

ELECTRICAL POWER TRANSMISSION AND DISTRIBUTION

BRANCH: EE/EEE

SEM: 5TH

MODULE: III

Short Question

① what are the various cause of failure of insulator.

Ans:- The following are the cause of failure of insulator.

- (i) mechanical Stress
- (ii) flash over.
- (iii) Porosity of material.
- (iv) cracking of insulator.

② what are the various test of insulators.

The test of insulators are

- (i) mechanical test
- (ii) Electrical insulation test.
- (iii) temporary cycle.
- (iv) environmental tests.

③ what are the types of suspension insulators.

Ans the type of suspension insulators are

- (i) core and lone type.
- (ii) cemented cap type
- (iii) Helical or interlinking type.

Q where did the stream insulators are used

Ques:- These insulators are used at dead end towers or bends or corners of transmission line or when making very long span.

Q5 Name atleast 4 insulating material for O.H line.

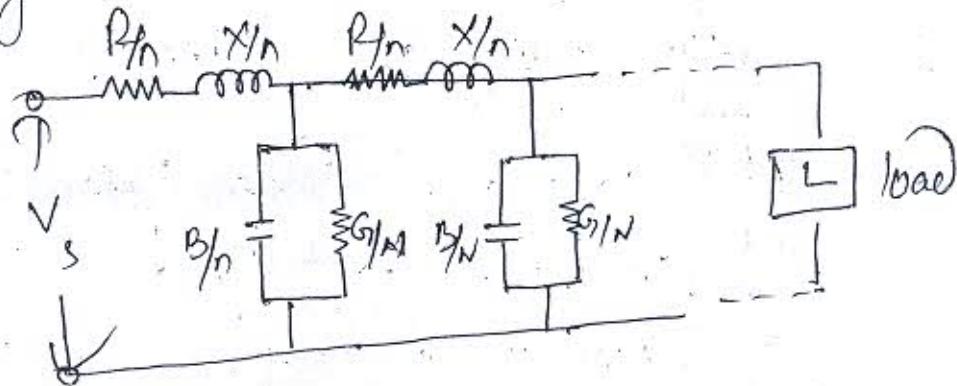
Ans The main 4 materials for O.H lines are

- (i) Porcelain
- (ii) glass
- (iii) Steatite
- (iv) Synthetic resin.

Q6 How constant voltage transmission will be maintained along the line.

Ans Constant voltage in the transmission line will be maintained by installing designed synchronous motor at the receiving end.

Q7 Draw the equivalent circuit of a long transmission line of n -section.



Q8) What are the effect of Power factor on transmission efficiency.

Ans The power delivered to the load

$$P = V \cdot I \cdot \cos\phi$$

$$\Rightarrow I = \frac{P}{V \cdot \cos\phi}$$

It is clear that for a given amount of power to be transmitted and V_R , the load current is inversely proportional to the load P.f ($\cos\phi$). Consequently if the load decreases, the load current and line losses increase. Thus the transmission is more efficient vice versa.

Q9) What are the effect of Power factor on regulation.

$$V_R = \frac{I_R \cos\phi_R + I_X \sin\phi_R}{V_R}$$

(i) If P.f is unity or lagging then

$$I_R \cos\phi_R > I_X \sin\phi_R$$

$\Rightarrow V_R$ is +ve.

(ii) But if P.f is leading, then

$$I_R \cos\phi_R < I_X \sin\phi_R$$

$\Rightarrow V_R$ is -ve

(iii) for a given V_R and I , the V.R of transmission line increases if P.f is leading

10 what is flash over voltage for an insulator.

ans It is the voltage at which the arc discharge between conductors and insulator pin (the ear) and the discharge jump across the air gap following shortest distance.

11 write two advantage of suspension type insulator over pin type insulator.

ans (i) Depending upon the working voltage the numbers of disc can be adjusted and each disc is suited for the system voltage of 11 KV.

(ii) If any one of the disc is damaged then the whole string is not affected but if one pin insulator is damaged the the supply system will hamper.

