1. Explain Fuses?

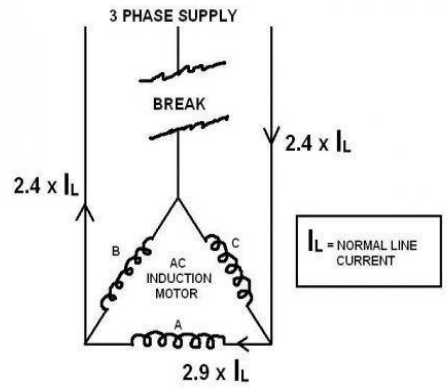
In electronics and electrical engineering, a **fuse** is an electrical safety device that operates to provide overcurrent protection of an electrical circuit. Its essential component is a metal wire or strip that melts when too much current flows through it, thereby interrupting the current.
It is rated as per current capacity-1,2,5 Amp
Fuse markings are: Current readings, Voltage readings, Time-current characterisitic ie. Fuse speed, Part no. Series.
Types of Fuses are:
HRC, Ribbon tube, glass filled, Blade type, NFB(no fuse breaker)
Fuses are checked by multimeter (in resistance mode)
Fuse is OK if meter reading changes to a low resistance value
Fuse is blown if meter reading does not change.

2. How to check multimeter?

Multimeter has to be checked for current , voltage, resistance.
For voltage, connect probe to line point (ac/dc)
For resistance,put to resistance mode and then touch both probes to each other, it should show zero reading.

3. What is single phasing?

The 3 phase motors must be connected to rated voltage and load for proper working. If due to some reasons, one phase of the motor gets disconnected, the motor will continue to run from the active 2 phase supply. This is called Single phasing.
If the 3 phase motor is running and then one of the phase gets disconnected, the motor will continue run with vibrations and reduced speed. However depending on the loading conditions, the motors may/may not start on two phases.
Single phasing is not desirable for the proper operation of the induction motors and appropriate measures should be taken to protect the machine.



Causes:

- One of the three back up fuses blows (or fuse wire melts).
- One of the contactor for motor is open circuited.
- Wrong setting of the protection devices provided on the motor.
- Relay contacts may be damage or broken.

Effects of single phasing:

- The motor runs with a reduced speed.
- It operates with an uneven torque and produces a humming noise.
- There will be vibration on the motor
- It may cause overloading of the generator.
- If the motor is arranged for standby and automatic starting then the motor will not start, and if the overload relay provided fails to function then the motor may burn.
- *No effect on single phasing in star-delta, as Line current equals to phase current, Phase current high enough to damage windings then overload relay will trip contactor and isolate from supply.*

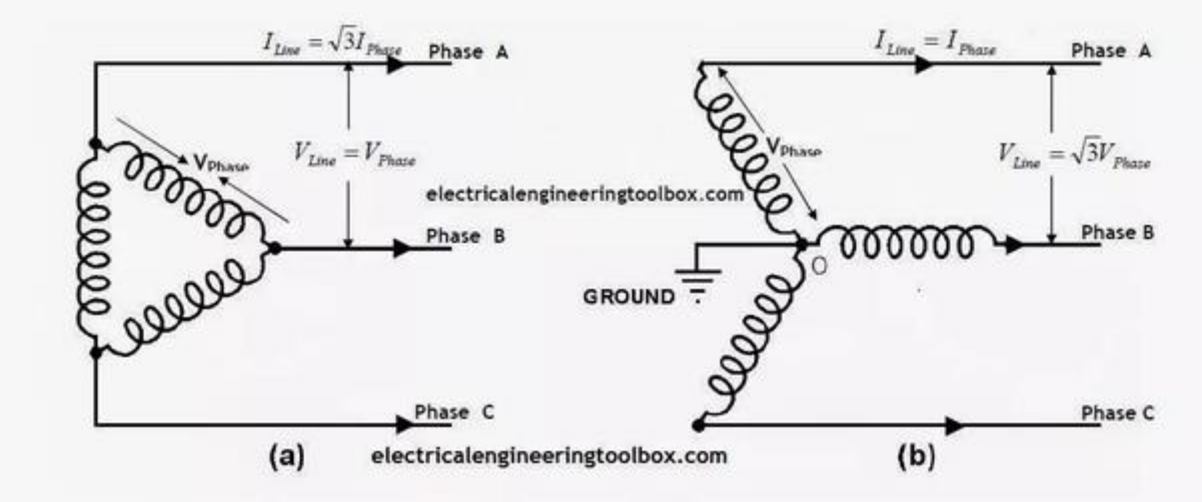
Overload relay

Protection devices:

- ***Overload relay:*** All the three phases of the motor are fitted with an overload relay. If there is any increase in the value of the current then this relay activates automatically and the motor trips.
- ***Thermistors:*** They are used along with the electromagnetic relay and inserted in the 3 windings of the motor. They sense the increase in the temperature and a signal is sent to the amplifier which in turn amplifies the current signal and operates the relay coil resulting in tripping.
- ***Bi-metallic Strip:*** They work on the basis of thermal expansion.

4. Difference between Star & Delta.

First of all I want to clear you that Star & Delta Connection only possible in 3 phase system, So in our domestic system it is not possible, because generally all house hold electrical equipment are designed with single phase supply.



Delta Connected System.

- In a Delta Connected system Line Voltage is equal to Phase Voltage.
- While phase current is √3 times less than Line current.
- Insulation level is high because line voltage = Phase Voltage.
- It is generally used where high starting Torque is required.

Star Connected System.

- Star connection is used where we require Neutral terminal to obtain Phase voltage like above image.
- in a star connected system VL=√3Vph,mean Phase voltage is root 3 times less than line voltage.
- In a star Connected system IL=I phase.
- Star connected system require less insulation level.
- Star Connected system is used where low starting current is required.

5. How electricity is produced onboard?

Shipboard power is generated using a prime mover and an alternator working together. For this an alternating current generator is used on board. The generator works on the principle that when there is a relative motion between conductor and magnetic field, emf will be induced. This emf is directly proportional to the rate of flux. This is also known as Faraday's law of electromagnetic induction. $E = \frac{d\phi}{dt}$

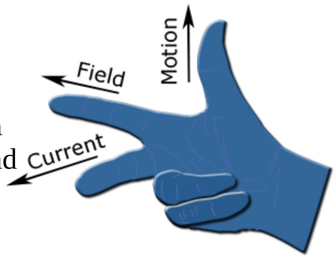
6. Power distribution onboard?

A shipboard distribution system consists of different component for distribution and safe operation of the system. They are:

- Ship Generator consisting of prime mover and alternator
  Main switch board which is a metal enclosure taking power from the diesel generator and supplying it to different machinery.
- Bus Bars which acts as a carrier and allow transfer of load from one point to another. Circuit breakers which act as a switch and in unsafe condition can be tripped to avoid breakdown and accidents. Fuses as safety device for machinery.
- Transformers to step up or step down the voltage. When supply is to be given to the lighting system a step down transformer is used in the distribution system.
- In a power distribution system, the voltage at which the system works is usually 440v.

- There are some large installations where the voltage is as high as 6600v.
- Power is supplied through circuit breakers to large auxiliary machinery at high voltage.
- For smaller supply fuse and miniature circuit breakers are used.
- The distribution system is three wires and can be neutrally insulated or earthed.
- Insulated system is more preferred as compare to earthed system because during an earth fault essential machinery such as steering gear can be lost.

7. Fleming's right hand rule: (also known as generator rule)



Emf or the current produced by Faraday's law, its direction can be find out with Flemings right hand rule. The right hand is held with the thumb, index finger and the middle finger mutually perpendicular to each other (at right angles), as shown in figure.

- The thu**m**b is pointed in the direction of the **m**otion of the conductor relative to the magnetic field.
- The **f**irst finger is pointed in the direction of the magnetic **f**ield. (north to south)
- Then the se**c**ond finger represents the direction of the induced or generated **c**urrent within the conductor

8. Fleming's left hand rule: (also known as motor rule)

Whenever a current carrying conductor is placed in a magnetic field, the conductor experiences a force which is perpendicular to both the magnetic field and the direction of current. According to **Fleming's left hand rule**, if the thumb, fore-finger and middle finger of the left hand are stretched to be perpendicular to each other as shown in the illustration at left, and if the fore finger represents the direction of magnetic field, the middle finger represents the direction of current, then the thumb represents the direction of force. Fleming's left hand rule is applicable for motors.

- The **Th**umb represents the direction of **Th**rust on the conductor (force on the conductor).
- The **F**ore finger represents the direction of the magnetic **F**ield.
- The **C**enter finger (middle finger) the direction of the **C**urrent.

9. Lenz's law

Lenz's law states that when an emf is generated by a change in magnetic flux according to Faraday's Law, the polarity of the induced emf is such, that it produces a current and it's magnetic field opposes the change which produces it. It is also called Back Emf.
The negative sign used in Faraday's law of electromagnetic induction, indicates that the induced emf (ε) and the change in magnetic flux ($\delta\Phi_B$) have opposite signs.

$$\epsilon = -N\frac{\partial \Phi_B}{\partial t}$$

10. Main Switchboard safeties

- Ebonite rod
- Rubber mat (infront of switchboard of 15mm thickness)
- Deadfront type switchboard
- 0.6m gap behind switchboard
- Fuse
- Circuit breaker
- Earth fault indicator
- Panel door earth
- Oil, water, steam pipeline not to pass from vicinity
- Undervoltage relay
- Reverse power trip
- Preferential trip
- Overcurrent trip (carried out in dry dock)
- Arc chutes
- Short cicuit trip

(Above underlined ones are alternator safeties)
MCB safeties are overcurrent trip, UV relay and reverse power trip

Jai Mata Di
Electrical Oral Notes Prepared By Ankur Sharma

11. Emergency Switchboard safeties?

- All safeties same as MSB safeties, but the most important is interlock between ESB and MSB, so that both breakers do not operate at the same time.
- Should be installed as near as possible to emergency source of electrical power.
- ESB should be supplied during normal operation from MSB with an interconnector.
- No accumulation batteries should be fitted in the same place.
- Should be located in the uppermost continuous deck.
- Easily accessible from an open deck

12. What is emergency switch board ?

- It is a switchboard which distributes emergency load that power is supplied from emergency generator during the main power source failure.
- It has two sections- one for 440V and another is 220V.
- Under normal condition, 440 V supply is taken from E/R Main Switchboard, through a Circuit Breaker
- When main power is lost, this Circuit breaker is tripped (opened)
- Emergency generator comes into action, and supplies power through another circuit breaker
- An interlock is provided, to prevent simultaneous closing of both breaker (both main and emergency generator may be running, simultaneously)

13. Emergency Switchboard Distribution

- Emergency Bilge pump (440 V)
- Sprinkler system (440 V)
- One of the steering gears (440 V)
- Navigation Equipment (220 V)
- Radio Communication (220 V)
- Transformed and rectified supply to Battery systems (220 V)
- Transitional Emergency Power Battery (Emergency lights for 30 minutes)
- Low power DC system Battery (Alarms and control system)

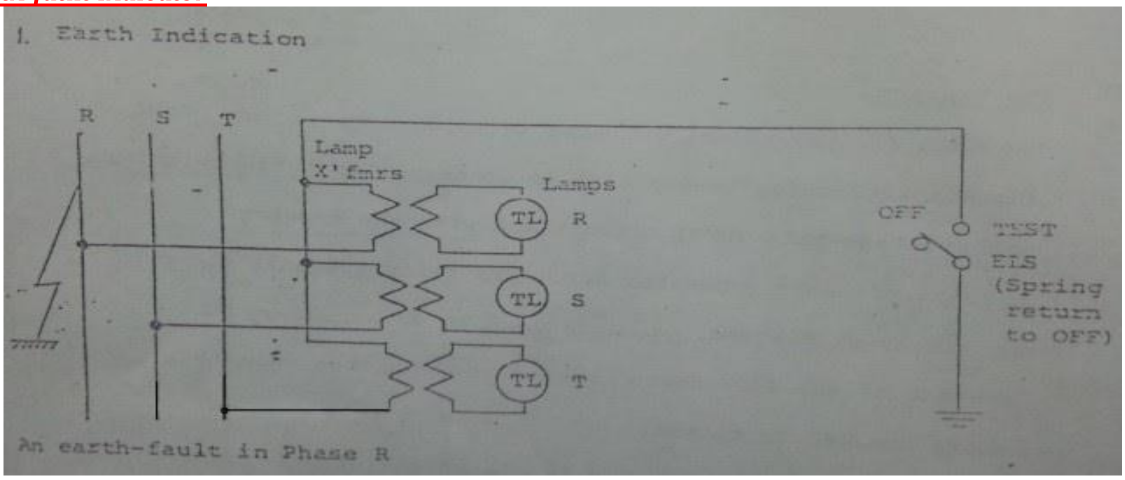
14. What are the equipment which get supply from emergency generator ?

- It is called emergency load
- Emergency lightening to alley way /boat deck / engine room.
- Navigation system
- Steering gear
- Emergency fire pump
- Emergency air compressor
- Battery charging
- Fire detecting and alarming system
- Radio equipments (Communication equipment)
- Daylight signaling lamp and ship's whistle
- Navigation Aids
- General Alarm
- Manual fire alarm
- Watertight doors

15. What are the requirements / regulations for emergency power sources on ships ?

- All passenger and cargo vessels shall be provided with emergency sources of electrical power, for essential services under emergency conditions.
- Emergency source may be generator or batteries, but must be complied with the rules
- Emergency sources must be installed in position such that they are unlikely to be damaged or affected by any incident, which has caused to main power.
- Emergency source of power should be capable of operating with a list of up to 22 ½ ° and a trim of up to 10 °
- Emergency generator with its switchboard, is located in a compartment which is outside and away from main and auxiliary machinery space, above the uppermost continuous deck, and not forward of collision bulkhead
- For batteries, the above same rules applied, nut must not be fitted in the same place as emergency switchboard.

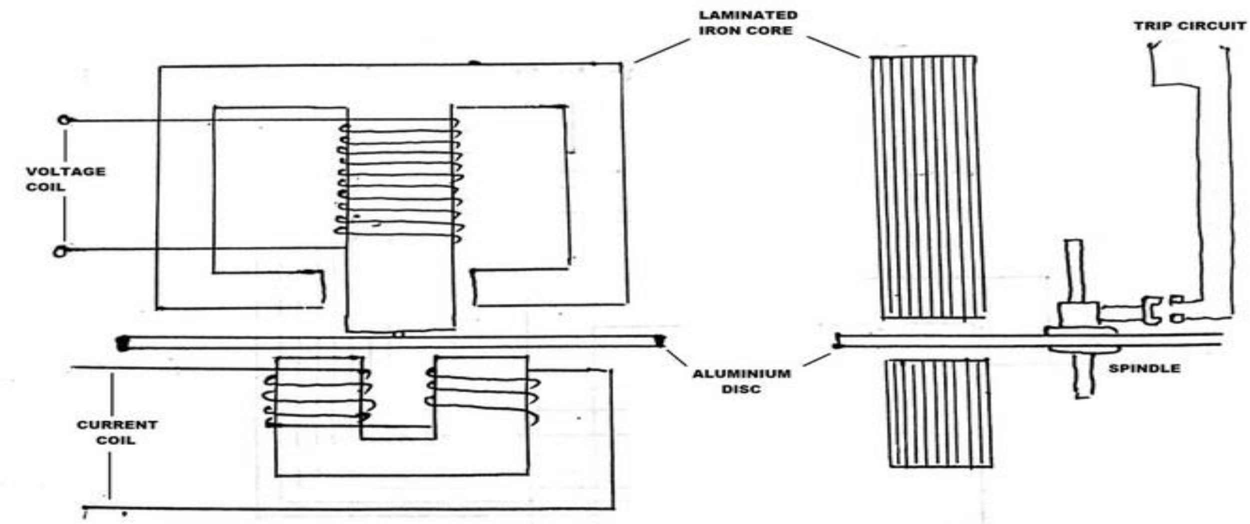
16. Earth fault indicator



When "EARTH LAMP" switch (ELS) on a feeder panel is in OFF position, the neutral of the star connected primaries of three lamp transformers is disconnected from the earth, and the voltage across the primary is the same for each transformer regardless whether the ship's feeder system contains an earth fault or not. Therefore, three indicator lamps (TLs) connected to the respective transformer secondaries are on at the same brightness.
To check the ship's feeder system's insulation resistance to earth, put "EARTH LAMP" switch (ELS) to TEST (this earths the neutral of the star connected primaries of lamp transformers). If there is an earth fault in phase R, for example, the lamp R would be less bright than other two; or if it is a complete earth fault, the lamp R would be off. Where there is no earth fault, switching of the ELS from OFF to TEST gives no change in lamps' brightness.

17. What are the ACB trips?

(A)Reverse power trips:



Reverse Power Relay is a directional protective relay that prevents/protect the generator from motoring effect (going to reverse direction). It is used where generator runs in parallel with other utility or generator. The relay monitors the power supply from the generator and in case the generator output falls below a preset value, it quickly activates the trip and disconnects the generator.

CONSTRUCTION

The relay is made up of lightweight non-magnetic **Aluminium disc** between two soft laminated iron core electromagnets. The upper magnet is wound with Voltage Coil (PT) which is supplied from one phase & artificial neutral of generator output. The other output magnet is wound with Current Coil (CT) connected to the same phase as the voltage in the upper electromagnet.

WORKING

Since Voltage Coil has more number of turns, so it has move inductive value and more induced current that lag in the coil by an angle of 90°. The current coil has less number of turns, so it has less inductive valve & less induced current that lag less.

As we all know that current carrying conductor produces the magnetic field. So both upper and lower section produces magnetic fields. But Induced current in PT lags more than CT so magnetic field produced in upper section will be weaker than lower section & both magnetic fields will have a difference of 90°

When both fields pass through the Aluminium disc, it produces eddy current. As a result of the formation of eddy current torque is generated that tries to rotate the disc. Under normal power flow, the trip contact on the disc are open and rotation is restricted by stoppers but if a reverse power starts to flow the disc is rotated in opposite direction, moves away from the stoppers in the direction of trip contact that activates the trip.

Why is Reverse Power Relay required?

When two or more power units are running in parallel and if reverse power flow occurs, the same unit will start drawing power from the main bus bar. it can cause overloading of the other power supply unit and hence leads for the preferential trip or may lead to total power failure(Blackout). At the same time the faulty unit will draw power from main bus bar and go for motoring effect and RPM will soot up which leads to over speed trip or in worst case some mechanical failure to the prime mover.

When does reverse power flow…..?

- When the prime mover of a generator is not supplying sufficient torque to keep the generator rotor spinning at the same frequency as the bus goes to which the generator is supposed to be connected, the generator will start behaving like a motor and instead of supplying power it will draw power from bus bar.
- During synchronization, it might be possible to have the synchroscope rotates slow (anticlockwise direction) and then close the breakup. under this condition. The generator would then be drawing current from the bus for instead of supplying current through the bus (which occurs when the breaker is closed with the synchroscope rotates in the fast anticlockwise direction).
- Faulty Governer of the prime mover.
- Loss of excitation in the alternator.

How do you test reverse power trip?

Reverse power trip can be tested by load shifting with the help of Governor control. when the Load has shifted sufficiently from the generator to be offloaded (Nearly 10% of the max rated), reverse power relay will open the ACB of the same generator. this relay can be tested by simulation using boost test push button on the relay to see if it gives a trip signal.

(B) Under Voltage Trip:

Its main function is to trip the breaker when a severe voltage dip occurs.
It also prevents the closure of the circuit breaker by mistake of the dead generator.

(C) Overcurrent trip:

Once in drydock in presence of surveyor by current iinjection method.
It will trip at 110% of the rated current, the surveyor will break the seal.

18. What are the electric checks in dry dock?

ICCP, MGPS, Auxiliary Blower, MSB contact cleaning, ACB, All motors, Busbar contactor,Alternator, Busbar mounting for cracks,

19. Single phase motor?

A single phase induction motor is one designed to run on a single phase supply while in three phase motors, The three phases are 120 degrees apart, so that a proper rotating field is produced. They tend to be smaller and cheaper and run smoother than an equivalent single phase motor. They can be more efficient than some single phase motors.

Single phase induction motor is not the self starting so, to make it self start we can use capacitor & capacitor also provides high starting torque.

Types of single phase motors are:
Split phase, capacitor type, Shreaded Pol

20. How to check insulation of alternator?

- Isolate prime mover
- Switch off the heater
- Disconnect AVR
- Disconnect rectifier assembly
- Open terminal box and clean with vaccum cleaner
- Check insulation with megger 500 V dc
- DC, because in case of AC we will also get impedance and we only want to know resistancce.

(According to class, IR should be always greater than 1 Mega-ohm).

