MALABAR POLYTECHNIC CAMPUS CHERPULASSERY

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING
LABORATORY MANUAL

OF

INDUSTRAIL ELECTRICAL ENGINEERING LAB
Course Code: **5038**

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NAME : ………………………………………………………………..

REG. NO:……………………………………………………………….

ROLL

NO;……………………………………………………………….

INSTITUTION VISION

To be a centre of excellence by moulding young talented, globally competent professionals to meet the challenges of Industry and Society.

INSTITUTION MISSION

- ❑ Equip Students to adapt changing global scenario.
- ❑ Enhance the skills to meet Scientific and Engineering needs of the Society.
- ❑ To create hands-on experience through Industry-Institute Interactions.
- ❑ Explore ample opportunities in Entrepreneurship and Employability.

DEPARTMENTOFELECTRICALANDELECTRONICSENGINEERINGVI

SION

To be a competence center for serving the future needs and challenges of the society and industry Through quality education in Electrical and Electronics Engineering.

MISSION

- To develop innovative,competent and goal oriented Electrical and Electronics Engineers through cutting-edge technology.
- Prepare socially responsible Electrical and Electronics Engineers for life long learning to meet intellectual and career changes.
- To improve the quality of students through Industry-Institution Interactions.

COURSE INFORMATIVE SHEET

Course Code : **5038**	Course Title: **Industrial Electrical EngineeringLab**
Semester : **5**	Credits: **1.5**
Course Category: **Program Core**	
Periods per week: **3 (L:0 T:0 P:3)**	Periods per semester: **45**

Course Objectives:

- To develop Industrial and panel wiring with its maintenance
- To identify the cable sizes and perform conduit and cable works
- To develop starters for induction motors
- To practice routine maintenance of DG Sets

Course Pre-requisites:

Topic	Course code	Course name	Semester
Basics of Electrical circuits		Fundamentals of electric circuits	3
Induction Motors		Induction Machines	4

Course Outcomes:

On completion of the course, the student will be able to:

Con	Description	Duration (Hours)	Cognitive Level
CO1	Demonstrate and perform Industrial and panel wiring with its maintenance	9	Applying
CO2	Identify the cable sizes and perform conduit and cable works	9	Applying
CO3	Develop different types of starters for induction motors and demonstrate the maintenance of different motors	12	Applying

CO4	Apply day to day routine maintenance of DG Sets	9	Applying
	Lab Exam	6	

CO-PO Mapping:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO1				3			
CO2				3			
CO3				3			
CO4				3			
3- Strongly mapped 2- Moderately mapped 1- Weakly mapped							

Course Outline:

Module Outcome	Description	Duration (Hours)	Cognitive Level
CO1	**Demonstrate and perform Industrial and panel wiring with its maintenance.**		
M1.01	Outline the dismantling and assembling of switchgears in simple electrical installations and identify various elements	3	Applying
M1.02	Design and develop industrial and panel wiring	3	Applying
M1.03	Demonstrate the procedure to fabricate different types of cable tray bending 45º and 90º.	3	Applying
CO2	**Identify the cable sizes and perform conduit and cable works**		
M2.01	Carry out bending of PVC conduits.	1	Applying

M2.02	Demonstrate the procedures to practice laying of cables and trunking of cables	1	Applying
M2.03	Demonstrate the procedures to practice different types of cable jointing.	1	Applying
M2.04	Identify the procedures to practice glanding of cables,	3	Applying
M 2.05	Apply cable bending, stripping, crimping and connecting sockets.	3	Applying
	Lab Exam - 1	3	
CO3	**Develop different types of starters for induction motors and demonstrate the maintenance of different motors**		
M3.01	Identify the common maintenance activities carried out on a single phase and 3 phase induction motor	1	Applying
M3.02	Develop Contactor control circuits using Push button NO /NC contacts.	2	Applying
M3.03	Organize and connect star delta and DOL starter to a three phase squirrel cage induction motor	3	Applying
M3.04	Organize and connect rotor resistance starter to a three phase slip ring inductionmotor	1	Applying
M3.05	Build control circuits for motors using ON/OFF switch locally and remotecontrol.	2	Applying
M3.06	Develop suitable circuit to change the direction of rotation of three phase induction motor using contactors	3	Applying
CO4	**Apply day to day routine maintenance of DG Sets**		
M4.01	Identify the application of single phase preventer	3	Applying
M4.02	Choose starting method and Practice on changing of lubricant, coolant of DG Sets.	3	Applying
M4.03	Organize and Examine the working on DG Set panel and its protection.	3	Applying
	Lab Exam - 2	3	

Text / Reference:

T/ R	Book Title/Auth or
T1	Electric Motor Drives | First Edition | By Pearson by V Rajini (Author), VS Nagarajan (Author)
R 1	SK Bhattacharya (Author), S. Chatterjee (Author),Industrial Electronics and Control, TTTI Chandigarh.
R 2	Illustrated Guide to the National Electrical Code (Illustrated Guide to the National Electrical Code (Nec)) by Charles Miller (Author)

Online Resources:

Sl. No	Website Link
1	https://nptel.ac.in/courses/108102046/
2	https://www.daltco.com/sites/daltco.com/files/resource/schneider-wiring-diagram-book.pdf
3	https://www.edata.omron.com.au/eData/IO_Systems/Y222-E1-01.pdf
4	https://www.bcew.com/pdf/IS_6.pdf

Suggested Open-ended Experiments:

Students can do open ended experiments as a group of 3-5. There is no duplication in experiments in between groups. This is mainly for the purpose of continuous internal evaluation and a score of 15 marks. Students should prepare a separate report on open ended experiment of their choice.

Example:

Design and develop a simple panel board.

LIST OF EXPERIMENTS

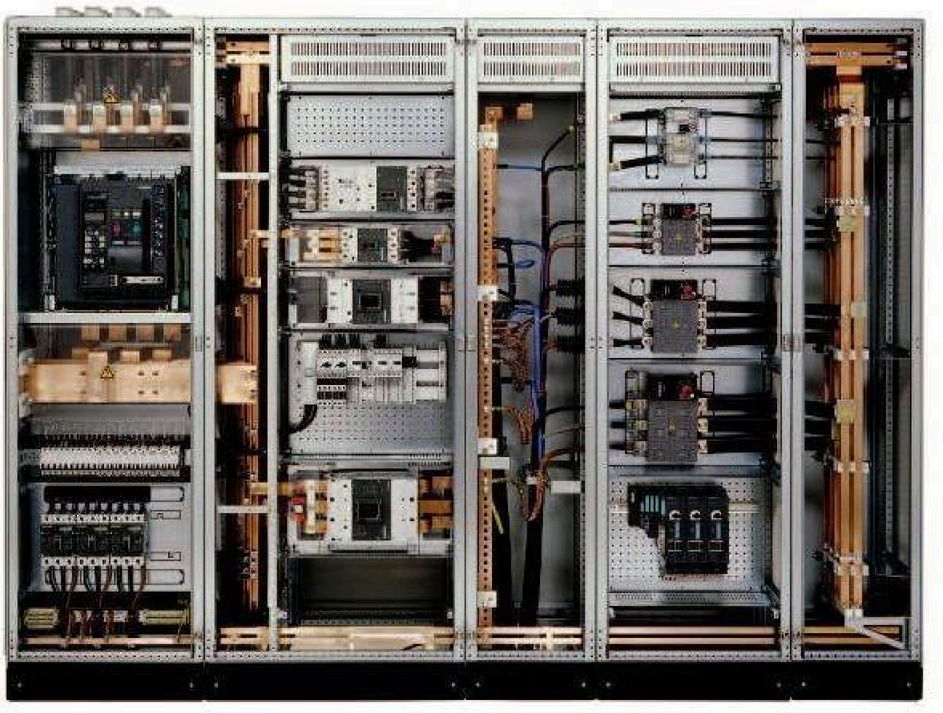
CO1	**Demonstrate and perform Industrial panel wiring with its maintenance.**
EX.1	***Design and develop an industrial panel wiring***
	(i) Outline the dismantling and assembling of switchgears in simple electrical installations and identify various elements
	(ii) Design and develop industrial panel wiring
	(iii) Demonstrate the procedure to fabricate different types of cable tray bending 45º and 90º.
CO2	**Identify the cable sizes and perform conduit and cable works**
EX.2	***Practice cable bending, stripping, crimping, connecting sockets and cable jointing.***
	(i) Carry out bending of PVC conduits.
	(ii) Demonstrate the procedures to practice laying of cables and trunking of cables
	(iii) Demonstrate the procedures to practice different types of cable jointing.
	(iv) Identify the procedures to practice glanding of cables,
	(v) Apply cable bending, stripping, crimping and connecting sockets.
CO3	**Develop different types of starters for induction motors and demonstrate the maintenance of different motors**
EX.3	***Use of one push button for both starting and stopping***
EX.4	***Use of separate push buttons for starting and stopping***
EX.5	***Multiple push button stations***
EX.6	***Push button interlocking***
EX.7	***Automatic sequence control with time delay***
EX.8	***Direct on line (DOL) starting of three phase induction motor***
EX.9	***Direct reversing of a three phase induction motor***
EX.10	***Semi-automatic star delta starter for three phase induction motor***
EX.11	***Automatic star delta starter for a three phase induction motor***
CO 4	**Apply day to day routine maintenance of DG Sets**
EX 12	***Examine the working on DG Set panel and its protection.***
	(i) Identify the application of single phase preventer
	(ii) Choose starting method and Practice on changing of lubricant, coolant of DG Sets.
	(iii) Organize and examine the working on DG Set panel and its protection.

CO1 Demonstrate and perform Industrial panel wiring with its maintenance.

Important points to be considered while design a panel board

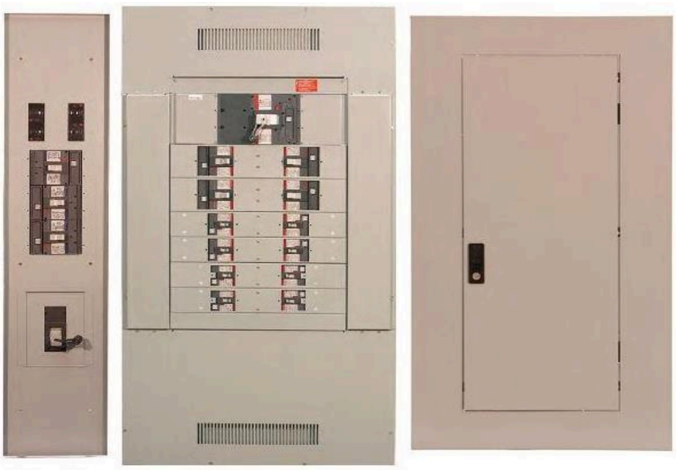
1. **PANEL BOARDS**

Building projects requires Panel Boards for distribution of power to each utility. A good electrical distribution network will have proper design, right components, and future load provisions. Space utilization will also be an important factor for maintenance and handling of the equipment. Here we look into what are the features required for design, manufacture, install a Distribution panel board including its BIS (IS) standards that serving quality building projects.



Electrical Sub-Main Distribution Boards (SMDB) is the integral part of Electrical LV Power distribution network in the end user premises of a medium and large scale projects. SMDB acts as a mediator between Main Distribution Board (MDB) and Final Distribution Boards (FDB) that serves approximately 100A to 400A load range.

Low Voltage Switchgear is familiar to every people since they are the controlling mediators between low voltage utilities and equipment with human beings. Be it a common home DB or an isolator or control centres, they all are being manufactured to use untrained people ie. common people. The scope of works shall cover the supply installation, testing and commissioning of main and sub-distribution boards, panel boards, fusible safety switches, circuit breakers etc. Associated minor building works require for the erection of the distribution boards and panels shall be included in the scope of work.



1.1.Scope of Work

The scope of this section covers manufacture, supply, installation, testing and commissioning of indoor Medium Voltage Distribution Panels Boards in Electrical Construction Contract Works.

1.2.Applicable Standards for Indoor Type Distribution Panel Boards

The following Indian Standards (IS/BIS) shall be applicable. The list shown here may be out dated hence the manufacturer to make sure they use the latest or superseded BIS standards.

IS 4237 of 1982: General requirements for switch gear and control-gear for voltage not exceeding 1000 Volts.

IS 5578-1985: Guide for marking of insulated conductors.

IS 11353-85: Guide for uniform system of marking and identification of conductors and apparatus terminals.

IS 2516: AC Circuit Breakers. (Part I) Sec. I 1989.

IS 4064-1978: Heavy Duty Air Break Switches for voltage not exceeding 1000 Volts.

IS 2147-1962: Degree of protection provided by enclosure for low voltage switch gear and control gear.

IS 2675-1983: Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000V.

IS 2551-1982: Danger notice plates.

IS 1818-1972: Alternating current isolators (dis-connectors) and earthing switches.

IS 8828-78: Miniature air break circuit breakers for voltages not exceeding 1000V.

IS 3202-1965: Code of practice for climate proofing of electrical equipment.

IS 722-1977: AC Electric Meters.

IS 2705-1964: Current Transformers (Part 1 to 4).

IS 9224-1979: HRC fuse upto 650 V.

IS 649-19: PVC insulated cables upto 1100V.

IS 8623-77: Factory built assemblies of switch gear and control gear.
IS 8544-1979: Motor Starters for voltage not exceeding1000 Volt AC or 1200 Volt DC.
IS 2959-1985: Contactors for voltages not exceeding 1000 volt AC or 1200 volts DC

IS 12640-1989: Residual current operated circuit breakers.

IS 1248-1983: Direct acting indicating (all parts) analogue electrical measuring instruments & and their accessories.

IS 4201-1983: Application guide for voltage transformers.

IS 8197-1976: Terminal markings for electrical measuring instruments & their accessories.

IS 3072-1965: Code of practice for installation and maintenance of switch gear.

IS 3231-1965: Electrical relays for power system

protection. IS 2516-1967: Molded Case Circuit Breakers.

1.3.The salient feature of construction of panels shall be as follows:

Sheet Steel 2 mm thick for frames, cable glands plates and equipment mounting plates and 1.6 mm thick for front and rear doors and covers.

Welded construction, with shipping section bolted together. All such joints to be gasketted. Lifting lugs to be provided.

The cubicles shall be totally dust and vermin proof conforming to IP 54 of IS 2147.

All doors to be hinged type except bus bar chamber covers which shall be bolted type. The panel shall be of flush front design, suitable for access from front and rear.

The construction shall be such as to facilitate easy extension at both ends.

The design shall be such as to have individual feeders in separate compartments, with proper barriers between adjacent feeders, bus bar chamber and cable box chambers.

1.4. Painting of The Panel Boards

All sheet steel work shall be properly cleaned and degreased. Rust and scale shall be removed by pickling and phosphatising. After phosphatising, two coats of finishing synthetic enamel paint of approved shade as per IS-5. The painting shall be stove enameled or epoxy paint as called for.

1.5. Air Circuit Breakers (ACB) Used In Panel Boards

The circuit breaker shall be air-break, conform to IS 2516 (I,II,III) & shall be air-break, horizontal draw out feature shall show 3 positions viz.: SERVICE, TEST and ISOLATED. These positions along with "OPEN" and "CLOSE" positions shall be visibly marked.

All positions shall have provisions for locking. The ACB shall have shutter assembly and arc-chutes and mechanical trip features.

The ACB shall have 6 NO + 6 NC auxiliary contacts rated at 10 A, 240 V, AC.

'RED' and 'GREEN' indicating lamps shall be provided on the cubicle.

The ACB door shall not have any lamps or instruments. All such accessories shall be mounted on a separate compartment.

The ACB shall have proper interlocks such that it cannot be 'plugged in or out ' 'SERVICE' position, if the breaker is in 'ON' condition. It shall not be possible to operate as circuit breaker unless it is properly engaged in any of the three positions.

The ACB shall have series CT operated over-current and short-circuit releases with facilities to mount the under voltage and shunt- trip releases.

The operating mechanism shall be independent, manual spring charged stored energy type. The mechanism shall ensure quick-break, quick make action and the ACB shall be trip-free in operation.

1.6.Air Break Switches

The air break switches shall be of AC23,(heavy) duty, quick make-quick break, fault-make type as per IS 4047.The contacts shall be silver plated.

The switches shall be capable of withstanding the mechanical and thermal stresses produced by overloads and short-circuits.

All switches of all ratings shall have interlocks with the compartment doors. Switches of 250 A and above shall be lockable in the 'OFF' position. All live parts shall be shrouded. It shall be possible to intentionally defeat the interlocks if required.

'RED' indicating lamp shall be provided for 'ON' indication.

1.7. Fuses

All fuses shall be of HRC cartage fuse-link type having a certified rupturing capacity of not less than 46 KA at 415 volts AC. The HRC fuses shall conform to IS 9224 1979. All fuses shall have visible indication to indicate "Blown" condition. The rupturing capacity of fuses shall be as per IS 2000-1962.

1.8. HRC Fuse Carriers

The HRC fuse carriers/bases shall be of high grade phenolic moldings. The contacts shall be silver plated and the contact blocks shall be suitable to receive the rated conductors of aluminum, through lugs.

The fuse carriers shall have an aperture to view the conditions of HRC fuse mounted inside.

1.9.Contactors

The motor starter contactors shall be of the electro magnetic, double-break, non-gravity type rated for uninterrupted duty suitable for operation under AC-3 utilization category as per IS 2959. The contacts shall be silver plated.

2 NO and 2 NC auxiliary contacts shall be included.

The operating coils shall have class 'E' insulation of wire and shall be suitable for operation of any specified control supply system.

1.10. Thermal Overload Relays

The thermal overload relays shall be provided where specified, having 3 element, positive action, ambient temperature compensated with a time lag and adjustable settings. The setting range shall be selected in accordance with the ratings of the motor.

The relay shall be self-reset/hand reset as called for. In the case of hand-reset, the reset button shall be fixed on the compartment door.

The relay shall have at least one 'NC' and one 'NO' or one change-over contact.

1.11. Molded Case Circuit Breakers

The molded case circuit breakers, MCCBs shall be provided where specified. The MCCBs shall conform to the latest applicable IS 2516-1977.

For AC Circuits the MCCBs shall be triple pole construction and shall have independent manual opening and closing mechanism. The mechanism shall be quick-make and quick-break type and the breakers shall be trip-free in operation. The 'ON', 'OFF' and 'TRIP' mechanism shall be clearly indicated.

Bolted type neutral link to be provided with TP MCCB.

It shall be possible to mount accessories on the MCCBs like shunt-trip and under voltage release, alarm contacts, etc.

The MCCBs shall have thermal/static trip devices.

The MCCBs shall have rupturing capacities as specified in BOQ/Single Line Diagram.

1.12. Miniature Circuit Breakers

The MCBs shall be of single pole, double pole, triple pole or four pole as required. The CBS shall be of magnetic type with a maximum rupturing capacity of 9KA at 415V. The CBS shall conform to BS 3871 (Part I) 1965 and IS 8825.

1.13. Current Transformers

The CT's shall be of dry type and shall have short-time withstand rating equal to the short-time withstand rating of the associated switch gear for 1 second.

The measuring instrument CT's shall be of 15 VA, minimum accuracy class 1.0 and an instrument safety factor of 5.

The protection relay CT's shall be of 15 VA, minimum accuracy class 5P and an accuracy limit factor of 10.

1.14. Indicating Instruments and Meters

Electrical indicating instruments shall be 72 mm/96mm/ 144 mm square size, suitable for flush mounting.

The zero adjustment shall be done from outside the cover.

The dials to be parallax free with black numerals on a white dial.

1.15. Indicating Lamps

Indicating lamps shall be of the filament type and of low watt consumption, provided with series resistors and HRC fuse link for protection.

The lens shall be easily replaceable from the front.

1.16. Control and Selector Switches

The control and selector switches shall be of rotary type, adequately rated for the application but with a minimum rating of 10 Amps at 240 V AC and 1 Amp at 220 V DC. The plates shall have clear position markings.

The control switches shall have pistol grip handles spring return to normal. The selector switches shall have oval knobs and shall be contact stay-put type.

1.17. Push Buttons

The push buttons shall be of the momentary contact, push to actuate rated for 10 A at 240V AC and 1 A 220 V DC. The 'START' push buttons shall be green and shrouded. The 'STOP' push button shall be red and unshrouded. All other push buttons shall be black.

The elements shall be enclosed with 1 'NO' and1 'NC' contacts. It should be possible to add on easily extra elements to increase the number of 'NO' and 'NC' contacts.

1.18. Main & Auxiliary Buses

The busbars shall be of high conductivity aluminium alloy of E91E, grade. The busbar shall be of uniform cross-section throughout the length of the panels.

All main and auxiliary busbars shall be insulated with sleeves. The sleeves shall be of high dielectric strength, non-corrosive and of phase and neutral colours.

The busbars shall be supported on cast epoxy/resin/DMC/SMC Fiberglass insulators and the spacing of the supports shall be such as to withstand the stresses of the short circuit currents. The busbar spacings shall be adequate for 3 phase voltage upto 600V.

The busbar shall be as chosen for specific current ratings with a minimum density of 1 amp for sq. mm area.

1.19. Internal Wiring

All internal wiring shall be carried out with 1100 V/650 V grades PVC insulated, stranded conductor copper wires. The minimum size of wires shall be 2.5 sq. mm copper and for CTs also 2.5 sq. mm copper.

All individual control and CTs wiring shall be labeled with engraved identifications ferrules, yellow in colour with black letters.

All wiring shall be terminated on stud type terminal blocks through crimping sockets. No more than 2 connection shall be made on any one terminal block.

All spare auxiliary contacts of contactors and relays shall be wired to control terminal blocks.

1.20. Terminal Blocks

Terminal blocks for power and control shall be of reputed make stud type, with washers, nuts and locknuts. All adjacent terminals shall have insulating barriers.

All power terminal blocks shall be appropriately rated for current with a minimum of 30 Amps. The control terminal blocks shall be rated for a minimum of 10 A and suitable for atleast 2 conductors each of 2.5 sq. mm

All sets of power and control power terminal blocks shall be identified with engraved plastic labels, black background and white letters.

1.21. Identifications Labels

All labels shall be black plastic with white engravings of letters of minimum 6 mm sizes.

1.22. Earthing

All switchgears shall have continuous run of earth busbar. The size and materials of the earth busbar shall be specified.

1.23. Space Heater

Each vertical cubicle shall be having a Space Heater of 60 watts with thermostat wherever necessary.

1.24. Tariff Advisory Committee and CPRI Tested

The switch gear shall be approved by the Tariff Advisory Committee(for Fire Insurance), and CPRI tested for short circuit test and enclosure test.

1.25. Tests

High Voltage test at 2.5 KV.

Power and Control Circuits Continuity Tests.

Insulation resistance test with 1000 V Meggar.

Operational Test.

Three Sets of test certificates to be submitted.

1.3. Panel board design

Calculating Electrical Load Capacity for a Home/industry

Understanding capacity and load becomes necessary if you are planning the electrical service for a new home/industry, or if you are considering an electrical service upgrade to an older home/industry. Understanding the load needs will let you choose an electrical service with an appropriate capacity. In older homes/industries, it's extremely common for the existing service to be badly undersized for the needs of all the modern appliances and features now in use.

Total electrical capacity of an electrical service is measured in amperage (amps).

How do you know if your current electrical service is adequate, or how do you plan for new electrical service? Determining this requires math to compare the total available capacity against the likely load that will be placed on that capacity.

Understanding Electrical Capacity

Calculating how much power your home/industry needs is a matter of calculating the amperage load of all the various appliances and fixtures, then building in a margin of safety. Generally, it's recommended that the load never exceeds 80% of the electrical service's capacity.

To use the math, you need to understand the relationship between watts, volts, and amps. These three common electrical terms have a mathematical relationship that can be expressed in a couple of different ways:

Volts x Amps = Watts

Amps = Watts/Volts

These formulas can be used to calculate the capacity and loads of individual circuits, as well as for the entire electrical service.

[*For example, a 20-amp, 120-volt branch circuit has a total capacity of 2,400 watts (20 amps x 120 volts). Since the standard recommendation is for the load to total no more than 80 percent* *of the capacity, this means that the 20-amp circuit has a realistic capacity of 1920 watts. So to avoid the danger of circuit overloads, all the light fixtures and plug-in appliances together on this circuit should consume no more than 1,920 watts of power*.

It is fairly easy to read the wattage ratings of the light bulbs, television sets, and other appliances on the circuit to determine if a circuit is likely to overload. For example, if you routinely plug a 1500-watt space heater into a circuit, and run several light fixtures or lamps with 100-watt bulbs on the same circuit, you have already used up most of the safe 1920-watt capacity.]

The same formula can be used to determine the capacity of the house's overall electrical service. Because a home's main service is 240 volts, the math looks like this:

240 volts x 100 amps = 24,000 watts

80 percent of 24,000 watts = 19,200 watts

In other words, a 100-amp electrical service should be expected to provide no more than 19,200 watts of power load at any given time.

In three phase system we use

Power = $\sqrt{3}$ x Line voltage x Line current x Power factor

Calculating Load

After you know the capacity of individual circuits and of the home's/industries full electrical service, you can then compare this with the load, which you can calculate simply by adding up the wattage ratings of all the various fixtures and appliances that will be drawing power at the same time.