12 What is string efficiency?

ans The ratio of voltage across the whole string to the product of number of disc and voltage across the disc nearest to the conductor.

$$\text{String efficiency} = \frac{\text{Voltage across the string}}{\text{Voltage across the disc nearest to conductor}}$$

③ what is % voltage regulation of a transmission line.

ans The difference in voltage at the receiving end of transmission line between condition of no load and full load is called voltage regulation and is expressed as a percentage of receiving end voltage.

$$\% \text{ VR} = \frac{V_s - V_R}{V_R} \times 100$$

④ what is safety factor of insulator.

ans The ratio of puncture strength to flash over voltage is known as safety factor.

$$\text{Safety factor} = \frac{\text{Puncture Strength}}{\text{Flash over Voltage}}$$

⑤ why capacitor banks are connected at receiving end of voltage transmission.

ans The capacitor bank are connected at receiving end of voltage transmission because all the losses are remaining in the receiving end side and the power factor of these loads are to be improved if necessary by these capacitor bank.

16) List the main Components of HVDC System.

Ans The main Components of HVDC system are (i) converters, (ii) Converter transformer (iii) Smoothing reactor in overhead line.

(iv) Reactive power source (v) Earth electrode

7) what are the different type of DC lines

Ans DC lines are three type

- (i) monopolar
- (ii) bipolar
- (iii) homopolar.

8) How, String efficiency can be improved?

String efficiency can be improved by

- (i) longer cross arm.
- (ii) By grading the insulators.
- (iii) by using a guard ring.

9) How transmission line are classified.

Ans Transmission line classified as

- (i) short transmission line
- (ii) medium transmission line
- (iii) long transmission.

10) Prove for a short transmission line

$$AD - BC = 1$$

What is required for Module - III

Revision notes for May 2015

Q-21 What are the types of Conductors used in overhead lines?

Ans:- The most commonly used conductor material for overhead lines are Copper, aluminium, Steel - Coated aluminium, galvanised steel and Cadmium Copper.

Q-22 what are the advantages that aluminium is considered over copper.

- Ans :- (i) aluminium conductor is light
(ii) low cost
(iii) cheap and used widely.

Q-23 why ACSR conductors are preferred in transmission line.

Ans:- (i) ACSR conductors are widely used for following reason.

- (1) ACSR conductors will produce smaller sag and hence longer span is used.
(2) Due to smaller sag tower of small height can be used.

Q-24 What do you mean by sag in overhead transmission line.

Ans. The difference in level between Point of support and lowest point on the conductor is called sag.

Sag for equal level support

$$S = \frac{wl^2}{8T}$$

Sag for unequal level support

$$S_1 = \frac{wx^2}{2T}, S_2 = \frac{wx^2}{2T}$$

25. what are the Various Support in Electrical Transmission and distribution line.

Ans. The various support in electrical transmission and distribution line are

- (i) wooden pole.
- (ii) steel pole
- (iii) RCC Pole.
- (iv) steel tower.

26. what are the various factors affecting sag

Ans. The various factors affecting sag are

- (i) Atmosphere.
- (ii) conductor size.
- (iii) spacing between conductors.
- (iv) line voltage.

27. what is sagging chart and how it is useful.

Ans. This is a chart which is being plotted between sag-temperature and tension-temperature for a given conductor and cooling condition.

this is helpful in providing sag-tension at any temperature of a transmission line erection.

28. What is corona, how it can be reduced?

corona:- The phenomenon of violet glow, hissing noise and production of ozone gas in overhead transmission line is known as corona.

method of reducing corona

(i) By increasing Conductor Size.

(ii) By increasing Conductor Spacing.

29. Define Disruptive Voltage and visual Critical voltage.

ans. It is the minimum phase-neutral voltage at which corona occurs.

$$V_d = g_0 \times \log_e \frac{d}{\delta}, V$$

visual critical voltage

It is the minimum phase neutral voltage at which corona glow appears all along the line conductor.

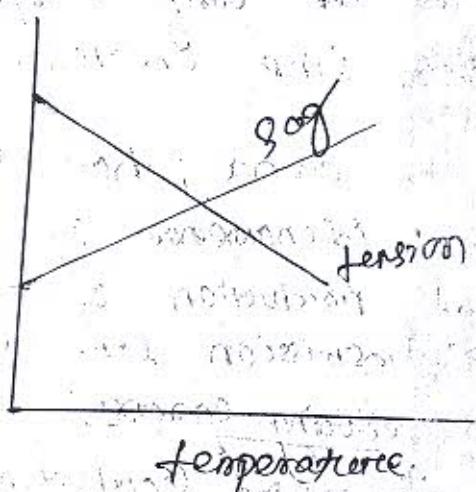
$$V_v = m g_0 s \delta \left(1 + \frac{0.3}{\sqrt{s} \delta} \right) \log_e \frac{d}{\delta}, \text{ volt}$$

g_0 = breakdown strength.

s = air density factor.

m = irregularities factor.

