typical C-track system

2.6.3 Typical Square Bar System:

Square bar systems provide a rigid and stable support for cable carriers without the weight and greater cost of an I-beam installation. Square bar installations also mean that carriers travel on exposed surfaces and permit easy access to moving parts for maintenance. The carriers have guide wheels that contact all four surfaces of the bar and are less prone to sway from side-to-side.

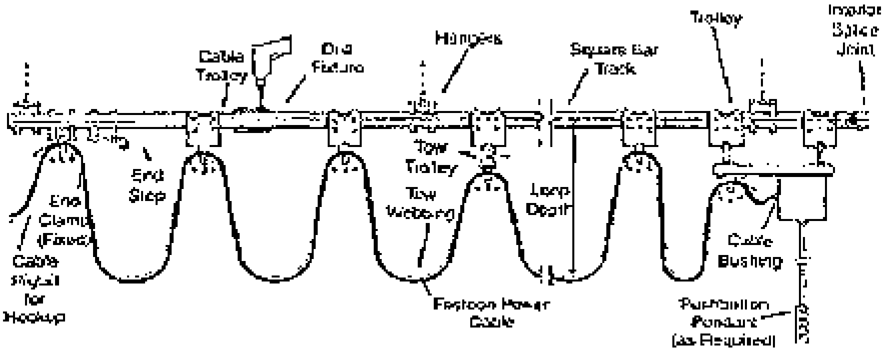


fig2.19 Typical Square Bar System

2.6.4 Typical I-B earn System:

I-beam festoons are for use when needs merit a sophisticated solution.

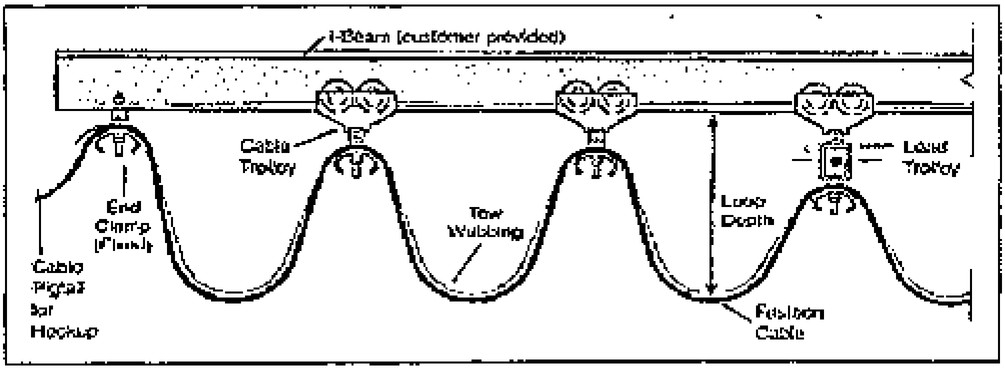


fig.2.20 Typical I-B earn System

2.7 Girder mechanical Design:

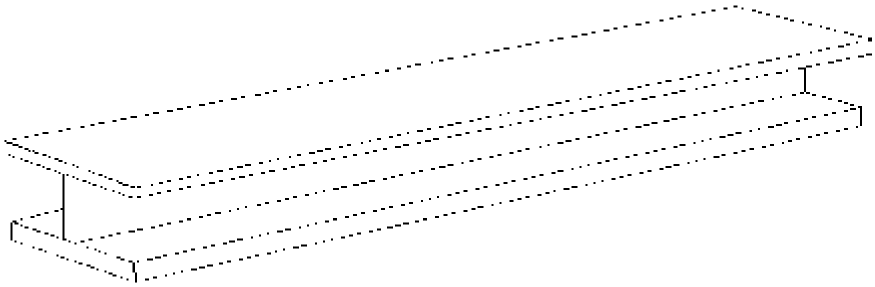


fig.2.21 the beam

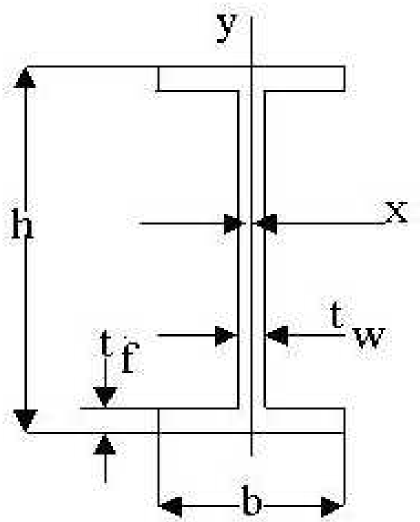


Fig.2.22 the beam distance

The weight of beam:

$m = v * \rho$ ……………………………………………………..………… (2.1)

$V = (2* L*b*t_f)+((h-2*t_f)*L*t_w)$ … ……………………………….……… (2.2)

$m = \rho\,[(2* L*b*t_f)+((h-2*t_f)*L*t_w)]$ ………………………………..……. (2.3)

W: weight of the beam (N)

ρ : Material density (kg/m^3)

V: beam volume (m^3)

m: mass of the beam (kg)

2.8 Dynamic stress analysis:

Stress: is external system forces or loads on a body and the internal forces (equal and opposite) are set up various section of the body, which resist the external forces. This internal forces per unit area at any section of the body is known as a unit stress or simply stress.

The maximum stress force is applied on the center of the beam

σ =F/A ………………………………………………………... ………. (2.4)

F=$m_{b}*g$ ………………………………………………………... ………. (2.5)

m_{c} : chain hoist mass (kg)

σ: beam stress(N/$m^{2)}$

A: area of the beam (m^2) .

F : applied force on the beam (N)

from table (2.1) that make stand hand for mechanical engineers design of the weights of the hoisting trolley.

m_c=197— 211 kg ≈220 kg

m_{L} : looking basined load

m_b: mass on the beam

mb= mc+ mL =220 kg …………………………………………………….(2.6)

F =(1220)*9.81=11968.2 N

A=L.W …………………………………………………………......... (2.7)

σ = F/A (N/$m^{2)}$ ……………………………………………............. (2.8)

δ = F.L/A.E

Where

δ: Is the total deformation of the beam

F: beam force

L: beam length

A: surface Area of the beam

E: modulus of elasticity .

M: Moment.

θ: Slope, tensional deflection.

V: shear force.

Table (2.2) that make stand hand for mechanical engineers design of the weights of the hoisting trolley

Capacity		Lifting speed		Beam to high hook distance		Net weight		motor	
Shoottons		ft/min	m/min	in	mm	Ib	Kg	hp	Kw
½	0.4	60	18	27	686	430	195	4.5	3.36
¾	0.68	37	11	27	686	430	195	4.5	3.36
1	0.91	30	9	25	635	465	211	4.5	3.36
1	0.91	37	11	27	686	435	197	4.5	3.36
1	0.91	60	18	27	686	445	202	4.5	3.36
1½	1.36	18	5.5	25	635	464	211	4.5	3.36
1½	1.36	30	9	25	635	464	211	4.5	3.36
1½	1.36	37	11	27	686	445	202	4.5	3.36
2	1.81	18	5.5	25	635	465	211	4.5	3.36
2	1.81	30	9	25	635	480	218	4.5	3.36
3	2.7	18	5.5	25	635	560	254	4.5	3.36
5	4.5	13	4	30	762	710	322	4.5	3.36
7½	6.8	15	4.6	36	914	1100	499	7.5	5.59
10	9.1	13.5	4.1	40	1016	1785	810	10	7.46
15	13.6	13	4	49	1245	2510	1139	15	11.19

2.9 Deflection due to bending:

The relation involved in the binding of beams are well known and are given here for reference purposes as follows :

$$\frac{q}{EI} = \frac{d^4y}{dx^4} \quad \text{...} \quad (2.9)$$

$$\frac{V}{EI} = \frac{d^3y}{dx^3} \quad \text{...} \quad (2.10)$$

$$\frac{M}{EI} = \frac{d^2y}{dx^2} \quad \text{...} \quad (2.11)$$

$$- = \frac{dy}{dx} \quad \text{...} \quad (2.12)$$

$$y = f(x) \quad \text{...} \quad (2.13)$$

These relation are illustrated by the beam of Fig (2.23) .note that the x axis is positive to the right and the y axis is positive upward .All quantities ,loading ,shear force, support reaction, moment, slope, and deflection have the same sense as y ; they are positive if upward ,negative if downward.

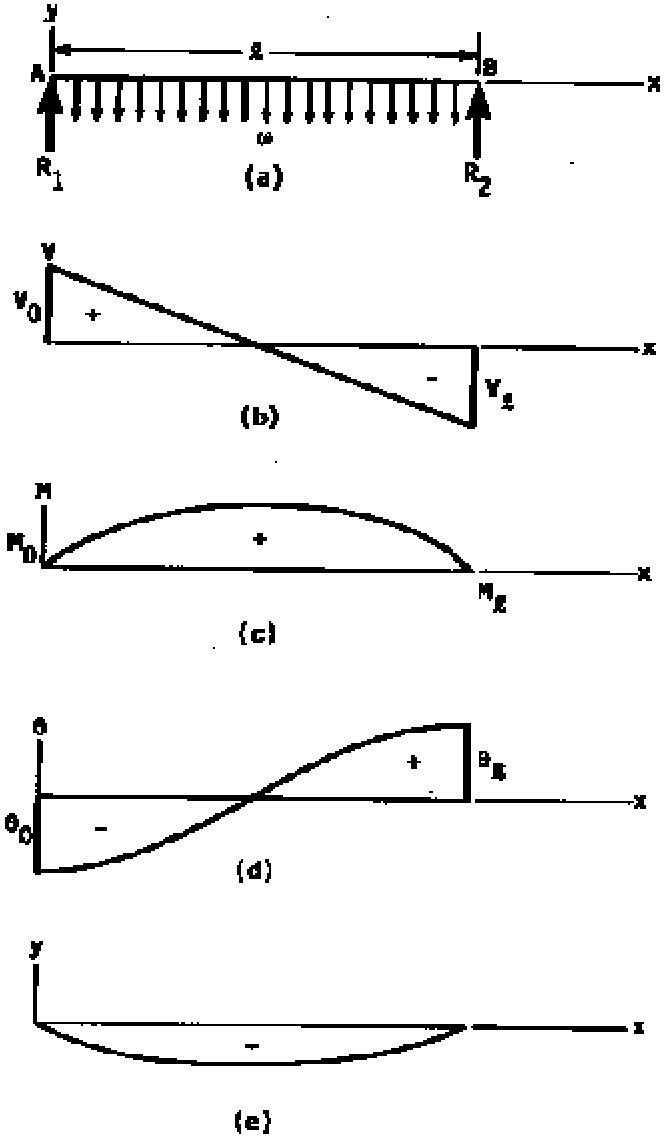


Fig 2.23 (a) loading diagram showing beam supported at A and B with uniform load

W having units of force per unit length, $R_1 = R_2 = wl/2$ *; (b) shear –force diagram showing end conditions; (c) moment diagram ;(d) slope diagram ; (e) deflection diagram .*

Chapter 3

Electrical Design

3.1 Introduction:

The crane electric consists of a power distribution unit, speed control electric for each motion, a controller consisting of a man-machine interface, protective devices, and wiring.

Power distribution unit:

Electricity for the crane is brought to the power distribution unit. This unit contains the mandatory main switches and fuses or circuit breakers. This unit can also contain protective devices, such as over/under voltage protectors, phase failure detectors, and condition monitoring systems. The electric power is then distributed to crane mechanisms and controllers

Like all electrical components, the dimensioning of their individual parts and functions are strictly controlled by local and international regulations.

3.3 Speed Control Electric of induction motor:

The behavior and hence performance of a crane is dependent to a great extent upon the speed control system of each motion. This system can be one of the following:

1. Speed control based on the number of pole-pairs. This system is very common in low cost equipment having squirrel cage motors that are either switched off or run at the speed determined by the number of pole-pairs. The nominal speed cannot be varied. Modifications of this system include squirrel cage motors with two or more sets of windings (pole-change motors) and two motor systems to provide main speed.

2. Torque control system. In this system, the crane operator usually controls one system parameter. Usually, this one system parameter is set for the value of the rotor resistors. This information also includes the direction of the movement. Consequently, the motor generates a required torque to move the load. The actual speed attained depends on a combination of load and motor torque.

3. Speed control system. In this system, the crane operator gives a speed reference value. This speed reference value is normally a voltage, whose polarity indicates direction of the movement. The control unit adjusts the actual speed requested by using the feedback given by a tachometer or a similar device and then modifying the system parameters so that the equilibrium between the required and the actual speed is reached and kept.

The construction of the speed control system depends on the motor type.

3.4 How we can control of Induction motors:

1. Stator voltage control.
2. Rotor voltage control.
3. Stator voltage and frequency control.
4. Frequency control.
5. Stator current control.
6. Voltage, current and frequency control.

Although all of the above strategies are used in cranes, the most common strategies are the stator voltage control, the rotor voltage control, and the stator voltage and frequency control. The aforementioned classification of the strategies is purely theoretical from the crane maker's point of view. The rotor voltage control is in practice a rotor resistance control.

3.5 Characteristics of Induction Motors

Some of the important characteristics of induction motors are:

I) For the same slip, the torque varies as the square of the terminal voltage;
II) The slip is proportional to the load, and since the slip varies over a small range only, the speed of an induction motor is more or less constant with load;
III) The torque varies directly with the slip;
IV) The slip varies inversely as the square of the terminal voltage; and
V) The efficiency of an induction motor is inversely proportional to slip.

A motor with a lower value of slip will be more efficient than a motor with a higher slip because of the increased losses in the rotor of the latter. The efficiency of three phase induction motors varies with type, size and load. It ranges from 85% to 99% in the case of squirrel cage motors above 5 HP. It is about 75% for smaller motors. The efficiency is less in the case of slip-ring motors, slow speed motors and motors running at part load.

The advantages of an AC induction motor are as follows:

- Simple design.
- Rugged construction.
- Reliable operation.
- Low initial cost.
- Easy operation and maintenance.
- Simple control gear for starting and speed control.
- High efficiency.

3.5.1 Construction of Induction Motors

Broadly there are two types of three-phase induction motors:

- Squirrel-cage induction motor; and
- Wound-rotor or slip-ring induction motor.

Each of these two types of three phase induction motors consist of:

- The Stator.
- The Rotor.

