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Internal Assesment Test - II

Sub:	Switchgear and Protection							Code:	10EE62
Date:	09 / 05 / 2017	Duration:	90 mins	Max Marks:	50	Sem:	6th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1 (a)	Explain in detail the synthetic testing of a circuit breaker.	[10]	CO2	L4
2 (a)	List the various causes of overvoltage in power systems.	[04]	CO6	L1
(b)	Explain the basic principle of operation of a lightning arrester.	[06]	CO6	L4
3 (a)	Explain the characteristics of good protective relaying.	[10]	CO3	L4
4 (a)	What do you mean by zone of protection? What is the primary and back up protection in a power system?	[10]	CO2	L1
5 (a)	With a neat sketch explain Non-Directional Over current relay.	[10]	CO3	L4
6 (a)	Explain microprocessor-based over-current relay with a block diagram.	[07]	CO3	L4
(b)	Draw the R-X diagram of Reactance relay.	[03]	CO3	L1
7 (a)	The current rating of an over current relay is 5A. It has a PSM = 2, TSM = 0.3, CT ratio = 400/5, Fault current = 4000A. Determine the time of operation of the relay assuming IDMT characteristics as given below.	[05]	CO3	L3

PSM	2	4	5	8	10	20
Operating Time	10	5	4	3	2.8	2.4

(b)	With a neat sketch, explain the expulsion-type lightning arrester.	[05]	CO6	L4
8 (a)	With a neat sketch explain Buchholz relay.	[10]	CO3	L4

1.

11.16. SYNTHETIC TESTING

Fig. 11.9 illustrates the principle of synthetic testing.

The synthetic test employs two sources namely.

(1) Current source (of relatively low voltage)

(2) Voltage source (of relatively low current).

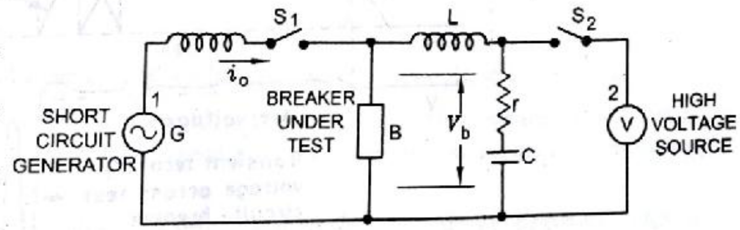


Fig. 11.9. Synthetic Testing Test Circuit (simplified).

The current source provides short-circuit current. The voltage source provides restriking voltage plus recovery voltage. Other L, r, C etc. are used to get desired test conditions. The switch S_1 is closed to supply short-circuit current L_G. At near final current zero switch S_2 (which is usually a spark gap) is closed and V_3 is applied to the breaker at an appropriate moment. The voltage will have transient because of L and C of the circuit.

The advantages of this method are the following.

(1) The breaker can be tested for desired TRV and R.R.R.V.

(2) The short-circuit generator has to supply currents at a relatively less voltage (as compared to direct testing).

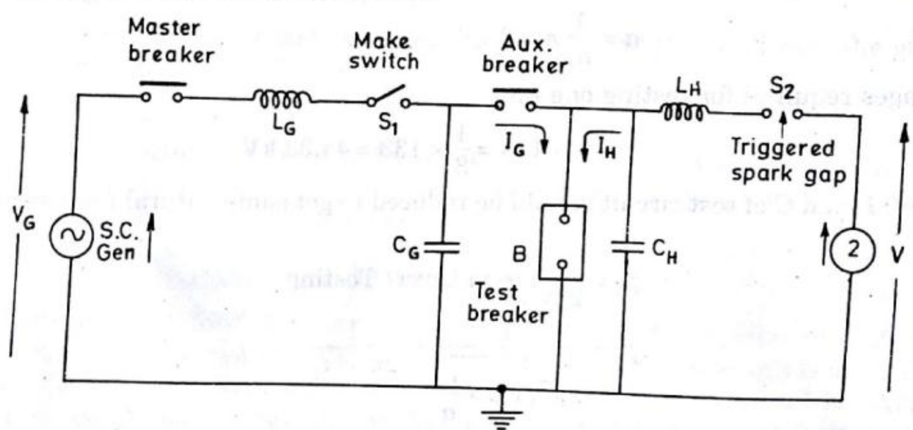
(3) Both test current and test voltage can be independently varied. This gives flexibility to the test.

