14EE704

Hall Ticket Number:

IV/IV B.Tech (Regular/Supplementary) DEGREE EXAMINATION

Jan/Feb, 2021 — **Electrical and Electronics Engineering**

Seventh Semester — **Switch Gear and Protection**

Time: Three Hours — **Maximum :** 60 Marks

Answer ALL Questions from PART-A. (1X12 = 12 Marks)
Answer ***ANY FOUR*** *questions from PART-B.* (4X12=48 Marks)

Part - A

1 Answer all questions (1X12=12 Marks)

a) What is pick up value

b) Mention any 2 applications of differential relays.

c) Name the parts of attracted armature relay

d) Write any two types of static relays.

e) What is instantaneous relay

f) What is Time setting multiplier

g) Name any two Bus bar protection Schemes

h) Name the method used to for protection against Large internal faults in an alternator.

i) Why neutral resistor is added between neutral and earth of an alternator

j) What is resistance switching

k) What is RRRV

l) Write the classification of circuit breakers based on the medium used for arc extinction

Part - B

2	a)	Explain in detail the primary and back-up protection. What are the unit system of protection and non-unit system of protection?	6M
	b)	Explain principle operation of Buchholz relay.	6M
3	a)	Show that the torque on the disc of an induction disc relay is maximum when the phase difference between the two fluxes is 90^0.	6M
	b)	Compare the characteristics of impedance relay and reactance relay. Also, give their applications.	6M
4	a)	Compare electromagnetic and static relays	6M
	b)	Briefly Explain construction and working of static impedance relay	6M
5	a)	Discuss how an amplitude comparator can be converted to a phase comparator	6M
	b)	Explain static instantaneous over current relays with block diagram?	6M
6	a)	Explain Merz-price protection of a star- Delta transformer	6M

	b)	A 3-phase, 66/11 kV star-delta connected transformer is protected by Merz-price system. The CT's on low voltage side have a ratio of 420/5 A. Find the ratio of CT's on the high voltage side.	6M
7	a)	Give various schemes of protection for feeders.	6M
	b)	Determine the value of reactance to be connected in the neutral connection to neutralize the capacitance current of an overhead line having line to ground capacitance of each line equal to 0.015µ f , Frequency = 50Hz.	6M
8	a)	Explain the restriking phenomenon for circuit breakers.	6M
	b)	What is the principle of operation of air blast circuit breaker?	6M
9	a)	What is a minimum oil circuit breaker? What are its main advantages and disadvantages?	6M
	b)	A 11 kV, 50 Hz, 3 –ϕ alternator is connected to a C.B the inductive reactance up to the C.B is 10 ohms per phase. The distributed capacitance up to C.B between phase and neutral is 0.03 µF . Determine the following. i) Maximum restriking voltage across the C.B contacts. ii) Frequency of restriking voltage transient. iii) Average RRRV up to peak restriking voltage.	6M

Scheme of Evaluation

2a)	Definition of primary and back-up protection -2M. Definition of unit system of protection and non-unit system of protection – 2M Explanation -2M
b)	Circuit diagram of Buchholz relay – 2 M Explanation of operation—3M Advantages and drawbacks -1M
3a)	Diagram of induction disc relay -2M Explanation of operation 2M Derivation of torque equation – 2M
b)	R-X diagram of impedance relay and reactance relay -2M Operation -2M. Applications-2M
4a)	Advantages and dis advantages of electromagnetic relays -3M Advantages and dis advantages of static relays -3M
b)	Circuit Diagram -2M Explanation of operation -4M
5a)	Circuit diagram -2M Phasor diagram –2M

	Explanation-2M
b)	Circuit diagram -2M Explanation-4M
6a)	Circuit diagram -2M Phasor diagram –1M Explanation-3M
b)	Problem solution -6M
7a)	Scheme-1 circuit diagram and explanation -3M Translay relay circuit diagram and explanation protection for feeders.-3M
b)	Problem solution -6M
8 a)	Phenomena of arcing -2M Arc interruption phenomena -2M Restriking phenomenon-2M
b)	Circuit diagram -2M Explanation-3M Applications-1M
9 a)	Circuit diagram -2M Explanation-3M Advantages and disadvantages -1M
b)	. i) Maximum restriking voltage across the C.B contacts- 2M ii) Frequency of restriking voltage transient 2M iii) Average RRRV up to peak restriking voltage 2M

PART-A

a) What is pick up value?

The threshold value of the actuating quantity (current, voltage, etc.)above which the relay operates

b) Mention any 2 applications of differential relays.

1.For the protection of Generator.

2. For the protection of transformers.

c) Name the parts of attracted armature relay

Electro magnet, Armature, coil.

d) Write any two types of static relays.

Electronic Relays, Rectifier bridge relays, Hall effect relays.

e) What is instantaneous relay.

An instantaneous relay has no intentional time delay in its operation. It operates in 0.1 second.

f) What is Time setting multiplier

The adjustment of travelling distance of an electromechanical relay is commonly known as **time setting**. This adjustment is commonly known as **time setting multiplier** of relay. The **time setting** dial is calibrated from 0 to 1 in steps of 0.05 sec.

g) Name any two Bus bar protection Schemes

1.Frame leakage protection

2. Circulating current protection..

h) Name the method used to for protection against Large internal faults in an alternator.

Differential circulating current scheme or Mertz price differential current protection scheme

i) Why neutral resistor is added between neutral and earth of an alternator

In order to limit the flow of current through **neutral and earth** a **resistor** is introduced **between** them.

j) What is resistance switching.

