Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner should assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.

5) Credits to be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept

1 **Attempt any FOUR of the following:** 16

1 a) State the causes of faults in power system.

Ans:

Causes of faults in power systems:

1) Over voltages due to direct lightning strokes.
2) Over voltages due to switching surges.
3) Falling of external conducting objects, tree branches etc. on conducting lines.
4) Accumulation of dust, dirt etc. on exposed components as lines, insulators etc.
5) Perching of birds on lines, insulators or other components.
6) Ill-maintained sections of the power systems.
7) Heavy unbalanced loading on three phase lines even for short times.
8) Prolonged unbalanced loading conditions leading to overheating (due to harmonics).
9) Failure of joints.
10) Open circuited or broken conductors.
11) Mechanical damage to components of the power systems.
12) Unusually severe atmospheric conditions as storm, rains, too high humidity,
13) Defective/improper selection of components used and Faulty design of the power system sections.
14) Failure of insulation of components and equipment parts.
15) Accidents.
16) Over temperature.
17) Excessive internal and external stresses.

Each point 1 Mark (any four points) = 4 Marks

1 b) Draw and explain important characteristic of high rupturing capacity fuse.

Ans:

Characteristics of HRC Fuse:

A Fuse operates when its element melts due to heat produced by I^2R_F, where R_F is Fuse resistance. This heat produced increases if the current flowing through the Fuse element increases. Therefore, we can conclude that a Fuse element will melt faster for large fault current while it will take some time for lower value of fault current. This time-current relationship of Fuse is known as Characteristics of Fuse and is very useful for proper selection of Fuse for a particular circuit and for coordination purpose. A typical Fuse characteristic is shown in figure below.

Explanation 2Marks

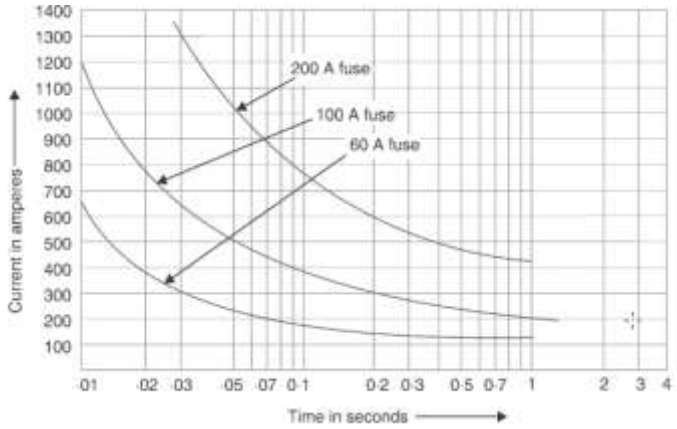


Diagram 2Marks

1 c) A circuit breaker is rated at 2kA, 1000MVA, 33kV, 3Sec, 3-phase. Determine breaking capacity, making capacity, short time rating of the breaker.

Ans:

Breaking capacity = 1000 MVA (given) 1Mark

Rated symmetrical breaking current = Breaking capacity / ($\sqrt{3}$ x rated votage)

$= 1000 \times 10^6 / (\sqrt{3} \times 33 \times 10^3)$

= 17495.46 amps 1Mark

Rated making current = 2.55 x Symmetrical breaking current

= 2.55 x 17495.46

= 44613.42 amps (peak) 1Mark

Short time rating = 17495.46 amps for 3 sec. 1Mark

1 d) Explain the fundamental requirements of protector relaying.

Ans:

Fundamental requirements of protective relaying:

i) Selectivity: It is the ability of protective system to select correctly that part of system in trouble and disconnect the faulty part without disturbing the rest of the system.

ii) Speed: The relay system should disconnect the faulty section as fast as possible to prevent the electrical apparatus from damage and for system stability.

iii) Sensitivity: It is the ability of the relay system to operate with low value of actuating quantity.

iv) Reliability: It is the ability of the relay system to operate under predetermined conditions.

v) Simplicity: The relay system should be simple so that it can be easily maintained.

vi) Economy: The most important factor in the choice of particular protection scheme is the economic aspect. The protective gear should not cost more than 5% of the total cost of equipment to be protected.

Each point 1 Mark (any four points) = 4 Marks

OR

Fundamental requirements :

1) Detect abnormal conditions
2) Disconnect abnormally operating part so as to prevent the subsequent fault.
3) Disconnect faulty part quickly so as to improve system stability, service continuity and system performance
4) Improve Transient stability

Qualities of relay:

1) Selectivity.
2) Speed.
3) Sensitivity
4) Reliability / Trust worthiness.
5) Simplicity
6) Economical

1 e) State any four advantages of static overcurrent relay.

Ans:

Advantages of static overcurrent relay:

1) Low power required hence less burden.
2) No motional parts hence bouncing, friction, erosion, arcing etc. eliminated.

3) Not affected by gravity, may be used in any position.
4) Improved selectivity as resetting and over shoot times is reduced.
5) Lower operating times.
6) One static relay can be used for multiple purposes.
7) Higher torque /weight ratio.
8) Compact.
9) Good discriminating characteristics and reliability.
10) Suitable for reliable remote operation with PLCC.
11) Can be programmed as required.

Each point 1 Mark (any four points) = 4 Marks

1 f) List out all possible faults which may occur on an alternator.

Ans:

Possible faults occurring on an Alternator:

1) Stator winding faults.
2) Thermal overheating.
3) Rotor winding faults.
4) Loss of field.
5) Under/Over frequency.
6) Vibration &Bearing overheating.
7) Motoring of generator.
8) Faults because of external causes.
9) Over voltages.
10) Over speed.
11) Over current.

Each point 1 Mark (any four points) = 4 Marks

2 **Attempt any <u>FOUR</u> of the following:** 16

2 a) State stepwise procedure for symmetrical fault calculations.