21. *Why AC is preferred over DC?*

- AC voltage can be step up or down.
- AC can be transmitted to long distance with low losses
- The cable are thin.
- DC machines are bulky.
- AC motor gives higher output.
- It is easier to convert AC to DC rather than the other way around.

22. *What is Synchronization of Generators?*

The process of matching parameters such as voltage, frequency, phase angle, phase sequence of generator with a healthy or running power system is called synchronization.
Synchronization matches various parameters of one alternator (or generator) to another alternator or to the bus bar. The process of synchronization is also called as paralleling of alternators.

Conditions for Synchronization or Paralleling of Generators

Mentioned below are the requirements that must be met for successful paralleling of alternators.

Phase Sequence
The phase sequence of the three phases of the incoming alternator must be same as the phase sequence of the three phases of the bus bar. This problem comes mainly in the event of initial installation or after maintenance.

Voltage Magnitude
The RMS voltage of the incoming alternator should be same as the RMS voltage of the bus bar. If the incoming alternator voltage is more than the bus bar voltage, there will be a high reactive power that flows from the generator into the bus bar. If the incoming alternator voltage is lower than the bus bar voltage, generator absorbs the high reactive power from the bus bar.

Frequency
The frequency of the incoming generator must be equal to the frequency of the bus bar. Improper matching of frequency results high acceleration and deceleration in the prime mover that increases the transient torque.

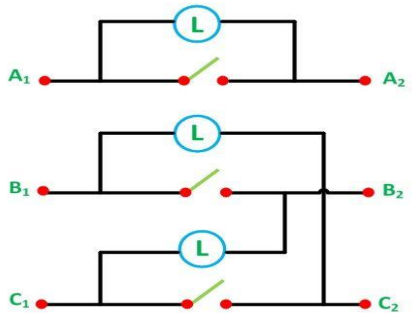
Phase Angle
The phase angle between the incoming generator voltage and voltage of the bus bar should be zero.

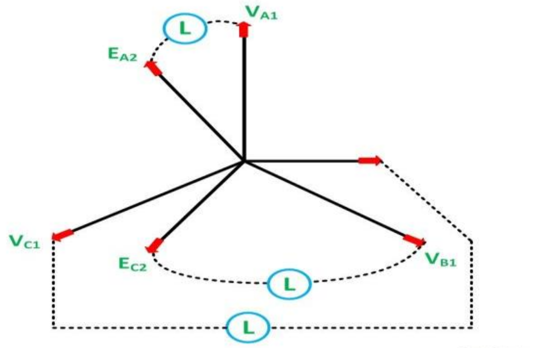
23. *Method of synchronization?*

Dark Lamp Method
In this method, the lamps are connected in the same phases such as A_1 is connected to A_2, B_1 is connected to B_2 and C_1 is connected to C_2. If all the three lamps get bright and dark together, this means that the phase sequence is correct. The correct instant of closing the synchronising switch is when all lamps are dark.

Three Bright Lamp Method
In this method, the lamps are connected across the phases such as A_1 is connected to B_2, B_1 is connected to C_2 and C_1 is connected to A_2. If all the three lamps get bright and dark together, this means that the phase sequence is correct. The correct instant of closing the synchronising switch is when all lamps are bright.

Two Bright One Dark Lamp Method
In this method, one lamp is connected between corresponding phases while the two others are cross-connected between the other two phases as shown in the figure below.

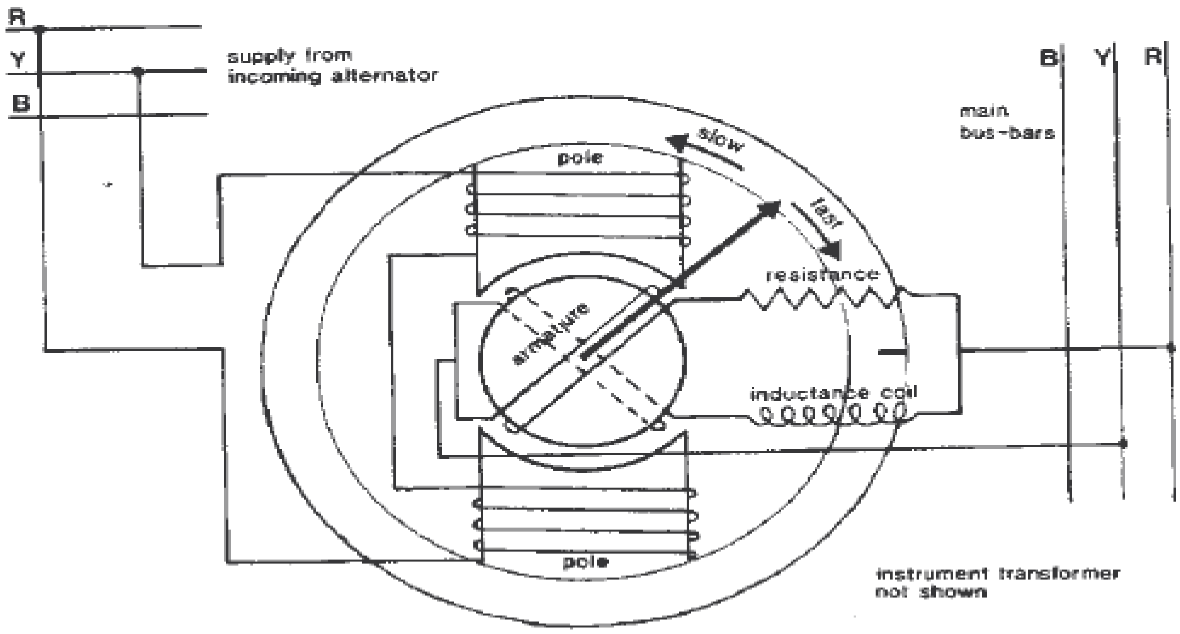




Here, A_1 is connected to A_2, B_1 to C_2 and C_1 to B_2. The prime mover of the incoming machine is started and brought up to its rated speed. The excitation of the incoming machine is adjusted in such a way that the incoming machine induces the voltage E_{A1}, E_{B2}, E_{C3}, which is equal to the Busbar voltages V_{A1}, V_{B1} and V_{C1}.

The correct moment to close the switch is obtained at the instant when the straight connected lamp is dark, and the connected cross lamps are equally bright. If the phase sequence is incorrect, no such instant will take place, and all the lamps will be dark simultaneously.
The direction of rotation of the incoming machine is changed by interchanging the two lines of the machine. Since the dark range of the lamp extends to a considerable voltage range, a voltmeter V_1 is connected across the straight lamp. The synchronising switch is closed when the voltmeter reading is zero.
Thus, the incoming machine is now floating on the Busbar and is ready to take up the load as a generator. If the prime mover is disconnected, it behaves as a motor. For paralleling small machines in power stations, three lamps along with the synchroscope are used. For synchronising very large machine in power stations, the whole procedure is performed automatically by the computer.

Synchroscope method or explain synchroscope



- The synchroscope consists of a small motor with coils on the two poles connected across two phases. Let's say it is connected in red and yellow phases of the incoming machine and armature windings supplied from red and yellow phases from the switchboard bus bars.
- The bus bar circuit consists of an inductance and resistance connected in parallel.
- The inductor circuit has the delaying current effect by 90 degrees relative to current in resistance.
- These dual currents are fed into the synchroscope with the help of slip rings to the armature windings which produces a rotating magnetic field.
- The polarity of the poles will change alternatively in north/south direction with changes in red and yellow phases of the incoming machine.
- The rotating field will react with the poles by turning the rotor either in clockwise or anticlockwise direction.
- If the rotor is moving in clockwise direction this means that the incoming machine is running faster than the bus bar and slower when running in anticlockwise direction.
- Generally, it is preferred to adjust the alternator speed slightly higher, which will move the pointer on synchroscope is in clockwise direction.
- The breaker is closed just before the pointer reaches 12 o clock position, at which the incoming machine is in phase with the bus bar.
- *Note: Without the aid of synchroscope and lamp method, alternators can be synchronised by using a voltmeter connected across one pole of the incoming generator circuit breaker. When the voltmeter shoots from 0 to maximum, close the circuit breaker, on adjusting generator speed passing through zero.*

24. Advantages and disadvantages of Dark Lamp Method

Advantages of the Dark Lamp Method

This method is cheaper.
The correct phase sequence is easily determined.

Disadvantages of the Dark Lamp Method

The lamp becomes dark at about half of its rated voltage. Hence, it is possible that the synchronising switch might be switched off even when there is a phase difference between the machine.
The filament of the lamp might burn out.
The flicker of the lamps does not indicate that which lamp has the higher frequency.

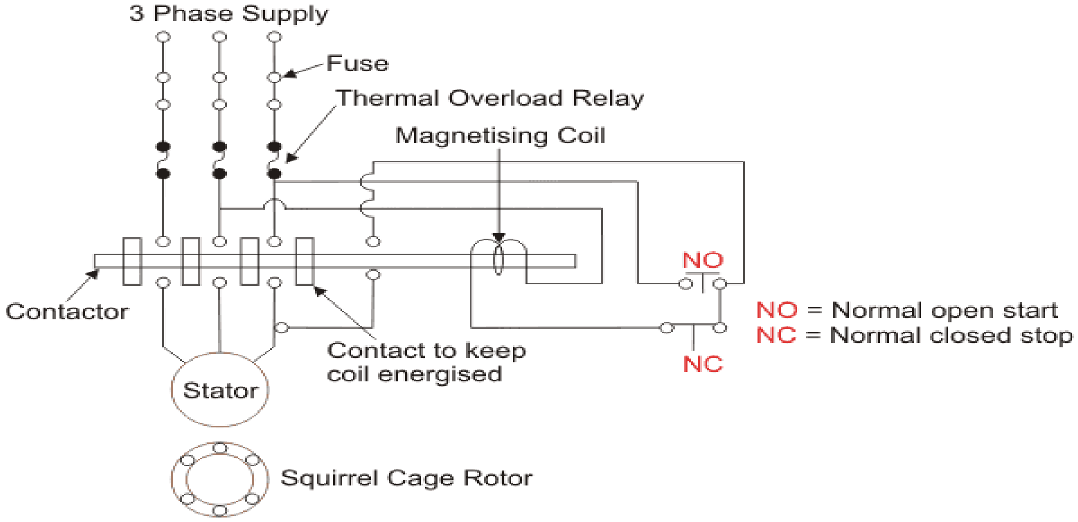
25. Maintenance to be done on alternator?

- Shut down the prime mover
- Circuit breaker is locked off, auto start circuits are disabled.
- Electric heaters are isolated and switched off.
- Inform Chief Engineer
- Work permit on electrical equipment, risk assessment done.
- Wiring inspected for damage and frayed insulation, tightness of terminal connection.
- Checks for the signs of oil and water on the terminal
- Checks for the air intake passage is not chocked.
- Cleaning of stator winding and rotor winding dust.
- If presence of oil, removing or cleaning with degreasant liquid like electro cleaner
- Minor abrasions on windings can be repaired by application of dry varnish.
- Generator excitation transformers, AVR components and rotating diodes must be kept free of dirt, oil and dampness.
- Measuring insulation resistance of the stator and rotor windings to earth and between stator phases.
- On checking IR, disconnect electronic circuit components which are likely to be damaged by HV insulation test
- Minimum IR acceptable is 1Megaohm- 0.8 to 1.5 ohm for DC test and not lesser below 1kiloohm/1volt.
- On no-load running, check for excess temperature rise and load sharing stability when running in parallel. Air gap clearance measured should be 1.5-2.0 mm

26. Types of Starters?

- Direct Online Starter (DOL)
- Star-Delta Starter
- Auto transformer starter
- Soft Starter

Direct Online Starter



DOL Starter Working

The above wiring connection is of DOL starter. The **DOL starter** connects the 3-phase main with the motor. The control circuit is connected to any two phases and energised from them only. When we press the start button, the current flows through contactor coil (Magnetizing Coil) and control circuit also. The current energises the contactor coil and leads to close the contacts, and hence 3-phase supply becomes available to the motor. If we press the stop button, the current through the contact becomes discontinued, hence supply to the motor will not be available, and the similar thing will happen when overload relay operates. Since the supply of motor breaks, the machine will come to rest. The contactor coil (Magnetizing Coil) gets supply even though we release start button because when we release start button, it will get supply from the primary contacts as illustrated in the diagram of the **Direct Online Starter**.

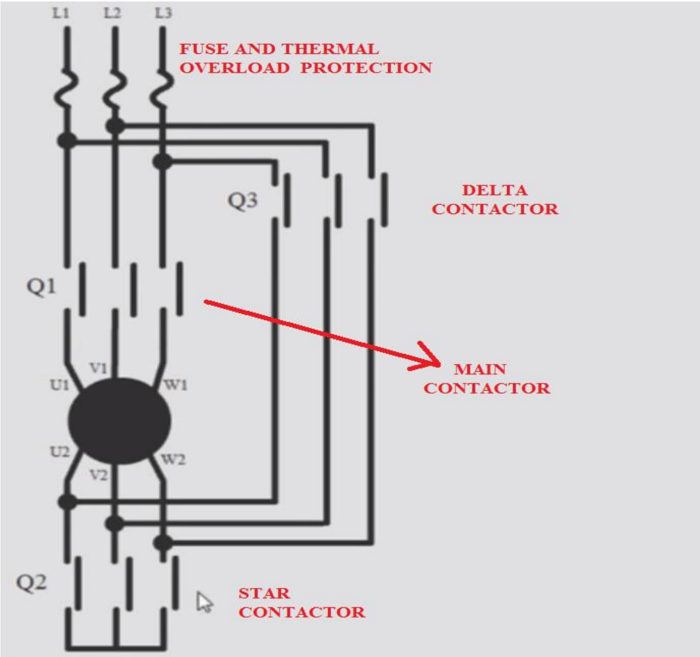
Advantages of DOL Starter

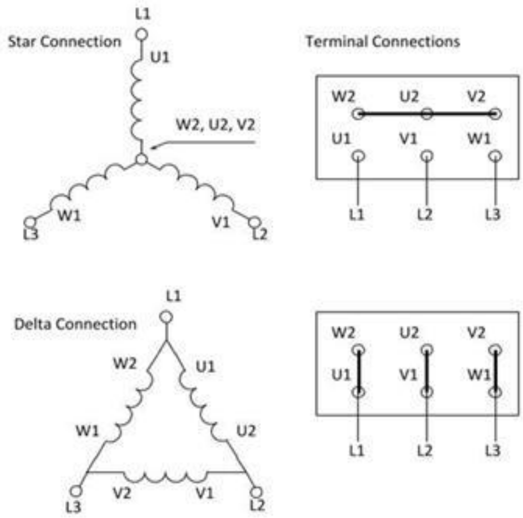
Simple and most economical starter.
More comfortable to design, operate and control.
Provides nearly full starting torque at starting.
Easy to understand and troubleshoot.
DOL starter connects the supply to the delta winding of the motor.

Disadvantages of DOL Starter
High starting current (5-8 times of full load current).
DOL Starter causes a significant dip in voltage, hence suitable only for small motors.
DOL Starter reduces the lifespan of the machine.
Mechanically tough.
Unnecessary high starting torque

Applications of DOL Starter
We use the DOL starter where high inrush currents do not cause any harm, like to start small water pumps, compressors, fans and conveyor belts etc.

Star-Delta Starter





In star delta starting, the motor is connected in STAR mode throughout the starting period. When the motor reached the required speed, the motor is connected in DELTA mode.

Components of a Star-Delta Starter:
Contactors: The Star- Delta starter circuit comprises of three contactors: Main, star and delta contactors. The three contactors are solicited to unite the motor windings first in star and afterward in delta.
Timer: The contactors are regulated by a timer incorporated with the started.
Interlock switches: Interlock switches are connected between star and delta contactors of the control circuit as a safety measure so one can't activate delta contactor without deactivating star contactor. By any chance if star and delta contactors are actuated at the same time, the motor will be damaged.
Thermal overload relay: A thermal over-load relay is likewise consolidated into star-delta control circuit to ensure the motor from intemperate heat which might expedite motor finding fire or wearing out. In the event that the temperature goes past a preset quality, the contact is open and power supply is cut in this manner ensuring the motor.

Working of Star-Delta Starter:
At first the primary contactor and the star contactors are shut. After a time interval the timer signs to the star contactor to head off to the open position and the primary, delta contactors to head off to the shut position, accordingly structuring delta circuit.
At the time of starting when the stator windings are star associated, every stator stage gets voltage $VL/\sqrt{3}$, where VL is the line voltage. Hence, the line current drawn by the motor at starting is decreased to one-third as contrasted with starting current with the windings associated in delta. Likewise, since the torque advanced by an induction motor is corresponding to the square of the applied voltage; star- delta starter decreases the starting torque to one- third of that possible by immediate delta starting.
The timer controls conversion from star connection to delta connection. A timer in star delta starter for a 3-phase motor is intended to do the move from star mode, utilizing which the motor runs on a decreased voltage and current and produces less torque – to the delta mode indispensible for running the motor at its full power, utilizing high voltage and current to transform a high torque.

Terminal Connections in Star and Delta Configurations:
L1, L2 and L3 are the 3-phase line voltages, which are given to primary contactor. The main motor coils are U, V and W is shown in figure. In star mode of motor windings, the primary contactor associate the mains to essential winding terminals U1, V1 and W1.the star contactor shorts the auxiliary winding terminals U2, V2 and W2 as indicated in figure. Notwithstanding when the primary contactor is shut supply arrives at terminals A1, B1, C1 and consequently the motor windings are energized in star-mode.
The timer is initiated in the meantime moment when star contactor is energized. After the timer achieves the specified time period, the star contactor is de-energized and delta contactor is energized.
The point when delta contactor closes, the motor winding terminals U2, V2 and W2 get associated with V1, W1 and U1 individually through the shut contacts of primary contactor. That is for delta association, fulfilling end of one winding is to be joined with beginning end of the other winding. The motor windings are reconfigured in delta by supplying line voltage L1 to winding terminals W2 and U1, line voltage L2 to winding terminals U2 and V1; and line voltage L3 to winding terminals V2 and W1, as indicated in figure.

Advantages of Star Delta Starter
Inexpensive
No heat is produced, or tap changing device needs to be used, hence efficiency increases.
Starting current reduced to 1/3 of direct online starting current.
Produce high torque per ampere of line current.

Disadvantages of Star Delta Starter
Starting torque is reduced to 1/3 of full load torque.
A particular set of motors required.

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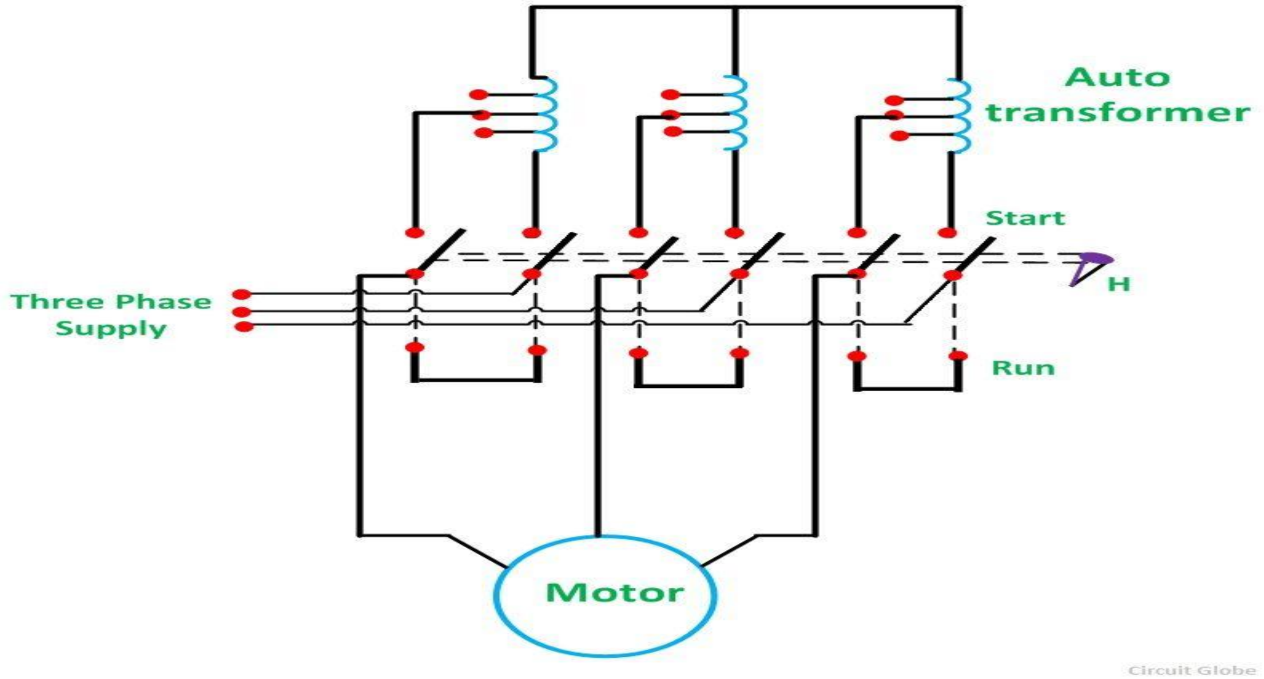
Applications of Star Delta Starter
By seeing above advantages and disadvantages, we can say that we usually use **star delta starter** where the required starting current is low and where the line current draw must be at a minimum value.
Example – Centrifugal compressor.

