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

Nov,2019 **Electrical and Electronics Engineering**

Seventh Semester **Switch Gear &Protection (14EE704)**

Maximum:60 Marks

Answer Question No.1 compulsorily. **(1*12=12 Marks)**

Answer ONE question from each unit. **(4*12=48 Marks)**

1.Answer all questions **(1*12=12Marks)**

a) Define pick-up.

The current for which the relay initiates its operation is called pick up current of relay.

b) Define backup protection.

The backup protection may duplicate the main protection or may be intended to operate only if the main protection system fails to operate or is temporarily out of service.

c) State basic requirements of protective relay.

1. **Selectivity 2.Speed 3.Sensitivity 4.Reliability.5.Simplicity 6.Economy**

d) List the basic components of static relay.

1.CT/PT 2.Rectifier .Relay measuring circuit 4.Amplifier 5.printer

e) State the function of Amplitude comparator in static relays.

Amplitude comparator compares amplitude of input signals .

f) Define plug setting multiplier.

Plug setting multiplier of relay is referred as ratio of fault current in the relay to its pick up current.

$$PSM = \frac{Fault\ current\ in\ relay\ coil}{Pick\ up\ current}$$

$$= \frac{Fault\ current\ in\ relay\ coil}{Rated\ CT\ secondary\ current \times Current\ setting}$$

g) Define soil resistivity.

The measure of the resistance offered by the soil in the flow of electricity, is called the soil resistivity. The resistivity of the soil depends on the various factors likes soil composition, moisture, temperature, etc. Generally, the soil is not homogenous, and their resistivity varies with the depth. The soil having a low resistivity is good for designing the grounding system. The resistivity of the soil is measured in ohmmeter or ohm-centimeters.

h) State the objective of power system earthing.

1.The earthing protects the personnel from the shortcircuit current.

2.The earthing provides the easiest path to the flow of shortcircuit current even after the failure of the insulation.

3.The earthing protects the apparatus and personnel from the high voltage surges and lightning discharge.

i) List any two advantages of neutral points of three phase ac system are earthed at eachvoltage levels.

Reduced magnitude of transient over voltages
Simplified ground fault location
Improved system and equipment fault protection
Reduced maintenance time and expense
Greater safety for personnel
Improved lightning protection
Reduction in frequency of faults.

j) Define arc time constant.

$T = CR_{Arc}$

k) List types of circuit breakers.

1)Air Circuit Breaker
i) Air Break Circuit Breaker
ii)Air Blast Circuit Breaker
a)Axial Blast
b) Radial Blast
2)SF6 Circuit Breaker
3)Vacuum Circuit Breaker
4)Oil Circuit Breaker
i)Min.oil circuit Breaker
ii)Bulk oil circuit Breaker
a) Single Breaker
b) Double Breaker

l) Define restriking voltage.

Restriking voltage is the transient voltage appearing across the breaker contacts immediately after the opening of breaker contacts. It is also called Transient Recovery Voltage (TRV). Restriking voltage is associated with high frequency which die out quickly. Even though restriking voltage is lasts for very short duration, its importance for breaker fault clearing cannot be ignored. If the rate of rise of dielectric strength of medium is less than the restrining voltage,arc quenching will not take place and hence fault will not be interrupted. This will in turn increase the fault clearing time which is not desirable.

UNIT I

2.a)Describe the various types of constructions of attracted armature type relay.(3+3=6M)

In Electromagnetic Attraction Relays, there is a coil which energises an electromagnet.When the operating current becomes large, the magnetic field produced by an electromagnet is so high that it attracts the armature or plunger, making contact with the trip circuit contacts.These are the simplest type of relays.

The various types of electromagnetic attraction type relays are

1. Attracted armature relay

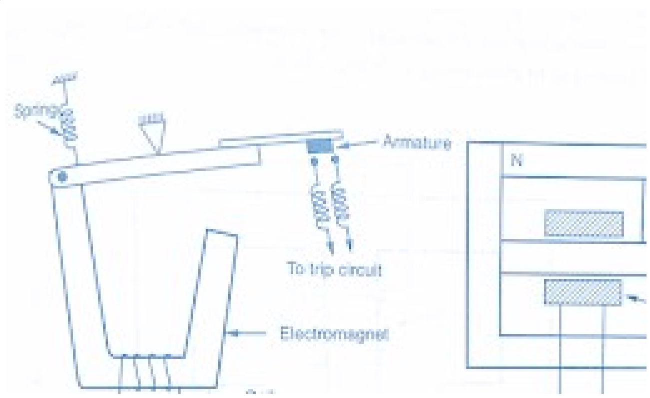
2. Solenoid and plunger type relay

Attracted Armature Type Relay:

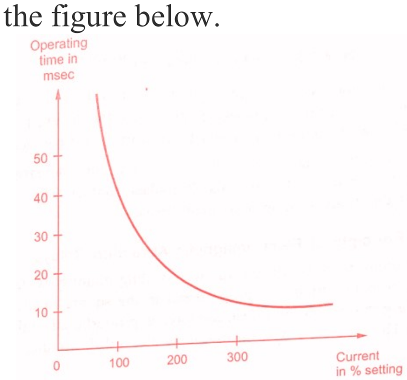
There are two types of structures available for attracted armature type relay which are,
i) Hinged armature type

ii) Polarised moving iron type

The two types of attracted armature type relays are shown in the Figure(a) and (b).In attracted armature type, there exists a laminated electromagnet which carries a coil.The coil is energised by the operating quantity which is proportional to the circuit voltage or current.The armature or a moving iron is subjected to the magnetic force produced by the operating quantity.The force produced is proportional to the square of current hence Electromagnetic Attraction Relays relays can be used for a.c. as well as d.c.
Generally, the number of tappings are provided on the relay coil with which its turns can be selected as per the requirement.This is used to adjust the set value of an operating quantity at which relay should operate.

