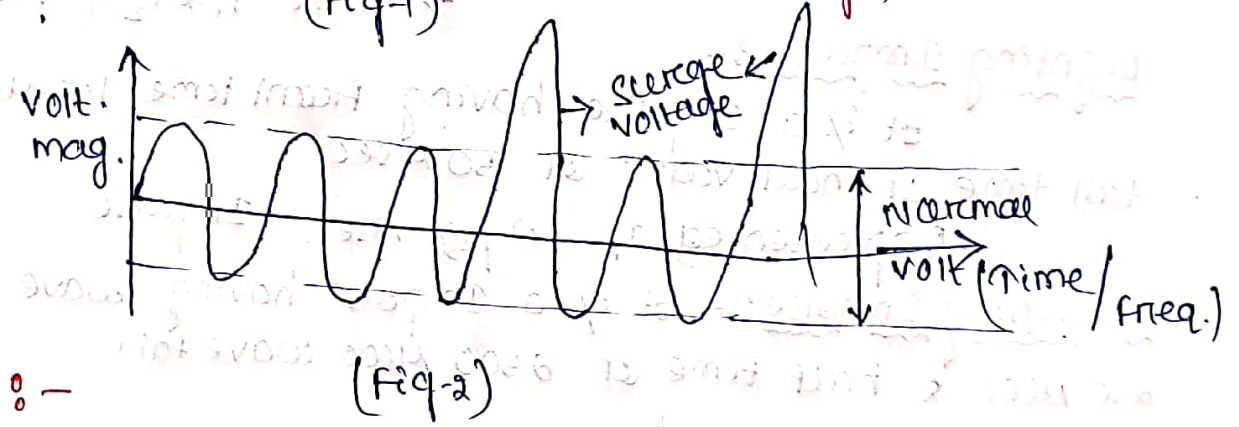
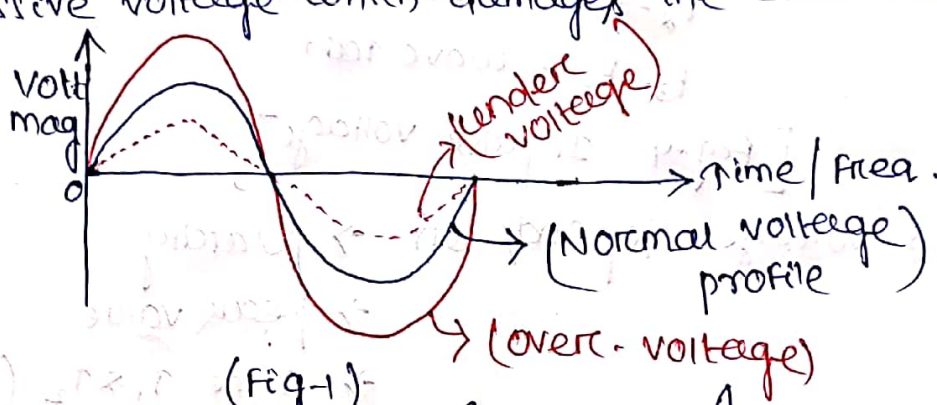


PROTECTION AGAINST OVER VOLTAGE & LIGHTNING (1)

Protection:- The act of keeping Equipments / devices / Tools / Part of power system ^{safe} is called protection or keeping safe from damages is also known as protection.

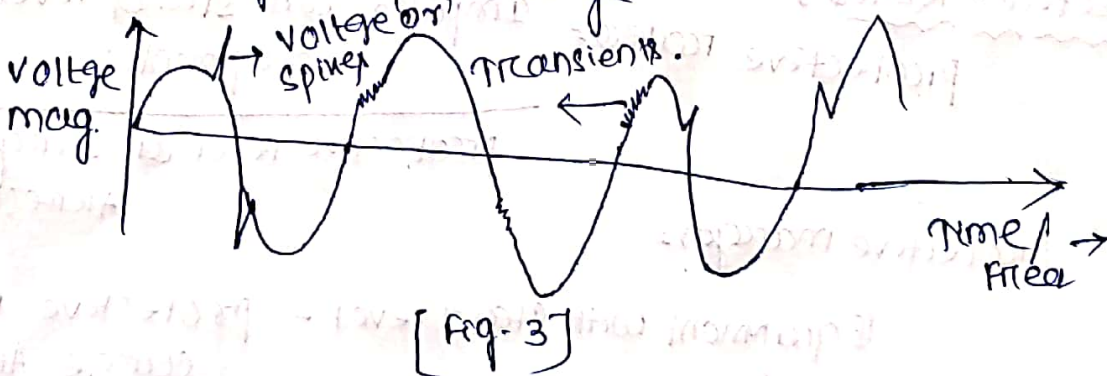
Over-voltage:- over voltages, surges or transients are impulse voltage waves of magnitude higher than normal value & persist for a short duration of time.