Auto-transformer starter:

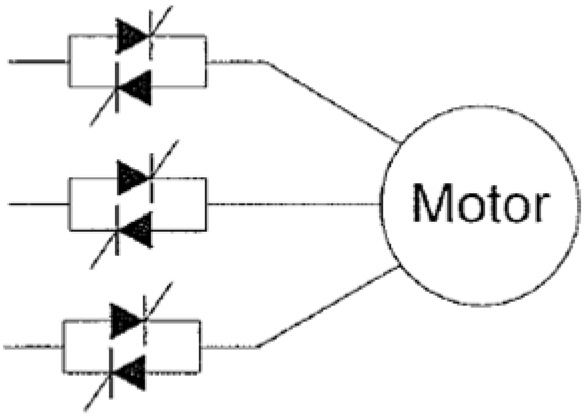


It is provided with a number of tappings. The starter is connected to one particular tapping to obtain the most suitable starting voltage. A double throw switch S is used to connect the auto transformer in the circuit for starting. When the **handle H** of the switch S in the **START** position. The primary of the auto transformer is connected to the supply line, and the motor is connected to the secondary of the auto transformer.
When the motor picks up the speed of about 80 percent of its rated value, the handle H is quickly moved to the **RUN** position. Thus, the auto transformer is disconnected from the circuit, and the motor is directly connected to the line and achieve its full rated voltage. The handle is held in the **RUN** position by the under voltage relay.
If the supply voltage fails or falls below a certain value, the handle is released and returns to the **OFF** position.
Thermal overload relays provide the overload protection.

ADVANTAGES OF AUTO TRANSFORMER STARTER:
a) On the 65% tapping the line current is approximately equal tp that of a Star-Delta starter, however, at the time of switching from reduced voltage to the full supply voltage, the motor is not disconnected so that the second peak is very much reduced since the transformer is converted into reactance for a short time.
b) It is possible to vary the tapping from 65% to 80% or even up to 90% of the supply voltage in order to ensure that the motor starts satisfactorily.

Disadvantages:
a) One of its great disadvantages is the limitation of its operation frequency. It is always necessary to know the operation frequency in order to determine a suitably rated auto-transformer.
b) The compensating switch is much more expensive than a Star-Delta starter due to the auto-transformer.
c) Due to the size of the auto-transformer starter, much larger control panels are required which increases the price.

Soft Starter
The soft starter operates on a different premise. This principle is that by adjusting the voltage applied to the motor during starting, the current and torque characteristics can be limited and controlled.
For induction motors, the starting torque (LRT) is approximately proportional to the square of the starting current (LRA) drawn from the line. LRT ∝ I2. This starting current is proportional to the applied voltage (V). So the torque can also be considered to be approximately proportional to the applied voltage. LRT ∝ V2.. By adjusting voltage during starting, the current drawn by the motor and the torque produced by the motor can be reduced and controlled.
By using six SCR's in a back to back configuration as shown in figure 2, the soft starter is able to regulate the voltage applied to the motor during starting from 0 volts up to line voltage. Unlike the VFD, line frequency is always applied to the motor. Only the voltage changes.



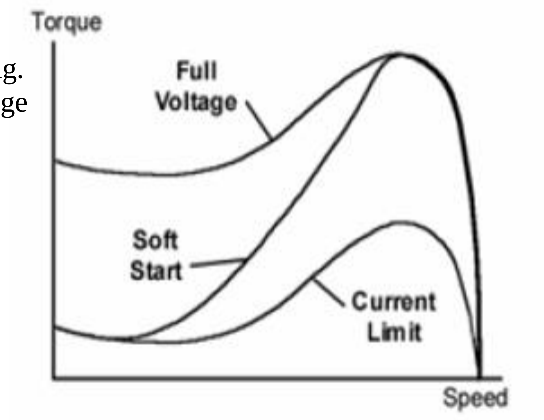
Operation of Soft starters

Timing of when to turn on the SCR's is the key to controlling the voltage output of a soft starter. During the starting sequence the logic of the soft starter determines when to turn on the SCR's. It does not turn on the SCR's at the point that the voltage goes from negative to positive, but waits for some time after that. This is known as "phasing back" the SCR's. The point that the SCR's are turned on is set or programmed by what is called either initial torque, initial current or current limit setting.
The input voltage to the soft starter is the same as the VFD shown in figure 3. The result of phasing back the SCR's is a non-sinusoidal reduced voltage at the terminals of the motor which is shown in figures 7. Since the motor is inductive and the current lags the voltage, the SCR stays turned on and conduct until the current goes to zero. This is after the voltage has gone negative.

Advantages of Soft Start
- **Improved Efficiency**: The efficiency of soft starter system using solid state switches is more owing to the low on state voltage.
- **Controlled startup**: The starting current can be controlled smoothly by easily altering the starting voltage and this ensures smooth starting of the motor without any jerks.
- **Controlled acceleration**: Motor acceleration is controlled smoothly.
- **Low Cost and size**: This is ensured with the use of solid state switches.

Applications:
- In pump applications- a soft start can avoid pressure surges
- In conveyor belt systems- avoids jerk and stress on drive components.
- Fans or other systems with belt drive- to avoid slipping of belt
- In all systems- limits the inrush current and so improves the stability of power supply.

Soft starters do have an advantage over conventional reduced voltage starting. They are able to adjust voltage, current and therefore torque over a wide range instead of single or a few fixed values. This can be seen in Figure 10. When voltage or current is held to a constant value, the speed-torque curve labelled "Current Limit" is produced. This curve would move up or down depending on the current limit setting. The upper boundary of this adjustment is the "Full Voltage" curve.

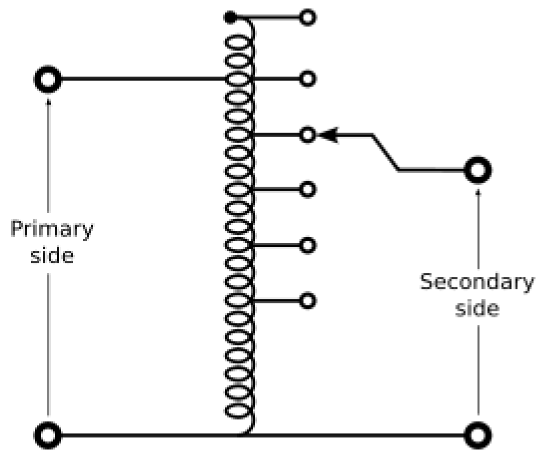


27. What is Autotransformer?

An autotransformer is an electrical transformer with only one winding. The "auto" (Greek for "self") prefix refers to the single coil acting alone, not to any kind of automatic mechanism. In an autotransformer, portions of the same winding act as both the primary and secondary sides of the transformer. In contrast, an ordinary transformer has separate primary and secondary windings which are not electrically connected.

The winding has at least three taps where electrical connections are made. Since part of the winding does "double duty", autotransformers have the advantages of often being smaller, lighter, and cheaper than typical dual-winding transformers, but the disadvantage of not providing electrical isolation between primary and secondary circuits. Other advantages of autotransformers include lower leakage reactance, lower losses, lower excitation current, and increased VA rating for a given size and mass.

An example of an application of an autotransformer is one style of traveller's voltage converter, that allows 230 volt devices to be used on 120 volt supply circuits, or the reverse. An autotransformer with multiple taps may be applied to adjust voltage at the end of a long distribution circuit to correct for excess voltage drop; when automatically controlled, this is one example of a voltage regulator.



Applications for Autotransformer

Reduced voltage starter for induction motor
Starting gear for certain types of fluorescent light fixtures
Booster at the end of long transmission line to compensate for line losses
Multi-tap type feeding the primary of plating rectifier transformer, to enable rectifier output control.

28. Ingress Protection AB

Degree of protection against ingress of solids and liquids coded by two figured numbers.
IP 23= Alternator (>12.5mm, enclosure @60degrees)
IP 44= Engine room motor (>1mm, Splash resist)
IP 55= Total enclosed motor (Partial protection from dust ingress, partial protection from water jet)
IP 56= Open deck motor (same as above for solid, Partial protection from water at all sides)
IP 68= Submerged motor (Full protection for 2 to 8 hrs, submerged for long period)

Value of A
0= No protection against live or moving parts
1= Protection against large solid particles > 50mm
2= Protection against medium solid particles > 12mm (protection from fingers)
3= Protection against small solid particles >2.5 mm
4= Protection against smaller solid particles >1.0 mm
5= Partial protection against dust but no more dust can interfere the satisfactory operation.
6= Protection against ingress of dust.

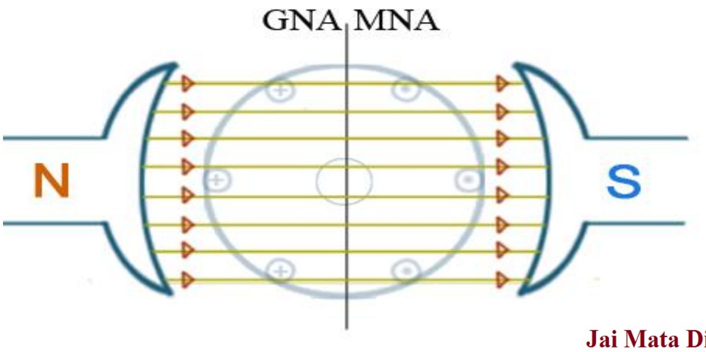
Value of B
0= No protection
1= Protection against drops of condensed water (drip proof)
2= Protection against drops of liquid is vertical.
3= Protection against drops of rain 60degree from vertical
4= Protection against splashing
5= Protection against water jets
6= Protection against condition on ship's deck
7= Protection against immersion in water
8= Protection against indefinite immersion in water.

29. *What is armature reaction in DC machines?*

In a DC machine, two kinds of magnetic fluxes are present; 'armature flux' and 'main field flux'. The effect of armature flux on the main field flux is called as **armature reaction**.

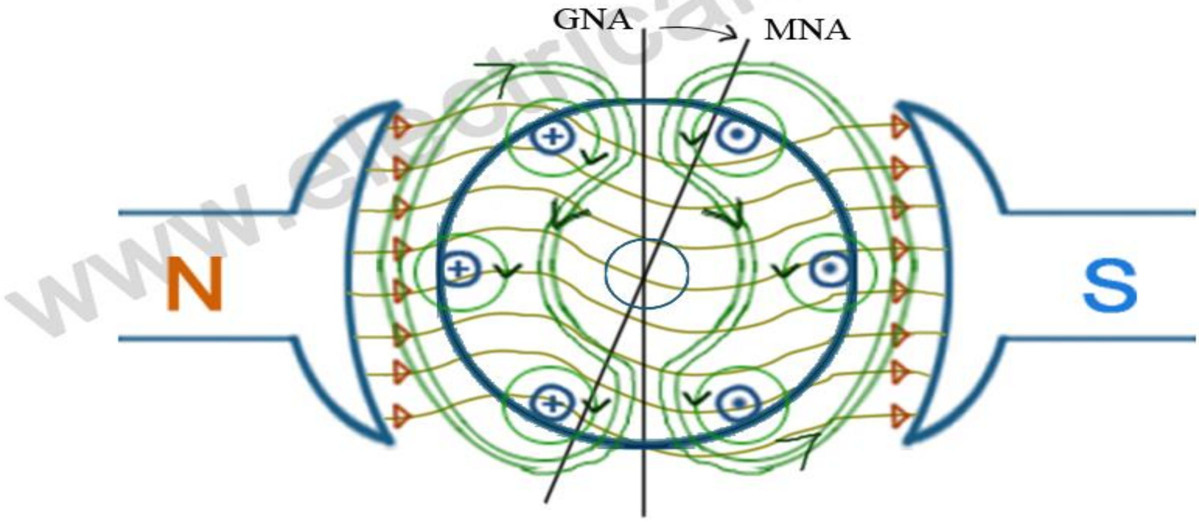
MNA And GNA

EMF is induced in the armature conductors when they cut the magnetic field lines. There is an axis (or, you may say, a plane) along which armature conductors move parallel to the flux lines and, hence, they do not cut the flux lines while on that plane. MNA (Magnetic Neutral Axis) may be defined as the axis along which no emf is generated in the armature conductors as they move parallel to the flux lines. Brushes are always placed along the MNA because reversal of current in the armature conductors takes place along this axis.
GNA (Geometrical Neutral Axis) may be defined as the axis which is perpendicular to the stator field axis.
Armature Reaction
The **effect of armature reaction** is well illustrated in the figure below



Main field flux

Armature Flux



Distortion of main field flux due to armature flux - Armature reaction

Consider, no current is flowing in the armature conductors and only the field winding is energized (as shown in the first figure of the above image). In this case, magnetic flux lines of the field poles are uniform and symmetrical to the polar axis. The 'Magnetic Neutral Axis' (M.N.A.) coincides with the 'Geometric Neutral Axis' (G.N.A.).
The second figure in the above image shows armature flux lines due to the armature current. Field poles are de-energised.
Now, when a DC machine is running, both the fluxes (flux due to the armature conductors and flux due to the field winding) will be present at a time. The armature flux superimposes with the main field flux and, hence, disturbs the main field flux (as shown in third figure the of above image). This effect is called as **armature reaction in DC machines**.

The Adverse Effects Of Armature Reaction:

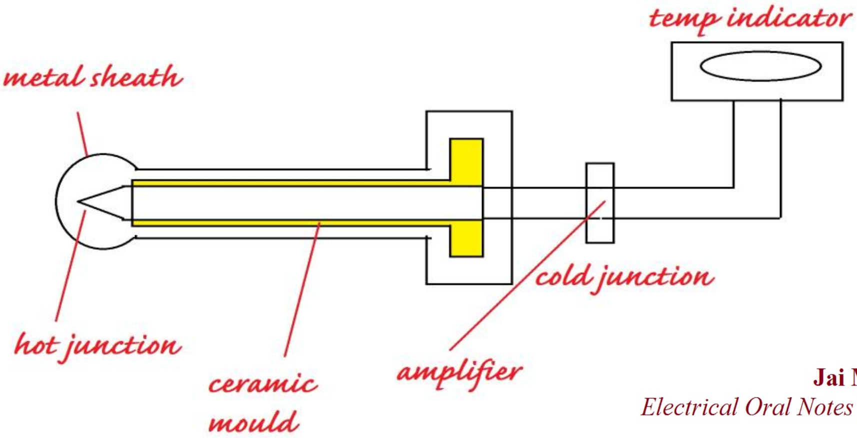
Armature reaction weakens the main flux. In case of a dc generator, weakening of the main flux reduces the generated voltage.
Armature reaction distorts the main flux, hence the position of M.N.A. gets shifted (M.N.A. is perpendicular to the flux lines of main field flux). Brushes should be placed on the M.N.A., otherwise, it will lead to sparking at the surface of brushes. So, due to armature reaction, it is hard to determine the exact position of the MNA
For a loaded dc generator, MNA will be shifted in the direction of the rotation. On the other hand, for a loaded dc motor, MNA will be shifted in the direction opposite to that of the rotation.

How To Reduce Armature Reaction?
Usually, no special efforts are taken for small machines (up to few kilowatts) to reduce the armature reaction. But for large DC machines, compensating winding and interpoles are used to get rid of the ill effects of armature reaction**.**

Compensating winding: Now we know that the armature reaction is due to the presence of armature flux. Armature flux is produced due to the current flowing in armature conductors. Now, if we place another winding in close proximity of the armature winding and if it carries the same current but in the opposite direction as that of the armature current, then this will nullify the armature field. Such an additional winding is called as compensating winding and it is placed on the pole faces. Compensating winding is connected in series with the armature winding in such a way that it carries the current in opposite direction.

Interpoles: Interpoles are the small auxiliary poles placed between the main field poles. Winding on the interpoles is connected in series with the armature. Each interpole is wound in such a way that its magnetic polarity is same as that of the main pole ahead of it. Interpoles nullify the quadrature axis armature flux.

30. *Exhaust gas pyrometer?*

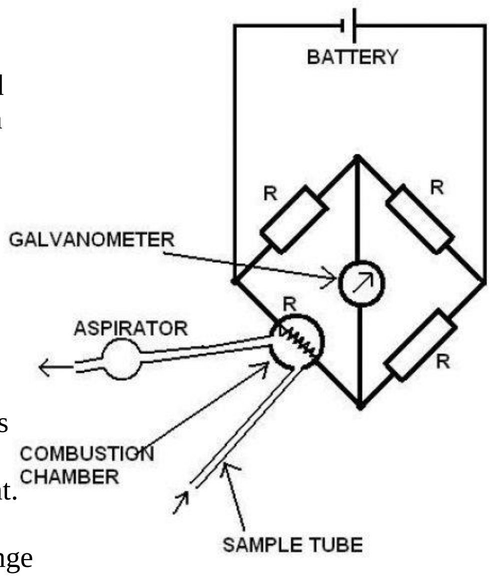


EXHAUST GAS PYROMETER

It works on the principle of Seebeck effect. It is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one.
Made of two different alloy or metal joined together.
Two junctions maintained at different temperature, one junction which is cold maintained at constant temperature and other junction is easily found.

31. *Explosimeter principle and diagram?*

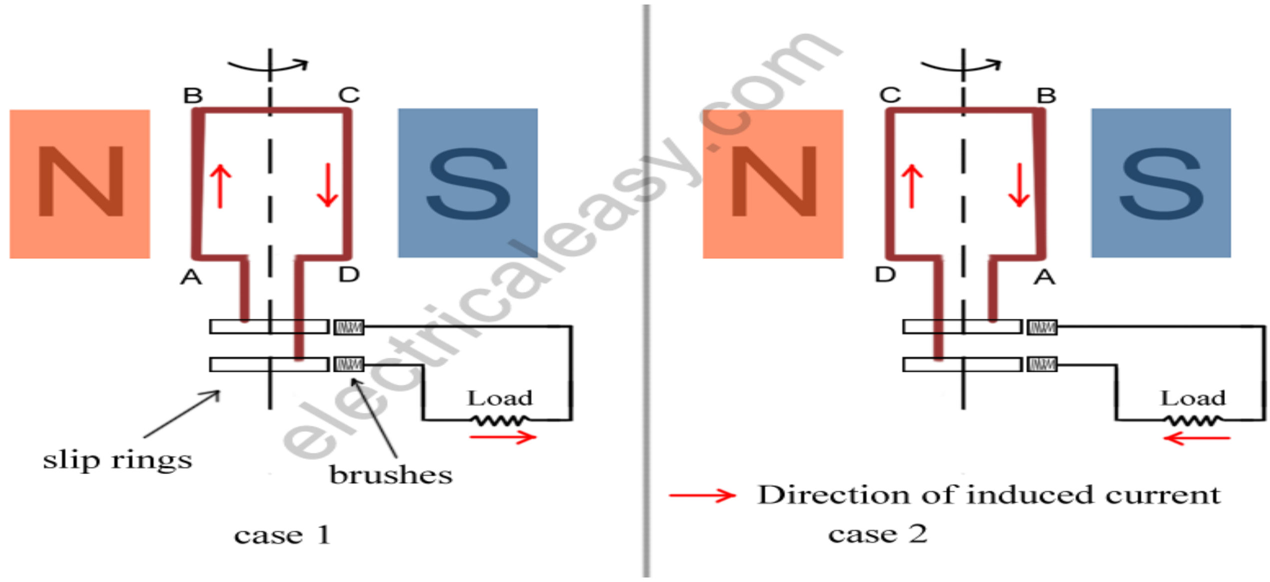
The atmosphere of a tank or pump room can be tested with a combustible gas indicator which is calibrated for hydrocarbons. Frequently the scale is in terms of the lower explosive or lower flammable limit (LFL) and marked as a percentage of the lower limit. Alternatively, the scale may be marked in parts per million (ppm).
The combustible gas indicator shown diagrammatically above consists of a Wheatstone bridge with current supplied from a battery. When the bridge resistances are balanced, no current flows through the galvanometer. One resistance is a hot filament in a combustion chamber. An aspirator bulb and flexible tube are used to draw a gas sample into the chamber. The gas will burn in the presence of the red hot filament causing the temperature of the filament to rise. Rise of temperature increases the resistance of the filament and this change of filament unbalances the bridge. The current flow registers on the meter which is scaled in percentage of LFL or ppm.
A lean mixture will burn in the combustion chamber, because of the filament. False readings are likely when oxygen content of the sample is low or when inert gas is present. The instrument is designed for detecting vapour in a range up to the lower flammable limit and with large percentages of gas (rich mixture) a false zero reading may also be obtained.