30) Define Sag-tension curve.



31 How Overhead conductors is protected against mechanical vibration and swing.

ans. overhead conductors is protected against mechanical vibration and swing by using dampers.

32. what are the classification of distribution system.

The classification of distribution system are

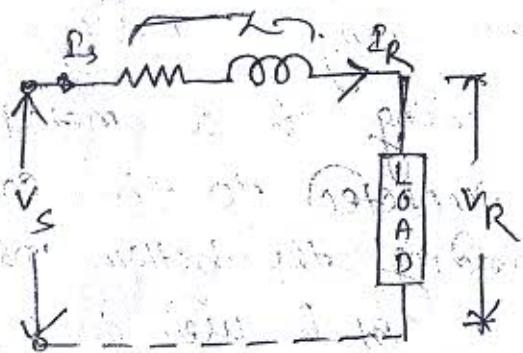
- (i) According to nature of current
- (ii) According to types of construction.
- (iii) According to the scheme of connection.

33 Define a distribution system? what are the component of a distribution system?

Qm The part of power system which distributes electrical power for local use is known as distribution system. The various component of a distribution system are

- (i) Feeder (ii) distributor (iii) service main.

Q4



$$\text{Here } \vec{V}_s = \vec{V}_R \quad \text{--- (1)}$$

$$V_s = \vec{V}_R + \vec{P}_R Z \quad \text{--- (2)}$$

The generalized eqn of \vec{V}_s , eqn of transmission line

$$\vec{V}_s = A \vec{V}_R + B \vec{P}_R \quad \text{--- (3)}$$

$$\vec{V}_s = C \vec{V}_R + D \vec{P}_R \quad \text{--- (4)}$$

Comparing eqn (1) and eqn (2) with eqn (3) & (4)

$$A=1, B=2, C=0, D=1$$

$$AD - BC = 1 \times 1 - 2 \times 0 = 1$$

$$\therefore \boxed{AD - BC = 1}$$

Q5

why HVDC line don't require any reactive power compensation.

(i) In HVDC line there are no line which block the flow of reactive power from one end to another end. These reactive powers are required by some load that may be fulfilled by the inverters.

(ii)

HVDC line don't have resistance i.e. inductance or capacitance, thus reactive power absorption or generation is not happening.

Q) What is Guard ring and why it is used?
Ans. Guard ring is a metal ring
electrically connected to the conductor
and surrounding the bottom insulator.
It is used to improve the
string efficiency.

Long TYPE mod-ly

1 List out the main component of a HVDC system.

Ans:- main component of HVDC system are

Converters :- Each HVDC line has at least two converters, one at each end. Sending end converter works as rectifier and receiving end works as an inverter. Normally six pulse operation is adopted in this system. Some time 12 pulse is also used.

Converters Transformer

For a 3-pulse Converter, a conventional 3- ϕ or three 1- ϕ Transformers are used. For a 12-pulse Converter - Configuration, following (a) six-pulse two winding (b) three 1- ϕ three winding (c) two 3- ϕ two winding transformers are used.

Smoothing reactor

These reactors, are used for smoothing the dc current off in the d.c line. It also limit the rate of rise of fault current.

Harmonic filters :- Harmonic filters are used to provide low - impedance path to the ground for the harmonic current.

overhead lines The basic principle of design of dc overhead line is almost same as ac line design such as configuration, tower, insulator etc.

reactive Power Sources

filter, capacitor, Synchronous Condenser are
main reactive power sources

- Q. what are the different types of insulator used in overhead transmission line? describe any two with neat sketch.

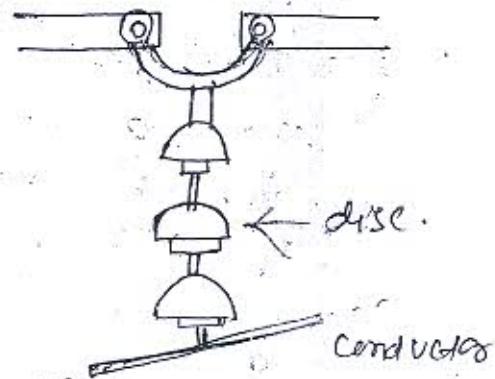
Pin Insulators



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This insulator is secured to the cross arm of the pole. There is groove on the upper end of the insulator for housing the conductor. The conductor passes through the ~~groove~~ and bounded by annealed wire of the same material as the conductor. This insulator used upon to 33 KV.

