Model Answers

Winter – 2019 Examination

Subject &Code: Switchgear And Protection (17508)

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.

Model Answers
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1 a) **Attempt any <u>THREE</u> of the following:** **12**

1 a) (i) State any two advantages of current limiting reactor, using single line diagram show the placement of reactor in power system.

Ans:

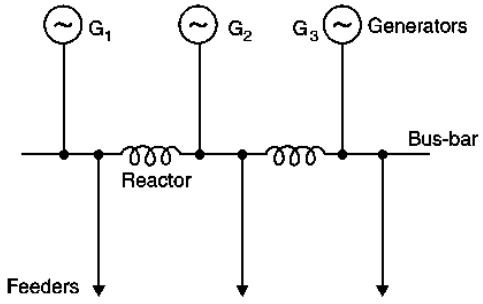
Advantages of Current Limiting Reactor:

1) Reduction of electromechanical loading and thermal stress of transformers and switchgears.
2) Improvement of the stability of primary bus voltage during a fault on feeder.
3) Reduction of line to line fault current to levels below those of line to ground faults or vice versa.
4) Protection of distribution transformer, power equipment and devices from the voltage transients.
5) Increase in system reliability.
6) As fault current/short circuit current is controlled suitable small capacity circuit breaker can be used safely.
7) Introduction of reactor in the system ensure continuity of supply as troubles are isolated.
8) Current limiting reactor reduces the magnitude of voltage disturbances which is caused by short circuits.
9) It limits the fault current to flow into the healthy feeders or parts of the system, thereby avoiding the fault from spreading.

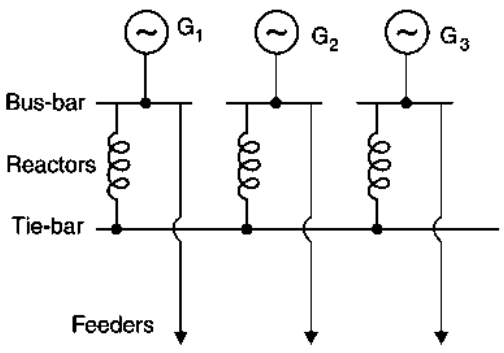
1 Mark for each of any two advantages = 2 Marks

Single Line Diagram of Current Limiting Reactor Showing the Placement of Reactor in Power System:

1)Bus Bar Reactor:



Ring system

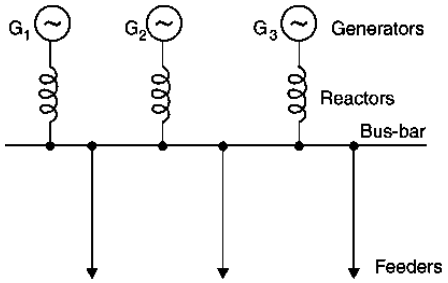


Tie - Bar system

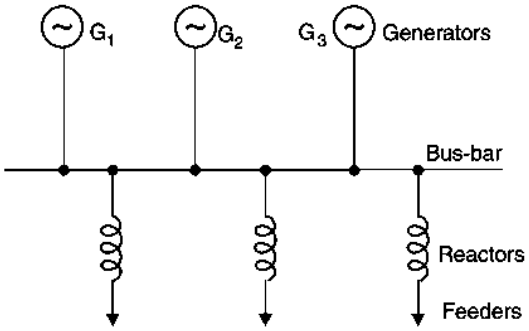
½ Mark for each diagram

= 2 Marks

2)Generator Reactor:



3)Feeder Reactor:



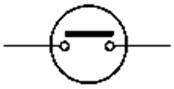
1 a) (ii) State functions with their symbols:

1) Circuit Breaker
2) Lighting arrester
3) Earthing switch
4) Current transformer

Ans:

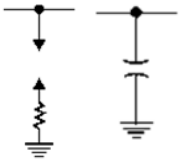
1) Circuit Breaker:

To make or break a circuit manually or remotely under normal condition and to break circuit automatically under fault condition.



2)Lighting Arrester:

To divert the high voltage surges towards the earth,due to lightning or switching.



1 Mark for each function and symbol = 4 Marks

3) Earthing Switch:

To discharge voltage on the line (due to charges of line capacitance) to earth after disconnecting line from live section.

4) Current Transformer:

To step down the magnitude of line current for measurement, protection and control.

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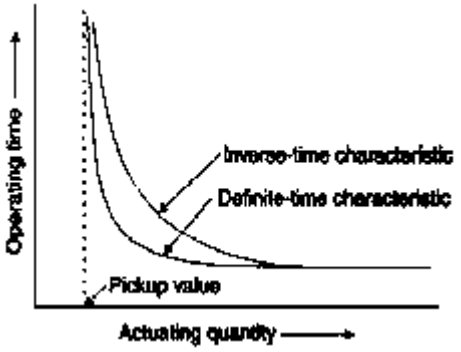
OR Equivalent Answer

1 a) (iii) Describe the difference between definite characteristics and inverse characteristics of relays.

Ans:

Difference Between Definite Characteristics and Inverse Characteristics of Relays:



2 Marks for diagram

The difference between the definite and inverse characteristics in respect of relay is that the Definite time relays operate after a predetermined time when the current exceeds the pickup value irrespective of the current magnitude. Whereas the Inverse time relays operate in similar manner but the operating time depends on the current magnitude. Higher the magnitude lower will be the operating time.

2 Marks for Explanation

1 a) (iv) State Basic Insulation Level (BIL). Explain its significance w.r.t. insulation co-ordination of power system.

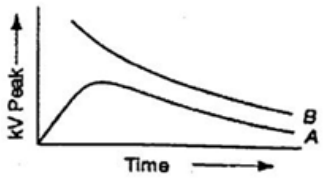
Ans:

Basic Insulation Level(BIL):

Basic impulse insulation level (BIL) is the reference level expressed in impulse crest voltage with a standard wave not longer than a 1.2/50μsec wave according to IS.