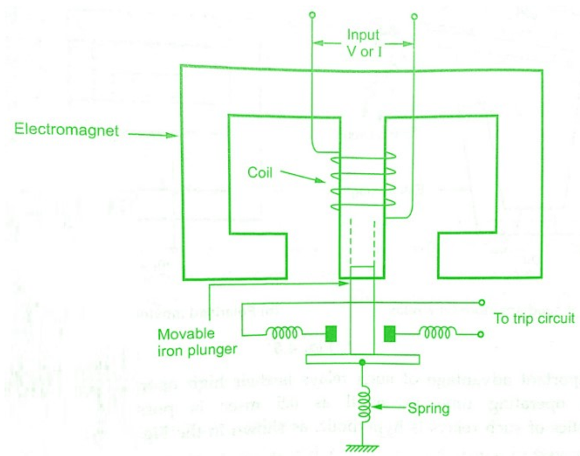


An important advantage of such relays is their high operating speed. In modern relays an operating time as small as 0.5ms is possible.The current-time characteristics of such relays is hyperbolic, as shown in the figure below.



Solenoid and Plunger Type Relay:

The below figure is Solenoid and Plunger Type Relay which works on the principle of electromagnetic attraction.



It consists of a solenoid which is nothing but an electromagnet. It also consists a movable iron plunger. Under normal working conditions, the spring holds the plunger in the position such that it cannot make contact with trip circuit contacts.

Under fault conditions, when the current through relay coil increases, the solenoid draws the plunger upwards.Due to this,it makes contact with the trip circuit contacts, which results in an opening of a circuit breaker.

Operating Principle of Electromagnetic Attraction Relays:

The electromagnetic force produced due to the operating quantity which is exerted on the armature, moving iron or plunger is proportional to the square of the flux in the air gap.Thus neglecting the saturation effect, the force is proportional to the square of the operating current. Hence such relays are useful for a.c. and d.c. both.

dvantages of Electromagnetic Relays:

The various advantages of **electromagnetic relays** are

1. Can be used for both a.c. and d.c.

2. They have fast operation and fast reset.

3.Electromagnetic Attraction Relays are almost instantaneous.Though instantaneous, the operating to varies with current. With extra arrangements like dashpot, copper ring etc, slow operating and resetting times can be obtained.

4. High operating speed with operating time in few milliseconds also can be achieved.

5. The pickup can be as high as 90-95% for d.c. operation and 60 to 90% for the d.c. operation.
6. Modern relays are compact, simple, reliable and robust.

Disadvantages of Electromagnetic Relays:

The few disadvantages of Electromagnetic Attraction Relays are,

1. The directional feature is absent.

2. Due to fast operation the working can be affected by the transients. As transients contain d.c. as well as pulsating component, under steady state value less than set value, the relay can operate .

b) Explain the buchholz relay with neat sketch. .(3+3=6M)

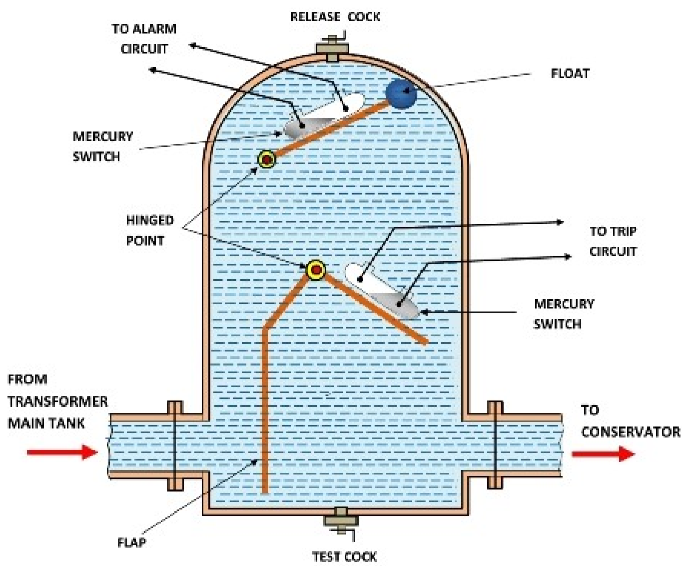
Buchholz relay is a safety device which is generally used in large oil immersed transformers (rated more than 500 kVA). It is a type of oil and gas actuated protection relay. It is used for the protection of a transformer from the faults occurring inside the transformer, such as impulse breakdown of the insulating oil, insulation failure of turns etc.

Working Principle Of Buchholz Relay

Whenever a fault occurs inside the transformer, such as insulation failure of turns, breakdown of core or excess core heating, the fault is accompanied by production of excess heat. This excess heat decomposes the transformer insulating oil which results in production of gas. The generation of gases depend on intensity the of fault. Gas bubbles tend to flow in upward direction towards conservator and hence they are collected in the buchholz relay which is placed on the pipe connecting the transformer tank and conservator.

Construction

Buchholz relay consists of an oil filled chamber. There are two hinged floats, one at the top and other at the bottom in the chamber. Each float is accompanied by a mercury switch. The mercury switch on the upper float is connected to an alarm circuit and that on the lower float is connected to an external trip breaker.



Working Principle of Buchholz Relay

Whenever a minor fault occurs inside the transformer, heat is produced by the fault currents. The produced heat causes decomposition of transformer oil and gas bubbles are produced. These gas bubbles flow in upward direction and get collected in the buchholz relay. The collected gas displaces the oil in buchholz relay and the displacement is equivalent to the volume of gas collected. The displacement of oil causes the upper float to close the upper mercury switch which is connected to an alarm circuit. Hence, when minor fault occurs, the connected alarm gets activated. The collected amount of gas indicates the severity of the fault occurred. During minor faults the production of gas is not enough to move the lower float. Hence, during minor faults, the lower float is unaffected.
During major faults, like phase to earth short circuit, the heat generated is high and a large amount of gas is produced. This large amount of gas will similarly flow upwards, but its motion is high enough to tilt the lower float in the buccholz relay. In this case, the lower float will cause the lower mercury switch which will trip the transformer from the supply, i.e. transformer is isolated from the supply.

Advantages Of Buchholz Relay

- Buchholz relay indicates the internal faults due to heating and it helps in avoiding the major faults.
- Severity of the fault can be determined without even dismantling the transformer.
- If a major fault occurs, the transformer can be isolated with the help of buchholz relay to prevent accidents.

