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Internal Assesment Test - III

Sub:	POWER SYSTEM PROTECTION							Code:	18EE72
Date:	2-1-24	Duration:	90 mins	Max Marks:	50	Sem:	7th (A & B)	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	With neat circuit diagram explain the synthetic testing of a circuit breaker.	[10]	CO5	L2
2	Explain the construction and working of ‘Klydonograph’.	[10]	CO6	L2
3	Explain the working of Air axial blast circuit breaker with the help of neat sketch.	[10]	CO5	L2
4.A	Write short note on Arcing horn with diagram.	[4]	CO6	L1

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4.B	A 132kV system, the reactance and capacitance up to the location of the circuit breaker is 3 ohms and 0.05µF, respectively. Calculate the following (i)The frequency of transient oscillation (ii)The maximum value of restriking voltage across the contacts of the circuit breaker (iii)The maximum value of RRRV	[6]	CO5	L3
5	Define following terms: (a) Breaking capacity (b) Making capacity (c) Short-time capacity (d) Rated Voltage, Current & Frequency (e) Rated operating Duty	[10]	CO5	L1
6.a	Explain the working of 'HVDC' circuit breaker with a schematic diagram.	[6]	CO5	L2
6.b	Explain the phenomenon of current chopping in a circuit breaker.	[4]	CO5	L2

CI CCI HOD

4.B	A 132kV system, the reactance and capacitance up to the location of the circuit breaker is 3 ohms and 0.05µF, respectively. Calculate the following (i)The frequency of transient oscillation (ii)The maximum value of restriking voltage across the contacts of the circuit breaker (iii)The maximum value of RRRV	[6]	CO5	L3

5	Define following terms: (f) Breaking capacity (g) Making capacity (h) Short-time capacity (i) Rated Voltage, Current & Frequency (j) Rated operating Duty	[10]	CO5	L1

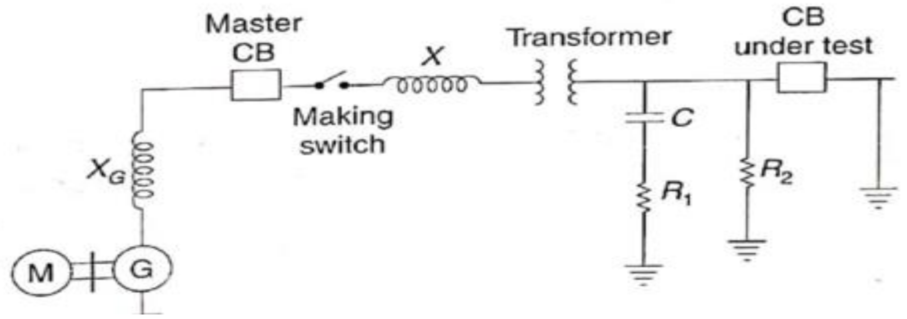
6.a	Explain the working of 'HVDC' circuit breaker with a schematic diagram.	[6]	CO5	L2
6.b	Explain the phenomenon of current chopping in a circuit breaker.	[4]	CO5	L2

CI CCI HOD

Q. 1

14.19.3 Direct Testing

In direct testing, the circuit breaker is tested under the conditions which actually exist on power systems. It is subjected to restriking voltage which is expected in practical situations. Figure 14.30 shows an arrangement for direct testing. The reactor X is to control short-circuit current. C, R_1 and R_2 are to adjust transient restriking voltage. Short-circuit tests to be performed are as follows.