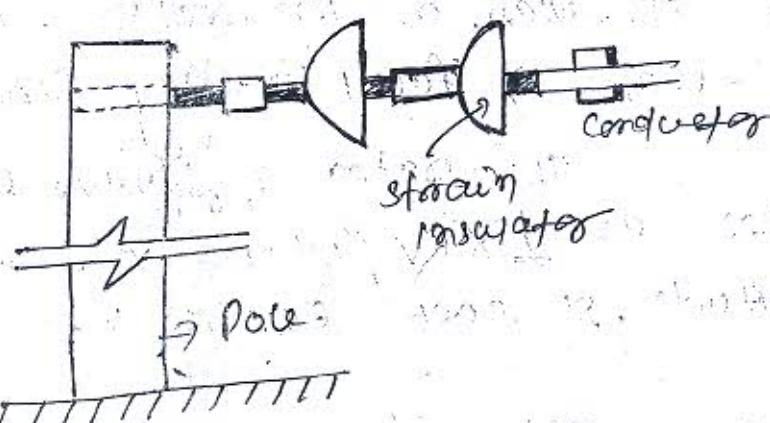
Suspension type insulator



3 En

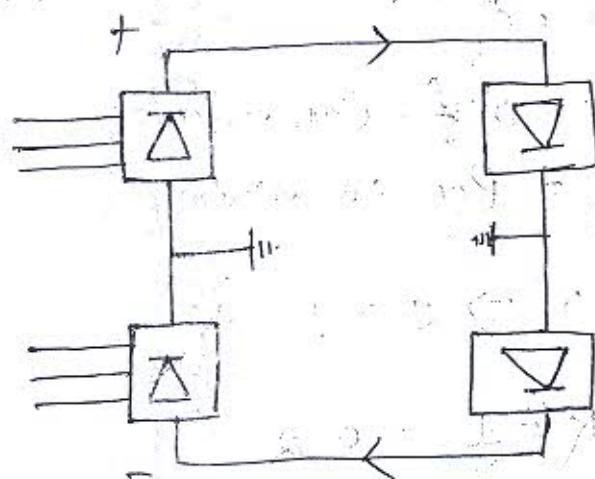
These insulators are most preferred beyond 33 KV, for H.V above 33 KV these insulators are less costly than Pin type. This insulator consists of several disc connected by a metal link from string. conductor is suspended at the bottom end of the string is secured to the cross arm.

Strain Insulator



When there is a dead end of the line or there is corner or sharp curve, the line is subjected to greater tension and in that case these insulators are preferred.

3 Explain a Bipolar ac links in HV.DC transmission system with diagram.



In bipolar type link, two conductors are needed. One conductor operate at negative polarity and the other ~~operates~~ at the positive polarity as shown in the fig.

The main advantage of these links compared to monopolar is the case of ~~single~~ fault in any line. In normal operation, there is no current through ground but is grounded because of its operation as monopolar. In the event of fault in any line.

The rating of bipolar link is expressed as $\pm x \text{ kV}$, where x is the no. of magnitude of each line in kV .

- (4) Determine the storing efficiency of a storing insulator of three unit having self-capacitance equal to 5 times the sum to earth capacitance.

Sol According to question self-capacitance
 $= 5 \times \text{sum to earth capacitance}$