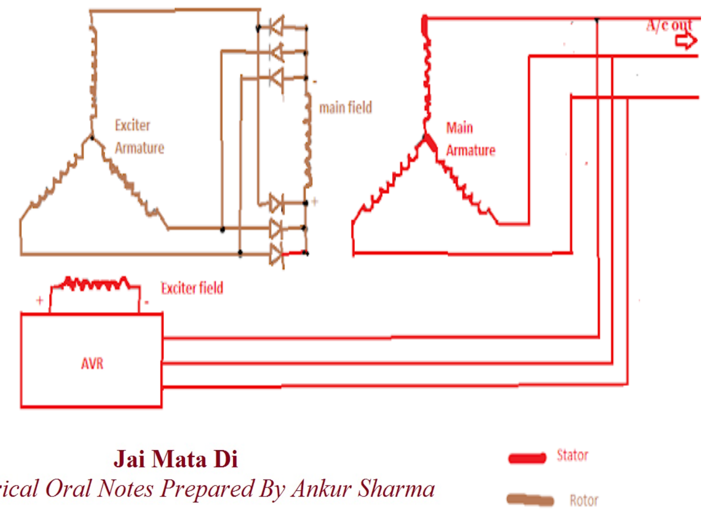
Zero setting is done by atmospheric air.
Span setting is done by pentene.

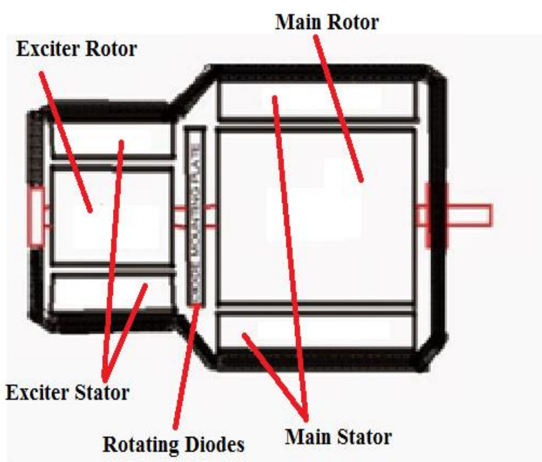
32. Working of AC generator?

The working principle of an alternator or AC generator is similar to the basic working principle of a DC generator. Below given figure helps you understanding how an alternator or AC generator works. According to the Faraday's law of electromagnetic induction, whenever a conductor moves in a magnetic field EMF gets induced across the conductor. If the close path is provided to the conductor, induced emf causes current to flow in the circuit.
Now, see the above figure. Let the conductor coil ABCD is placed in a magnetic field. The direction of magnetic flux will be form N pole to S pole. The coil is connected to slip rings, and the load is connected through brushes resting on the slip rings.
Now, consider the case 1 from above figure. The coil is rotating clockwise, in this case the direction of induced current can be given by Fleming's right hand rule, and it will be along A-B-C-D.
As the coil is rotating clockwise, after half of the time period, the position of the coil will be as in second case of above figure. In this case, the direction of the induced current according to Fleming's right hand rule will be along D-C-B-A. It shows that, the direction of the current changes after half of the time period, that means we get an alternating current.



33. Brushless alternator working and AVR working?





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It these alternators, slip rings and brushes are eliminated that is the reason behind its name Brushless Alternator. The components of alternator are as follows. There is a stator body and rotor assembly. Stator body houses the main stator and the exciter stator. Similarly rotor assembly consists of a main rotor and the exciter rotor along with the bridge rectifier assembly mounted on a plate attached to the rotor. The exciter stator has residual magnetism present in it. When the rotor starts rotating AC output, is generated in the exciter rotor coil. This output is passed through a bridge rectifier and is converted to DC and given to the main rotor. The moving main rotor generates AC current in the stationary main stator coils. This is the final output of the alternator. The exciter plays a key role in controlling the output of alternator. Supplies DC magnetising current to the rotor which is the field the main alternator. Thus if we increase or decrease the amount of current to the stationary exciter field coils, the output of main alternator can be varied.

Automatic Voltage Regulator

Automatic voltage regulator circuit performs this important operator of controlling the exciter current.

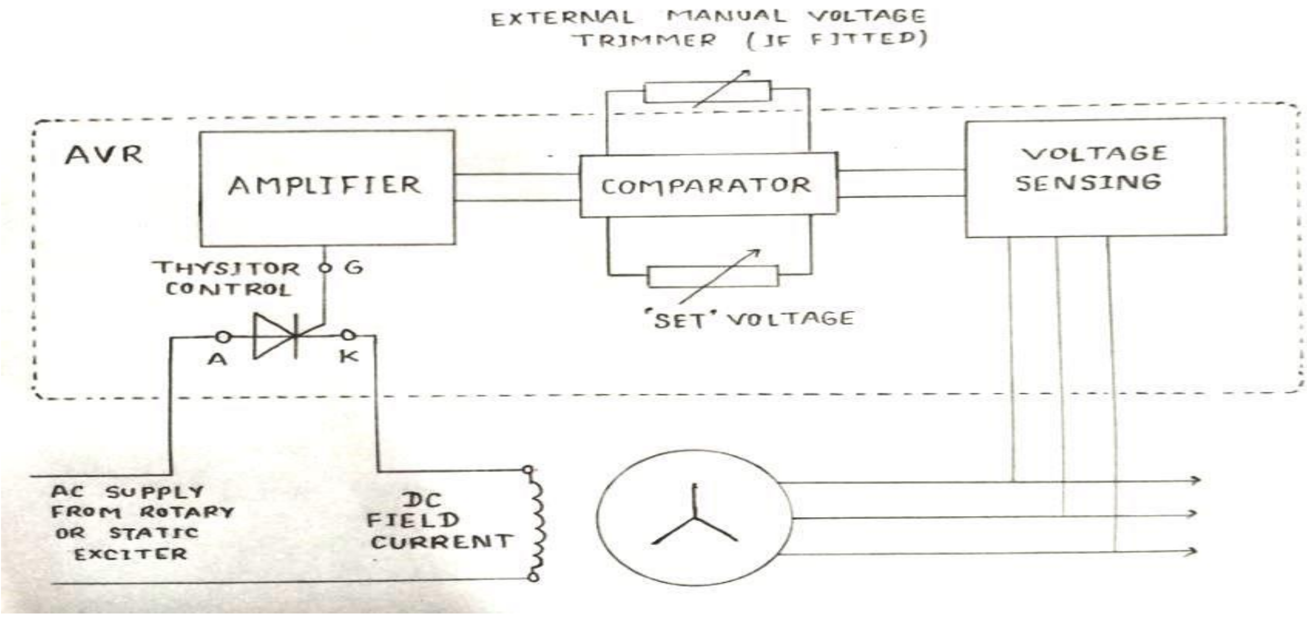
For example lets assume the output voltage is low, AVR senses this and increases excitation current in the exciter stator. This in turn increases the output from the excitor rotor. This increased output is converted to DC fed to the main rotor, thus increasing its magnetic field strength.resulting in increase in the output.

Similarly when the output is high, its works vice versa.

In a process control of voltage regulation by electronic **AVR** involves the following components

- voltage sensing unit – to check the present value of the voltage
- voltage comparing unit – to check error .i.e. difference in voltage
- amplifying unit – to amplify the error signal
- correcting unit – to apply actions to process control as per error to get desired output voltage

The basic block diagram is shown below:

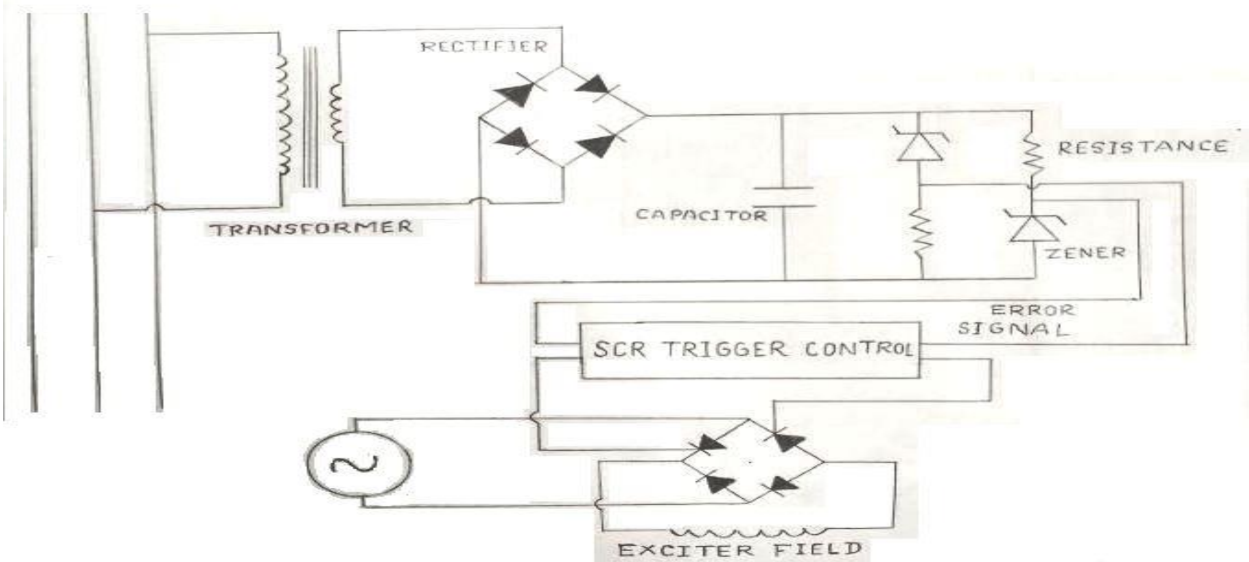


The direct current derived from the alternator output through the transformer is rectified and filtered. Then it is applied to a Wheatstone bridge which has fixed resistance on two arms and variable resistances (Zener diode voltage reference) on the other two.

The Zener operate in the reverse breakdown mode, as these diodes are manufactured with a Zener breakdown voltage of very low value. Zener diode voltage remains constant once breakdown voltage has occurred despite the change in the current.This implies that changes in applied voltage, while not affecting voltage across the diode, will cause a change in resistance which permits the change in current. As with a Wheatstone bridge, imbalance of the resistance changes the flow pattern and produces in the voltage measuring bridge an error signal.

The error signal can be amplified and used to control alternator excitation. Thus it can control the firing angle of thyristors through a triggering circuit to give the desired voltage. It can be used in the statically excited alternator to correct small errors through a magnetic amplifier arrangement. The error signal has also been amplified through transistors in series, for excitation control.

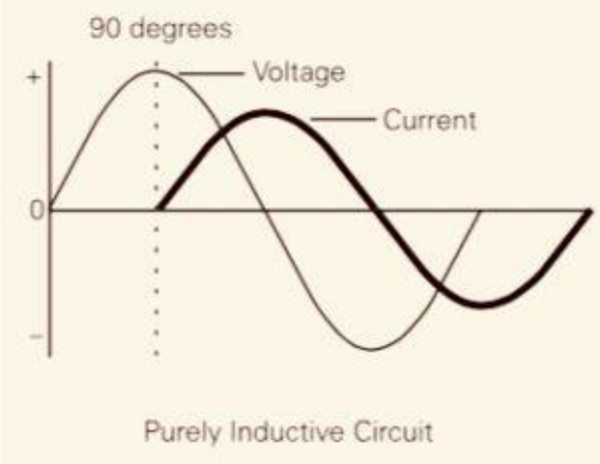
Simple Explanation of AVR:

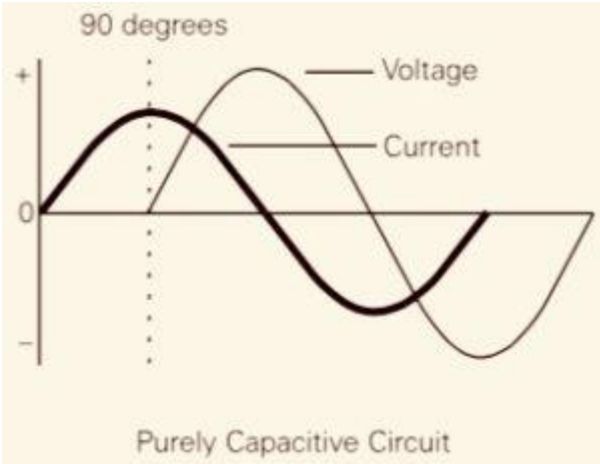


Referring above diagram, we take tapping from the output of alternator and connected to step down transformer and then to a bridge rectifier to convert it from AC to DC and then capacitor is used to smoothen the generator output voltage. As we know Zener is a reverse biased, if the voltage increases, then it will send a signal that is called error signal. The error signal will go to SCR (Silicon Controlled Rectifier), there it will trigger the bridge rectifier, which will give supply to exciter coil to produce magnetic field.

34. What is True Power, Apparent Power, Power factor? What is leading and lagging power factor?

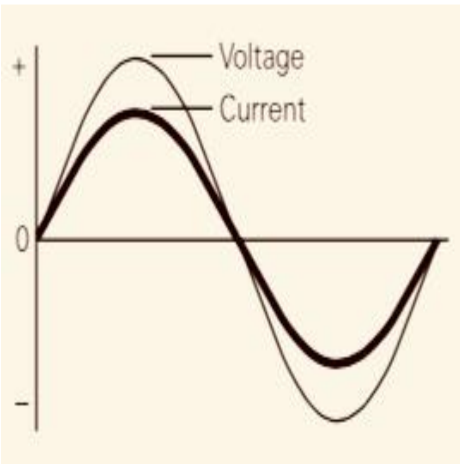
Inductive loads: Inductive loads include motors, transformers, and solenoids. In a purely inductive circuit, current lags behind voltage by 90°. Current and voltage are said to be "out of phase."

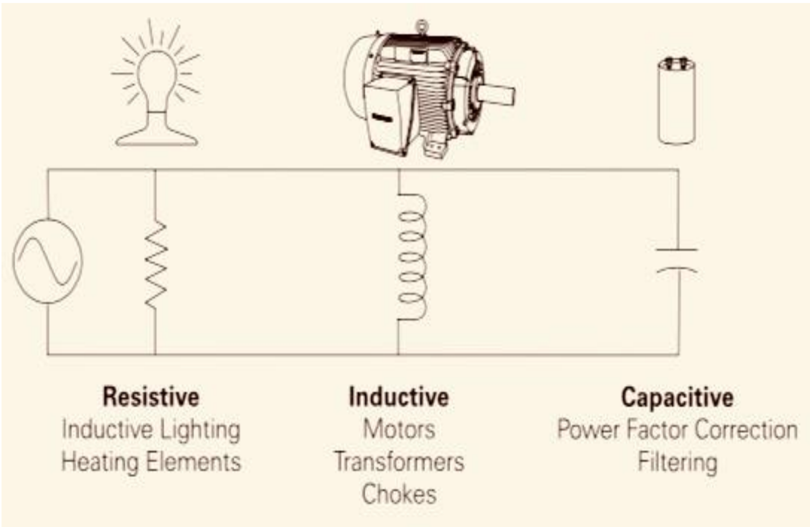


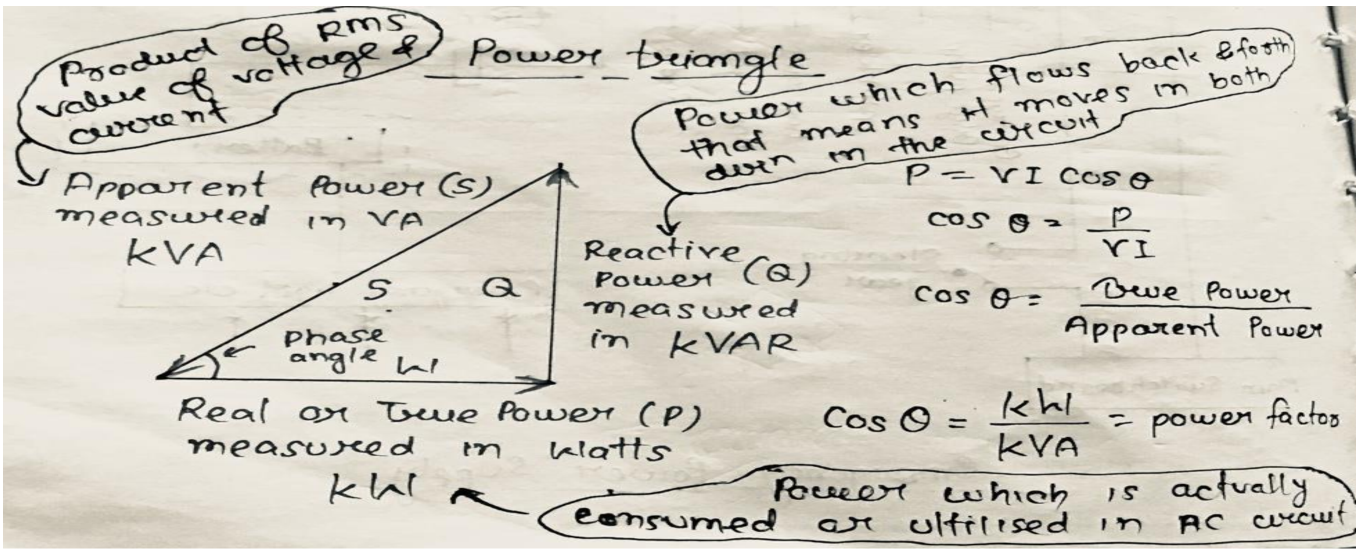


Capacitive loads: Capacitive loads include power factor correction capacitors and filtering capacitors. In a purely capacitive circuit, current leads voltage by 90°.

Resistive loads: Resistive loads include devices such as heating elements and incandescent lighting. In a purely resistive circuit, current and voltage rise and fall at the same time. They are said to be "in phase.

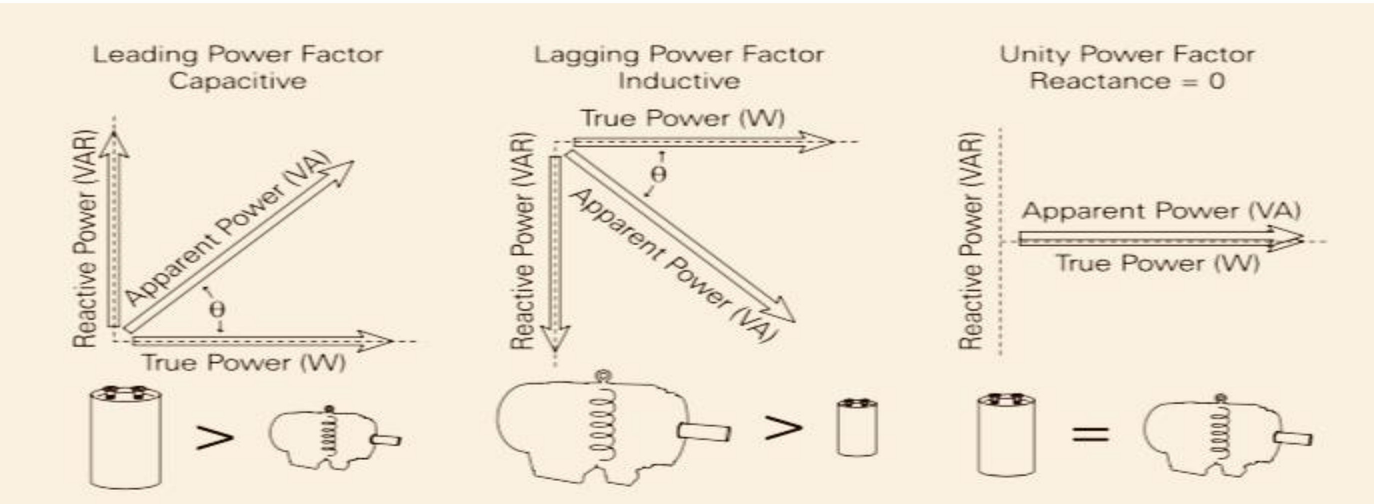






True Power: Power drawn by a resistive circuit is converted into useful work. This is known as **the true power** in a resistive circuit. **True power is measured in watts (W), kilowatts (kW), or megawatts (MW).** In a DC circuit or in a purely resistive AC circuit, true power can easily be determined by measuring voltage and current. True power in a resistive circuit is equal to system voltage (V) times current (I).
for example, an incandescent light (resistive load) is connected to 120 VAC. The current meter shows the light is drawing 0.833 amps. In this circuit, 100 watts of work is done (120 VAC x 0.833 amps).
Reactive Power: Reactive power is measured in volt-amps reactive (VAR). Reactive power represents the energy alternately stored and returned to the system by capacitors and/or inductors. Although reactive power does not produce useful work, it still needs to be generated and distributed to provide sufficient true power to enable electrical processes to run.
Apparent Power: Apparent power is the vector sum of true power, which represents a purely resistive load, and reactive power, which represents a purely reactive load.
Power Factor
Power factor (PF) is the ratio of true power (PT) to apparent power (PA) or a measurement of how much power is consumed and how much power is returned to the source. Power factor is equal to the cosine of the angle theta in the above diagram.

