Lecture-8

circuit breaker ratings, current chopping

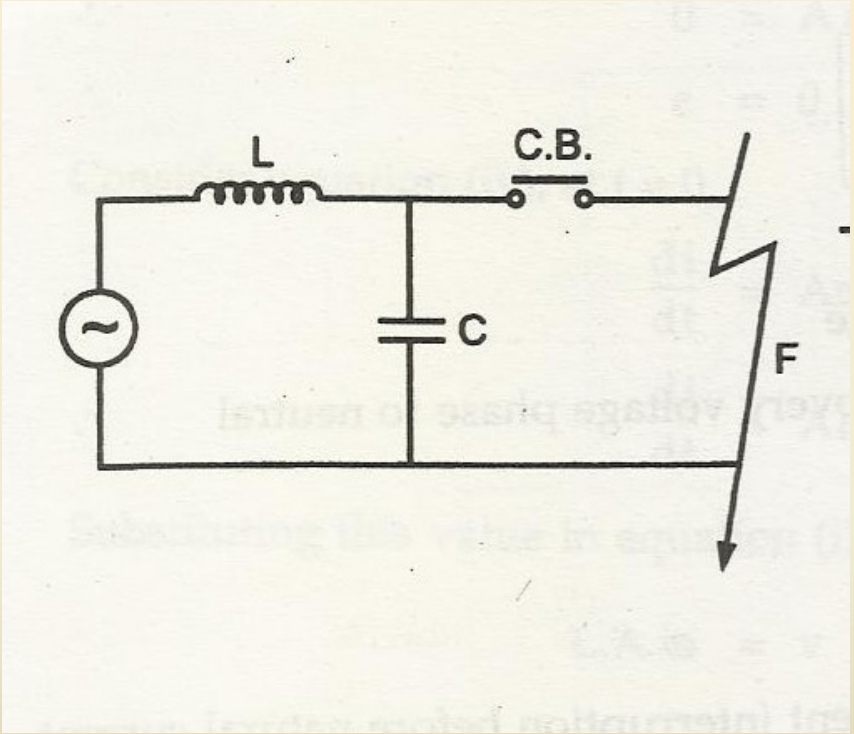
Topic Covered

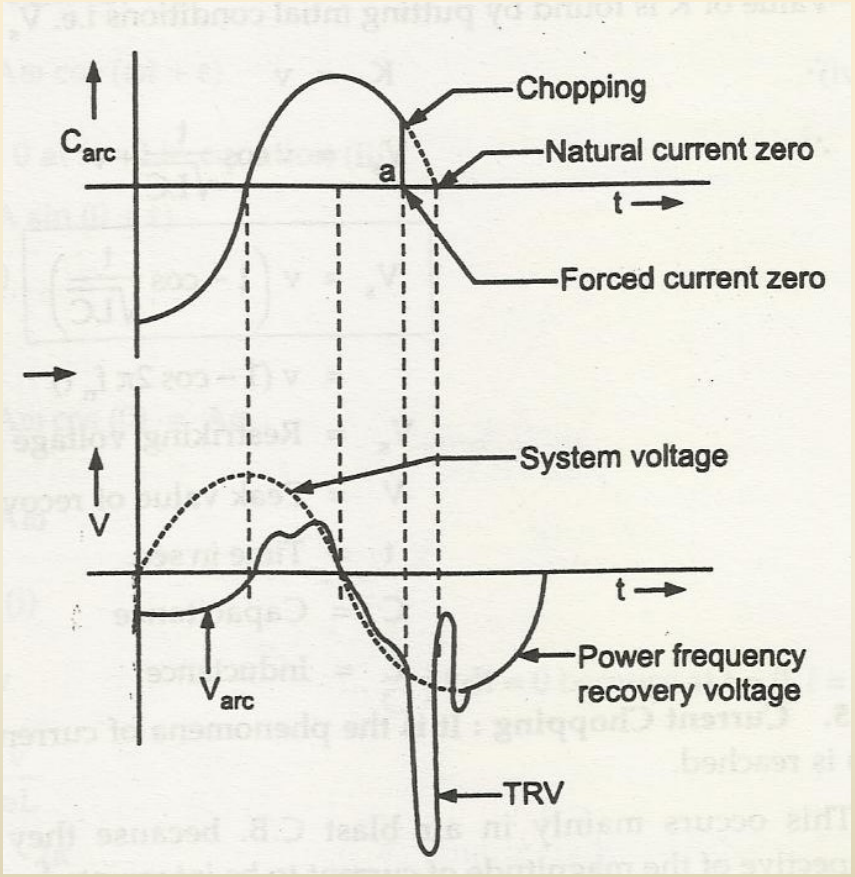
- Current Chopping
- Resistance Switching
- Circuit Breaker Rating
- Example