Ans:

Stepwise procedure for symmetrical fault calculations:

1) Draw a single line diagram of the complete network indicating the rating, voltage and percentage reactance of each element of the network.
2) Choose a numerically convenient value of base kVA and convert all percentage reactances to the base value.
3) Corresponding to the single line diagram of the network, draw the reactance diagram showing one phase of the system and the neutral. Indicate the % reactances on the base kVA in the reactance diagram. The transformer in the system should be represented by aa reactance in series.
4) Find the total %reactance of the network upto the point of fault. Let it be X%.
5) Find the full-load current corresponding to the selected base kVA and the normal system voltage at the fault point. Let it be I.
6) Then the various short-circuit calculations are:

3 Steps, 2 Marks.

6 Steps, 4 Marks.

Short-circuit current, $I_{SC} = I \times \frac{100}{\%X}$

$$Short - circuit\ kVA = Base\ kVA \times \frac{100}{\%X}$$

2 b) Compare Fuse and MCCB on:

(i) size
(ii) cost
(iii) reliability

(iv) safety

Ans:

Each point 1 Mark = 4 Marks

Comparison between Fuse and MCCB:

Sr. No	Point	Fuse	MCCB
1	Size	Small	Comparatively Big
2	Cost	Economical	Costly/Expensive
3	Reliability	Less reliable	More reliable
4	Safety	Less safe	More safe

2 c) With neat diagram explain working of directional overcurrent relay.

Ans:

Directional overcurrent relay:

Under normal operating conditions, power flows in the normal direction in the circuit. Therefore directional power relay does not operate and overcurrent element remains unenergized

However, when a short circuit occurs, and if the current or the power flows in the reverse direction, the disc of the upper element rotates to bridge the fixed contacts 1 & 2. This completes the circuit for over current element. The disc of this element rotates and moving contact attached to it closes the trip circuit. This operates circuit breaker which isolates the faulty section.

Working 2 Marks

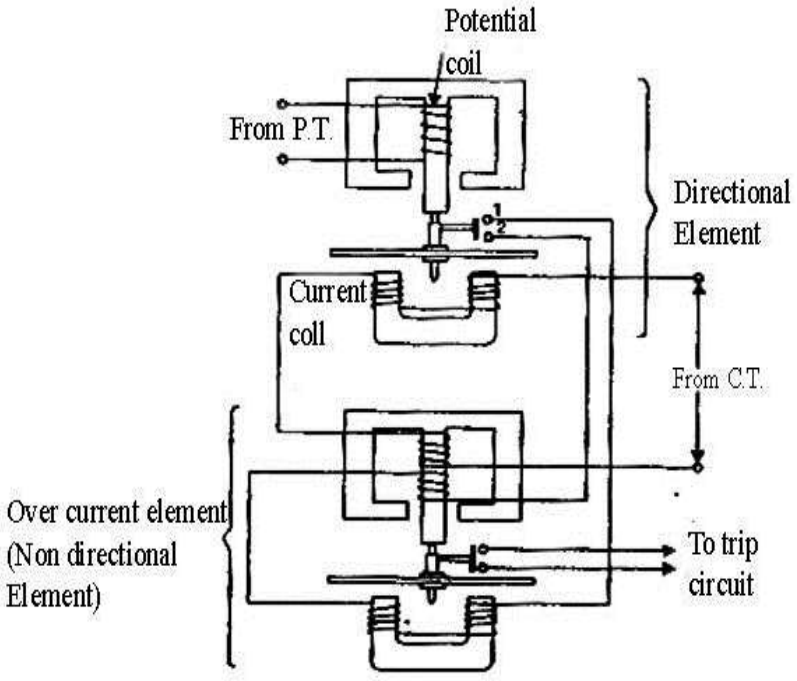


Diagram 2 Marks

2 d) Draw neat diagram of Buchholz relay and explain working in brief.

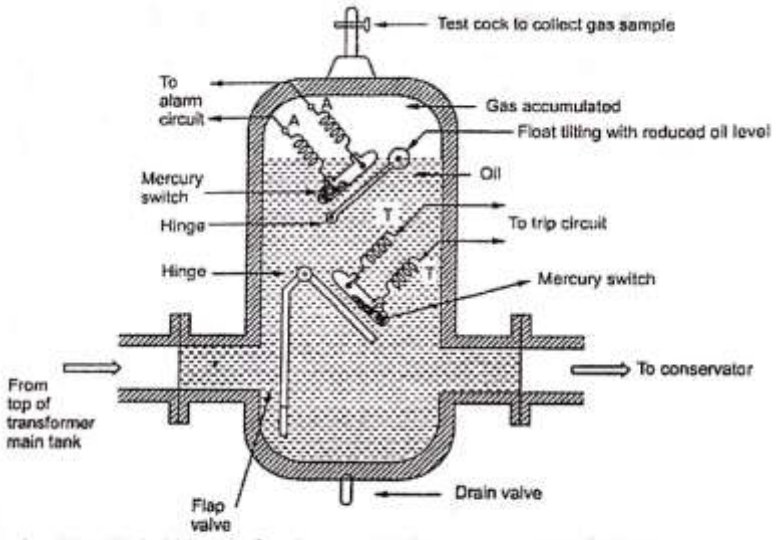
Ans:

Working of Buchholz relay:

The relay is located in the path of the oil from transformer tank to conservator. As seen from diagram, the upper mercury switch operates the alarm circuit due to tilting of the float by accumulation of gas evolved slowly in the transformer tank

due to minor faults which may develop into major ones if the alarm is not investigated. Working 2Marks

Further lower mercury switch operates the trip circuit to switch off the circuit breaker related to the transformer when there is a sudden flow of oil from the transformer tank to conservator. Such flow occurs when there is serious fault in the transformer tank. Here the float (lower) is placed in such a manner that it senses the sudden violent movement of oil from transformer tank to conservator.



Terminals 'A' : are for alarm and Terminals 'T': are for tripping.

Buchholz relay

Diagram 2Marks

2 e) What is the meaning of insulation co-ordination? Give example.