To reduce the restriking voltage, RRRV and severity of the transient oscillations, a resistance is connected across the contacts of the circuit breaker. This is known as resistance switching.

k) What is RRRV

The power frequency rms voltage, which appears across the breaker contacts after the arc is finally extinguished and transient oscillations die out is called recovery voltage. The rate of raise of restriking voltage is RRRV.

l) Write the classification of circuit breakers based on the medium used for arc extinction

(i) Air-break circuit breakers:
(ii) Oil circuit breakers
(iii) Air blast circuit breakers
(iv) Sulphur hexafluoride (SF6) circuit breakers
(v) Vacuum circuit breakers

Part - B

2. a) Explain in detail the primary and back-up protection. What are the unit system of protection and non-unit system of protection?

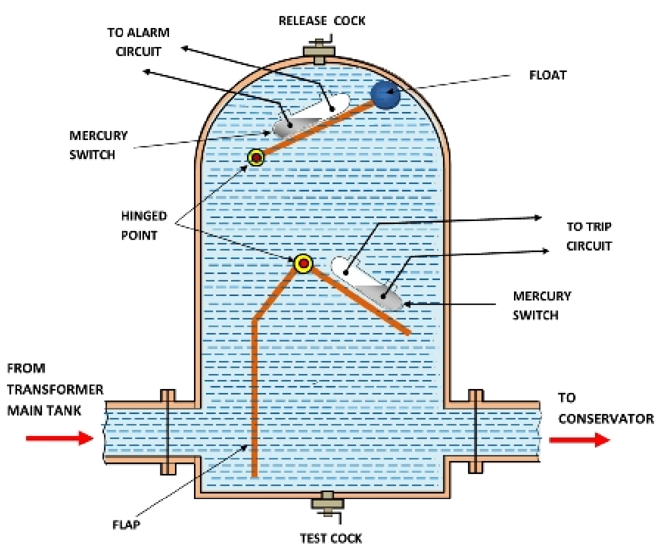
It has already been explained that a power system is divided into various zones for its protection. There is a suitable protective scheme for each zone. If a fault occurs in a particular zone, it is the duty of the primary relays of that zone to isolate the faulty element. The primary relay is the first line of defence. If due to any reason, the primary relay fails to operate, there is a back-up protective scheme to clear the fault as a second line of defence. The back-up relays are made independent of those factors which might cause primary relays to fail. A back-up relay operates after a time delay to give the primary relay sufficient time to operate. When a back-up relay operates, a larger part of the power system is disconnected from the power source, but this is unavoidable. As far as possible, a back-up relay should be placed at a different station. Sometimes, a local back-up is also used. It should be located in such a way that it does not employ components (VT, CT, measuring unit, etc.) common with the primary relays which are to be backed up.

A unit system of protection is one which is able to detect and respond to faults occurring only within its own zone of protection. It is said to have absolute discrimination. Its zone of protection is well defined. It does not respond to the faults occurring beyond its own zone of protection. A non-unit system of protection does not have absolute discrimination (selectivity). It has dependent or relative discrimination. The protective system which operates for faults both within and outside the zone of protection is called non-unit system of protection.

b) Explain principle operation of Buchholz relay.

Buchholz relay function is based on very simple mechanical phenomenon. It is mechanically actuated. Whenever there will be a minor internal fault in the transformer such as an insulation faults between turns, break down of core of transformer, core heating, the transformer insulating oil will be decomposed in different hydrocarbon gases, CO_2 and CO. The gases produced due to decomposition of transformer insulating oil will accumulate in the upper part the Buchholz container which causes fall of oil level in it.

Fall of oil level means lowering the position of float and thereby tilting the mercury switch. The contacts of this mercury switch are closed and an alarm circuit energized. Sometime due to oil leakage on the main tank air bubbles may be accumulated in the upper part the Buchholz container which may also cause fall of oil level in it and alarm circuit will be energized. By collecting the accumulated gases from the gas release pockets on the top of the relay and by analyzing them one can predict the type of fault in the transformer.



The various advantages of the Buchholz relay are,

1. Normally a protective relay does not indicate the appearance of the fault. It operates when fault occurs. But Buchholz relay gives an indication of the fault at very early stage, by anticipating the fault and operating the alarm circuit. Thus the transformer can be taken out of service before any type of serious damage occurs.
2. It is the simplest protection in case of transformers.

Limitations

e various limitations of the Buchholz relay are,

Can be used only for oil immersed transformers having conservator tanks.

Only faults below oil level are detected.

Setting of the mercury switches can not be kept too sensitive otherwise the relay can operate due to bubbles, vibration, earthquakes mechanical shocks etc.

The relay is slow to operate having minimum operating time of 0.1 seconds and average time of 0.2 seconds.

3.a) Show that the torque on the disc of an induction disc relay is maximum when the phase difference between the two fluxes is 90^0.

$$i_1 \propto \frac{d\phi_1}{dt} \propto \frac{d}{dt}(\phi_{1max} \sin \omega t)$$