(4) The method is simple. It can be applied to unit testing also.

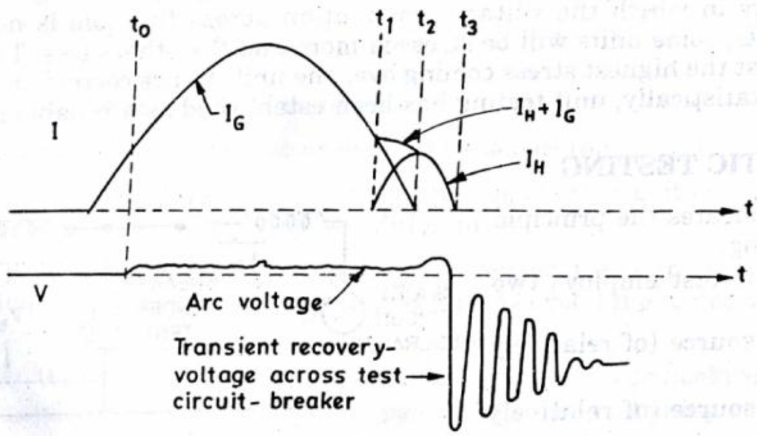
(5) With this method a breaker of capacity (MVA) of five time that of the capacity (MVA) of the test plan can be tested.

Types of Synthetic Test Circuits

There are two types of synthetic test circuit.



(*a*) Parallel current injection



(*b*) Waveforms

Fig. 11.10. Synthetic Test Circuit and waveform based on Parallel Current Injection Method.

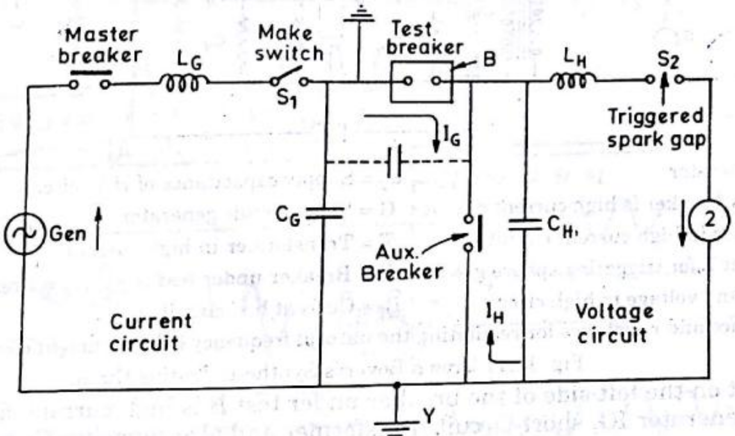
[In parallel current injection method, voltage circuit (2) is effectively connected in parallel with current (1) and the test breaker 'B' before the main current I_G reaches zero. This method is widely used for synthetic test circuits for getting frequencies of TRV]

— Parallel Current Injection Method (Fig. 11.10)