Ans:

Insulation Co-ordination:

It is the correlation of the insulation of electrical equipment and the lines with the characteristics of protective devices such that the insulation of the whole power system is protected from the excessive over voltages. 2 Marks

Example of Insulation Co-ordination:

The insulation strength of various equipment like transformers , circuit breakers etc. should be higher than that of lightning arresters and other surge protective devices. The insulation Co-ordination is thus the matching of the volt time flash over and break down characteristcs of equipment and protective devices in order to obtain maximum protective margin at a reasonable cost. 2 Marks

3 a) **Attempt any <u>THREE</u> of the following**: 12

3 a) i) What is reactor? Classify the reactors on the basis of their location.

Ans:

Reactor:

A Reactor is a coil of number of turns designed to have large inductance with nigligible ohmic resistance connected in series with equipment to limit the short circuit current. 2 Marks

Classification of reactors :

1) Generator reactors

2) Feeder reactors 2 Marks

3) Bus bar reactors
i) Ring Systems
ii) Tie bar system.

3 a) ii) Distinguish between circuit breaker and isolator.

Ans:

Difference between Circuit breaker & Isolator:

Sr.No.	**Circuit breaker**	**Isolator**
1	Symbol 	Symbol 
2	Operated ON load /on occurrence of fault.	Operated on NO load.
3	Heavy current is interrupted, arc is produced hence arc quenching facility is provided.	No arcing during ON/OFF so no arc quenching provision.
4	Operation is in oil or gas chamber (not visible).	Visible operation in open air (opening & closing of contacts).
5	Big sound on operation.	Noise-less operation.
6	Costly/Expensive.	Economical
7	Periodic maintenance is very much required.	No periodic maintenance required (only contact cleaning).
8	Occupy more space.	Occupy less space.
9	Requires tripping circuit for operation.	No tripping circuit.
10	Manually operated in normal condition & automatically operated in fault condition.	Operation may be manual/mechanical/pneumatic.
11	Types are as: (a) Air break C. B. (b) Oil C.B. (c) Air blast C.B. (d) Vacuum C.B. (e) SF6 C.B. (f) MCCB etc.	Types are as: (a) Vertical break type (b) Horizontal break type (c) Pantograph type etc.
12	Complicated in construction.	Simple in construction.

Each point 1 Mark four points = 4 Marks

3 a) iii) Define the following:

1) Relay time
2) Fault clearing time
3) Reset
4) Pick-up value

Ans:

1) **Relay Time:** The time interval between occurrence of fault and closure of relay contacts.
2) **Fault clearing time:** It is the time between the instant of fault and instant of final arc interruption in circuit breaker.

Each definition 1 Mark = 4 Marks

3) **Reset:** The value of current below which the relay resets and comes back to its original state is called as reset current or dropout.
4) **Pickup value:** The threshold value of operating current above which the relay operates.

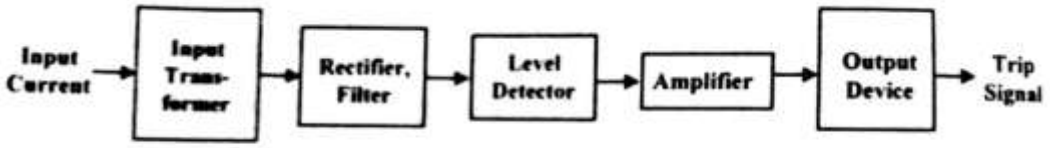
OR

It is the minimum current in the relay coil at which the relay starts to operate.

3 a) iv) Describe operation of static overcurrent relay with block diagram.

Ans:

Static over current relay:



Block diagram of static over current relay

Block diagram 2 Marks

The current derived from the main CT is feed to the input transformer which gives a proportional output voltage. The input transformer has an air gap in the iron core to give linearity in the current voltage relationship up to the highest value of current expected and is provided with taping on its secondary to obtain different current settings. The output voltage is then rectified and then filtered at a single stage to avoid undesirable time delay in filtering so as to excurse high speed of operation. A zener diode is also incorporated in the circuit to limit the rectified voltage to safe values even when the input current is very high under fault conditions.

A fixed portion of the rectified filtered voltage is compared against a preset pick-up value by a level detector and if exceeds the pick-up value, a singal through an amplifier is given to the output device which issues the trip signal.

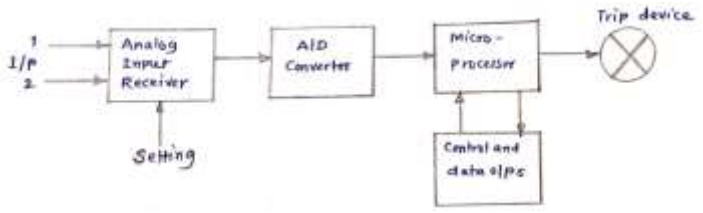
Operation 2 Marks

3 b) **Attempt any <u>ONE</u> of the following:** 06

3 b) i) Explain operation of microprocessor based relay with neat diagram

Ans:

Operation of microprocessor based relay:



Block diagram 2 Marks

The inputs from the power system through CTs and PTS are received by the analog Input receiver; they are sampled simultaneously or sequentially at uniform time intervals. They are then converted into digital form through A/D converter and transferred to micro-processor. Digital signals are in the form of coded square pulses which represent discrete data. The signals are fed to micro-processor which is being set with the recommended values, compares the dynamic inputs and

Operation 4 Marks

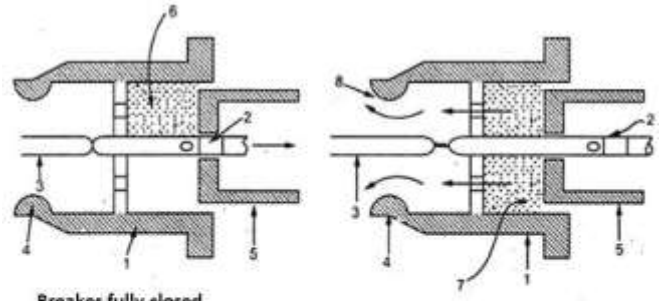
decides accordingly to generate trip/alarm signal to the output device.