You might think this involves adding up the wattage of all the light fixture light bulbs, all the plug-in appliances, and all the hard-wired appliances, and then comparing this to the total capacity. But it is rare for all electrical appliances and fixtures to run at the same time—you wouldn't run the furnace and the air conditioner at the same time, *for example; nor is it likely that you would be vacuuming while the toaster is running. For this reason, professional electricians generally have alternative methods for determining the appropriate size for the electrical service. Here is one method that is sometimes used:*

Add together the wattage capacity of all general lighting branch circuits.

Add in the wattage rating of all plug-in outlet circuits.

Add in the wattage rating of all permanent appliances (ranges, dryers, water heaters, etc.)

Subtract 10,000.

Multiply this number by .40

Add 10,000.

Look for the full wattage rating of permanent air conditioners, and the wattage rating heating appliances (furnace plus space heaters), then add in whichever is the larger of these two numbers. (You don't heat and cool at the same time, so don't need to add both numbers.)

Divide the total by 240.

This resulting number gives the suggested amperage needed to power the home adequately. You can easily evaluate your current electrical service by using this formula.

Other electricians suggest another simple rule-of-thumb:

100-amp service is generally large enough to power a small- to moderate-sized home's general branch circuits, plus one or two electric appliances, such as a range, water heater, or clothes dryer. This service may be sufficient for a home under 2,500 square feet if the heating appliances run on gas.

200-amp service will handle the same load as 100-amp service, plus electric appliances and electric heating/cooling equipment in homes up to about 3,000 square feet in size.

300- or 400-amp service is recommended for large homes (more than 3,500 square feet) with all-electric appliances and electric heating/cooling equipment. This service size is recommended where the expected electric heat load is over 20,000 watts. A 300- or 400-amp service is usually provided by installing two service panels—one providing 200 amps and a second providing another 100 or 200 amps.

Plan for the Future

It is generally a good idea to oversize an electrical service to make future expansion possible. In the same way that 100-amp service quickly became undersized when electric appliances become common, today's 200-amp service may someday seem badly undersized when you find yourself recharging two or three electric cars. Another device that can quickly use up your 200 amp service is an electric tank less water heater, which often uses 120 amps. An oversized electrical service will also make it possible to run a sub-panel out to your garage or shed if you someday choose to take up woodworking, welding, pottery, or another hobby requiring lots of power.

How to Determine the Load Capacity of Your Circuit Breaker

Understanding Circuit Breakers: Circuit breakers in your electrical panel are considered "Safety buffers." Their job is to disconnect from power when they detect the passing current exceeds its amperage. When you don't measure your circuit breaker's load capacity, you run the risk of damaging your appliances, or worse…setting your building on fire! In this blog, we will go over the key essentials to understanding how much amperage your circuit can hold.

Key Essentials:

(i) Evaluating your electrical load capacity
(ii) Determining the number of electrical devices your breaker can handle
(iii) Troubleshooting and inspecting your breaker box

When you're considering installing a new heater, HVAC unit, thermostat, or any electrical appliance for that matter, it's important to know exactly how much electricity your circuit breakers can handle before the circuit trips.

Every electrical appliance you use requires a specific level of electrical power for it to operate safely. Commonly referred to as the "Power Rating," this load level helps to determine how much power your device can handle without overheating

WATT does it all mean?

Well, before we jump into load capacity and all that other technical jargon, let's learn a little bit about amps, watts, and volts.

What is an amp?

Amp is short for Ampere. Amps measure the amount of electrical charge flowing past a given point in one second. In laymen's terms, the number of amps indicates how much of an electrical current is being drawn through power cables (1).

What is a volt?

Voltage (volts, V) measures how strongly electricity is being pushed through a circuit. In other words, the number of volts tells you the amount of pressure being pushed (1).

What is a watt?

Wattage measures the amount of electrical power that a device uses. Watts is the unit of measure that indicates the total amount of electrical current flowing through an electrical device. By measuring the amount of power a building consumes, the power company is able to determine your utility bill.

How to evaluate your electrical load capacity

Every circuit breaker has a specified amperage (amount of current). This rating is labeled on the breaker itself. The standard for most household circuits are rated either 15 amps or 20 amps.

An important note to remember is that circuit breakers can only handle about 80% of their overall amperage. That means a 15-amp circuit breaker can handle around 12-amps and a 20-amp circuit breaker can handle about 16 amps.

STEPS:

First, find the breaker that correlates to the electrical device you are using (This is normally either a 15-amp or 20-amp circuit).

Multiply the amperage by 0.8. This is because a circuit breaker should never exceed 80% of its max amperage. Not doing this could leave room for calculation errors, or even worse – electrical fires!

Calculate the amperage draw of ALL the devices you wish to plug into the circuit.

Determining the number of electrical devices your breaker can handle

It's very important to understand how much amperage your electrical device draws before installing them into your breaker box. Whether you're looking to install a heater, AC unit, light switch, or GFCI outlet, there are a few steps you must take.

STEPS:

Check the wattage (max power rating) on your device. This is usually labeled somewhere on the back of the device.

Measure the voltage on the circuit you wish to install your electrical devices. Most household circuits are 240V and larger commercial spaces are 415V .

To calculate amperage, use the equation Amps = Watts/Volts. For example, a 200W light bulb on a 120V circuit would draw about 1.67 amps.

Calculate the TOTAL amperage rating of all devices. Make sure they DO NOT exceed 80% of the breaker's total amperage.

Troubleshooting and inspecting your breaker panel

Your circuit breaker is an essential part in the safety of your home or building. It keeps your electrical wiring system from overheating. If you are experiencing frequent power outages, electrical trips, and other oddities, we've got some troubleshooting tips for you!

What are some common reasons for a circuit breaker to trip?

1. Overloading the circuit with too many appliances that draw too much amperage
2. Short in the electrical wiring, loose wiring, or wiring
3. Circuit breaker is old, worn out, or damaged

PRACTICAL

EX.NO:1 DESIGN AND DEVELOP AN INDUSTRIAL PANEL WIRING

Date

Aim: To design and develop an electrical scheme and panel boards for electrical machines lab / mechanical machines lab / other laboratories as per BIS standards.

[This is an open ended experiment. Students can do open ended experiments as a group of 3-5. There is no duplication in experiments in between groups. This is mainly for the purpose of continuous internal evaluation and a score of 15 marks. Students should prepare a separate report on open ended experiment of their choice.]

1. LAYOUT OF INSTALLATION

LIST OF ELECTRICAL LOAD

SL NO	DESCRIPTION	POWER RATING	VOLTAGE	REMARKS
1				
2				
3				
4				

DATA SHEET

1. Selection of circuit breaker

- Power (KW/KVA/HP)
- Rated Current.
- System Voltage
- Breaking Capacity
- Making Capacity
- Category A or B
- Suitability to site Condition (Indian Condition)
- Maintenance Definitions
- Effect of harmonics

2. **Calculation formula**

Total power in **KVA = √3 x Vx I**

KW = √3 x Vx I

cos□ HP = 0.745x

KW

Rated current [I] = KW/ √3 x Vx cos□

= KW/ 1.732x 415x0.8

= 1.8xKW

3. **System of LT / HT connection**

HVPN supply
GO switch
HT metering
VCB
Transformer
LT panel [power control centre, power factor panel, AMF]
Distribution panel
Sub distribution panel

4. **Selection of GO switch for 11KV**

Gang operated switch comprises of
Lighting arrestor
GO switch
Drop off fuse [DO Fuse]
Plate earthing -2 nos [one for LA and one for GO switch]

5. **Selection of CT & PT**

CT [current transformer / 5A] selected as per the full load current of transformer.
PT [potential transformer] as per the system voltage; 11KV/220V/110V/24V
Calculation of HT current for CT KVA/11 KV /1.732
Try vector meter selected as per HT current

6. **VCB panel**

Vacuum circuit breaker is used for switching carrying normal current and breaking abnormal current at high voltage.

- 630A (short circuit current) and above
- Over load , short circuit & E/F protection
- Measurement of current, voltage etc.

7. **Transformer**
   - Selection of transformer as per total load
   - 11KV(input) /433V (output)

8. **LT panel**

PCC – Power control center
MCC –Motor control center
AMF – Auto main failure panel
APFC – Automatic power factor correction
Distribution panel

9. **Starter for three phase induction motor**

DOL starter used up to 10 HP
Star – Delta starter [manual star delta starters are *not used*, automatic star delta starters are used]
Soft starters
VFD

10. **Starter panel for motors**
    - Contactors + over load + MCCB/ MPCB
    - Motor protection relay
    - On delay timer + capacitor duty contactor + capacitors
    - Under voltage & over voltage relay
    - Hour meter
    - Time switch

11. **Components to be used in starters**

DOL starter – MPCB-1 no, contactor -1 no, push button – 2 nos, On indication -1 no, Single phase preventer -1 no up to 10 HP

STAR - DELTA starter – MCCB-1 no, contactor -3 nos, MPR – 1no, star delta timer 1 no, ammeter with CT – 1 no, push button – 2 nos, On indication -1 no, Single phase preventer -1 no

SOFT STARTER – MCCB-1 no, semiconductor fuse -3 nos, line contactor -1 no, soft starter – 1 no [with built in bypass contactor & soft starter selected as per duty or application] ,push button -2 nos.
VFD - MCCB-1 no, semiconductor fuse -3 nos, line contactor -1 no, VFD1 – 1no, push button -2 nos, input/ output chokes

12. MCB selection

MCB [miniature circuit breaker] – rated current not more than 63A, thermal or thermal magnetic operation.
MCCB[moulded case circuit breaker] – rated current above 32A up to 630A, trip current may be adjustable, thermal or thermal magnetic operation.

MCB Selection

- Overload which is intended to prevent the accidental overloading of the cable in a no fault situation. The speed of the MCB tripping will vary with the degree of the overload. This is usually achieved by the use of a thermal device in the MCB.
- The second characteristic is the magnetic fault protection, which is intended to operate when the fault reaches a predetermined level and to trip the MCB within one tenth of a second. The level of this magnetic trip gives the MCB its type characteristic as follows:

Type	Tripping Current	Operating Time
Type B (Domestic)	3 To 5 time full load current	0.04 To 13 Sec
Type C (Industrial)	5 To 10 times full load current	0.04 To 5 Sec
Type D (Capacitor)	10 To 20 times full load current	0.04 To 3 Sec

13. Cable selection

Cable Selection

- Armoured Cables (For Out door, under ground)
- Unarmoured Cables (for indoor but open in cable trays)
- Submersible cables
- Size of Cable (as per load)
- Insulation on cable (PVC, XLPE)
- Core 3 (where neutral not required) or 3 ½ cable (where neutral required)
- 3 core cable in HT, Motor, capacitor
- 3 ½ Core in light load,

Design of electrical scheme & Panel board

Result

CO2 Identify the cable sizes and perform conduit and cable works

Electric power can be transmitted or distributed either by overhead transmission systems or by underground cables. Cables are mainly designed for a specific requirement. Power cables are mainly used for power transmission and distribution purposes. It is an assembly of one or more individually insulated electrical conductors, usually held together with an overall sheath. The assembly is used for transmission and distribution of electrical power.

Electrical power cables may be installed as permanent wiring within buildings, buried in the ground, and run overhead or exposed. Flexible power cables are used for portable devices, mobile tools, and machinery.

These are designed and manufactured as per voltage, current to be carried, operating maximum temperature and purpose of applications desired by the customer.

For mining, we give extra mechanical strength to cable with double armoring. For wind power plant customers generally, require flexible and UV protected cable with the mechanical tough sheath so we design as per their requirement. The underground cables have several advantages such as less liable to damage through storms, lightning, low maintenance cost, a lower chance of faults, a smaller voltage drop, and a better general appearance.

Rating of Power Cable

Short Circuit Rating

It happens frequently that the conductor size necessary for installation is dictated by its ability to carry short-circuit current rather than sustained current. During a short-circuit, there is a sudden inrush of current for a few cycles followed by a steadier flow of current for a short period until the protection switchgear operators, normally between 0.1 – 0.3 seconds.

Conductor Size and Material	Insulation Material	Operating Maximum Temperature	Short Circuit Rating
120 sq-mm Copper conductor	PVC Insulation	70ºC	13.80 KA/SEC
120 sq-mm Aluminium conductor	PVC Insulation	70ºC	9.12 KA/SEC
120 sq-mm Copper conductor	PVC Insulation	85ºC	12.48 KA/SEC
120 sq-mm Aluminium conductor	PVC Insulation	85ºC	8.28 KA/SEC

Current Carrying Capacity

The current carrying capacity is an important aspect is the selection of the optimum size of the conductor. Voltage drop and short rating is also a very important aspect to select the economical and optimum size of conductor. The safe current carrying capacity of an underground cable is determined by the maximum permissible temperature rise. The cause of temperature rise is the losses that occur in a cable which appear as heat.

Continuous Current Rating of (Cables laid singly)	2 Core × 16 mm^2	2 Core × 25 mm^2
(i) In Ground (Ground Temp 30ºC)	103 A	131 A
(ii) In Duct (Ground Temp 30ºC)	86 A	111 A
(iii) In Air (Ambient AirTemp 40ºC)	94 A	125 A

Voltage Drop

The allowable maximum voltage drops from source to load is another aspect of power cable conductor design.

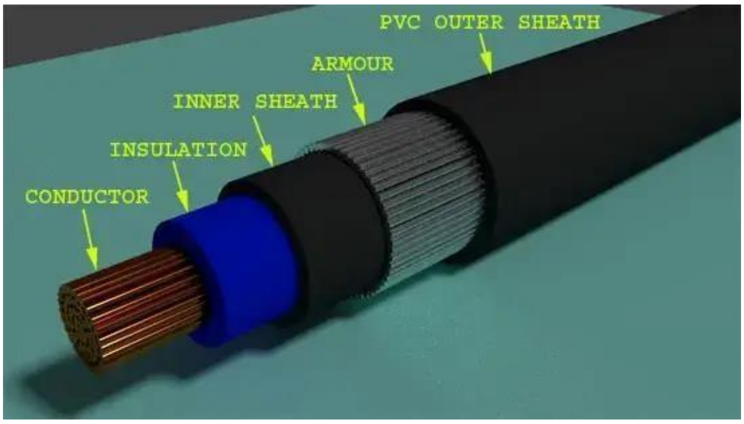
As per Ohm’s law, V = IR. The first is the choice of material used for the wire. Copper is a better conductor than The first is the choice of material used for the wire. Copper is a better conductor than and will have less voltage drop than aluminum for a given length and wire size.

Wire size is another important factor in determining voltage drop. Larger wire sizes (those with a greater diameter) will have less voltage drop than smaller wire sizes of the same length. In American wire gauge, every 6 gauge decrease gives a doubling of the wire diameter, and every 3 gauge decrease doubles the wire cross-sectional area. In the Metric Gauge scale, the gauge is 10 times the diameter in millimeters, so a 50 gauge metric wire would be 5 mm in diameter.

Construction of Power Cable

There are various parts of a cable to be taken care of during construction. The power cable mainly consists of

Conductor, Insulation, LAY for Multicore cables only, Bedding, Beading/Armouring (if required), Outer Sheath



Conductor

Conductors are the only power carrying path in a power cable. Conductors are of different materials. Mainly in the cable industry, we use copper (ATC, ABC) and aluminum conductors for power cables. There are different types of a conductor as Class 1: solid, Class 2 stranded, Class 5 flexible, Class 6 Extra flexible (Mostly used for cords and welding), etc. Conductor sizes are identified with conductor resistance.

Insulation

The insulation provided on each conductor of a cable by mainly PVC (Poly Vinyl Chloride), XLPE (Crosslinked Polyethylene), RUBBER (Various Types of Rubber). The insulating material is based on operating temperature.

Insulation Material	Maximum Operating Temperature
PVC TYPE A	75ºC
PVC TYPE B	85ºC
PVC TYPE C	85ºC
XLPE	90ºC
RUBBER – EPR IE-1	90ºC
RUBBER – EPR IE-2, EPR IE-3, EPR IE-4, SILICON IE-5	150ºC

Cores are identified by color-coding by using different colors on insulation or by number printing on cores

Beading (Inner Sheath)

This portion of the cable is also known as the inner sheath. Mostly it is used in Multi-core cables. It works as a binder for insulated conductors together in multi-core power cables and provides bedding to armor/braid. This portion of the cable is mainly made of PVC(PVC ST-1, PVC ST-2), RUBBER (CSP SE-3, CSP SE-4, and PCP SE-3, PCP SE-4, HOFR SE-3 HOFR SE-4, HD HOFR SE-3 ETC).

Armoring

There are mainly G.I. WIRE ARMOURING, G.I. STEEL STRIP armoring. It is done by placing G.I. WIREs, GI, or STEEL STRIPs one by one on inner sheath. Armoring is a process that is done mainly for providing an earthing shield to the current-carrying conductors as well as it is also used for earthing purposes of the cable for safety.

When there is any insulation failure in the conductor, the fault current gets enough paths to flow through the armor if it is properly earthed. Providing extra mechanical protection and strength to cable is an important added advantage of armoring. In mining cables this is done for conductance.

Beading

ANNEALED TINNED COPPER WIRE, NYLON BRAID, COTTON BRAID are mainly used for this purpose. Braiding is the process which gives high mechanical protection to cable and also used for earthing purpose. The significance of braiding is it is more flexible in comparison to armoring.

Outer Sheath

This is the outermost cover of the cable normally made of PVC (Poly Vinyl Chloride), RUBBER (Various Types of Rubber), and often the same material as the bedding. It is provided over the armor for overall mechanical, weather, chemical, and electrical protection. The outer sheath is the protection offered to the cable not much electrically but more mechanically.

Mainly above 6 square mm cables are called power cables but it depends upon the use of a cable. For PVC power cables we use IS:1554 and for XLPE power cables we use IS:7098 and for Rubber-based power cables, we use IS:9968 and other relevant specifications. Power cables are defined by voltage grade and nominal cross-sectional area.

Electrical Cable Jointing Methods

Jointing of power cables should be as simple as twisting and taping the wire. For jointing of a cable variety of in-line adapters and connectors are used. The method used for a cable joint depends on the voltage, type of cable, type of joint, type of connector, application and other factors. Proper tools and equipment are to be used for jointing the cable.

Given below are some important factors to ensure reliable connections, such as

□ Proper size of connectors should be used for a particular cable,

□ Proper tools and equipment are to be used,

□ Cuts and stripping should be very clean,

□ Proper technique is to be used for cable jointing and

□ restoring the insulation, outer-sheath and armour

Western Union Splice Joint

The cables are manufactured for a particular length. To increase the length of a cable a straight joint is used for small solid cables (Figs. 1and2).

1. Remove the insulation of cable

2. Bring the two conductors to a crossed position and then make a long bend or twist in each wire.

3. Wrap the end of one of the wires around the straight portion of the other wire, and then do the same for the other wire. Repeat this for about four or five times.

4. Press ends of the wires down close to the straight portions of the wire to prevent the ends from piercing through the insulation tape.

5. Insulate the joint using the insulation tape

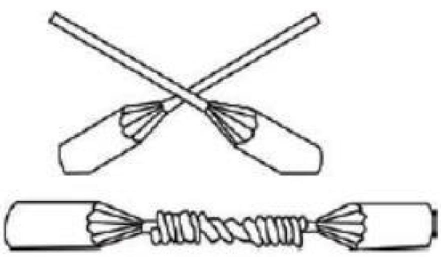


Fig 1 *Western union splice and straight joints*

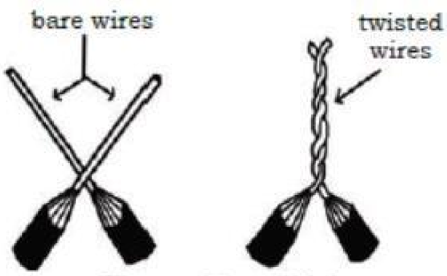


Fig. 2 *Rattail joints*

Fixture Joint

This is a type of branch joint connecting a thin wire (for branch line) to the thick wire (main line), such as those used in lighting fixtures.

1. Remove the insulation of wire
2. Wrap the fixture wire around the branch wire
3. Bend the branch wire over the completed turns
4. Wrap the remaining fixture wire over the bent branch wire
5. This can be followed by soldering and taping, or simply taping of the joint

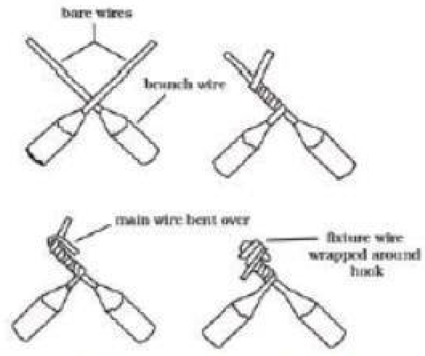


Fig. 3 Fixture joint

Knotted Tap Joint

The knotted tap joint is also used for branch joints to connect a branch wire (thin wire) to a continuous or main wire (thick wire) (Fig. 5.5).

1. Remove about 1 inch of insulation from the main wire and about 3 inches from the branch wire.
2. Place the branch wire behind the main wire so that three-fourths of its bare wire extends above the main wire.
3. Bring the branch wire over the main wire, around itself, and finally over the main wire so that it forms a knot. Wrap the wire around the main conductor in short, tight turns and trim the end

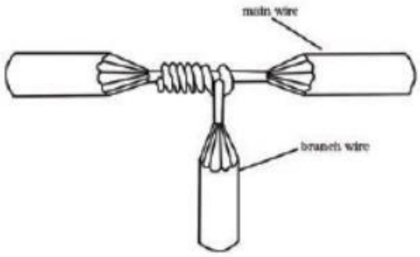


Fig. 4 Knotted tap joint

Joints Using Wire Nut and Split Bolt

The rattail joint is replaced by wire nut. The nut is usually housed in a plastic insulating casing. To make a joint

1. Strip the conductors

2. Place the two joints to be joined into the wire nut

3. Twist the nut

Split Bolt Connector

The split bolt is used to join big sized conductors. This replaces the knotted tap joint and can be used to join three ends or join a branch conductor to a continuous (main) conductor (see Fig.5).

The bare wires are placed through the space between the two bolts, after which the nut is tightened to ensure a sound joint. The material required for making straight or branch joints for steel wired armour cables are as follows:

- Connectors
- Copper mesh tape
- Constant force springs for holding the wire armour and copper mesh tape
- Standard PVC/Vinyl tape, which provides a mechanical barrier between the over sheath layer and the armour layer.


Fig 5 Split bolt

Preparing the Cable

Preparing the cable before jointing includes the following steps (Fig. 6):

1. Remove the over sheath and the wire armour
2. Separate the wire armour and bend the wires away from the cable, place the support ring under the armour at each side of the joint
3. cut back the cable insulation
4. Remove the insulation from each of the conductors

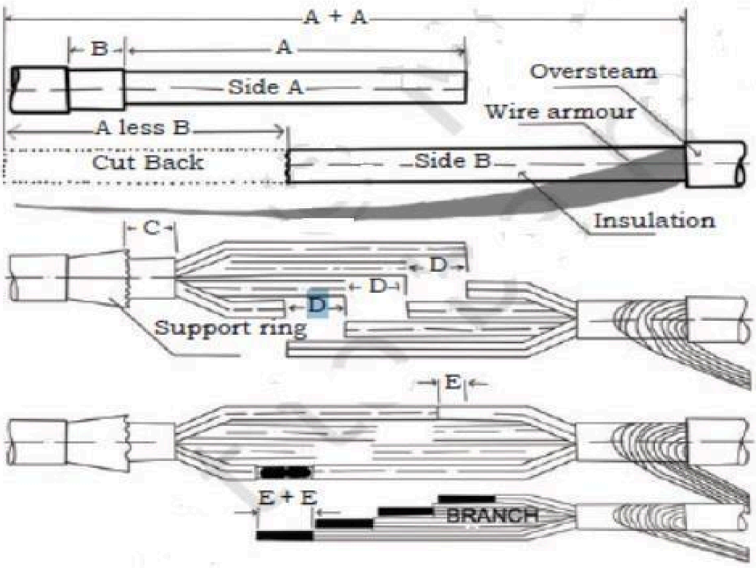


Fig. 6 Preparation of a three-core armoured cable

Crimping and Insulating Each Cable

Once the cable is ready, connect each end of the three conductors to a suitable connector (copper or aluminium). Suitable-sized connectors are to be used. Tightly fix the suitable connectors and test the connection.

Tape the crimped connectors, wrap around and extend to cover at least 25mm of the cable insulation of the conductor entering the connectors (Fig. 7).

Fig. 7 Taped, crimped connectors on individual cables

Binding the Cables

Bind the wires tightly and then tape them together (Fig. 8).

Fig. **8** *Wires taped together*

Restoring Armour and Applying Mesh Tape

1. Tightly wrap the cable from armour to armour while applying adequate tension around the insulation.

2. Join the wire armour from one end to the other end and cut excess wire to the correct length. Ensure the armour spreads evenly over the entire joint.

3. Wrap the cable with the mesh tape and then use the standard vinyl/PVC tape to wrap over the mesh to provide insulation against stray wire ends. For the branch joint, bring both the main and branch cables together before wrapping.

Next, use standard vinyl or PVC tape to wrap over the constant force springs placed over the under-armour rings. The tape provides a barrier against sharp edges (Fig. 9).