Q.2

16.5.1 Klydonograph

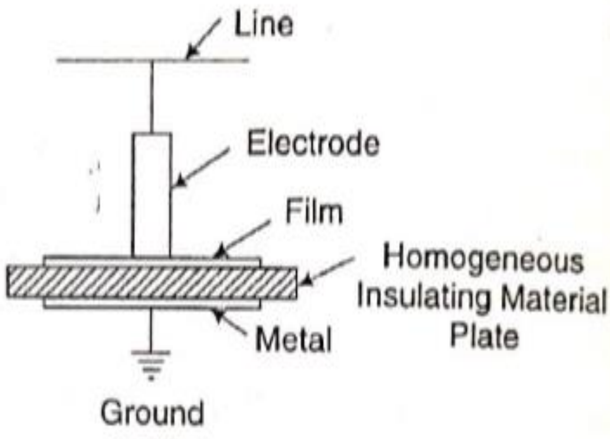


Fig. 16.4 *Klydonograph*

The klydonograph is an instrument for the measurement of surge voltage on transmission lines caused by lightning. It measures voltage by means of Lichtenberg figures, when suitably coupled to the line whose surge voltage is to be measured. The klydonograph contains a rounded electrode connected to the line whose surge voltage is to be measured. The electrode rests on the emulsion side of a photographic film or plate, which in turn rests on the smooth surface of an insulating plate made of homogeneous insulating material, backed by a metal plate electrode as shown in Fig. 16.4.

The photographic plate or the film is turned or moved by a clockwork mechanism for bringing in the element of time. Three assemblies are generally placed in the same box, for simultaneously measuring the voltages on the three phases of a transmission line.

With this arrangement, a positive Lichtenberg figure is produced by a positive surge, and a negative Lichtenberg figure by a negative surge, as illustrated in Fig.16.5. Positive Lichtenberg figures are found to be superior to the negative ones for voltage measurement purpose, since they are much larger than the negative figures for the same voltage, as shown in Fig. 16.5. Diameter of positive Lichtenberg figure is a

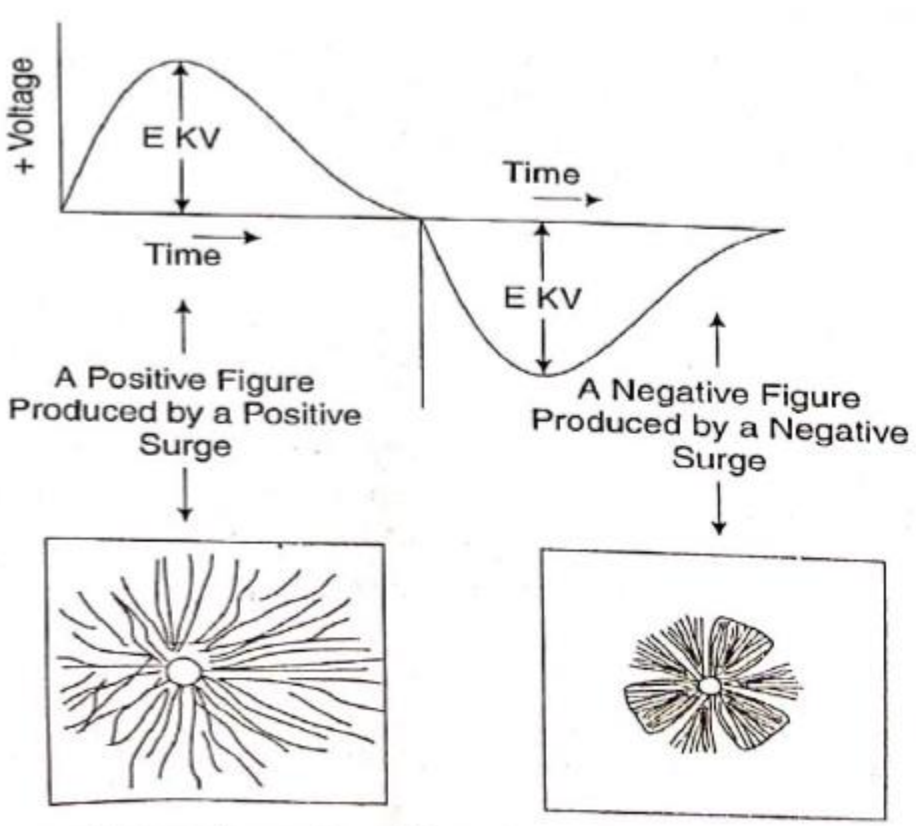
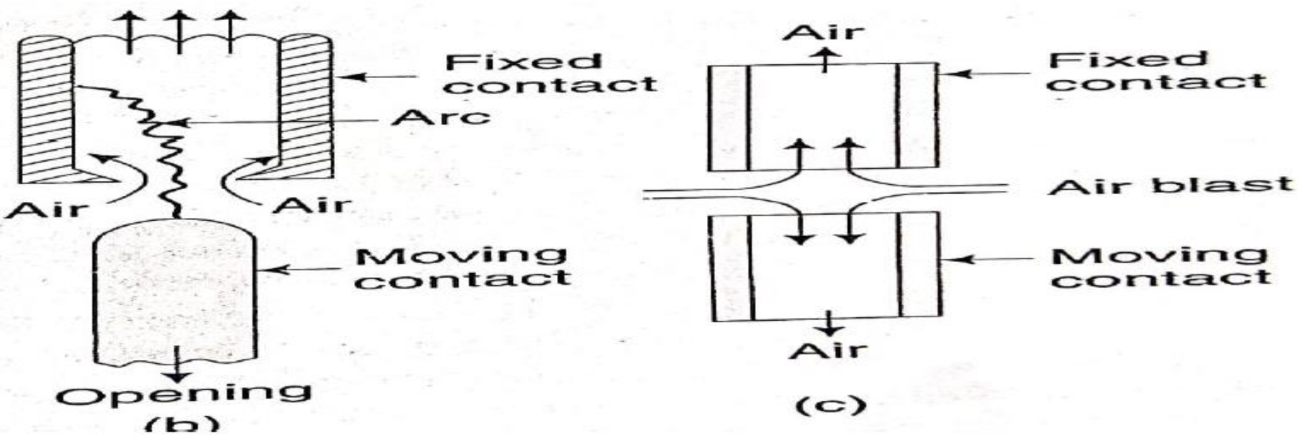