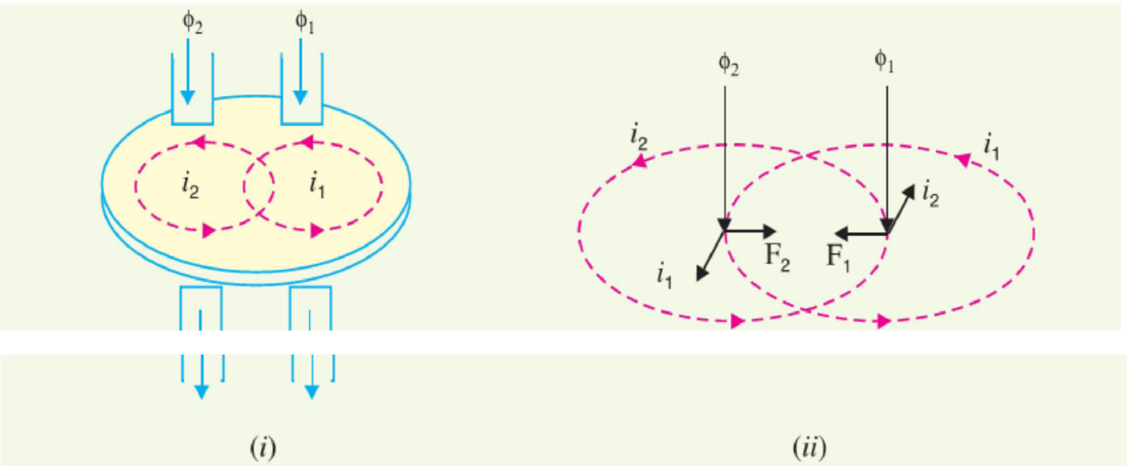


Fig. 21.6

$$\propto \phi_{1max} \cos \omega t$$

and $$i_2 \propto \frac{d\phi_2}{dt} \propto \phi_{2max} \cos(\omega t + \alpha)$$

Now, $$F_1 \propto \phi_1 i_2 \quad \text{and} \quad F_2 \propto \phi_2 i_1$$

Fig. 21.6 (*ii*) shows that the two forces are in opposition.

∴ Net force F at the instant considered is

$$\begin{aligned} F &\propto F_2 - F_1 \\ &\propto \phi_2 i_1 - \phi_1 i_2 \\ &\propto \phi_{2max} \sin(\omega t + \alpha)\, \phi_{1max} \cos \omega t - \phi_{1max} \sin \omega t\, \phi_{2max} \cos(\omega t + \alpha) \\ &\propto \phi_{1max}\, \phi_{2max} [\sin(\omega t + \alpha) \cos \omega t - \sin \omega t \cos(\omega t + \alpha)] \\ &\propto \phi_{1max}\, \phi_{2max} \sin \alpha \\ &\propto \phi_1 \phi_2 \sin \alpha \qquad ...(i) \end{aligned}$$

The greater the phase angle α between the phases, the greater is the net force applied to the disc. Obviously the maximum force will be produced when the two fluxes are 90 degrees out out of phase. Then $F \propto Ø_1 Ø_2$.

b) Compare the characteristics of impedance relay and reactance relay. Also, give their applications.

Figure 6.1 shows the operating characteristic of an impedance relay in terms of voltage and current. In case of an electromagnetic relay, the characteristic is slightly bent near the origin due to the effect of the control spring. In case of microprocessor based or static relay, the characteristic will be a straight line.
A more useful way is to draw a distance relay characteristic on the R-X diagram. Figure 6.2 shows an impedance relay characteristic on the R-X diagram, where Z =K represents a circle and Z < K indicates the area within the circle. Thus, it is seen that the zone within the circle is the operating zone of the relay. Its radius is Z = K, which is the setting of the relay. K is equal to the impedance of the line which is to be protected. f is the phase angle between V and I. As the operating characteristic is a circle, the relay operation is independent of the phase angle f. The operation depends on the magnitude of Z. If a fault point is on the protected section of the line, it will
lie within the circle. For this condition, the relay will operate and send a tripping signal to the circuit breaker. The region outside the circle is the blocking zone. If a fault point lies in this zone, i.e. it is beyond the protected section of the line, the relay will not respond. In such a situation, the fault point may lie in the protection zone of some other relay. The operating time of the relay is constant.
A reactance relay measures the reactance of the line at the relay location, and is not affected by variations in resistance. Hence, its performance remains unaffected by arc resistance during the occurrence of fault. In case of a fault on the protected line, the measured reactance is the reactance of the line between the relay location and the fault point. Its characteristic on the R-X diagram is a straight line, parallel to R-axis as shown in Fig. 6.14(a).
Fig. 6.14 (a) Operating characteristic of a reactance relay(b) Reactance relay with starting unit
6.15

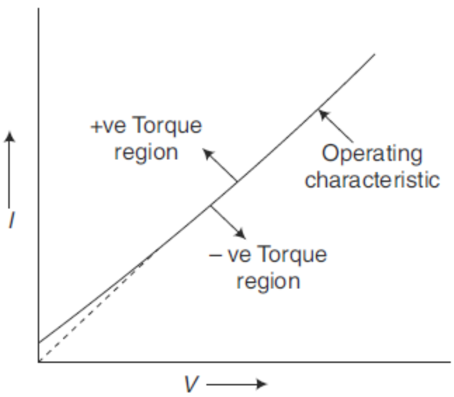


Fig. 6.1 *Operating characteristic of an impedance relay*

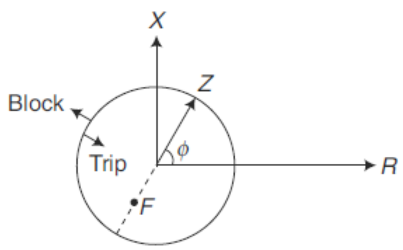


Fig. 6.2 *Operating characteristic of an impedance relay on the R-X diagram*

A reactance relay measures the reactance of the line at the relay location, and is not affected by variations in resistance. Hence, its performance remains unaffected by arc resistance during the occurrence of fault. In case of a fault on the protected line, the measured reactance is the reactance of the line between the relay location and the fault point. Its characteristic on the R-X diagram is a straight line, parallel to R-axis as shown in Fig. 6.14(a).