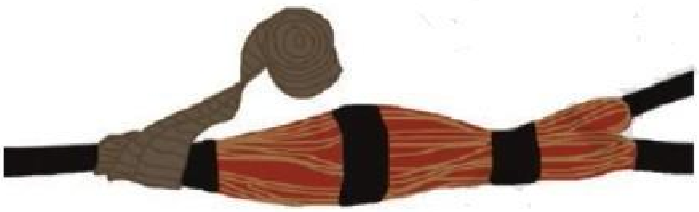


Fig. **9** *Wrapping the cable with mesh tape*

Re-establish the Over Sheath

1. Use a self fusing tape to wrap over the cable and establish the outer sheath. Start in the center and apply one layer of tape to one end, wrapping over the jacket for at least 25 mm. Apply the tape from the end towards the center so that you have two layers on each side.
2. For branch joints, wrap over the insulation for both the main and the branch cable, by at least 50mm. Bring the two together and fill it in with the insulating putty from both sides. Do this up to 25 mm away from the place where the branch and the main cables are joined.
3. Put the two cables together and bind the main and branch tightly over the filling. Finally, wrap the crotch while pulling the branch away from the main cable (Fig. 10).

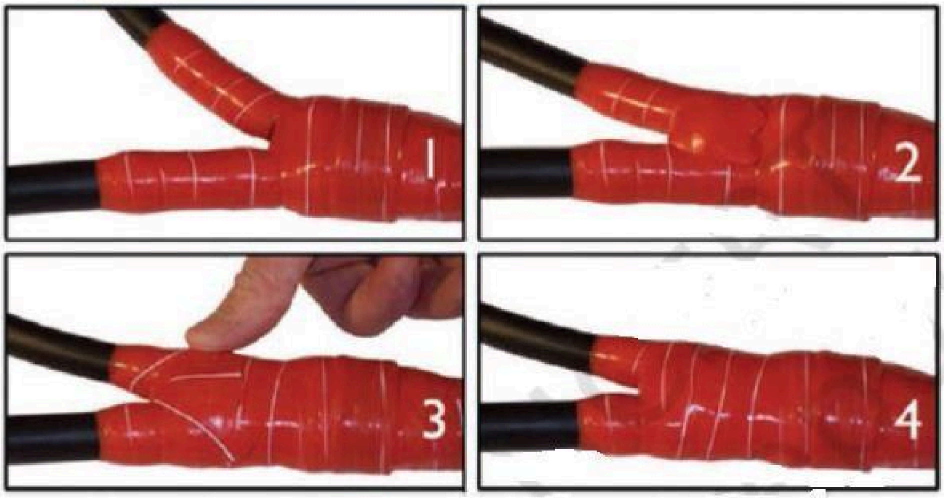


Fig. 10 Restoring the over sheath on a branch joint

Electrical Power Cable Terminations

The electrical cable termination is a cable end that connects to the terminal of the equipment or another cable to extend the length (Fig.11).

The method used for termination of the cables varies according to the type of cable, type of connector and application. Some common types of terminations are

- crimp connection
- soldered connection
- compression termination
- wire-wrapping connection
- direct connection
- loop or eye connection

Some of the factors which are considered for termination of cables are:

- Outdoor or indoor cable
- Voltage of the line
- Overhead or underground cable
- Type of connector on the equipment where the cable will be connected

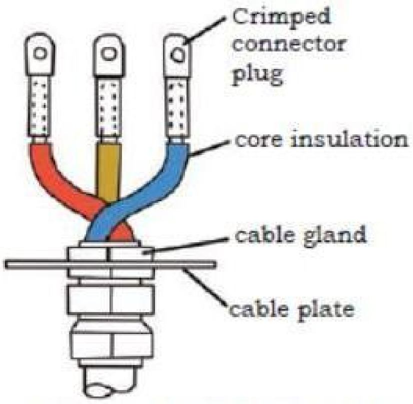


Fig. 11 Low voltage cable termination

Cable Joints

A power cable consists of two or more electrical conductors, held together wrapped with insulation and outer surface with an overall sheath (Fig. 5.13). The cables are used for transmission of electrical power. Power cables is being used for permanent wiring within buildings. The cable can be run under ground, run overhead, or exposed. Cables consist of three major components: conductors, insulation and protective jacket. The structure of individual cables varies according to application. Power cables use stranded copper or aluminium conductors, although in some cases solid conductors is used.

After the introduction of electric cables in electrical circuit the problem of how to join them together arises in order to achieve the degree of insulation, tensile and crushing strengths, conductivity and accessibility. To cope up the requirements a junction box is introduced.

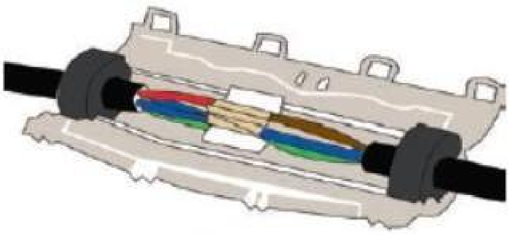


Fig. 12 Cable joint

The junction box typically incorporates:

- A method of securing the cable conductors (usually by soldering, screw-clamps or compressed ferrules).
- A method of insulation, which may be air, oil, bitumen or insulation applied in the form of tapes.
- a method of enclosure and protection applicable to the environment.

As per The Electricity Regulations every joint and connection should be mechanically and electrically suitable for its use. In this respect the joint or connection should be of proper construction as regards conductivity, insulation, mechanical strength and protection.

Joints in Non-flexible Cables

Underground cables are joined by ferrules or lugs (crimped) and the outer protection enclosure or box is usually filled with a plastic or bituminous compound. Such joints are often used above-ground for non-flexible cables and are adequately protected and supported. Other cables which are fixed wiring installations enclosed junction boxes are used to making a joint between two cables. These junction boxes are not securing the cable against strain.

Joints in Flexible Cables

Joints in flexible cables are not usually satisfactory because:

1. stranded conductors are not suitable for certain methods of jointing.

2. mechanical tensile strength and resistance are difficult to maintain.

3. fatigue damage may occur when rigid joint is being done.

Some joints and cable connectors are much more acceptable these incorporate terminals or compression fittings suitable for stranded conductors. Cable clamps are used for plugs to reduce the flexing. Heat-shrinkable or pre-stretched sleeving may be adequate in some cases but other circumstances may demand additional protection.

Types of Cable Joints and Equipment

A great majority of failure in cable network is associated with faulty cable jointing. It is, therefore, essential to use proper jointing technique, good quality insulating material and standard accessories for cable jointing.

Cable joints are of three types:

Straight through Joint

Straight through Joints are an important part of today's power cable networks (Fig. 13). These joints offer reliability and flexibility to meet the demands of cable network.

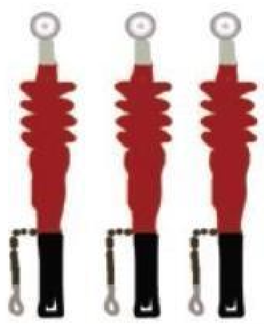


Fig. 13 Single Core Straight through Joint Kits

Straight through Joints provide

- quick cable preparation
- high electrical insulation
- no moisture ingress
- good mechanical strength
- compact dimensions and is suitable for all conductor, shape and material

Straight through Joints are made by metal joining processes, such as welding and soldering (Fig14).

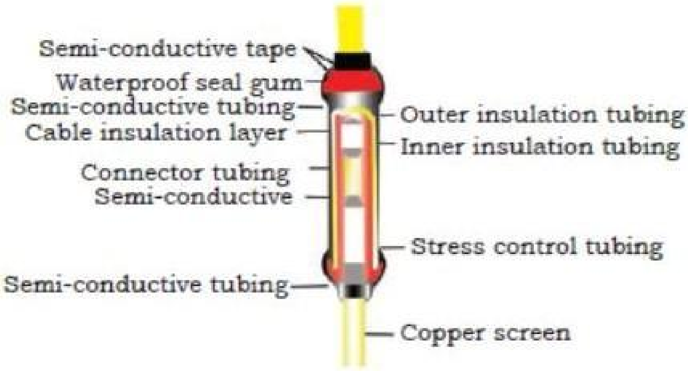


Fig. **14** *Straight through Joint*

T-Joint

These types of joints are used for branching of a service cable from a main cable. T-joints are helpful as turning and twisting of cable damages its outer core (Fig. 15).

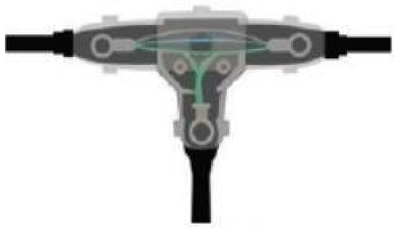


Fig. **15** *T-Joint*

Terminal Joint

These types of joints connect cable to switch gear, transformer terminal or to an overhead line (Fig. 16).

Fig. **16** *Terminal Joint*

Conductor Joint

The length of distribution lines are in kilometres and one coil of conductor is unable to solve the length problem. Hence, jointing the conductor is necessary.

Britannia Joint

This type of joint is made only on solid conductors and cannot be made on stranded conductor. Two conductors to be joined are brought in front of each other of about 6 inch (150 mm) of length. Both the conductors should be clean. If the conductor is of copper; it should make good electrical connection. Then ends of both conductors are bent through half centimetre and placed on each other. The length of contact portion should be min. 100 mm. This joint should be bound by 14 mm copper wire as shown in Fig. 17.

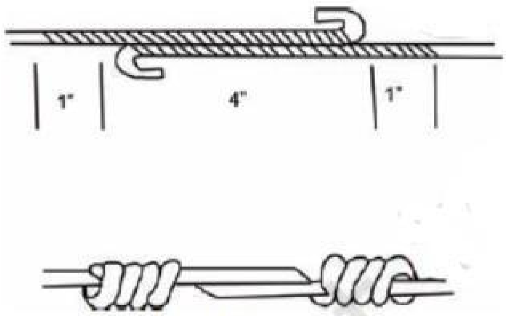


Fig. **17** *Britannia Joint*

Married Joints

This joint is made between copper conductors having central strand of GI wire (Fig. 18). It should not be made between aluminium (Al) conductors. Approximately 175 to 200 mm length conductor strands are unwound. The GI strand of both conductors should be broken up to 175 mm in length. Both conductors should be brought in front of each other and their strands should be woven in each other. The strand of one conductor is twisted on other conductor, and strand of other conductor is twisted on the first. Like wise all the strands twisted and then soldered. This is used only for small span length.

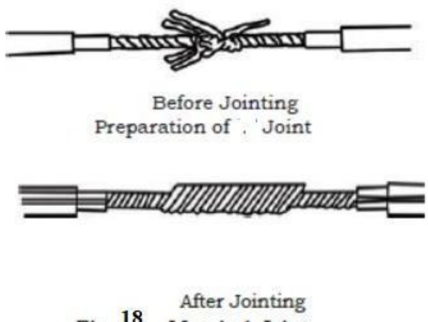
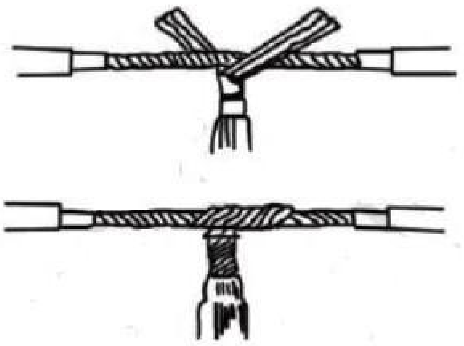


Fig. **18** *Married Joint*

Sleeve Joint

It can be made with any type of aluminium conductor. Graphite Greece is applied over the conductor and as shown in Figs. 19 and 20 sleeves should be taken. These sleeves should be placed on the onductor as shown. Sleeves should be twisted by twisting wrench. This joint is made for LT, HT, ACSR, AAC conductor up to 0.06 cm^2.



'T' Joint After Completion

Fig. 19 *'T' Joint*

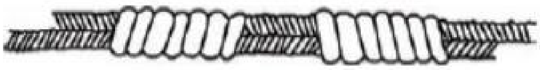


Fig. 20 *Sleeve Joint*

Compression Joint

This joint is used for conductors of more than 0.06 cm2 sizes. For jointing, two different sleeves are used. Steel sleeve is used for steel conductor strands and aluminium. sleeve is used for Al. conductor strands. There are two holes in Al. sleeve. Rebating is done through these holes. Then Al. sleeve to be mounted on one side. The length of steel sleeve is then measured. Its half distance is taken. Suppose it is 'X' cm. Then the ends which are to be joined and more to 'X' cm distance is taken on the conductor is banded there. The Al. strands are opened up to that point and cut. Steel strand should not be touched during this. They are placed in the steel sleeve. They should be kept in front of each other. Then the center of steel sleeve is compressed through compression machine. Then on the half portion of the right side sleeve be compressed and then on the left half portion. Due to compression the length of sleeve will be increased by 6mm on both sides and it will reach Al. strands. Then Al. sleeve should be measured. It should be halved. Suppose it is 'Y' cm then 'Y' cm should be measured and marked on both sides of conductor measured from center of steel sleeve. Both parts of conductor are brought in sleeve in front of each other. The filler parts should be filled in the sleeve by Grease until it comes out of the holes. Both the holes are then closed by rivets and hammered by hammer. There is one stencil mark on Al. sleeve. The first compression will be there; afterwards it will be compressed up to one end. Similarly the other part is compressed up to the other end.

Jumpering

Connecting two conductors or wires is called jumpering (Fig. 21).

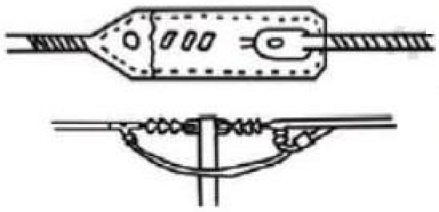


Fig. 21 *Jumpering*

Jumper should not be connected to the main conductor. The jumper should always be connected by PG clamps.

When the jumpers are near metallic portion, all such jumpers are covered with alkathane pipe.

Conductor joints are marked on ACSR conductorwhen dispatched. Mid-span joint should be made before stringing as the steel strand is not kept continuous. Hence, it is necessary to replace the company joint. Care should be taken that mid-span joint is not less than 40 ft. from pole. Every joint should be done carefully.

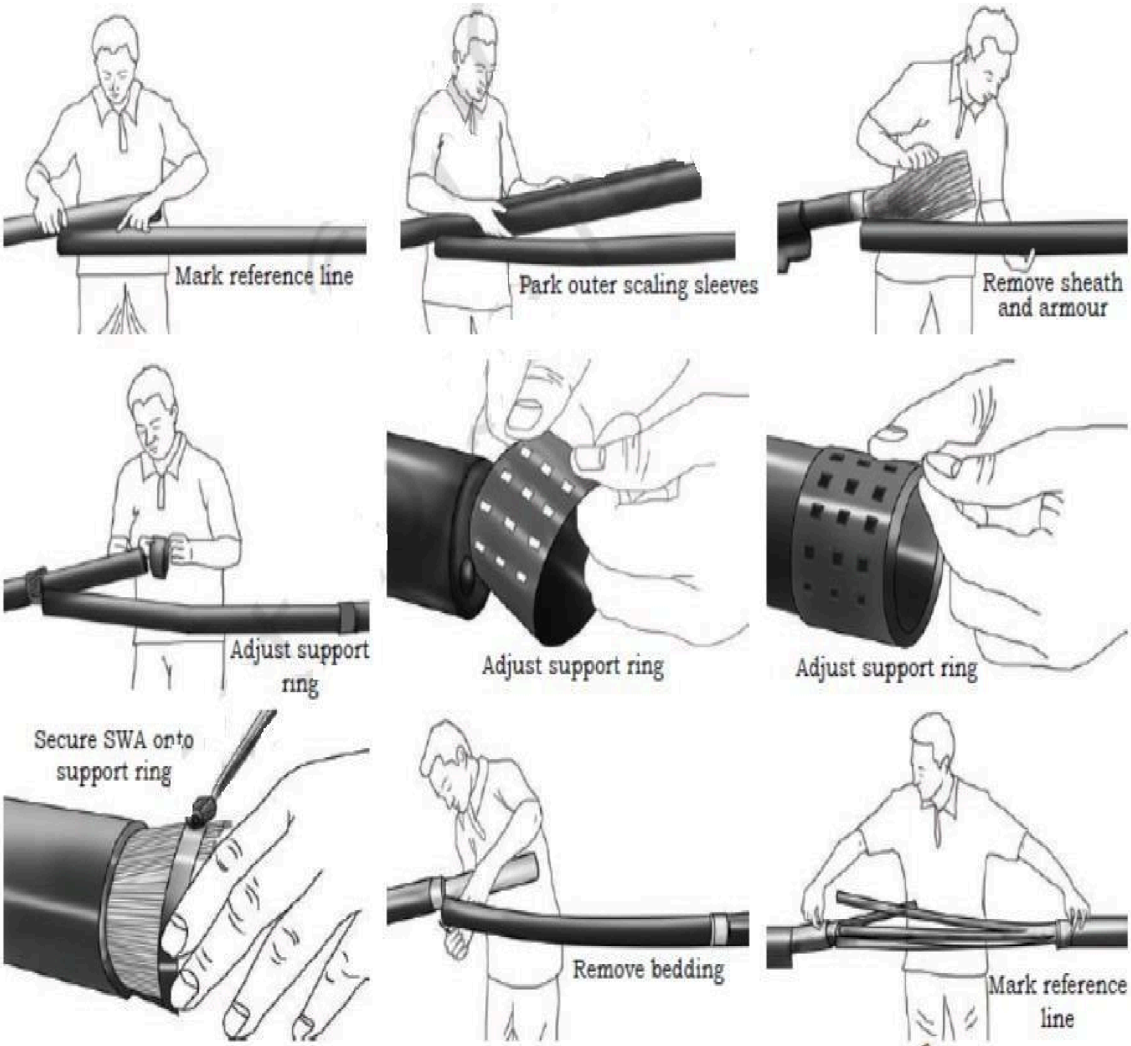
Where conductor strands are cut, repair sleeve is used. Conductor joint strength should be 95% that of conductor, and resistance should be that of a main conductor.

HV Cable Jointers Tools

Using the correct cable tools to prepare industrial and utility cables before cable jointing and terminating reduces catastrophic cable failures. Some of the important cable jointer tools include:

- Cable cutting tool
- Cable crimping tool (hydraulic, battery, ratchet) copper/aluminium cables
- Cable spiking tools for LV-HV cables (cartridge/ hydraulic)
- Heat shrink gas torches for LV-HV jointing
- Screen scoring tools for bonded/easy peel HV cables
- Outer sheath stripping tools, LV-HV cables
- Insulation (XLPE) stripping tools, HV cables
- Insulated tools for live-working
- Cable laying rollers, socks, jacks and pulling equipment
- Conduit duct rods

Procedure for Heat Shrink Straight through Joint




Cut cores at reference line


Remove copper tape shield

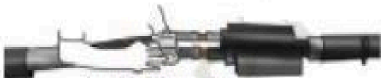

File screen cut


Remove conductive layer


Remove insulation


Shrink stress control tubing

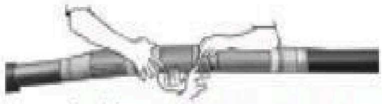

Park insulation tubing

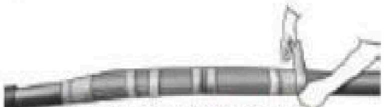

Apply filler putty


Apply stress control patch


Position insulation tubing


Apply copper mesh shielding


Position and secure armour case


Protect protruding edges

EX No :2

Date:

Practice cable bending, stripping, crimping, connecting sockets and cable jointing.

Aim: To study about cable bending, stripping, crimping socket and cable jointing

Materials required:

Sl no	Description	Specification	Quantity	Remarks

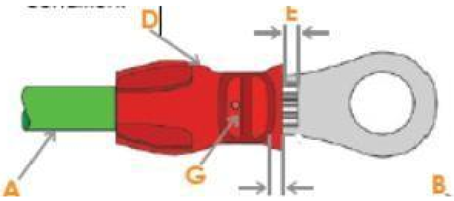
Tools required:

Sl no	Name of tool	Quantity

Procedure:

Crimping Procedure

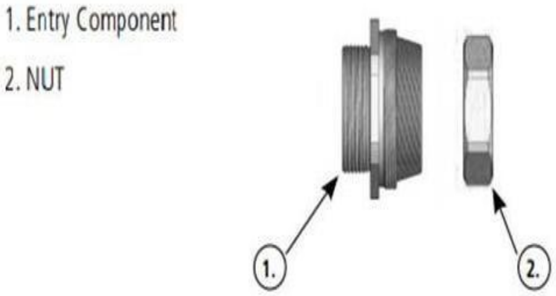
1. Cut wire to length, cleanly. Strip wire ends, ensuring the insulation is removed cleanly and square with axis, with no breaking or nicking of wire ends visible.
2. Use the recommended stripped length appropriate to the connector being used, ensuring all strands are inserted into the crimp barrel.
3. Ensure the selected crimp die form is suitable for the correct combination of wire size and connector being used.
4. Insert conductor, stripped, to a length which leaves approximately 1mm visible at front of barrel
5. Position in die such as to leave approximately 1mm of barrel to form a bell mouth at the front of the barrel.
6. Check the correct Dot Code is being used. Ensure the tool and dies are calibrated and maintained in a serviceable condition.

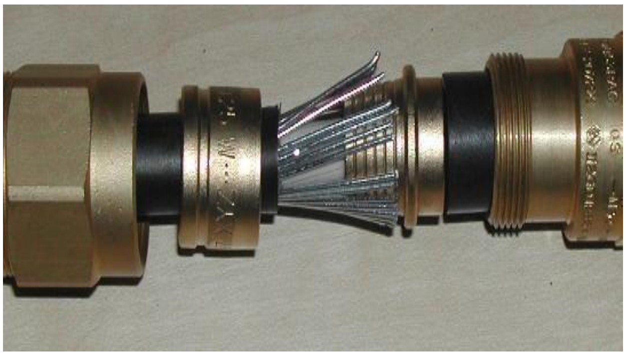


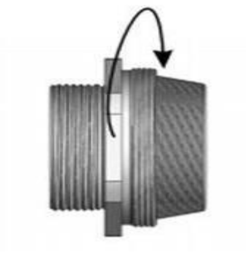
Cable glanding

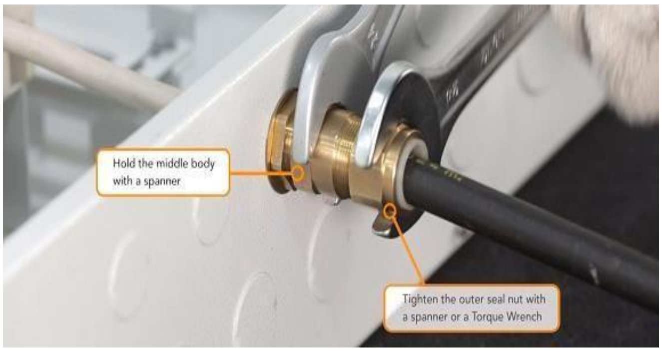
To start the cable gland installation

1. Detached components (1) and (2).
2. If needed, fit a shroud over your outer cable
3. Manage the cable by eliminating the cable outer sheath and the armor/braid to fit the geometry of the equipment.
4. Take away 18 millimeters further of the outer sheath to reveal the armor.
5. If applicable, get rid of any wrappings or tapes to show the inner sheath.
6. Then, secure the entry component into your equipment as shown.
7. Pass your cable through the entry item and space the armor or braid evenly around the cone.
8. While keeping to push the cable forward to prevent contact between the cone and the armor, tighten the nut by hand to engage the armor.
9. Hold the entry component along with a spanner and tighten the nut with the help of a spanner 'til the armor is secured.
10. The installation is now complete.









Result :

CO3 Develop different types of starters for induction motors and demonstrate the maintenance of different motors

<u>Magnetic control system</u>

The starting and stopping of a motor by using control devices like push buttons, contactors and over-load relays, we are in a position to discuss the advantages of magnetic control over the manual control. The various advantages are listed as follows:

1) Magnetic control permits installation of power contacts close to motor whereas the actuating control device i.e., a push button switch could be located away from the motor in a position most convenient to the operator.

2) Magnetic control provides safety to the operator as remote operation described above minimizes the danger to the operator of coming into accidental contact with live parts or being exposed to power arc and flashes at the main contacts.

3) The most important advantage of magnetic control is the elimination of dependence on operators' skill for control of motor performance. Current and torque peaks could be limited thus resulting in less wear and less maintenance.

4) Magnetic control also makes interlocking (to be discussed later) between various operations of a multi motor drive easy. The various operations can be performed in the desired sequence automatically.

5) With the demand for more production in industry, it became necessary to atomize the machinery to meet the challenge. Today in our industrial plants most of the machines are automatic. Once the machine is started most of the operations are carried out automatically.