3.5.2 Equivalent Circuit of an Induction motor:

The exact equivalent circuit model of an Induction motor is

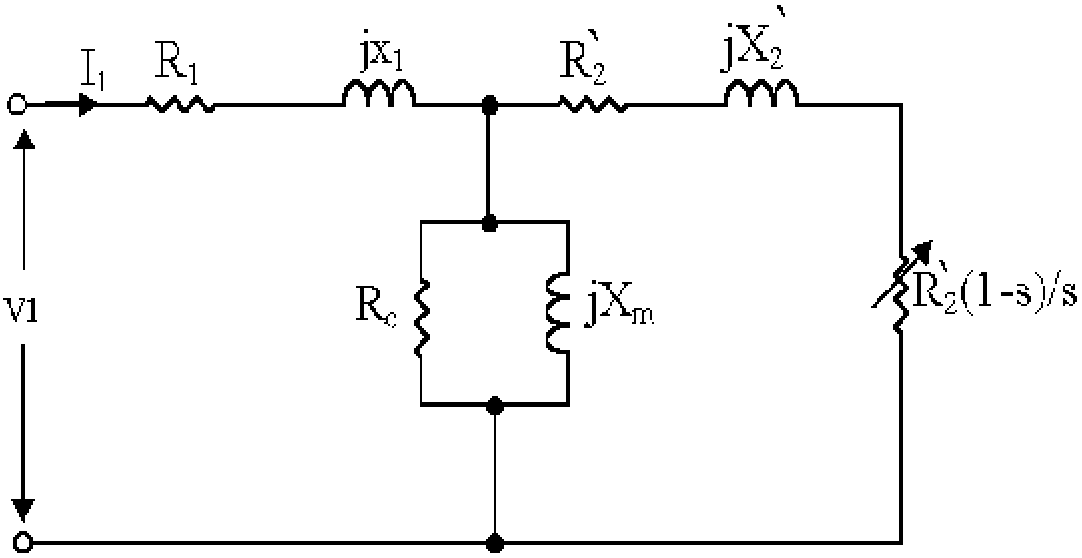


fig.3.1 Equivalent Circuit of an Induction motor

Where:

R1: is the stator resistance per phase.

X1: is the stator reactance per phase.

R2’: is the equivalent rotor resistance referred to stator per phase.

X2’: is the equivalent rotor reactance referred to stator per phase.

Rc: is the resistance representing core losses.

Xm: is the magnetizing reactance per phase .

V1: is the per phase supply voltage to the stator s is the slip of the motor.

S: is the slip of the motor

3.5.3 **Power flow in an Induction motor** :

$$P_g = 3 \times I_2'^2 \times [R_2' + R_2' \times (1-s)/s] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

The equation can be split into two part as follows-

$$P_g = 3 \times I_2'^2 \times R_2' + 3 \times I_2'^2 \times R_2' \times (1-s)/s \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Such that $P_g = P_{rc} + P_m$ ……………………………………… ………. (3.3)

$$\text{such that } P_g = P_{rc} + P_m \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

and $$P_m = 3 \times I_2'^2 \times R_2' \times (1-s)/s \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

from the equivalent circuit can be see that the equivalent resistance $R_2^1(1-s)/s$ is variable resistance and is equivalent to the mechanical power developed thus the part P_m corresponds to the mechanical power developed to meet the load .

From the circuit, we see that the total power input to the rotor P_g is

The power flow diagram is-

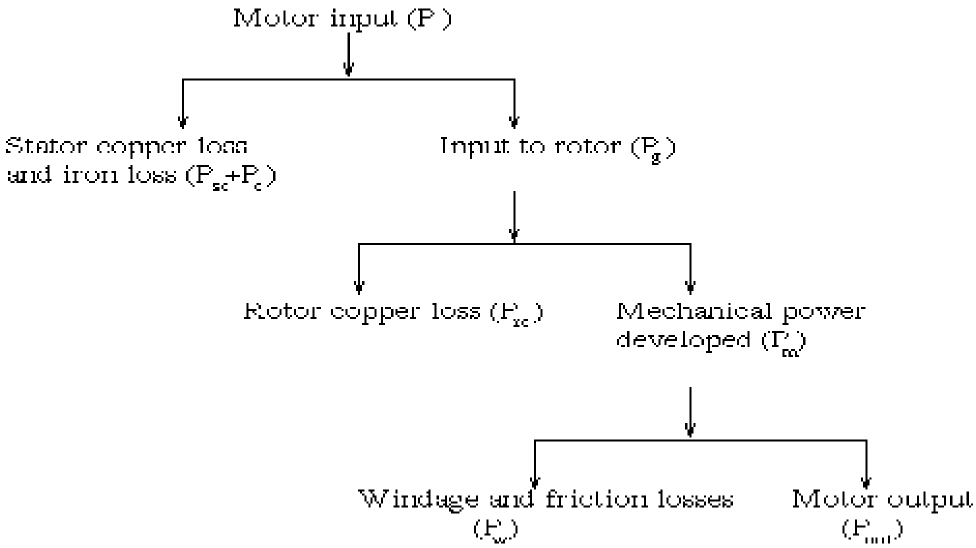


fig3.2 The power flow diagram

3.5.4 Soft Starters for Induction Motors:

Definition:

A soft starter is another form of reduced voltage starter for A.C. induction motors. The soft starter is similar to a primary resistance or primary reactance starter in that it is in series with the supply to the motor. The current into the starter equals the current out. The soft starter employs solid state devices to control the current flow and therefore the voltage applied to the motor. In theory, soft starters can be connected in series with the line voltage applied to the motor, or can be connected inside the delta loop of a delta connected motor, controlling the voltage applied to each winding.

The starting current of an AC motor can vary from 3 to 7 times the nominal current.

This is because a large amount of energy is required to magnetize the motor enough to overcome the inertia the system has at standstill. The high current drawn from the network can cause problems such as voltage drop, high transients and, in some cases, uncontrolled shutdown. High starting current also causes great mechanical stress on the motor's rotor bars and windings, and can affect the driven equipment and the Foundations. Several starting methods exist, all aiming to reduce these stresses.

The load, the motor and the supply network determine the most appropriate starting Method. When selecting and dimensioning the starting equipment and any protective

Devices, the following factors must be taken into account:

- The voltage drop in the supply network when starting the motor
- The required load torque during start
- The required starting time

3.5.5 How does a motor start in the first place?

Motors convert electrical energy drawn from the power supply into a mechanical form, usually as a shaft rotating at a speed fixed by the frequency of the supply. The power available from the shaft is equal to the torque (moment) multiplied by the shaft speed (rpm). From an initial value at standstill, the torque alters, up or down, as the machine accelerates, reaching a peak at about two-thirds full speed, finally to become zero at synchronous speed. This characteristic means that induction motors always run at slightly less than synchronous speed in order to develop power the 'slip speed' and, hence the term asynchronous. The (fig) below, which shows an induction motor torque/speed curve, illustrates this most important characteristic.

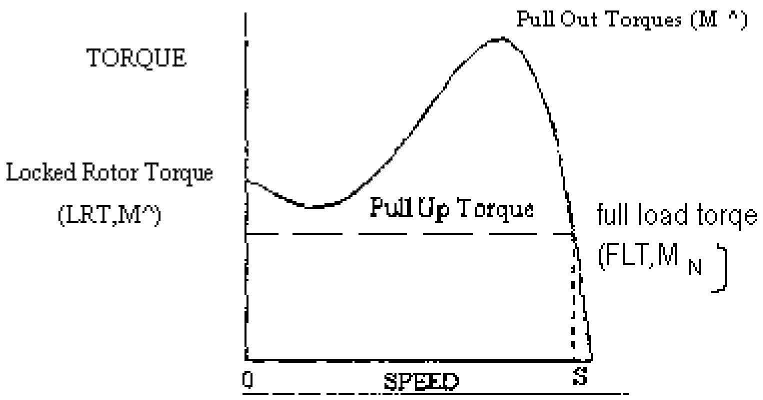


fig3.3 Induction motor torque/speed curve

3.6 Braking of induction motor:

Braking occurs by the methods:

3.6.1 Regenerative braking

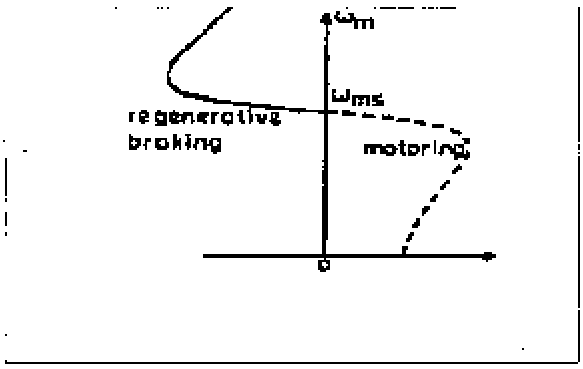


fig3.4 Regenerative braking

When regenerative braking is employed for holding motor-speed against an active load, stable operation is generally possible between synchronous speed and the speed for which braking torque is maximum.

Main advantage of regenerative braking is that generated power is usefully employed and main drawback being that when fed from a constant frequency source, it cannot be employed below synchronous speed.

3.6.2 Plugging or reverse voltage braking

In this method, mechanical energy supplied to the rotor, either by active load or form kinetic energy stored in motor and load inertia, is covered into electrical energy and wasted in rotor resistance.

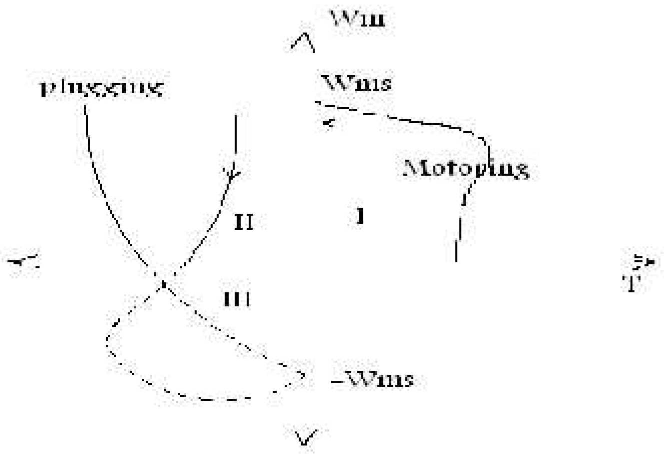


fig3.5 Plugging or reverse voltage braking

3.6.3 Dynamic braking:

ac dynamic braking is obtained when the motor is run on a single phase supply by disconnecting one phase from the source and either leaving it open as in last fig. (b) or connecting it with another machine phase as in the last fig (c) . the two connection of the last fig. in (b)&(c) are respectively known as two and three lead connections.

When connected to a 1-phase supply, the motor can be considered to be fed by positive and negative sequence three phase set of voltage. Net torque produced by the machine is sum of torques due to positive and negative sequence voltages. When rotor has a high resistance, the net torque is negative and braking operation is obtained.

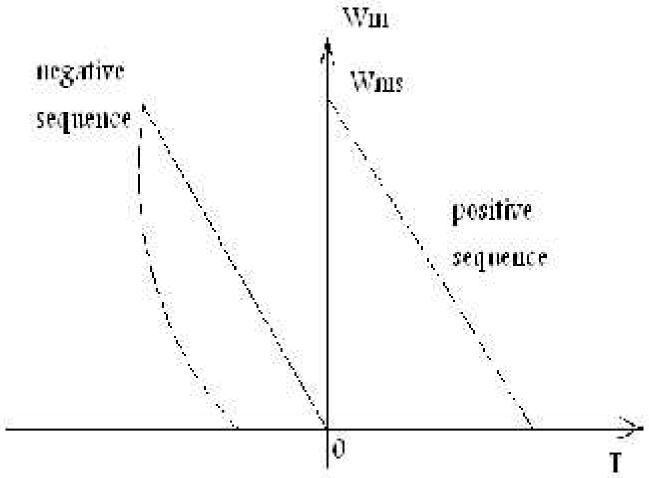


Fig3.6 Dynamic braking

3.7 Power electronics circuits:

That has two circuits

1. Triggering circuit.

This circuit to give trigger to triac in the power circuit.

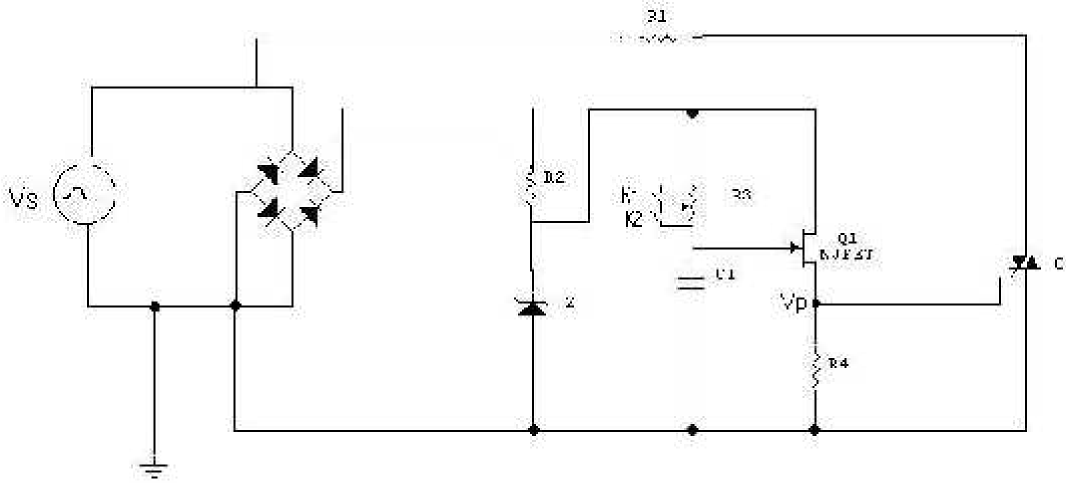


fig3.7 triggering circuit

2. Power circuit.

It’s take the trigger pulses to operate the triac.