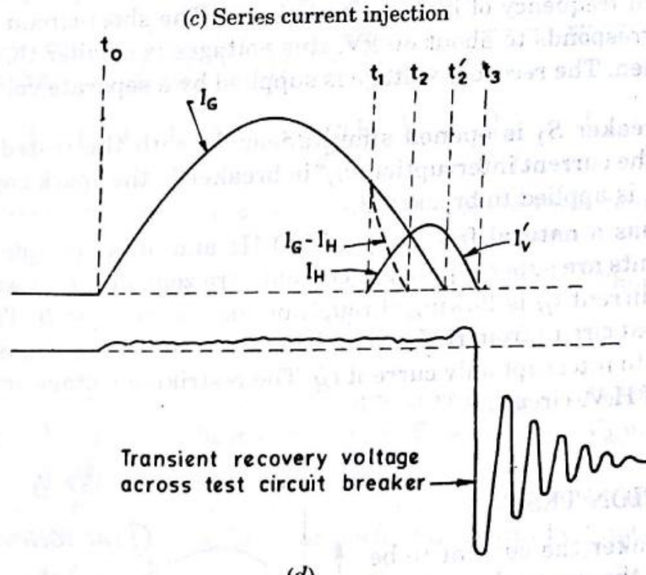
— Series Current Injection Method

Parallel Current Injection Method widely used for testing circuit-breakers because it can give high frequency transient voltages as required by standards.

Ref. 11.10 (*a*). In parallel current injection method, the voltage circuit (2) is effectively connected *in parallel* with current circuit (1) and the test breaker *before* the main current I_G in test breaker current is properly simulated.



(*c*) Series current injection



(*d*)

Fig. 11.10. Synthetic Test Circuit and waveform based on Series Current Injection Method.

2.

(a)

The overvoltages on a power system may be broadly divided into two main categories *viz.*

1. **Internal causes**

(*i*) Switching surges (*ii*) Insulation failure

(*iii*) Arcing ground (*iv*) Resonance

2. **External causes** *i.e.* lightning

(b)

The earthing screen and ground wires can well protect the electrical system against direct lightning strokes but they fail to provide protection against travelling waves which may reach the terminal apparatus. The lightning arresters or surge diverters provide protection against such surges.

A **lightning arrester** *or a* **surge diverter** *is a protective device which conducts the high voltage surges on the power system to the ground.*

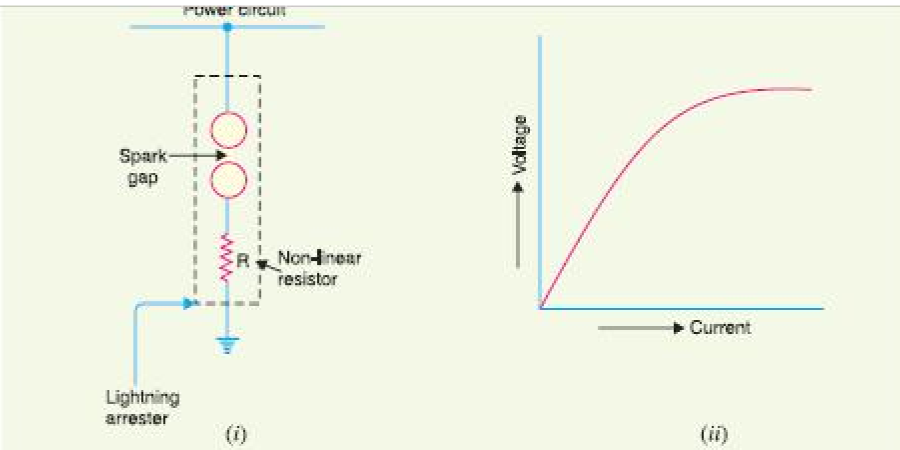


Fig. 24.8

Fig. 24.8 (*i*) shows the basic form of a surge diverter. It consists of a spark gap in series with a non-linear resistor. One end of the diverter is connected to the terminal of the equipment to be protected and the other end is effectively grounded. The length of the gap is so set that normal line voltage is not enough to cause an arc across the gap but a dangerously high voltage will break down the air insulation and form an arc. The property of the non-linear resistance is that its resistance decreases as the voltage (or current) increases and vice-versa. This is clear from the *volt/amp characteristic of the resistor shown in Fig. 24.8 (*ii*).

Action. The action of the lightning arrester or surge diverter is as under :

(*i*) Under normal operation, the lightning arrester is off the line *i.e.* it conducts **no current to earth or the gap is non-conducting.