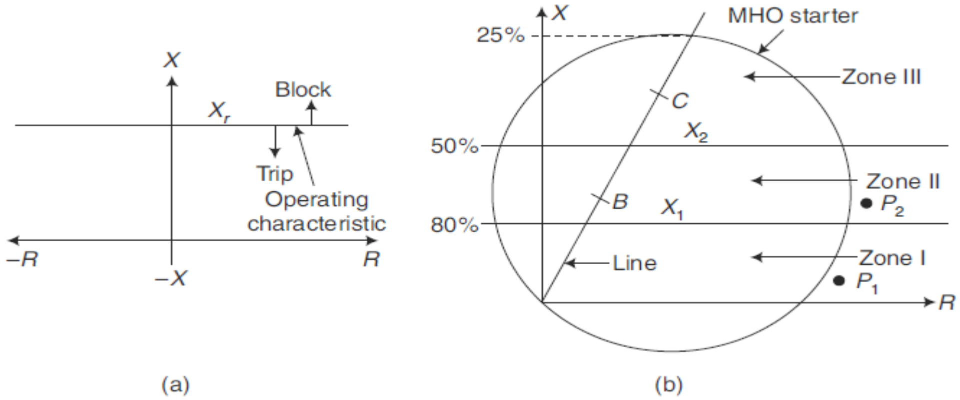


Fig. 6.14 *(a) Operating characteristic of a reactance relay*
(b) Reactance relay with starting unit

Distance relays are used for the protection of high and extra high voltage transmission and sub transmission lines. These relays provide high speed fault clearance. These are used for the protection of transmission lines and sub transmission lines at 220kv, 132kv, 66kv, 33kv and in some cases even for 11kv.

The various advantages of the distance relays are.

1. Gives faster operation
2. Simpler to co-ordinate
3. Less effect of fault levels and fault current magnitudes
4. Permits high line loading.
5. With the need at readjustments, permanent settings can be done.

Thus the distance relays are used for providing the primary i.e. main protection and backup protection for a.c. transmission and distribution lines against the following faults,

1. Three phase faults
2. Phase to phase faults
3. Phase to earth faults.

4.a) Compare electromagnetic and static relays

The advantages of static relays over electromechanical relays are as follows.
(i) Low burden on CTs and VTs. The static relays consume less power and in most of the cases they draw power from the auxiliary dc supply
(ii) Fast response
(iii) Long life
(iv) High resistance to shock and vibration
(v) Less maintenance due to the absence of moving parts and bearings
(vi) Frequent operations cause no deterioration
(vii) Quick resetting and absence of overshoot
(viii) Compact size
(ix) Greater sensitivity as amplifi cation can be provided easily
(x) Complex relaying characteristics can easily be obtained
(xi) Logic circuits can be used for complex protective schemes
The logic circuit may take decisions to operate under certain conditions and not to operate under other conditions.
The demerits of static relays are as follows:
(i) Static relays are temperature sensitive. Their characteristics may vary with the variation of temperature. Temperature compensation can be made by using thermistors and by using digital techniques for measurements, etc.
(ii) Static relays are sensitive to voltage transients. The semiconductor components

may get damaged due to voltage spikes. Filters and shielding can be used for their protection against voltage spikes.
(iii) Static relays need an auxiliary power supply. This can however be easily supplied by a battery or a stabilized power supply.

b) Briefly Explain construction and working of static impedance relay

Static Impedance Relay Using an Amplitude Comparator
Rectifier bridge comparator is used to realise an impedance relay characteristic. Since it is an amplitude comparator, I is compared with V. I is an operating quantity and V the restraining quantity. As the rectifier bridge arrangement is a current comparator, it is supplied with the operating current I0 and restraining current Ir, as shown in Fig. 6.10. I0 is proportional to the load current I, and Ir is proportional to the system voltage V.

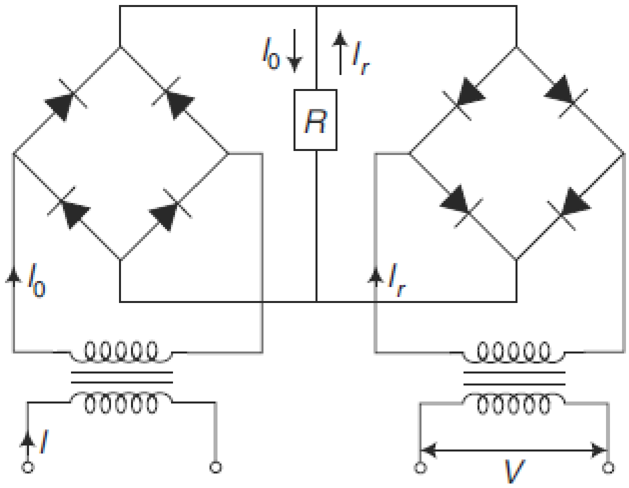


Fig. 6.10 *Static impedance relay unit using amplitude comparator*

Static impedance relay with either amplitude comparator or with phase comparator can also be presented.

5 a) Discuss how an amplitude comparator can be converted to a phase comparator

An amplitude comparator can be converted to a phase comparator and vice versa if the input quantities to the comparator are modified. The modified input quantities are the sum and difference of the original two input quantities. To understand this fact, consider the operation of an amplitude comparator which has two input signals M and N as shown in Fig. 2.19(a). It operates when |M| > |N|. Now change the input quantities to (M + N) and (M – N) as shown in Fig. 2.19(b). As its circuit is designed for amplitude comparison, now with the changed input, it will operate when |M + N|> |M – N|. This condition will be satisfied only when the phase angle between M and N is less than 90°. This has been illustrated with the phasor diagram shown in Fig.2.20. It means that the comparator with the modified inputs has now become a phase comparator for the original input signals M and N.