(OR)

3.a)Describe impedance type distance relay with relative characteristics.(2+2+2=6M)

The relay whose working depends on the distance between the impedance of the faulty section and the position on which relay installed is known as the impedance relay or distance relay. It is a voltage controlled equipment.

The relay measures the impedance of the faulty point, if the impedance is less than the impedance of the relay setting, it gives the tripping command to the circuit breaker for closing their contacts. The impedance relay continuously monitors the line current and voltage flows through the CT and PT respectively. If the ratio of voltage and current is less than the relay starts operating then the relay starts operating.

Principle of Operation of Impedance Relay

In the normal operating condition, the value of the line voltage is more than the current. But when the fault occurs on the line the magnitude of the current rises and the voltage becomes less. The line current is inversely proportional to the impedance of the transmission line. Thus, the impedance decreases because of which the impedance relay starts operating.

The figure below explains the impedance relay in much easier way. The potential transformer supplies the voltage to the transmission line and the current flows because of the current transformer. The current transformer is connected in series with the circuit.

Consider the impedance relay is placed on the transmission line for the protection of the line AB. The Z is the impedance of the line in normal operating condition. If the impedances of the line fall below the impedance Z then the relay starts working.

Let, the fault F1 occur in the line AB. This fault decreases the impedance of the line below the relay setting impedance. The relay starts operating, and its send the tripping command to the circuit breaker. If the fault reached beyond the protective zone, the contacts of the relay remain unclosed.

Operating Characteristic of an Impedance Relay

The voltage and the current operating elements are the two important component of the impedance relay. The current operating element generates the deflecting torque while the voltage storage element generates the restoring torque. The torque equation of the relay is shown in the figure below

$$T = k_1 I^2 - k_2 V^2 \; -$$

The $-K_3$ is the spring effect of the relay. The V and I are the value of the voltage and current. When the relay is in normal operating condition, then the net torque of the relay becomes zero.

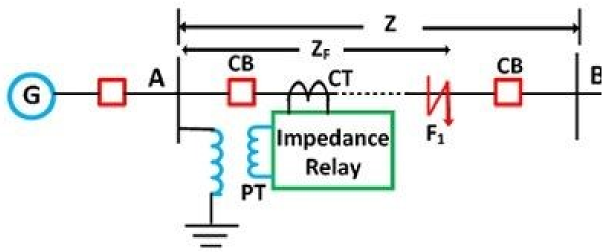
$$k_2 V^2 = k_1 I^2 -$$

$$\frac{V}{I} = Z = \sqrt{\frac{k_1}{k_2} - \frac{}{k}}$$

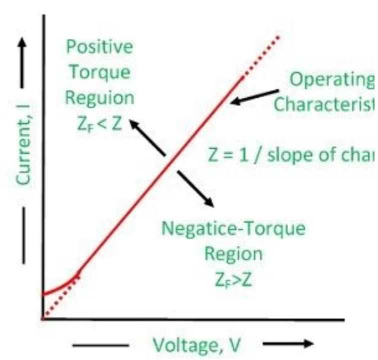
If the spring control effect becomes neglected, the equation becomes

$$Z = \sqrt{\frac{k_1}{k_2}} = Const$$

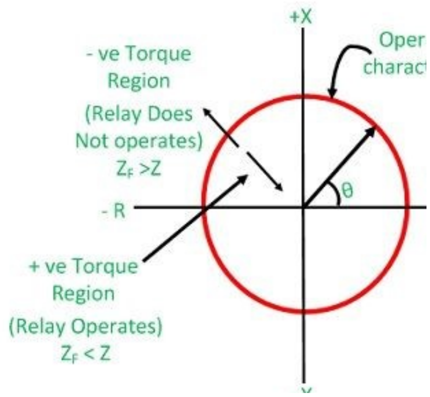
The operating characteristic concerning the voltage and current is shown in the figure below. The dashed line in the image represents the operating condition at the constant line impedance.



The operating characteristic of the impedance relay is shown in the figure below. The positive torque region of the impedance relay is above the operating characteristic line. In positive torque region, the impedance of the line is more than the impedance of the faulty section. Similarly, in negative region, the impedance of the faulty section is more than the line impedance



The impedance of the line is represented by the radius of the circle. The phase angle between the X and R axis represents the position of the vector. If the impedance of the line is less than the radius of the circle, then it shows the positive torque region. If the impedance is greater than the negative region, then it represents the negative torque region.

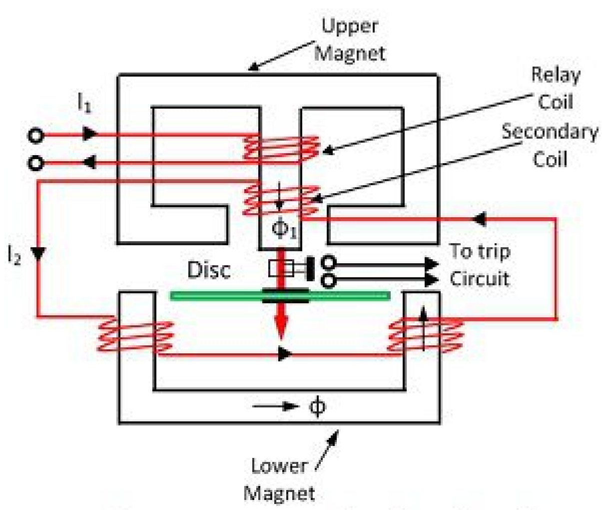


This type of relay is called the high-speed relay.

b) Describe the construction and principle of operation of an induction type disc relay.
(3+3=6M)

Watt-hour Meter Structure

This structure consists E shape electromagnet and a U shape electromagnet with a disc-free to rotate in between them. The phase displacement between the fluxes produced by the electromagnet is obtained by the flux generated by the two magnets having different resistance and inductance for the two circuits.



Watt-hour Meter Type Induction Disc Relay

The E-shaped electromagnet carries the two windings the primary and the secondary. The primary current was carrying the relay current I_1 while the secondary winding is connected to the windings of the U-shaped electromagnet.