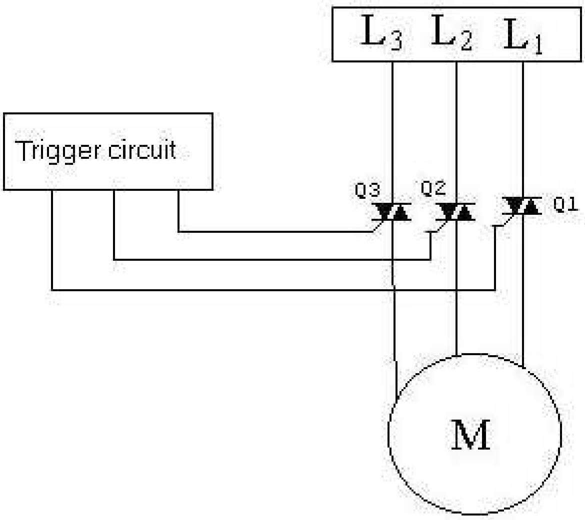


fig3.8power circuit

3.8 Power calculates of the motor In hoisting:

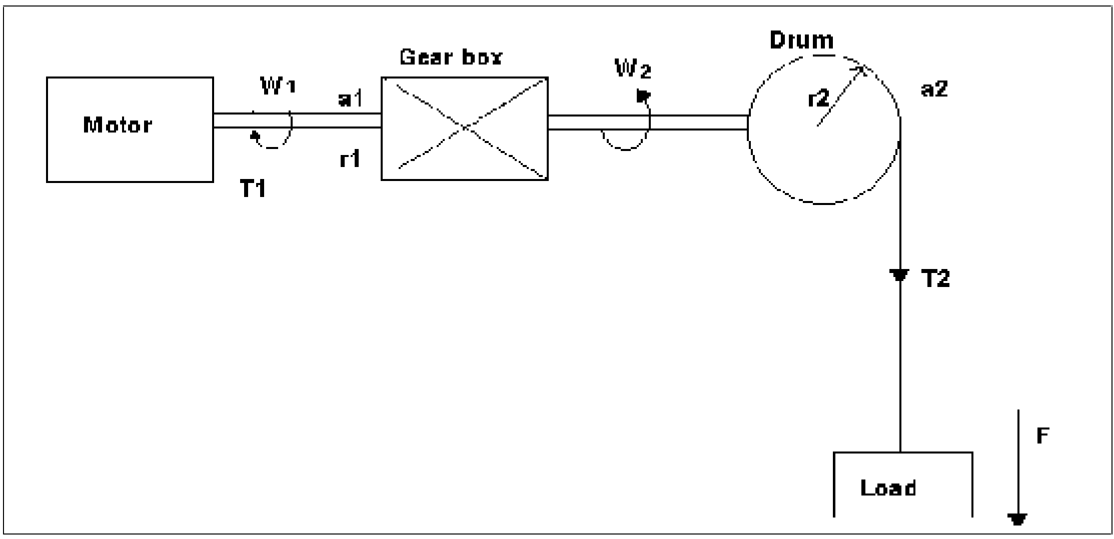


fig3.7 motor In hoisting

3.9 power analysis:

3.9.1 Analysis of the required power of the lifting motor:

The power requirement of the motor to safety carry the loads be found by using the maximum torque theory, using the following equation

$$\mathbf{T1 \times \omega1 = T2 \times \omega2} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3.6)$$

Where:

T1: Torque of motor, N.m.

ω1: Angular velocity of the motor, rad/s.

T2: Torque produced from the loads, N.m.

ω2: Angular velocity of lifting wheel, rad/s.

The torque produced from the loads can be found using the following equation:

$$\mathbf{T2 = N \times F \times r} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3.7)$$

Where:

N: Factor of safety corresponding dynamic loads.

F: Force produced by loads, N.

r: Radius of the lifting wheel, m

3.9.2 Analysis of the power required for bridge movement:

After selecting the dimensions of the train for bridge in this section we will cheek weather the selection satisfies the power requirement for moving the bridge, that is, If the reduction train suggested can move the crane when it is fully loaded.

The power requirement for the bridge movement can be represented by the following equation:

$$\mathbf{P= (F \times v) \div (1000 \times \eta)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.8)}$$

Where:

P: Power required, Kw.

F: Resistance force resulting from loads, N.

V: Lifting speed, m/s.

η: Efficiency of drives belts.

$$\mathbf{F= (W_0 + W1) \times g \times B \times ((f \times d + 2 \times k) / D)} \quad \ldots\ldots\ldots\ldots\ldots \text{(3.9)}$$

Where:

F: Resistance force resulting from friction, N.

W0: Weight of the crane, Kg.

W1: Maximum weight lifted, Kg.

G: Standard acceleration of gravity, m/s2.

B: Correction factor for the friction between wheels and the path.

f.: Friction factor for the bearings. Diameter of shaft, mm.

K: Rolling correction factor.

D: Diameter of wheel, mm.

3.9.3 Analysis of the power required for trolley movement:

The power required to move the trolley when fully loaded is found by:

$$\mathbf{P= (F \times v) \div (1000 \times \eta)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(9.10)}$$

Where:

P: Power required, Kw.

F: Resistance force resulting from loads, N.

V: Lifting speed, m/s.

η: Efficiency of drives belts.

$$F=(W_o + W_1) \times g \times B \times ((f \times d + 2 \times k) / D) \quad (3.11)$$

Where:

F: Resistance force resulting from friction, N.

W0: Weight of the trolley, Kg.

W1: Maximum weight lifted, Kg.

G: Standard acceleration of gravity, m/s2.

B: Correction factor for the friction between wheels and the path.

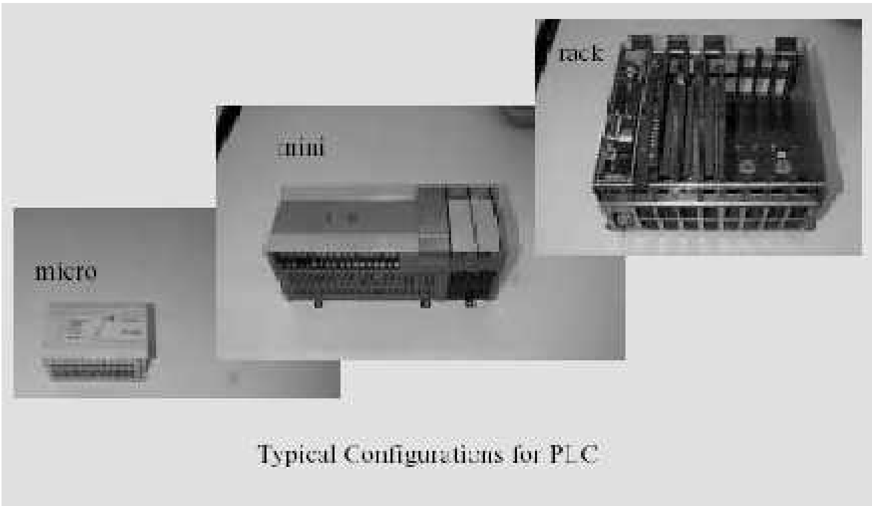
f.: Friction factor for the bearings. Diameter of shaft, mm.

K: Rolling correction factor.

D: Diameter of wheel, mm.

Chapter 4

Programmable Logic Controller (PLC)



4.1 the (PLC) devices

4.1 Introduction:

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 pie 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 pie.

4.2 PLC History:

Control engineering has evolved over time. In the past humans were the main method for controlling a system. More recently electricity has been used for control and early electrical control was based on relays. These relays allow power to be switched on and off without a mechanical switch. It is common to use relays to make simple logical control decisions. The development of low cost computer has brought the most recent revolution, the Programmable Logic Controller (PLC). The advent of the PLC began in the 1970s, and has become the most common choice for manufacturing controls.

PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come. Most of this is because of the advantages they offer.

- Cost effective for controlling complex systems.
- Flexible and can be reapplied to control other systems quickly and easily.
- Computational abilities allow more sophisticated control.
- Trouble shooting aids make programming easier and reduce downtime.
- Reliable components make these likely to operate for years before failure.

4.3 The main parts of (PLC) and there functions:

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.
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.
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.
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 Is.
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.
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.

4.4 The (PLC) devices:

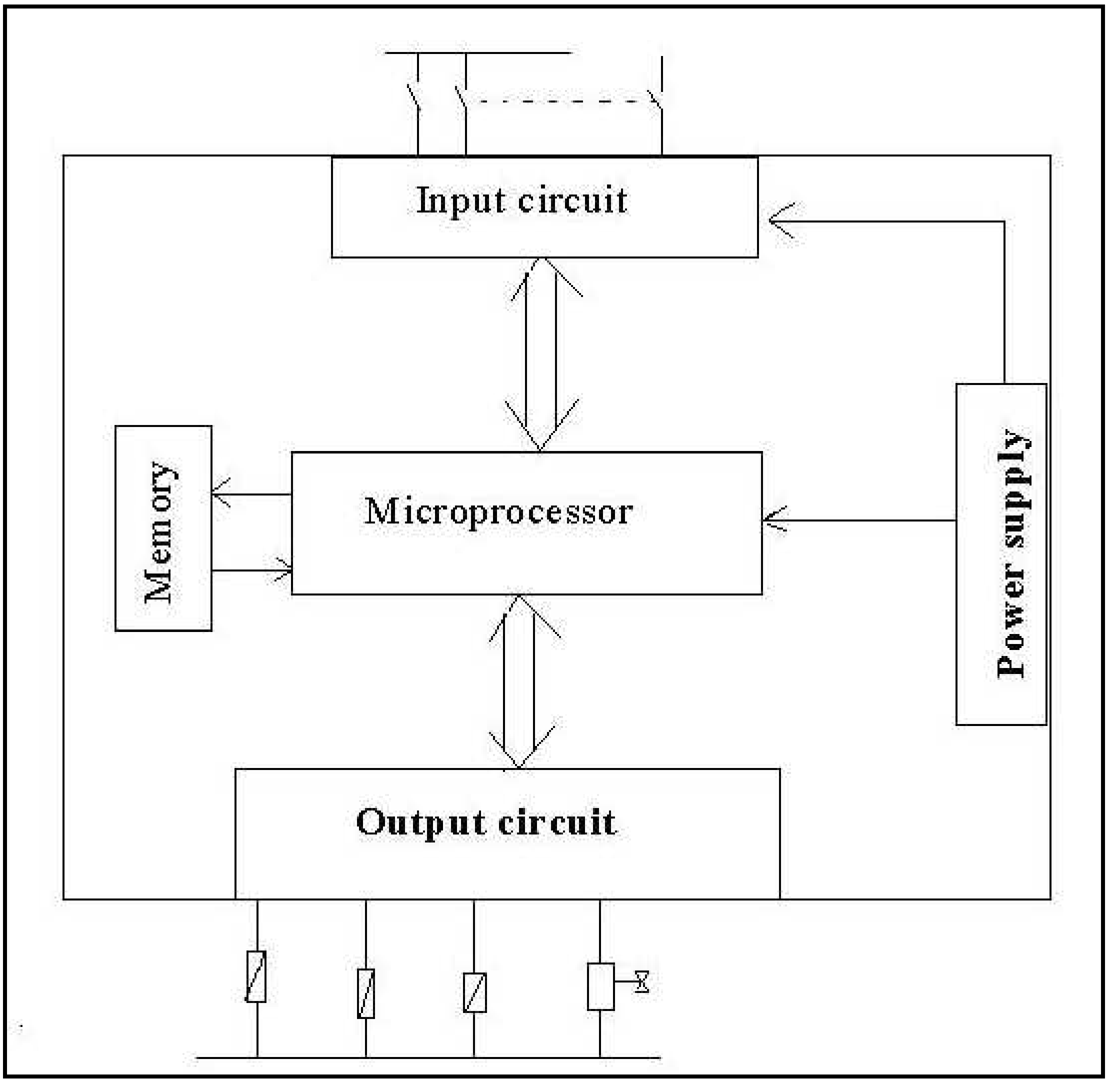


fig 4.2 The (PLC) devices

4.4.1 Microprocessor devices:

For simple programming the relay model of the PLC is sufficient. As more complex functions are used the more complex VonNeuman model of the PLC must be used. A VonNeuman computer processes one instruction at a time. Most computers operate this way, although they appear to be doing many things at once. Consider the computer components shown last block diagram:

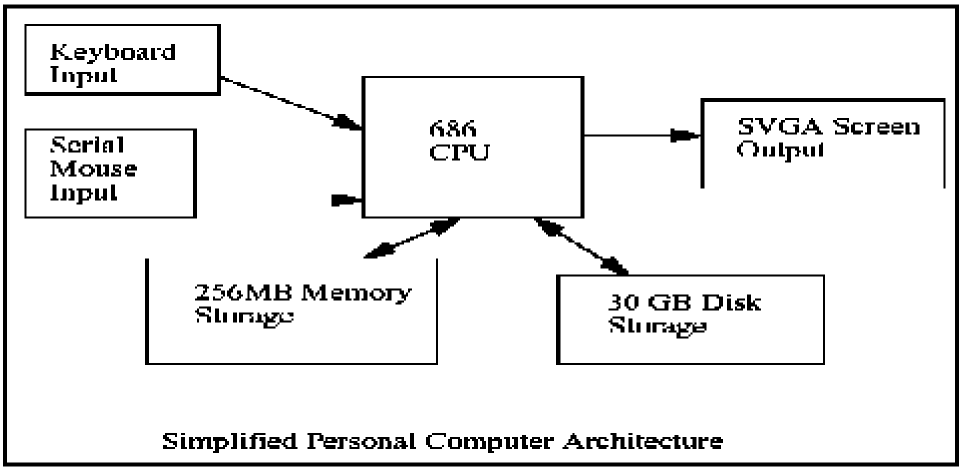


fig4.3 Simplified Personal Computer Architecture

Input is obtained from the keyboard and mouse, output is sent to the screen, and the disk and memory are used for both input and output for storage. (Note: the directions of these arrows are very important to engineers, always pay attention to indicate where information is flowing.) This figure can be redrawn as fig.(4.3) clarify the role of inputs and outputs.