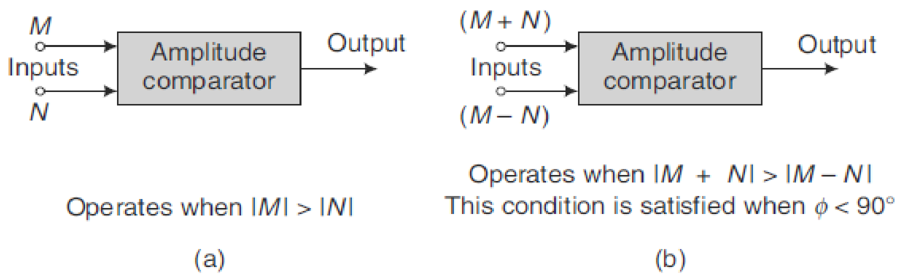


Fig. 2.19 *(a) Amplitude comparator (b) Amplitude comparator used for phase comparison*

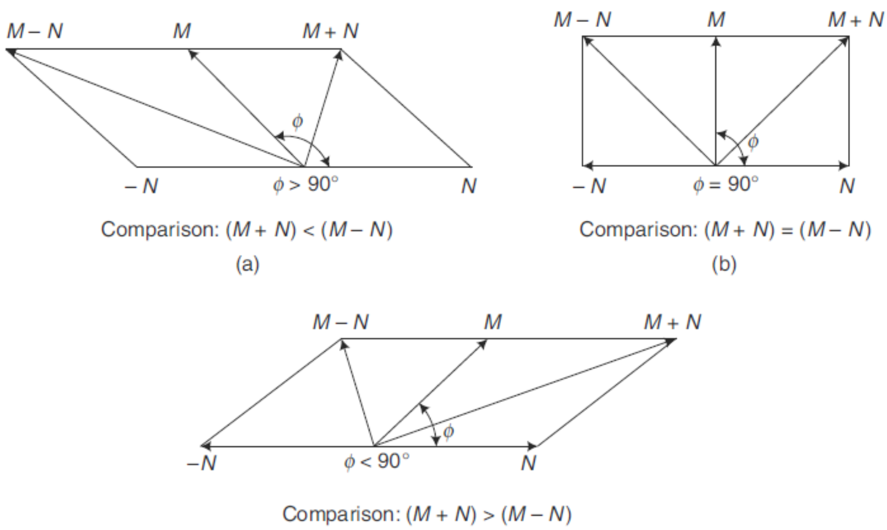


Fig. 2.20 *Phasor diagram for amplitude comparator used for phase comparison*

b) lain static instantaneous over current relays with block diagram?

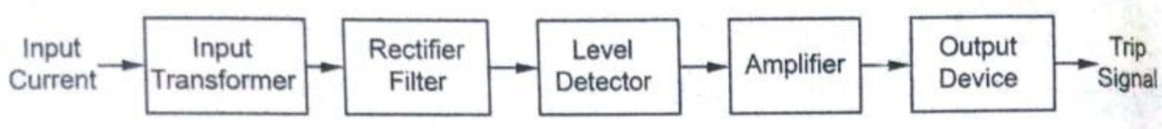
Static instantaneous over current relay

•The current derived from the main C.T. is fed 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 highest value of current expected, and is provided with tappings on its secondary winding to obtain different current settings.

•The output voltage of the transformer is rectified through a rectifier and then filtered at a single stage to avoid undesirable time delay in filtering so as to ensure high speed of operation.

•A limiter made of 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 and filtered voltage through a potential divider is compared against a pre-set 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.

6 a) Explain Merz-price protection of a star- Delta transformer

Let us study the Merz-Price protection for the star-delta power transformer. The primary of the power transformer is star connected while the secondary is delta connected. Hence to compensate for the phase difference, the C.T. secondaries on primary side must be connected in delta while the C.T. secondaries on delta side must be connected in star. The star point of the power transformer primary as well as the star connected C.T. secondaries must be grounded.

The circuit diagram of the scheme is shown in the Fig. 7.2

The restraining coils are connected across the C.T. secondary windings while the operating coils are connected between the tapping points on the restraining coils and the star point of C.T. secondaries.