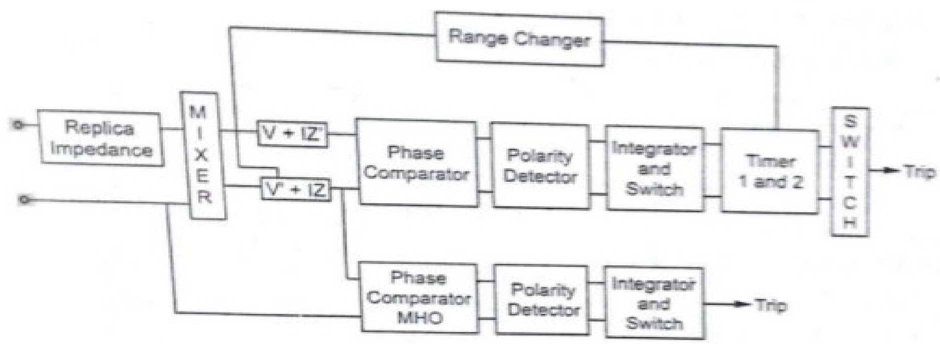
The primary winding carries relay current I_1 while the secondary current induces the emf in the secondary and so circulate the current I_2 in it. The flux φ_1 induces in the E shed magnet, and the flux φ induces in the U-shaped magnet. These fluxes induced in the upper and lower magnetic differs in phase by angle θ which will develop a driving torque on the disc proportional to $\varphi_1\varphi$ $\sin\theta$.

The most important feature of the relay is that opening can control their operation or close the secondary winding circuit. If the secondary winding is opened, then no torque will be developed, and thus relay can be made inoperative.

UNIT II

4.a) With the help of block diagram explain the function of a static distance relay.(3+3=6M)

- In the distance relay, the operation is dependent on the ratio of the voltage and current, which is expressed in terms of impedance. The relay operates when the ratio V/I i.e.,



- The measurement of impedance, reactance, and admittance are done by comparison of input current and voltage. In static comparators the two input quantities are either V or I.
- Current is converted to equivalent voltage by producing a voltage drop in impedance with in the relay.
- This voltage drop is then compared with the other voltage.
- The output from the comparator is fed into a polarity detector where, when the input currents to the comparator are 90 apart, the output device will be turned on for +90 and turned -90 and hence the output wave will be a square wave with equal space ratios.
- Static distance relay are used extremely for protection of medium and long transmission lines, parallel feeders and unit back up protections as well as interconnected lines.

b)State the advantages of static relays over electromagnetic relays.(1*6=6M)

1.No moving contacts; hence associated problems of arcing, contact bounce, erosion, replacement of contacts

2.Low power consumption as low as 1mW

3.No gravity effect on operation of static relays. Hence can be used in vessels ie, ships, aircrafts etc.

4.A single relay can perform several functions like over current, under voltage, single phasing protection by incorporating respective functional blocks. This is not possible in electromagnetic relays

4.Static relay is compact

5.Superior operating characteristics and accuracy

6.Static relay can think , programmable operation is possible with static relay

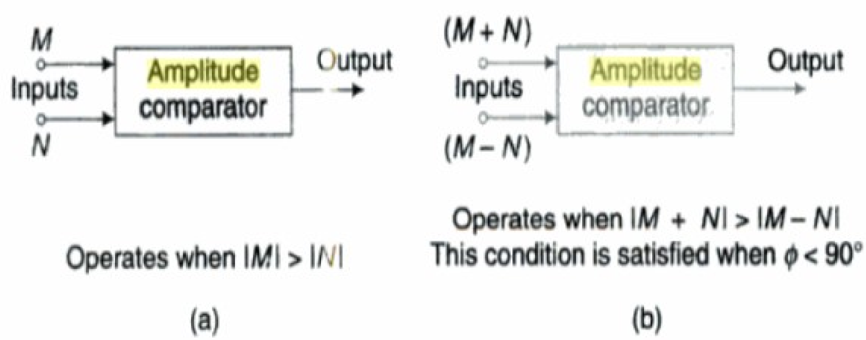
7.Effect of vibration is nil, hence can be used in earthquake-prone areas o Simplified testing and servicing. Can convert even non-electrical quantities to electrical in conjunction with transducers.

(OR)

5.Explain duality between amplitude and phase comparators.(6+6=12M)

Duality between Amplitude and Phase Comparators

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.



(a) Amplitude comparator (b) Amplitude comparator used for phase comparison

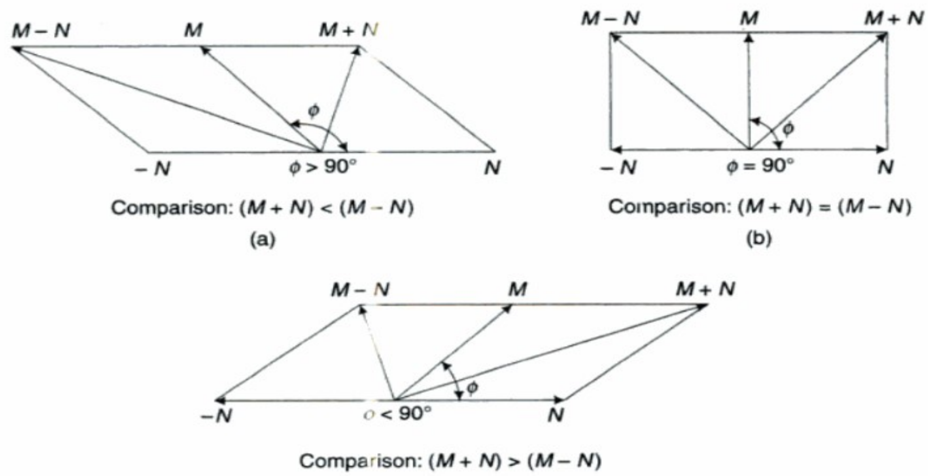


Fig. 2.20 *Phasor diagram for amplitude comparator used for phase comparison*

Similarly, consider a phase comparator shown in Fig. 2.21(a). It compares the phases of input signals M and N. If the phase angle between M and N, i.e. angle ϕ is less than 90°, the comparator operates. Now change the input, signals to $(M + N)$ and $(M - N)$, as in Fig. 2.21(b). With these changed inputs the comparator will operate when phase angle between $(M + N)$ and $(M - N)$, i.e. angle λ is less than 90°. This condition will be satisfied only when $|M| > |N|$. In other words, the phase comparator with changed inputs has now become an amplitude comparator for the original input signals M and N. This has been illustrated with phasor diagrams as shown in Fig. 2.22.