Or EQUIVALENT DIAGRAM AND DESCRIPTION

3 b) ii) With a neat labeled diagram explain working of SF_6 circuit breaker.

Ans:

Working of SF_6 circuit breaker:



Single pressure puffer type SF6 circuit breaker

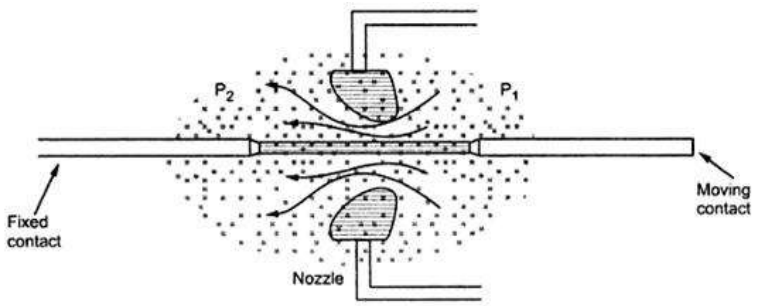
Diagram 3 Marks

Gas is compressed by the moving cylinder and is released through the nozzle and rapidly absorbs the free electrons to extinguish the arc formed.

The moving cylinder (1) connected to moving contact (2) against the fixed piston (5). Due to relative motion between (1) and (5) the gas gets compressed in enclosure (6) and is released through nozzle for arc extinction. This happens by puffing action. At current zero the diameter becomes too small and arc gets extinguished.

Working 3 Marks

OR



Double pressure type breaker:

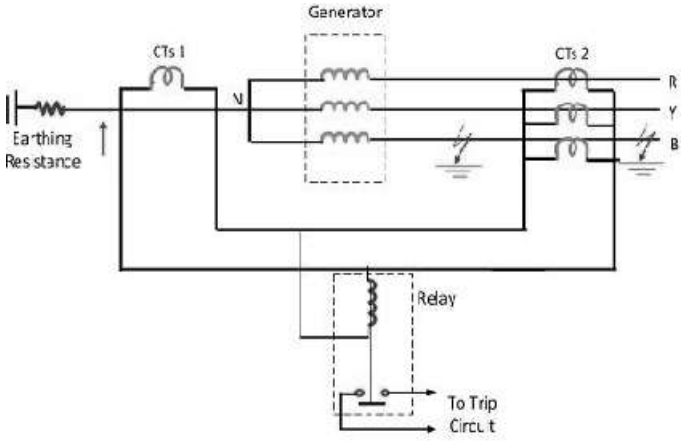
Here the gas is made to flow from area P_1 to P_2 through a convergent-divergent nozzle. The flowing gas covers the arc. In the divergent section the speed of the gas is very high and carries away most of the heat and absorbs free electrons from the periphery of arc that results in the reduction of diameter of arc, which becomes nearly zero at current zero, leading to arc being extinguished. Finally the gas enters the contact space increasing the dielectric strength.

4 **Attempt any <u>FOUR</u> of the following**: 16

4 a) Describe with neat diagram how balanced earth fault protection is applied to small size generators.

Ans:

Balanced earth fault protection to small size generators:



Balanced Earth Fault Protection

Diagram
2 Marks

Operation/Working:

When the generator is in a normal operating condition the sum of the currents flow in the secondary of the current transformers is zero and the current flow into secondary to neutral is also zero. Thus the relay remains de-energized. When the fault occurs in the protected zone (left of the line) the fault current flow through the primary of current transformers and the corresponding secondary current flow through the relay which trips the circuit breaker.

When the fault develops external of the protective zone (right of the current transformer) the sum of the currents at the terminal of the generator is exactly equal to the current in the neutral connection. Hence, no current flows through the relay operating coil.

Operation
2 marks

4 b) A 3-phase transformer of 220V/22kV line volts is connected in λ/Δ. The protective transformer on 220V side have current ratio of 400/5. What should be the CT ratio on 22kV side?

Ans:

1) Line current on 220 V side is 400 amp
   Phase current on delta connected CT's on 220 V side = 5 amp
2) Line current of delta connected CT's on 220 V side = 5 √3 amp
   = 8.66 amp.
   This current i.e. 8.66 amp will flow through the pilot wires, obviously this will be the current which flows through the secondary of CTs on the 22kV side.
   Therfore,

1 Mark

3) Phase current of star connected CT on 22 kV side = 5 √3 amp
   = 8.66 amp
   If I_2 is the line current on 22kV side,

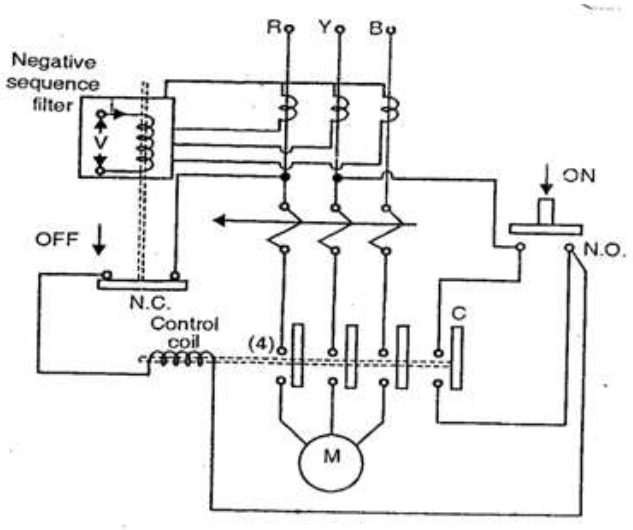
1 Mark

4) For transformer ,

$\sqrt{3}\ V_1\ I_1 = \sqrt{3}\ V_2\ I_2$
$\sqrt{3} \times 220 \times 400 = \sqrt{3} \times 22000 \times I_2$ 1 Mark
$I_2 = (\sqrt{3} \times 220 \times 400) / (\sqrt{3} \times 22000)$
$I_2 = 4$ amp