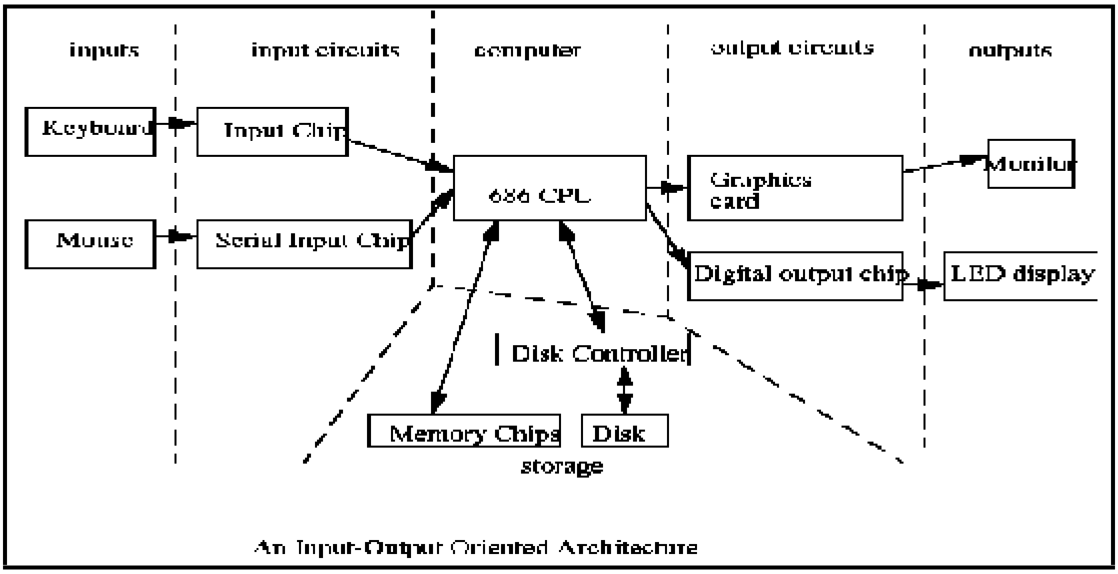


fig4.4 An input-output oriented architecture

In the figure(4.4) the data enters the left side through the inputs. (Note: most engineering diagrams have inputs on the left and outputs on the right.) It travels through buffering circuits before it enters the CPU. The CPU outputs data through other circuits. Memory and disks are used for storage of data that is not destined for output. If we look at a personal computer as a controller, it is controlling the user by outputting stimuli on the screen, and inputting responses from the mouse and the keyboard.

A PLC is also a computer controlling a process. When fully integrated into an application the analogies become; Inputs - the keyboard is analogous to a proximity switch Input circuits - the serial input chip is like a 24Vdc input card Computer - the 686 CPU is like a PLC CPU unit Output circuits - a graphics card is like a triac output card Outputs - a monitor is like a light Storage - memory in PLCs is similar to memories in personal computers It is also possible to implement a PLC using a normal Personal Computer, although this is not advisable. In the case of a PLC the inputs and outputs are designed to be more reliable and rugged for harsh production environments.

4.4.2 Input and Out put of PLC device:

Inputs to, and outputs from, a PLC are necessary to monitor and control a process. Both inputs and outputs can be categorized into two basic types:

- Logical.
- Continuous.

4.4.2.1 Input devices:

In smaller PLCs the inputs are normally built in and are specified when purchasing the PLC. For larger PLCs the inputs are purchased as modules, or cards, with 8 or 16 inputs of the same type on each card. For discussion purposes we will discuss all inputs as if they have been purchased as cards. The list below shows typical ranges for input voltages, and is roughly in order of popularity.

1. 12-24 Vdc
2. 100-120 Vac
3. 10-60 Vdc
4. 12-24 Vac/dc
5. 5 Vdc (TTL)
6. 200-240 Vac
7. 48 Vdc
8. 24 Vac

PLC input cards rarely supply power, this means that an external power supply is needed to supply power for the inputs and sensors. The next Figure is shows how to connect an AC input card.

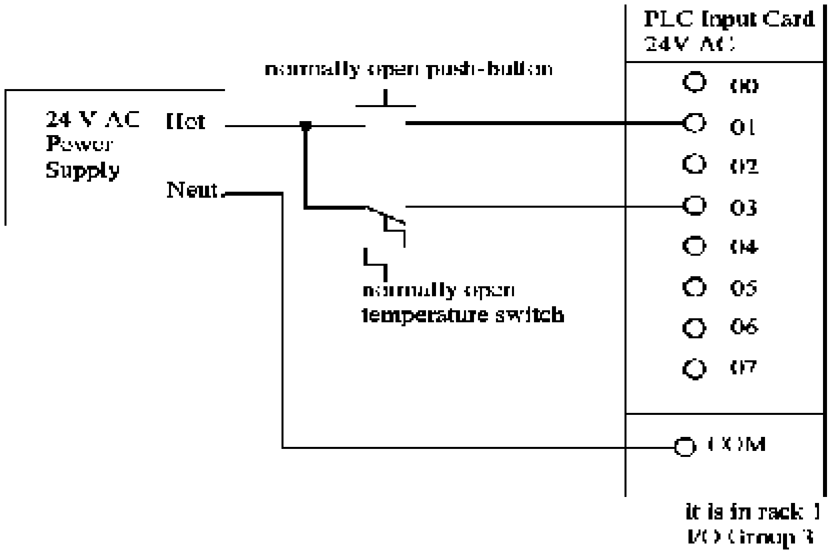


fig4.5 input devices

In the last fig. there are two inputs, one is a normally open push button, and the second is a temperature switch, or thermal relay. Both of the switches are powered by the hot output of the 24Vac power supply - this is like the positive terminal on a DC supply. Power is supplied to the left side of both of the switches. When the switches are open there is no voltage passed to the input card. If either of the switches is closed power will be supplied to the input card. In this case inputs 1 and 3 are used - notice that the inputs start at 0.

The input card compares these voltages to the common. If the input voltage is within a given tolerance range the inputs will switch on. Ladder logic is shown in the figure for the inputs.

Here it uses Allen Bradley notation for PLC-5 racks. At the top is the location of the input card I: 013 which indicate that the card is an Input card in rack 01 in slot 3. The input number on the card is shown below the contact as 01 and 03.

Many beginners become confused about where connections are needed in the circuit above. The key word to remember is circuit, which means that there is a full loop that the voltage must be able to follow. In the last Figure we can start following the circuit (loop) at the power supply. The path goes through the switches, through the input card, and back to the power supply where it flows back through to the start. In a full PLC implementation there will be many circuits that must each be complete.

A second important concept is the common. Here the neutral on the power supply is the common, or reference voltage. In effect we have chosen this to be our 0V reference, and all other voltages are measured relative to it. If we had a second power supply, we would also need to connect the neutral so that both neutrals would be connected to the same common. Often common and ground will be confused. The common is a reference, or datum voltage that is used for 0V, but the ground is used to prevent shocks and damage to equipment. The ground is connected under a building to a metal pipe or grid in the ground. This is connected to the electrical system of a building, to the power outlets, where the metal cases of electrical equipment are connected. When power flows through the ground it is bad. Unfortunately many engineers and manufacturers mix up ground and common. It is very common to find a power supply with the ground and common mislabeled.

One final concept that tends to trap beginners is that each input card is isolated.

This means that if you have connected a common to only one card, then the other cards are not connected. When this happens the other cards will not work properly. You must connect a common for each of the output cards.

There are many trade-offs when deciding which type of input cards to use.

- DC voltages are usually lower and therefore safer (i.e., 12-24V).
- DC inputs are very fast, AC inputs require a longer on-time. For example, a 60Hz wave may require up to 1/60sec for reasonable recognition.
- DC voltages can be connected to larger variety of electrical systems.
- AC signals are more immune to noise than DC, so they are suited to long distances, and noisy (magnetic) environments.
- AC power is easier and less expensive to supply to equipment.

- AC signals are very common in many existing automation devices.

4.4.2.2 Output devices:

As with input modules, output modules rarely supply any power, but instead act as switches. External power supplies are connected to the output card and the card will switch the power on or off for each output. Typical output voltages are listed below, and roughly ordered by popularity.

- 120 Vac
- 24 Vdc
- 12-48 Vac
- 12-48 Vdc
- 5Vdc (TTL)
- 230 Vac

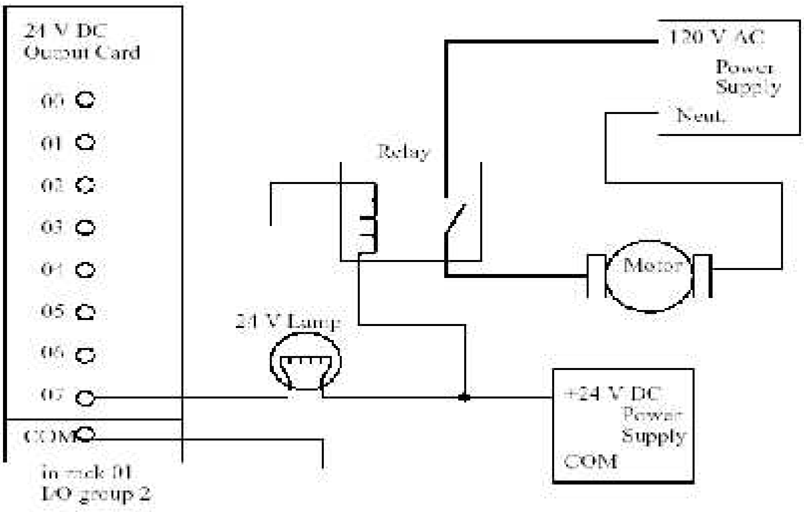


fig 4.6 Output devices

These cards typically have 8 to 16 outputs of the same type and can be purchased with different current ratings. A common choice when purchasing output cards is relays, transistors or triacs. Relays are the most flexible output devices. They are capable of switching both AC and DC outputs. But, they are slower (about 10ms switching is typical), they are bulkier, they cost more, and they will wear out after millions of cycles. Relay outputs are often called dry contacts. Transistors are limited to DC outputs, and Triacs are limited to AC outputs. Transistor and triac outputs are called switched outputs.

1- Dry contacts - a separate relay is dedicated to each output. This allows mixed voltages (AC or DC and voltage levels up to the maximum), as well as isolated outputs to protect other outputs and the PLC. Response times are often greater than 10ms. This method is the least sensitive to voltage variations and spikes.

2 - Switched outputs - a voltage is supplied to the PLC card, and the card switches it to different outputs using solid state circuitry (transistors, triacs, etc.) Triacs are well suited to AC devices requiring less than 1A. Transistor outputs use NPN or PNP transistors up to 1A typically. Their response time is well under 1ms.

Accidentally connected to a DC transistor output it will only be on for the positive half of the cycle, and appear to be working with a diminished voltage. If DC is connected to an AC triac output it will turn on and appear to work, but you will not be able to turn it off without turning off the entire PLC.

4.5 Programming:

After definition the program logic control (PLC) and who it is programmable, and what is the software and the hardware of the PLC, now we can write the program, which is, describe the crane work.

Table of PLC program:

Table here is describing the input and the output of the PLC.

table 4.1 of describe the input and the output of the PLC

Tools	Condition	Works	Symbols
F0	Nc	Over load m1	I0.0
F1	Nc	Over load m2	I0.1
F2	Nc	Over load m3	10.2
F3	Nc	Over load m4	I2.4
Em	Nc	Emergency	I0.3
S0	No	Stop	I0.4
S1	No	Start	I0.5
S2	No	Quickly	I0.6
S3	No	Slow	I0.7
S4	No	Lifting up	I1.0
S5	No	Down	I1.1
S6	No	Left	I1.2
S7	No	Right	I1.3
S8	No	Forward	I1.4
S9	No	Backward	I1.5
L1	NO	Max right	I1.6

L2	NO	Max lift	I1.7
L3	NO	Max Forward	I2.0
L4	NO	Max Backward	I2.1
L5	NO	Max up	I2.2
L6	NO	Max down	I2.3
K1	---	Quickly	Q3.0
K2	---	Slow	Q3.1
K3	---	Lifting up	Q3.2
K4	---	Down	Q3.3
K5	---	Left	Q3.4
K6	---	Right	Q3.5
K7	---	Forward	Q3.6
K8	---	Backward	Q3.7

Programming:

The PLC need program in hardware to control to machine , the program is saved in the memory of the PLC box ,the program her is control the work of the crane by changing the input to give the output . the program is by (STL) programming