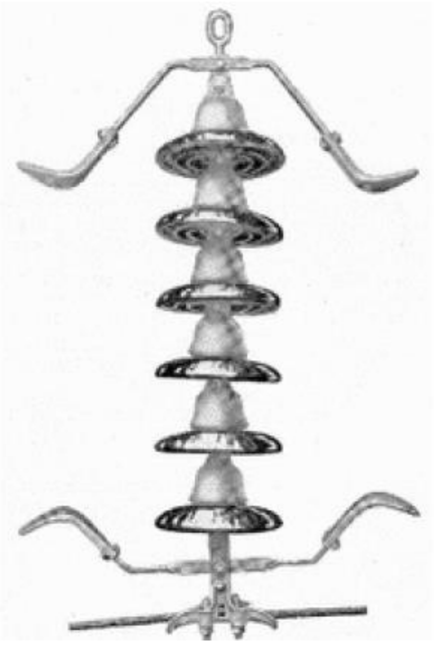
Fig. 16.5 *Positive and negative Lichtenberg figures produces by positive and negative surge voltages of same magnitude and wave shape*

Q.3



type circuit breakers. Figure 9.18(b) shows a single blast type. Whereas Fig. 9.18 (c) shows a double blast type or radial blast type. Axial blast circuit breakers are suitable for EHV and super high voltage application. This is because interrupting chambers can be fully enclosed in porcelain tubes. Resistance switching is employed to reduce the transient overvoltages. The number of breaks depends upon the system voltage, for example, 4 at 220 kV and 8 at 750 kV. Air-blast circuit breakers have also been commissioned for 1100 kV system.

Q.4.a



Arcing Horns bypasses the high voltage across the Insulator using air as a conductive medium between the Horns. The small gap between the horns ensures that the air between them breaks down resulting in a flashover and conducts the voltage surge rather than cause damage to the insulator.

Q.4.b

a) frequency of transient oscillation

$$L = \frac{R}{2\pi f}$$

$$L = \frac{3}{2\pi \times 50} = 0.00954\,H.$$

$$f_n = \frac{1}{2\pi\sqrt{LC}} = 7.290\,kHz$$

b) The restriking voltage

$$V_C = E[1 - \cos\omega_n t]$$

The maximum voltage is

$= 2$ peak

$= 2 \times \frac{132}{\sqrt{3}} \times \sqrt{2} = 215.55\,kV$

c) The maximum value of RRRV

$= \omega_n E_{peak}$

$= 2\pi f_n \times E_{peak}$

$= 4.93418\ kV/\mu s$

Q.5

14.18.1 Breaking Capacity

The breaking capacity of a circuit breaker is of two types.