Voltage-Surge:- voltage surge is defined as the sudden rise in excessive voltage which damages the Electrical Equipments



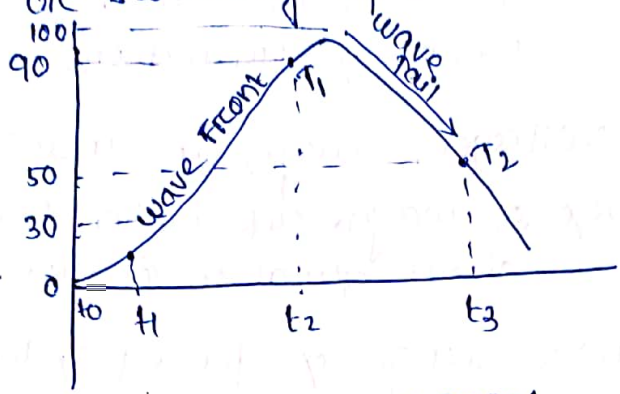
Transient:-

Transient is a short-lived burst of energy in a system caused by sudden change of state



Impulse Voltage:- Impulse voltage is a uni-directional voltage that rapidly rises to peak value & then drops to zero less rapidly.

- * It is also called as pulse voltage.
- * To study the effect of transient & over-voltage generated by lightning or switching operations on the system.



$t_2 - t_1 = \text{wave front}$
 $t_3 - t_0 = \text{wave tail}$

[Fig-4 Impulse voltage]

- * Impulse voltage depends on → polarity
 → peak value
 → time T_1 & T_2 (Full & Half times)

Lighting Impulse :-

It is a impulse having front time 1.2 msec time to tail time of half value of 50 msec

Represented as 1.2/50 msec Impulse

Switching Impulse :-

It is a impulse having wave front of 250 msec & half time of 2500 msec wave tail

i.e. 250/2500 Impulse

Protective Ratio :-

protective ratio = $\frac{\text{Impulse with stand level of Equipment}}{\text{protective level of surge arrester}}$

Protective margin =

Equipment with stand level - protective level of surge arrester.