Leading and Lagging Power Factor
Since current leads voltage in a capacitive circuit, power factor is considered leading if there is more capacitive reactance than inductive reactance. Power factor is considered lagging if there is more inductive reactance than capacitive reactance since current lags voltage in an inductive circuit. Power factor is unity when there is no reactive power or when inductive reactance and capacitive reactance are equal, effectively canceling each other.
It is usually more economical to correct poor power factor than to pay large utility bills. In most industrial applications motors account for approximately 60% or more of electric power consumption, resulting in a lagging power factor (more inductive than capacitive). Power factor correction capacitors can be added to improve the power factor.



35. What will be the effect of reduced Power factor on Diesel Engines? How to improve Power factor?

It won't effect much as True power (KW) is taken care by governor and Reactive Power (KVar) is taken care by alternator. But still if power factor is not improved, the results are high cost of production of electricity, low efficiency, High fuel consumption.

36. How to improve Power factor?

The ways to improve power factor are nothing but the ways to generate reactive power.

Capacitor or capacitor banks: Capacitors: Improving power factor means reducing the phase difference between voltage and current. Since majority of loads are of inductive nature, they require some amount of reactive power for them to function. This reactive power is provided by the capacitor or bank of capacitors installed parallel to the load.

Synchronous motors: When a Synchronous motor operates at No-Load and over-exited then it's called a synchronous Condenser. Whenever a Synchronous motor is over-exited then it provides leading current and works like a capacitor. When a synchronous condenser is connected across supply voltage (in parallel) then it draws leading current and partially eliminates the re-active component and this way, power factor is improved. Generally, synchronous condenser is used to improve the power factor in large industries.

37. What is ICCP?

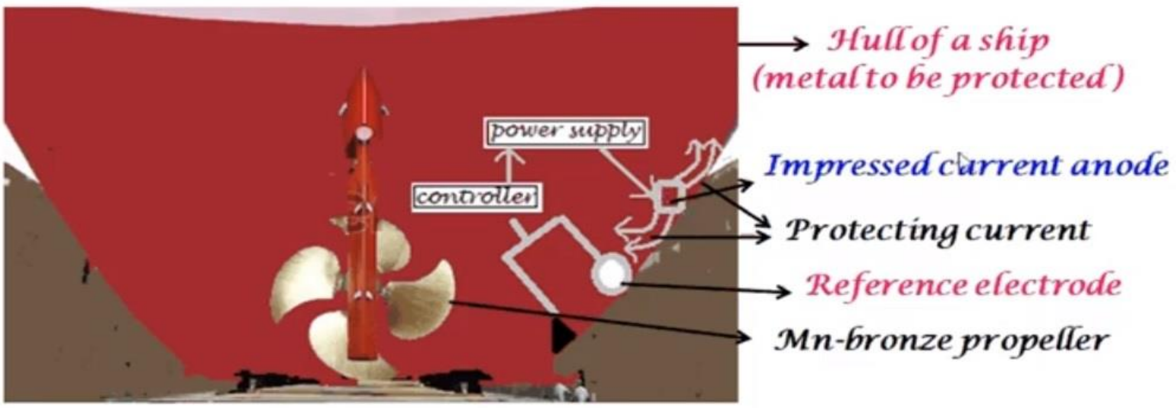
Cathodic protection is a method of corrosion control that can be applied to buried and submerged metallic structures. The material to be protected is supplied with an external cathodic current. The electrochemical potential of the protected material is moved in a negative direction to the immune area. The material is completely protected when it reaches the protection potential.

There are two ways of cathodic protection:

1. Sacrificial anode
2. Impressed current

For larger structures, galvanic anodes can't economically deliver enough current to provide complete protection. In this method, the metal to be protected is connected to an insoluble anode and current is passed using DC power source (or AC powered transformer rectifier) opposite to the corrosion current, so that the corroding metal gets converted from anode to cathode and is protected from corrosion.
Insoluble anodes are like graphite, platinum, stainless steel, platinised titanium etc.

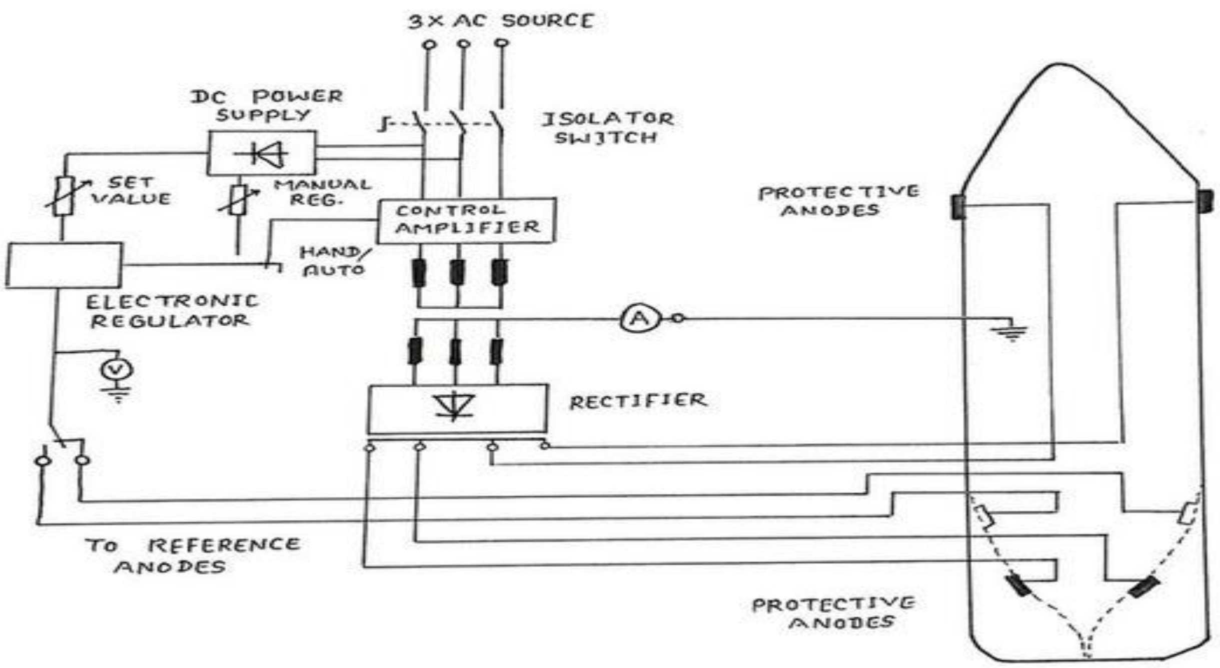
APPLICATIONS



Hull of a ship – Rusts at the stern (steel) which is closer to Mn-Bronze propellers and sea water acts as the electrolyte

In this method, we impress a direct current between an inert anode and the structure to be protected. Since electrons flow to the structure, it is protected from becoming the source of electrons (anode).The impressed current cathodic protection system usually provides electrodes of a much longer lifespan than a sacrificial anode.

Construction and Working



These systems include a rectifier that converts the alternating current power source to a direct current, that is properly calibrated to provide the required protection

- The impress current system consists of a source of direct current, anodes, apparatus for measuring and controlling the current and a high quality inert protective coating around the area of the hull nearest to the anode.
- Continuous control of the impressed current required for adequate protection varies with the immersed area, depth, the ship speed, the salinity of the water and condition of the hull paintwork.
- Continuous control is usually obtained by the use of reference anode positioned some distance from the operating anode. If higher current is supplied then it will peel- off the paint coatings on the ship hull. Around the anode, a protective coating is epoxy resin is applied directly to hull for a radius of one meter or more since highly alkaline condition arise near the anode.
- This method is similar to galvanic protection except for the fact that an external electrical current is provided through a power supply. It gives more lasting protection as the anode does not rely on its environment for it to react. This way, the life of the anode lasts longer for it becomes less vulnerable to corrosion and damage.

Impressed current cathodic protection systems are the ultimate state-of-the-art, long-term solution to corrosion problems, and are recognized as a superior alternative to sacrificial anode systems, which require frequent replacement. Impressed current cathodic protection systems are preferred by ship owners because they reduce fuel cost and maintenance.

Our systems work by supplying a controlled amount of DC current to submerged surfaces using highly reliable mixed metal oxide anodes and zinc reference electrodes. This electrical current constantly monitored and regulated by the system itself to prevent the electrochemical action of galvanic corrosion before it begins.

For more than 25 years, sea-going vessels of every type and size – oil tankers, LNG carriers, cruise ships, pleasure craft, workboats, semi-submersibles, and more – have benefited from the 24-hour protection provided by Impressed current cathodic protection systems against the costly, corrosive effects of electrolysis

System Advantage

Increased life of rudders, shafts, struts, and propellers as well as any other underwater parts affected by electrolysis
Anodes are light, sturdy and compact for easy shipping, storage, and installation
Anodes, reference cells, and automatic control systems maintain just the right amount of protection for underwater hulls and fittings, unlike standard zinc anodes, which can't adjust to changes in salinity or compensate for extreme paint loss
Automatic control equipment ensures reliable, simple operation
Optimum documented corrosion protection at a minimum overall cost
Only one installation required for the life of the vessel or structure
Increased dry-dock interval

Reference Cell / Electrode

The correct value of protection correct can be determined by the reference cell. It measures the voltage between the hull & seawater. These are either Zinc (Zn) or Silver (Ag) attached to the hull, but insulated from it, below the water line.

Power Supply Unit / Control Panel

Each standard ICCP system utilizes a solid-state controller which monitors and controls the protection as measured by the Zinc Reference electrode. Anode current automatically increases when the electrode potential falls below the designated control value. An over- and an under-potential alarm is provided with the system package.

For new hull, anode current to be about 10 to 40 mA/m2
For rusted hull, anode current to be about 100 to 150 mA/m2
Reference electrode voltage hull potential 220mV
Anode ampere 40mA
Anode volt 4.8 Volt

During dry dock, main anodes and reference electrodes are covered with paper tape to prevent paint contamination.

38. What is High Voltage?

Any Voltage used on board a ship if less than 1kV(1000 V) then it is called as LV (Low Voltage) system and any voltage above 1kV is termed as High Voltage.

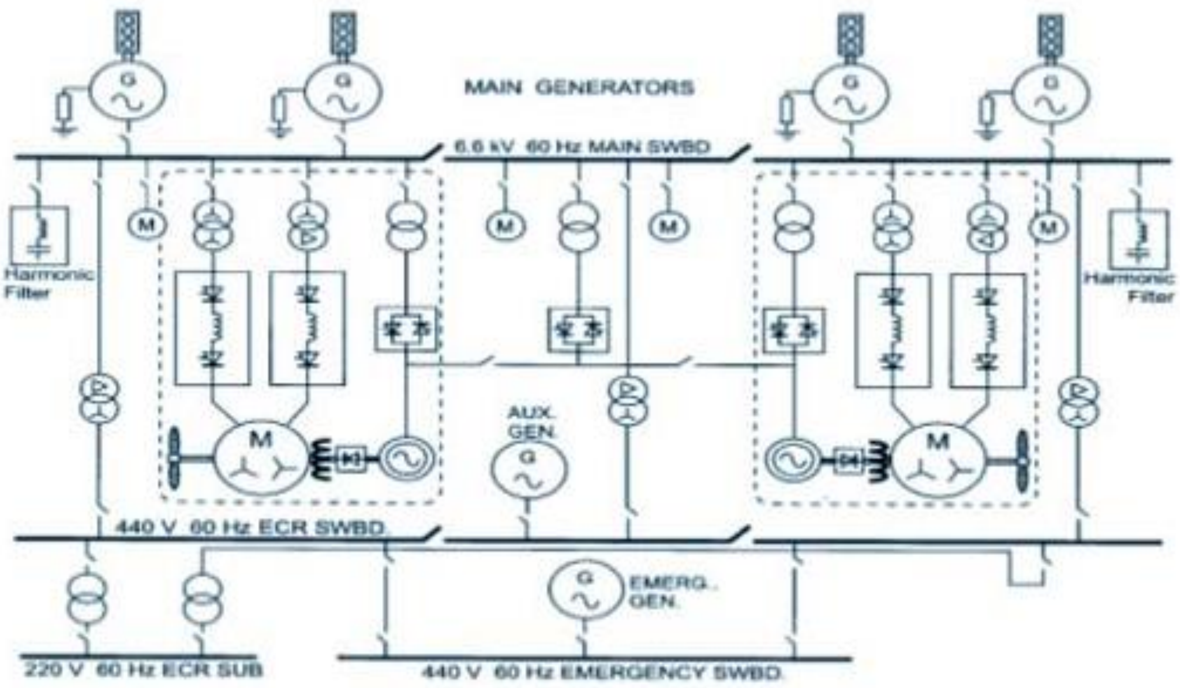
Typical Marine HV systems operate usually at 3.3kV or 6.6kV. Passenger Liners like QE2 operate at 10kV.

The design benefits relate to the simple ohms law relationship that current (for a given power) is reduced as the voltage is increased. Working at high voltage significantly reduces the relative overall size and weight of electrical power equipment.

Insulation is to be tested by 5000V DC.

<u>AS PER OHMS LAW</u>
POWER = VOLTAGE x CURRENT
For a given Power,
Higher the Voltage, Lesser is the Current
440 KW = 440,000 Watts

= 440 Volts x 1000 Amps
=1100 Volts x 400 Amps
=11000 Volts x 40 Amps
– When large loads are connected to the LV system the magnitude of current flow becomes too large resulting in overheating due to high iron and copper losses.
P = VI CosΦ
Copper loss =I^2 R [kW]



THE MAJOR DIFFERENCES BETWEEN HIGH VOLTAGE SUPPLY AND LOW VOLTAGE SUPPLY ON BOARD SHIPS ARE:

1. High voltage systems are more extensive with complex networks and connections,
2. Isolated equipment MUST BE earthed down
3. Access to high voltage areas should be strictly limited and controlled
4. Isolation procedures are more involved
5. Switching strategies should be formulated and recorded
6. Specific high voltage test probes and instruments must be used
7. Diagnostic insulation resistance testing is necessary
8. High voltage systems are usually earthed neutral and use current limiting resistors
9. Special high voltage circuit breakers have to be installed

Advantages:
For a given power, Higher voltage means Lower current, resulting in:
– Reduction in size of generators, motors, cables etc.
– Saving of Space and weight
– Ease of Installation
– Reduction in cost of Installation
– Lower losses – more efficient utilization of generated power
– Reduction in short circuit levels in the system which decides the design and application of the electrical equipment used in the power system.

Disadvantages:
1. Higher Insulation Requirements for cables and equipment used in the system.
2. Higher risk factor and the necessity for strict adherence to stringent safety procedures.

*The HV system has separate device called **negative phase sequence (NPS) relay**. It is used to measure the amount of unbalance in the motor current.*

Hazards of High Voltage

Arcing:
An unintentional electric arc occurs during opening of a breaker, contactor or switch, when the circuit tries to maintain itself in the form of an arc.
During an insulation failure, when current flows to ground or any other short circuit path in the form of accidental tool slipping between conducting surfaces, causing a short circuit.
Results of an electric arc:
Temperatures at the arc terminals can reach or exceed 35,000° f or 20,000˚c or four times the temperature of sun's surface. The heat and intense light at the point of arc is called the arc flash.
Air surrounding the arc is instantly heated and the conductors are vaporised causing a pressure wave termed as **ARC BLAST.**

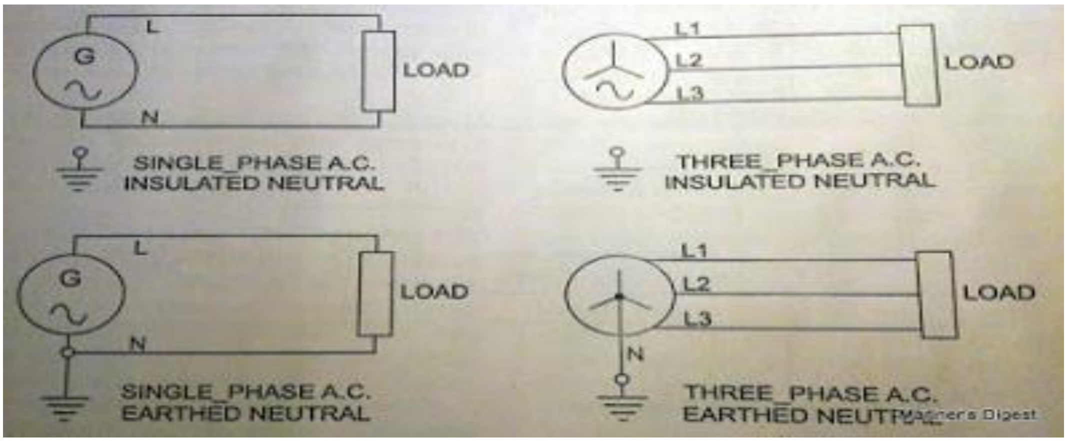
Harmonic filters:
Three-phase harmonic filters are shunt elements that are used in power systems for decreasing voltage distortion and for power factor correction. Nonlinear elements such as power electronic converters generate harmonic currents or harmonicvoltages, which are injected into the power system.

High voltage system safeties:

- They are earthed neutral with neutral earthing resistor,so that earth fault current not to exceed generator full load current.
- High voltage circuit breakers like Vaccum circuit breaker, Sulphur hexaflow breaker (SFE)
- High Voltage test probes and instruments.
- Isolated equipments are earthed down.
- Switchboards are deadfront.
- Harmonic filters are used.

39. ***What is earthed neutral and isolated neutral system and neutral earthing resistor?***

In neutral insulated system, the star point of the source is not connected to earth. Hence there happens to be only 3 leads (3 phase wires R,Y,B) emanating from the source.
In neutral earthed system, the star point is earthed to ground. So 4 wires emanating from source (3 phase and 1 neutral).



In an electrical system, 3 different types of fault may occur:

- **Open circuit fault (A)** : due to break in the conductor so that current cannot flow.
- **Short circuit fault (C)** : due to break in insulation so that two conductor touches each other giving a short path to current and allowing a very large current to bypass the load.
- **Earth Fault (B)** : This is also due to break in insulation, but the conductor touches the metal enclosure or the hull indirectly.

The discussion of the two types of electrical system(Insulated or earthed neutral) depends on a large extent to the earth fault occurring in the circuit.
If a single earth fault occurs in the line of an earthed neutral system, then it would be equivalent to a short circuit fault.

The reason being, the earthed neutral creates a closed path for the earth current to flow through the hull of the vessel.Since this path has a minimal resistance, the earth current can increase to a very large extent.
Onboard ship, if the earth current increases beyond the current rating of the generator, the entire system may collapse causing irreparable damage. To limit this earth current, a **Neutral Earthing Resistor** is connected to the earthed neutral of the source. This resistor is of sufficient ohmic value to limit the earth current within rating of the generator. However, the magnitude of earth current is sufficiently large to operate the tripping mechanism of the faulted equipment immediately isolating it from supply and rendering it safe.

Onboard a ship, the priority requirement is to maintain continuity of the electrical supply to essential equipment in event of a single earth fault occurring.Keeping this in mind, it is well understood that onboard a ship, a neutral insulated system is to be used. And, in shore installations neutral earthed system is used.

Shipboard main LV systems at 440 V are normally provided with neutral insulated system. On the other hand HV system (1000 V to 3.3 KV) are usually provided with neutral earthed system via a neutral earthing resistor.

Both the Insulated neutral and Earthed neutral system have got their own advantages and disadvantages. Where it is easier in the earthed neutral system to detect any earth faults in system, it is easier in isolated neutral system to maintain the continuity of service.

40. *What is deadfront?*

Dead front is defined in Article 100 of the NEC as being "without live parts exposed to a person on the operating side of the equipment." Section 408.38 requires that panelboards be mounted in cabinets, cutout boxes or enclosures designed for the purpose and shall be dead front.
Concept of dead front electrical panel is to ensure the safety of user or operator from accidental touching of bare electrical energized parts. This bare electrically energized parts are as example- the bus bars in panel, connection point of circuit breakers and all applicable connection to various electrical appliances in the panel.

41. *Why no Cos phi (Cosθ) in DC?*

As there is no reactance, as V & I are in same phase.
Therefore (Cosθ)=1 as value of θ is 0
Hence no (Cosθ) in DC.