What is Contactor : Construction, Types and Applications

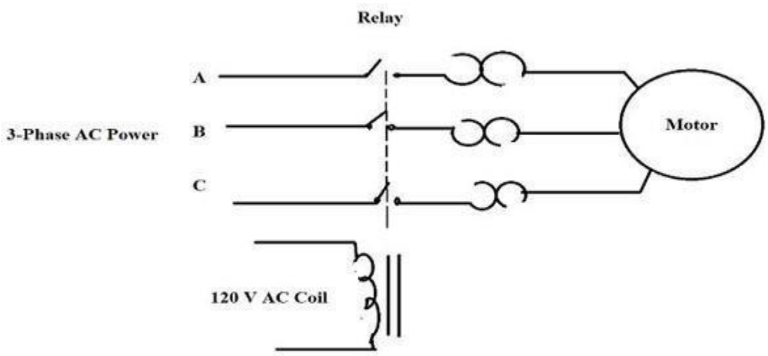
A contactor is one of the main electrical circuit parts, which can stand on its own power control device or a part of a starter. They are used to connect and break power supply lines running through power lines or repeatedly establish and interrupt electrical power circuits. These are used in light loads, complex machine control. They are used with motors, transformers, heaters. It can be considered as an intersection point between the control circuit and power circuit because it is controlled by the control circuit, it also controls the circuit between power and loads. This article focuses on the importance of contactor in and electric field.

What is Contactor?

Definition: Contactors are electrically controlled switching devices which are used for switching electrically. The basic operation of this is similar to a relay, but the only difference is that contractors can carry large current compared to relay up to 12500A. They cannot provide short circuit or overload protection but can break the contact when coil excites.

Construction of a Contactor

The contactor consists of two iron cores, where one is fixed and the other one is the movable coil and it is an insulated copper coil. Where the copper coil is located on the fixed core. There are six main contacts for power connection, where three are fixed cores and the other three are movable cores. These contacts are made from pure copper, and the contact points are made from special alloy to withstand high starting current and temperature. A spring which is located between coil and the movable core, auxiliary contacts it could be normally open or closed. The main contacts cut on and off the light current loads such as contactors coil, relays, timers, and many other control circuit parts are linked to contact mechanism. A three-phase AC power supply provided to the circuit which is shown below,



It consists of three main parts they are

Coil

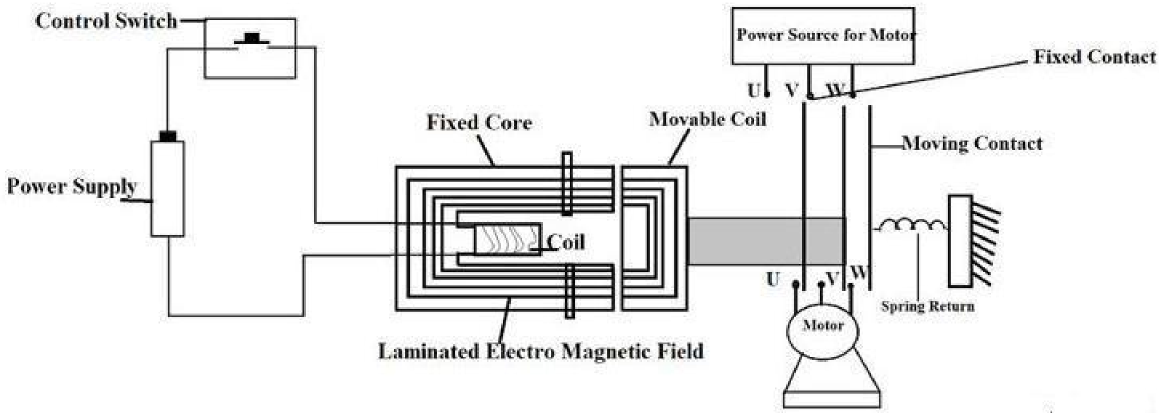
It provides a force which is required to close the contact. The coil is also named as an electromagnet. An enclosure is used to safeguard the coil and contactor.

Enclosure

It acts like an insulator and protector, which protects the circuit form any electrical contact, dust, oil, etc. They are made up of different materials like Nylon 6, Bakelite, Thermosetting plastic, etc.

Contacts

The main function of this is that it carries the current to various parts of the circuit. There are classified into contact springs, axillary contacts, and power contacts. Where each of the contacts has its own functions, which is explained in principle of operation of the contactor.



Block-Diagram-of-Contactor

Working Principle of Contactors

An electromagnetic field is generated whenever current flows where the moving coils attract each other. A large amount of current is drawn initially by an electromagnetic coil. The moving contact is pushed forward by moving core, as a result, the force created by the electromagnet holds the moving and fixed contacts together.

On de-energizing, the contactor coil gravity or spring moves back the electro-magnetic coil to its initial position and there is no flow of current in the circuit.

If contactors are energized with AC current, a small portion of the coil is the shaded coil, where the magnetic flux in the core is slightly delayed. This effect is too average as it prevents the core from buzzing at twice line frequency. There are internal tipping point processes to ensure rapid action so that contactors can open and closed very rapidly.

From the figure the supply is given using a switch, that is when the switch is closed current flows through the contactor coil and attaches the moving core. The contactor attached to the moving core closes and the motor starts running. When the switch is released the electromagnetic energizes spring arrangement pause the moving coil back to its initial position and power supply to the motor is cut off.

How to Choose a Correct Replacement for a Contactor?

A correct replacement for this can be chosen as follows

Firstly, one should check the coil voltage, which is a voltage used to energize the contactor.

Checking for auxiliary contacts available, that is how many open and closed nodes are used in the contactor.

Checking the rating which is mentioned in a table format on it.

ARC suppression concept arises whenever the contacts are open or closed. If there is a heavy load breakdown, an arc that is formed damages the contacts. Along with it if the temperature is high the arc causes harmful gases like carbon monoxide which leads to a reduction of the lifetime of motors.

Types of Contactors

These are classified based on three factors they are

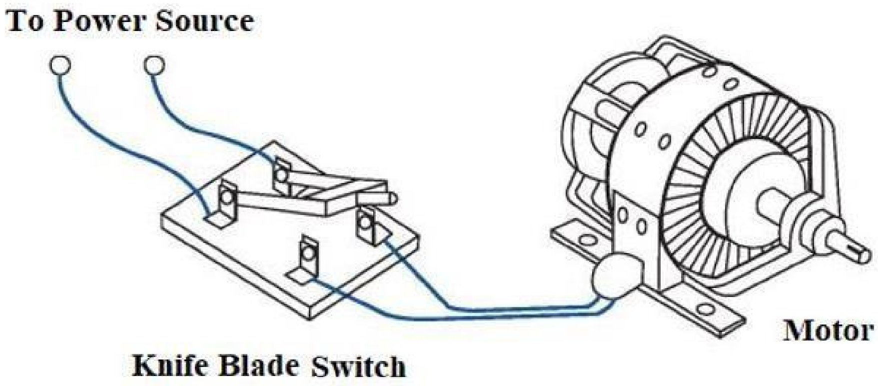
The load being used

The current capacity and

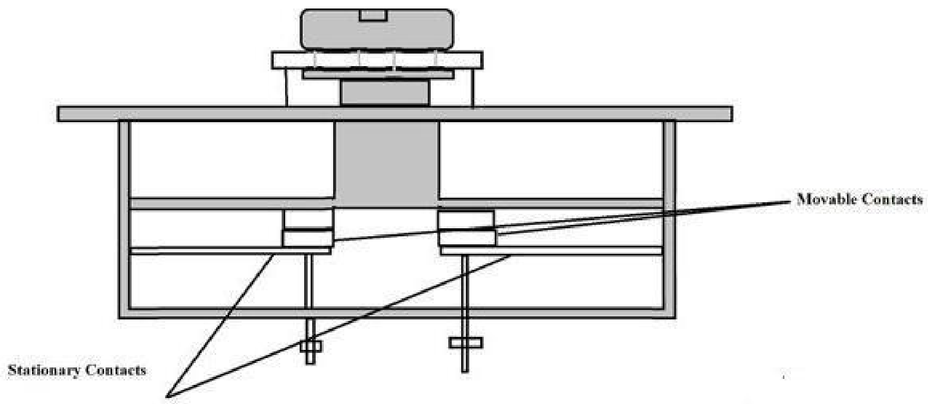
The power rating.

Knife Blade Switch

It is the first contactor used to control an electric motor in the late 1800s. It consists of a metal strip, which acts as a switch in connecting and disconnecting the connection. But the disadvantage of this method is that it switching process if very fast, due to which corrosion occurs in the copper material, depending on the capacity of current the size of the motor is increased which leads to high physical damage.



Manual Contactor



The disadvantages of knife blade contractors are overcome using a manual contactor. Some of the features of these are,

The operation performed is safe

They are properly encased in order to protect from external environment problem

The size of the manual connector is small

Only a single break is used

The switches are controlled using a contactor.

Magnetic Contactor

It operates electromagnetically that is it can be operated remotely, less amount of current is enough to make a connection and remove the connection. It is the most advanced contactor.

The difference between AC and DC contactor are as follows,

AC Contactors	DC Contactors
They are designed for the contactors with self-extinguishing arc is drawn whenever the contact opens	They are specially designed to suppress electrical arching when there is switching in the DC circuit
They don't use freewheel diode	They use freewheel diode
Separation time is less	Separation time is higher if the load is heavy a shunt load is attached to the main contact.

Advantages

The following are the advantages of the contactor

Fast switching operation

Suitable for both AC and DC devices

Simple in construction.

Disadvantages

The following are the disadvantages of the contactor

In the absence of magnetic-filed, the coil may burn

Aging of components causes corrosion of materials when exposed to moister.

Applications of Contactors

The following are the application of contactors

It controls lighting

Magnetic starter

Vacuum contactor

. What is the difference between a relay and a contactor?

The main difference between a relay and a contractor is

that,

Relay	Contactor
A relay is used for low voltage switching purpose	It is used for high voltage switching purpose
The relay contactor is similar to the axillary contactor.	There are two types of contactors auxiliary and power
The size of the relay is small	The size of the contactor is large
Cannot be repaired	Can be repaired

2. What is a contactor used for?

It is a switch used to switch high power load and protect the motor from external damage.

3). What is a normally closed contactor?

A normally closed contactor can be represented as NC, which means the connection is made and the circuit is normally on.

4). How do you wire a 3 phase contactor?

The connection of three-phase contactor is made as follows

Disconnect the power supply

The three colored phase wires are connected to three terminals T1, T2, T3 of machine

Connect the power supply and allow the current to flow.

5). How do you size a contactor?

The size of this is a product of 100% and full load current.

BASIC COMPONENTS FOR CONTROL CIRCUITS

Introduction

Industrial control, in its broadest sense, encompasses all the methods used to control the performance of an electrical system. When applied to machinery, it involves the starting, acceleration, reversal, deceleration, and stopping of a motor and its load. In this section we will study the electrical (but not electronic) control of 3-phase alternating current motors. Our study is limited to elementary circuits because industrial circuits are usually too intricate to explain briefly. However, the basic principles covered here apply to any system of control, no matter how complex it may appear to be.

Control devices

Every control circuit is composed of a number of basic components connected together to achieve the desired performance. The size of the components varies with the power of the motor, but the principle of operation remains the same. Using only a dozen basic components, it's possible to design control systems that are very complex. The basic components are the following:

1. Disconnecting switches
2. Manual circuit breakers
3. Cam switches
4. Pushbuttons
5. Relays
6. Magnetic contactors
7. Thermal relays and fuses
8. Pilot lights
9. Limit switches and other special switches
10. Resistors, reactors, transformers, and

capacitors BASIC COMPONENTS FOR CONTROL

CIRCUITS

Disconnecting switches

Three-phase, fused disconnecting switch rated 600V, 30A. A disconnecting switch isolates the motor from the power source. It consists of 3 knife-switches and 3 line fuses enclosed in a metallic box. The knife-switches can be opened and closed simultaneously by means of an external handle. An interlocking mechanism prevents the hinged cover from opening when the switch is closed. Disconnecting switches (and their fuses) are selected to carry the nominal full- load current of the mo tor, and to withstand short-circuit currents for brief intervals.

Manual circuit breakers

A manual circuit breaker opens and closes a circuit, like a toggle switch. It trips (opens) automatically when the current exceeds a predetermined limit. After tripping, it can be reset manually. Manual circuit breakers are often used instead of disconnecting switches because no fuses have to be replaced.

Cam switches

A cam switch has a group of fixed contacts and an equal number of moveable contacts. The contacts can be made to open and close in a preset sequence by rotating a handle or knob. Cam switches are used to control the motion and position of hoists, callenders, machine tools, and so on.

Push-buttons

A pushbutton is a switch activated by finger pressure.

AB Push Buttons, 30 mm NEMA

Two or more contacts open or close when the button is depressed. Push-buttons are usually spring loaded so as to return to their normal position when pressure is re moved.

--4. Mechanical-interlocked push buttons with NO (normally open) and NC (normally closed) contacts; rated to interrupt an ac current of 6 A one million times.

Control relays

A control relay is an electromagnetic switch that opens and closes a set of contacts when the relay coil is energized. The relay coil produces a strong magnetic field which attracts a movable armature bearing the contacts.

Control relays are mainly used in low-power circuits.

Siemens The 3TG10 power relays come as the ideal solution for all applications requiring small, low-noise relays or contactors at low costs. The power relays are suitable for basic controls and particularly for use in large-scale series devices and controls. They are ideal for applications which require only one auxiliary contact and no overload relay – and place increased requirements upon switching capacity, switching voltage and service life.They include time- delay relays whose contacts open or close after a definite time interval. Thus, a time-delay closing relay actuates its contacts after the relay coil has been energized. On the other hand, a time-delay opening relay actuates its contacts some time after the relay coil has been de- energized.

--5. Single-phase relays: 25A, 115/230V and 5A, 115V.

Thermal relays

A thermal relay (or overload is a temperature sensitive device whose contacts open or close when the motor current exceeds a preset limit. The current flows through a small, calibrated heating element which raises the temperature of the relay. Thermal relays are inherent time-delay devices because the temperature cannot follow the instantaneous changes in current.

Magnetic contactors

A magnetic contactor is basically a control relay designed to open and close a power circuit. It possesses a relay coil and a magnetic plunger, which carries a set of movable contacts. When the relay coil is energized, it attracts the magnetic plunger, causing it to rise quickly against the force of gravity. The movable contacts come in contact with a set of fixed contacts, thereby closing the power circuit. In addition to the power contacts, one or more normally open or normally closed auxiliary contacts are usually available, for control purposes. When the relay coil is de-energized, the plunger falls, thereby opening and closing the respective contacts. Magnetic contactors are used to control motors ranging from 0.5 hp to several hundred horsepower. The size, dimensions, and performance of contactors are standardized.

Pilot lights

A pilot light indicates the on/off state of a remote component in a control system.

--8. Pilot light, 120 V, 3 W mounted in a start-stop push button station. (Siemens)

Limit switches and special switches: A limit switch is a low-power snap-action device that opens or closes a contact, depending upon the position of a mechanical part. Other limit switches are sensitive to pressure, temperature, liquid level, direction of rotation, and so on.

--9a Limit switch with one NC contact; rated for ten million operations; position accuracy: 0.5 mm. (Square D)

--9b Liquid level switch. (Square D)

Proximity detectors: Proximity detectors are sealed devices that can detect objects without coming in direct contact with them.

Their service life is independent of the number of operations. They are wired to an external dc source and generate an alternating magnetic field by mean" of an internal oscillator. When a metal object comes within a few millimeters of the detector, the magnetic field decreases, which in turn causes a dc control current to flow. This current can be used to activate another control device, such as a relay or a programmable logic controller.

Capacitive proximity detectors, based on a similar principle but generating an ac electric field, are able to detect non-metallic objects, including liquids.

--10 Proximity detector to monitor the loading of a conveyor belt (Telemecanique, Groupe Schneider)

In order to understand the sections that follow the legends should be read before proceeding further.

Normally open and normally closed contacts

Control circuit diagrams always show components in a state of rest, that is, when they are not energized (electrically) or activated (mechanically). In this state, some electrical contacts are open while others are closed. They are respectively called normally open contacts (NO) and normally closed contacts (NC) and are designated by the following symbols: normally open contact (NO) normally closed contact (NC)

Relay coil exciting current

When a magnetic contactor is in its de-energized or open position, the magnetic circuit has a very long air gap, compared to when the contactor is closed.

Consequently, in the case of an ac contactor the inductive reactance of the relay coil is much lower when the contactor is open than when it's closed.

Because the coil is excited by a fixed ac voltage, the magnetizing current is much higher in the open than in the closed contactor position. In other words, a considerable inrush current is drawn by the relay coil at the moment it's excited. This places a heavier than expected duty on auxiliary contacts that energize the coil.

Control diagrams

A control system can be represented by four types of circuit diagrams. They are listed as follows, in order of increasing detail and completeness:

- block diagram
- one-line diagram
- wiring diagram
- schematic diagram

Inching and jogging

In some mechanical systems, we have to adjust the position of a motorized part very precisely. To accomplish this, we energize the motor in short spurts so that it barely starts before it again comes to a halt.

A double-contact pushbutton J is added to the usual start/stop circuit. This arrangement permits conventional start-stop control as well as jogging, or inching. The following description shows how the control circuit operates.

If the jog button J is in its normal position (not depressed) relay coil A is excited as soon as the start button is depressed. Sealing contact Ax in the main contactor closes and so the motor will continue to turn after the start button is released. Thus, the control circuit operates in the same way.

Suppose now that the motor is stopped and we depress the jog button. This closes contacts 3, 4 and relay coil A is excited. Contact Ax closes, but contacts 1, 2 are now open and the closure of Ax has no effect. The motor will pick up speed so long as the jog button is depressed. However, when it's re leased, coil A will become de-energized and contactor A will drop out, causing Ax to open. Thus, when contacts 1, 2 are again bridged, the motor will come to a halt. Thus, by momentarily depressing the jog button we can briefly apply power to the motor.

Jogging imposes severe duty on the main power contacts A because they continually make and break currents that are 6 times greater than normal.

It's estimated that each impulse corresponds to 30 normal start-stop operations. Thus, a contactor that can normally start and stop a motor 3 million times, can only jog the motor 100000 times, because the contacts have to be replaced. * Furthermore, jogging should not be repeated too quickly, because the intense heat of the breaking arc may cause the main contacts to weld together. Repeated jogging will also overheat the motor. When is required, the contactor is usually selected to be one NEMA size larger than that for normal duty.

Plugging

We have already seen that an induction motor can be brought to a rapid stop by reversing two of the lines (Section 14.8). However, to prevent the motor from running in reverse, a zero-speed switch must open the line as soon as the machine has come to rest. The circuit of ---24a shows the basic elements of such a plugging circuit.

The circuit operates as follows:

1. Contactor A is used to start the motor. In addition to its 3 main contacts A, it has 2 small auxiliary contacts Ax I and

2. The start pushbutton has one NO contact 1, 2 and one NC contact 3, 4 which operate together. Thus, contact 3, 4 opens before contact 1, 2 closes.

3. Contactor B is used to stop the motor. It’s identical to contactor A, having 2 auxiliary contacts Bx_1 and Bx_2 in addition to the 3 main contacts B.

4. The stop pushbutton is identical to the start pushbutton. Thus, when it’s depressed contact 7, 8 opens before contact 5, 6 closes.

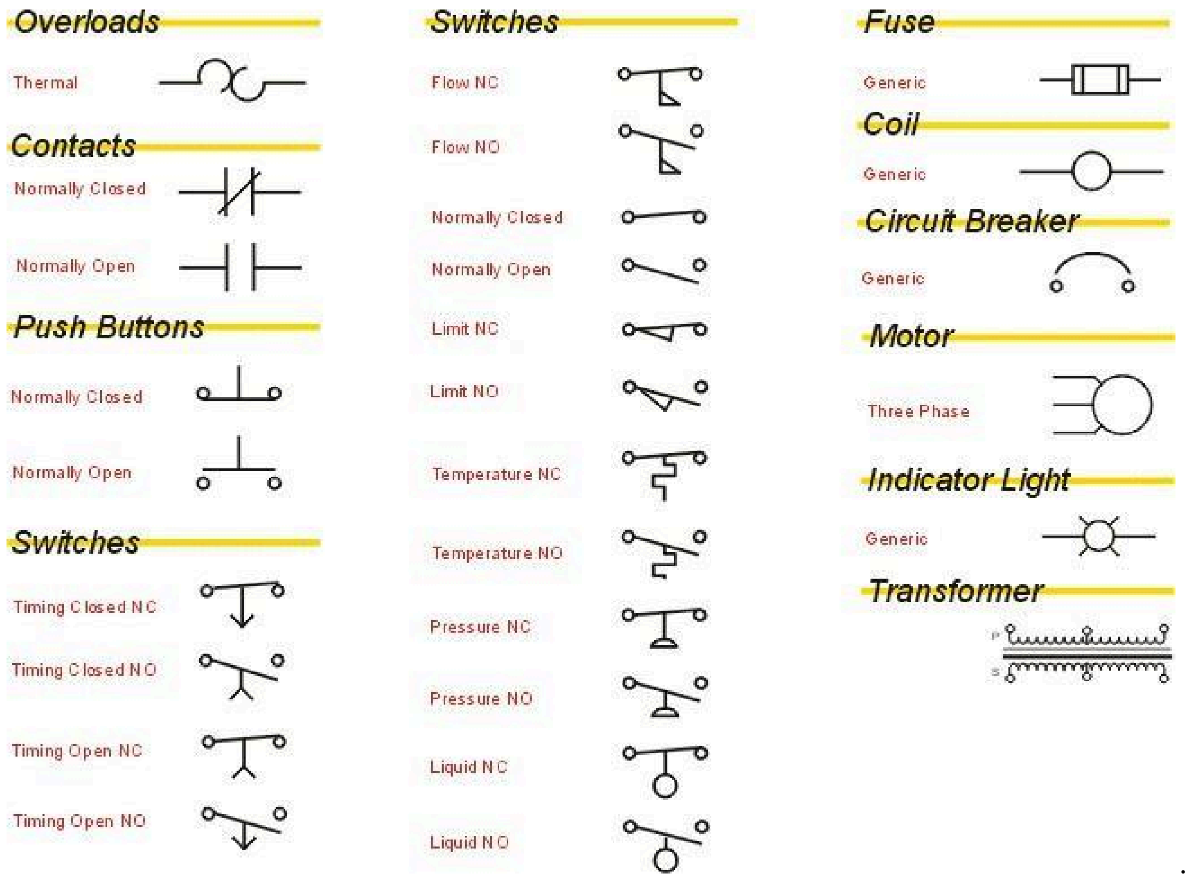
5. Contact F-C of the zero-speed switch is normally open, but it closes as soon as the motor turns in the forward direction. This prepares the plugging circuit for the eventual operation of coil B.

6. Contacts Ax 1 and Bx 1 are sealing contacts so that pushbuttons A and B have only to be pressed momentarily to start or stop the motor.

7. Contacts Ax2 and Bx2 are electrical interlocks to prevent the relay coils A and B from being ex cited at the same time. Thus, when the motor is running, contact Ax2 is open. Consequently, relay coil B cannot become excited by de pressing pushbutton B until such time as contactor A has dropped out, causing contact Ax_1 to reclose.

Several types of zero-speed switches are on the market and ---24b shows one that operates on the principle of an induction motor. It consists of a small permanent magnet rotor N, S and a bronze ring or cup supported on bearings, which is free to pivot between stationary contacts F and R. The permanent magnet is coupled to the shaft of the main motor. As soon as the motor turns clockwise, the permanent magnet drags the ring along in the same direction, thereby closing contacts F-C. When the motor stops turning, the brass ring returns to the off position. Because of its function and shape, the ring is often called a drag-cup.

--24c shows another zero-speed switch that operates on the principle of centrifugal force.

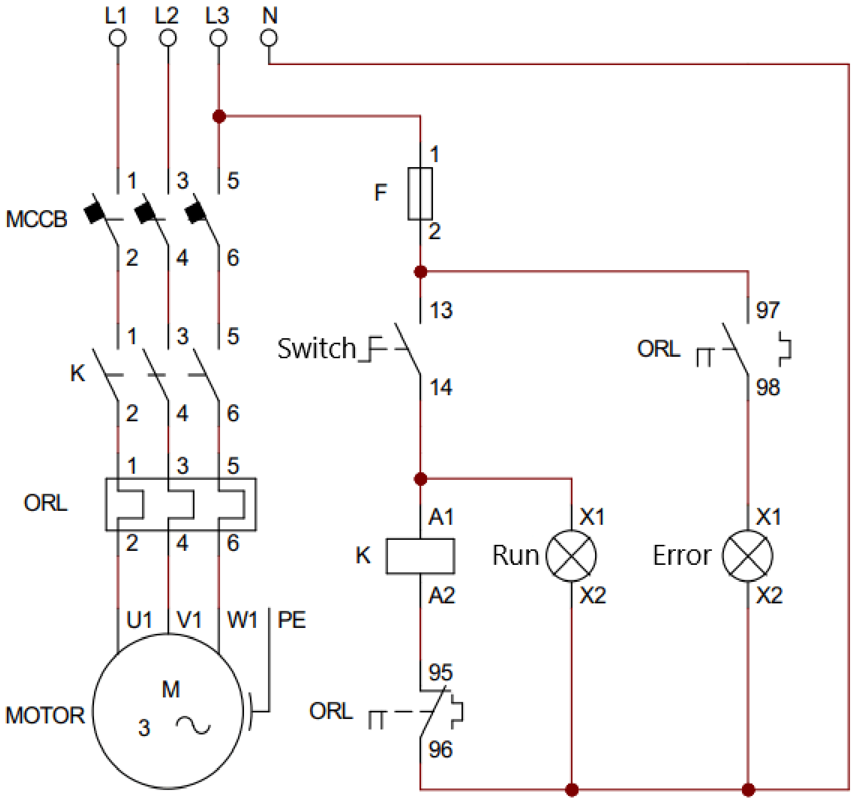


Important control circuits

1. Use of one push button for both starting and stopping
2. Use of separate pushbuttons for starting and stopping
3. Multiple push button stations
4. Push button interlocking
5. Automatic sequence control
6. Automatic sequence control with time delay
7. Direct on Line (DOL) starting of a three phase induction motor
8. Direct reversing of a three phase induction motor
9. Two speed motor control
10. Forward reverse operation with remote control facility
11. Semi automatic star delta starter for a three phase induction motor
12. Automatic star delta starter for a three phase induction motor
13. Plugging of induction motor
14. Dynamic braking
15. Regenerative braking

Use of one push button for both starting and stopping

One push button with ON contact can be used to energies and de-energise a contactor. As long as the pressure on the push button is held, the contactor will remain energized, its contact will operate and through its main contacts the motor will be provided with supply. Both the control circuit and the power circuit have been shown separately in figure. The motor is stopped by withdrawing the pressure on the push button. Such an operation is called *inching* , as is done in control of an overhead crane driven by a motor. The operator has the push button control in his hand and he controls the movement of the crane with precision.