Program:

```
A I0.0
A I0.1
A I0.2
AI2.4
A I0.3
A I0.4
A I0.5
```

S F0.0

AN I0.0

AN I0.1

AN I0.2

AN I0.3

AN I0.4

R F0.0

.... **Quickly**

A F0.0

A I0.6

S Q2.0

AN F0.0

A I0.7

R Q3.0

.... **Slow**

A F0.0

A I0.7

S Q2.1

A NF0.0

A I0.6

R Q3.1

.... **Lifting up**

A F0.0

A I1.0

ANI2.2

AN Q2.3

= Q3.2

.... **Down**

A F0.0

A I1.1

ANI2.3

AN Q2.2

= Q3.3

Left

A F0.0

A I1.2

ANI1.7

AN Q2.5

= Q3.4

Right

A F0.0

A I1.3

ANI1.6

AN Q2.4

= Q3.5

Forward

A F0.0

A I1.4

ANI2.0

AN Q2.7

= Q3.6

Backward

A F0.0

A I1.5

ANI2.1

AN Q2.6

= Q3.7

4.5.3 The (PLC) Connection:

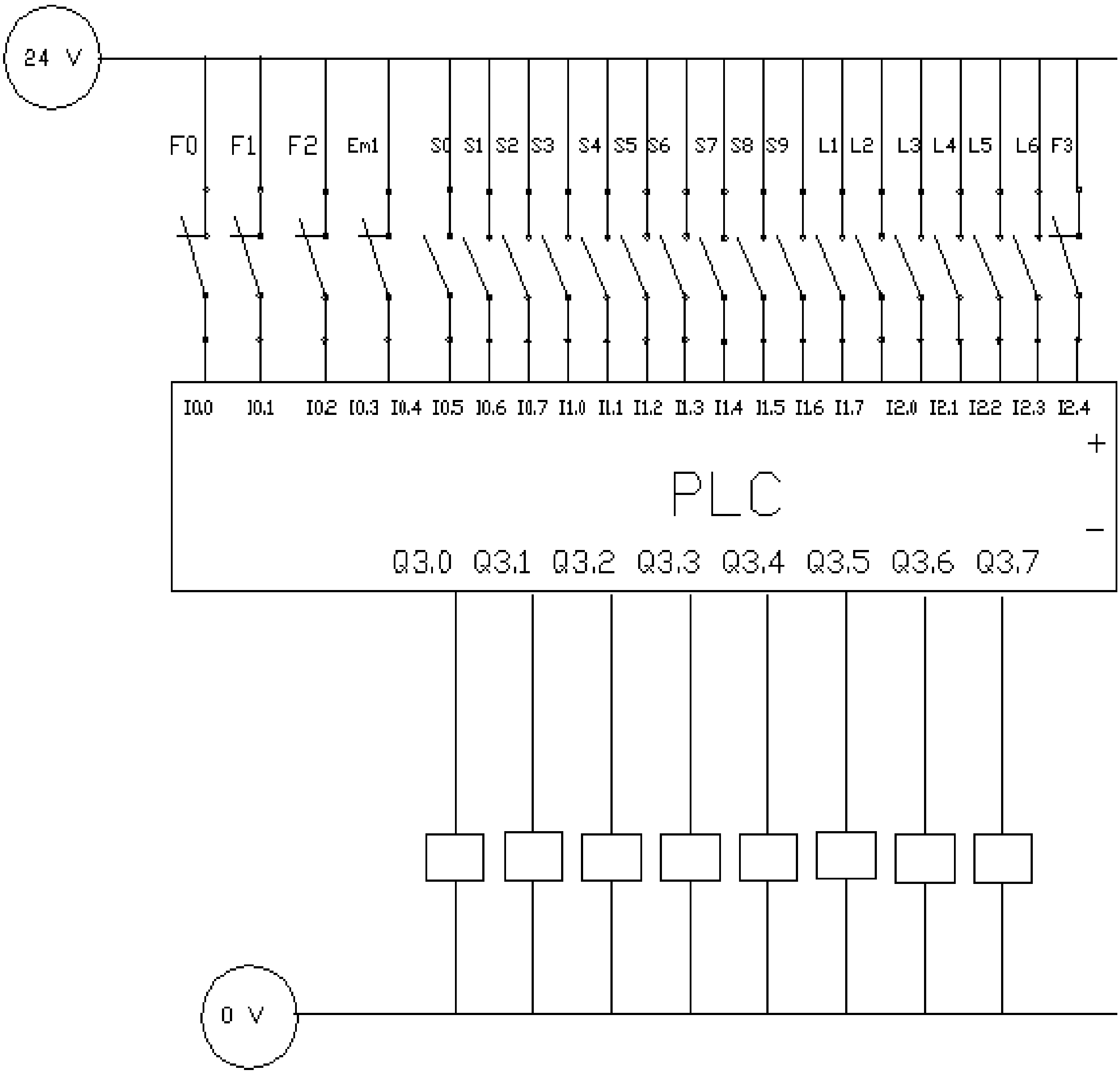


fig4.7 The (PLC) Connection

Chapter 5

Remote Control

5.1 Introduction:

Nowadays, it is common practice in industrial environments to use remote control equipment to operate load-lifting machinery. The advantages that the use of this equipment offers are as follows:

• Increased productivity: as the cranes are no longer operated from the cabin but rather from the surrounding area, the operator is also able to hook up and unhook the load.

• Maneuverability is improved, particularly high precision maneuvers as the operator is no longer obliged to remain in the cabin and becomes free to position himself in the best possible vantage point. In addition, the operator no longer depends on a second person to signal him, which sometimes leads to confusion.

• Safety and work conditions are improved for the crane operator as he can choose the safest and most convenient spot from which to work, away from dangerous areas and unpleasant environmental conditions, (heat, smoke, noise, etc...).

The choice of remote control equipment will depend on the nature of the machine maneuvers to be carried out. Similarly, the receiver will need to have a certain number of outputs to control the machine properly, receivers with from 6 to 60 relays are available as well as up to 6 analog outputs. With these characteristics it is possible to cover all imaginable requirements .The transmitter will depend on the type of electric control used by the crane and falls into two categories: Pendant controller and cabins.

5.2 Pendant Controllers:

The configuration of the remote control transmitter for overhead cranes is quite similar to the pendant controller it is replacing. The commands are dual effect buttons, which enable the control of maneuvers at up to two speeds. The buttons have been designed in such a way that other types of commands, such as spring-return and maintained 1-0-1 toggle switches or rotary switches can easily substitute them. These offers great flexibility in the configuration of our equipment so it may be adapted to all kinds of machinery .All equipment comes fitted with an emergency stop button.

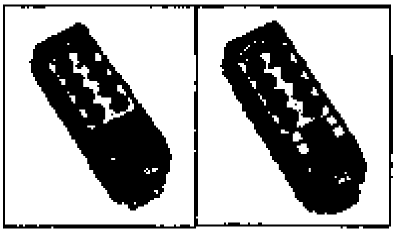


Fig.5.1: Pendent Controller

5.3 Cabins controllers :

For cabin cranes, multi-step joysticks are used to control the main maneuvers. The remote control equipment for this type of crane is a portable console with small joysticks similar to those found in the crane cabin .The joysticks use optical reading, which offers optimum reliability, as they do not have electrical contacts. In addition, this enables the simultaneous control of two maneuvers at up to 5 different speed steps or steeples .As well as the optical joy sticks and emergency stop button, the transmitters may come with other control fittings for other functions such as the selection of trolley or hook, crab, magnets, over-riding limit switches, lights, horns etc.

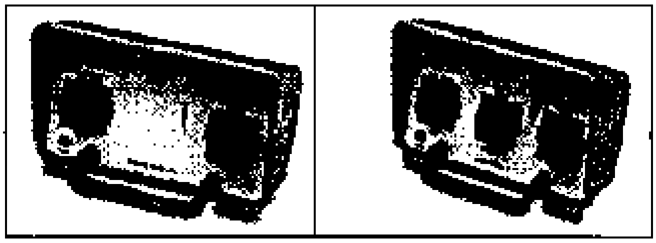


Fig.5.2: Cabins

5.4 Types Of Remote Control:

5.4.1 Radio Remote Control:

Radio remote control for cranes and other equipment eliminates the need to rely on crane (or locomotive, etc.) cab control and pendant control as the only means of operation. The addition of radio remote controls allows you to convert from a two-person operation to a single-Person operation, since you no longer need that extra person providing hand signals at ground level. (Occasionally you convert from a three-person to a two-person operation but the effect is the same in terms of saving one person's labor.).

Load positioning and damage control are improved too, because a radio operator can better judge crane load or rail car clearance. Placing the operator on the floor avoids the health hazards of high humidity, vapors, smoke, radiation, high voltage, etc.

With radio control, one person can control several cranes or other material handling vehicles, one at a time, from a single transmit. Maintenance is simple and can be handled by your in-plant personnel. A pendant control forces the operator to walk with the load, which often translates as running an obstacle course. As well, the swinging pendant is clumsy and a hazard in its own right. Radio control eliminates these problems. Radio controls have available options to provide adjustable controlled range (typically 75 to 100 feet), with the crane automatically stopping or not being able to start when the operator can no longer safely see the load. In the case of signal failure, all motion comes to a safe stop. Magnets and vacuum lifts, for example, retain their last commanded state with the option of latching circuits.

To move a crane, for example, the operator activates a lever or button to send a radio signal, which is picked up by the receiving antenna mounted on the crane. The antenna passes the signal to the receiver unit, also on the crane. This unit transforms the signal into electrical energy and passes it on to the intermediate relay unit on the crane, and the appropriate contact is activated. The operator, from floor level,' can not only control forward, backward and other crane and hoist motions, but also the speed at which things happen. There are optional safeguards to prevent moves that the operator cannot see and to prevent collisions with other equipment.

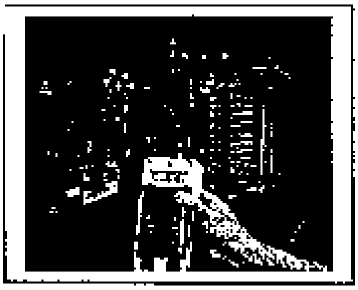


Fig.5.3: Radio Remote Control

5.4.2 Infra Red Remote Control*:*

Problems of pendent for hoist and cable control for machinery have become a thing of the past. Now, the highly cost-effective fail-safe remote control system offers an economical alternative to previous cable-limited controls.

We can forget the inconvenience-and danger-associated with struggling around obstacles with cable control. A crane operator may now move freely in high area, controlling the crane remotely from wherever he chooses. Unrestricted freedom of movement decreases the time to complete the job, benefiting profitability while increasing safety.

The innovative engineering results in:

- Wide range of application.
- 100% fail-safe operation.
- No need for a license.

5.5 The transmitter

The transmitter is designed to transmit 14 universal commands. The individual keys can be linked into function groups via the coding circuit. Depending on the specific application the following mode is available:

- 3 drives each 2 stage (3X2-0-2) & 2 individual function.
- 2 drives each 2 stage (2X2-0-2) & 6 individual function.
- 1 drive, 2 stage.
- 14 individual function.

Labeling of the keyboard may be changed to accommodate specific requirements. Unauthorized use of the transmitter is prevented by mean of an electronic lock for which various switch-on key codes can be reselected.

5.6 The receiver

The receiver is designed for universal applications on a number of operating voltages. Control output is via industrial relays a (415/16A). The electronic circuit and the relays are all on a single PCB, housed in a robust metal case. The infra-red sensor is external and positioned for optimum reception. To extend the range a second infra red sensor can be added.

5.7 Technical data

- Infra-red wavelength: approx. 950 nm.
- Transmission rate: 9,600 bits per second.

- Range: max. 30m (100 feet).
- Transmitter power: 4X1.5V miniature (AA) batteries or 4X1.2 V(AA) NiCades cells.
- Transmitter dimension: 240x70x59 mm.
- Transmitter weight: approx. 480g including battery.
- Protection: IP 54.
- Operating temperature range: -15 deg. Centigrade to +60 deg. Centigrade.
- Receiver relays: Output relays: 415V AC/8A main protection 415V AC/6A (positively driven fail safe relay).
- Receiver dimensions: 110x270x220 mm.
- Receiver power: 48V, 62V, 110V, 220V, 245V 50/60Hz, or 24V DC.

5.8 Transmitter circuit:

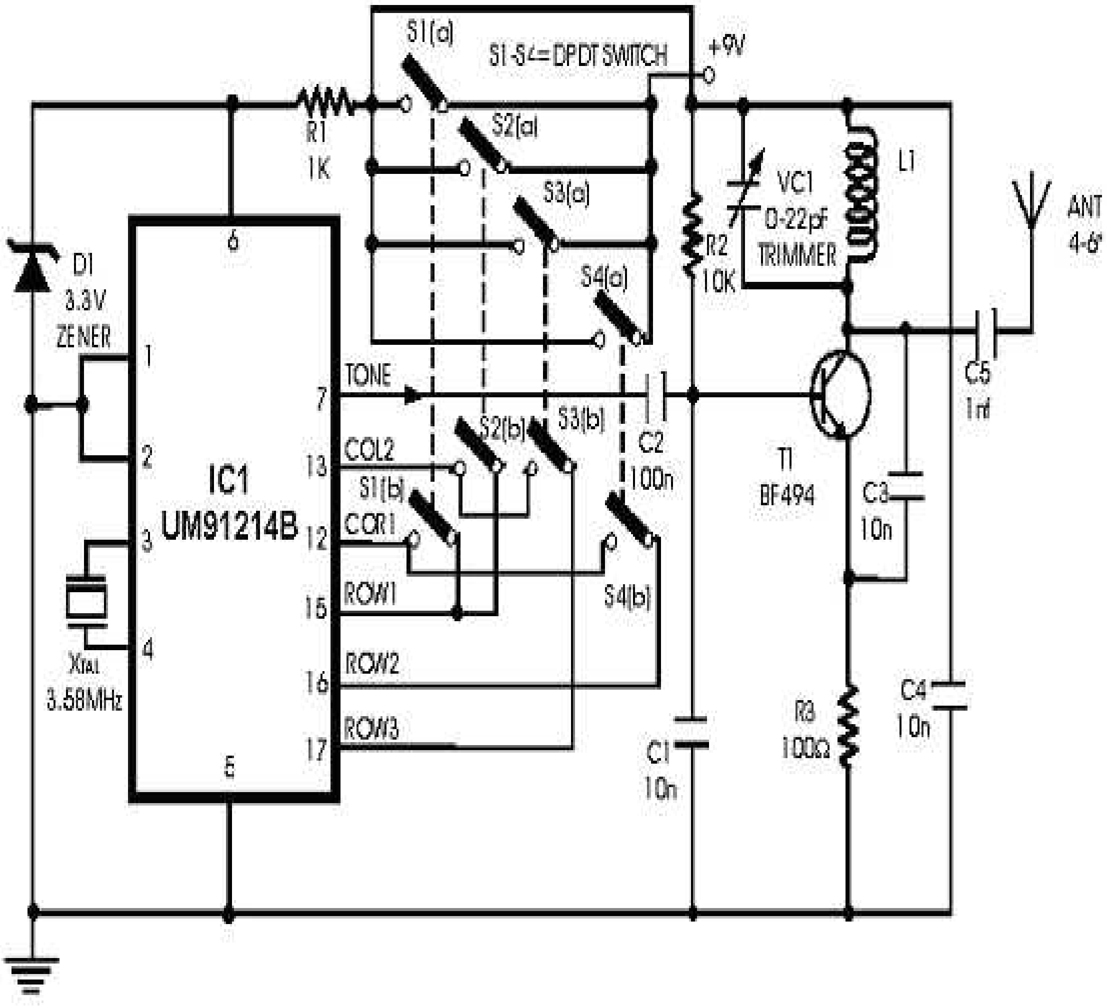


fig5.4 Transmitter circuit

We use two transmitter circuit for our case that inside the remote control.