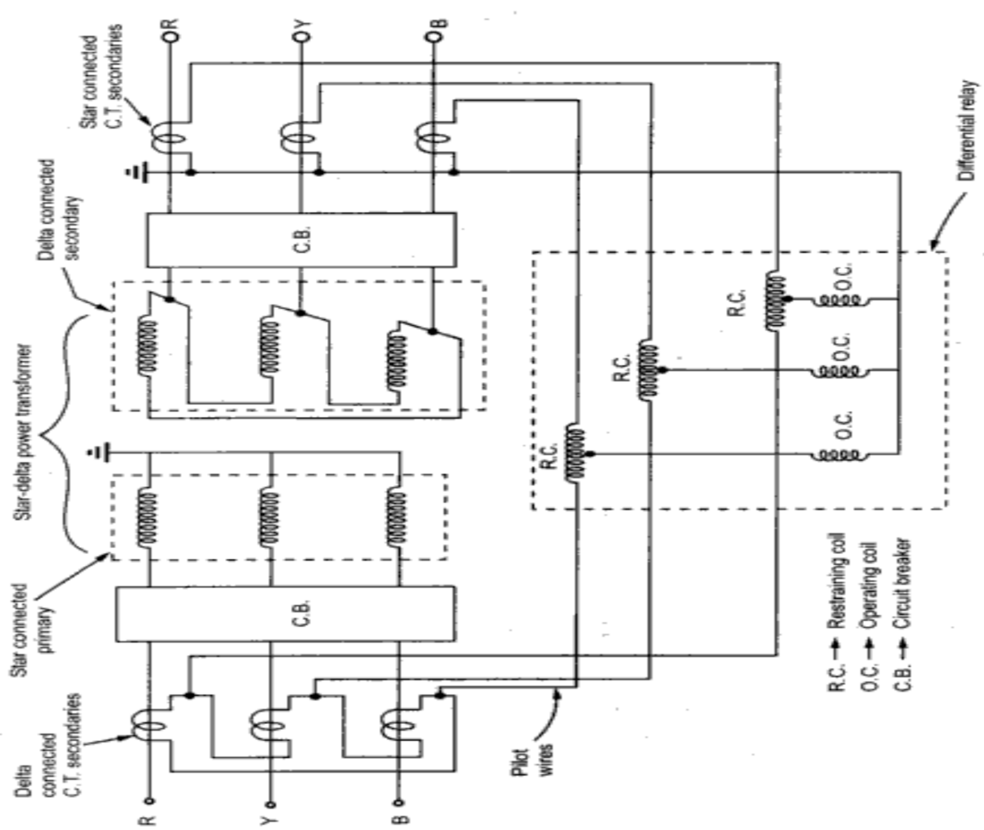
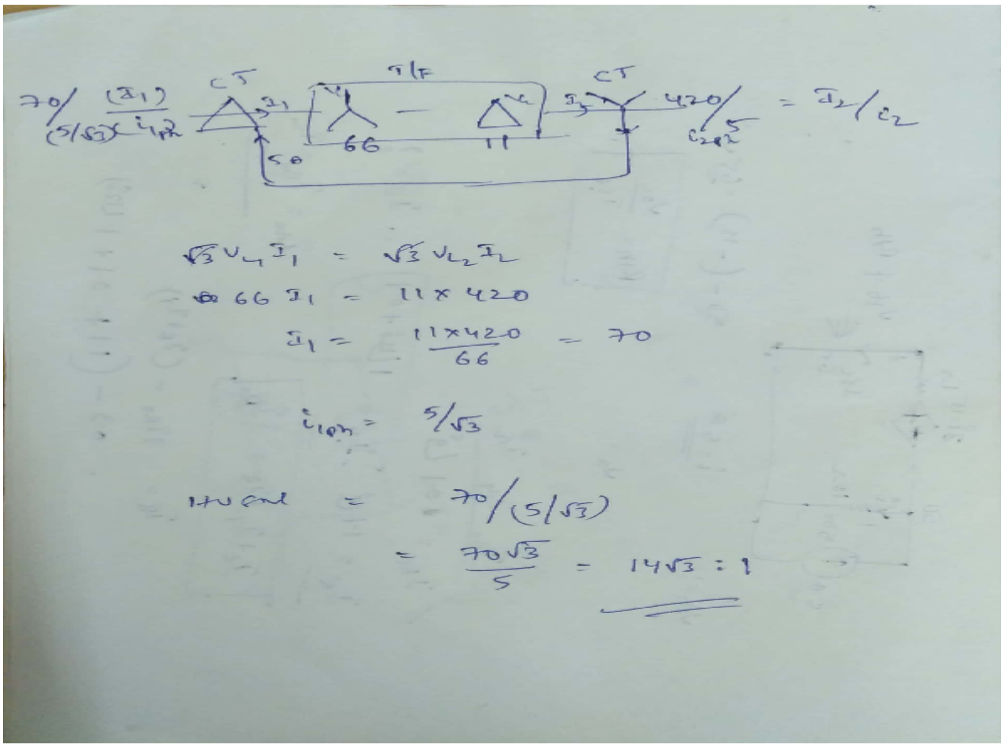


Fig. 7.2 Merz-Price protection for star-delta power transformer

With the proper selection of turns ratio of C.T.s the coils are under balanced condition during normal operating conditions. The C.T. secondaries carry equal currents which are in phase under normal conditions. So no current flows through the relay and the relay is inoperative.

With an internal fault in power transformer windings, the balance in the C.T.s get disturbed. The operating coils of differential relay carry currents proportional to the difference of current between the two sides of a power transformer. This causes the relay operation which trips the main circuit breakers on both the sides of the power transformer.

b)A 3-phase, 66/11 kV star-delta connected transformer is protected by Merz-price system. The CT’s on low voltage side have a ratio of 420/5 A. Find the ratio of CT’s on the high voltage side.



7 a) Give various schemes of protection for feeders.

The word feeder here means the connecting link between two circuits. The feeder cod be in the form of a transmission line, short, medium or long, or this could be a distribution circuit. The various methods of protecting the feeders are:

1. **Over current protection.**
2. **Distance protection.**
3. **Pilot relaying protection.**

of these, over current protection is the simples and cheapest form of protection. It is most difficult to apply and needs readjustment, should a change in the circuit occur. This may even have to be replaced depending upon the circuit conditions.

The discrimination using over current protection is achieved in the following ways:

(i) **Time graded system.**
(ii) **Current graded system**.
(iii) **Time-current graded system**.