$$\Rightarrow C = 5C_1$$

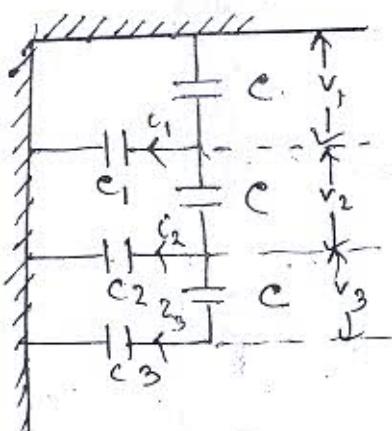
where $C = \text{self capacitance}$

$C_1 = \text{sum to earth}$

$$\frac{C}{C_1} = 5 \Rightarrow C = \frac{1}{5} C_1 = K$$

$$K = \frac{1}{5} = 0.2$$

for insulator of 3 unit
we get



$$v_2 = (1+k)v_1 \text{ and } v_3 = (k^2 + 3k + 1)v_1$$

$$v_2 = (1+0.2)v_1 = 1.2v_1$$

$$v_3 = (0.2^2 + 3 \cdot 0.2 + 1)v_1 \\ = 0.64v_1$$

$$V = v_1 + v_2 + v_3 = v_1 + 1.2v_1 + 0.64v_1 \\ = 3.84v_1$$

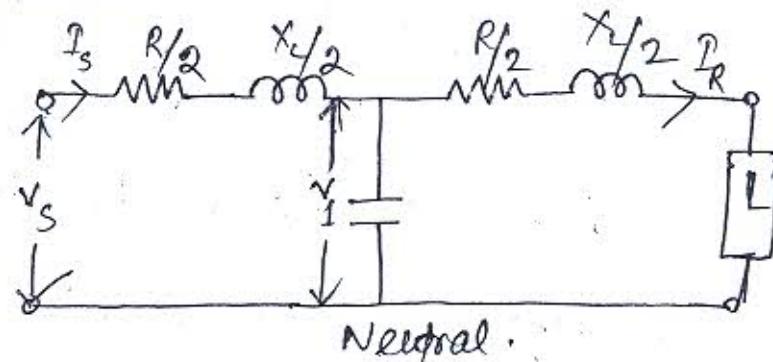
$$\boxed{V = 3.84v_1}$$

string efficiency = $\frac{\text{Voltage across string}}{\eta \times \text{Voltage across one near to conductor}}$

$$2 \quad \frac{V}{3 \times v_1} = \frac{3.84v_1}{3 \times 1.64v_1} \times 100 \\ = 78\%$$

- ⑤ In a medium transmission line by using nominal γ -method. Find out the voltage regulation.

Sol:- fig



Let I_R = load current per phase

X = inductive reactance per phase.

R = resistance per phase.

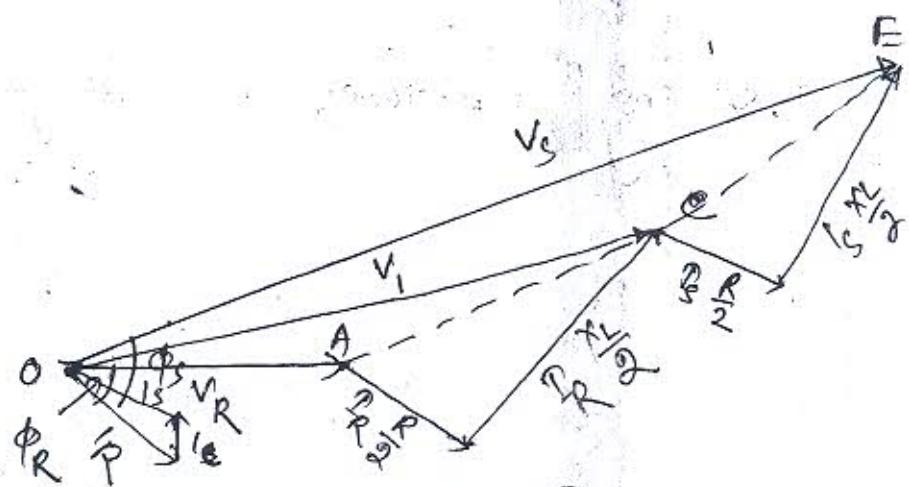
C = capacitance per phase.

$\cos\phi$ = receiving end power factor.

V_S = sending end voltage / phase,

V = voltage across capacitor C

Phasor diagram



receiving end voltage $V_R = V + jI_R$

load current $I_R = I_R (\cos\phi - j \sin\phi)$

voltage across C $V_C = V_R + \frac{I_R}{R} Z \frac{1}{2}$

$$= V_R + I_R (\cos\phi - j \sin\phi) \left(\frac{R}{2} + j \frac{X_L}{2} \right)$$

$$I_C = j \omega C V_C = j 2\pi f C V_C$$

sending end current $I_S = I_R + I_C$

sending end voltage $V_S = V_R + \frac{I_S}{Z} \frac{Z}{2}$

$$V_p^2 + \frac{V_s^2}{2} \left(\frac{R}{2} + j \frac{X_L}{2} \right)$$

$$\% R = \frac{V_s - V_p}{V_p} \times 100$$

(b) What are the methods to improve Storing efficiency.