5.9 The receiver circuit:

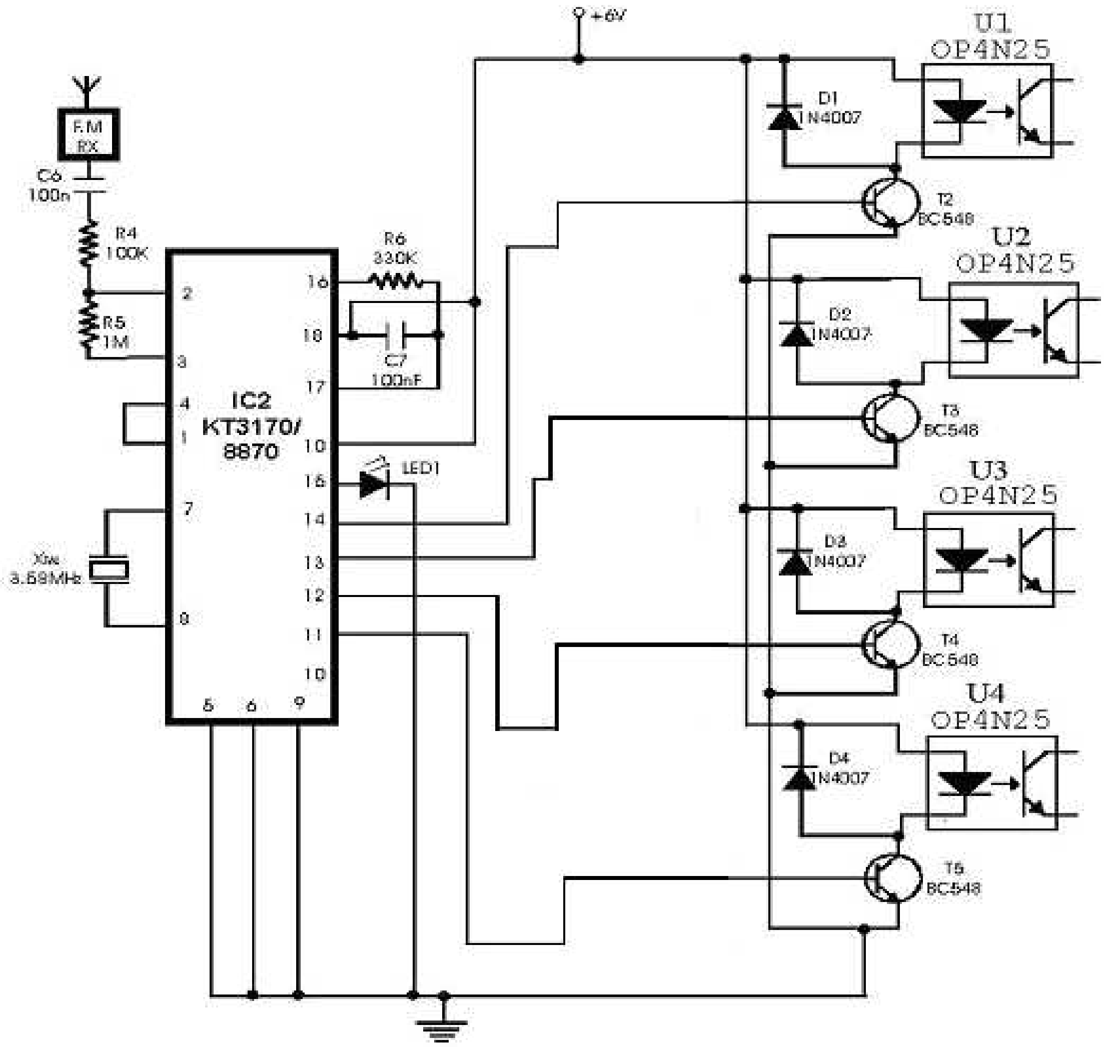


fig 5.5 The receiver circuit:

We use two receiver circuit for our case that inside the receiver block.

Chapter 6

Protection

6.1 Definition

What is electrical protection?

Electrical protection it is the protect the electrical system from dangerous that happened from fault in the electrical system. From that the electrical protection not prevent occur the electrical fault but it is prevent the dangerous which is damage the system.

So the electrical protection is the science solve the electrical fault an the effect of it with small speed to make continuity in the system.

6.2 Requirements of the electrical protection system:

1. Reliability: it must operate in unnatural condition.
2. Speed :the time of the operate must less than or equal three Cycles.
4. Selectivity: it must keep the continuity of the power with less Number times of cutting the current.
4. Simplicity and economy.

6.3 Protection against over current:

An over current is the current grater than the rated current of the circuit it may occur in tow ways:

1. As an overload current.
2. As short-circuit of fault current**.**

These conditions need to be protecting against in order to avoid damage to circuit conductors and equipment. In practice, fuses and circuit breakers will fulfil both is this needs.

6.4 Overload:

Overheads are over current occurring in healthy circuit they may be caused, for example, and faulty appliances or by surges due to motors starting.

The current that we limit the overload is equal or less of the max. Full load current.

6.5 Short circuit:

A short circuit current that will flow when a" dead short " occurs between life conductors (phase to neutral for single phase; phase to phase for three phase). Prospective short circuit current is the same,, But the term is usually used to signify the value of short circuit at fuse or circuit breaker position.

6.6 fuse and circuit breaker:

fuse in the weak link in a circuit which will break when too much current flows, those protecting the circuit conductors from damage. There are many different types and sizes of fuse, all designed to perform a cretin function .

6.6.1 There conditions of select the fuse:

1. Construction and dimension wire of fuse.
2. The operation current and voltage.
3. Porcelain housing of the fuse.

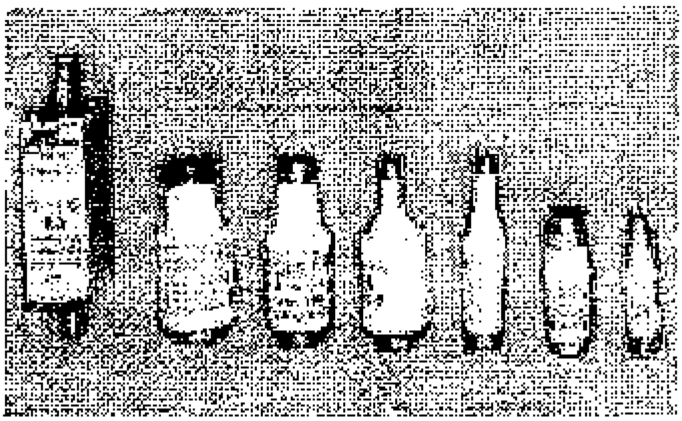


fig 6.1 shape of fuses

6.6.2 Type fuses:

1. Open or link fuse.
2. Enclosed fuse.
3. Expulsion fuse.

6.6.3 Circuit breaker:

The on off of the circuit is consider the basic operation in any electrical system, this operation occur by means of circuit breaker.

But the circuit barker very important used of the circuit breaker in order to open the circuit if any unnatural condition occur.

6.7 Cable and wiring for power circuit:

A great number of types of cable are available ranging from the very smallest signal-core wire used in the electric circuit , we discuss the cable in the low voltage only. A cable comprises two parts: the conductor or conductors and the Sheathing and insulation.

And from table (6.1) we can see the motor power ,nominal current ,thickness of cable ,maximum length of the cable ,over load current and the fuse current.

6.8 reverse diode:

This type of diodes is use to protect darlington transistor from the reverse current in the power circuit

6.9 Optocoplure :

1. We use the Optocupler as switch .
2. Also we used Optocupler to isolation the power circuit from the control circuit .

6.10 Heat sink:

Its use to keep the transistor temperature at safety level ; also it 's used to absorb the transistor temperature

table (6.1)motor power ,nominal current ,thickness of cable ,maximum length of the cable ,over load current and the fuse current.

Motor power (kw)	Nominal Current In (A)	Thickness of the cable q^N (mm)	Maximum Length of the cable (m)	Over load Current (A)	Fuse current (A)
0.06	0.22	1.5	2800	0.2-0.3	1
0.09	0.33	1.5	1890	0.3-0.5	1
0.12	0.42	1.5	1400	0.3-0.50	2
0.18	0.64	1.5	950	0.45-0.75	2
0.25	0.88	1.5	700	0.7-1.1	2
0.37	1.22	1.5	510	1-1.6	4
0.55	1.5	1.5	410	1-1.6	4
0.75	2.00	1.5	310	1.4 -2.2	4
1.1	2.6	1.5	240	2-3.2	4
1.5	3.5	1.5	170	3-5	6
2.2	5.00	1.5	120	4.5-7.52	10
3.00	6.6	1.5	90	4.5-7.5	16
4.00	8.5	1.5	70	7-12	16
5.5	11.5	1.5	50	7-12	20
7.5	15.5	2.5	65	11-18	25
11	22	4	75	16-25	35
15	30	4	55	20-32	50
18.5	37	6	65	30-45	63
22	44	6	55	30-45	63
30	60	10	65	40-63	80
37	72	16	90	60-90	100
45	85	16	75	60-90	125
55	105	25	95	80-130	160
75	140	35	100	100-160	200
90	170	50	120	130-210	250
110	205	70	140	160-210	250
132	245	95	160	160-250	315
160	295	120	165	200-400	400
200	370	185	205	200-400	500

Chapter 7

Design sample

7.1 Introduction:

In this chapter we will talk about the sample of our project (three dimension crane) that we designed, in this sample or model we explain the main parts of the crane explained in previous chapters.

These figures show the model, which we designed, when we see the all crane constructs parts and the dimensions of the crane.

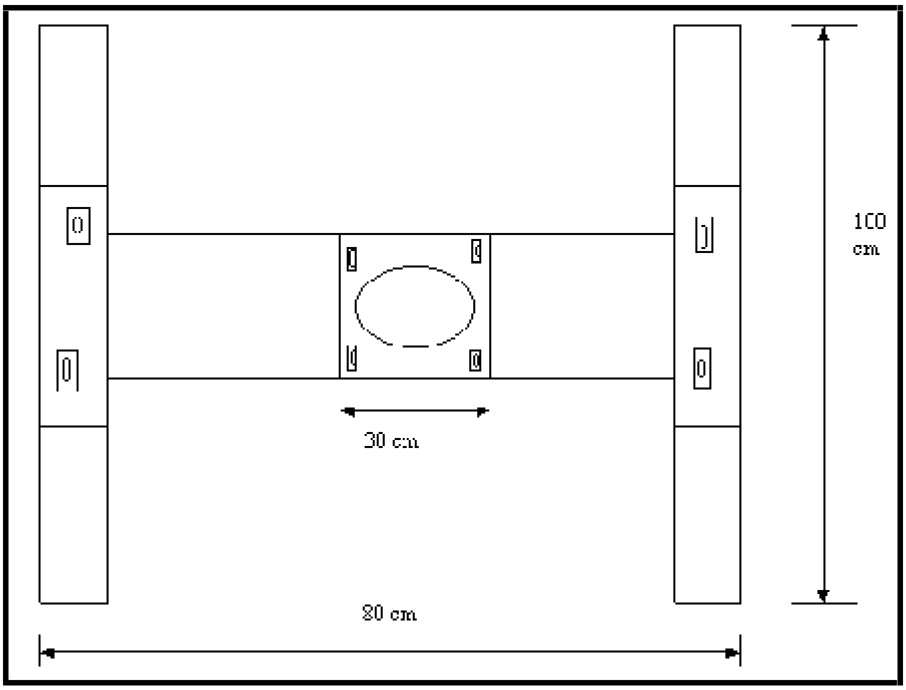


fig 7.1 lengths of the model

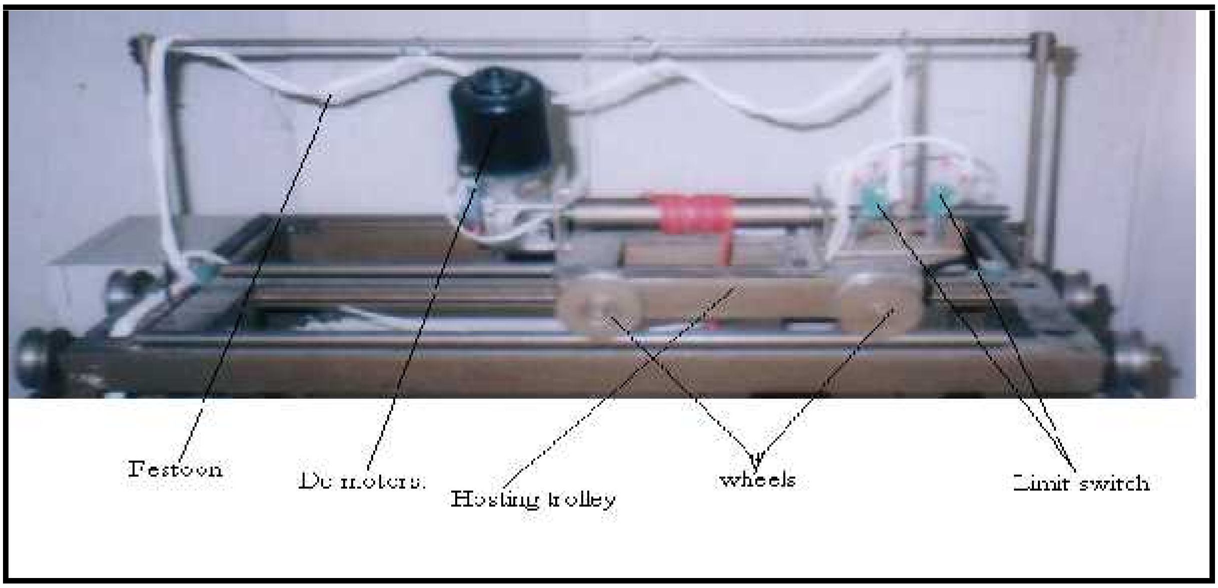


fig 7.2 parts of the models

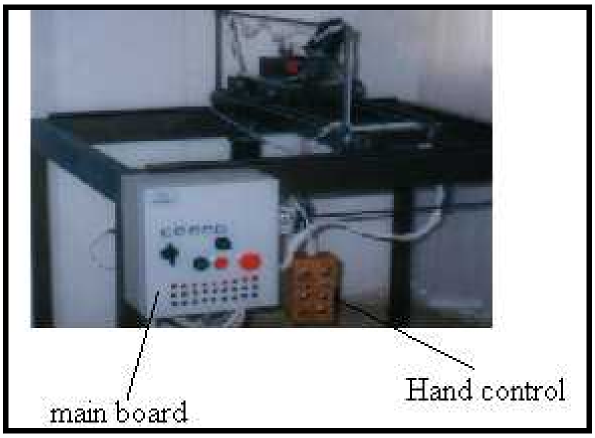


Fig7.3 parts of the model.

7.2 The designed sample consists of the following element:

1. Dc motors (3 P.M motors)
2. Hosting trolley .(80 cm active movement distance)
3. End truck. (limit switch).

4. Festoon. (connecting cable)
5. Main board

7.3 DC motors:

This section contains information about implementing dc motors in a mechanical system, such as those that are typically encountered in ME 3110. Although there is some limited information on stepper and other, specialized types of motors; primary emphasis is placed on DC permanent magnet motors, since these motors are the most common, least expensive, and lightest type of motors.