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42. *Generator is not producing voltage, Reasons?*

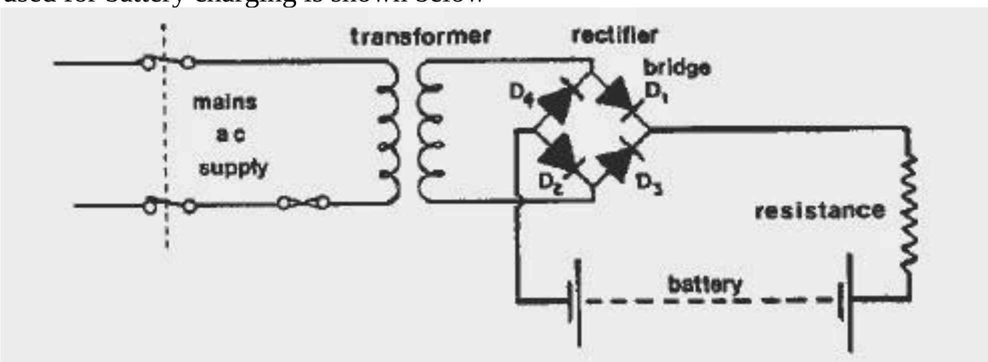
- Voltmeter faulty
- Rectifier damage
- AVR faulty
- Loss of residual mechanism
- Short circuit in winding.

43. *Explain residual magnetism restoring process or flashing up of generator?*

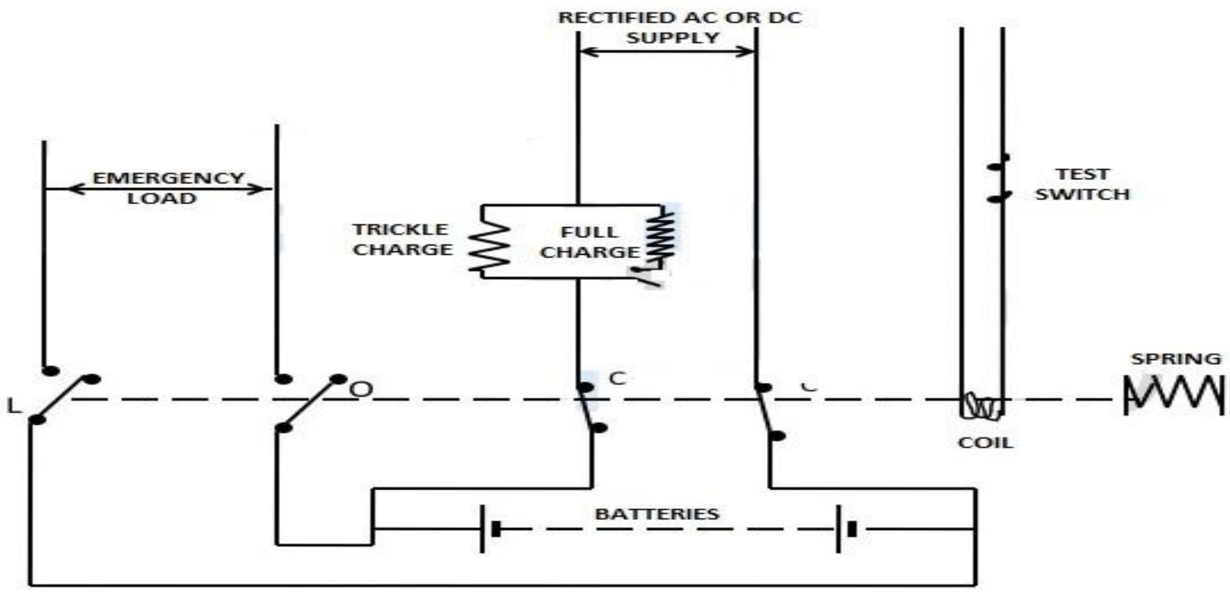
- Connect 12 Volt battery to exciter field
- Remove leads from exciter field to AVR
- If leads are not removed, then during flashing up, it will destroy the regulator.
- Check resistance, No grounding and connect the battery for 5 to 10 seconds.
- Reconnect the leads to AVR
- Repeat the process if generator fails to build voltage.

44. *Explain battery charging circuit?*

The batteries can be charged with the help of dc power supply; however, presently there are no ships working on dc supply system and thus it is required to change the ac power into dc to charge the batteries.
A simple circuit used for battery charging is shown below



For converting AC into DC several components are required as shown in the circuit diagram above. First of all the AC is stepped down to the required voltage and then the AC is converted to DC with the help of rectifier system which changes sinusoidal wave of AC to DC system.
The only problem in the above circuit is that there is no arrangement provided for maintaining the charge, and the usage of the same circuit will lead to overcharging and reduction of the battery life. In order to avoid this, a slight modification is done on the same circuit and an arrangement is provided to maintain the charges at the terminals. Also, an arrangement to connect automatically to low voltage DC system is provided in case of a power failure.
In normal circumstances, the battery is charged using the full charge circuit and once the battery is fully charged, the charges on the battery are maintained by the trickle charge circuit.



As it can be seen in the diagram, the batteries are in standby mode with the charging switches C closed and the load switches L open. The positions of these switches are held with the help of an electromagnetic coil against the spring tension. The electromagnetic coil gets its supply from the main power source available on the ship. As soon as there is a loss of main power, the electromagnetic coil loses its power and the batteries are connected to load switch L which gets disconnected from the charging switch C.

Once the power is available from the main system, the batteries are connected back to the charging circuit again manually. Also, there is a test switch provided to test the system as a part of the routine tests.
To measure the condition of a battery, generally two parameters are taken, specific gravity and voltage. The specific gravity is measured using a hydrometer while the latter is measured using a voltage meter.

Lead Acid Battery

Charged→	Voltage=1.95V	Specific gravity=1.28
Discharged→	Voltage=1.8V	Specific gravity=1.12

Ni-Cd Battery

Charged→	Voltage=1.2V	Specific gravity=1.21
Discharged→	Voltage=1.1V	Specific gravity=1.17

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During Charging, $PbSO_4 + H_2$--------------> $Pb + H_2SO_4$
$Pb + O_2$-------------------> PbO_2
During Discharging, $Pb + SO_4$---------------> $PbSO_4$
$PbO_2 + 2H_2$---------------> $Pb + 2H_2O$

45. Battery room safeties and maintenance to be done?

- Ventilation arrangements are provided on top of any battery equipment.
- All openings to battery room must be weather proof.
- Motor located outside the ventilation passage.
- Exhaust fan blades must be of non sparking material.
- Outlet ventilation ducts are made of corrosion resistant material.
- Ventilation inlets are located below the battery level.
- Use of naked lights prohibited.
- Only flameproof lighting are permitted.

Maintenance:

- Keep cell tops clean and dry
- Ensure tightness of connections, apply petroleum jelly to prevent corrosion.
- Careful while dealing with electrolyte, for checking its density using hydrometer, use gloves and goggles for protection.
- Insulated tools to be used to prevent unexpected short circuiting resulting cell damage.

46. *Navigation Light Panel*

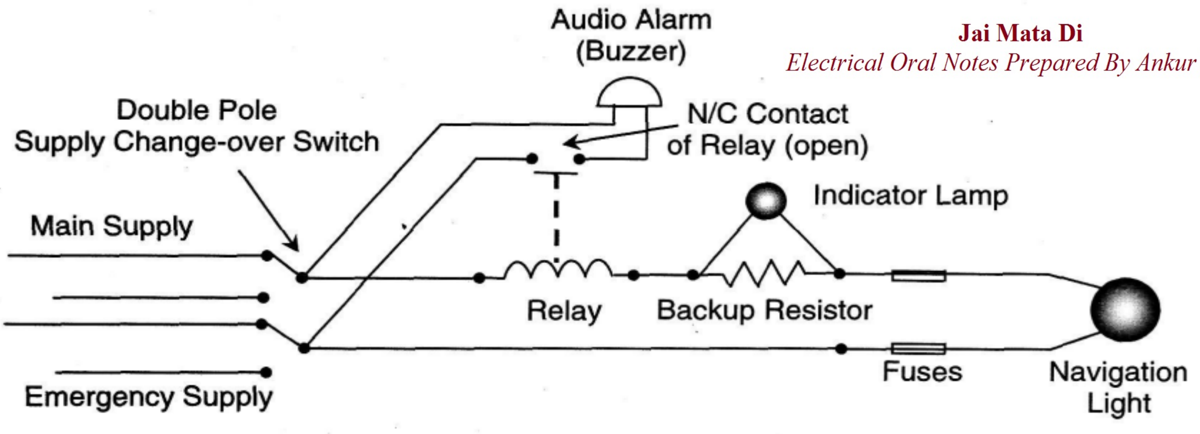


Figure 22.11 – Alternative Navigation Light Circuit (circuit energised)

Operation

Referring to Figure 22.11, when the double pole switch is closed the navigation light is illuminated. Current in the relay circuit causes the relay coil to energise, which pulls the NC (normally closed) contact open so that the audio alarm (buzzer) circuit is now open. Only a low voltage lamp is needed for the indicating lamp. This ensures a small voltage drop across that part of the circuit. Keeping regulatory requirements in mind, if the indicating lamp fails, the circuit is completed through the back-up resistor, so the navigation light does not fail.

If the navigation light fails, or if a fuse blows, the current in the circuit ceases and the relay is de-energised. The NC contact springs back to activate the buzzer circuit. In case of failure of the ship's mains, the double pole switch may be changed over to emergency supply.

47. Types of circuit breakers?

Electrical Circuit breakers are the circuit current interrupting mechanism which opens or closes as per the operator command or any fault.

LV System circuit breaker:

- Air Circuit breaker: This uses air as interrupting and insulating medium. These are further classified as Air magnetic circuit breakers and Air blast circuit breakers.

- Moulded case circuit breaker (MCCB's): These current ratings are higher at 1000A. This has earth fault protection in addition to over current protection. The trip settings of the breaker can vary easily.

- Miniature Circuit Breaker (MCB's): These current ratings are less than 100A with only one over current protection in built within it. The trip settings are not adjustable in MCB.

HV system circuit breaker:

- Sulphur Hexafluoride type: SF6 has 100 times high dielectric strength than air and oil as interrupting medium. The breaker with SF6 interrupting medium is called as SF6 circuit breaker.

- Vaccum type breakers: This uses vacuum as the interrupting medium because of its high dielectric and diffusive properties as interrupting medium.

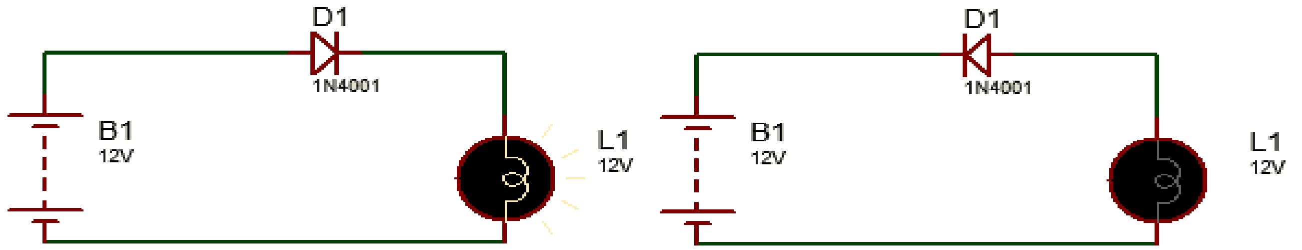
48. What are the maintenance to be done on Circuit breakers?

- Incoming power has to be removed, lock out tag out has to be done.
- Manually operate operating mechanism to check if it is working properly.
- Inspection of contacts caused by arcing or corrosion.
- Lubrication of mechanical contacts.
- Arc chutes are removed, inspected for broken parts and erosion of the steel splitter plates.

49. What is Zener diode?

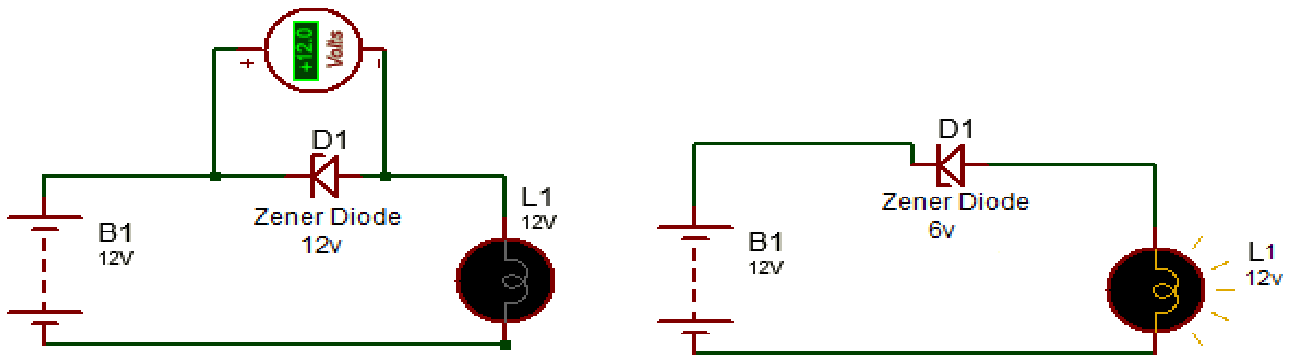
A heavily doped semiconductor diode which is designed to operate in reverse direction is known as the Zener diode. Diodes generally are known as a device that allows the flow of current in one direction (forward biased) and offers resistance to the flow of current when used in reverse bias. Whereas Zener Diode not only allow the flow of current when used in forward bias, but they also allow the flow of current when used in the reversed bias so far the applied voltage is above the breakdown voltage known as the Zener Breakdown Voltage. Or in other words Breakdown voltage is the voltage, on which Zener Diode starts conducting in reverse direction.
As the reverse voltage applied to the Zener diode increases towards the specified Breakdown Voltage (Vz), a current starts flowing through the diode and this current is known as the Zener Current and this process is known as *Avalanche Breakdown.*
.

Consider the Images below of a **normal diode in action**.



Lamp On (Forward Biased) | Lamp Off (Reversed bias)

To show the **operations of the zener diode**, consider the two experiments (A and B) below.



12v Zener diode operation | 6v Zener diode operation

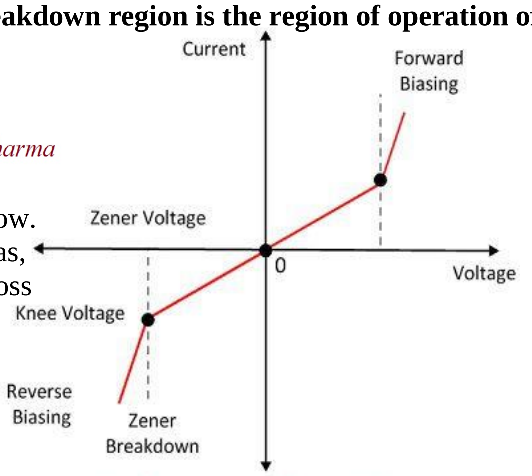
In **Experiment A**, a 12V zener diode is connected in reversed biased as shown in the image and it can be seen that the zener diode blocked the voltage effectively because it was less/equal to the breakdown voltage of the particular zener diode and the lamp thus stayed off.

In **Experiment B**, a 6v Zener Diode used is conducting (the bulb comes on) in reverse biased because the applied voltage is greater than its breakdown voltage and thus shows that the **breakdown region is the region of operation of the zener diode**.

Characteristic of Zener Diode

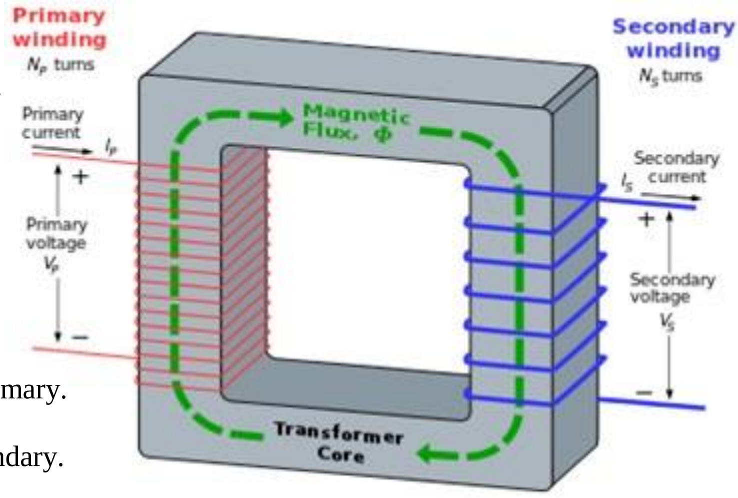
The VI characteristic graph of the Zener diode is shown in the figure below. This curve shows that the Zener diode, when connected in forwarding bias, behaves like an ordinary diode. But when the reverse voltage applies across it and the reverse voltage rises beyond the predetermined rating, the Zener breakdown occurs in the diode. At Zener breakdown voltage the current starts flowing in the reverse direction.

Zener Diode Symbol | Generic Diode Symbol



VI Characteristic of Zener Diode

50. *Transformer?*



It is an static apparatus in which electric power in one circuit is transformed into electric power of same frequency in other circuit. It can raise or lower the voltage in a circuit but with corresponding raise or decrease in current.
Its done by mutual induction, two circuits are linked by magnetic flux.

Step up transformers:
Secondary coil has more number of turns than primary.
Step down transformers:
Primary coil has more number of turns than secondary.

$Ep/Es = Ns/Np = Vs/Vp = Ip/Is = k$

Procedure of Insulation Resistance Test of Transformer

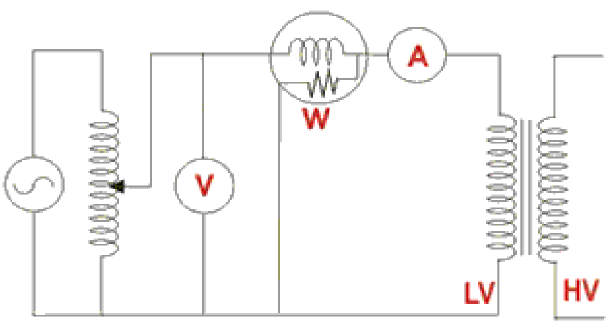
- Disconnect all the line and neutral terminals of the transformer
- Megger leads to be connected to LV and HV bushing studs to measure insulation resistance IR value in between the LV and HV windings
- Megger leads to be connected to HV bushing studs and transformer tank earth point to measure insulation resistance IR value in between the HV windings and earth
- Megger leads to be connected to LV bushing studs and transformer tank earth point to measure insulation resistance IR value in between the LV windings and earth

Tests to be done to check performance of a transformer?

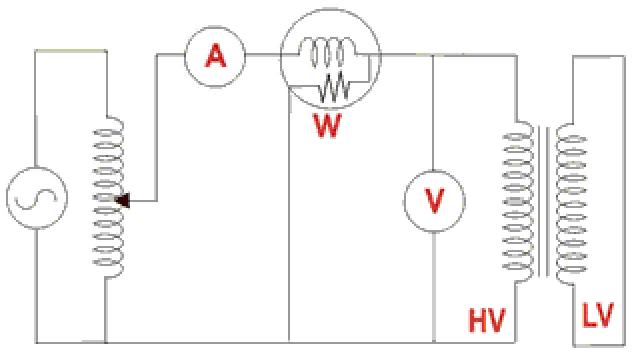
- **Open Circuit Test on Transformer:**

The connection diagram for open circuit test on transformer is shown in the figure. A voltmeter, wattmeter, and an ammeter are connected in LV side of the transformer as shown. The voltage at rated frequency is applied to that LV side with the help of a variac of variable ratio auto transformer.

The HV side of the transformer is kept open. Now with the help of variac, applied voltage gets slowly increased until the voltmeter gives reading equal to the rated voltage of the LV side. After reaching rated LV side voltage, we record all the three instruments reading (Voltmeter, Ammeter and Wattmeter readings).
The ammeter reading gives the no load current Ie. As no load current Ie is quite small compared to rated current of the transformer, the voltage drops due to this current that can be taken as negligible.
Since voltmeter reading V1 can be considered equal to the secondary induced voltage of the transformer, wattmeter reading indicates the input power during the test. As the transformer is open circuited, there is no output, hence the input power here consists of core losses in transformer and copper loss in transformer during no load condition. But as said earlier, the no-load current in the transformer is quite small compared to the full load current so, we can neglect the copper loss due to the no-load current. Hence, can take the wattmeter reading as equal to the core losses in the transformer.
Therefore it is seen that the open circuit test on transformer is used to determine core losses in transformer



Open Circuit Test on Transformer



Short Circuit Test on Transformer

Short Circuit Test on Transformer

The connection diagram for short circuit test on transformer is shown in the figure. A voltmeter, wattmeter, and an ammeter are connected in HV side of the transformer as shown. The voltage at rated frequency is applied to that HV side with the help of a variac of variable ratio auto transformer. We short-circuit the LV side of the transformer. Now with the help of variac applied voltage is slowly increased until the wattmeter, and an ammeter gives reading equal to the rated current of the HV side.