The various method to improve storing efficiency

by using longer Cross arm :-

The value of storing efficiency depend upon the value of K i.e. the ratio of shunt capacitance to mutual capacitance. Lesser the value of K , the greater is the storing efficiency and more uniform is

the voltage distribution. The value of K can be decreased by reducing shunt Capacitance. In order to reduce shunt Capacitance the distance of conductors from tower is increased.

By grading Insulator

In this method, Insulators of different dimension are so chosen that each has a different Capacitance. The insulators are Capacitance graded. They are assembled in the storing in such away that the top unit has the minimum capacitance and increase progressively as the bottom unit.

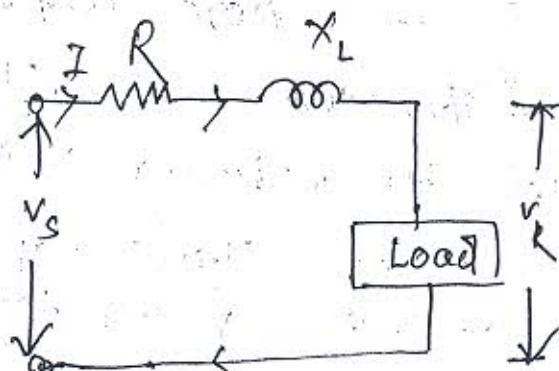
Since voltage is inversely proportional to $\frac{1}{C}$.
 Capacitance, this method tends to equalise
 the potential distribution across the unit in
 the string.

By using a guard ring

The potential across each unit in a string
 can be equalised by using a guard
 ring, which is a metal ring electrically
 connected to the conductor and surrounding
 the bottom insulator.

7. Explain the performance of 1ϕ short
 transmission line with equivalent and phasor diag

Sol:-



Let $I = \text{load current}$.

$R = \text{loop resistance}$.

$X_L = \text{loop reactance}$.

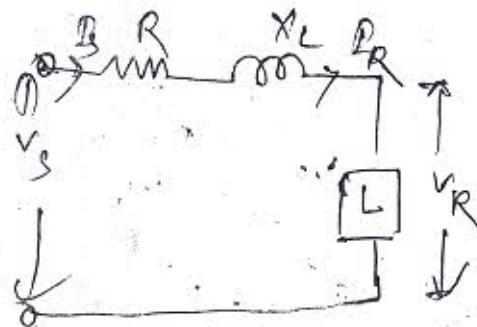
$V_R = \text{receiving end voltage}$.

$\cos \phi_R = \text{receiving end power factor}$

$V_s = \text{sending end voltage}$.

$\cos \phi_s = \text{sending end power factor}$.