(*ii*) On the occurrence of overvoltage, the air insulation across the gap breaks down and an arc is formed, providing a low resistance path for the surge to the ground. In this way, the excess charge on the line due to the surge is harmlessly conducted through the arrester to the ground instead of being sent back over the line.

(*iii*) It is worthwhile to mention the function of non-linear resistor in the operation of arrester. As the gap sparks over due to overvoltage, the arc would be a short-circuit on the power system and may cause power-follow current in the arrester. Since the characteristic of the resistor is to offer high resistance to high voltage (or current), it prevents the effect of a short-circuit. After the surge is over, the resistor offers high resistance to make the gap non-conducting.

Two things must be taken care of in the design of a lightning arrester. Firstly, when the surge is over, the arc in gap should cease. If the arc does not go out, the current would continue to flow through the resistor and both resistor and gap may be destroyed. Secondly, IR drop (where I is the surge current) across the arrester when carrying surge current should not exceed the breakdown strength of the insulation of the equipment to be protected.

time-delay, the main relay closes the contact of a back-up relay which trips all other circuit breakers on the bus if the proper breaker does not trip within a specified time after its trip coil is energised.

1.9 Essential Qualities of Protection

The basic requirements of a protective system are as follows:

(i) Selectivity or discrimination
(ii) Reliability
(iii) Sensitivity
(iv) Stability
(v) Fast Operation

1.9.1 *Selectivity or Discrimination*

Selectivity, is the quality of a protective relay by which it is able to discriminate between a fault in the protected section and the normal condition. Also, it should be able to distinguish whether a fault lies within its zone of protection or outside the zone. Sometimes, this quality of the relay is also called discrimination. When a fault occurs on a power system, only the faulty part of the system should be isolated. No healthy part of the system should be deprived of electric supply and hence should be left intact. The relay should also be able to discriminate between a fault and transient conditions like power surges or inrush of a transformer's magnetising current. The magnetising current of a large transformer is comparable to a fault current, which may be 5 to 7 times the full load current. When generators of two interconnected power plants lose synchronism because of disturbances, heavy currents flow through the equipment and lines. This condition is like a short circuit. The flow of heavy currents is known as a power surge. The protective relay should be able to distinguish between a fault or power surge either by its inherent characteristic or with the help of an auxiliary relay. Thus, we see that a protective relay must be able to discriminate between those conditions for which instantaneous tripping is required and those for which no operation or a time-delay operation is required.

1.9.2 *Reliability*

A protective system must operate reliably when a fault occurs in its zone of protection. The failure of a protective system may be due to the failure of any one or more elements of the protective system. Its important elements are the protective relay, circuit breaker, P.T., C.T., wiring, battery, etc. To achieve a high degree of reliability, greater attention should be given to the design, installation, maintenance and testing of the various elements of the protective system. Robustness and simplicity of the relaying equipment also contribute to reliability. The contact pressure, the contact material of the relay, and the prevention of contact contamination are also very important from the

3.

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high contact P, workmanship

reliability point of view. A typical value of reliability of a protective scheme is 95%.

1.9.3 Sensitivity

A protective relay should operate when the magnitude of the current exceeds the preset value. This value is called the pick-up current. The relay should not operate when the current is below its pick-up value. A relay should be sufficiently sensitive to operate when the operating current just exceeds its pick-up value.

1.9.4 Stability

A protective system should remain stable even when a large current is flowing through its protective zone due to an external fault, which does not lie in its zone. The concerned circuit breaker is supposed to clear the fault. But the protective system will not wait indefinitely if the protective scheme of the zone in which fault has occurred fails to operate. After a preset delay the relay will operate to trip the circuit breaker.