Therefore CT's Ratio on 22000 V side = 4 : 8.66 1 Mark
In standard form, the CT ratio is $(4/\sqrt{3}) : (8.66/\sqrt{3})$ i.e 2.31: 5

4 c) Draw a neat sketch of single phasing preventer.
Ans:
Single phasing preventer:



Labeled Diagram 4 Marks

Partially labeled diagram 3 Marks

Unlabeled diagram 2 Marks

4 d) State the disadvantages of pilot wire protection.
Ans:
Disadvantages of pilot wire protection;

1. Accurate matching of current transformers is very essential.
2. If there is a break in the pilot –wire circuit, the system will not operate.
3. This system is very expensive owing to the greater length of pilot wire required.
4. In case of long lines charging current due to pilot-wire capacitance effects may be sufficient to cause relay operation even under normal condition.
5. This system cannot be used for line voltages beyond 33kV because of constructional difficulties in matching the current transformers.

1 Mark for each of any 4 points = 4 Marks

4 e) What is arcing ground phenomenon? How is it minimized?
Ans:
Arcing ground phenomenon:
During a line to ground fault on an underground system, till the fault is cleared there will be intermittent discharges to ground through the capacitance between the healthy phases and ground. This phenomenon is called arcing ground**.** 2 Marks

How to minimize Arcing Ground?
The surge voltage due to arcing ground can be removed by using the arc suppression coil or Peterson coil. The arc suppression coil has an iron cored tapped

reactor connected in neutral to ground connection**.** 2 Marks

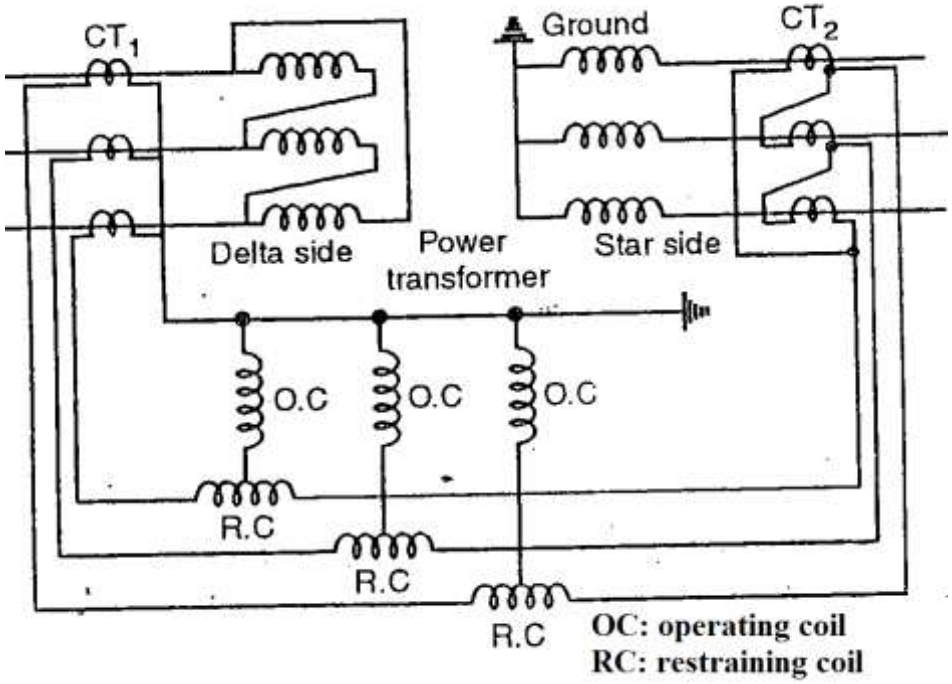
The reactor of the arc suppression coil extinguishes the arcing ground by neutralizing the capacitive current. The Peterson coil isolates the system, in which the healthy phases continue supplies power and avoid the complete shut down on the system till the fault was located and isolated.

5 a) Attempt any <u>THREE</u> of the following: 12

5 a) i) Draw neat sketch of percentage differential protection of a transformer.

Ans:

Percentage differential protection for transformers:



Correct CT location 2 Marks, OC location 1 Mark, RC location 1 Mark

(if the students draw any other type then accordingly the connection of CTs will be as follows:

Three phase transformers:

Delta side of protected transformer CTs to be in star,

Star side protected transformer CTs to be in delta.

Single phase transformers:

Only one CT on each side.

OR Equivalent Diagram

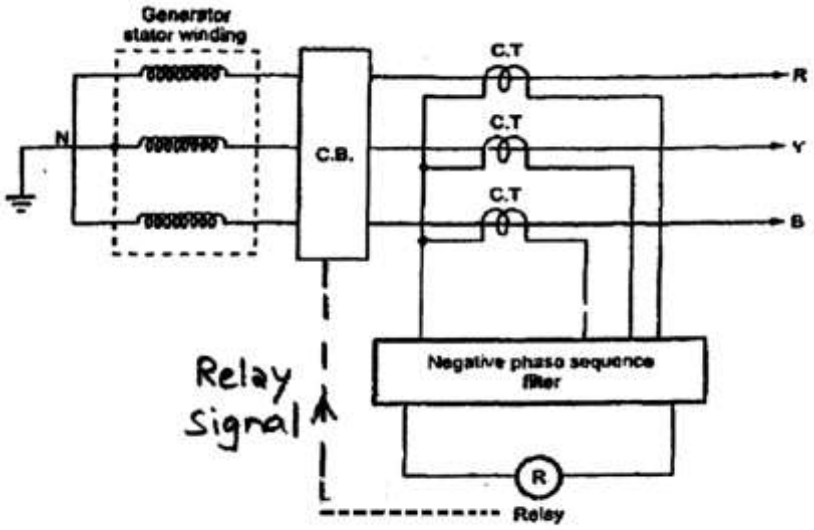
5 a) ii) Explain with neat sketch negative phase sequence protection of an alternator.