.After reaching rated current of HV side, we record all the three instruments reading (Voltmeter, Ammeter and Watt-meter readings). The ammeter reading gives the primary equivalent of full load current I_L. As the voltage applied for full load current in short circuit test on transformer is quite small compared to the rated primary voltage of the transformer, the core losses in transformer can be taken as negligible here.

Let's say, voltmeter reading is V_{sc}. The watt-meter reading indicates the input power during the test. As we have short-circuited the transformer, there is no output; hence the input power here consists of copper losses in the transformer. Since the applied voltage $V_{sc}$is short circuit voltage in the transformer and hence it is quite small compared to the rated voltage, so, we can neglect the core loss due to the small applied voltage. Hence the wattmeter reading can be taken as equal to copper losses in the transformer.

Hence the short-circuit test of a transformer is used to determine copper losses in the transformer at full load.

Why rating of transformer is in KVA?

Cu loss of transformer depends on current, Iron loss on voltage.
So total transformer loss depends on Volt-Ampere (VA) and not on phase angle between voltage and current (ie. load power factor).
That is why it is in KVA.

51. *What is Polarization index test?*

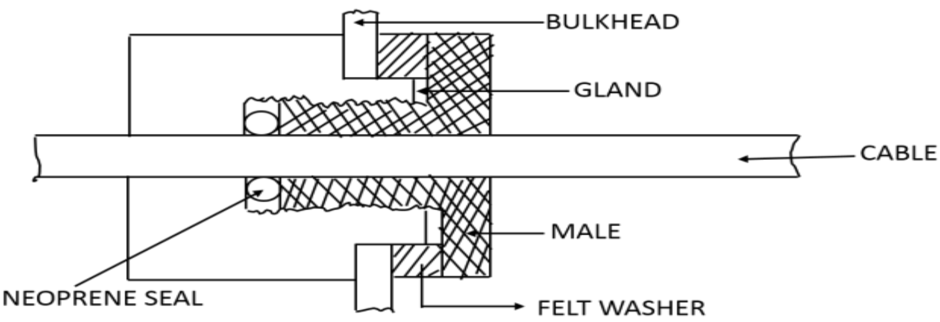
It is done only by 5000 V DC megger test. It is used to determine the fitness of a motor or generator for use. This index gives an indication of build up of dirt or moisture, deterioration of insulation.

Before measuring IR, we should remove all connections to the machine and discharge windings to ground machine frame. Using meghometer, an electric current of either 500 or 1000 Volts DC should be applied between winding and ground. Voltage that is applied should be kept constant for 10 minutes. An initial reading of IR is recorded at 1 minute and second reading is recorded at 10 minutes. The ratio between 10 minute and 1 minute measurements gives polarization index. The polarization index should be atleast 2.0

52. *If motor gets flooded with sea water? Actions?*

- Machine/motor should be disconnected from power source and dismantled.
- All salt deposits wash out with fresh water.
- If deposited with oily bilge water, wash out with electrocleaner.
- Should be heated with lamp, moisture should escape.
- Hottest part of the machine should not exceed 90 degrees C while heating.
- IR readings and temperatures taken regularly, until constant value reach about 1 mega ohm.
- Then spray the windings with insulation varnish.
- Assemble and try out by keeping an eye.

53. *Electric cable to pass through bulkhead, describe arrangement.*



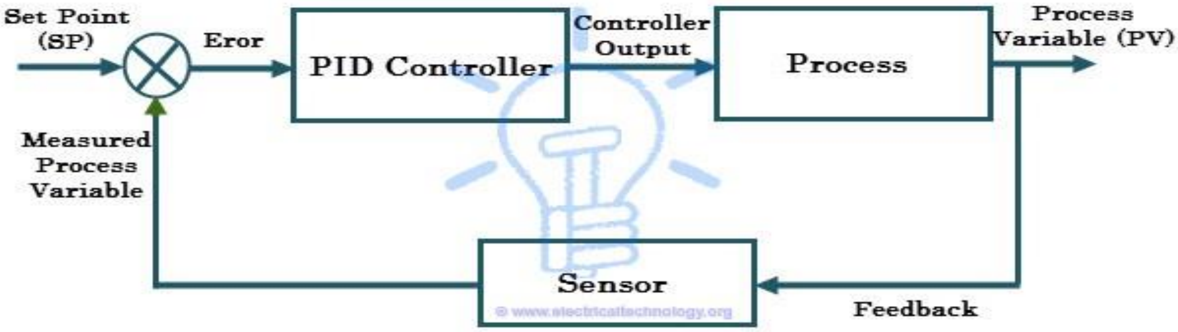
54. Difference between sealed and unsealed batteries?

- Unsealed batteries contains a liquid combination of water and sulphuric acid while sealed batteries hold only enough liquid to allow the electrolyte to flow.
- Unsealed batteries needs more maintenance while sealed batteries are maintenance free.
- Unsealed batteries need regular care to maintain correct level of liquid while sealed batteries do not need as electrolyte is completely absorbed in the separator and do not need water to add.
- Unsealed batteries lasts longer as compared to sealed ones.
- Unsealed batteries takes more time to get charged.
- Unsealed batteries cannot withstand with too much varying climates.
- Unsealed batteries used for power backup, telecom and utility etc. While sealed batteries are used in robotics and uninterrupted power system.

55. What is PID controller?

A PID controller is an instrument used to regulate temperature, flow, pressure, velocity and other process variables. PID stands for Proportional Integral Derivative Control. A proportional–integral–derivative controller (PID controller) is a control loop feedback mechanism. A PID controller continuously calculates an error value, as the difference between a desired set point (SP) and a measured process variable (PV) and applies a correction based on proportional, integral, and derivative terms (denoted P, I, and D respectively), hence the name.

"P" accounts for present value of error.
"I" accounts for past value of error.
"D" accounts for possible further value of error based on present rate of change.



Consider the typical control system shown in above figure in which the process variable of a process has to be maintained at a particular level. Assume that the process variable is temperature (in centigrade). In order to measure the process variable (i.e., temperature), a sensor is used (let us say an RTD).

A set point is the desired response of the process. Suppose the process has to be maintained at 80 degree centigrade, and then the set point is 80 degree centigrade. Assume that the measured temperature from the sensor is 50 degree centigrade, (which is nothing but a process variable) but the temperature set point is 80 degree centigrade.

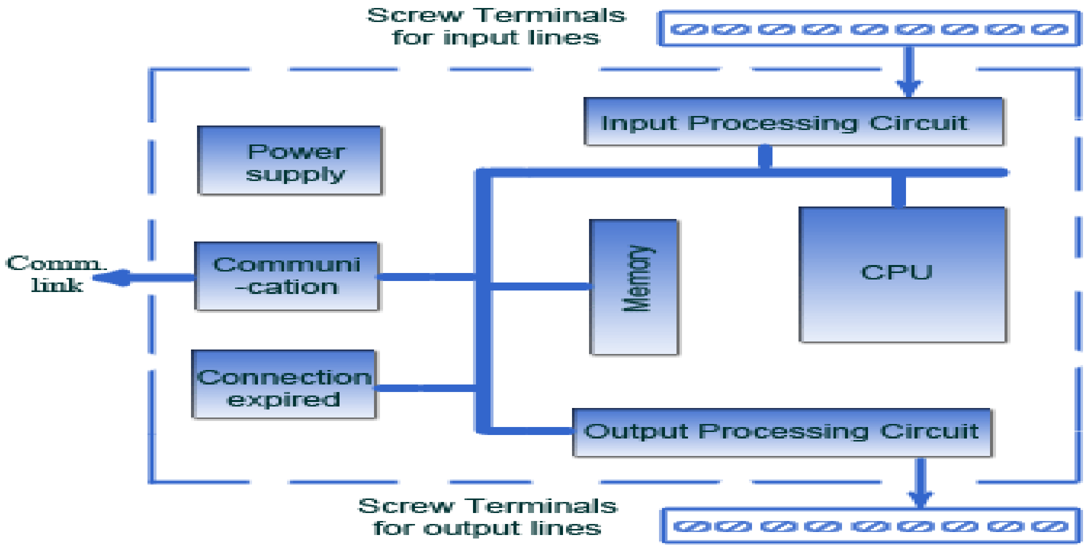
This deviation of actual value from the desired value in the PID control algorithm causes to produce the output to the actuator (here it is a heater) depending on the combination of proportional, integral and derivative responses. So the PID controller continuously varies the output to the actuator till the process variable settle down to the set value. This is also called as closed loop feedback control system.

56. What is PLC and its components? Applications?

Programmable Logic Controller (PLC) is a digital computer used for the automation of various electro-mechanical processes in industries. These controllers are specially designed to survive in harsh situations and shielded from heat, cold, dust, and moisture etc. PLC consists of a microprocessor which is programmed using the computer language.

The program is written on a computer and is downloaded to the PLC via cable. These loaded programs are stored in non – volatile memory of the PLC. During the transition of relay control panels to PLC, the hard wired relay logic was exchanged for the program fed by the user. A visual programming language known as the Ladder Logic was created to program the PLC.

Components of a PLC system are CPU, Memory, Input /Output, Power supply unit, and programming device. Below is a diagram of the system overview of PLC.



- **CPU** – Keeps checking the PLC controller to avoid errors. They perform functions including logic operations, arithmetic operations, computer interface and many more.
- **Memory** – Fixed data is used by the CPU. System (ROM) stores the data permanently for the operating system. RAM stores the information of the status of input and output devices, and the values of timers, counters and other internal devices.
- **I/O section** – Input keeps a track on field devices which includes sensors, switches.
- **O/P Section -** Output has a control over the other devices which includes motors, pumps, lights and solenoids. The I/O ports are based on Reduced Instruction Set Computer (RISC).
- **Power supply** – Certain PLCs have an isolated power supply. But, most of the PLCs work at 220VAC or 24VDC.
- **Programming device** – This device is used to feed the program into the memory of the processor. The program is first fed to the programming device and later it is transmitted to the PLC's memory.
- **System Buses** – Buses are the paths through which the digital signal flows internally of the PLC. The four system buses are:

· Data bus is used by the CPU to transfer data among different elements.

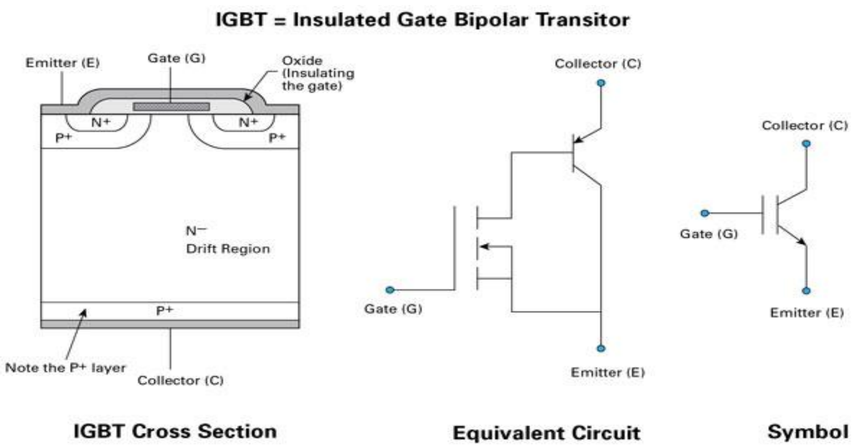
· Control bus transfers signals related to the action that are controlled internally.

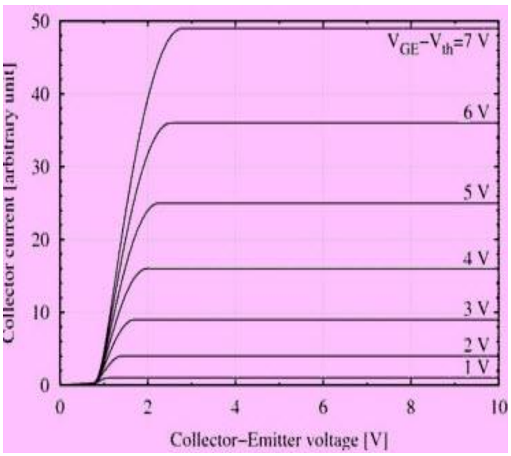
· Address bus sends the location's addresses to access the data.

· System bus helps the I/O port and I/O unit to communicate with each other.

57. What is IGBT?

The IGBT (insulated gate bipolar transistor) is a three-terminal electronic component, and these terminals are termed as emitter, collector and gate. Two of its terminals namely collector and emitter are associated with a conductance path and the remaining terminal 'G' is associated with its control.The sum of amplification is achieved by the IGBT is a radio between its input and output signal.
An IGBT is simply switched "ON" and "OFF" by triggering and disabling its Gate terminal. A constant +Ve voltage i/p signal across the 'G' and the 'E' will retain the device in its "ON" state, while deduction of the i/p signal will cause it to turn "OFF"





IGBT Characteristics
The induction gate bipolar transistor is a voltage controlled device, it only needs a small amount of voltage on the gate terminal to continue conduction through the device
IGBT can switch current in the unidirectional that is in the forward direction(Collector to Emitter)

Advantages and Disadvantages of IGBT

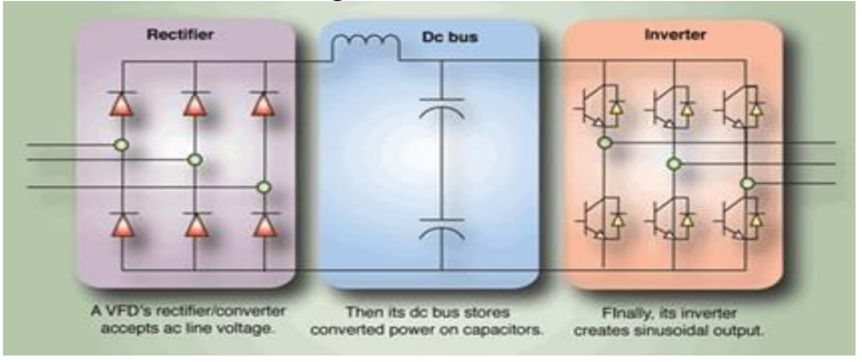
The main advantages of IGBT compared with various kinds of transistors are low ON resistance, high voltage -capacity, fast switching speed, ease of drive and joined with zero gate drive current creates a good option for sensible speed, and various high voltage applications like PWM, SMPS, variable speed control, AC to DC converter powered by solar and frequency converter applications which operates with a hundred's of KHz.

The main disadvantages are: The speed of the Switching is lower to a Power MOSFET and higher to a BJT. The collector current following due to the minority charge carriers roots the turnoff speed to be slow. 2. There is a chance of latch up due to the internal structure of PNPN thyristor.

58. What is VFD?

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. Other names for a VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, microdrive, and inverter.

The two main features of variable frequency drive are adjustable speeds and soft start/stop capabilities. These two features make VFD's a powerful controller to control the AC motors. VFD consists of mainly four sections; those are rectifier, intermediate DC link, inverter and controlling circuit.



Rectifier:
It is the first stage of variable frequency drive. It converts AC power fed from mains to DC power. This section can be unidirectional or bidirectional based on the application used like four quadrant operation of the motor. It utilizes diodes, SCR's, transistors and other electronic switching devices.
If it uses diodes, converted DC power is uncontrolled output while using SCR, DC output power is varied by gate control. A minimum of six diodes are required for the three phase conversion, so the rectifier unit is considered as six pulse converter.
DC bus:
DC power from the rectifier section is fed to DC link. This section consists of capacitors and inductors to smooth against ripples and store the DC power. The main function of DC link is to receive, store and deliver DC power.
Inverter:
This section comprises of electronic switches like transistors, thyristors, IGBT, etc. It receives DC power from DC link and converts into AC which is delivered to the motor. It uses modulation techniques like pulse width modulation by to vary output frequency for controlling the speed of induction motor.
Control circuit:
It consists of microprocessor unit and performs various functions like controlling, configuring drive settings, fault conditions and interfacing communication protocols. It receives feedback signal from motor as current speed reference and accordingly regulates the ratio of voltage to frequency to control motor speed.

Advantages of VFD
- Energy saving
- Limits starting current
- Smooth operation
- High power factor
- Easy installation.

59. How welding transformer works

More number of turns on primary and less number of turns on secondary, which produces high current and low voltage. One end connected to the secondary electrode and other to work piece and other to work piece to be welded. Due to high contact resistance, very high current flows. Therefore more I2R heat produces and electrode melts and fills the gap between the pieces.

60. What happen if one diode in exciter gets (a) open circuit (b) short circuit?

(a) **Open circuit**: This will not have much problem because other diode will supply at main field. In manual mode, generator voltage will slightly reduced whereas in AVR, it will automatically maintain the exciter field current and hence generator voltage and hence exciter will gradually overheat.

(b) **Short circuit**: This will lead to rapid overheating of exciter.

61. If shore supply has 440 Volt and 50 Hz?

The ship has variable frequency drive (VFD) to convert it to 440 Volt and 60 Hz.

62. Steering Gear safety?

- In this overload alarm set at 150%
- Short circuit trip
- Low level trip
- Phase failure alarm
- High temperature alarm
- 200% insulation of motor
- Auto start on power failure
- No volt alarm
- Auto changeover alarm
- Low level trip
- High oil temperature alarm

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63. Why to check air gapbetween stator and rotor of alternator?

To avoid mechanical contact between rotor and stator, and to determine the condition of bearings.

64. Motor is not starting, What are the checks can be done?

- Check supply from MSB
- Fuse is not blown off.
- Any trip is activated
- Coupling is too tight.
- Single phasing

65. Motor is running hot, what are the possible reasons?

- Single phasing
- Overload
- Bearing damage
- Fan not working.

66. What is RMS value?

ROOT MEAN SQUARE (RMS) VALUE The value of an AC voltage is continually changing from zero up to the positive peak, through zero to the negative peak and back to zero again.
Clearly, for most of the time it is less than the peak voltage
VRMS Vpeak = 0.7× or Vpeak = 1.4× VRMS
AC voltmeters and ammeters show the RMS value of the voltage or current.

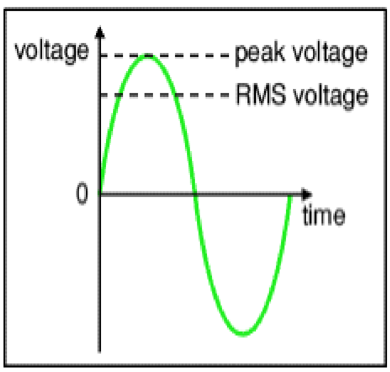


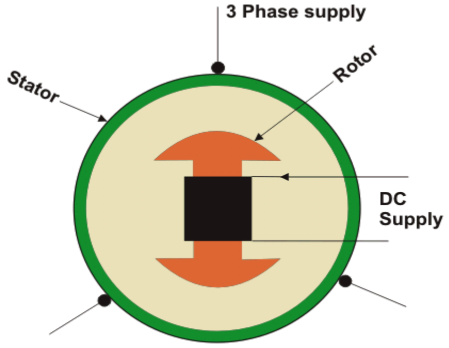
Figure-1: Difference between peak and RMS voltage

67. Types of AC motors?

There are mainly two types of AC motors:
Induction motor and Synchronous motor

Synchronous motor:

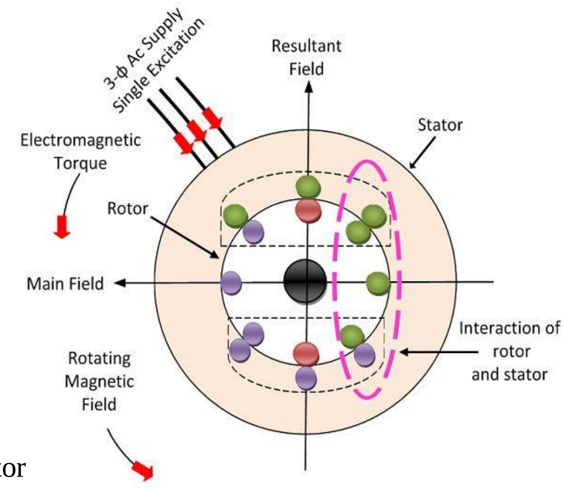
Synchronous motors are not self starting motors
Connection of 3 phase supply to stator will produce a rotating magnetic field. Effect of rotating magnetic field on rotor is attractive and repulsive, hence rotor inertia will prevent rotation.
So the rotor has to be brought to synchronous speed and the rotor poles and rotating magnetic field will get locked together.
One method of starting synchronous motor is by having solid copper bars permanently embedded in the rotor pole lips and short circuited by rings to make it as a temporary induction motor. When machine runs at around 95% synchronous speed, DC excitation is switched on and rotor is pulled into synchronisation. **Use onboard** in Gyro compass, Viscotherm etc.