1.9.5 Fast Operation

A protective system should be fast enough to isolate the faulty element of the system as quickly as possible to minimise damage to the equipment and to maintain the system stability. For a modern power system, the stability criterion is very important and hence, the operating time of the protective system should not exceed the critical clearing time to avoid the loss of synchronism. Other points under consideration for quick operation are protection of the equipment from burning due to heavy fault currents, interruption of supply to consumers and the fall in system voltage which may result in the loss of industrial loads. The operating time of a protective relay is usually one cycle. Half-cycle relays are also available. For distribution systems the operating time may be more than one cycle.

4.

1.7 Zones of Protection

A power system contains generators, transformers, bus bars, transmission and distribution lines, etc. There is a separate protective scheme for each piece of equipment or element of the power system, such as generator protection, transformer protection, transmission line protection, bus bar protection, etc. Thus, a power system is divided into a number of zones for protection. A protective zone covers one or at the most two elements of a power system. The protective zones are planned in such a way that the entire power system is collectively covered by them, and thus, no part of the system is left unprotected. The various protective zones of a typical power system are shown in Fig. 1.1. Adjacent protective zones must overlap each other, failing which a fault on the boundry of the zones may not lie in any of the zones (this may be due to errors in the measurement of actuating quantities, etc.), and hence no circuit breaker would trip. Thus, the overlapping between the adjacent zones is unavoidable. If a fault occurs in the overlapping zone in a properly protected scheme, more circuit breakers than the minimum necessary to isolate the faulty element of the system would trip. A relatively low extent of overlap reduces the probability of faults in this region and consequently, tripping of too many breakers does not occur frequently.