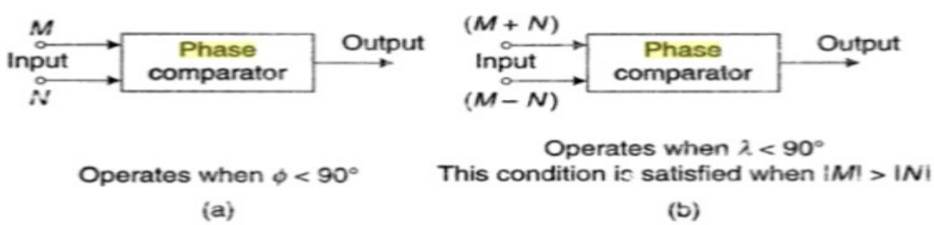


Fig. 2.21 *(a) Phase comparator (b) Phase comparator used for amplitude comparison*

Figure 2.20 shows three phasor diagrams for an amplitude comparator. The phase angle between the original inputs M and N is ϕ. Now the inputs to the amplitude comparator are changed to $(M + N)$ and $(M - N)$ and its behaviour is examined with the help of three phasor diagrams. The three phasor diagrams are with phase angle ϕ (*i*) greater than 90°, (ii) equal to 90° and (iii) less than 90°, respectively. When ϕ is less than 90°, $|M + N|$ become greater than $|M - N|$ and the relay operates with the modified inputs. When ϕ is equal to 90° or greater than 90°, the relay does not operate.

The phasor diagrams show that $|M + N|$ becomes greater than $|M - N|$ only when ϕ

is less than 90°. This will be true irrespective of the magnitude of M and N. In other words, this will be true whether $|M| = |N|$ or $|M| > |N|$ or $|M| < |N|$. The figures have been drawn with $|M| = |N|$. The reader can draw phasor diagrams with $|M| < |N|$ or $|M| > |N|$. The results will remain the same. This shows that with changed inputs, the amplitude comparator is converted to a phase comparator for the original inputs.

Figure 2.22 shows three phasor diagrams for a phase comparator. The original inputs are M and N. Now the inputs of the phase comparators are changed to $(M + N)$ and $(M - N)$, and its behavior is examined with the help of three phasor diagrams drawn for (i) $|M| < |N|$, (ii) $|M| = |N|$ and (iii) $|M| > |N|$. The angle between $(M + N)$ and $(M - N)$ is λ. The angle λ becomes less than 90° only when $|M| > |N|$. As the comparator under consideration is a phase comparator, the relay will trip. But for the original inputs M and N, the comparator behaves as an amplitude comparator. This will be true irrespective of the phase angle ϕ between M and N. The figure has been drawn with ϕ less than 90°. The reader can check it by drawing phasors with $\phi = 90°$ or $\phi > 90°$. The result will remain the same.

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UNIT III

6.a) Explain the translay relay with neat sketch. (3+3=6M)

Translay System:

This system is the modified form of voltage-balance system. Although the principle of balanced (opposed) voltages is retained, it differs from the above voltage-balance system in that the balance or opposition is between voltages induced in the secondary coils wound on the relay magnets and not between the secondary voltages of the line current transformers. Since the current transformersused with Translay System have only to supply to a relay coil, they can be made of normal design without any air gaps. This permits the scheme to be used for feeders of any voltage.

Constructional details: Fig. shows the simplified diagram illustrating the principle of Translay System. It consists of two identical double winding induction type relays fitted at either end of the feeder to be protected. The primary circuits (11, 11a) of these relays are supplied through a pair of current transformers. The secondary windings (12, 13 and 12a, 13a) of the two relays are connected in series by pilot wires in such a way that voltages induced in the former opposes the other. The compensating devices (18, 18a) neutralize the effects of pilot-wire capacitance currents and of inherent lack of balance between the two current transformers.

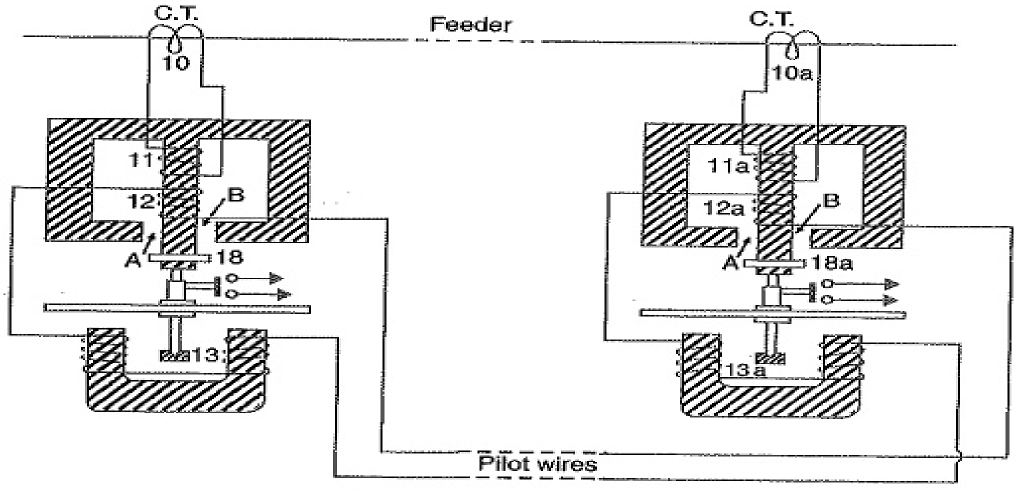


Fig. 21.28

Operation: Under healthy conditions of Translay System, current at the two ends of the protected feeder is the same and the primary windings (11,11a) of the relays carry the same current. The windings 11 and 11a induce equal emits in the secondary windings 12, 12a and 13, 13a. As these windings are so connected that their induced voltages are in opposition, no current will flow through the pilots or operating coils and hence no torque will be exerted on the disc of either relay. In the event of fault on the protected feeder, current leaving the feeder will differ from the current entering the feeder. Consequently, unequal voltages will be induced in the secondary windings of the relays and current will circulate between the two windings, causing the torque to be exerted on the disc of each relay.