7.3.1 Types of motors:

There are several different types of dc (direct current) motors that are available. Their advantages, disadvantages, and other basic information are listed below in tabular form.

Table (7.1) Different between the type of the dc motors

Type	Advantages	Disadvantages
Stepper Motor	Very precise speed and position control. High Torque at low speed	Expensive and hard to find. Require a switching control circuit

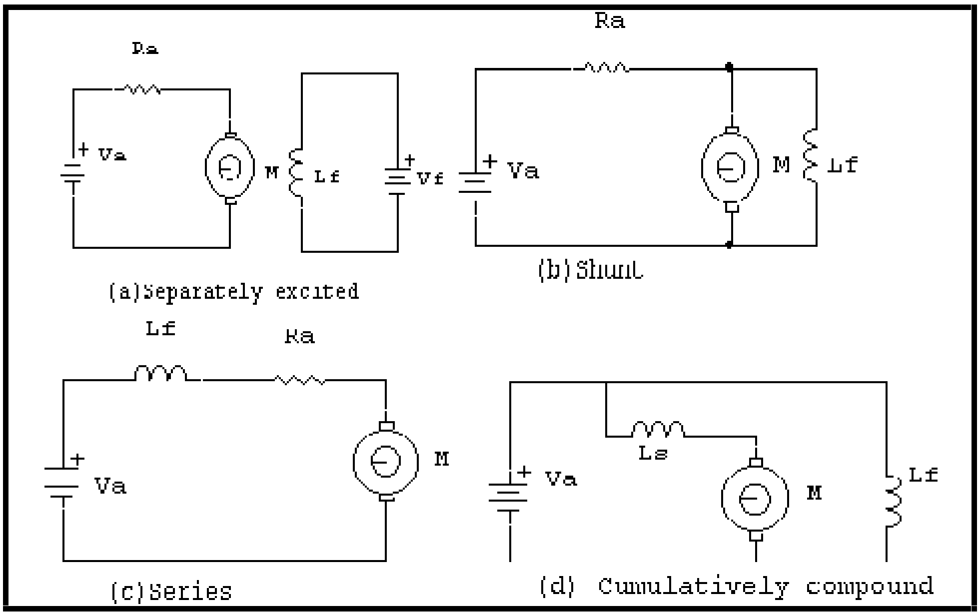
DC Motor w/field coil	Wide range of speeds and torques. More powerful than permanent magnet motors	Require more current than permanent magnet motors, since field coil must be energized. Generally heavier than permanent magnet motors. More difficult to obtain.
DC permanent magnet motor	Small, compact, and easy to find. Very inexpensive	Generally small. Cannot vary magnetic field strength.

Almost without exception, dc permanent magnet motors are by far the best choice projects. Their small size, compactness, and common availability make them a good choice on almost any machine that doesn't require a huge amount of power output.

7.3.2 Dc motors and their performance:

Commonly used dc motor is shown in (fig 7.4). In a separately exited motor, field and armature can be controlled independent of each other.

In a shunt motor , field and armature are connected to common source . In case of a series motor , field current is same as armature current ,and therefore field flux is function of armature current . In a cumulatively compound motor , the magneto-motive force of the series field is a function of armature current and is in same direction as mmf of the shunt field .



.fig7.4 commonly used dc motors

7.3.3 Elementary Theory of DC Permanent Magnet Motors:

Since this type of motor uses a permanent magnet to generate the magnetic field in which the armature rotates, the motor can be modeled by the electrical circuit in the armature alone. If we further simplify the circuit by ignoring the inductance of the armature coil, we arrive with the following circuit diagram for a simple motor:

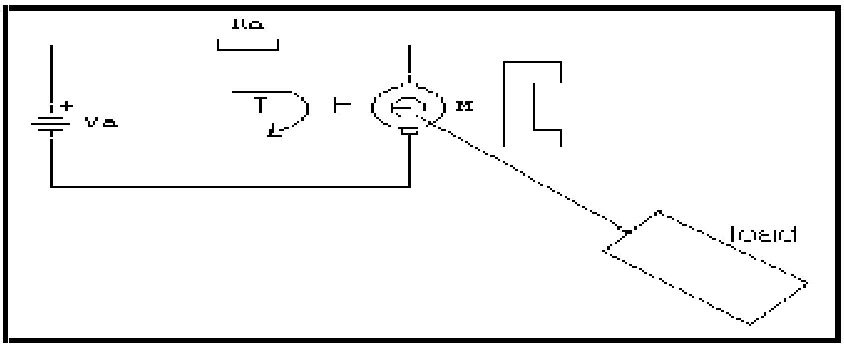


Fig7.5 pm dc motor

V is the voltage supplied by the power source (usually a battery), and R is the resistance of the motor's armature coil. This resistance cannot be measured at rest, since it changes as speed increases towards the steady state speed. Kerchief's voltage law leads to the following equation:

$$V=I_aR_a+E \quad \text{………………………………………………………..…………..(7.1)}$$

Where:

Va : Armature DC supply.

E : Induced voltage in armature windings.

Ra: armature circuit resistance.

Ia : armature current.

$$E = C\Phi\omega \quad \text{………………………………………………………………….(7.2)}$$

Where:

C : armature constant.

Φ : Flux.

ω : The angular velocity of the Rotor.

$$\omega=(2\pi/60)\times n \quad \text{……………………………………….……..………………..(7.3)}$$

n : The rotor speed.

$$T=C\Phi\, I_a \quad \text{……………………………………………………..………………..(7.4)}$$

T : Developed electrical torque.

$$\omega=(V_a/C\Phi) - (R_a/C\Phi) * I_a \quad \text{……………………………………………….(7.5)}$$

ω=(Va/CΦ) – (Ra/CΦ²)*T $\omega=(Va/C\Phi)-(Ra/C\Phi^2)*T$ ……………………………………………….…….(7.6)

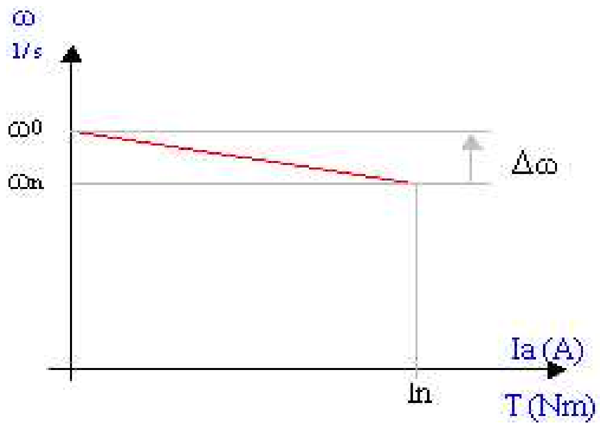


fig 7.6 Natural mechanicl Characteristic

7.3.4 Speed control:

The purpose of speed control is to determine new-rated speeds at the same load depending on the technology process.

Sep. DC motor has the following characteristic equation:

$$\omega = \frac{Va}{C\Phi} - \frac{Ra}{(C\Phi)^2} \quad \text{……………………………………………..(7.7)}$$

According to last equation; speed can be controlled by any of the following methods:

1- Armature voltage control.

2- Field flux control.

3- Armature resistance control.

7.4 Power calculation

the main lifting motor choose light power PM dc motor with purpose to lift :
The load which we need to left is 5kg , and the current of the motor is Ia =1.8A, and Va= 12v . and the radius r =0.02 cm

P_{in}=Ia * Va ……………………………………………………………….(7.8)

P_{in}= 1.80 *12 = 21.6 watt

P_{out}= ω* T ………………………………………………………………..(7.9)

T_{out}= F * r ……..……………………………………………………….. (7.10)

F= W * g …………………………………………….……………………(7.11)

F= 5* 9.81 =49.05 N

T = 49.05 * 0.02 = 0.981 N. m

ω= P_{out}/T_{out} ……………………………………………..……………..(7.12)

ω = 21.6/ 0.981 =2 2 rad /sec

V= ω * r …………………………………………………………………….(7.13)

V= 22 * 0.02 = 0.24 m/s

Where:

p : power of the motor .

ω : the angular velocity

T : the torque of the motor .

W: the weight of the load .

g: gravitational acceleration .

7.5 Gears:

Inside the dc motor box from the (fig 7.2) have Worm Gear gears .the advantages of this gear is to reduce the speed of the motor, and to increase the torque of the dc motor, the another advantages is to braking the motor. We see the fig of the Worm Gear from fig 7.7.

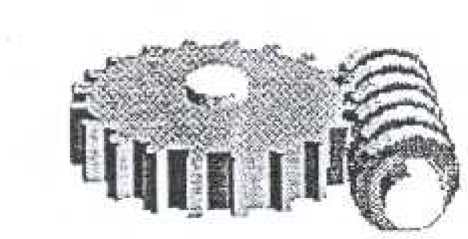


Fig 7.7 Worm Gear

7.6 Festoon:

From the figures we see how we connected the wire to the electrical parts on the crane, motors, limit switch, and bell.

7.7 Limit switch:

In the crane we have six limit switch's or end truck switch's , and this switch s stop the motion of the motors in the end of the allowed distance, by sending a signal to the PLC machine , to stop the motors motions.

7.8 The main board:

This board is responsible for providing the crane with the power to produce the required motion. It is supplied by 220 V AC. This board contains the all-electrical parts that realize the electrical protection and the required motion.

The main board contains the following parts:

7.8.1 On the cover of the board:

1. Emergency switch.
2. Start switch.
3. Stop switch.
4. Power switch.
5. Fuses.
6. Plugs for PLC device

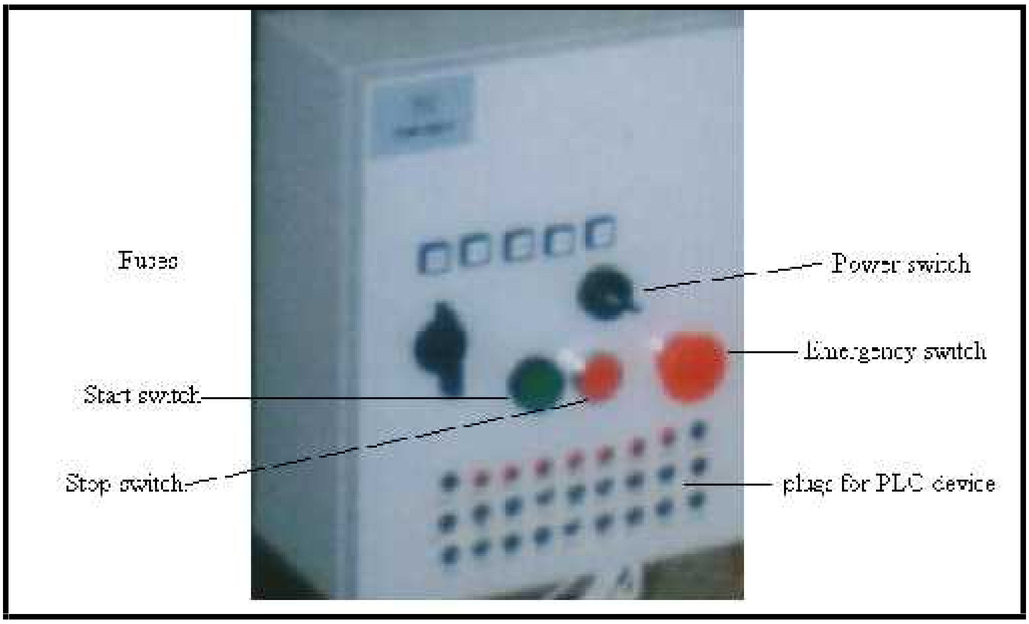


Fig 7.8 cover of the board

7.8.2 Inside of the main board :

1. Transformer (220v ac to 12v dc)
2. Receiver of the remote circuit
3. Motor control circuit
4. Clemens
5. Fan

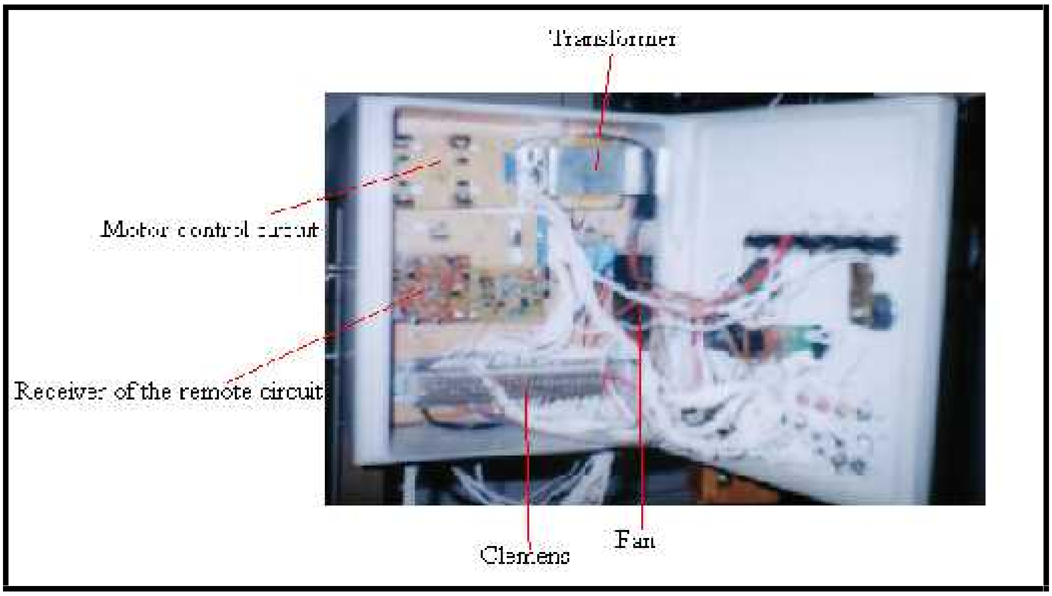


Fig7.9 Inside of the main board

7.9 Power circuit of the motor:

To run the motor we build the power electronic circuit as shown in figure (7.14). By this circuit we can control of the motor by using the signals from the PLC device to run every motor in two diminutions; left or right and up or down.