1 Mark

Significance of BIL in Insulation coordination:



Insulation coordination is the co-relation of the insulation of electric equipment and lines with the characteristics of protective devices such that the insulation of the whole power system is protected from excessive over voltages. In order to protect the equipment of power system from over-voltages of very high magnitude, it is necessary to fix an insulation level for the system to see that any insulation in the system does not breakdown or flash over below BIL.

Curve A is volt time curve of protective device and curve B is that of equipment (apparatus) to be protected.

3 Marks for explanation

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

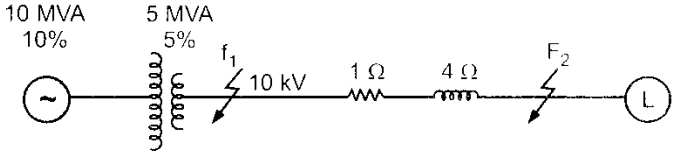
1 b) (i) A3 phase transmission line operating at 10kv and having a resistance of 1 ohm and reactance of 4 ohm is connected to the generating station bus bars through 5 MVA step-up transformer having a reactance of 5%. The bus-bars are supplied by a 10 MVA alternator having 10% reactance. Calculate the short circuit kVA fed to symmetrical fault between phases if it occurs

1) At the load end of transmission line,

2) At the high voltage terminals of the transformer.

Ans:

Figure 1 shows the single line diagram of the network. Let 10,000 kVA be the base kVA.



1 Mark

Figure-1

% Reactance of alternator on base kVA,

$$\% X_A = \frac{Base\ kVA}{Rated\ kVA} \times \%\ reactance\ at\ rated\ kVA$$

$$\% X_A = \frac{10000}{10 \times 10^3} \times 10 = 10\%$$

% Reactance of transformer at base kVA,

$$\%X_T = \frac{10000}{5 \times 10^3} \times 5 = 10\%$$

The line impedance is given in ohms. It can be converted into percentage impedance by using expression.

% reactance of transmission line is

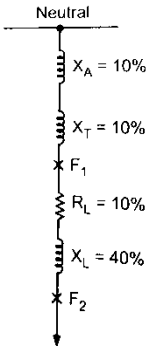
$$\% X_L = \frac{(kVA) \times reactance\ in\ \Omega}{10 \times (kV)^2}$$

$$= \frac{10000 \times 4}{10 \times (10)^2} = 40\%$$

1 Mark

% Resistance of transmission line,

$$\% R_L = \frac{10000 \times 1}{10 \times (10)^2} = 10\%$$



1 Mark

Figure-2

The reactance diagram of the network on the selected base kVA is shown in Fig.2 For a fault at the end of a transmission line (point F2),

Total % reactance = $\%X_A + \% X_T + \%X_L$

$= 10 + 10 + 40 = 60\%$

% resistance = 10%

∴ % Impedance from generator neutral upto fault point F2

$$\% Z = \sqrt{(60)^2 + (10)^2} = 60{\cdot}83\%$$

1 Mark

∴ Short-circuit kVA = 10,000 × 100/60·83

= **16,440kVA**

1 Mark

(i) For a fault at the high voltage terminals of the transformer (point F1),

Total % Reactance from generator neutral upto fault point F1

$= \% X_A + \% X_T = 10 + 10 = 20\%$

$\therefore$ Short-circuit kVA = 10,000 × 100/20

= 50,000 kVA 1 Mark

1b) (ii) A 3 phase 66/11 kV star-delta connected transformer is protected by Merz-Price protection scheme. The CT's on the LT side have a ratio of 400/5 A. Find the ratios of CT's on the HT side. Also draw a neat connection diagram of the complete scheme.

Ans:

The CTs on LV side are connected in star as transformer windings are in delta. Whereas those on HV side are in delta as the transformer windings are in star on that side.

Assume CT line current on LV side to be 5 A and then that on HV side will also be 5 A. But HV side CTs are in delta. Hence the HV side CT current will be

(CT line current)/√3 = 5/√3 A. 1 Mark

Assume line current (for convenience) of 400 A on LV side (delta side) of transformer. When transformed to HV side the line current will be I_{Lht} given by

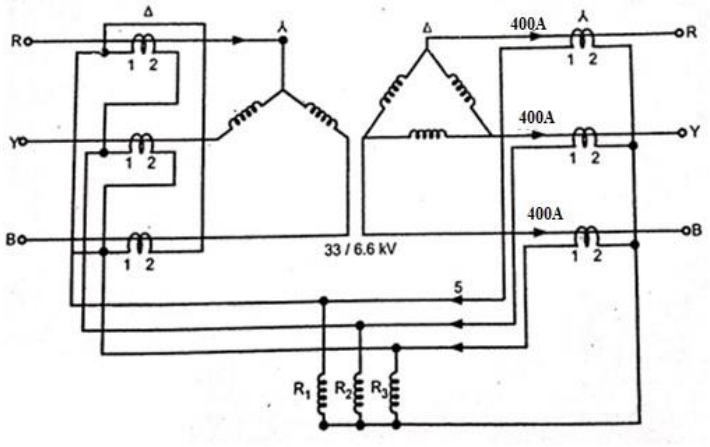
$\sqrt{3} \times 66 \times I_{Lht} = \sqrt{3} \times 11 \times 400$

$I_{Lht} = (11/66)x(400) = 66.67$ A. 1 Mark

On HV side the CT primary current is 66.67 A and CT secondary current is 5/√3 A, hence the CT ratio is 66.67/(5/√3) = (66.67√3/5) = 115.47/5. 1 Mark

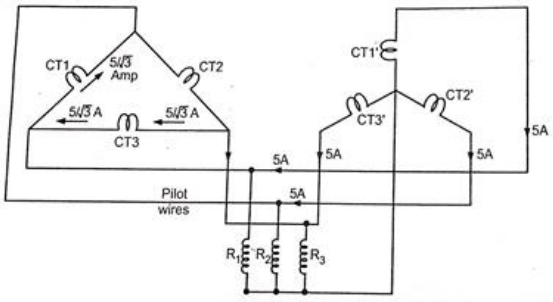
Connection Diagram of the Complete Scheme:

Suppose current flowing in secondary side of transformer is 400 amp. This current is primary current for the CT's connected to delta side of transformer. The secondary current of the CT will be 5 amp, since CT ratio is 400/5 A.