short line



$$\text{Here } \vec{v}_s = \vec{v}_R$$

$$\vec{v}_s = \vec{v}_R + \vec{Z} \vec{I}$$

Comparing these with eq's ① and ②

$$\vec{A} = 1, \vec{B} = 2, \vec{C} = 0, \vec{D} = 1$$

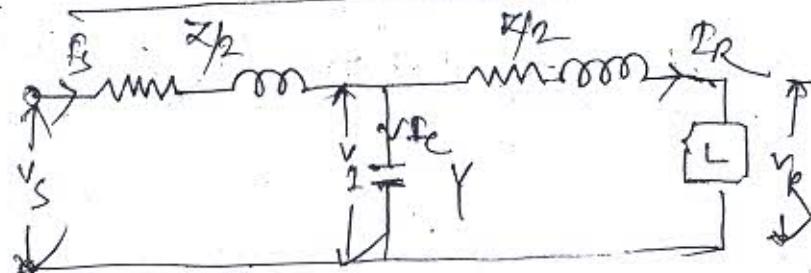
$$\vec{A} = \vec{D}$$

$$\vec{AD} - \vec{BC} = 1 \times 1 - 2 \times 0 = 1$$

$$\boxed{\vec{AD} - \vec{BC} = 1}$$

Medium line - Nominal T-method

fig

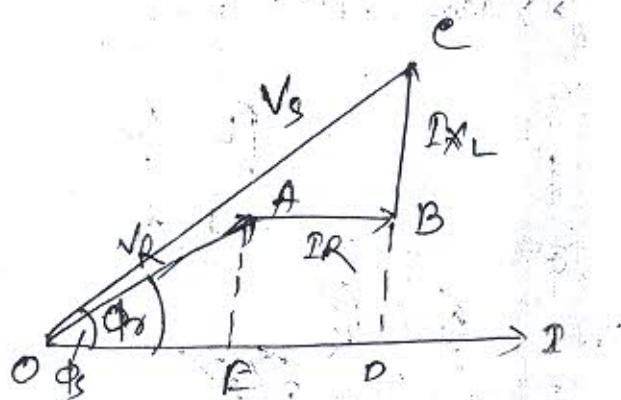


$$\text{Here } \vec{v}_s = \vec{v}_c + \vec{Z} \frac{\vec{z}}{2} \quad \text{--- ③}$$

$$\vec{v}_c = \vec{v}_s + \vec{Z} \frac{\vec{z}}{2}$$

$$\text{Now } \vec{v}_c = \frac{\vec{v}_s - \vec{v}_R}{\vec{R}} = \vec{v}_s - \vec{v}_R = \vec{v}_s \left(1 - \frac{\vec{Z}}{\vec{R}} \right)$$

Phasor diag



In the right angled triangle ODC, we get

$$V_C^2 = OD^2 + DC^2$$

$$= (OE + ED)^2 + (OB - BC)^2$$

$$V_s^2 = \left(V_R \cos \phi + I_R \right)^2 + \left(\frac{V_R \sin \phi}{R} + I_x L \right)^2$$

$$V_s = \sqrt{\left(V_R \cos \phi + I_R \right)^2 + \left(\frac{V_R \sin \phi}{R} + I_x L \right)^2}$$

% regulation, $R = \frac{V_s - V_R}{V_R} \times 100$

Q8) Determine the generalised constant for transmission line for transmission line (short and medium line).

Sol : The eqn of sending end voltage and sending end current can be expressed as

$$\vec{V}_s = A \vec{V}_R + B \vec{I}_R$$

$$\vec{I}_s = C \vec{V}_R + D \vec{I}_R$$

$$\vec{v}_3 = \vec{v}_R + Y \vec{v}_R + Y \frac{\vec{v}_R \vec{z}}{2}$$

$$= Y \vec{v}_R + \vec{v}_R \left(1 + \frac{Y \vec{z}}{2} \right)$$

Substituting the value of \vec{v}_1 in eqⁿ ③

$$\vec{v}_3 = Y \vec{v}_R + \frac{\vec{v}_R \vec{z}}{2} + \frac{\vec{v}_R \vec{z}}{2}$$

Substituting the value of \vec{v}_1 in eqⁿ ③

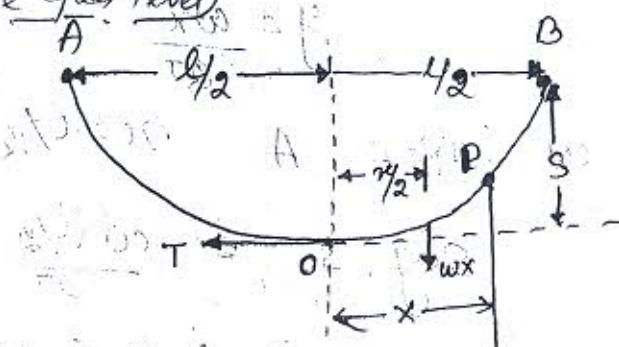
$$\vec{v}_3 = Y \vec{v}_R + \frac{\vec{v}_R \vec{z}}{2} + \frac{\vec{v}_R \vec{z}}{2}$$

Substituting the value of \vec{v}_3 we get

$$\vec{v}_3 = \left(1 + \frac{Y \vec{z}}{2} \right) \vec{v}_R + \left(\vec{z} + \frac{Y \vec{z}^2}{2} \right) \vec{r}$$

Q) Derive the expression for sag in overhead line with different level support.

Fig (When supports are equal level)



Consider a conductor between two equivalent supports A and B with O as the lowest point. It can be proved as shown in Fig above. that lowest point will be at the mid span.

Let l = length of span

w = weight per unit length of conductor

T = tension in the conductor.