As the direction of secondary current will be opposite in the two relays, therefore, the torque in one relay will tend to close the trip circuit while in the other relay, the torque will hold the movement in the normal unoperated position. It may be noted that resulting operating torque depends upon the position and nature of the fault in the protected zone and at least one element of either relay will operate under any fault condition.

It is worthwhile here to mention the role of closed copper rings (18, 18a) in neutralizing the effects of pilot capacitive currents. Capacitive currents lead the voltage impressed across the pilots by 90° and when they flow in the operating winding 13 and 13a (which are of low inductance), they produce fluxes that also lead the pilot voltage by 90°.

Since pilot voltage is that induced in the secondary windings 12 and 12a, it lags by a substantial angle behind the fluxes in the field magnet air gaps A and B. The closed copper rings (18, 18a) are so adjusted that this angle is approximately 90°. In this way fluxes acting on the disc are in phase and hence no torque is exerted on the relay disc.

6.b) What are the objectives of earthing. 6M

Objective of safety grounding –

-To provide means to carry electric currents into the earth under normal and fault conditions without exceeding any operating and equipment limits or adversely affecting continuity of service.

-to assure that a person in the vicinity of grounded facilities is not exposed to the danger of critical electric shock.
So **objective of earthing** are as follows

- Fixing the potential of live conductors with respect to the earth in normal operation,
- Limiting voltage between the non-current carrying parts in electrical system (such as frames of electrical equipment) and the earth should an insulation fault occur.
- Implementing protection devices which remove the risk of electric shocks or electrocution of person;
- In low voltage network limiting rises in potential due to Medium Voltage faults.

(OR)

7.a)What are the merits and demerits of resistance grounding compared to solid grounding?(3+3=6M)

1. By adjusting the value of R, the arcing grounds can be minimized. Suppose earth fault occurs in phase B as shown in Fig. 26.14. The capacitive currents I_R and I_Y flow in the healthy phases R and Y respectively. The fault current I_F lags behind the phase voltage of the faulted phase by a certain angle depending upon the earthing resistance R and the reactance of the system upto the point of fault. The fault current I_F can be resolved into two components viz.

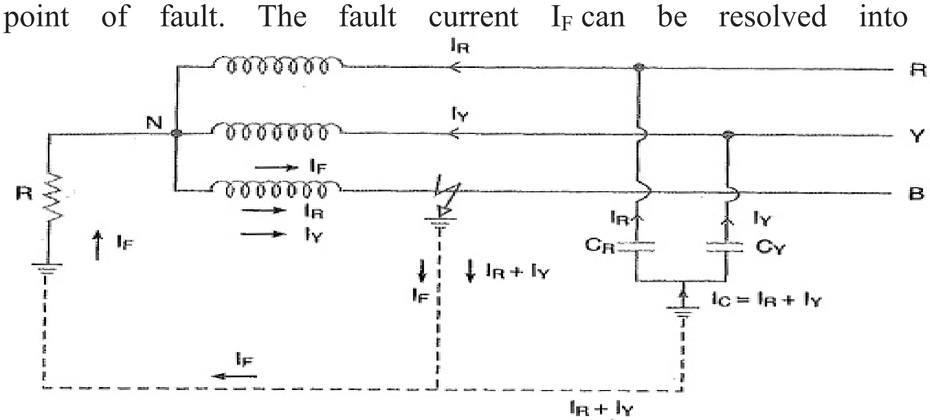


Fig. 26.14

I_{F2} lagging behind the faulty phase voltage by 90°.

The lagging component I_{F2} is in phase opposition to the total capacitive current I_C. If the value of earthing resistance R is so adjusted that $I_{F2} = I_C$, the arcing ground is completely eliminated and the operation of the system becomes that of solidly grounded system. However, if R is so adjusted that $I_{F2} < I_C$, the operation of the system becomes that of ungrounded neutral system.

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.

The following are the disadvantages of resistance grounding :

1. Since the system neutral is displaced during earth faults, the equipment has to be insulated for higher voltages.

2. This system is costlier than the solidly grounded system.

3. A large amount of energy is produced in the earthing resistance during earth faults. Sometimes it becomes difficult to dissipate this energy to atmosphere.

Applications:

It is used on a system operating at voltages between 2.2 kV and 33 kV with power source capacity more than 5000 kVA.

7.b) Explain the principle of differential system of protection applied to power transformers. (3+3=6M)

The transformer is one of the major equipment in power system. It is a static device, totally enclosed and usually oil immersed, and therefore the fault occurs on them are usually rare. But the effect of even a rare fault may be very serious for a power transformer. Hence the protection of power transformer against possible fault is very important.

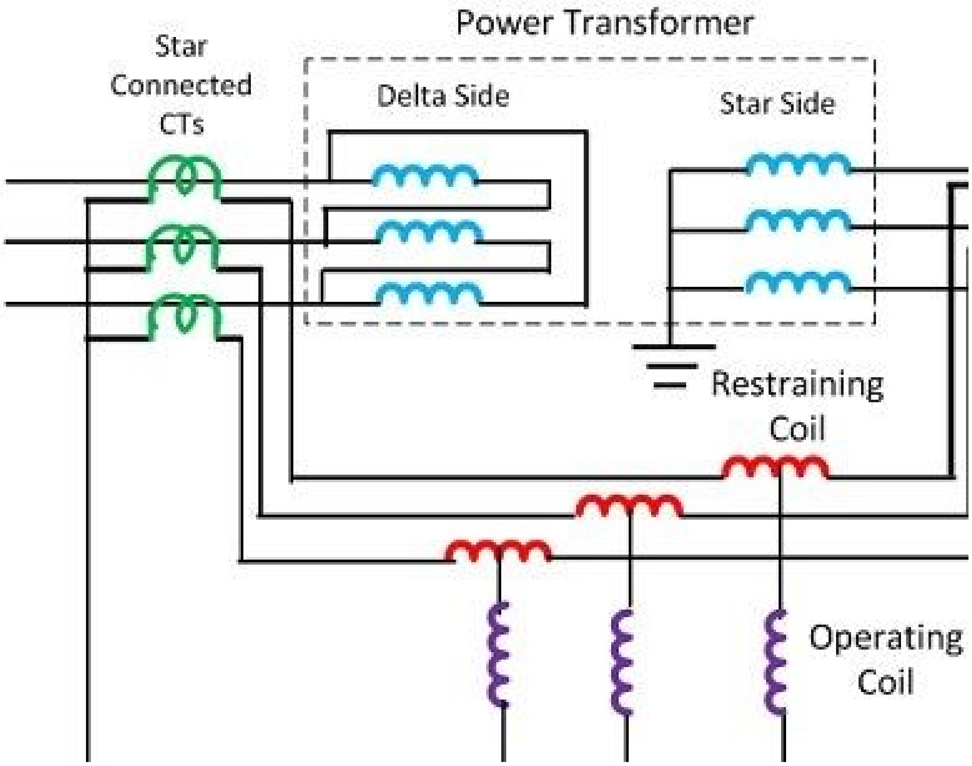
The fault occurs on the transformer is mainly divided into two type external faults and internal fault. External fault is cleared by the relay system outside the transformer within the shortest possible time in order to avoid any danger to the transformer due to these faults. The protection for internal fault in such type of transformer is to be provided by using differential protection system.