Time Graded System

The selectivity is achieved based on the time of operation of the relays. Consider a radial feeder in Fig. The feeder is being fed from one source and has three substations indicated by the vertical lines. The crosses represent the location of the relays. The relays used are simple over current relays. The time of operation of the relays at various locations is so adjusted that the relay farthest from the source will have minimum time of operation and as it is approached towards the source the operating time will be increases

Current Graded System

This type of grading is done on a system where the fault current varies appreciably with the fault. This means as we go towards the source the fault current will be increases. With this if the relays are set to pick at a progressively higher current towards the source, then the dis-advantage of the long-time delay that occurs in case of time graded systems can be partially overcome. This is known as current grading.

Time-Current Grading

This type of grading is achieved with the help of inverse time over current relays and the most widely used is the IDMT relay. The other inverse characteristics, e.g. very inverse or extremely inverse are also employed depending upon the system requirements are slow at low values of overloads, extremely inverse relays are used and if the fault current reduces substantially as the fault location moves away from the source, very inverse type of relays are used.

b) Determine the value of reactance to be connected in the neutral connection to neutralize the ıcitance current of an overhead line having line to ground capacitance of each line equal to .5µ f , Frequency = 50Hz.

Line to ground capacitance of each line=5micro farads.

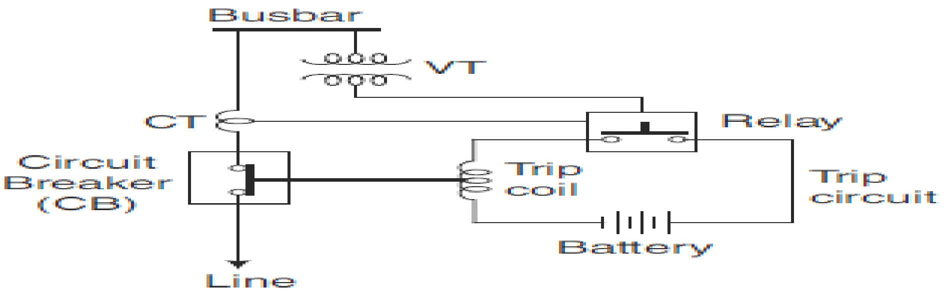
Frequency=50Hz. $X_{L}= X_{c/3}$

$Xc=1/2\pi fc=1/2x\pi x50x5x10^{6}=636.94$ohms

$X_L=636.94/3=212.31$ohms.

8 a) Explain the restriking phenomenon for circuit breakers.

A circuit breaker has two contacts – a fixed contact and a moving contact. The contacts are placed in a closed chamber containing a fluid insulating medium (either liquid or gas) which quenches(extinguishes) the arc formed between the contacts. Under normal conditions the contacts remain in closed position. When the circuit breaker is required to isolate the faulty part, the moving contact moves to interrupt the circuit. On the separation of the contacts, an arc is formed between them and the current continues to flow from one contact to the other through the arc as shown in Fig. 14.2. The circuit is interrupted (isolated) when the arc is finally extinguished.



The voltage across the contacts of the circuit breaker is arc voltage when the arc persists. This voltage becomes the system voltage when the arc is extinguished. The arc is extinguished at the instant of current zero. After the arc has been extinguished, the voltage across the breaker terminals does not normalise instantaneously but it oscillates and there is a transient condition. The transient voltage which appears across the breaker contacts at the instant of arc being extinguished is known as restriking voltage.

b)What is the principle of operation of air blast circuit breaker?

Air blast circuit breaker used compressed air or gas as the arc interrupting medium. In the air blast, circuit breaker compressed air is stored in a tank and released through a nozzle to produce a high-velocity jet; this is used to extinguish the arc. Air blast circuit breakers are used for indoor services in the medium high voltage field and medium rupturing capacity. Generally up to voltages of 15 KV and rupturing capacities of 2500 MVA. The air blast circuit breaker is now employed in high voltage circuits in the outdoors switch yard for 220 KV lines.Though gasses such as carbon dioxide, nitrogen, freon or hydrogen are used as the arc interrupting medium, compressed air is the accepted circuit breaking medium for gas blast circuit breakers.

Principle of Arc Extinction in Circuit Breaker

The air blast needs an additional compressed air system which supplies air to the air receiver. When opening air is required, compressed air is admitted to the arc extinction chamber. It pushes away the moving contacts. In doing so, the contacts are pulled apart, and the air blast moves away the ionized gas along with it and assists arc extinction. Air blast extinguishes the arc within one or more cycles, and the arc chamber is filled with high-pressure air, which prevents restrikes. The air blast circuit breakers fall under the category of external extinguishing energy type. The energy supplied for arc quenching is achieved from the high-pressure air, and it is free from the current to be interrupted.

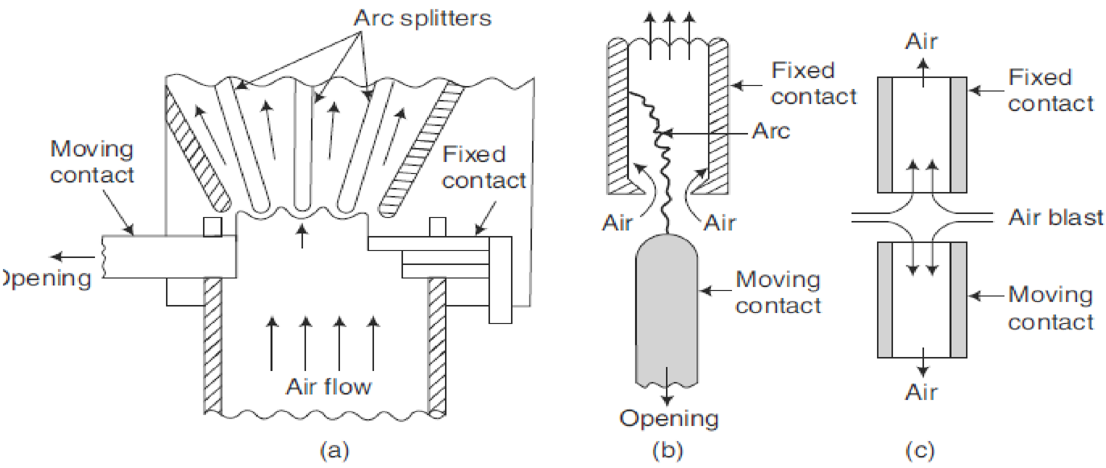


Fig. 14.21 *(a) Cross-blast circuit breaker (b) Single blast type axial-blast circuit breaker (c) Double blast type (or radial-blast type) axial-blast circuit breaker*