(i) Symmetrical breaking capacity
(ii) Asymmetrical breaking capacity

Symmetrical Breaking Capacity

It is the rms value of the ac component of the fault current that the circuit breaker is capable of breaking under specified conditions of recovery voltage.

Asymmetrical Breaking Capacity

It is the rms value of the total current comprising of both ac and dc components of the fault current that the circuit breaker can break under specified conditions of recovery voltage.

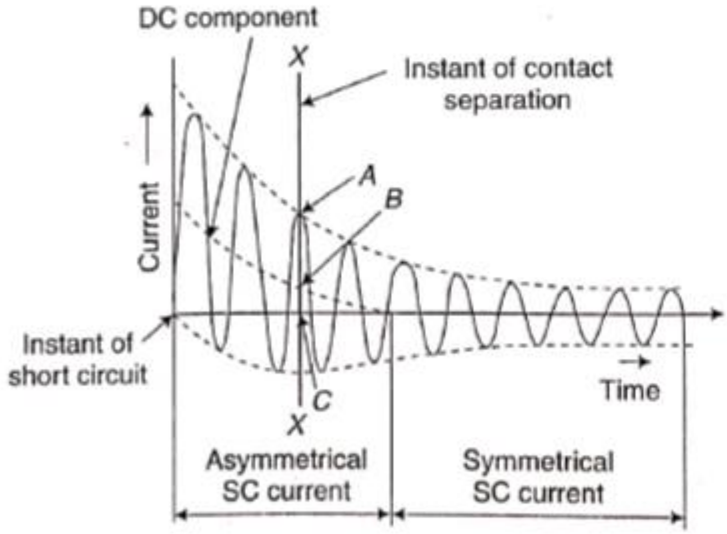


Fig. 14.29 *Short-circuit current waveform*

14.18.2 Making Capacity

The possiblity of a circuit breaker to be closed on short-circuit is also considered. The rated making current is defined as the peak value of the current (including the dc component) in the first cycle at which a circuit breaker can be closed onto a short-circuit. I_p in Fig. 14.29 is the making current. The capacity of a circuit breaker to be closed onto a short-circuit depends upon its ability to withstand the effects of electromagnetic forces.

$$\text{Making current} = \sqrt{2} \times 1.8 \times \text{symmetrical breaking current.}$$

The multiplication by $\sqrt{2}$ is to obtain the peak value and again by 1.8 to take the dc component into account.

$$\text{Making capacity} = \sqrt{2} \times 1.8 \times \text{symmetrical breaking capacity}$$
$$= 2.55 \times \text{symmetrical breaking capacity.}$$

14.18.3 Short-time Current Rating

The short-time current rating is based on thermal and mechanical limitations. The circuit breaker must be capable of carrying short-circuit current for a short period while another circuit breaker (in series) is clearing the fault. The rated short-time current is the rms value (total current, both ac and dc components) of the current that the circuit breaker can carry safely for a specified short period. According to British standard, the time is 3 seconds if the ratio of symmetrical breaking current to rated normal current is equal to or less than 40 and 1 second if this ratio is more than 40. According to ASA there are two short-time ratings, one is the current which the circuit breaker can withstand for 1 second or less. Another is rated 4-second current which is the current that the circuit breaker can withstand for a period longer than 1 second but not more than 4 seconds.

d.

14.18.4 Rated Voltage, Current and Frequency

In a power system, the voltage level at all points is not the same. It varies, depending upon the system operating conditions. Due to this reason manufacturers have specified a rated maximum voltage at which the operation of the circuit breaker is guaranteed. The specified voltage is somewhat higher than the rated nominal voltage.

The rated current is the rms value of the current that a circuit breaker can carry continuously without any temperature rise in excess of its specified limit.

The rated frequency is also mentioned by the manufacture. It is the frequency at which the circuit breaker has been designed to operate. The standard frequency is 50 Hz. If a circuit breaker is to be used at a frequency other than its rated frequency, its effects should be taken into consideration.

e.