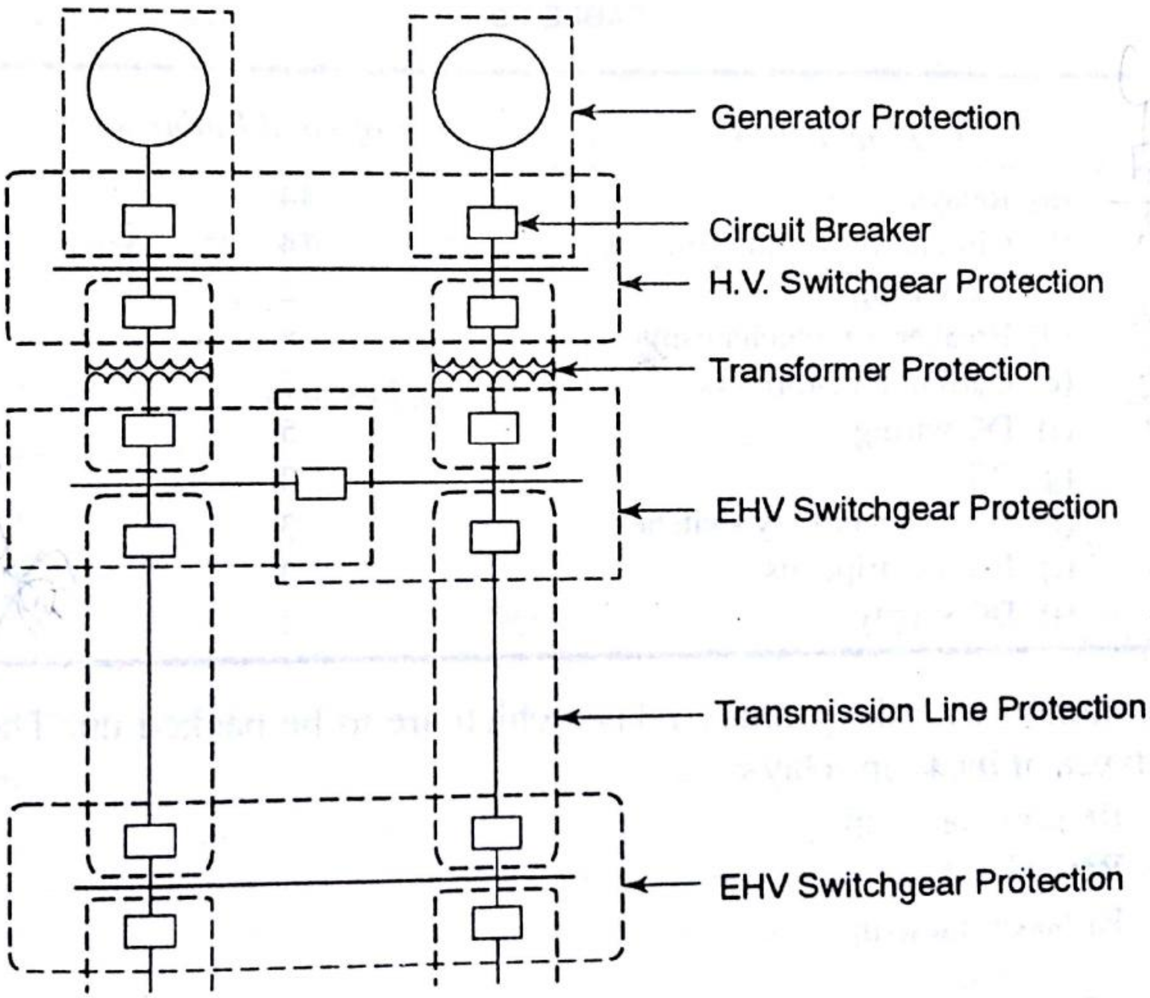


FIGURE 1.1 Zones of protection

1.8 Primary and Back-up 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 causes of failures of a protective scheme may be due to the failure of various elements, as mentioned in Table 1.3. The probability of failures is shown against each item.

The reliability of a protective scheme should at least be 95%. With proper design, installation and maintenance of the relays, circuit breakers, trip mechanisms, ac and dc wiring, etc. a very high degree of reliability can be achieved.

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 (P.T., C.T., measuring unit, etc.) common with the primary relays which are to be backed up. There are three types of back-up relays:

(a) Remote back-up
(b) Relay back-up
(c) Breaker back-up

1.8.1 Remote Back-up

When back-up relays are located at a neighbouring station,they back-up the entire primary protective scheme which includes the relay, circuit breaker, P.T., C.T. and other elements, in case of a failure of the primary protective scheme. It is the cheapest and the simplest form of back-up protection and is a widely used back-up protection for transmission lines. It is most desirable because of the fact that it will not fail due to the factors causing the failure of the primary protection.

1.8.2 Relay Back-up

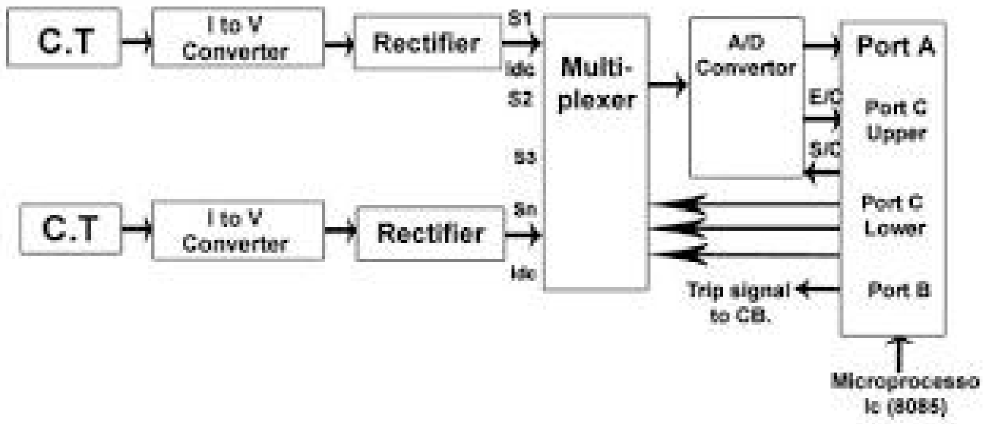
This is a kind of a local back-up in which an additional relay is provided for back-up protection. It trips the same circuit breaker if the primary relay fails and this operation takes place without delay. Though such a back-up is costly, it can be recommended where a remote back-up is not possible. For back-up relays, principles of operation that are different from those of the primary protection are desirable. They should be supplied from separate current and potential transformers.