1.5 Mark

The secondary connection of CT,s are as: 1.5 Mark



CT secondary connections

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

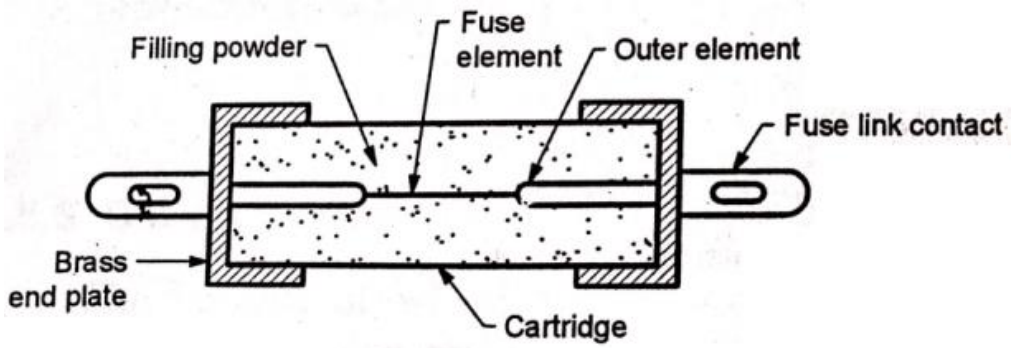
2a) With a neat sketch, explain the construction and working of HRC fuse.

Ans:

Construction of HRC Fuse:

HRC fuse mainly consists of heat resisting ceramic body. The fuse elements are fitted inside the body. The ends of fuse elements are connected to the metal end caps. The current carrying fuse element is compactly surrounded by the filling powder. Filling material acts as an arc quenching and cooling medium when the fuse element blows off due to excessive heat generated under abnormal conditions.

1 Mark for construction



H.R.C. fuse

2 Marks for diagram

Working:

Under normal conditions, the fuse element is at a temperature below its melting point. Therefore, it carries the normal current without overheating.

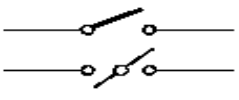
When a fault occurs, the current increases and the heat produced is sufficient to melt these elements. Fuse element melts before the fault current reaches its first peak value. Vaporized metal /fuse element chemically reacts with filling powder and results in the formation of high resistance substance that helps in quenching the arc.

1 Mark for working

2b) Differentiate between isolator and circuit breaker (any four point).

Ans:

Difference Between Circuit Breaker and Isolator:

Sr.No.	**Isolator**	**Circuit breaker**
1	Symbol 	Symbol 

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

1 Mark for each of any four points = 4 Marks

2 c) State the precautions while using C.T with justification.

Ans:

Safety Precautions while using C.T:

1) CT secondary terminals should never be kept open. CTs must be energized only after connecting the burden across them. If it is left open then current through its secondary becomes zero hence the ampere turns produced by secondary becomes zero. As there is no counter m.m.f., unopposed primary m.m.f. produces high flux in the core which produces excessive core losses and heating the core beyond the limits. Similarly heavy e.m.f. will induced on primary and secondary which may damage insulation of primary and secondary winding. This is also very dangerous from the operator point of view.
2) PT secondary should never be shorted as they are designed for high impedance burdens (extremely low currents).
3) To be used as per the specified rating of voltage, current & burdens only. The burdens should never be exceeded when multiple ones are connected across one instrument transformer. As they are designed to give the highest accuracy at the rated burdens only, else for lower and slightly higher burdens, ratio & phase angle errors are present and compensation is needed.
4) CTs for measurement must not be interchanged with those for protection and

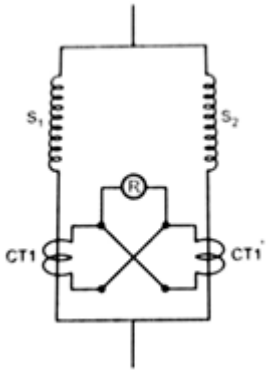
Each point 1 Mark (any four points) = 4 Marks

vice versa as there is difference in design of measurement CTs and protection CTs. The protection CTs has to carry heavy fault current for some duration of time whereas measurement CTs has to carry only current upto rated value only.

2 d) With the neat sketch describe protection scheme of an alternator against inter-turn faults.

Ans:

Inter-turn Fault Protection:



2 marks for Diagram

Figure shows scheme for one phase only. It is identical for other three phases. Under normal working condition, the two currents in the stator winding sections (S_1 and S_2) are identical and by virtue of the cross connected CT secondary the current flowing through relay is zero, hence no relay operation. But when one of the windings is faulty (inter turn fault) its current differs and hence the two CT secondary currents are different, due which the difference current is diverted through the relay coil to operate it, leading to isolation of the alternator from the power system.

2 Marks for description

2 e) State the meaning of the term resistance earthing. List its any three advantages.

Ans:

Meaning of the Term Resistance Earthing:

When the neutral point of a 3-phase system (e.g. 3-phase generator, 3-phase transformer etc.) is connected to earth through a resistor, it is called resistance earthing.