Ans:

Negative phase sequence current protection for alternators:

The CTs as shown in the diagram feed. The negative phase sequence filter that consists of resistors and inductors so arranged that under normal balanced load conditions the relay does not operate. Description 2 Marks

But when an appreciable unbalance occurs. The negative phase sequence currents sensed by the CTs and fed to the negative phase sequence filter result in sufficient current to operate the relay R that trips the circuit breaker CB.



Negative sequence protection

Figure
2 Marks.

5 a) iii) State the faults that occur on 3 phase induction motors.

Ans:

Faults that occur on 3 phase induction motors:

Squirrel cage induction motors:

A) Electrical / magnetic sections:

1) Electrical supply failure due to single phasing, under voltage, unbalanced voltages and reversal of phases.
2) Short circuit faults between turns of a stator coil due to failure of insulation.
3) Short circuit faults between stator coils due to failure of insulation.
4) Short circuit faults between stator coil/s and body of motor due to failure of insulation.
5) Open circuit in stator winding/coils or their terminal connections.
6) Loose or broken rotor bars.
7) Damaged core stampings/teeth.

Any eight
½ Mark
each
= 4 Marks

B) Mechanical section:

1) Unbalanced rotor.
2) Damaged bearings.
3) End play in shaft, bent shaft.
4) Cooling/ventilation system failures, damaged fan.
5) Failure/disturbances of alignment.
6) Foundation arrangement disturbed.

Slip ring induction motors:

A) Electrical / magnetic sections:

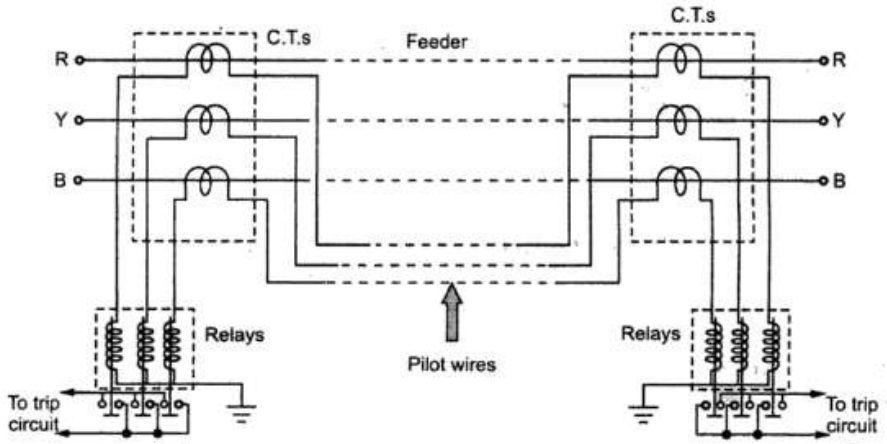
1) Electrical supply failure due to single phasing, under voltage, unbalanced voltages and reversal of phases.
2) Short circuit faults between turns of a coil on stator or rotor due to failure of insulation.
3) Short circuit faults between coils due to failure of insulation.
4) Short circuit faults between coil/s and body of motor due to failure of insulation.
5) Open circuit in stator or rotor winding/coils or their terminal connections.
6) Damaged core stampings/teeth of stator or rotor.

B) Mechanical section:

1) Unbalanced rotor.

2) Damaged bearings.
3) Grooved slip rings.
4) Worn out brushes leading to abnormal operation with sparking etc.
5) End play in shaft, bent shaft.
6) Cooling/ventilation system failures, damaged fan.
7) Failure/disturbances of alignment.
8) Foundation arrangement disturbed.

5 a) iv) Describe Merz-Price voltage balance protection scheme.
Ans:



Merz Price voltage balance protection scheme

Labeled figure 3 Marks, partially labeled 2 Marks, unlabeled 1 Mark (or other equivalent figure)

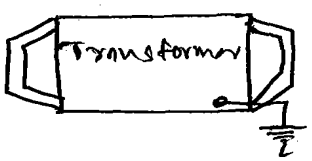
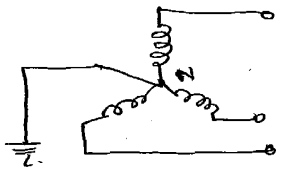
Under balanced (healthy) condition the voltages in the series connected CT secondaries add up to result in zero relay currents. But under abnormal/unbalance conditions (due to fault on the feeder) these voltages have a resultant that acts to circulate currents in the relay coils to operate the protection system.

Description 1 Mark

OR Equivalent diagram

5 b) Attempt any <u>ONE</u> of the following: 6

5 b) i) Give comparison between equipment earthing and neutral earthing.
Ans:

No	Equipment earthing	Neutral earthing
1		
2	When the non current carrying metallic part of the electrical equipment are connected to earth through a very resistance path it is called as equipment earthing.	When neutral of three phase star connected sides of transformers, generators, motors is connected to earth it is called as neutral earthing.
3	It provides protection to living beings (animals/humans) against electric shocks.	Provides elimination of arching grounds and over voltage surges.
4	Does affect stability of the power system in any way.	Stability of the power system is increased.
5	Equipment earthing is provided through Pipe earthing, Plate earthing	Neutral earthing is provided through solid earthing, Resistance earthing,

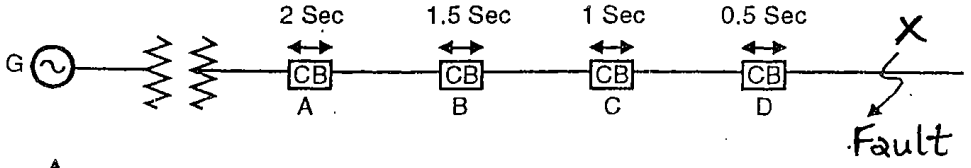
1 Mark each point = 6 Marks.

	or earth mats etc.	reactance earthing.
6	It does not provide any means for protection of the system against earth faults	It provides suitable means for earth fault protection of equipment.