Differential protection schemes are mainly used for protection against phase-to-phase fault and phase to earth faults.The differential protection used for power transformers is based on Merz-Prize circulating current principle. Such types of protection are generally used for transformers of rating exceeding 2 MVA.

Connection for Differential Protection for Transformer

The power transformer is star connected on one side and delta connected on the other side. The CTs on the star connected side are delta-connected and those on delta-connected side are star-connected. The neutral of the current transformer star connection and power transformer star connections are grounded.

The restraining coil is connected between the secondary winding of the current transformers. Restraining coils controls the sensitive activity occurs on the system. The operating coil is placed between the tapping point of the restraining coil and the star point of the current transformer secondary windings.



Working of Differential Protection System

Normally, the operating coil carries no current as the current are balanced on both the side of the power transformers. When the internal fault occurs in the power transformer windings the balanced is disturbed and the operating coils of the differential relay carry current corresponding to the difference of the current among the two sides of the transformers.Thus, the relay trip the main circuit breakers on both sides of the power transformers.

UNIT IV

8.a) State the theories postulated to explain the arc extinction phenomenon and explain the significance of restriking voltage in the arc extinction process.(2+4=6M)

• **Energy balance or Cassie theory:**

This theory states that if the rate of heat dissipation between the contacts is greater than the rate at which heat is generated, the arc will be extinguish, otherwise it will restrike. During the faults the high heat is produced due to the higher voltage gradient or the high current densities between the contacts. Thus if the heat generated could be removed by cooling, lengthening or by arc splitter at a higher rate than the generation of the arc, then the arc will be extinguish.

• Recovery rate or Slepian's theory:

This theory states that is the rate at which the ions and the electrons combine to form or are replaced by the neutral molecules i.e. the rate at which the gap recovers its dielectrics strength is faster then the rate at which voltage stress rises, the arc will be extinguished: if otherwise the arc may be interrupted for a brief period but it again restrike. So in this process when the current is at zero value, the fresh air is entered to neutral the electrons.

RESTRIKING VOLTAGE IN CIRCUIT BREAKER

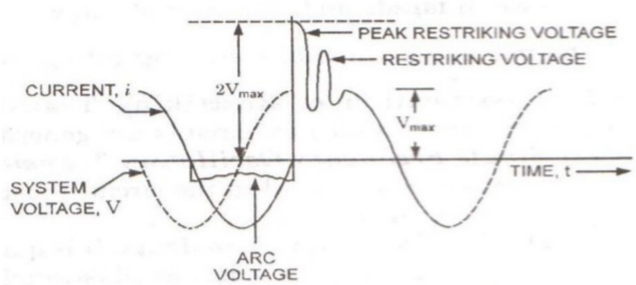
In ac circuit breakers, the current interruption takes place invariably at the natural zeroes of current wave.

• At current zero, a high frequency transient voltage appears across the breaker contacts and is caused by the rapid distribution of energy between the magnetic and electric fields associated with the plant and transmission line of the power system.

• This transient voltage is known as the restriking voltage. This voltage appearing across the breaker contacts at the moment of final current zero has a profound influence on the arc extinction process.

• Under the influence of this voltage the arc tries to restrike and hence it is named as restriking voltage. After current zero, the arc gets extinguished if the rate of rise of restriking voltage between the contacts is less than the rate at which dielectric strength of the medium between the contacts recovered.

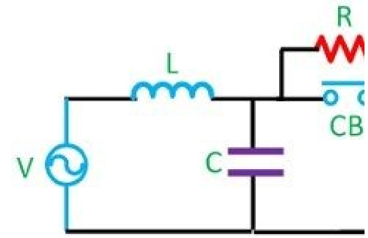
• Thus, restriking voltage may be defined as the resultant transient voltage which appears across the breaker contacts at the instant of arc extinction.



(c) Operating of a Circuit Breaker
Fig. 5.7

b)Explain about the resistance switching. (3+3=6M)

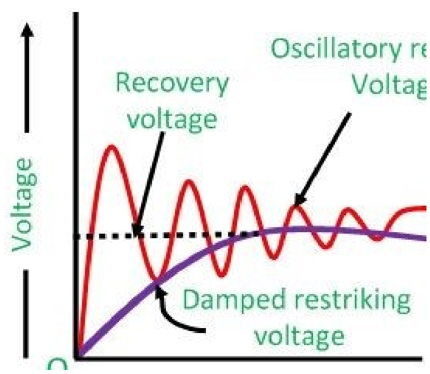
A fixed connection of resistance in parallel with the contact space or arc is called the resistance switching. Resistance switching is employed in circuit breakers having a high post zero resistance of contact space. The resistance switching is mainly used for reducing the restriking voltage and the transient voltage surge. Severe voltage occurs in the system because of two reasons, firstly because of the breaking of low voltage current, and secondly because of the breaking of capacitive current. The severe voltage may endanger the operation of the system. It can be avoided by using resistance switching (by connecting the resistor



across the contacts of the circuit breaker).