Current Chopping

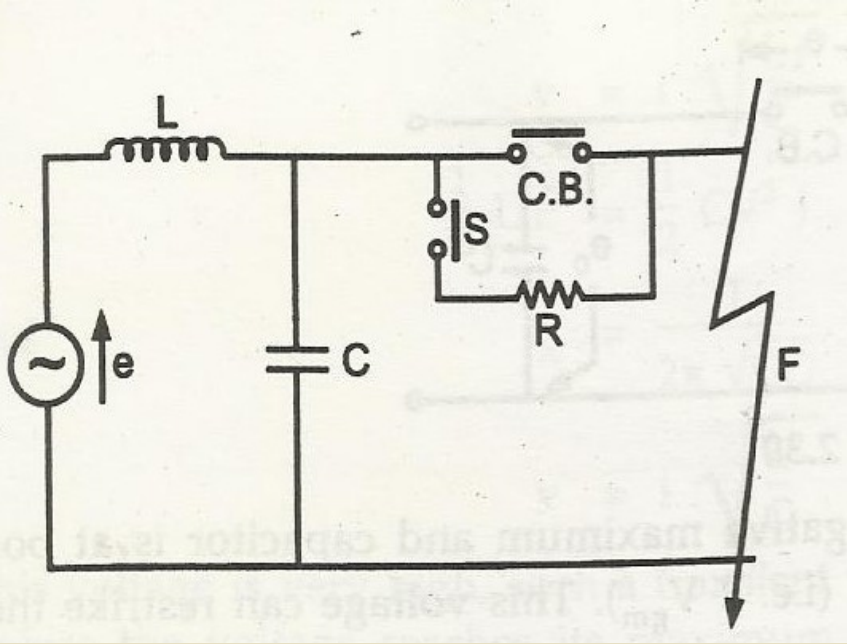
- It is the phenomena of current interruption before natural current zero is reached. It occurs in air blast circuit breaker because they retain same extinguishing power irrespective of the magnitude of current to be interrupted.
- When interrupting low inductive current e.g.magnetising current of transformer, a rapid deionizing effect causes current , to fall below its zero value before natural current zero is called current chopping.

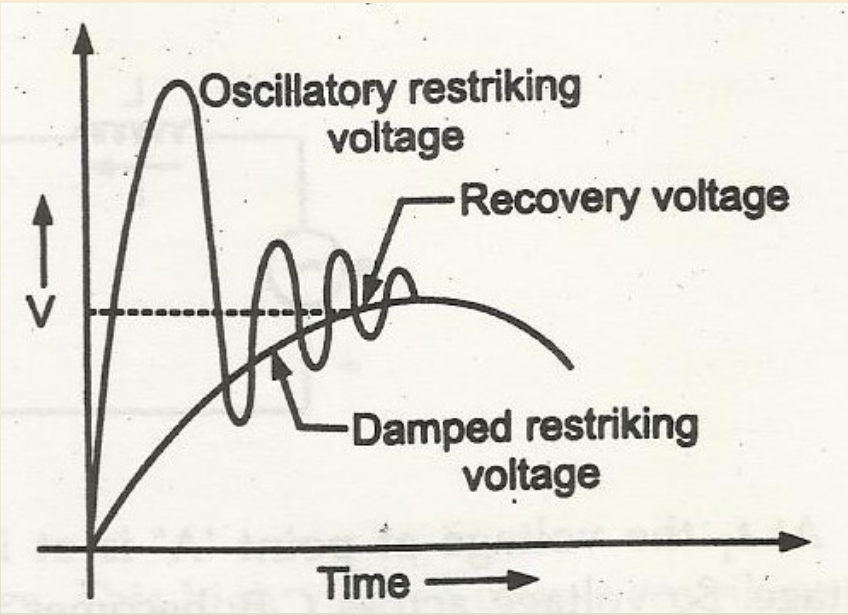
Current Chopping





Resistance Switching





Resistance Switching

The switching Resistor (R) is connected in parallel with the CB contacts. Current chopping produces high voltage oscillations which can be prevented by this method.