3. **Use of separate pushbuttons for starting and stopping**

Wiring diagram

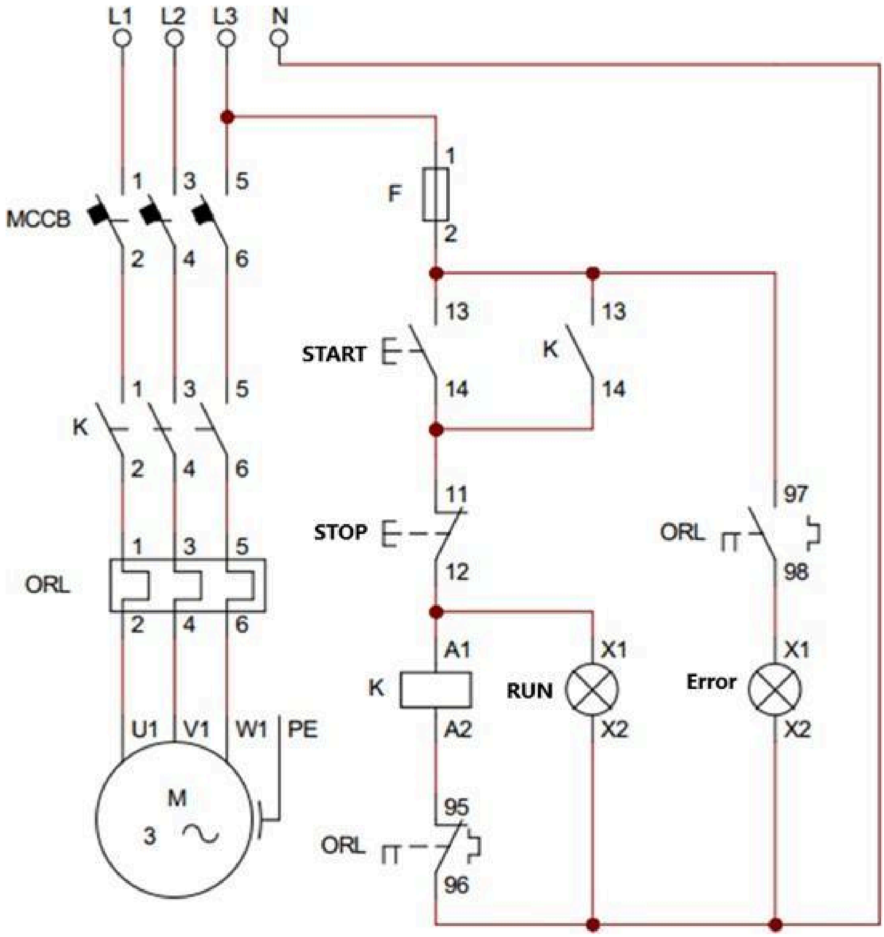
The 2-position switch is replaced by a normally open button Start in series with a normally closed button Stop. Auxiliary contact K is connected in parallel with the Start button to replace this button after it returns to its original state.

When we press the Start button, the control circuit is closed and the contactor is energized. The main contact and the auxiliary contact of contactor K will close. And the Motor is supplied with 3 phase power and starts to rotate.

After releasing the Start button to return to the open state, current flows through the auxiliary contact K, through the coil K. When we press the Stop button, the control circuit is open. So the contactor loses power, causing the motor to lose connection to the 3-phase voltage.

When the motor is overloaded, the current through the thermal relay is higher than the rated current. The bimetallic strip inside the thermal relay gets heated, changing its contact state.

The ORL contact (95 96) switches from normally closed to normally open, so contactor coil K is no longer energized. At the same time, the ORL contact (97 98) is closed, the Error indicator light is on.



4. Multiple push button stations

Circuits controlling a motor in two locations can place the controllers in two different places. The motor can control start and stop in both positions.

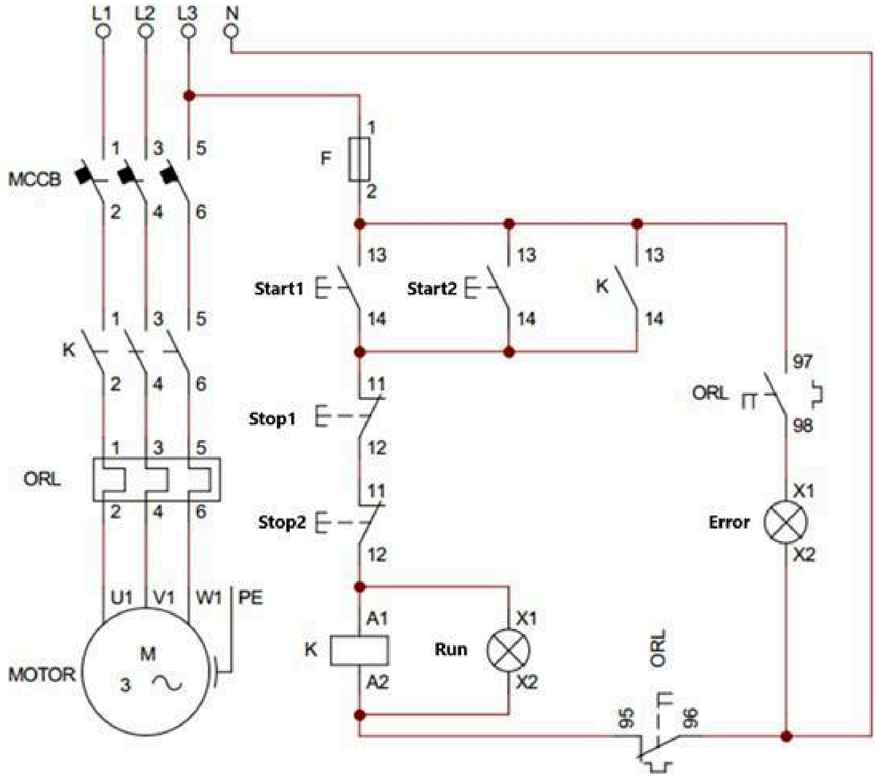
Wiring diagram

Using two normally open push buttons: Start1, Start2 connected in parallel with each other and parallel to the auxiliary contact K.

Two normally closed buttons: Stop1, Stop2 connected in series.

Working principle: When we press Start1 or Start2, the control circuit is closed and the motor operates.

When we press the Stop1 or Stop2 button, the control circuit is open circuit, the motor stops working.

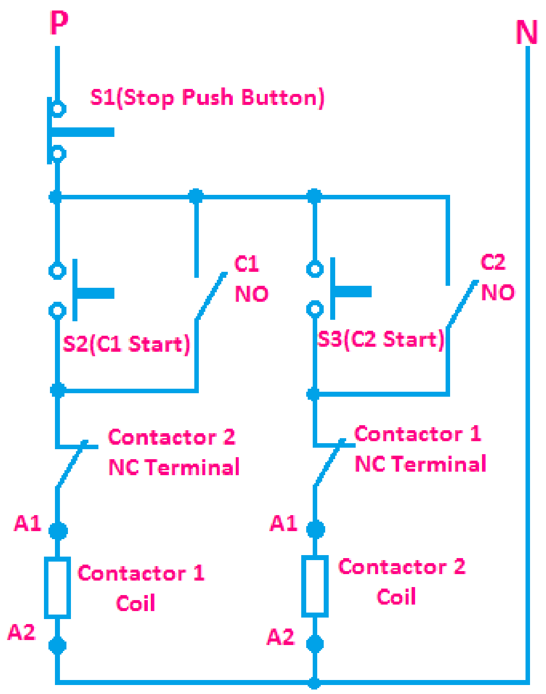


5. Push button interlocking

As per the above control diagram, you can see the coil of contactor 1 is connected through the NC points of contactor 2 and the coil of contactor 2 is connected through the NC points of contactor 1.

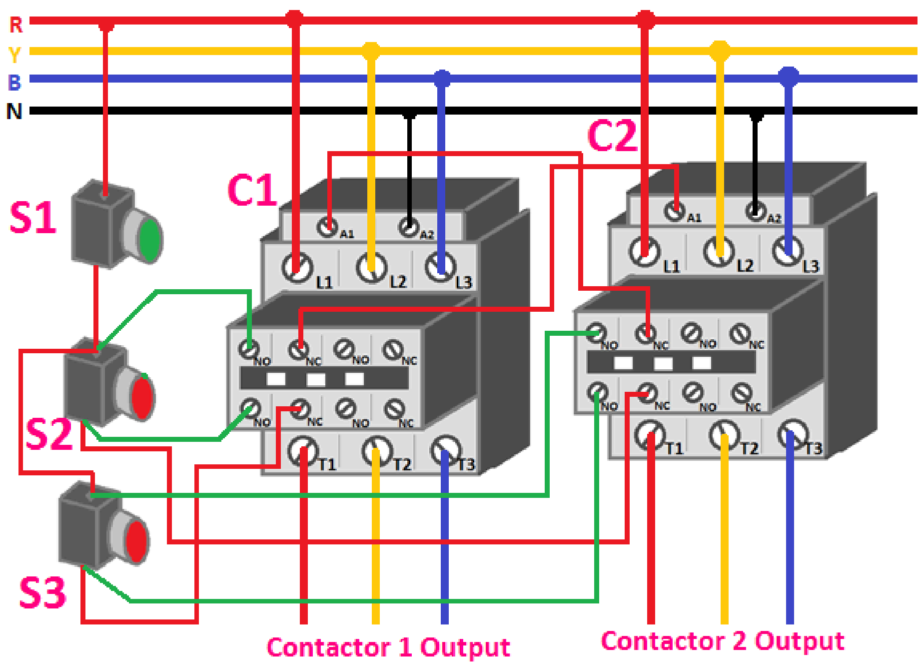
So when contactor 1 is in ON condition, its NC contacts become open so contactor 2 can not be turned on even if we push the switch S2 to turn on contactor 2 manually.

When contactor 2 is in ON condition, its NC contacts become open so contactor 1 can not be turned on even if we push the switch S1 to turn on contactor 1 manually.



Contactor Interlocking Circuit Control Diagram

Contactor Interlocking Circuit:



S1 = Stop Push Button, S2 = Contactor 1 Start, S3 = Contactor 2 Start

6. Sequential control circuit using push button

Sequential circuit diagram using 3 sets of ON and OFF buttons to control the motor to run and stop.

In the power circuit, each motor is connected to a separate contactor. And is protected from overload by thermal relay.

Set of push buttons ON1, OFF1 to control motor 1.

Set of push buttons ON2, OFF2 in series with ON1 push button to control motor 2

Two push buttons ON3, OFF3 in series with push buttons ON1, ON2 to control motor 3.

Working principle

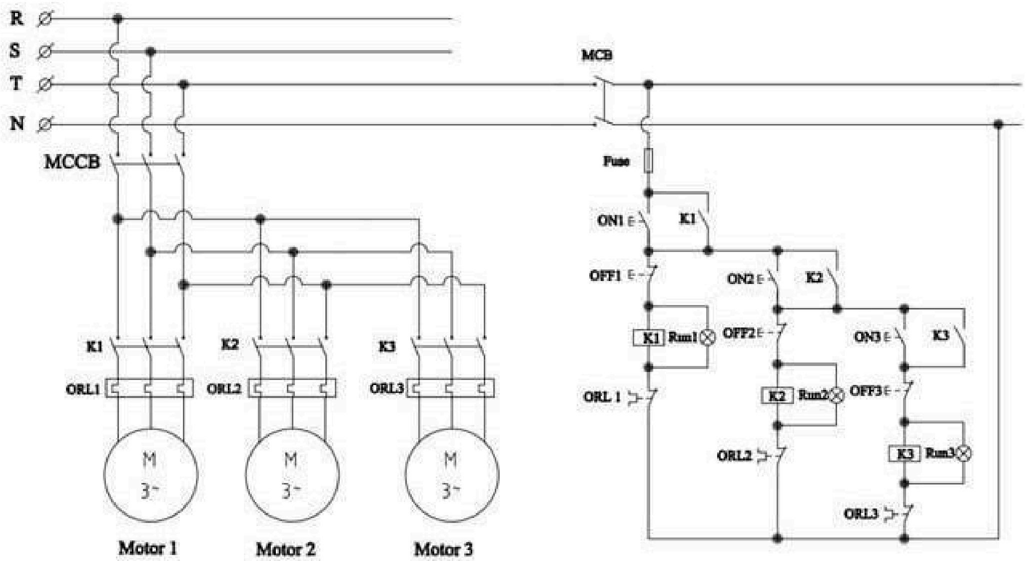
Motor 2 and motor 3 can only work when motor 1 is running, and motor 3 can only run when motor 2 is running.

When ON1 is pressed, contactor K1 is energized, changing the state of the contacts of the contactor. The main contact of contactor K closes to supply power to motor 1. At the same time, the normally open contact K1 closes to keep the circuit closed after the ON1 push button returns to the open state.

Contact K1 is closed so motor 2 is ready to operate when we press the ON2 button.

Similarly, when motor 2 is operating, if we press the ON3 button, motor 3 will run immediately.

We press OFF3 button to stop motor 3, press OFF2 to stop motor 2 and motor 3. And when we press OFF1 button to stop motor 1, 2, 3.



7. Control circuit using timer

Wiring diagram of a sequential motor control circuit using timer

Wiring diagram for sequential control circuit that switches automatically using only one set of ON, OFF push buttons.

The coil of timer T1 will connect the coil of contactor K2 in parallel. And timer coil T1 is in series with normally closed contact K2. Therefore, when contactor K2 is energized, the timer will be disconnected from the power supply but contactor K1 is still active.

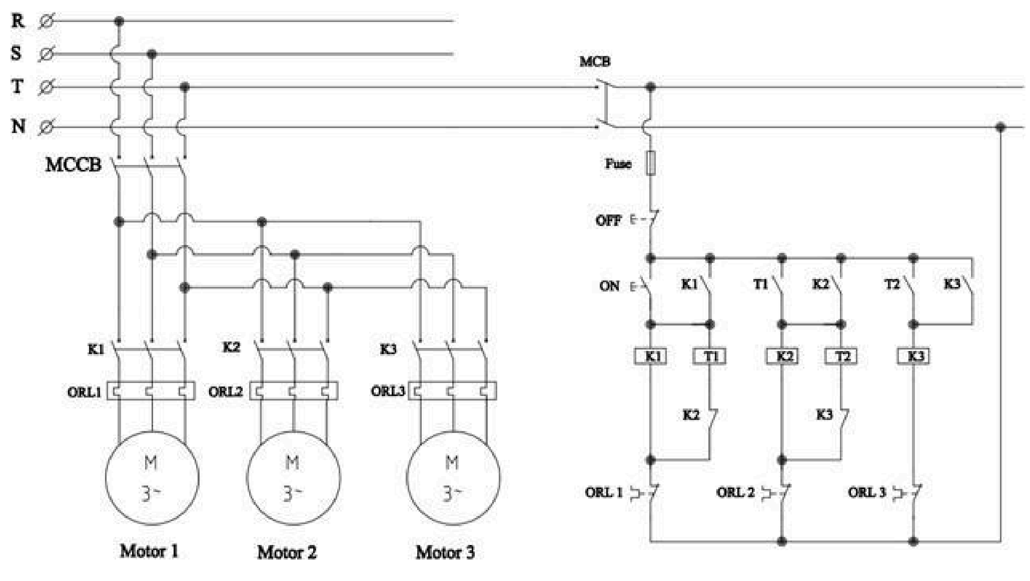
Working Principle:

When we press the ON button, the contact K1 closes, so motor 1 works. At the same time, the coil of Timer T1 is also energized and starts counting time.

When the Timer counts to the preset time, the normally open contact T1 closes to supply power to contactor K2, then motor 2 works.

The normally closed contact K2 opens to de-energize the Timer T1 coil. At the same time, the normally open contact K2 closes to keep contactor K2 operating. And timer coil T2 is also energized and starts counting.

When timer T2 counts to the preset time, contactor K3 is energized. Then motor 3 will operate and timer coil T2 is disconnected from the power supply.



8. Direct online starter (DOL Starter)

DOL starter of three phase induction motors control and power circuit consists MCB or fuse unit which connected in series with the supply. Power contactor, thermal overload relay for protection and stop and start push button.

Working Principle of Direct online starter (DOL Starter) :

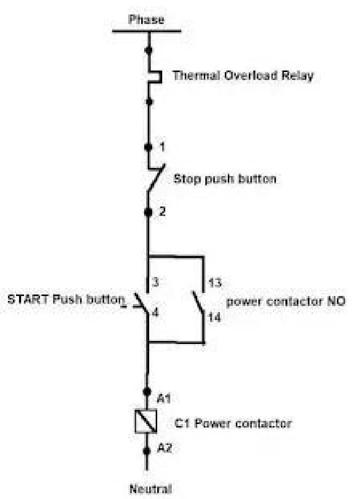
1) To start the motor, start push button is pressed. After that, the main power contactor coil energized due to electromechanical action and this latch contactor pole.it applies full line voltage to the motor terminals and the motor starts running. The motor will draw a very high inrush current for a short time.
2) As the motor accelerates and heads toward full speed, the current begins to drop but it will not drop significantly till the motor achieved full speed, about 85% of synchronous speed.
3) The motor load will affect the time taken for the motor to accelerate to full speed and therefore the duration of high starting current, but it will not affect the magnitude of starting current.
4) The torque developed by the motor exceeds the load torque at all speeds during the start cycle, the motor will reach full speed. If the torque developed by the motor is less than the torque of load at any speed during the start period. the motor stops accelerating.
5) If motor torque developed by DOL Motor starter is less for load, then the motor must be replaced by the motor which can develop high starting torque.

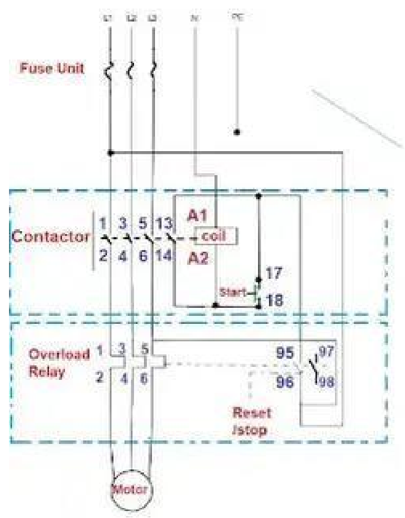
DOL starter working :

1) When the start push button on the direct online motor starter is pressed, the contactor coil gets energized and it latches contactor pole due to electromagnetic action. 3 phase supply get applied to the induction motor terminal and the motor start running

2) After that start push button gets released and the supply to contactor coil continued through latching contact provided to the main contractor of D O L starter.

3) At the time of stopping the motor we need to press the stop push button on dol starter circuit, this disconnect supply to the coil and contactor coil gets de-energized, and it releases the contactor latched pole, and the motor supply gets disconnected.





9. Direct reversing of a three phase induction motor

The reverse forward motor control operation is used to operate a three-phase motor in both forward and reverse directions. This type of control is commonly used in industrial and commercial applications where there is a need to change the direction of rotation of a motor.

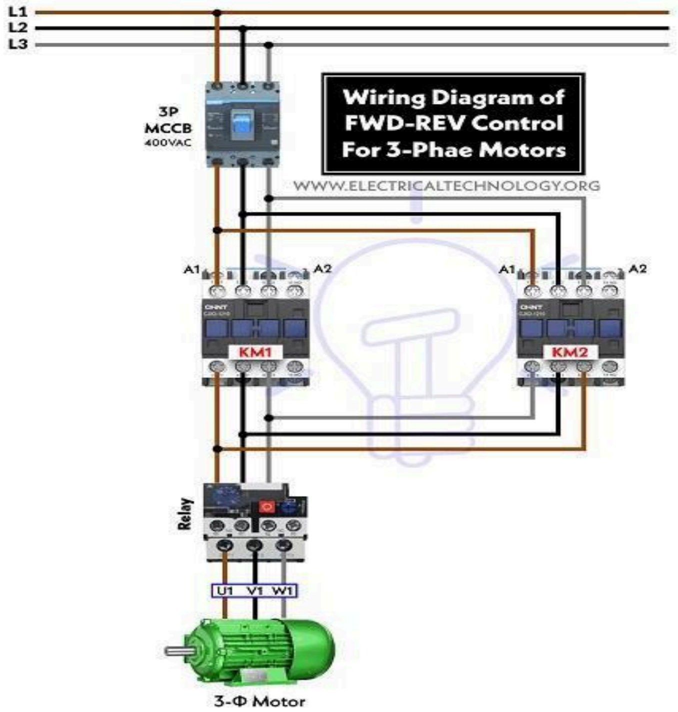
The reverse forward motor control operation can be achieved using various methods, including using a contactor and relay. In this article, we will discuss the reverse forward motor control operation of a three-phase motor using a contactor and relay.

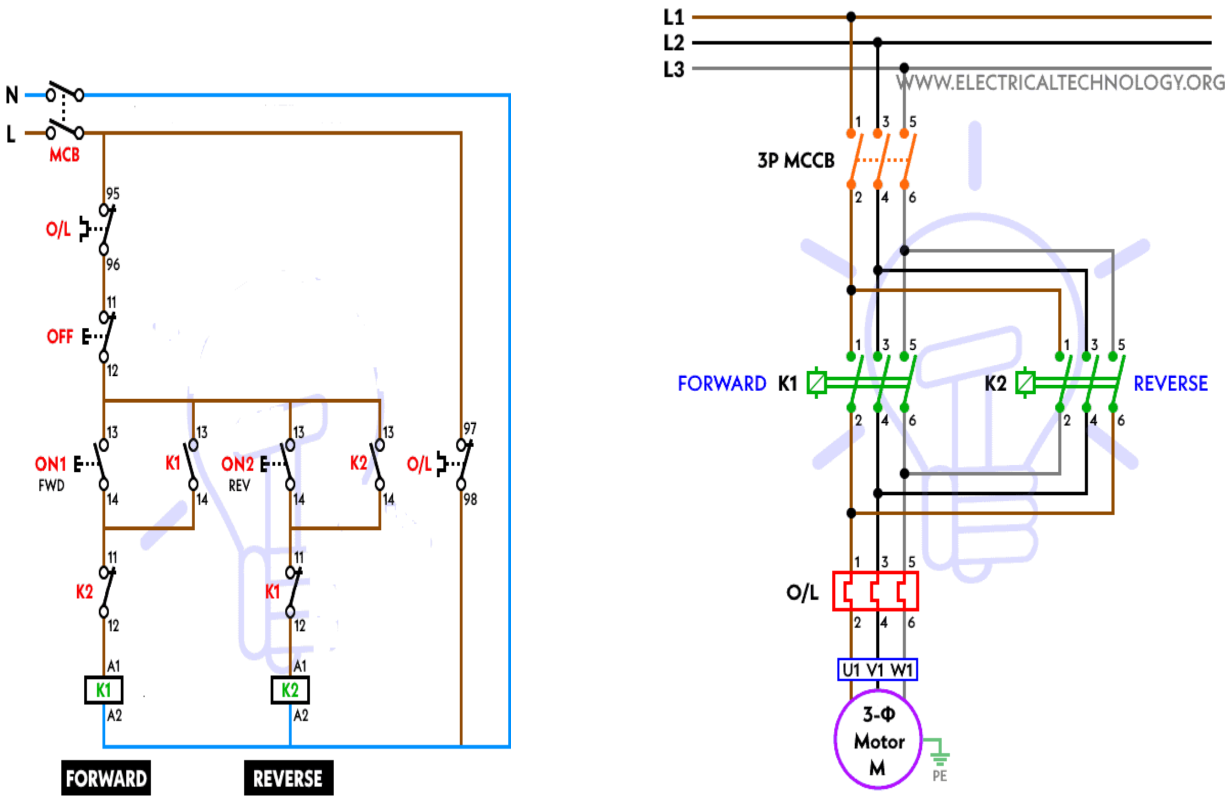
Working of the Circuit

The reverse forward direction of a motor can be achieved using two contactor (K1 & K2) and relay. The K1 contactor is used to switch the three-phase power supply to the motor and run in clockwise direction. The K2 contactor is used to run the motor in anti-clock wise direction. The relay is used to control the direction of rotation i.e. it changes the two lines supply out of three lines to the motor which is must to use for changing the direction of rotation of the motor.