14.18.5 Rated Operating Duty

The operating duty of a circuit breaker prescribes its operations which can be performed at stated time intervals. For the circuit breakers which are not meant for autoreclosing, there are two alternative operating duties as given below:

(i) O – t – CO – t' – CO

(ii) O – t'' – CO

where O denotes opening operation, CO denotes closing operation followed by opening without any intentional time lag, and t, t' and t'' are time intervals between successive operations. According to IEC, the value of t and t' is 3 minutes and t'' is 15 seconds.

For circuit breakers with auto-reclosing, the operating duty is as follows.

O – Dt – CO, where Dt is the dead time of the circuit breaker, which is expressed in cycle.

According to B.S.S. there is only one operating duty for the circuit breakers not intended for auto-reclosing. It is written as follows.

B – 3 – MB – 3 – MB, where B denotes breaking and MB denotes making followed by breaking without any intentional time delay. Three is the time interval in minutes.

For circuit breakers with auto-reclosing, the operating duty is written as

B – Dt – MB

Dt is the dead time and it is expressed in cycles.

Q.6.a

Fig. 14.27 *Artificial current zeros in dc*

Figure 14.28 shows the schematic diagram of a HVDC circuit breaker. It consists of a main circuit breaker MCB and a circuit to produce artificial current zero and to suppress transient voltage. The main circuit breaker MCB may either be an SF_6 or vacuum circuit breaker. R and C are connected in parallel with the main circuit breaker to reduce dv/dt after the final current zero. L is a saturable reactor in series with the main circuit breaker. It is used to reduce dI/dt before current zero. C_p and L_p are connected in parallel to produce artificial current zero after the separation of the contacts in the main circuit breaker MCB. A non-linear resistor is used to suppress the transient overvoltage which may be produced across the contacts of the main circuit breaker.

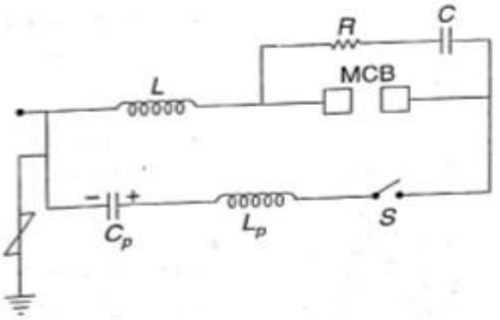


Fig. 14.28 *HVDC circuit breaker*

Switch S, which is a triggered vacuum gap, is switched immediately after the opening of the contacts of the main circuit breaker. The capacitor C_p is precharged in the direction as shown in the figure. When S is closed, the precharged capacitor C_p discharges through the main circuit breaker and sends a current in opposition to the main circuit current. This will force the main circuit current to become zero with a few oscillations. The arc is interrupted at a current zero.

Q.6.b

14.7 CURRENT CHOPPING

When low inductive current is being interrupted and the arc quenching force of the circuit breaker is more than necessary to interrupt a low magnitude of current, the current will be interrupted before its natural zero instant. In such a situation, the energy stored in the magnetic field appears in the form of high voltage across the stray capacitance, which will cause restriking of the arc. The energy stored in the magnetic field is ½ $L i^2$, if i is the instantaneous value of the current which is interrupted. This will appear in the form of electrostatic energy equal to ½ Cv^2. As these two energies are equal, they can be related as follows.

$$\frac{1}{2} Li^2 = \frac{1}{2} Cv^2$$

$$\therefore \quad v = i\sqrt{L/C} \qquad (14.19)$$

Figure 14.12 shows the current chopping phenomenon. If the value of v is more than the withstanding capacity of the gap between the contacts, the arc appears again. Since the quenching force is more, the current is again chopped. This phenomenon continues till the value of v becomes less than the withstanding capacity of the gap. The theoretical value of v is called the prospective value of the voltage.

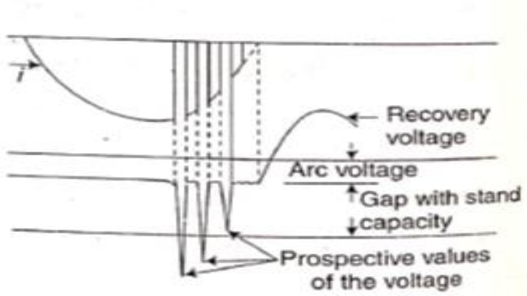


Fig. 14.12 *Current chopping*