During arc interruption CB contacts separate first and after arc gets extinguished ‘S’ opens depending upon the time delay provided to it.

When the fault occurs the CB contacts open and arc is struck between them. Since R is in parallel with Cb contacts ,a part of arc current flows through this resistance so arc current decreases and deionization rate increases. The arc resistance also increases so current through R increases. This continue till the arc current is insufficient to maintain the arc.

Circuit Breaker Rating

- Breaking capacity – It is the current (r.m.s.) that a Circuit Breaker is capable of breaking at given recovery voltage and under specified conditions.
- Making Capacity – The peak value of current (including DC component) during the first cycle of current wave after closure of circuit breaker is known as making capacity. Making capacity = 2.55 $\times$ symmetrical breaking capacity
- Short time rating – It is the period for which the CB is able to carry fault current while remaining closed.
- Normal current rating – It is the r.m.s. value of current which the CB is capable of carrying continuously at its rated frequency under rated specified conditions.

IEEE Standards for Selection of Circuit Breakers

Step 1.Calculate highest value of initial RMS current considering symmetrical fault. The current can be obtained by sub -transient reactance of synchronous generators and transient reactance of synchronous motors and induction motors are neglected.

Following Multiplying factors are applied to take into account dc components and decrement of dc components in current. If short circuit KVA exceeds 5000,000 ,then add 0.1 to the given factors

8 cycles or slow breaker	1.0
5 cycle breaker	1.1
3 cycle breaker	1.2
2 cycle breaker	1.4

IEEE Standards for Selection of Circuit Breakers

Step 2.To determine the rated momentary current with time 1 sec or less of a breaker. The calculation of highest value of initial rms current can be done as given in step1 without using sub-transient reactance of all machines including induction motors. Multiply the value obtained by 1.6 .

$$\text{Momentary RMS value of current} = 1.6 \times \frac{v}{xd''}$$

1) CB rated 1500A,1000MVA,33kV,3sec,3phase oil CB.Find a)rated normal current b) breaking capacity c)rated symmetrical current d)Rated making current e) short time rating f)rated service voltage

(a) Rated normal current = 1500 Amp.

(b) Breaking capacity = 1000 MVA

(c) Rated symmetrical breaking current

$$= \frac{1000 \times 10^6}{\sqrt{3} \times 33 \times 1000}$$

$$= 17495.5 \text{ (r.m.s.)}$$

$$\text{B.C.} = \sqrt{3}\ \text{VI}$$

$$\therefore \quad I = \frac{\text{B.C.}}{\sqrt{3} \times V}$$

(d) Rated making current = (Rated sym. breaking current) 17495.5×2.55

$$= 44613.43 \text{ (peak)}$$

(e) Short time rating = 17495.5 A for 3 seconds

(f) Rated service voltage = 33 kV (r.m.s.)

Problem –A generator connected through a 5 cycle circuit breaker to a transformer is rated 8000KVAand 13.8kV with the reactance of Xd"=10%,Xd'=16%,and Xd=100% .It is operating at no load and rated voltage when 3 phase short circuit occurs between breaker and transformer. Find

1.Sustained short circuit current in the breaker
2.The initial symmetrical rms current in the breaker
3.Maximum possible dc component in the breaker
4.Current to be interrupted by the breaker
5.The interrupting KVA

Let the base be 8000KVA

Sustained short circuit KVA= $\frac{8000}{100} \times 100$=8000 since Xd=100%

Sustained short circuit current = $\frac{KVA}{\sqrt{3}VL=}$

Let VL=13.8kV

Sustained short circuit current =$\frac{8000}{\sqrt{3}\times 13.8}$= 334.70A

Sub transient Short Circuit KVA=$\frac{8000}{10} \times 100 = 80000$

Sub Transient or initial Symmetrical Current =$\frac{80000}{\sqrt{3}\times 13.8}$=3347.05A

Maximum possible dc component = $\sqrt{2} \times 3347.05 = 4732.73A$

Momentary current rating = 1.6 × 3347.05 = 5355.28 A

Current to be interrupted = 1.1 × 3347.05 = 3681.75 A

Interrupting kVA = $\sqrt{3} \times 368175 \times 13.8 = 87999.836$ kVA