9 a) What is a minimum oil circuit breaker? What are its main advantages and disadvantages?

- Minimum oil circuit (also known as MOCB) breaker in which a small quantity of oil is used for arc extinction and for insulation purpose a solid material is used.

A **Minimum oil circuit breaker** has the following **advantage over a bulk oil circuit breaker** :

1. It requires small quantity of oil (only for are quenching purpose since for the

insulation purpose solid materials are used).

2. It requires small space, since the quantity of oil required is less and a small separation of contact is sufficient to quench the arc.

3. There is less risk of fire.

4. Maintenance problem are reduced.

Disadvantages of Minimum Oil Circuit Breaker :

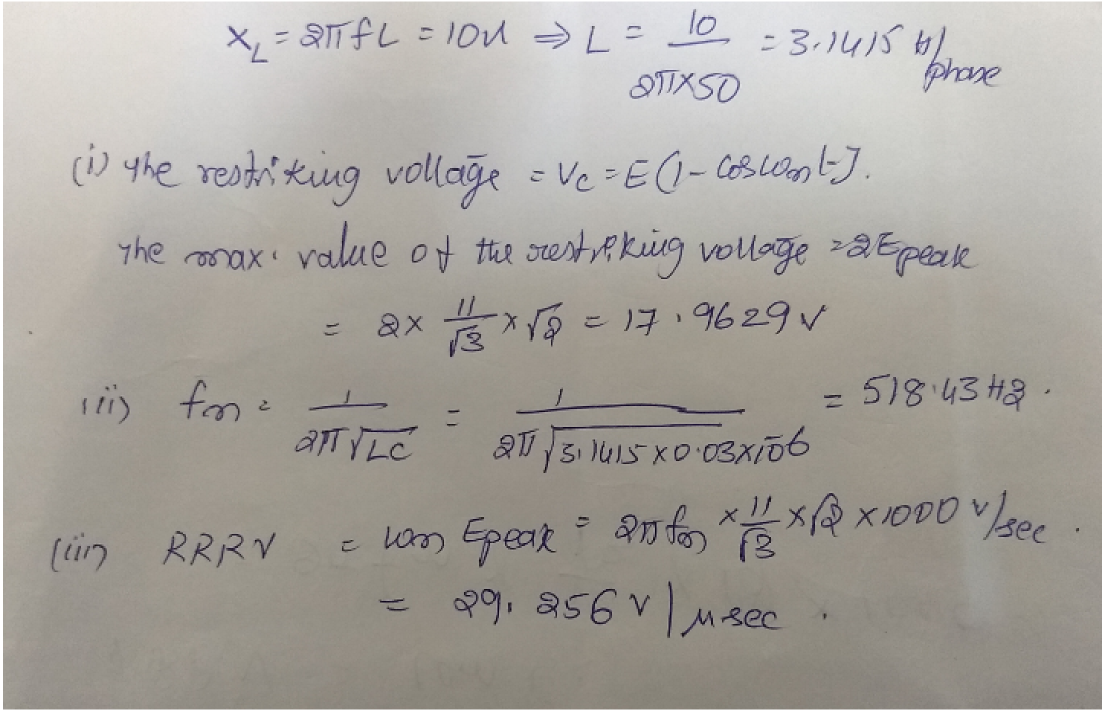
A low oil circuit breaker has the following disadvantage as compared to a bulk oil circuit breaker.

1. There is a difficulty of removing the gases from the contact space in time.

2. Due to smaller quantity of oil, the degree of carbonization is increased.

3. The dielectric strength of the oil deteriorates rapidly due to high degree of carbonization.

b)A 11 kV, 50 Hz, 3 −φ alternator is connected to a C.B the inductive reactance up to the C.B is 10 ohms per phase. The distributed capacitance up to C.B between phase and neutral is 0.03 μF . Determine the following. i) Maximum restriking voltage across the C.B contacts. ii) Frequency of restriking voltage transient. iii) Average RRRV up to peak restriking voltage.



$X_L = 2\pi f L = 10\Omega \Rightarrow L = \frac{10}{2\pi \times 50} = 3.1415$ H/phase

(i) the restriking voltage $= V_c = E(1-\cos\omega_n t)$.

The max. value of the restriking voltage $= 2E_{peak}$

$= 2 \times \frac{11}{\sqrt{3}} \times \sqrt{2} = 17.9629$ V

(ii) $f_n = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{3.1415 \times 0.03 \times 10^{-6}}} = 518.43$ Hz.

(iii) RRRV $= \omega_n E_{peak} = 2\pi f_n \times \frac{11}{\sqrt{3}} \times \sqrt{2} \times 1000$ V/sec.

$= 29.256$ V/μsec.

Signature of H.O.D

Signature of staff

1.

(K. Kamala Devi)

2.

(CH. Hari Prasad)

3.

(J. Pardasaradhi)