Synchronous Motor

Induction motors:

Three phase AC supply voltage are connected to the three stator phase windings, the resulting phase currents to produce a magnetic field which rotates at a speed known as synchronous speed around the stator core.
The stator magnetic flux cuts through the rotor copper bars conductors To induce alternating emf, as the conductors are connected, so it produces rotor currents.
As the current flows through the conductor, the flux induces on it. The direction of rotor flux is same as that of the rotor current.



Three Phase Induction Motor

Circuit Globe

Now we have two fluxes one because of the rotor and another because of the stator. These fluxes interact each other. On one end of the conductor the fluxes cancel each other, and on the other end, the density of the flux is very high. Thus, the high-density flux tries to push the conductor of rotor towards the low-density flux region. This phenomenon induces the torque on the conductor, and this torque is known as the electromagnetic torque.

The direction of electromagnetic torque and rotating magnetic field is same.
Thus, the rotor starts rotating in the same direction as that of the rotating magnetic field.
The speed of the rotor is always less than the rotating magnetic field or synchronous speed. The rotor tries to the run at the speed of the rotor, but it always slips away. Thus, the motor never runs at the speed of the rotating magnetic field, and this is the reason because of which the induction motor is also known as the asynchronous motor.

Why Rotor never runs at Synchronous Speed?

If the speed of the rotor is equal to the synchronous speed, no relative motion occurs between the rotating magnetic field of the stator and the conductors of the rotor. Thus the EMF is not induced on the conductor, and zero current develops on it. Without current, the torque is also not produced.

Applications: Lifts, cranes, hoists, large capacity exhaust fans, driving lathe machines, Crushers etc.

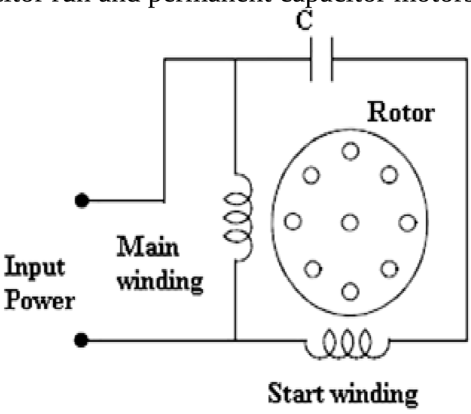
68. Difference between synchronous motors and induction motors?

Synchronous Motor	Induction Motor
1. Synchronous motors require DC excitation to be supplied to the rotor windings.	1. Induction Motors don't require DC excitation to be supplied to the rotor windings.
2. Synchronous motors require rotor windings.	2. Induction motors are most often constructed with conduction bars in the rotor that are shorted together at the ends to form a "squirrel cage."
3. Synchronous motors require a starting mechanism in addition to the mode of operation that is in effect once they reach synchronous speed.	3. Three phase induction motors can start by simply applying power, but single phase motors require an additional starting circuit.

Synchronous motor	Induction motor
Construction is complicated	Construction is simpler , particularly in case of cage rotor
Not self starting	Self starting
Separate DC source is required for rotor excitation	Rotor gets excited by the induced e.m.f so separate source is not necessary
The speed is always synchronous irrespective of the load	The speed is always less than synchronous but never synchronous
Speed control is not possible	Speed control is possible though difficult
As load increases, load angle increases, keeping speed constant at synchronous	AS load increases , the speed keeps on decreasing
By changing excitation , the motor p.f can be changed from lagging and leading	It always operates at lagging p.f and p.f control is not possible
It can be used as synchronous condenser for p.f improvement	It can not be used as synchronous condenser
Motor is sensitive to sudden load changes and hunting results	Phenomenon of hunting is absent
Motor is costly and requires frequent maintenance	Motor is cheap , especially cage rotors and maintenance free

69. Single phase induction motors?

Single phase induction motor: The single-phase induction motor is not self-starting. When the motor is connected to a single-phase power supply, the main winding carries an alternating current. It is logical that the least expensive, most reduced upkeep sort engine ought to be utilized most regularly. These are of different types based on their way of starting since these are of not self starting. Those are split phase, shaded pole and capacitor motors. Again capacitor motors are capacitor start, capacitor run and permanent capacitor motors. Permanent capacitor motor is shown below.



In these types of motors the start winding can have a series capacitor and/or a centrifugal switch. When the supply voltage is applied, current in the main winding lags the supply voltage because of the main winding impedance. And current in the start winding leads/lags the supply voltage depending on the starting mechanism impedance. The angel between the two windings is sufficient phase difference to provide a rotating magnitude field to produce a starting torque. The point when the motor reaches 70% to 80% of synchronous speed, a centrifugal switch on the motor shaft opens and disconnects the starting winding.

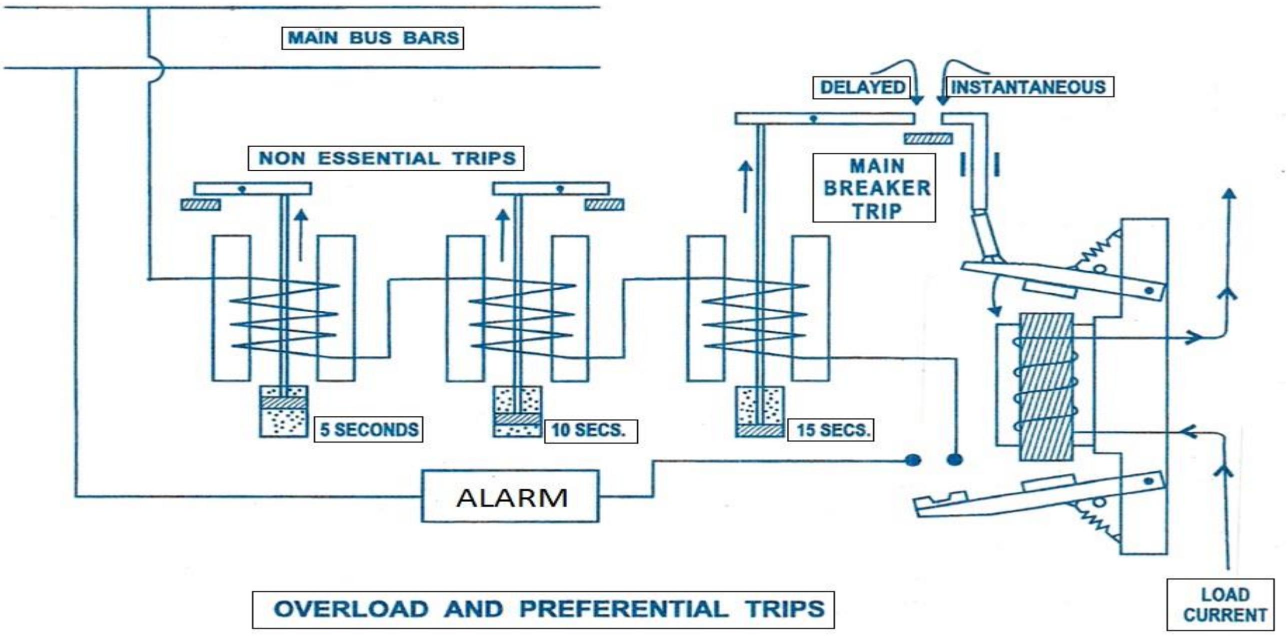
- **Applications**: Pumps Compressors, Small fans, Mixers, Toys, High speed vaccum cleaners, Electric shavers, Drilling machines

70. SOLAS Chapter II-1, Part D?

Regulation 40: General
Regulation 41: Main source of electrical power and lighting systems
Regulation 42: Emergency source of electrical power in passenger ships
Regulation 42-1:Supplementary for emergency lighting in ro-ro ships.
Regulation 43: Emergency source of electrical power in cargo ships.
Regulation 44: Starting arrangements for emergency generator sets.
Regulation 45: Precautions against shock, fire and other hazards of electrical origin.

71. What is Preferential trip?

Preferential trip is a kind of electrical arrangement on ship which is designed to disconnect the non-essential circuit i.e. non-essential load from the main bus bar in case of partial failure or overload of the main supply. The non-essential circuits or loads on ships are air conditioning, exhaust and ventilation fans, and galley equipments which can be disconnected momentarily and can be connected again after fault finding. The main advantage of preferential trip is that it helps in preventing the operation of main circuit breaker trip and loss of power on essential services and thus prevents blackout and overloading of generator. It is always set at 110% of load.



Construction:

The preferential trip circuit consists of an electromagnetic coil and a dashpot arrangement to provide some delay to disconnect the non-essential circuits. Along with this, there is also an alarm system provided, which functions as soon as an overload is detected and trips start operating. There are some mechanical linkages also in the circuit which instantaneously operates the circuit and completes the circuit for preferential trips.

The dashpot arrangement consists of a small piston with a small orifice and which is placed inside a small cylinder assembly. This piston moves up against the fluid silicon and the time delay is governed by the orifice in the piston.

Working:

The current passes through the electromagnetic coil and the linkages are kept from contacting using a spring arrangement. As soon as the current value increases the limit, the electromagnetic coil pulls the linkage up against the spring force and operates the instantaneous circuit and the alarm system. The lower linkage completes the circuit for the preferential trip circuit.

The current passes through the coil in the preferential trip circuit which pulls the piston in the dashpot arrangement. The movement of this piston is governed by the diameter of the orifice and the time delay made by the same. The preferential trip operates at 5, 10 and 15 seconds and the load is removed accordingly. If the overload still persists, then an audible and visual alarm is sounded.

The preferential trip is one of those important electrical circuit diagrams which help in removing the excessive load from the main bus bar, thus preventing situation like blackout which is a dangerous incident to ship, especially when the ship is sailing in restricted or congested waters.

Order of tripping varies in each vessel, most of the ships have the following order:

5 seconds = Air condition and ventilation
10 seconds = Refrigerated cargo plant
15 seconds = Deck equipment
If over current still exist after tripping of non-essential services, then overload trip gets activated after 20 seconds and trips the whole circuit.

Note: Preferential trip is tested by current injection

72. Describe shaft generator?

Static frequency converter for a shaft generator

The converter system shown in sketch serves the shaft generator of a ship with a fixed-pitch propeller and a large main-engine speed range. The shaft generator must supply full output over the permitted speed range, and to achieve this at the lower end (i.e. down to 40% of the rated speed), it is overrated for higher speeds.

The a.c. shaft generator itself is a synchronous machine which produces alternating current with a frequency that is dictated by variations in engine speed. At the full rated r.p.m., frequency may match that of the electrical system.

The output is delivered to the static converter, Which has two main parts. The first is a rectifier bridge to change shaft generator output from alternating to direct current. The second part is an inverter to change the d.c. back to alternating current, at the correct frequency.

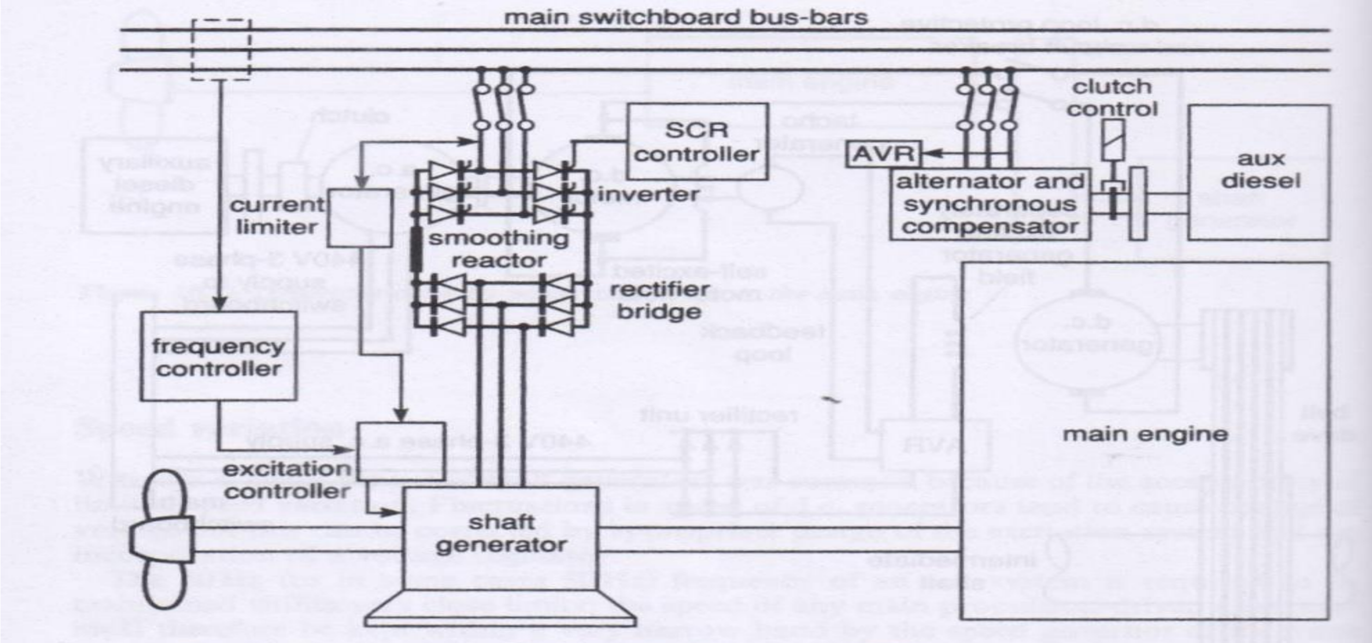


Figure 10.4 *Shaft generator system with static frequency converter*

Alternating current from the shaft generator, when delivered to the three-phase rectifier bridge, passes through the diodes in the forward direction only, as a direct current .The smoothing reactor reduces ripple. The original frequency (within the limits) is unimportant once the supply has been altered to d.c. by the rectifier. The inverter for transposition of the temporary direct current back to alternating current is a bridge made up of six thyristors. Direct current, available to the thyristor bridge, is blocked unless the thyristors are triggered or fired by gate signal. Gate signals are controlled to switch each thyristor on in sequence, to pass a pulse of current. The pattern of alternate current flow and break constitutes an approximation to a three-phase alternating current.

Voltage and frequency of the inverter supply to the a.c. system must be kept constant within limits. These characteristics are controlled for a normal alternator by the automatic voltage regulator and the governor of the prime mover, respectively. They could be controlled for the shaft alternator inverter by a separate diesel-driven synchronous alternator running in parallel. The extra alternator could also supply other effects necessary to the proper functioning of an inverter, but the objective of gaining fuel and maintenance economy with a shaft alternator would be lost.

Fortunately the benefits can be obtained from a synchronous compensator (sometimes termed a synchronous condenser), Which does not require a prime mover or driving motor except for starting. The compensator may be an exclusive device with its own starter motor or it may be an ordinary alternator with a clutch on the drive shaft from the prime mover.

The a.c. generator set that fulfils the role of synchronous compensator for the system shown is at the top right of the sketch. The diesel prime mover for the compensator is started and used to bring it up to speed for connection to the switchboard. The excitation is then set to provide the reactive power, and finally the clutch is opened, the diesel shut down and the synchronous machine then continues to rotate independently like a synchronous motor, at a speed corresponding to the frequency of the a.c. system.

A synchronous compensator is used with the monitoring and controlling system, to dictate or define the frequency. It also maintains constant a.c. system Voltage, damps any harmonics and meets the reactive power requirements of the system and converter, as well as supplying, in the event of a short circuit, the current necessary to operate trips. The cooling arrangements for static frequency converters included . The provision of fans as well as the necessary heat sinks for thyristors.

Advantages and Disadvantages of Shaft Generator:

Advantages of Shaft generator:

- The biggest advantage- it dose not cause air pollution unlike other traditional methods of power production in ship. Moreover, noise level is also low.
- It is more cost effective as it dose not requires expensive fuel for power generation as main engine itself is a prime mover.
- The wear and tear and hence the maintenance schedule and costs for the same reduces for independent driven generator.

- Installation space is less as it is installed close or in line with the shaft of the main engine.
- The investment cost depends on the type and system of the shaft generator but for a basic designed shaft generator it is low.
- The installation cost for shaft generator is also low as it doesn't require separate foundation, prime mover or exhaust system. Even time for installation is also less.
- Low spare parts cost and man – hour cost as the schedule maintenance period for shaft generator has larger time gap as compared to diesel generator.

Disadvantages of Shaft generator:

- For a basic shaft generator system, the efficiency of propeller and engine is reduced at low propulsion power. Since the frequency requirement is constant, for a main engine with a CPP, it has to run at constant speed even at low load.
- No power generation in port as the prim mover is in stop condition.
- Due to an additional attachment to shaft of the engine, the load in the engine also increases, resulting in increase in specific fuel and cylinder oil consumption when shaft generator is used.
- Cannot cope up alone when the load demand is high as it may affect the main engine performance and maintenance.
- It requires gears, couplings and other complicated arrangement for installation in some system.

73. Maintenance of motor?

- Regular cleaning of dust, dirt, oil and grease from inside and outside of motor.
- The insulation is cleaned by brushing and spraying de-greasant liquids.
- Replacement of worn bearings.
- Ensuring air gap between rotor and stator.
- Finding IR between phases and between phase and earth.
- On the contactors and relays,
  - Check for signs of overheating, loose connections.
  - Remove any dust and grease from magnet faces.
  - Ensuring magnet armature of contactors moves freely.
- On the contacts,
  - Check for excessive pitting and roughness due to burning
  - Checks on contact spring pressure.

74. What are the tests to be done on motor opened for overhaul?

Open circuit or continuity test:

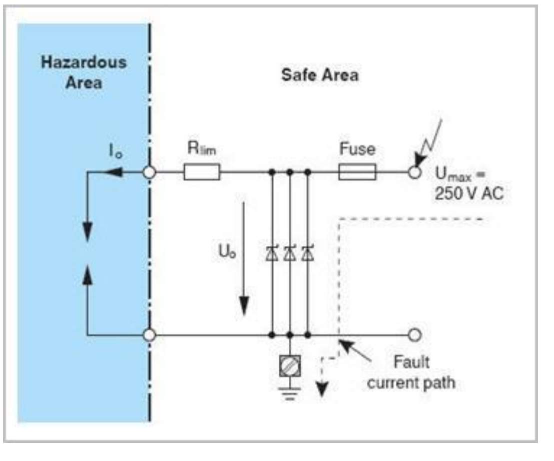
- This is commonly called Voltage drop test.
- By using IR tester, which incorporates low voltage continuity test facility (0.8 ohms – 1.5 ohms)
- On 3 phase motor carried out on each phase,
- Between U1 & U2, Between V1 & V2, Between W1 & W2
- All values should be equal or identical,
- If one reading is less, then possibility of Short circuit turns in that winding.
- High values indicates open circuit or loose connection.

Short circuit or IR test:

- It is also called growler's test. (1kilo ohms / volt)
- It is measured between insulated conductors and earth and also between conductors.
- Short two probes of tester, it should indicate zero
- Before testing, isolate from live supply.
- Readings are Phase to phase (U-V,V-W, W-U)
- Phase to Earth (U-E, V-E, W-E)

75. Working of Zener barrier in hazardous area?

An intrinsic safety barrier is used to provide protection to a device mounted in a hazardous location. The basic components that make up most intrinsic safety barriers are a fuse, zener diodes, and a resistor and are shown below in this simple electrical diagram:



A zener barrier is a simple device where the voltage & current (Power, Energy) is limited into the hazardous area. The voltage is limited/clamped by a zener diode and the current limited by an output resistor. The fuse is there to protect the zener diode. The key to safety is the Intrinsically safe earth. Without it, there is no protection.

The circuit (or instrument) in the hazardous area operates normally until a fault condition occurs. In the illustration above, a fault voltage is applied to the terminals of the intrinsic safety barrier thus causing the zener diodes to "operate" and safely pass fault current to ground (rather than into the hazardous area). As a result of the fault current, the fuse will open and the complete loop maintains safety.

76. How to order welding machine?

- Single phase or 3 phase transformer.
- System current requirement to be mentioned. (10 A – 200 A)
- Cable size and insulation requirements.
- Holder size (3.5 mm to 18 mm)
- Physical size of transformer
- Only for welding transformer rating in KW, (5 to 40 KW)

77. What are the electrical maintenance carried out in Dry Dock?

- Cleaning of switchboards internally and externally
- Checks on main busbars and auxiliary connections for tightness.
- Examine busbar supports for surface cracking and damage to insulation material.
- Feeder isolater blades and fuse holder contacts must be checked for any wear and damage.
- All voltmeter, ammeter and wattmeters tested.
- ACB overhaul
- ICCP checks (Reference electrode is Zn or Silver, Insoluble Anode is Platinised Titanium)
- MGPS checks (Cu or Al anodes which is supplied with 228 V supply)

78. Connection of interpoles in DC generator?