When the forward operation contacts of the relay are energized, they close, and the contactor K1 is activated, causing the motor to run in the forward direction. The three-phase power supply (via L1, L2 & L3) is applied to the motor's U, V, and W terminals, causing the motor to rotate in the clockwise direction.

When the reverse operation contacts of the relay are energized, they close, and the normally closed auxiliary contact of the contactor opens. This activates the reverse contactor K2 coil, causing the motor to run in the reverse direction. The three-phase power supply is now applied to the motor's W, V, and U terminals, causing the motor to rotate in the counterclockwise direction.





Applications of REV-FWD Operation of Motors

The reverse forward operation of a three-phase motor has several applications in various industries, including:

Conveyor systems: Conveyor systems are widely used in industries for material handling. The reverse forward operation of a three-phase motor is used to control the movement of the conveyor in both forward and reverse directions.

Cranes and hoists: Cranes and hoists are used for lifting and moving heavy loads. The reverse forward operation of a three-phase motor is used to control the direction of rotation of the motor, which controls the movement of the crane or hoist.

Pumps and compressors: Pumps and compressors are used to move fluids and gases in industrial applications. The reverse forward operation of a three-phase motor is used to control the direction of rotation of the motor, which controls the flow direction of the fluid or gas.

Machine tools: Machine tools such as lathes, milling machines, and drilling machines require the motor to operate in both forward and reverse directions. The reverse forward operation of a three-phase motor is used to control the direction of rotation of the motor, which controls the operation of the machine tool.

Fans and blowers: Fans and blowers are used for ventilation and air movement in various applications such as HVAC systems and industrial processes. The reverse forward operation of a three-phase motor is used to control the direction of rotation of the motor, which controls the direction of the airflow.

10. Automatic Star-Delta Starter (Y-Δ)

A Star-Delta starter is an electromechanical device used to start and control the speed of a three-phase induction motor. This starter employs the star-delta (Y-Δ) method for starting the motor, which involves changing the motor's winding connection from a Star configuration to a Delta configuration once the motor reaches a certain speed.

The Star-Delta starter includes a control circuit that typically consists of a timer, contactors, and overload relays. When the motor is started, it is initially connected in a Star configuration to reduce the starting current, which can be up to 6 times the motor's full-load current. After the motor reaches a specific speed, the timer switches the winding connection to a Delta configuration to ensure the motor operates efficiently.

This starter is widely used in industries where high-power motors are required, such as in oil and gas, mining, and manufacturing. The star/delta starter offers several advantages, including reduced starting current, better control of inrush current, and reduced stress on the motor windings during starting. However, it also has some disadvantages, including increased cost and complexity, longer starting time, and reduced torque during starting.

Operation & Working of Automatic Y-Δ Starter

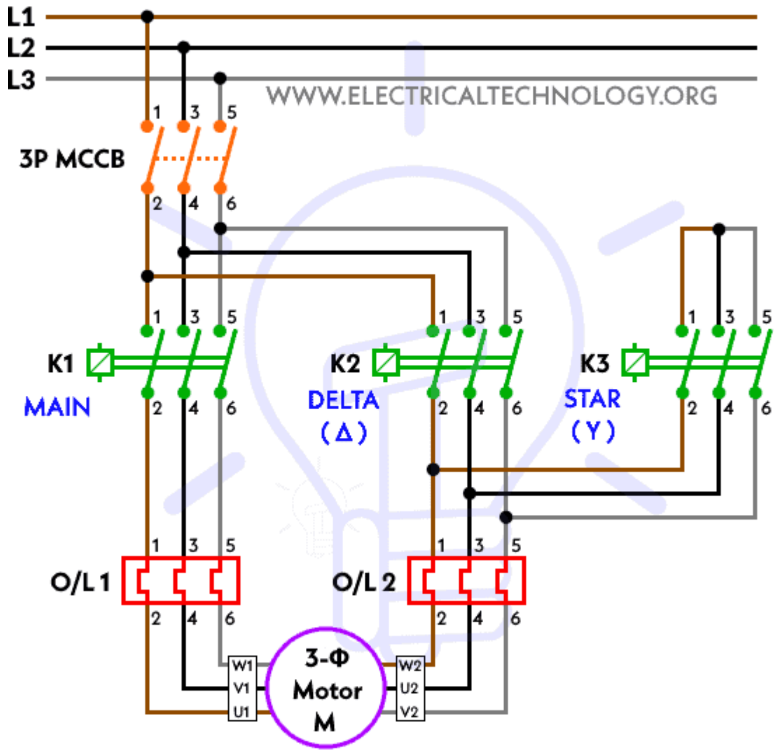
The phase current flows from L1 to the thermal overload contact through an MCB/MCCB or general fuse, then to the OFF push button, On push button interlocking contact 2, and then to K3. The circuit is thus completed, and both contactor coil C3 and timer coil (T) are energized simultaneously. As a result, the motor winding is connected in Star, and when K3 is energized, its auxiliary open links will close, and the close links will open.

Consequently, Contactor K1 is also energized, and the Three Phase Supply reaches the motor. Since the winding is connected in Star, each phase will receive √3 times less than the line voltage, which ensures safe motor starting. The close contact of K3 in the Delta line opens, preventing the activation of contactor 2 (K2).

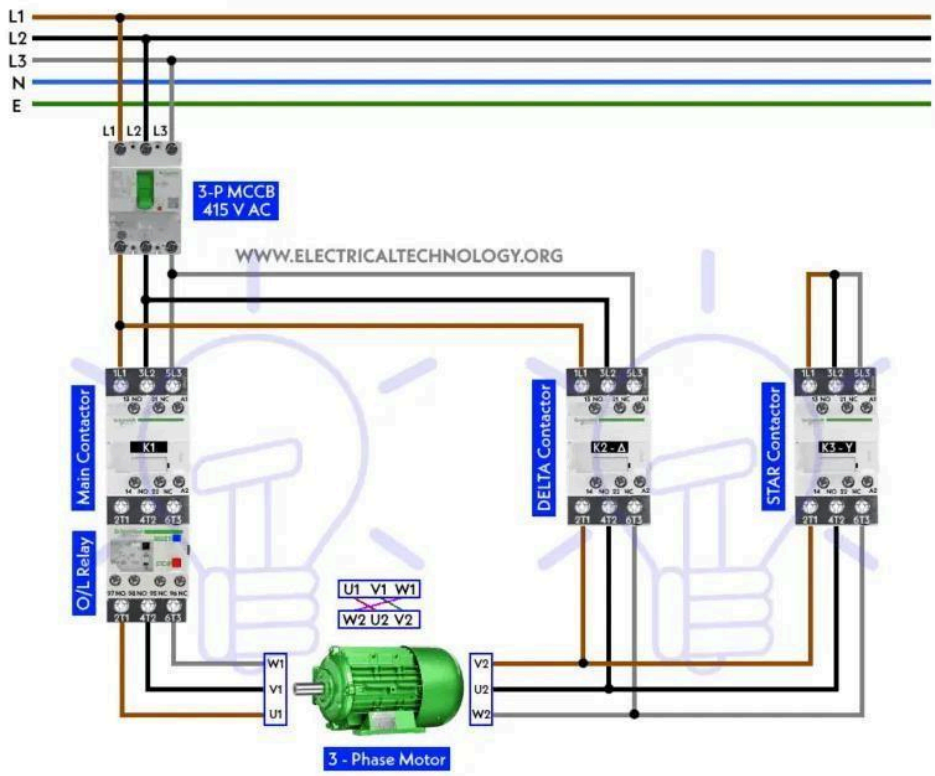
After the push button is released, Timer coil and coil 3 will receive a supply through Timer contact (Ia), Holding contact 3, and the close contact 2 of K2. When Contactor 1 (K1) is energized, the two open contacts in the line of K1 and K2 will close.

For a specific time (generally 5-10 seconds), the motor will be connected in Star. After that, the Timer contact (T) will open (which can be adjusted by rotating the timer knob to set the time again), and as a result, Contactor 3 (K3) will turn off, and the open link of K3 (in the line of K2) will close, causing K2 to energize. When K3 is off, the star connection of the winding will also open, and K2 will close, connecting the motor winding in Delta. Contact 2 (which is in the line K3) will also open, preventing the activation of coil 3 (K3).

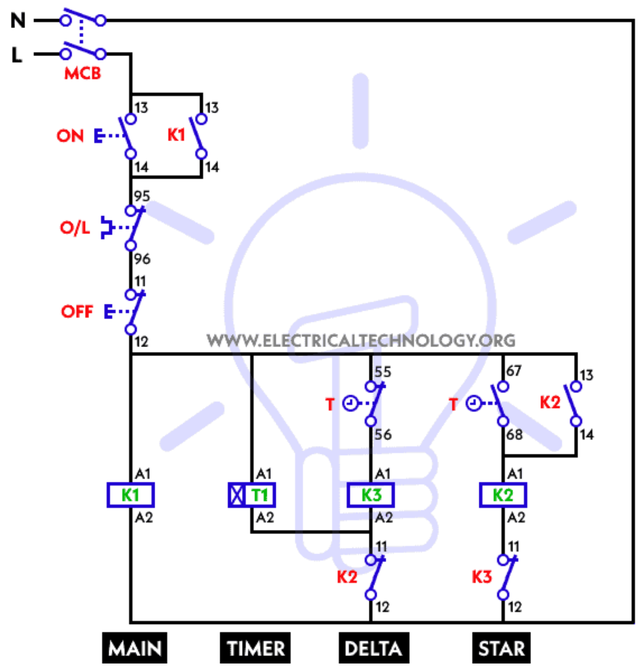
Now that the motor is connected in Delta, each phase will receive full line voltage (415V), and the motor will start to run at full speed.



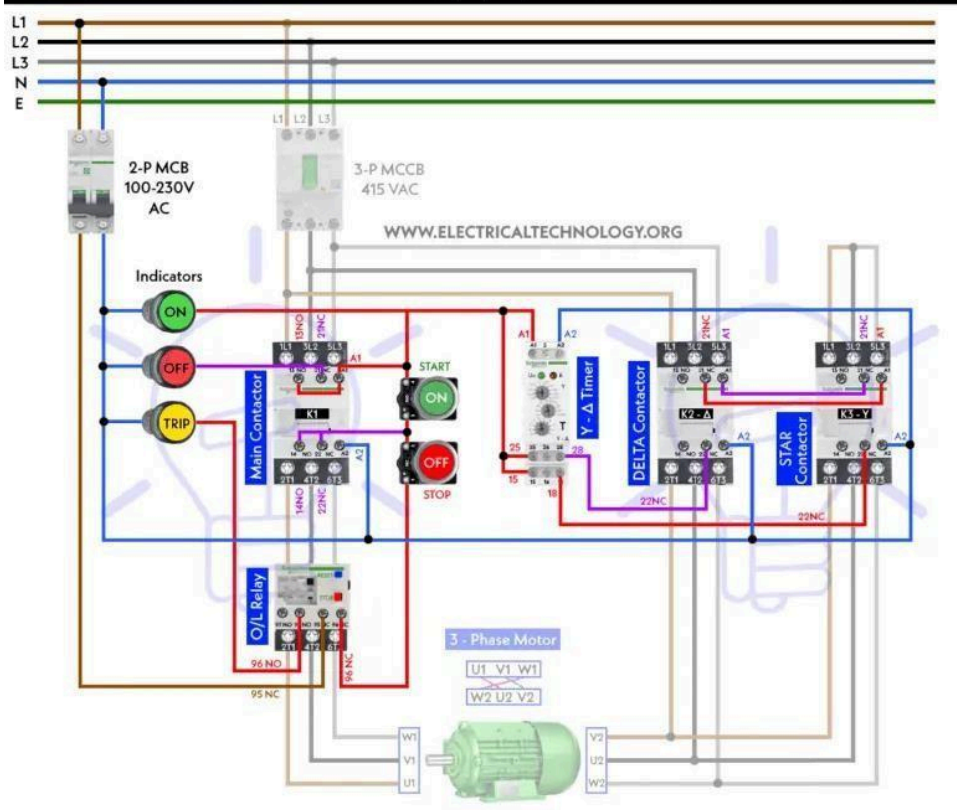
Power Wiring Diagram of Star - Delta Starter for 3-Phase Motor



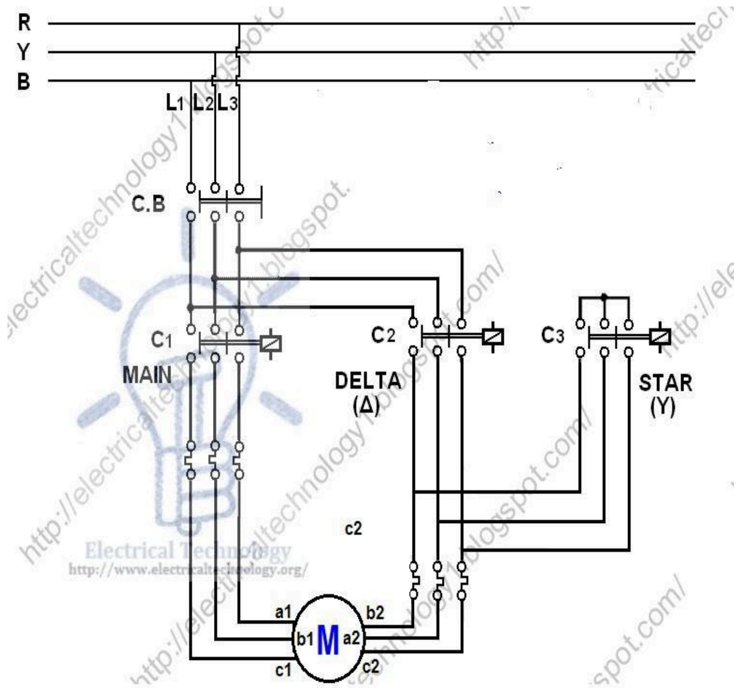
Control Circuit Diagram of Automatic Star / Delta Starter (Y-Δ) using Timer for 3-Φ Motor



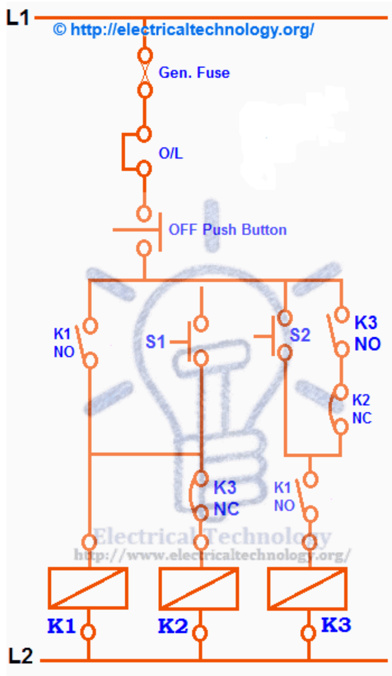
Control Circuit of Automatic Star - Delta (Y / Δ) Starter with Timer for 3-Phase Motors



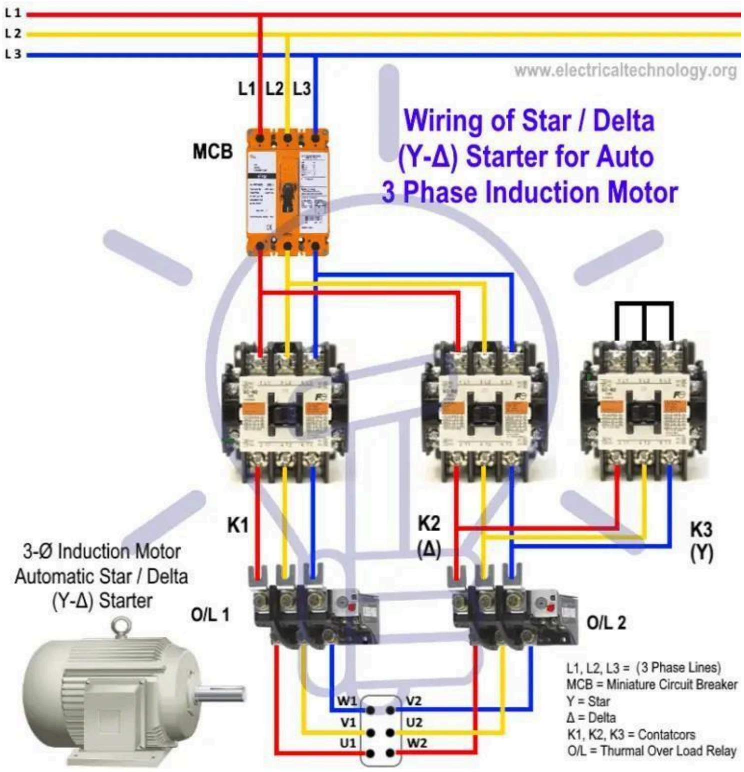
11. STAR-DELTA Starter Motor Starting Method Without Timer



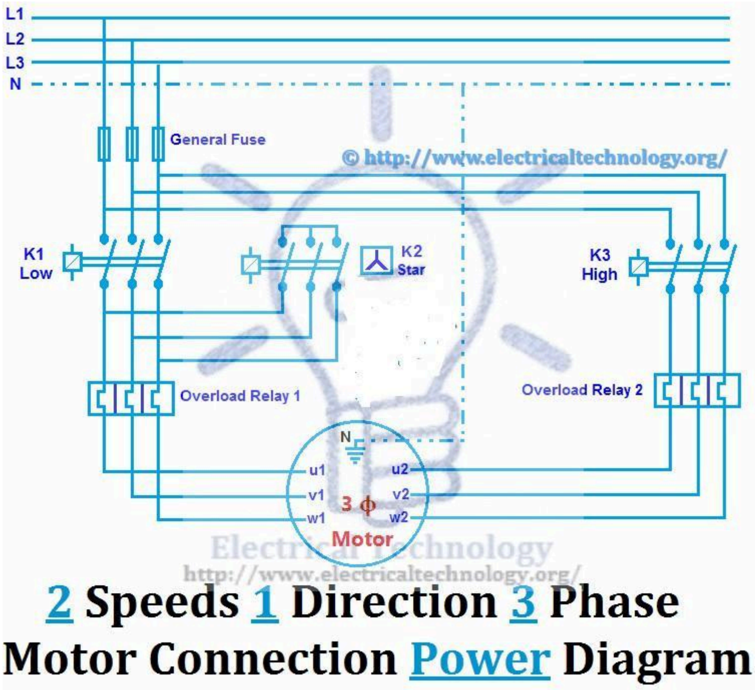
3 Phase Motor Connection STAR/DELTA Without Timer Power Diagram

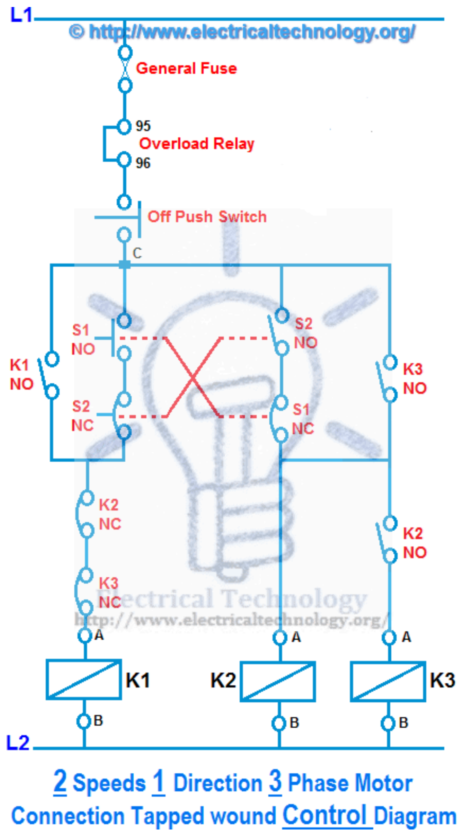


3 Phase Motor Connection STAR/DELTA Without Timer Control Diagram



12. 2 Speeds 1 Direction 3 Phase Motor Power and Control Diagrams





Braking of induction motors

Induction motors are used at various places. Speed control of induction motors is quite difficult and that's why their use was restricted and DC motors had to be used as their speed regulation was possible. But when induction motor drives were invented and implemented, they were given preference because of many advantages over DC motors. Whenever controlling of motors is done, braking is the most important term, so as with induction motors. Induction motor braking can be done by different methods, which are-

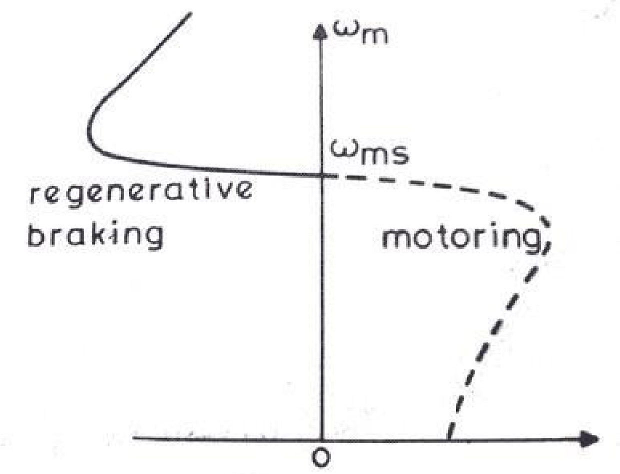
Regenerative braking of induction motor
Plugging Braking of induction motor
Dynamic braking of induction motor is further categorized as

AC dynamic breaking
Self excited braking using capacitors
DC dynamic braking
Zero Sequence braking

Regenerative Braking of Induction Motor

We know the power (input) of an induction motor is given as.

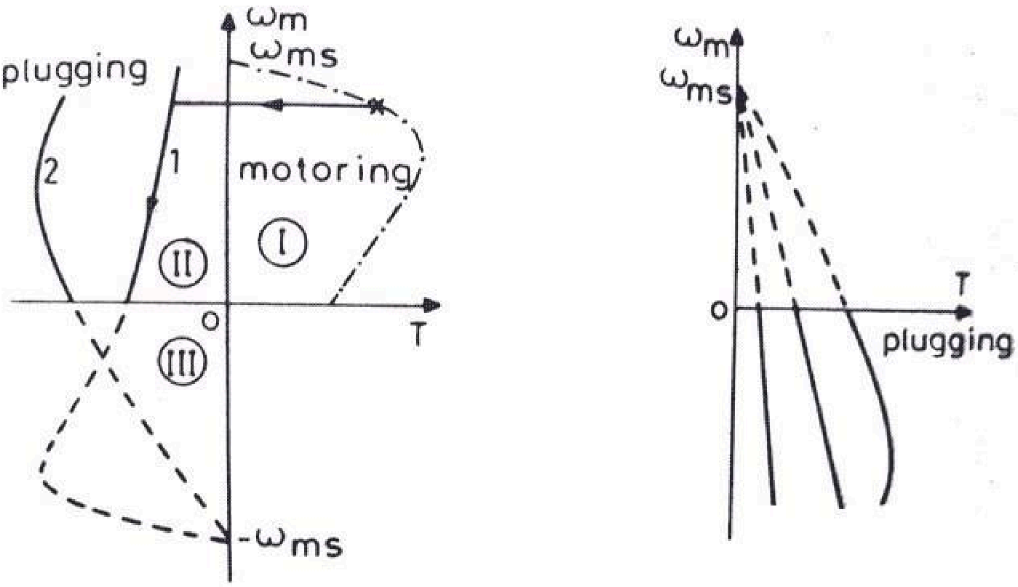
Pin = 3VIscosφs , Here, φs the phase angle between stator phase voltage V and the stator phase current Is. Now, for motoring operation φs < 90o and for braking operation φs > 90o. When the speed of the motor is more than the synchronous speed, relative speed between the motor conductors and air gap rotating field reverses, as a result the phase angle because greater than 90o and the power flow reverse and thus regenerative braking takes place. The nature of the speed torque curves are shown in the figure beside. It the source frequency is fixed then the regenerative braking of induction motor can only take place if the speed of the motor is greater than synchronous speed, but with a variable frequency source regenerative braking of induction motor can occur for speeds lower than synchronous speed. The main advantage of this kind of braking can be said that the generated power is use fully employed and the main disadvantage of this type of braking is that for fixed frequency sources, braking cannot happen below synchronous speeds.



Regenerative braking

Plugging Braking of Induction Motor

Plugging induction motor braking is done by reversing the phase sequence of the motor. Plugging braking of induction motor is done by interchanging connections of any two phases of stator with respect of supply terminals. And with that the operation of motoring shifts to plugging braking. During plugging the slip is (2 – s), if the original slip of the running motor is s, then it can be shown in the following way.