1.8.3 Breaker Back-up

This is also a kind of a local back-up. This type of a back-up is necessary for a bus bar system where a number of circuit breakers are connected to it. When a protective relay operates in response to a fault but the circuit breaker fails to trip, the fault is treated as a bus bar fault. In such a situation, it becomes necessary that all other circuit breakers on that bus bar should trip. After a

6.

a)



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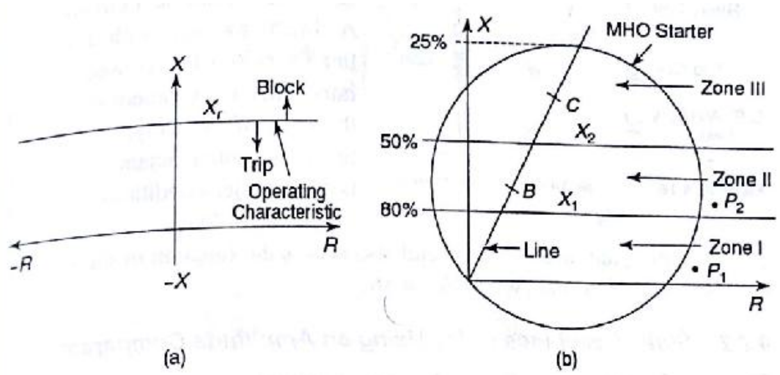


FIGURE 4.14 (a) Operating characteristic of a reactance relay
(b) Reactance relay with starting unit

7.

4. **Expulsion type arrester.** This type of arrester is also called 'protector tube' and is commonly used on system operating at voltages upto 33 kV. Fig. 24.12 (*i*) shows the essential parts of an expulsion type lightning arrester. It essentially consists of a rod gap *A A′* in series with a second gap enclosed within the fibre tube. The gap in the fibre tube is formed by two electrodes. The upper electrode is connected to rod gap and the lower electrode to the earth. One expulsion arrester is placed under each line conductor. Fig. 24.12 (*ii*) shows the installation of expulsion arrester on an overhead line.

On the occurrence of an overvoltage on the line, the series gap *A A′* is spanned and an arc is struck between the electrodes in the tube. The heat of the arc vaporises some of the fibre of tube walls, resulting in the production of a neutral gas*. In an extremely short time, the gas builds up high pressure and is expelled through the lower electrode which is hollow. As the gas leaves the tube violently, it carries away ionised air around the arc. This de-ionising effect is generally so strong that arc goes out at a current zero and will not be re-established.

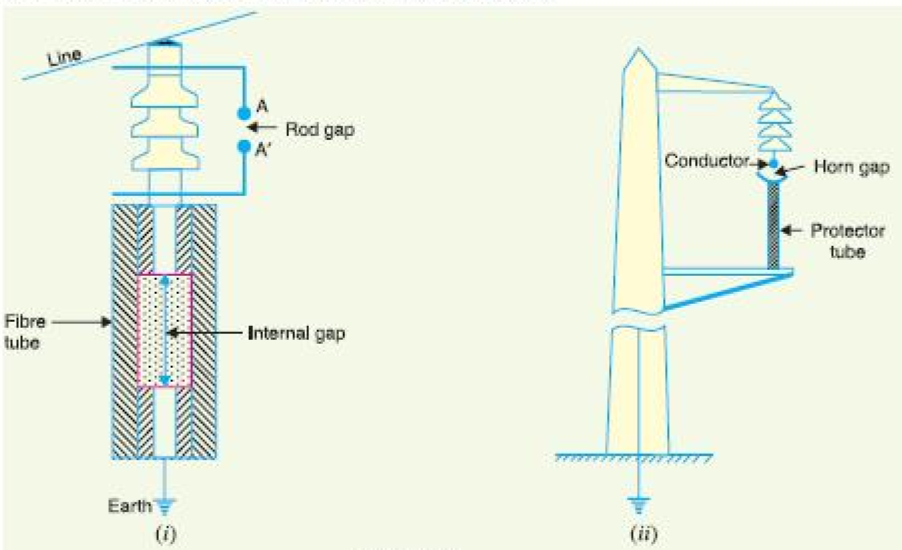


Fig. 24.12

Advantages

(*i*) They are not very expensive.