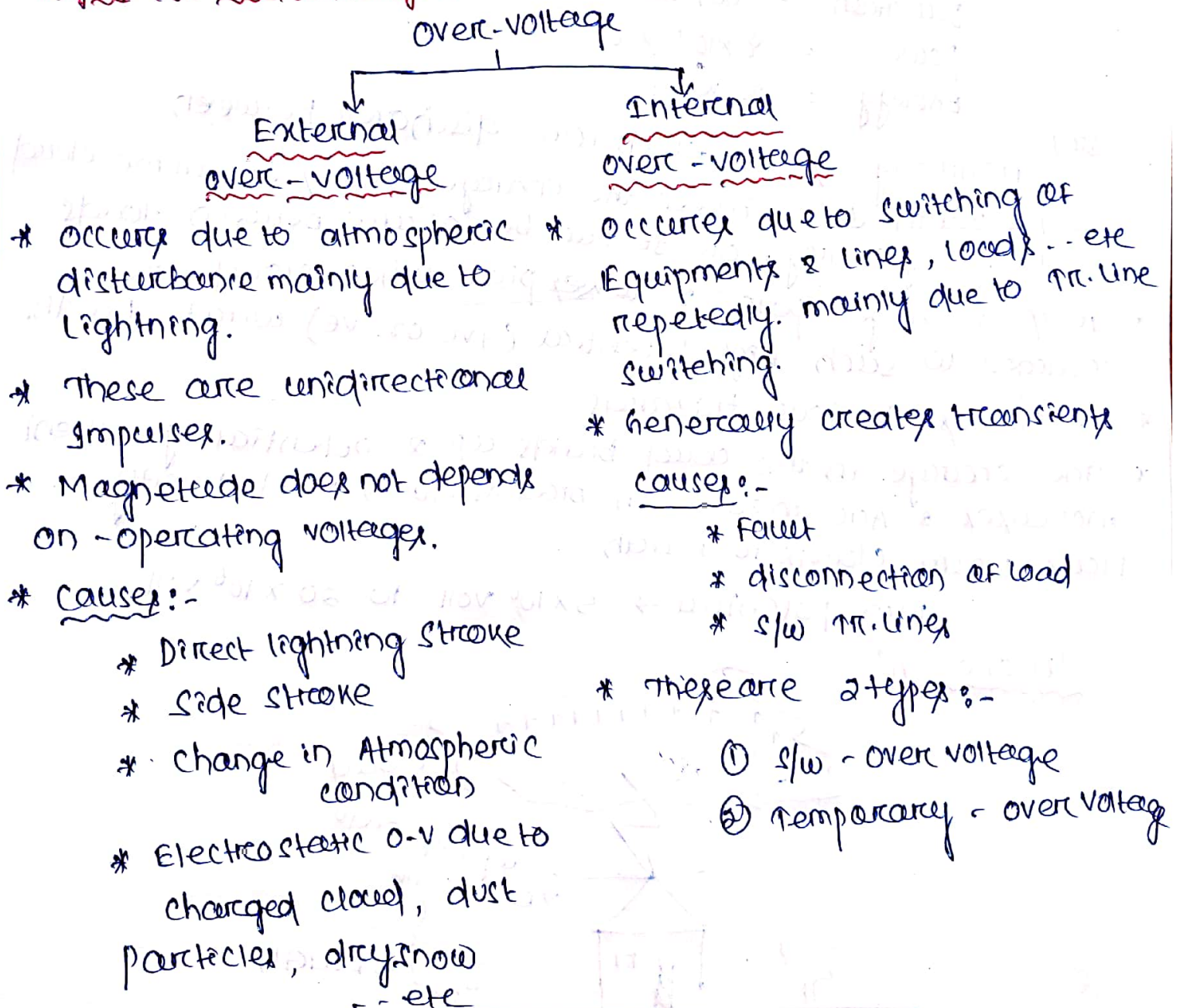
$P.R > 1.2$

$\frac{\text{lighting Impulse}}{\text{switching Impulse}} = 1.2$

Causes of over-voltage:-

- ① Lighting
- ② Switching } [Main causes]
- ③ Faults
- ④ Arcing Grounds
- ⑤ Insulation failure
- ⑥ Poor regulation of power source
- ⑦ Reactive power imbalance
- ⑧ Unbalance ckt
- ⑨ Load fluctuation
- ⑩ Resonance - - - etc

Types of over-voltage:-



Lightning:-

The large spark accompanied by light produced by sudden, discontinuous discharge of electricity through the air from the clouds under turbulent conditions of atmosphere called lightning. → "Benjamin Franklin"

Beforely → Act of GOD
Benjamin → Electric discharge & can can be protected by lightning rods.

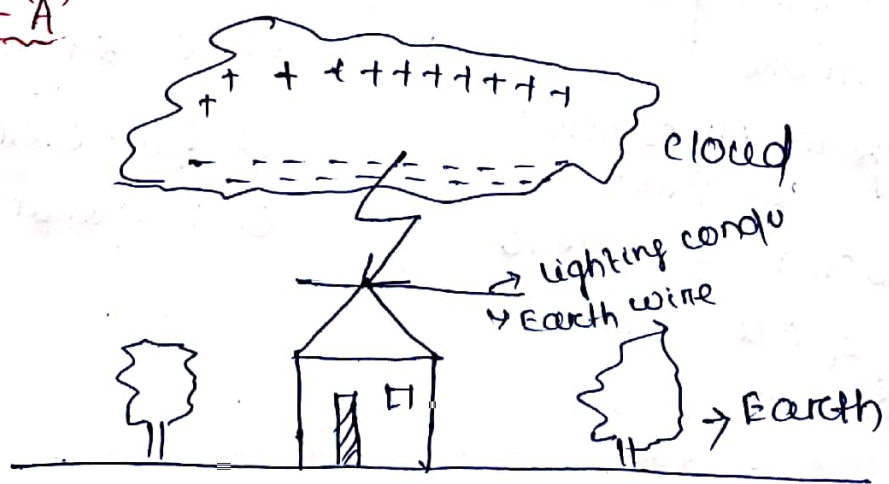
- Voltage = $200 \times 10^6 = 200 \text{ MV}$
- Current = 40 KA
- Duration = 100 Hsec
- Power = $8 \times 10^9 \text{ KW}$
- Energy = 22 kWh

OR// lightning is an electrical discharge between cloud & Earth or between the charge centres of same cloud known as lightning, or it can be occur between clouds

- * It is a huge spark & takes place when cloud are charged to such high potential (+ve or -ve) w.r.t. Earth.
- * It causes serious hazards
- * The charge in the cloud builds up & potential gradient increases & Air insulation breaks down & electricity flows from cloud to Earth

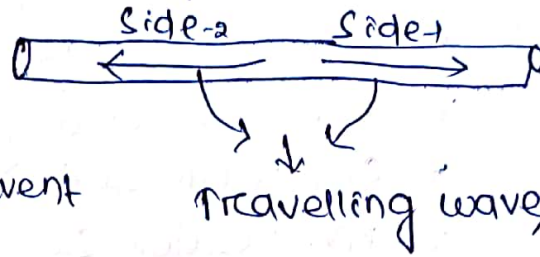
Min potential → $5 \times 10^6 \text{ volt}$ to $20 \times 10^6 \text{ volt}$