When the fault occurs, the contacts of the circuit breaker are open, and an arc is struck between the contacts. With the arc shunted by the resistance **R**, a part of arc current is diverted through the resistance. This results in the decreases of arc current and an increase in the rate of deionization of the arc path.

Thus, the arc resistance is increased, leading to the further increase in current through the shunt resistance **R**. This builds up process continue until the current becomes so small that it fails to maintain the arc shown in the figure below. Now the arc is extinguished, and the circuit breaker gets interrupted.



Alternatively, the resistance may be automatically switched in by transference of the arc from the main contacts to the probe contact as in the case of an axial blast circuit breaker, the time required for this action is very small. Having the arc path substituted by a metallic path, the current flowing through the resistance is limited and then easily broken.

The shunt resistor also helps in limiting the oscillatory growth of restriking voltage transients. It can be proved mathematically that the natural frequency (f_n) of oscillations of the circuit shown is given as

$$f_n = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{\quad}{4C}}$$

To sum up, resistor across the circuit breaker contacts may be used to perform any one or more of the following functions.

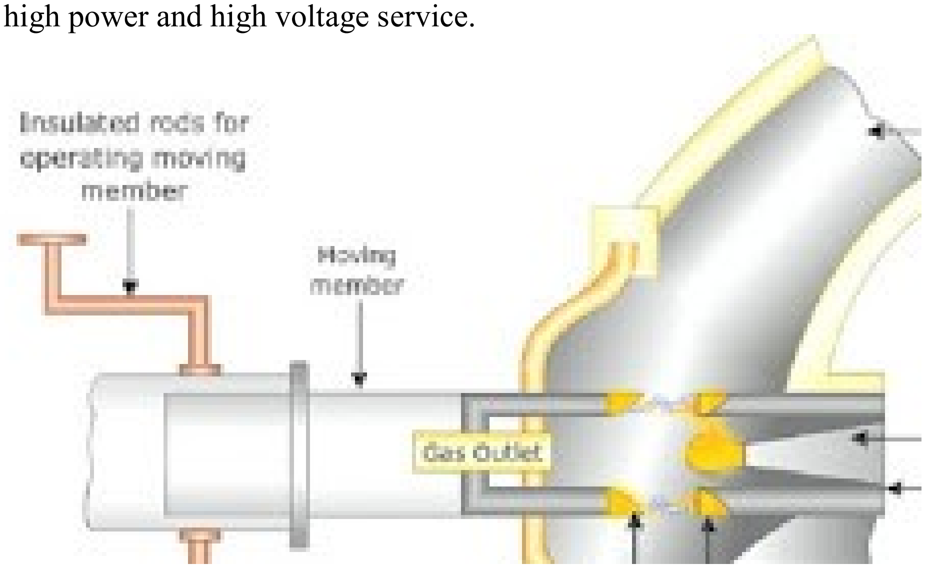
- It reduces the RRRV (Rate of Rising of Restriking Voltage) burden on the circuit breaker.
- It reduces the high-frequency restriking voltage transients during switching out inductive or capacitive loads.
- In a multi-break circuit breaker, it helps in distributing the transient recovery voltage more uniformly across the contact gaps.

The resistance switching is not required in the plan circuit breaker because their contact space is low.

(OR)

9.a)Explain the working principle of SF6 circuit breaker.(3+3=6M)

In SF6 circuit breakers, sulphur hexafluoride (SF6) gas is used as the arc quenching medium. The SF6 is an electro-negative gas and has a strong tendency to absorb free electrons. The contacts of the breaker are opened in a high-pressure flow of SF6 gas and an arc is struck between them. The conducting free electrons in the arc are rapidly captured by the gas to form relatively immobile negative ions. This loss of conducting electrons in the arc quickly builds up enough insulation strength to extinguish the arc. The SF6 circuit breakers have been found to be very effective for high power and high voltage service.



Working Principle of SF6 circuit breaker:

In the closed position of the **SF6 circuit breaker**, the contacts remain surrounded by SF6 gas at a pressure of about 2·8 kg/cm2. When the breaker operates, the moving contact is pulled apart and an arc is struck between the contacts. The movement of the moving contact is synchronised with the opening of a valve which permits SF6 gas at 14 kg/cm2 pressure from the reservoir to the arc interruption chamber.

The high-pressure flow of SF6 rapidly absorbs the free electrons in the arc path to form immobile negative ions which are ineffective as charge carriers. The result is that the medium between the contacts quickly builds up high dielectric strength and causes the extinction of the arc. After the breaker operation (i.e., after arc extinction), the valve is closed by the action of a set of springs.

b)State the advantages and disadvantages of SF6 circuit breaker.(3+3=6M)

SF6 circuit breakers Advantages:

Due to the superior arc quenching properties of SF6 gas, the **SF6 circuit breakers** have many advantages over oil or air circuit breakers. Some of them are listed below :

(i) Due to the superior arc quenching property of SF6, such circuit breakers have very short arcing time.

(ii) Since the dielectric strength of SF6 gas is 2 to 3 times that of air, such breakers can interrupt much larger currents.

(iii) The **SF6 circuit breaker** gives noiseless operation due to its closed gas circuit and no exhaust to atmosphere, unlike the air blast circuit breaker.

(iv) The closed gas enclosure keeps the interior dry so that there is no moisture problem.

(v) There is no risk of fire in such breakers because SF6 gas is non-inflammable.

(vi) There are no carbon deposits so that tracking and insulation problems are eliminated.

(vii) The **SF6 Circuit breakers** have a low maintenance cost, light foundation requirements and minimum auxiliary equipment.

(viii) Since SF6 breakers are totally enclosed and sealed from the atmosphere, they are particularly suitable where explosion hazard exists e.g., coal mines.

SF6 circuit breakers Disadvantages:

(i) SF6 breakers are costly due to the high cost of SF6.

(ii) Since SF6 gas has to be reconditioned after every operation of the breaker, additional equipment is required for this purpose.

SF6 circuit breakers Applications:

A typical **SF6 circuit breaker** consists of interrupter units each capable of dealing with currents up-to 60 kA and voltages in the range of 50—80 kVA number of units are connected in series according to