(*ii*) They are improved form of rod gap arresters as they block the flow of power frequency follow currents.

(*iii*) They can be easily installed.

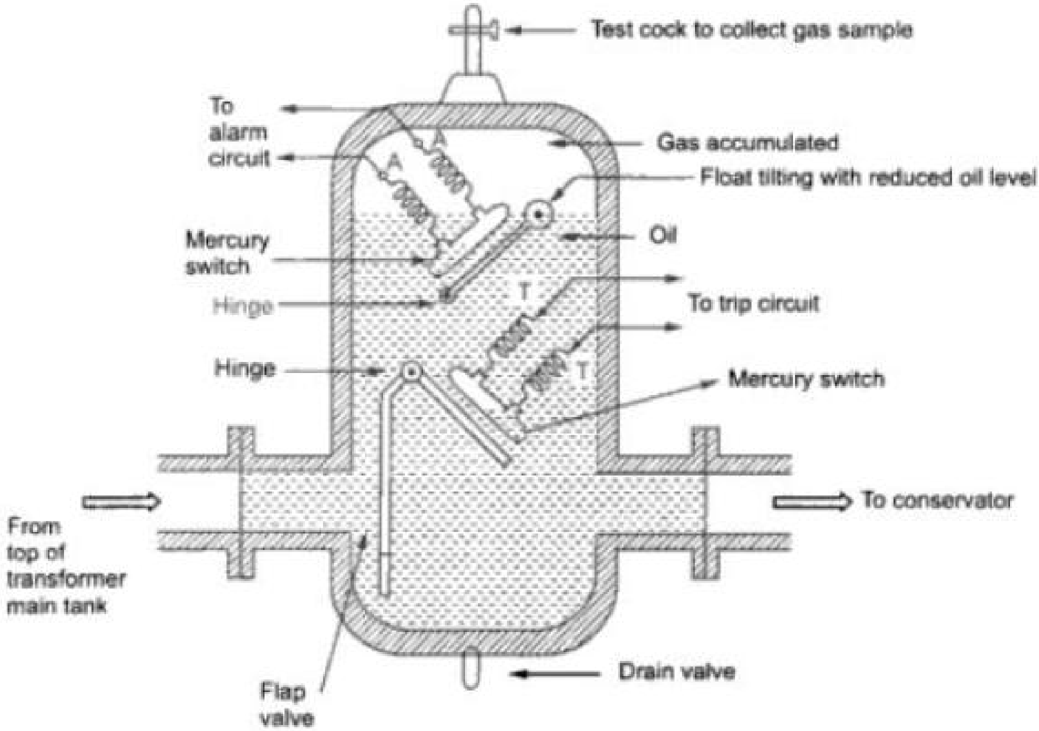
8.

Operation: There are many types of internal faults such as insulation fault, core heating, bad switch contacts, faulty joints etc. which can occur. When the fault occurs the decomposition of

The Buchholz relay working principle of is very simple. 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.

More severe types of faults, such as short circuit between phases or to earth and faults in the tap changing equipment, are accompanied by a surge of oil which strikes the baffle plate and causes the mercury switch of the lower element to close. This switch energized the trip circuit of the circuit breakers associated with the transformer and immediately isolate the faulty transformer from the rest of the electrical power system by inter tripping the circuit breakers associated with both LV and HV sides of the transformer. This is how Buchholz relay functions.



Construction of Buchholz relay