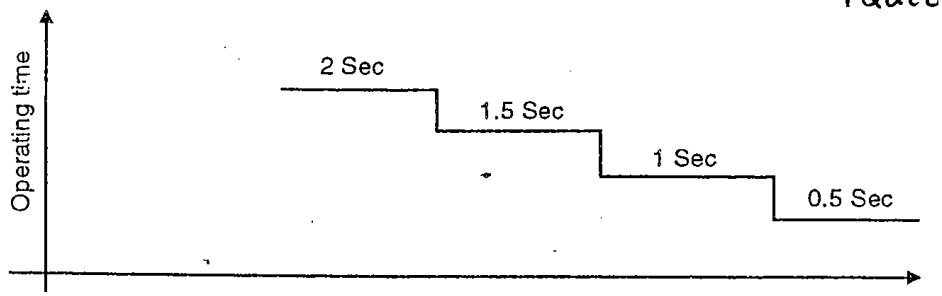
5 b) ii) Explain time graded over current protection of transmission line.

Ans:

Time graded over current protection transmission line:
(using definite time relay)



2 Marks



2 Marks

- Time of operation of relay depends upon its location with respect to supply feed end and the fault.
- Relay located near to the supply feed end are set to operate with time delays if the ones more nearer to fault location fail to operate.
- As seen in the diagram fault at 'X' should result in operation of relay D (CB). In case of failure of 'D' to operate in time 0.5sec) then relay C (CB) should operate. Thus the relays are successively time graded to operate if the one having time setting just lesser than it fails to operate. 2 Marks

Thus operation of relay with higher time will be a back up protection for the one just lesser than it.

OR Equivalent

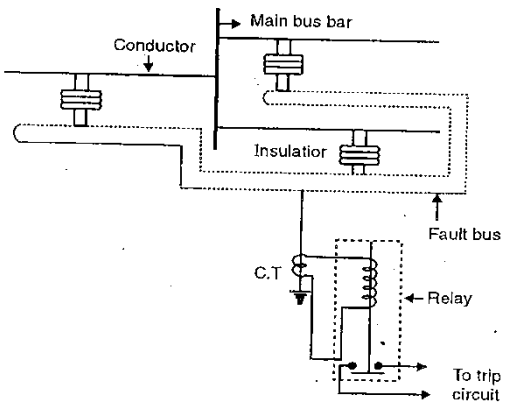
6 Attempt any <u>FOUR</u> of the following: 16

6 a) Describe the 'fault bus protection scheme' of the bus-bar.

Ans:

Fault bus protection scheme: 2 Marks for description

- Each phase bus is surrounded by an earthed metal mesh or structure – (called as fault bus)
- Hence the bus-bar fault will never be an inter-phase one.
- The earth path current is sensed by the CT and if it is above the relay setting value the relay trips the concerned circuit breaker indicating bus bar fault.



2 Marks for schematic diagram

6 b) How will you provide protection to motor against short circuit?

Ans:

SC protection:

Up to 150 kW HRC fuses in each power line. 1 Mark

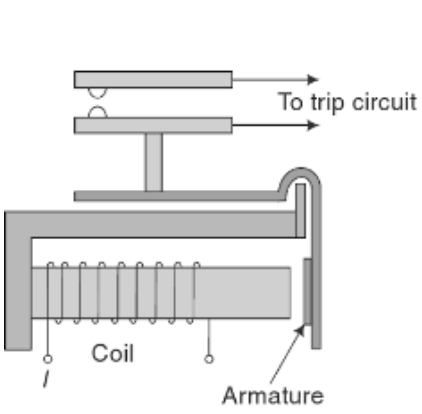
Above 150 kW circuit breakers are used with proper settings/characteristics; that is inverse/extremely inverse characteristics. 1 Mark

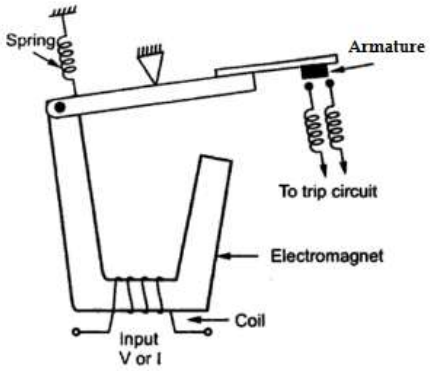
The short circuit element (fuse or CB as the case may be) provides protection for excessively high overcurrent faults.

- Phase-to-phase and phase-to-ground faults are common types of short circuits
- When a motor starts, the starting current (which is typically seven times the Full Load Current) has asymmetrical components. These asymmetrical currents may cause one phase to see as much as 1.7 times the RMS starting current. 1 Mark
- To avoid nuisance tripping during starting, the short circuit protection pick up value must be at least 1.7 times the maximum expected symmetrical starting current of motor. 1 Mark
- The breaker or contactor must have an interrupting capacity equal to or greater than the maximum fault current (or maximum fault VA).

6 c) Write working of attracted armature type relay with neat diagram.

Ans:





Hinged attracted armature relay

Any relevant diagram labeled 2 Marks, unlabeled 1 Mark

Working of attracted armature type relay:

The coil is energized by the actuating quantity current or voltage proportional to the system voltage or current as the case may be. The electromagnetic force on the armature is proportional to the square of the magnetic flux (the flux is proportional to the current in the coil) in the air gap between core and armature. As the armature is attracted its motion is linked to the trip contacts that operate to give the trip signal. The force of attraction increases as the armature nears the core (or as the air gap reduces). A restraining force in the form of a spring can be used to avoid unwanted operation of the armature relay for normal currents in the current coil.

Description 2 Marks

6 d) Explain low resistance arc extinction method in circuit breakers. State its limitations.

Ans:

Low arc resistance or current zero method of arc extinction:

Used only in AC circuit breakers. All modern high power CBs use this method.