1 Mark

Advantages Resistance Earthing:

1) By adjusting the value of R, the arcing grounds can be minimized.
2) The earth fault current is small due to the presence of earthing resistance; therefore, interference with communication circuits is reduced.
3) It improves the stability of the system.
4) It permits the use of discriminative protective gear.

1 Mark for each = 3 Marks

2 f) State different causes of over voltages in an electrical power system.

Ans:

Internal Causes of System Over-voltages:

1) Switching surges
2) Arcing ground
3) Insulation failures
4) Resonance

2 Marks

External Causes of System Over-voltages:

1) Direct Lightning strokes

2) Lightning discharge near the line
3) Voltage induced due to change in atmospheric condition
4) Voltage induced due to frictional effects of small particles such as dirt, dust, snow etc.

2 Marks

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

3a) Define the following terms.
(i) Arc voltage
(ii) Recovery voltage
(iii) Restriking voltage
(iv) RRRV

Ans:

i) Arc Voltage: The voltage that appears across the contacts of circuit breaker during the arcing period is called as the arc voltage.

ii) Recovery voltage: The normal power frequency r.m.s voltage that appears across the contacts after the final arc extinction is called recovery voltage.

iii) Restriking voltage: The transient voltage that appears across the contacts of the circuit breaker at or near the current zero during the arcing period is called as the restriking voltage.

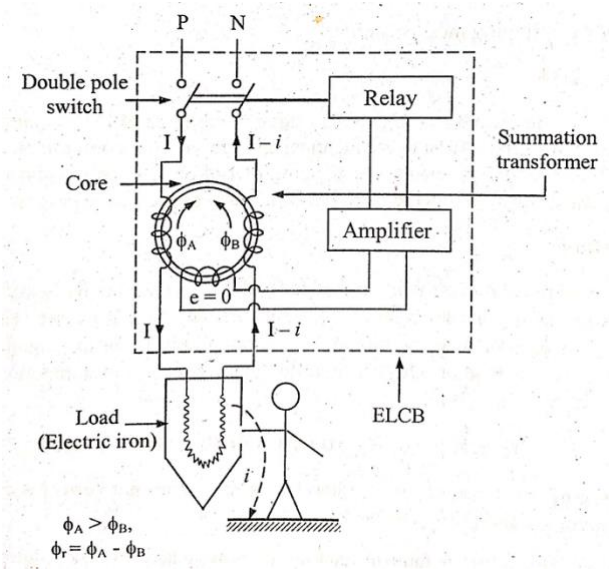
iv) RRRV: The RRRV (**R**ate of **R**ise of the **R**estriking**V**oltage) is defined as the slope of the steepest tangent to the restriking voltage curve. It is expressed in volts per micro-second.

1 Mark for each = 4 Marks

3b) Justify the statement 'ELCB' is must for a residential installation.

Ans:

ELCB is must for a Residential Installation:



2 Marks for Diagram

When the insulation of equipment fails and person touches the metal casing, the leakage current (say i) flows through human body and he may receive severe shock. However, if ELCB is used with residential installation, it senses the fault current (leakage current) and operates in very short time under such conditions and the current flowing through the body of person / operator is interrupted. Thus the person is protected from getting electric shock.

Referring to the figure, under normal condition, the phase current I flow through circuit and same amount of current I return through circuit hence relay does not

2 Marks for Explanation

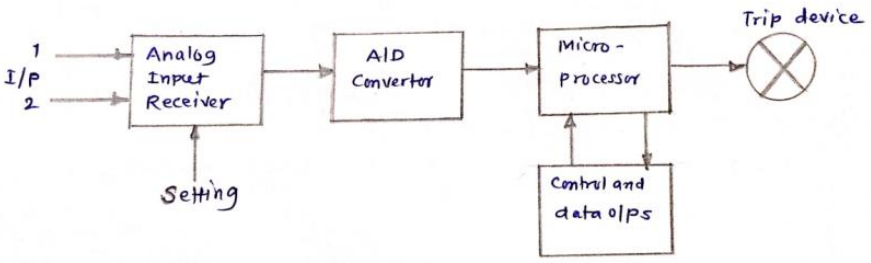
operate. But when fault occurs, a small part of I say i completes its path through fault, human being and earth. The return current through neutral gets reduced to (I - i).Therefore, flux ϕ_B reduces to a value less than the flux ϕ_A. Hence the resultant flux $\phi_r = (\phi_A - \phi_B)$ induces an emf, which is further amplified and operates relay circuit within 50ms, resulting into opening of the mains and ultimately protects the person / operator because of ELCB. So it is must for a residential installation.

OR Equivalent Answer

3c) Describe microprocessor based relay with the help of block diagram.

Ans:

Operation of Microprocessor Based Relay:



2 Marks for diagram

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

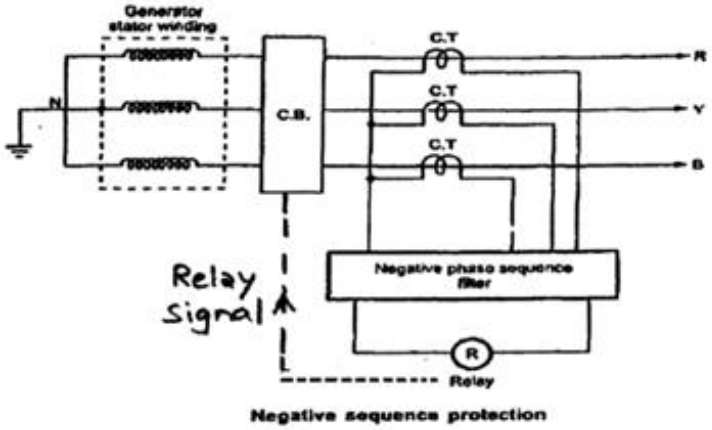
2 Marks for Operation

OR Equivalent Diagram and Description

3d) Explain negative phase sequence protection of alternator.