(a) 1: natural characteristic
2: with external resistance in rotor

(b) Plugging in IV quadrant with large external resistance in rotor

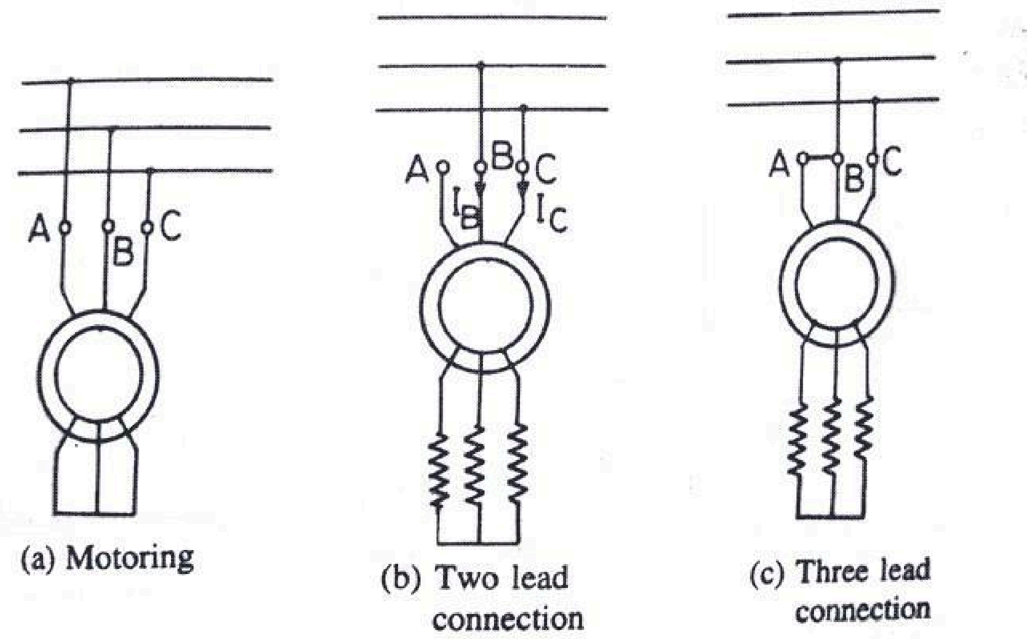
From the figure beside we can see that the torque is not zero at zero speed. That's why when the motor is needed to be stopped, it should be disconnected from the supply at near zero speed. The motor is connected to rotate in the reverse direction and the torque is not zero at zero or any other speed, and as a result the motor first decelerates to zero and then smoothly accelerates in the opposite direction.

Dynamic Braking of Induction Motor

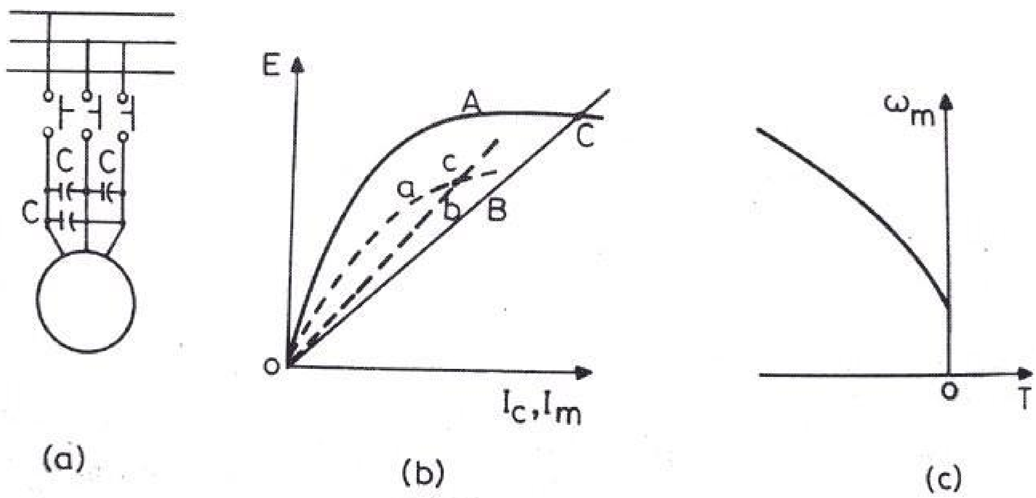
There are four type of dynamic braking of induction motor or rheostatic braking, we will discuss about then.

AC Dynamic Braking-

This type of induction motor braking is obtained when the motor is made to run on a single phase supply by disconnecting any one of the three phase from the source, and it is either left open or it is connected with another phase. When the disconnected phase is left open, it is called two lead connection and when the disconnected phase is connected to another machine phase it is known as three load connection. The braking operation can be understood easily. When the motor is running on 1-phase supply, the motor is fed by positive and negative sequence, net torque produced by the machine at that point of time is sum of torques due to positive and negative sequence voltage. At high resistance the net torque is found to be negative and braking occurs. From the figure below the two and three load connections can be understood.



Self-excited braking using capacitors



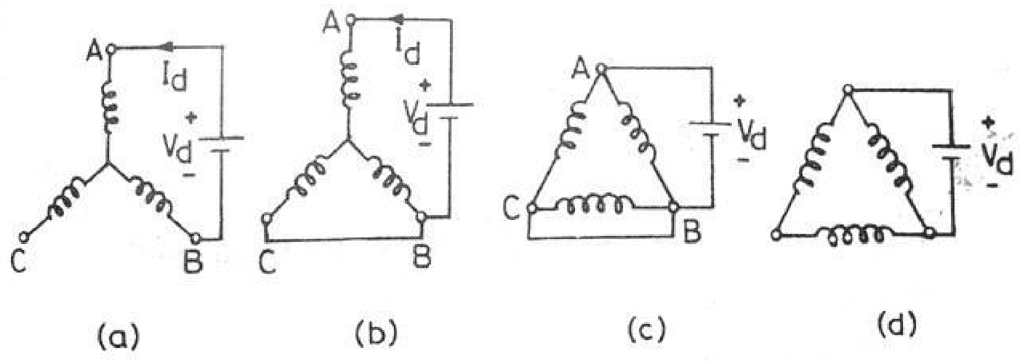
The figures above shows the circuit diagram and various characteristics of self excited braking using capacitors. As we can see from the figure, in this method there capacitors are kept permanently connected across the source terminals of the motor. The value of the capacitors are chosen depending upon their capability to deliver enough reactive current to excite the motor and make it work as a generator. So, that when the motor terminals are disconnected from the source the motor works as a self excited generator and the produced torque and field is in the opposite direction and the induction motor braking operation occurs. In the figure (b) the curve A represents the no load magnetization curve and line B is the current through capacitors, which is given by

Here, E is the stator induced voltage per phase

The speed torque characteristics under self excited braking is shown in the figure (c). To increase the braking torque and to utilize the generated energy sometimes external electrical resistance are connected across the stator terminals.

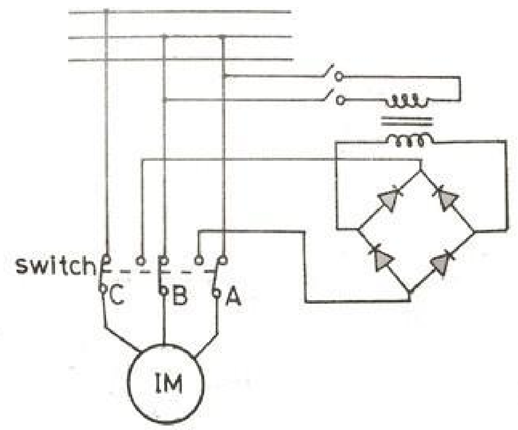
DC Dynamic Braking

To obtain this type of braking the stator of a running induction motor is connected to a DC supply. Two and three load connections are the two common type of connections for star and delta connected stators.



Various stator connections for dc dynamic braking (a) and (d) are two lead connections and (b) and (c) are three lead connection

Another diagram is shown below to illustrate how by diode bridge two load coonection can be obtained within a circuit.

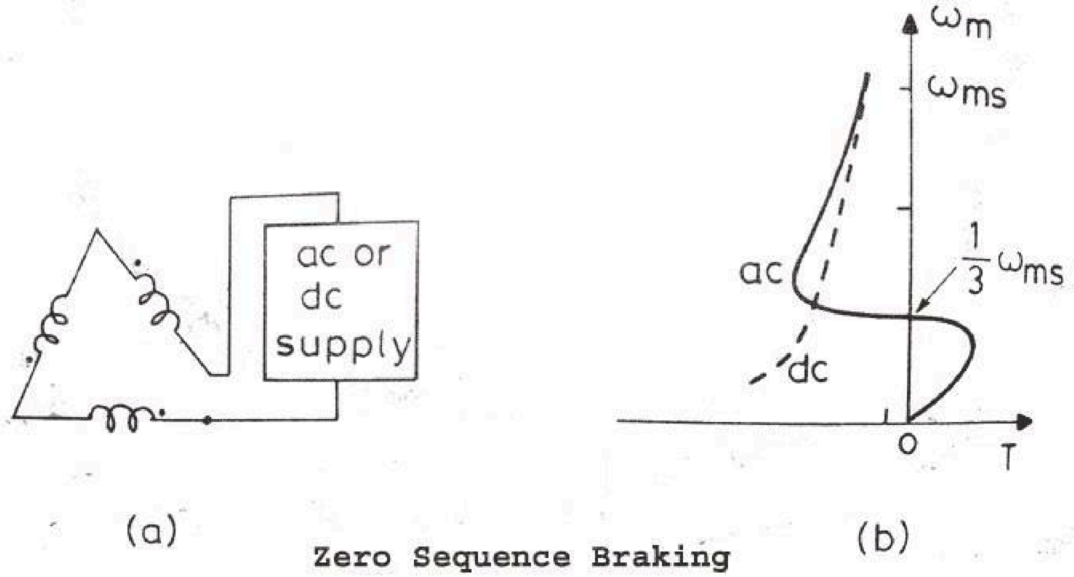


Two Loads DC Dynamic Braking Operation

Now coming to the method of operation, the moment when AC supply is disconnected and DC supply is introduced across the terminals of the induction motor, there is a stationery magnetic field generated due to the DC current flow and as the rotor of the motor rotates in that field, there is a field induces in the rotor winding, and as a result the machine works as a generator and the generated energy dissipates in the rotor circuit resistance and dynamic braking of induction motor occurs.

Zero Sequence Braking

In this type of braking all the three stator phases are connected in series and single phase AC or DC is connected across them (as shown in the figure). This type of connection is called zero-sequence connection, because current in all the stator windings are co-phasal. When the connected supply is AC, resultant field is stationery in space and pulsates at the frequency of supply, when the supply is DC, resultant field is stationery and is of constant magnitude. The main advantage of this induction motor braking is that all the stator phases are uniformly loaded. It does not require large rotor resistance like AC dynamic braking, it does not require large rotor resistance. The circuit diagram and the speed torque characteristics are shown below.



Zero Sequence Braking

Dynamic braking circuit

The stationary magnetic field that is formed depends on the connection at the stator windings and the magnitude of the DC voltage applied to the stator.

The larger the DC voltage, the more current flows in the stator, so the voltage directly affects the braking torque. The current should not exceed the rated current of the motor windings.

Circuit diagram of dynamic brake

When the SW switch is closed, the circuit provides a fast stop. If the SW switch is open, the deceleration time of the motor depends on the moment of inertia.

220V AC voltage is rectified into DC power through diode bridge. DC voltage is applied to the motor windings through the contactor K2.

Push button ON, OFF controls the opening and closing of contact K1.

Coil K2 is in series with normally open contact of OFF push button and normally closed contact of timer T1. Therefore, coil K2 will be energized when we press the OFF button. Then the coil is de-energized after a period of time T1.

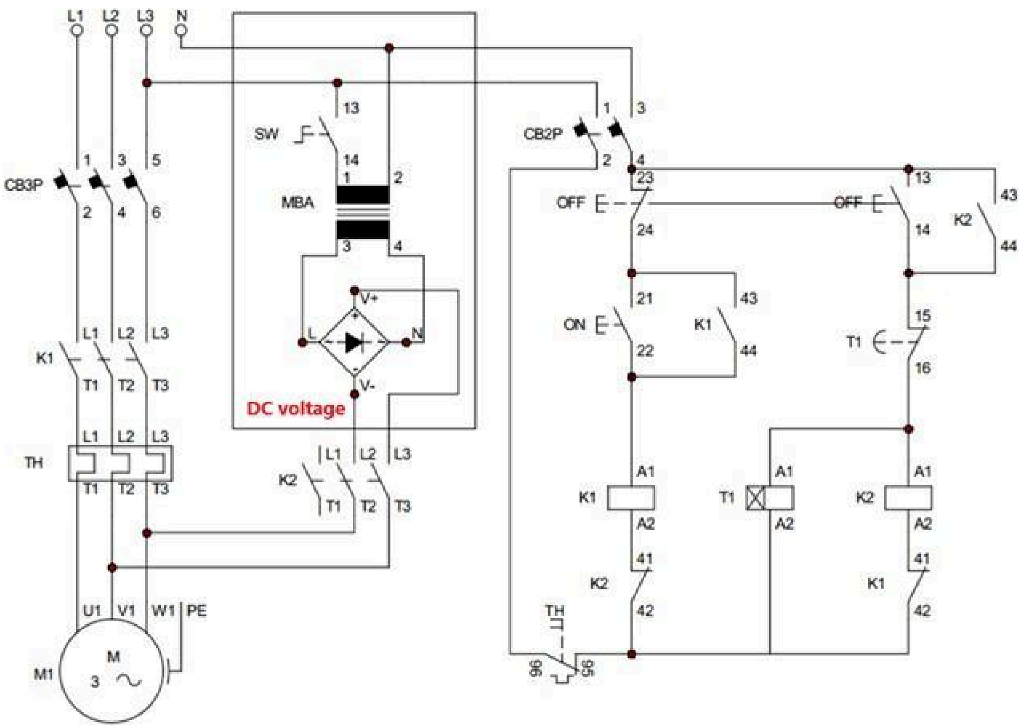
Principle of dynamic braking circuit:

When the ON button is pressed, coil K1 is energized, the main contact of contactor K1 is closed. Three-phase voltage is applied to the motor so the motor starts to work.

When the OFF button is pressed, the contact K1 returns to the original state, the motor stops working. At the same time contactor K2 is energized, so DC voltage is applied to the motor windings. And timer coil T1 is also energized so it starts counting time.

The DC voltage applied to the coil will generate a stationary magnetic field, keeping the motor's rotor in check. The motor stops quickly.

After the timer counts to the preset time, the normally closed contact of the timer opens and disconnects coil K2. The circuit returns to its original state.



Video link: https://youtu.be/lVLJjcpcWNc

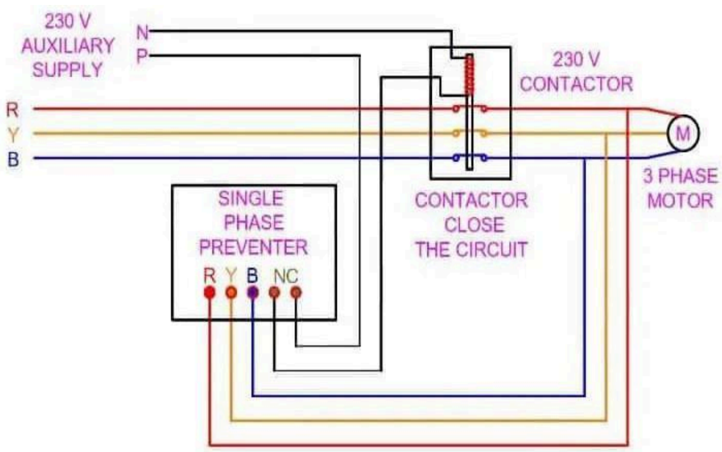
SINGLE PHASE PREVENTER

The single-phase preventer relay is the protective relay that detects the phase failure and trips the motor immediately on the occurrence of single phasing. The single-phase preventer relay functions on the principle of sensing the voltage and sensing the current of the three-phase supply system. We can classify the relay as;

Voltage sensing Relay
Current Sensing Relay

Voltage Sensing Single Phase Preventer

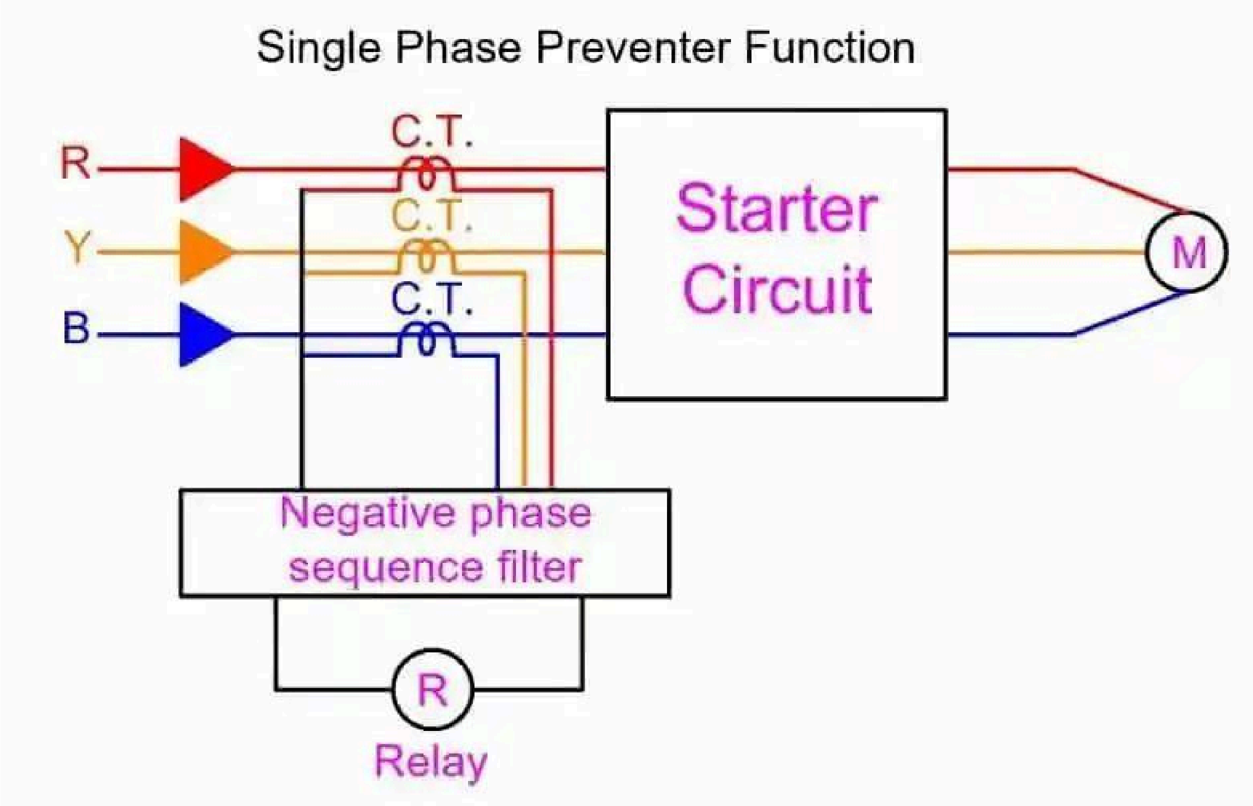
The voltage sensing relay continuously monitors the three-phase supply voltage. The auxiliary contact of the relay remains NC when the three-phase supply is healthy. The contact of the relay changeover from NC to NO in the case of even failure of one of the phases.



CONNECTION OF SINGLE PHASING PREVENTER WITHOUT ANY FAULT

Current Sensing Single Phase Preventer

Current sensing single phase preventer measures the current of three-phase supply going to the induction motor. The relay basically measures the negative sequence current of the motor. Under the current unbalance condition, the magnitude of negative phase sequence current increases, and relay trips the main contactor. The current transformer is placed in each phase to monitor the phase current. The current transformer output first goes in the filter circuit that separates the negative phase sequence current. The relay then measures the magnitude of the negative phase sequence current.



The control circuit of the relay receives current magnitude from the filter circuit and outputs the trip command to the contactor/ circuit breaker if the magnitude of the negative sequence current is more than the preset value.

EX.NO:
3 DATE

One push button for both starting and stopping

AIM : To develop a control circuit and main circuit of a three phase induction motor by using One push button for both starting and stopping

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

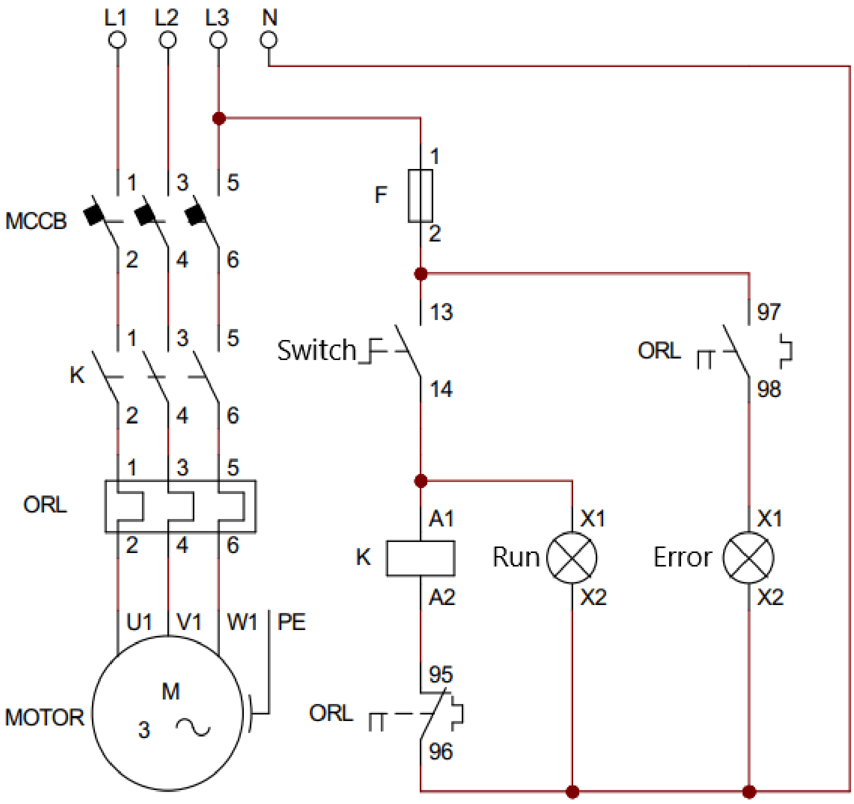
Working

One push button with ON contact can be used to energies and de-energise a contactor. As long as the pressure on the push button is held, the contactor will remain energized, its contact will operate and through its main contacts the motor will be provided with supply. Both the control circuit and the power circuit have been shown separately in figure. The motor is stopped by withdrawing the pressure on the push button. Such an operation is called inching , as is done in control of an overhead crane driven by a motor.

Procedure

1. Connections were made as per connection diagram
2. Switch on the MCB and press the push button, observe the motor rotation.
3. Remove the force on the push button and observe the motor.
4. Noted the observation and switch off the main.

Diagram



Result :

EX.NO:
4 DATE

Separate push buttons for starting and stopping

AIM : To develop a control circuit and main circuit of a three phase induction motor by using separate push buttons for starting and stopping

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

EX.NO:
5 DATE

Multiple push button stations

AIM : To develop a control circuit and main circuit of a three phase induction motor by using Multiple push button stations

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

EX.NO:
6 DATE

Push button interlocking

AIM : To develop a control circuit and main circuit of a three phase induction motor by using push button interlocking

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

EX.NO:
7 DATE

Automatic sequence control with time delay

AIM : To develop a control circuit and main circuit of a three phase induction motor by using automatic sequence control with time delay.

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

EX.NO:
8 DATE

Direct on line (DOL) starting of three phase induction motor

AIM : To develop a control circuit and main circuit of a three phase induction motor by using DOL starter

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

EX.NO:9
DATE

Direct reversing of a three phase induction motor

AIM : To develop a control circuit and main circuit of a three phase induction motor for direct reversing .