The resistance of the arc is kept to a very low value till the alternating fault current passes through zero value when the arc is naturally extinguished and is prevented from restriking though there may rising voltage across the CB contacts. This is achieved by buildup of the dielectric strength of the medium between the contacts at a rate greater than the rise of the restriking voltage. the buildup can be achieved by following: 2 Marks

1) Causing the ionized particles in the gap to recombine to form neutral molecules.
2) Sweeping the ionized particles away and replacing them with unionized particles.
3) Maintaining sufficiently large gap between the contacts.
4) Creating high pressure around the arc resulting in the higher rate of deionization.

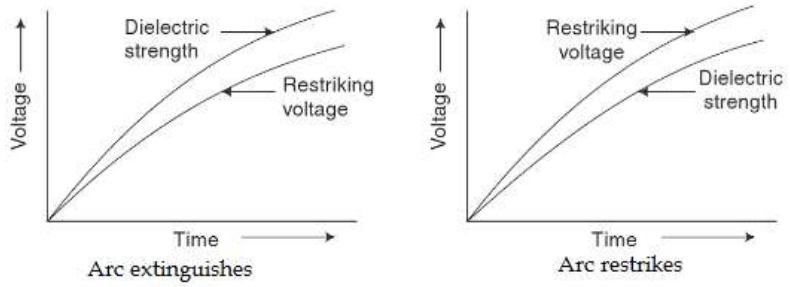


Diagram 1 Mark

Limitations:

- The arc might not be extinguished at the first current zero and will restrike as the voltage rises. Hence the point (time) of extinction cannot be very exactly predefined. 1 Mark
- Failure of providing the buildup of the dielectric strength leads to restriking of the arc again.

Design of the arc control/interruption chamber for proper arc extinction is critical (in respect of dielectric fluid flow etc.)

6 e) State the types of lightning arrestors. Explain the working of any one type.

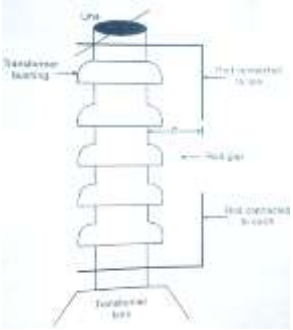
Ans:

Types of lightning arrestors: 1 Mark

i) Rod gap
ii) Horn gap
iii) Expulsion
iv) Thyrite or valve type.

i) Rod gap type:

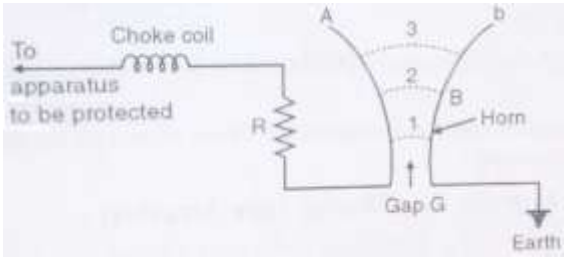
Gap breaks down under over voltages and conducts the excess over voltage charge to earth.



Any one diagram 2 Marks and its description 1 Mark

ii) Horn gap arrestor:

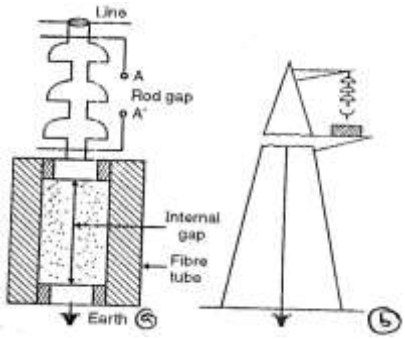
Choke coil has low reactance to normal line frequency but high for over voltages due to their high frequency (transients) and hence the over voltage is discharged to earth through horn gap. The resistance limits the fault current to small value.



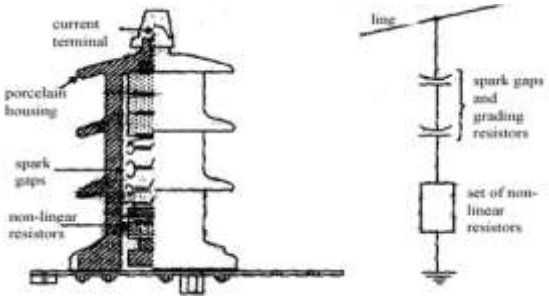
iii) Expulsion type:

On a voltage surge sparking occurs across gap AA' and arc is also struck across electrodes in tube.

Heat of arc vaporises some fibre of tube walls to produce neutral gas that builds up pressure to get expelled through hollow lower electrode. The gas also carries ionised air around the arc thus deionising the arc and quenching it and not allowing it to restrike.



iv) Thyrite type lightning arrestor : -



Working :-

When the line voltage is normal the air gap assembly does not break down.

When a lighting stroke occurs the series spark gap breaks down providing the earth path for the surge current through the nonlinear resistors, which offer a low resistance to surge current and again regain back high value after the surge gets conducted to earth

6 f) State various causes of over voltages in the electrical systems.

Ans:

Causes of over voltages in electrical systems:

Causes external to system.

Lightning strokes during strong or rainy weather. These can be so high that the magnitudes of voltage waves created can be in the range of 800 kV to 1500kV. — 1 Mark

Causes internal to system.

- Switching surges occur when switching operations of circuit breakers are carried out especially under abnormal conditions.
- Switching an unloaded line sets up travelling waves that on reflection create a doubling effect to produce an instantaneous max voltage of $2\sqrt{2}$ E where 'E' is the rms (line voltage) value. Similar effect is obtained when an unloaded line is switched off.
- Resonance in power systems: line capacitance and system inductance resonate.
- Interrupting currents before their natural zero leads to charges on lines and components.
- Arcing grounds.
- Insulation failures.

Five causes = 3 Marks, 4 causes = 2 Marks, two to three causes = 1 Mark, 1 cause ½ Mark.