Ans:

Negative Phase Sequence Current Protection for Alternators:



Negative sequence protection

2 Marks for diagram

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.

2 Marks for

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

3 e) State three protective devices used for the protection of alternator against:
(i) Over voltage
(ii) Over speed
(iii) Motoring
(iv) Rotor over heating

Ans:

Protective Devices Used for the Protection of Alternator:

Fault	Protecting Devices
i) Over voltage	(i) Lightning arrester (ii) Voltage regulators (iii) Surge diverters
ii) Over Speed	(i) Mechanical centrifugal device (ii) Over frequency relay (iii) Over speed relay
iii) Motoring	(i) Reverse Power relay
iv) Rotor overheating	(i) Thermal relays (ii) Temperature relays (Sound Alarm) (iii) Negative sequence relay

1 mark for each protection =4 Marks

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

4 a) i) State four advantages of SF_6 Circuit breaker over other types of CB's.

Ans:

Advantages of SF_6 Circuit Breaker over other types of CB's:

1) Due to superior arc quenching property, they have very short arcing time.
2) As SF_6 gas is non-inflammable, no risk of fire.
3) Noiseless operation.
4) It does not pollute the atmosphere.
5) Very much suitable in coal mines etc.
6) They have minimum maintenance cost.
7) The same gas is recycled and reused.
8) There are no carbon deposits on contact tips.
9) It is very much suitable for high voltage applications.
10) Because of very high dielectric strength, effective arc quenching is possible.

1 Mark for each of any four advantages = 4 Marks

4 a) ii) Draw and explain basic relay circuit.

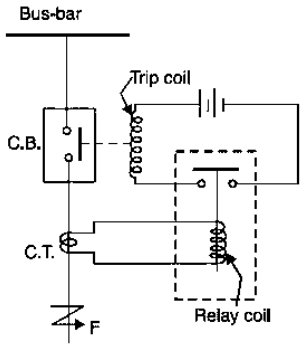
Ans:

Basic Relay Circuit:

A typical basic relay circuit is shown in Figure. This diagram shows one phase of 3-phase system for simplicity. The relay circuit connections can be divided into three parts.

1) First part is the primary winding of a current transformer (C.T.) which is connected in series with the line to be protected.
2) Second part consists of secondary winding of C.T. and relay operating coil.
3) Third part is the tripping circuit which may be either a.c. or d.c. It consists of

a source of supply, the trip coil of the circuit breaker and the relay stationary contacts.



2 Marks for diagram

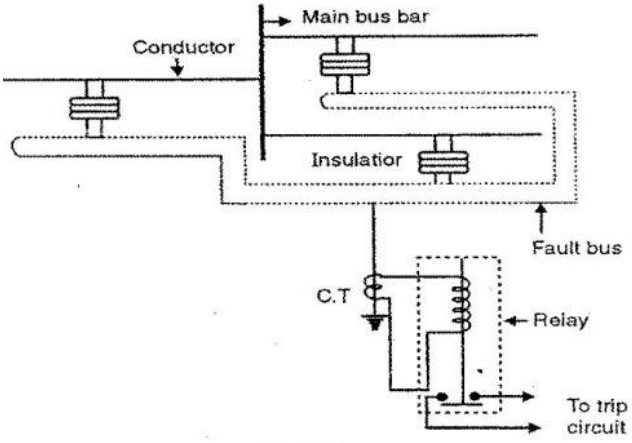
When a short circuit occurs at point F on the transmission line, the current flowing in the line increases to an enormous value. This results in a heavy current flow through the relay coil, causing the relay to operate by closing its contacts. This in turn closes the trip circuit of the breaker, making the circuit breaker open and isolating the faulty section from the rest of the system.

2 Marks for explanation

4 a) iii) Describe fault bus protection of busbars, with neat labeled diagram.

Ans:

Fault Bus Protection of bus-bar:



Fault bus protection

2 Marks for diagram

In this scheme, the substation is so designed that every fault on the bus bar is converted to earth fault. Under normal operating conditions, there is no current flowing through the fault bus to ground and the relay remains inoperative. When any fault occurs on bus-bar involving a connection between conductor and earthed support structure, it will cause a flow of current to earth through the fault bus. This results in operation of relay to actuate trip coil of CB to trip the circuit.

2 Marks for explanation

4 a) iv) State any four types of lighting arresters with their particular application.

Ans:

Types of Lightning Arrestors:

1) Rod gap lightning arrestor
2) Horn gap lightning arrestor

Any 4 types

3) Multi gap lightning arrestor
4) Expulsion lightning arrestor
5) Thyrite or valve lightning arrestor
6) ZnO lightning arrestor

= 2 Marks

Applications of Lightning Arrestors:

1) **Rod Gap Lightning Arrestor:** It is only used for back-up protection in case of main arresters.
2) **Horn Gap Lightning Arrestor:** It is only used for a second line of defense like a rod gap arrester.
3) **Multi Gap Lightning Arrestor:** These are used where system voltage does not exceed 33kV.
4) **Expulsion Lightning Arrestor:** These are commonly used on system operating at voltages up to 33kV.
5) **Thyrite or Valve Lightning Arrestor:** These are commonly used on system operating at voltages up to and above 220kV.
6) **ZnO Lightning Arrestor:** These are mainly used for surge protection.

Any 2 points = 2 Marks

4 b) **Attempt any <u>ONE</u> of the following.** **6**

4 b) i) Enlist the faults and normal abnormalities observed in induction motor. Explain working of single phase preventer with diagram.

Ans:

Different Causes of Abnormalities and Faults in Induction Motor:

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.

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.