Consider a point P on the conductor taking the lowest point O as the origin. Let the co-ordinate of point P be x and y . Assuming that curvature is small that curved length is equal to its horizontal projection ($OP = x$). Two forces acting on this portion of the conductor are.

(a) Weight wx of the conductor acting

at a distance $\frac{l}{2}$ from O

(b) Tension T acting at O

equating moment of force about O we get

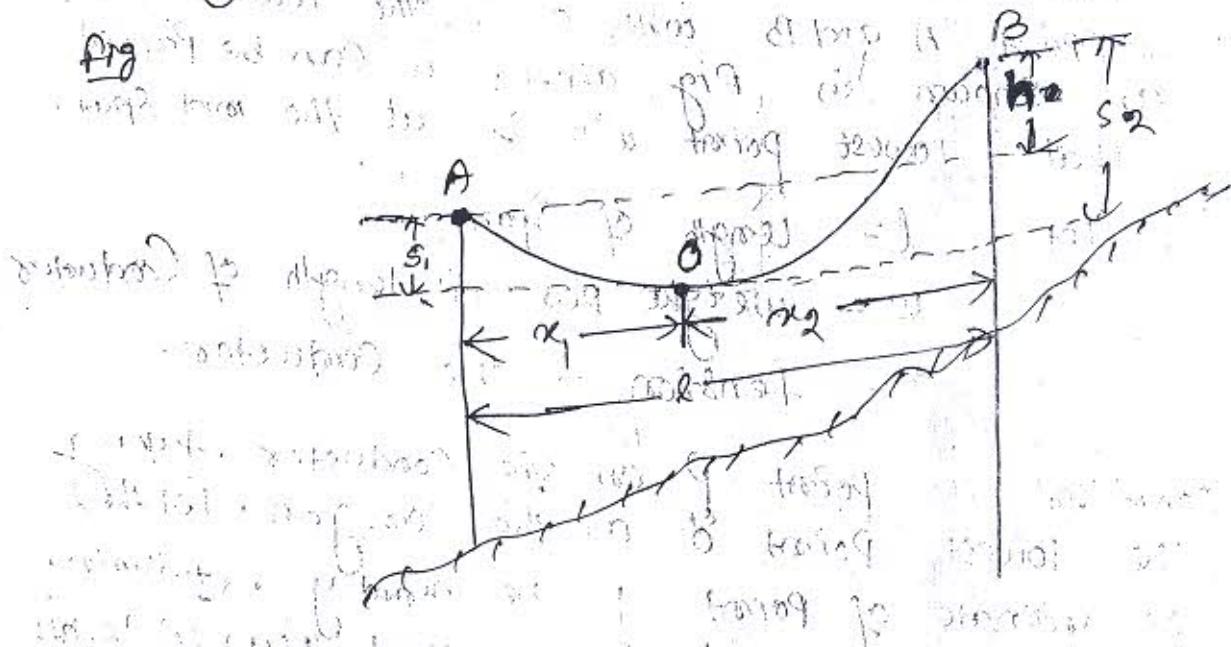
$$Ty = wx + \frac{w}{2}$$

$$y = \frac{wx^2}{2T}$$

at support A $x = l/2$ and $y = s$

$$\text{sag, } s_1 = \frac{w(l/2)^2}{2T} = \frac{wl^2}{8T}$$

sag at unequal level support



Let span length is l and difference in level between two supports is h .

x_1 = distance of support at lower level from O

x_2 = distance of support at higher level (i.e. B) from O

T = Tension in other conductor.

$T = \dots$

If w is the weight per unit length
of the conductor

$$\text{Sag } s_1 = \frac{w x_1^2}{2T}$$

$$\text{Sag } s_2 = \frac{w x_2^2}{2T}$$

also $x_1 + x_2 = l$

Now $s_2 - s_1 = \frac{w}{2T} [x_2^2 - x_1^2] = \frac{w}{2T} (x_2 + x_1)(x_2 - x_1)$

$$s_2 - s_1 = \frac{wl}{2T} (x_2 - x_1)$$

$$h = \frac{wl}{2T} (x_2 - x_1)$$

$$x_2 - x_1 = \frac{2Th}{wl}$$

Solving exp(i) and (ii), we get

$$x_1 = \frac{l}{2} - \frac{Th}{wl}$$

$$x_2 = \frac{l}{2} + \frac{Th}{wl}$$