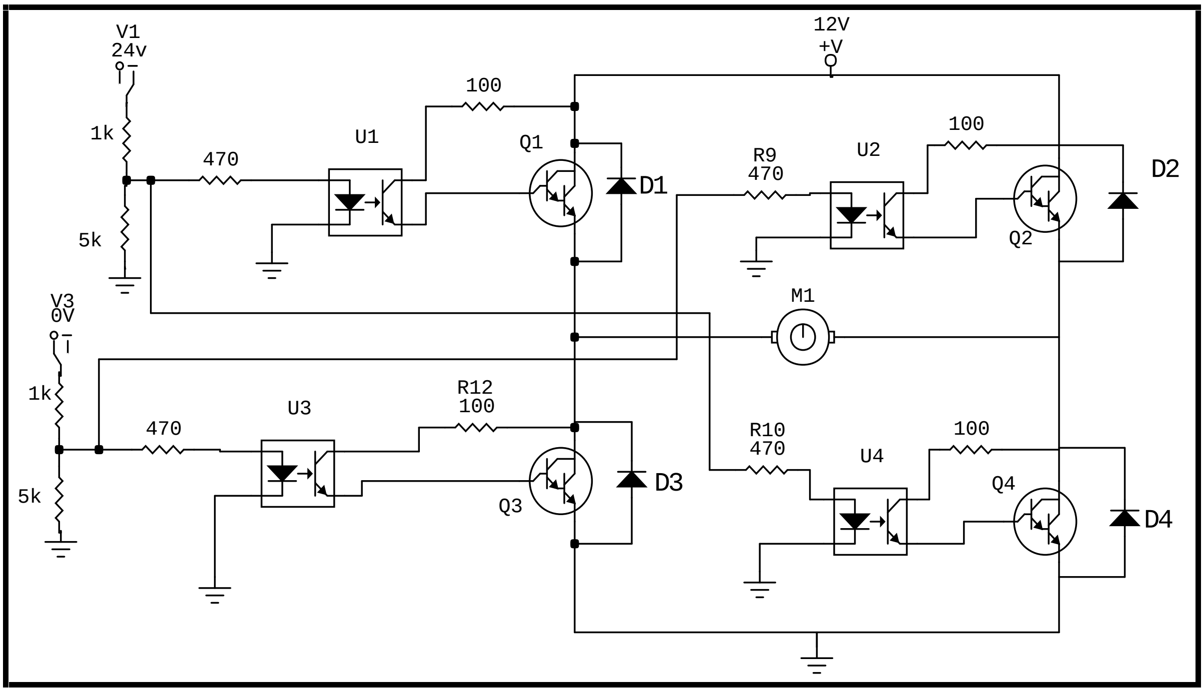


Fig 7.10 Power circuit of the motor

The power circuit contains :

1. Darlington transistor.

2. Optocoupler

3. Diode

4. Resistances

5. Power supplies

7.9.1 Darlington transistor:

Bipolar Transistor: NPN

This device operates as a current amplifier. It consists of three terminals, the Base, Emitter and Collector. Its circuit symbol is shown below.

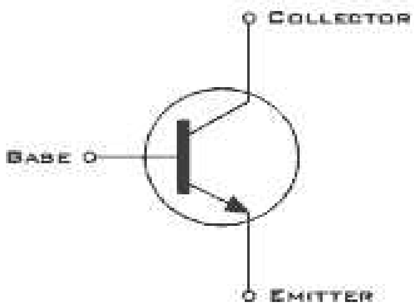


fig 7.11 figure of transistor

The device amplifies the current into the base terminal by allowing a much larger current to pass from the collector to the emitter. This gain varies between transistor types ranging from several hundred for small signal transistors to a few tens for high current power transistors. When used as a switching device the bipolar transistor is operated in saturation mode as shown below.

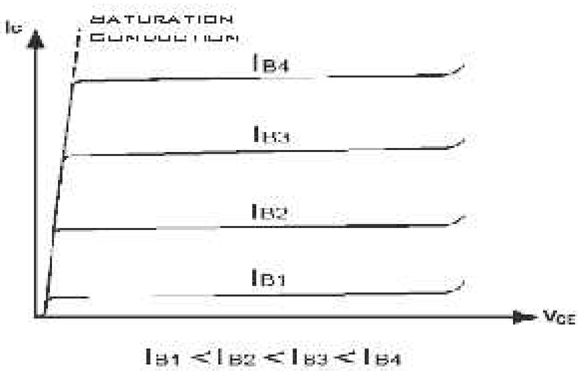


fig 7.12 Characteristic of Bipolar Transistor

When the device is saturated the voltage drop across the collector and emitter is minimized, and consequently so are the conduction losses You need to supply a large enough base current to ensure the device will be saturated at the required collector current.

While bipolar power transistors offer high current capacity they require substantial base drive current (as much as 10% of the collector current in some cases) and this requires additional signal processing from the control system.

$\mathbf{I_E = I_B + I_C}$ ……………………………………………….…………………..(7.14)

$\mathbf{\beta = I_C/I_B}$ ………………………….……………………………………..(7.15)

$\mathbf{I_B = (V_B - V_{BE}) / R_B}$ ………………………………………….…………………..(7.16)

$\mathbf{V_C = V_{CE}}$ ……………………………….……………………………..(7.17)

$\mathbf{V_{CE} = V_{CB} + V_{BE}}$ ……………………………………………………………..(7.18)

Where:

I_E: the emitter current .

I_C: Base current

I_C : the collector current

β: the current gain

The Darlington pair:

The higher the β, the higher the input impedance of the base. Many transistors have βs up to 300. With a *Darlington pair*, we can get much higher βs. From the figure …… Darlington pair. The collectors are connected, and emitter of the first transistor drives the base of the second. Because of this the over β is.

β= β1 β2

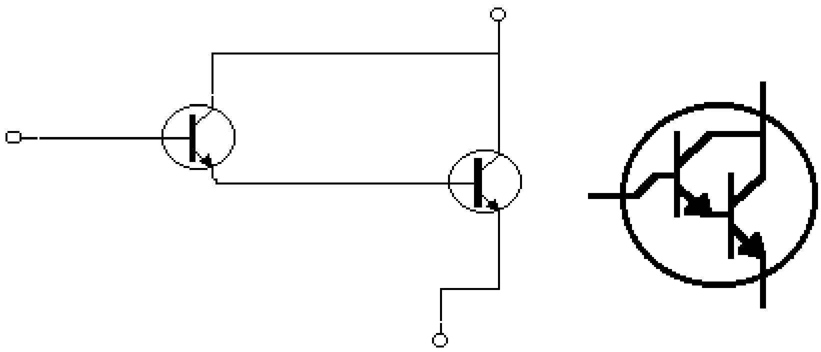


Fig 7.13 Darlington NPN transistor.

7.9.2 **Optocoupler** :

Here we use the Optocoupler as a switch

And we use it to isolation the power circuit from the control circu.

7.9.3 Diode:

The diode is used to pass the current in one way only

7.10 Programming (PLC):

After designed the model we programming the motion of it buy the PLC .
The program of the model is written (STL) programming for S5 SEMMENS

Table here is discretion the input and the out put of the PLC device.

Table(7.2)discretion the input and the out put of the PLC device.

Tools	Condition	Works	Symbols
EM1	NC	Emergency	I0.0
EM2	NO	Emergency	I0.1
S0	NO	Start	I0.2
S1	NO	Stop	I0.3
S2	NO	Right	I0.4
S3	NO	Lift	I0.5
S4	NO	Forward	I0.6
S5	NO	Backward	I0.7
S6	NO	Lifting up	I1.0
S7	NO	Down	I1.1
S8	NO	Warning bell	I1.2
L1	NO	Max right	I1.3
L2	NO	Max lift	I1.4
L3	NO	Max Forward	I1.5
L4	NO	Max Backward	I1.6
L5	NO	Max up	I1.7
L6	NO	Max down	I2.0
G1	______	Right	Q3.0
G2	______	Left	Q3.1
G3	______	Forward	Q3.2

G4	———	Backward	Q3.3
G5	———	Lifting up	Q3.4
G6	———	Down	Q3.5
G7	———	Warning bell	Q3.6

7.10.1 The program:

AI0.0

ANI0.1

AI0.2

ANI0.3

SF0.0

———

ANI0.0

OI0.1

OI0.3

RF0.0

——— **RIGHT**

AF0.0

AI0.4

ANI1.3

ANQ3.1

SQ3.0

———

ANF0.0

ONI0.4

OI1.3

OQ3.1

RQ3.0

——— **LEFT**

AF0.0

AI0.5

ANI1.4

ANQ3.0

SQ3.1

——

ANF0.0

ONI0.5

OI1.4

OQ3.0

RQ3.1

——— **FORWARD**

AF0.0

AI0.6

ANI1.5

ANQ3.3

SQ3.2

——

ANF0.0

ONI0.6

OI1.5

OQ3.3

RQ3.2

——— **BACKWARD**

AF0.0

AI0.7

ANI1.6

ANQ3.2

SQ3.3

———

ANF0.0

ONI0.7

OI1.6

OQ3.3

RQ3.3

——— **LIFTING UP**

AF0.0

AI1.0

ANI1.7

ANQ3.5

SQ3.4

———

ANF0.0

ONI1.0

OI1.7

OQ3.5

RQ3.4

——— **DOWN**

AF0.0

AI1.1

ANI2.0

ANQ3.4

SQ3.5

ANF0.0

ONI1.1

OI2.0

OQ3.4

RQ3.5

WARNING BELL

AF0.0

AI1.2

=Q3.6

the end.

7.10.2 The PLC connection:

The input and output are connect to the PLC device as shown in fig 7.19

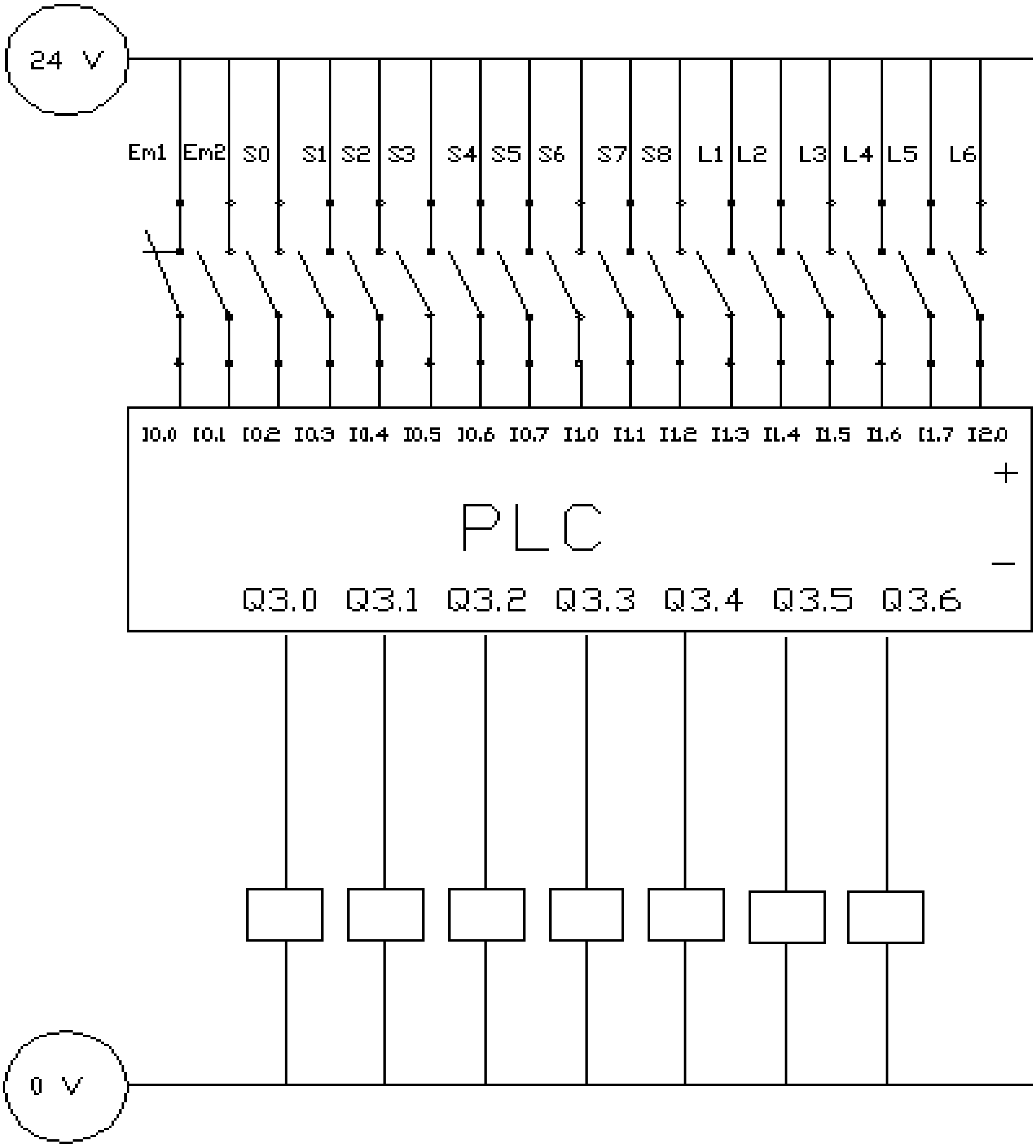


fig 7.14 the connection of PLC device

7.11 Plane of the electrical wire of the crane :

7.12 The samble economic cost.

Table (7.3) the project economic cost

type	number	Piece cost (N.I.S)	Total cost (N.I.S)
Motor	3	50	150
Board	50 cm	50	50
Darlington	14	8	112
Optocouplors	14	5	110
Diodes	14	1	14
Control box	1	50	50
Cooling fan	1	5	5
Em. Switch	1	35	35
Wires	50 m	0.6	30
Plugs	30	1	30
Resistances	50	0.33	16.5
Fuse house	5	3	15
Fuses	10	.35	3.5
Receiver	1	130	130
Transmitter	1	130	130
Control hands	2	10	20
Control hands switches	16	4	60
Bell	1	25	25
Turning	________	________	2000
Transformer	1	60	60

Chapter 8

Conclusion

- In all of the factories nearly it's important to use the crane that determine by the condition of industrial work .

- After analysis the mechanical design with increase the load on the crane that give curvature on the iron of the girder. And we choose the type of the iron by the load of the crane. We see the curvature of the iron on the fig (2.23).

- The motor which use to lifting, it's have a large power than others motors in the crane where used to moving the crane left right front and back.

- The (PLC) programming is use to definition and description the work of the machine . And we can change the program of PLC with the requirements and additional on machine work.

- The devise which use in protections is different by the employee way is in the protection and the element is protected.