Each abnormality 1 Mark (any two) = 2 Marks

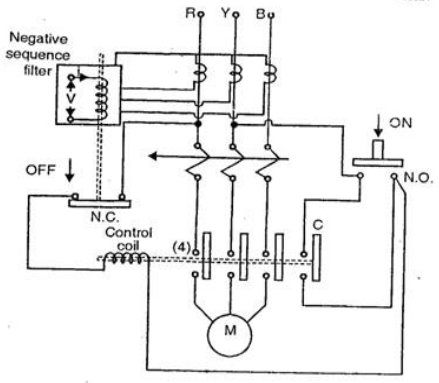
Slip Ring Induction Motors:

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.

Working of Single Phasing Preventer:



2 Marks for Diagram

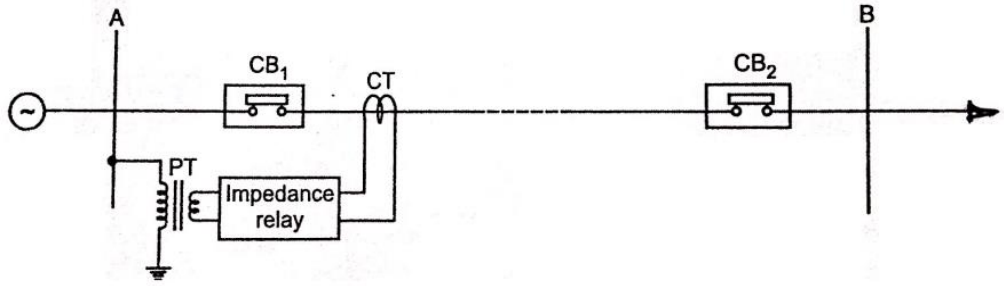
Single phasing preventers are connected in secondary of line CTs. These mainly contain a negative sequence filter. The output of negative sequence filter is fed to the level detector, which further sends tripping command to starter or CB. When one of the three input lines get disconnected because of any reason, ultimately the NC contact gets opened which stops the motor to avoid further damage when single phasing occurs.

2 Marks for working

4 b) ii) State and explain with diagram the principle of distance protection. What are the advantages of distance protection over other types of protection of feeders.

Ans:

Distance Protection Scheme for Transmission Line:



Distance protection scheme for typical transmission line

2 Marks for Diagram

Impedance or distance protection scheme uses impedance relay. The relay

operation is based on the impedance (or distance) between the relay and point of fault. Figure shows arrangement for distance protection for typical transmission line. — 2 Marks for explanation

The voltage element of impedance relay receives supply from PT secondary and current element receives supply from CT secondary. It measures Impedance at relay location (Z = V / I) The protection zone of line is between A and B. Under normal working conditions, the impedance of line is Z_L. The impedance relay is so designed that, it operates only when line impedance becomes less than Z_L.

When fault occurs between points A & B, the impedance of line becomes less than Z_L and impedance relay operates which operates the CB and line is protected.

Advantages of Distance Protection:

1) System is economical
2) High speed of interruption
3) Suitable for very long and high voltage transmission lines.
4) No problem of pilot wires.

— 2 Marks any two advantages

5 **Attempt any <u>FOUR</u> of the following** — **16**

5a) State the criteria to select MCCB and circuit breaker rating for motor.

Ans:

Factors to be Considered While Selecting MCCB / Circuit breaker for Motor Operation:

1) Specifications of motor (Rated voltage & HP capacity)
2) Type of motor.
3) Type of load and nature of duty.
4) Cost of motor and driven equipment.
5) Starting currents & Permissible overloads
6) Cost of protection schemes.
7) Breaking time.
8) Ambient conditions where motor is working.
9) Capacity of C.B (Making capacity / Breaking capacity /Short time rating)
10) Rating of MCCB
11) Whether 3 Phase or single phase.

— 4 Marks for any four points

5b) Explain arc formation process and state the various methods of arc extinction.

Ans:

Arc Formation Process:

When a fault occurs, a large current flows in a system and hence through circuit breaker connected in circuit. The circuit breaker is opened by protective system. At the instant when contacts just begin to separate, the face-to-face contact area between contacts reduces rapidly and the large fault current gets concentrated on reduced contact area. This causes very large current density at reduced contact area, which in turn rises temperature of contacts. With further movement of contact, the area again reduces, giving higher current densities and higher temperature rise. The heat produced due to very high temperature heats the surrounding medium and ionizes the medium. This ionized medium act as a conductor and establishes the current through separated contacts. This current through media due to ionization is called arc. — 3 Marks

Methods of Arc Extinction:

1) High resistance extinction method
2) Low resistance or Zero current extinction method.

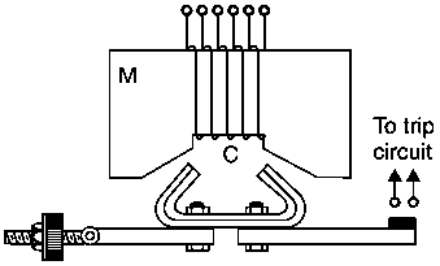
1 Mark

5c) Classify electromagnetic attraction armature relays with only basic constructional diagrams.

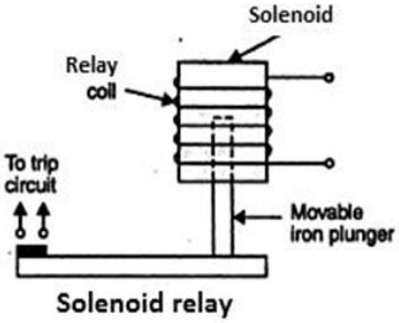
Ans:

Classification of Electromagnetic Attraction Armature Relays with only basic constructional diagrams:

1) Attracted Armature Type Relay:

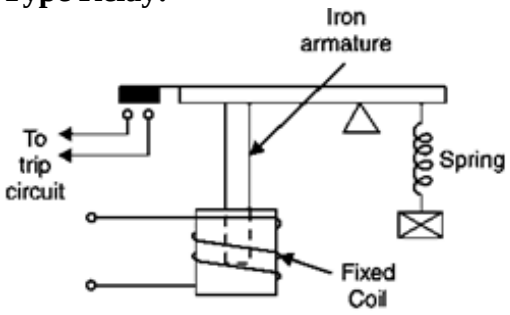


2) Solenoid Type Relay:



4 Marks

3) Balanced Beam Type Relay:

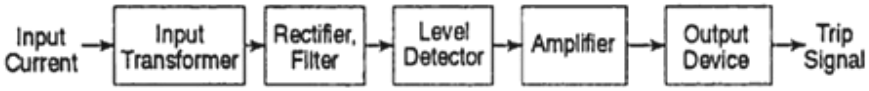


5d) Explain the operation of static overcurrent relay with block diagram and time current characteristics.