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

EX.NO:10
DATE

Semi-automatic star delta starter for three phase induction motor

AIM : To develop a control circuit and main circuit of a three phase induction motor by semi-automatic star delta starter

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

EX.NO:11
DATE

Automatic star delta starter for a three phase induction motor

AIM : To develop a control circuit and main circuit of a three phase induction motor by automatic star – delta starter

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Diagram

Result :

CO4 Apply day to day routine maintenance of DG Sets

VARIOUS PARTS OF DG SET

Diesel Generator set consists mainly following parts/assemblies:

· Diesel Engine
· Alternator
· Fuel Tank
· Auxiliary Alternator
· Starter Motor
· Battery
· Control Panel
· Acoustic Enclosure (Canopy)

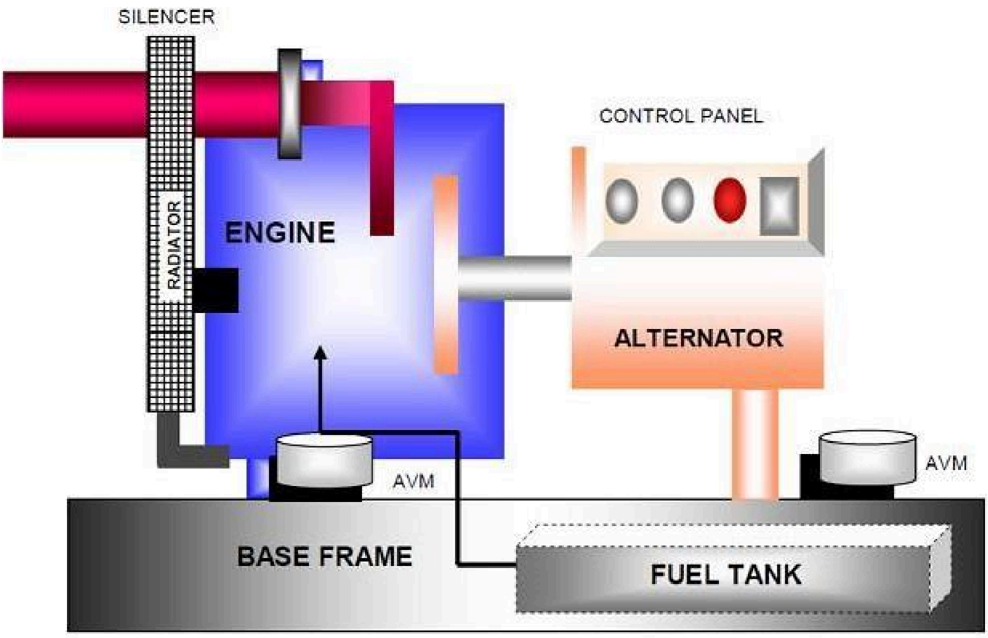
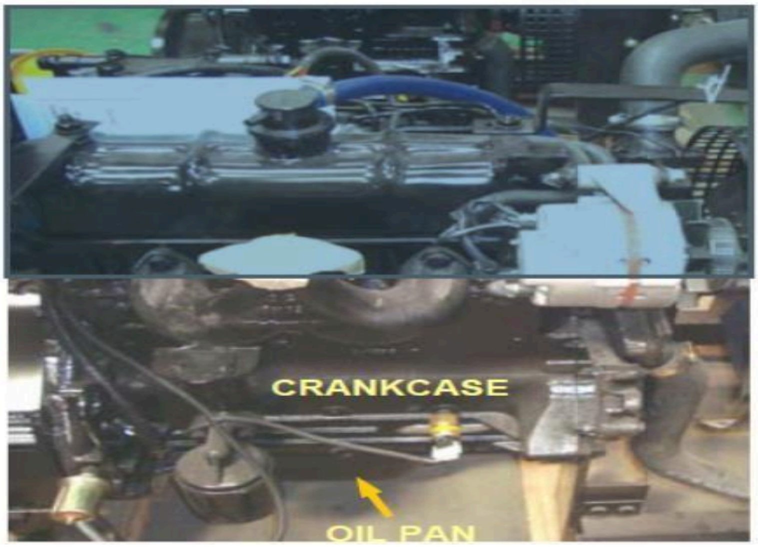


Figure 1. General layout of DG set

The Diesel Engine consists following main parts:

Crankcase and oil pan

These two components form the load bearing housing of the engine. They absorb the forces occurring during operation in the cylinder and at the crank assembly. The crankcase accommodates the cylinder liners, the crank assembly and the camshaft.



Cylinder Heads

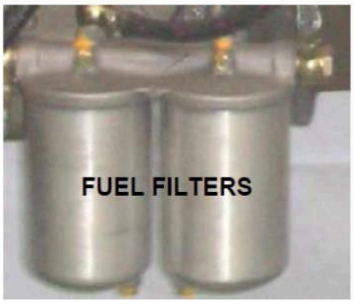
A cylinder head closes the top end of the cylinder. It makes a confined space for compressed air and the gases. Each cylinder head contains the inlet and exhaust valves and fuel injection valve. For cooling of the valve seats and injection valve, coolant is piped through cooling chambers arranged in the cylinder head.

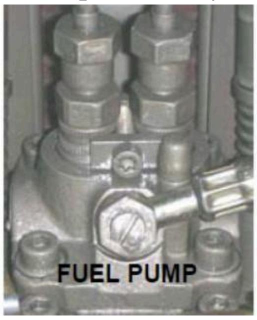
Driving mechanism

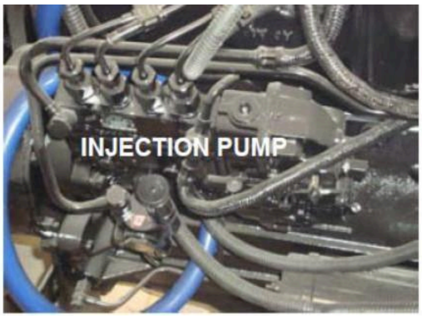
The crank shaft is driven via the connecting rods by means of the gas acting on the pistons. The forces of the rotary masses at the individual crank throws are compensated by means of balance weights. The crank shaft provided rotation of the camshaft via gear drive and also rotates the injection pump drive. The cams of the camshaft actuate inlet and exhaust valve via the push rod and rocker arm.

Fuel Pump, injection pump and Fuel system

By means of fuel pump, the fuel is pumped from fuel tank into the injection pump via filter. By means of the injection nozzles the fuel is squirted very finely into the combustion chamber.







For the purpose of cooling the injection pumps more fuel than the required for injection through the system by the fuel feed pump. The surplus fuel is returned to the fuel tank via an over flow valve at the injection pump.

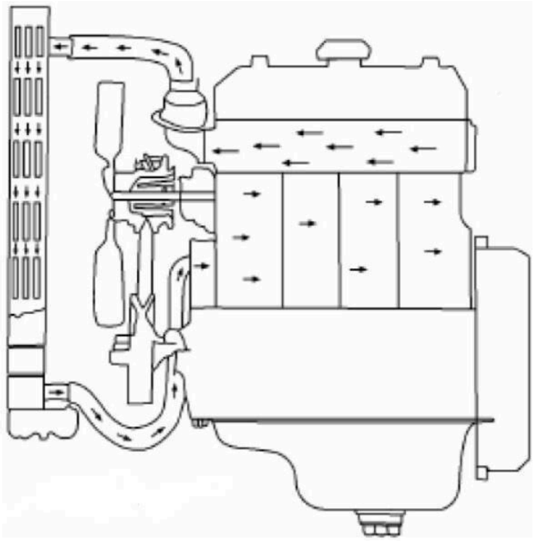
Lube pump and system

The bearings and the cylinder liners are lubricated to reduce friction and to dissipate heat. The lube oil pump draws the lube oil from the oil pan and pumps to the points of lubrication through oil cooler and filter.

OIL FILTER

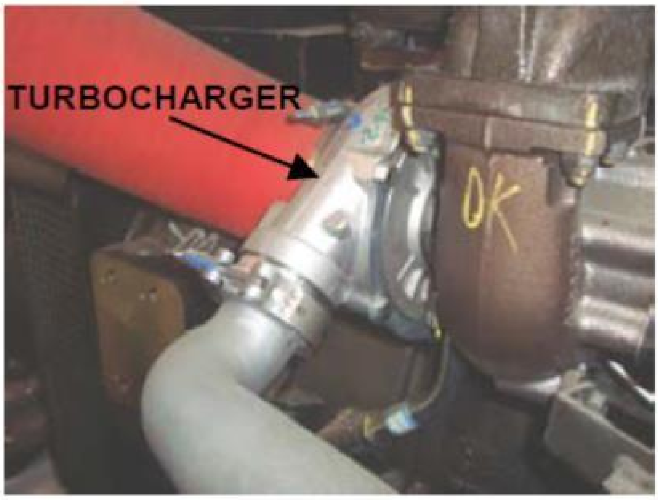
Radiator and cooling system

The thermal energy generated during fuel combustion can only be partly converted into mechanical energy. The part of the residual heat is eliminated by means of cooling the combustion chamber walls by coolant. The heat absorbed by coolant is passed on to atmosphere by means of radiator and fan.



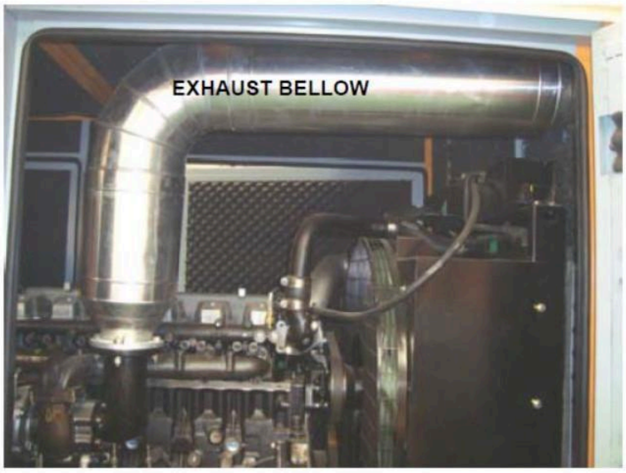
Turbocharger

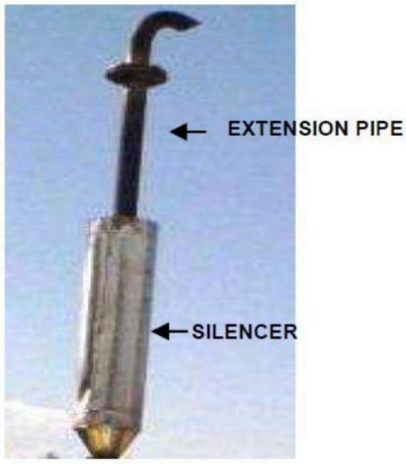
The turbocharger is provided to increase the power out put and efficiency of an engine by supplying compressed air to the engine intake manifold. The power to drive the turbocharger is expected from energy in the exhaust gases.



Exhaust System

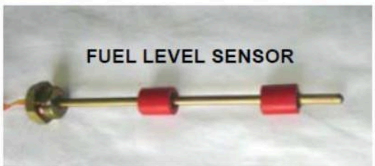
Exhaust bellow connects engine and DG silencer to drive away hot gases generated during operation of DG to atmosphere through silencer. Exhaust muffler reduces noise level of the engine as per designed parameter and exhaust extension pipe, connected to DG silencer outlet ensures that the hot gases are driven out to atmosphere.





Fuel Tank

It stores Diesel required for operation of DG set. It consists of Fuel Level Float which continuously monitors the level of Diesel available in tank and communicates fuel Gauge to provide indication. It also consists of Fuel Level Sensor which senses level of fuel in fuel tank and communicates engine safety unit to provide alarm or stopping of DG as per designed operating levels.



Alternator

A self excited, self regulated brushless type alternator is coupled directly with engine by means of flexible coupling. The alternator is designed for specified Kva rating in single/three phase at 230V/415V, 50 Hz, 1500 rpm and power factor 0.8 lagging. It is dynamically balanced and can withstand speed upto 20% in excess of the rated speed.

Following are the main parts of an Alternator:

– Stator

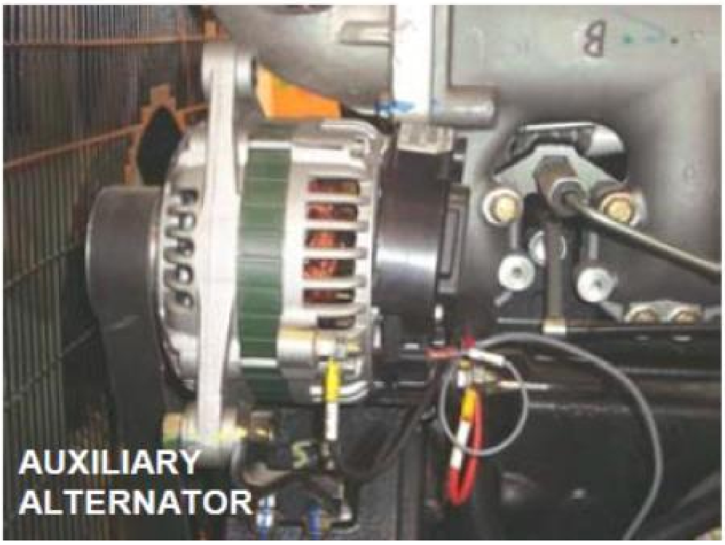
– Rotor

– Automatic Voltage Regulator (AVR)

– Terminal Box
– DE Adaptor
– Slotted Surround
– NDE Shield

Auxiliary Alternator

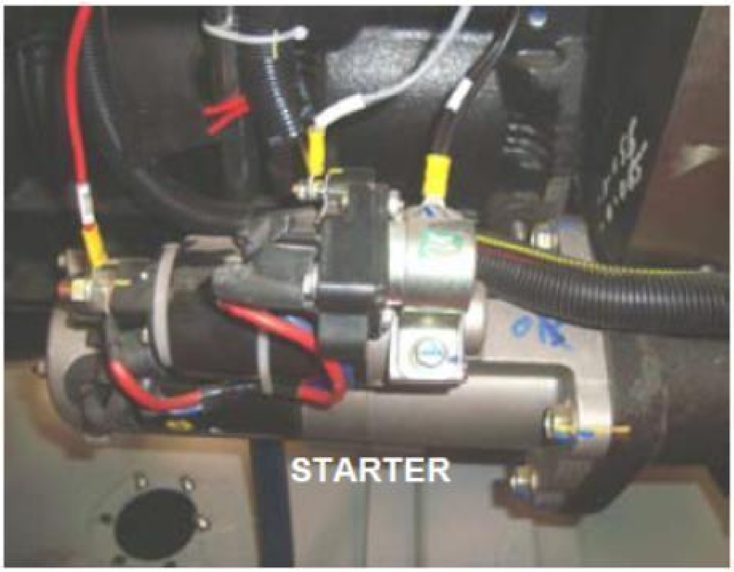
Auxiliary alternator is a machine that converts mechanical energy to electrical energy and its output is used to charge the battery. The inbuilt rectifier converts the A.C output to D.C. The inbuilt Regulator controls the output and it depends on the battery charge status



Starter Motor

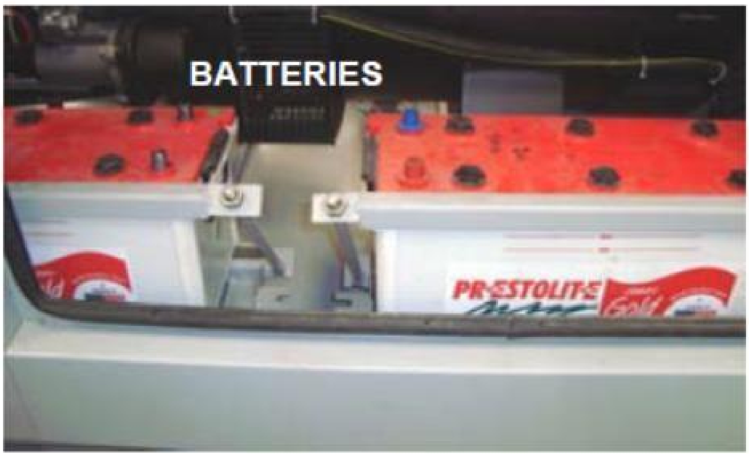
A Starter motor is a machine that converts electrical energy to mechanical energy. Its output is used to crank the engine. Starter motor gets supply from the battery. When the Starter solenoid switch getting energized, the pinion engages with the flywheel ring gear and rotates the same.

The starter performance depends on the battery charge status and the voltage drop in the starting circuit.



Battery

The battery is provided to feed the supply to the starter for cranking/ starting the DG set. A 12 V Low Maintenance/Maintenance Free lead acid battery for DG sets upto 125 kVA capacity and 24 V battery for DG sets above 140 kVA capacity is required. It also provides DC Power to engine safety unit and gauges.



Control Panel

This panel houses various electrical switchgears and controls such as Hour meter, Switches used for starting and stopping of DG and other electrical components which facilitates the following:

· Enable transfer of DG AC output to loads.

· Monitor performance of DG through Measuring instruments and Gauges.

· Engine related gauges and controls: Engine oil pressure gauge

Water Temperature gauge
Engine oil temperature gauge
Tachometer / Hour meter
Oil level gauge
Vacuum Indicator
Fuel level indicator
Air pressure gauge

Acoustic Enclosure (Canopy)

The complete DG set is housed in a modular type acoustic enclosure to control noise from the DG set. This enclosure is fabricated with 2mm CRCA (Cold Rolled Carbon Annealed) sheet. The noise level shall be 75 dBA or better at a 1 meter from the acoustic enclosure surface conforming to environmental (protection) rules issued by CPCB (Central Pollution Control Board), Government of
India.

ADVANTAGES OF DG SET

Following are the advantages of DG set:

- It can start quickly and requires less period for warming.
- No stand by losses.
- Requires less manpower for running.
- Requires less maintenance.
- Wearing out parts of DG sets are easily replaceable.
- Life of DG set can be extended easily and economically.
- DG set can be easily located near the load hence requiring less expenditure for interconnection.
- Sets of varying sizes and of small capacities are available.
- Requires less space and building layout is simple.
- Automatic starting of set makes it possible to reduce periods of power supplyinterruption.
- Fuel handling and storage is easy.
- Uniformly high efficiency for all sizes.
- It can be procured and installed quickly and easily.

OPERATION AND MAINTENANCE

MODES FOR STARTING DG SET

The following procedures are adopted for starting diesel generator set using battery.

- Push button (Manual)
- Auto start (Auto)
- Test mode (For testing purpose)

The mode of operation can be selected by means of selector switch.

Push Button Start/ Manual mode

After pressing the start push button and turning the ignition key toward start position, the battery is connected to the starter which cranks the engine shaft resulting in the start of the engine. This arrangement can also be provided in small DG sets. This requires least physical efforts to start DG set. To prevent damage to the starter, do not push the start button for more than 10 to 12 seconds.

Auto Starting System/ Auto mode

This method is adopted where the supply from the generator is regularly required. In this mode, the DG set starts automatically in case of (i) mains failure, (ii) low/high mains voltage beyond 150-250 V for single phase DG set and 360-460 V for 3 phase DG set (iii) single phasing or phase reversal of main supply. When the engine starts, and alternator reaches the preset voltage, the DG contactor closes and automatically restores the supply to the load.

The auto start system makes three attempts to start, in case it fails to start, the starting system automatically disconnected and locked out. After restoration of healthy mains voltage, the DG contactor opens and main supply extended to the load. However the DG set continuous to run for 3 minutes and shutdown after that if mains supply remain stable. During the above mentioned 3 minutes, if the mains fail again, the DG shutdown sequence discarded and the DG contactor closes again to restore the DG supply to the load.

Test mode

In this mode all functions are likely to manual mode but DG supply can not be transferred to load. This mode is provided for the purpose of testing the DG set.

STARTING OF DG SET

Before starting the engine, perform daily maintenance checks. Follow the instructions given below for reliable operation:

· To prevent damage to the starter, **do not push the start button** for more than 10 to 12 seconds. Wait for at least **2 minutes** between each attempt to start.

· If the engine does not start after three attempts, check the fuel supply system and fuel level in fuel tank. Absence of blur or white exhaust smoke during cranking indicates that no fuel is being delivered.

· Move the ignition key from start position to idle as soon as the engine starts.

· Monitor the oil pressure and coolant temperature gauges frequently.

STOPPING OF DG SET

· Remove the load from the engine.

· Run the engine few minutes (3 to 5 minutes) before routine shut down on no load.

It will allow the lubricating oil and coolant to carry heat away from the combustion chamber, bearings, shafts etc.

· Shut off the engine if oil pressure or coolant temperature is exceeding the specified limits.

· Avoid continuous operation of the engine with low or high coolant temperature, it may damage the engine.

WARNINGS/ INDICATIONS BEFORE ANY FAILURE

Most failures give an early warning. **Look** and **listen** for changes in **performance**, **sound** or **engine appearance** that can indicate service or engine repair is needed. Some changes to look for are as follows:

· Engine misfires

· Vibration

· Unusual engine noise

· Fuel, oil or coolant leakage

· Sudden change in engine operating temperature or oil pressure

· Excessive smoke

· Loss of power

· An increase in lube oil consumption

· An increase in fuel consumption

GENERAL SAFETY INSTRUCTIONS

Improper practices or carelessness can cause burns, cuts, mutilation or other bodily injury or death. Read & understand safety precautions and warnings before performing operation, any repair/maintenance.

- Do not wear loose clothing.
- Always wear protective glasses and protective shoes while working on the engine.
- Ensure that the work area surrounding the DG set is dry, well illuminated, ventilated and spacious.
- Ensure that the work area surrounding the DG set is free from loose tools, parts, ignition sources and hazardous substances.
- Rotating parts can cause cuts, injury or strangulation.
- Disconnect the battery (-ve) cable first and discharge before beginning any repair work.
- Use only the proper engine barring techniques for manually rotating the engine. Do not attempt to rotate the crankshaft by pulling or prying the fan. This practice can cause serious personal injury, property damage or damage to fan blades.
- If the engine has been operating and the coolant is hot, allow the engine to cool before you slowly loosen the filler cap and relieve the pressure from the cooling system.
- Do not work on anything that is supported only by lifting jacks or a hoist. Always use blocks or proper stands to support the job before performing any maintenance work.
- Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do not check for pressure leaks with your hand. High pressure oil or fuel can cause serious injury.
- Corrosion inhibitor contains alkali. Do not get the substance in your eyes. Avoid prolonged or repeated contact with your skin. Do not swallow internally. In case of contact, immediately wash skin with soap and water.
- To avoid burns, be alert for hot parts and hot fluids in lines, tubes and compartments.
- Always use tools that are in good condition. Use only genuine OEM replacement parts.
- Do not use fasteners of lesser quality if replacements are necessary.
- Avoid inhalation of vapour, ingestion and prolonged contact with used engine oil.

A-SCHEDULE (DAILY MAINTENANCE)

SN.	Proposed Maintenance	Work Involved	Remarks
1.	Cleaning	Clean engine and premises.	
2.	Checking of engine oil level.	Check engine oil level before starting the engine, top-up if required.	It should be between top and bottom mark of dipstick
3.	Checking of fuel supply.	• Drain sediments from fuel tank. Check and ensure sufficient quantity of fuel. • Clean breather hole on fuel tank. • Fill up the fuel tank at the end of each working day.	Never wait until the tank is empty
4.	Checking of air filter/ system	• Remove dust accumulated in the dry type air filter bowl, through vacuator valve. • Check the condition of rubber hoses and clamps.	
5.	Checking of cooling system	Check coolant level in radiator, top-up if required.	
6.	Checking of battery.	Check battery terminal and connections.	
7.	Checking of engine parameters	Check all meters for normal working in engine running condition.	

B-SCHEDULE (MAINTENANCE AFTER EVERY 50 HOURS)

SN.	Proposed Maintenance	Work Involved	Remarks
1.	Repeat Maintenance	Repeat A- Schedule	
2.	Checking of air filter/ system	• In very dusty condition, clean the bowl of dry type air cleaner and if necessary change the element. • In normal working condition, this is to be done only when a need for air cleaner service is indicated by the restriction indicator.	After filter replacement, reset the indicator
3.	Checking of 'V' belts tension	Check 'V' belts tension by pressing with the thumb midway between the pulleys.	Deflection not more than 10 to 15 mm
4.	Checking of battery.	Check electrolyte level, add distilled water if required.	
5.	Other maintenance	Check the cable connections at starter, battery, dynamo/ alternator and control panel.	

C- SCHEDULE (MAINTENANCE AFTER EVERY 300 HOURS)

SN.	Proposed Maintenance	Work Involved	Remarks
1.	Repeat Maintenance	Repeat A & B - Schedule	
2.	Changing of engine oil	Refer item no. 1 of first 50 hrs. Maintenance	300 hrs. or 12 months which ever is earlier
3.	Cleaning of centrifugal filter.	Refer item no. 2 of first 50 hrs. Maintenance	
4.	Checking of lube system	Refer item no. 4 of first 50 hrs. Maintenance	
5.	Fuel supply system	• Drain the fuel filter bowls to remove the accumulated sediments and water. • Clean the preliminary filter sieve with clean diesel, fitted on feed pump inlet.	

D- SCHEDULE (MAINTENANCE AFTER EVERY 600 HOURS)

SN.	Proposed Maintenance	Work Involved	Remarks
1.	Repeat Maintenance	Repeat A, B & C - Schedule	
2.	Changing of spin –on type filters	Refer item no. 3 of first 50 hrs. Maintenance	
4.	Fuel supply system	Replace the pre filter insert of fuel filter. (Do not change pre-filter & micro filter insert at the same time, first change the pre filter insert and after about 200 to 250 hours. change micro-filter insert.)	
	Checking of valve tappet clearance.	Refer item no. 8 of first 50 hrs. Maintenance	

E - SCHEDULE (MAINTENANCE AFTER EVERY 1200 HOURS)

SN.	Proposed Maintenance	Work Involved	Remarks
1.	Repeat Maintenance	Repeat A, B, C & D - Schedule	
2.	Checking of fuel injector	Check the nozzle spray on nozzle tester. Replace the nozzle sealing washer and refit the nozzle and connect high pressure pipe.	
3.	Cleaning of fuel tank	Clean the fuel tank thoroughly with diesel. Do not use water for cleaning.	1200 hrs. or every 6 months whichever is earlier
4.	Cleaning of radiator	Clean radiator externally by blowing pressurised air in the reverse direction of the flow of radiator fan.	Do not spill water on radiator fins.
5.	Checking of thermostat element.	Check thermostat element for its safe operation by visual inspection. Its element shall rest in its seat i.e. it should close tightly.	
6.	Other maintenance	Inspect electrical unit i.e. starter, dynamo/ alternator, regulator etc. Replace worn out, defective parts and carbon brushes as required. Lubricate dynamo, starter etc. as required.	

EX NO:12
DATE

DG SET

AIM : To study about DG set and examine the working on DG Set panel and its protection.

(i) Identify the application of single phase preventer

(ii) Choose starting method and Practice on changing of lubricant, coolant of DG Sets.

(iii) Organize and examine the working on DG Set panel and its protection.

Material Required

Sl no	Description	Quantity	Remarks

Tools Required

Sl no	Name of tool	Quantity	Remarks

Working

Procedure

Result :