Stroke - 'A'



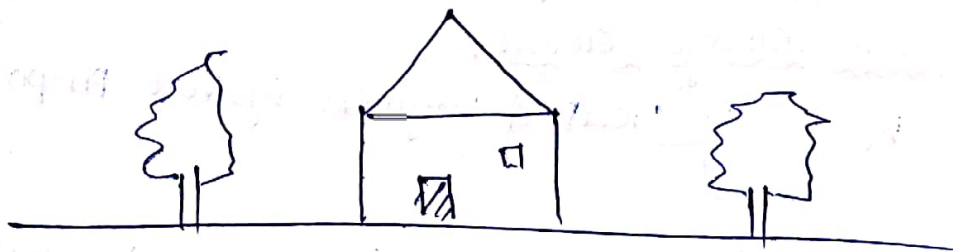
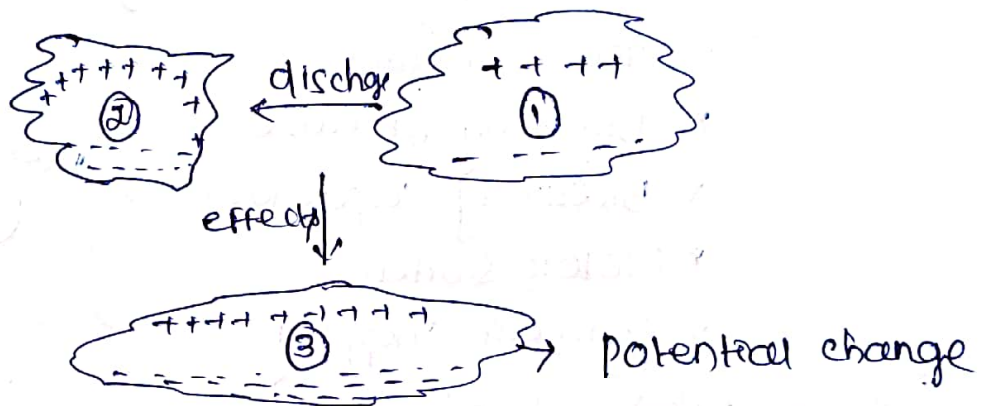
* Stroke A occurs between cloud & earth

- * Lightning conductor or earth wire can attract such ^(S) stroke
- * Tallest point in the area can be used as a protective medium. the overhead conductor accumulates the charge induced from cloud.
- * If the charged cloud moves away then accumulated conductors release charge, otherwise charge travels through both sides of the wire



- * Earth wire does not prevent such surges.

Stroke - 'B'



- * occurs due to sudden change in charge condition in the cloud
- * Earth wire / lightning conductors unable to attract such strokes.
- * Cloud 1 $\xrightarrow{\text{suddenly discharges}}$ Cloud 2 $\xrightarrow{\text{Results}}$ sudden change in Cloud-3
- * No protection works here.

Switching:-

When transmission line is suddenly charged by voltage source, the whole line gradually energized bcoz of L & C. This produces a voltage wave along with

current wave, these are called travelling waves, which causes over-voltage.

* S/w - over voltages are created due to

- * Faults
- * change in ckt condition
- * closing uncharged lines
- * closing charged lines → Main cause
- * Automatic closing of C.B → Main cause
- * Capacitor switching
- * HV Reactor switching
- * L-G Fault
- * Arcing Ground
- * Breaking of cable
- * Breaking capacitor bank
- * Motor switching
- * Current chopping

High voltage above 360 kV

less severe

less-severe

LV & Medium-voltage (111 to 36 kV)

[Refer Table 7.1 - page 447.]

Switching over-voltage factor:-

$$K = \frac{U}{U'} \text{ (rated highest sys volt ph-ph kV, rms)}$$

$$K = \frac{U}{\frac{\sqrt{2} U_n}{\sqrt{3}}} \left[\because U' = \sqrt{2} \frac{U_n}{\sqrt{3}} \right] = \text{Highest possible ph-ground peak voltage under heavy cond.}$$

$$K = \frac{\sqrt{3} U}{\sqrt{2} U_n}$$

K = Switching over-voltage factor

U = instantaneous ph-ground s/w over-voltage = KVP

Un = Normal highest phase to phase rms voltage

√2 = Factor to convert peak value

√3 = phase factor for 3-φ system.

↑ Refer Table 7.2 page - 448