Ans:

Static Over Current Relay:

1 Mark

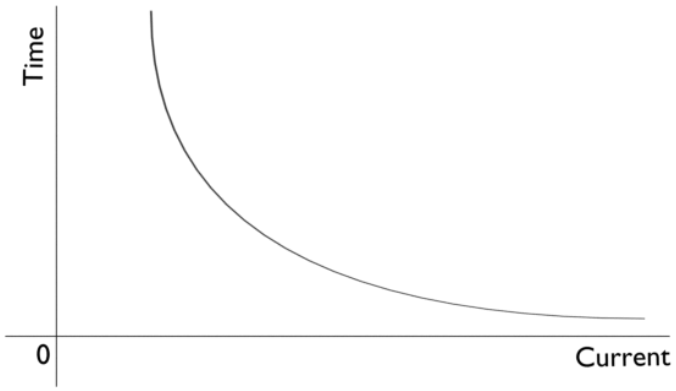


The current derived from the main CT is feed to the input transformer, which gives a proportional output voltage. The output voltage is then rectified and then filtered at a single stage to avoid undesirable time delay in filtering so as to excurse high speed of operation. A zener diode is also incorporated in the circuit to limit the rectified voltage to safe value even when the input current is very high under fault conditions.

1 Mark

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

Time Current Characteristics of Static Overcurrent Relay:



1 Mark

1 Mark

The AC current derived from C.T may contain harmonics , spikes etc. Hence filters and spike suppressors are provided in the inpute stage (level detector) of static relay. From the characteristics it should be understood that for more current less time for operation is taken by the static relay.

5e) State and explain quality requirement of relay with any four points.

Ans:

Quality Requirements of Relay:

1) **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.
2) **Speed:** The relay system should disconnect the faulty section as fast as possible to prevent the electrical apparatus from damage and for system stability.
3) **Sensitivity:** It is the ability of the relay system to operate with low value of actuating quantity.
4) **Reliability:** It is the ability of the relay system to operate under predetermined conditions.
5) **Simplicity:** The relay system should be simple so that it can be easily maintained.
6) **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

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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.

5f) State the significance of directional relay. State the type of relay as a directional relay with its working.

Ans:

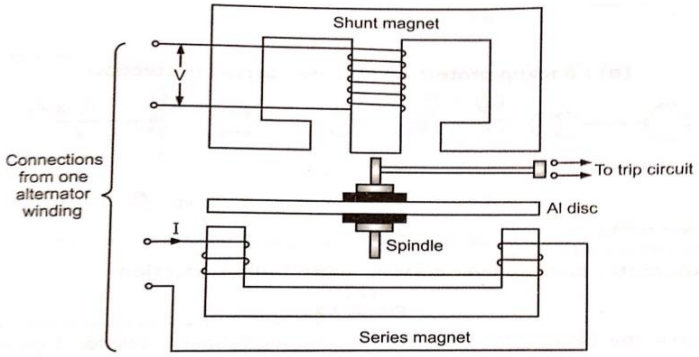
Significance of Directional Relay:

The directional operation of relay means that the relay operates only for a certain direction of power. It is set such that it actuates for fault occurring in one direction only or it does not allow the power to flow in revers direction. 1 Mark

Type of Relay as a Directional Relay:

Induction type reverse power relay. 1 Mark

Working of Induction Type Reverse Power Relay:



1 Mark

Figure shows the induction type directional relay used for the reverse power protection. Here the shunt magnet coil and series magnet coil are exited from machine to whom protection is to be provided (e.g. Alternator). When power flow direction is correct, the disc rotates in the normal direction and does not close trip contacts. But when the power flow reverses, the disc rotates in opposite direction causing closure of trip contacts. 1 Mark

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

6a) Determine the time operation of a 1 A, 3 seconds overcurrent relay having Plug setting of 125% and Time multiplier of 0.6. The supplying CT is rated 400:1 Amp and fault current is 4000 Amp. The relay characteristics as per given below:

PSM	1.3	2	4	8	10	20
Time of operation in sec	30	10	5	3.3	3	2.2

Ans:

Rated secondary current of C.T. =1A

Pick up current $= 1 \times 1.25 = 1.25A$

Fault current in relay coil = $4000 \times \frac{1}{400} = 10A$ 1 mark

Model Answers
Winter – 2019 Examination
Subject &Code: Switchgear And Protection (17508)

∴ Plug setting multiplier (PSM) = $\frac{fault\ current\ in\ relay\ coil}{pick-up\ current}$

$= \frac{10}{1.25} = 8$ 1 mark

Corresponding to PSM of 8 (consider given table), the time of operation is 3.3 seconds.

Actual relay operating time $= 3.3 \times time\ setting = 3.3 \times 0.6$ 1 mark

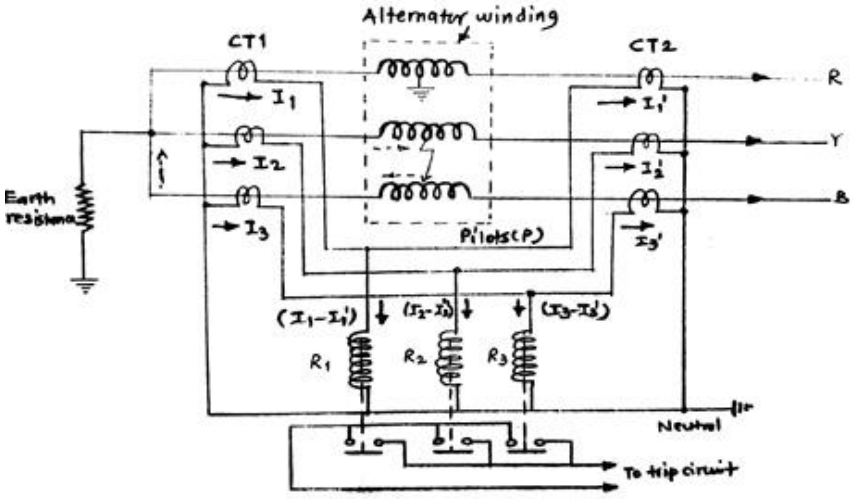
$= \mathbf{1.98\ second}$

1 mark

6b) Draw neat labeled circuit diagram with proper current direction of differential protection used for protection of alternator.

Ans:

Merz Price Protection of Alternator:



Labeled diagram 4 Marks

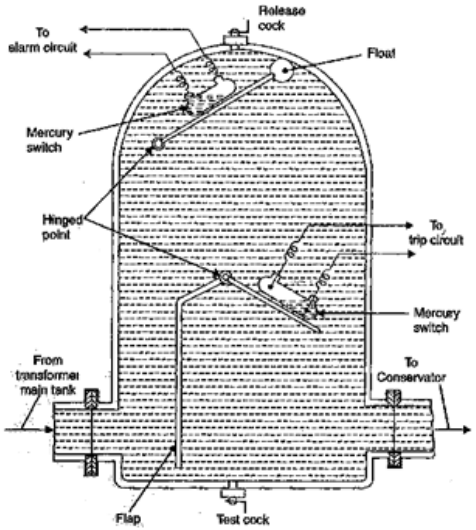
Partially Labeled diagram 3 Marks

Un-Labeled diagram 2 Marks

6c) State the protections provided by buchholz relay with constructional diagram. State the position of placement.

Ans:

Protections Provided by Buchholz Relay with Constructional Diagram:



2 Marks for diagram

Detect incipient faults (minor faults leading to decomposition of oil with gas formation) occurring below oil level in oil immersed transformers such as

phase-phase, phase-core and gives the alarm signals so that preventive action is taken before the condition leads to a major fault. 1 Mark

Detect sudden heavy oil movements due to severely violent faults in the tanks and give the trip signals.

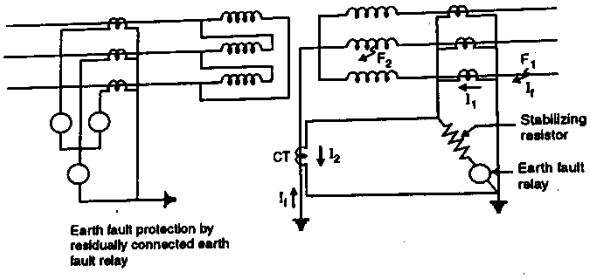
Position of Placement of Buchholz relay:

The buchholz relay is installed in the pipe connecting the conservator to main tank. Usually this pipe is inclined by 9-10 degrees with horizontal plane. 1 Mark

6d) Describe "restricted earth fault protection" of a star connected, neutral earthed side of power transformer.

Ans:

Restricted Earth Fault Protection:



Restricted earth fault protection

2 Marks for diagram

Referring to Figure, the star connected neutral earthed side is protected by restricted earth fault protection. An earth fault F_1 beyond the transformer causes the currents I_2 and I_1 to flow in CT secondary. Therefore, the resultant current in earth fault relay is negligible and relay does not operate for the faults beyond its region. For earth fault within the transformer star connected winding F_2 only I_2 flows and I_1 is negligible. So earth fault relay operates. 2 Marks for description

When fault occurs very near to neutral point, the voltage available for driving earth fault relay is very small. Hence the practice is to set the relay such that it operates for earth fault current of the order of 15% of rated current. Such setting protects restricted portion of winding, hence the name is restricted earth fault protection.

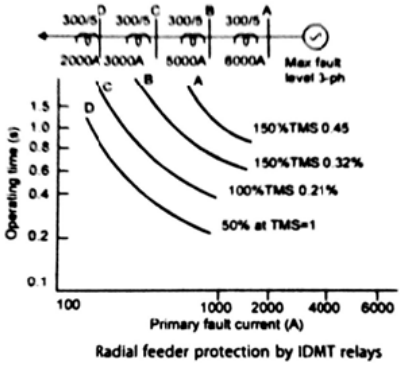
6e) Explain the principle of time graded protection used for protection of feeders using IDMT overcurrent relay.

Ans:

Time Graded Protection Used for Protection of Feeders Using IDMT Overcurrent Relay:

Figure shows time-graded over current protection of radial feeder using IDMT over-current relays. Here the operating time is inversely proportional to the fault current and finally becomes definite for particular current. With this arrangement, the farther the circuit-breaker from the generating station, the shorter is its relay operating time. The line or feeder is divided into number of sections. Over-current relays are provided for each section. On occurrence of fault in any section, all the relays towards generating station are initiated to operate but the nearest relay operates first and trips the respective CB. If this relay fails, the next relay towards generating station operates and so on. The 2 Marks for explanation

relays towards generating station are set for higher currents and they operate with time delays according to their inverse definite minimum time characteristics.



Radial feeder protection by IDMT relays

2 Marks for diagram