EEPC 16 – Transmission and Distribution of Electrical Energy

B. Tech – Semester IV

National Institute of Technology, Tiruchirappalli

Department of Electrical and Electronics Engineering

A MINIPROJECT ON

LAB MODEL of T CONFIGURATION of EHV LINES

Submitted by: 107118037

107118109

107118035

107118011

107118017

107118053

❖ CONTENTS:

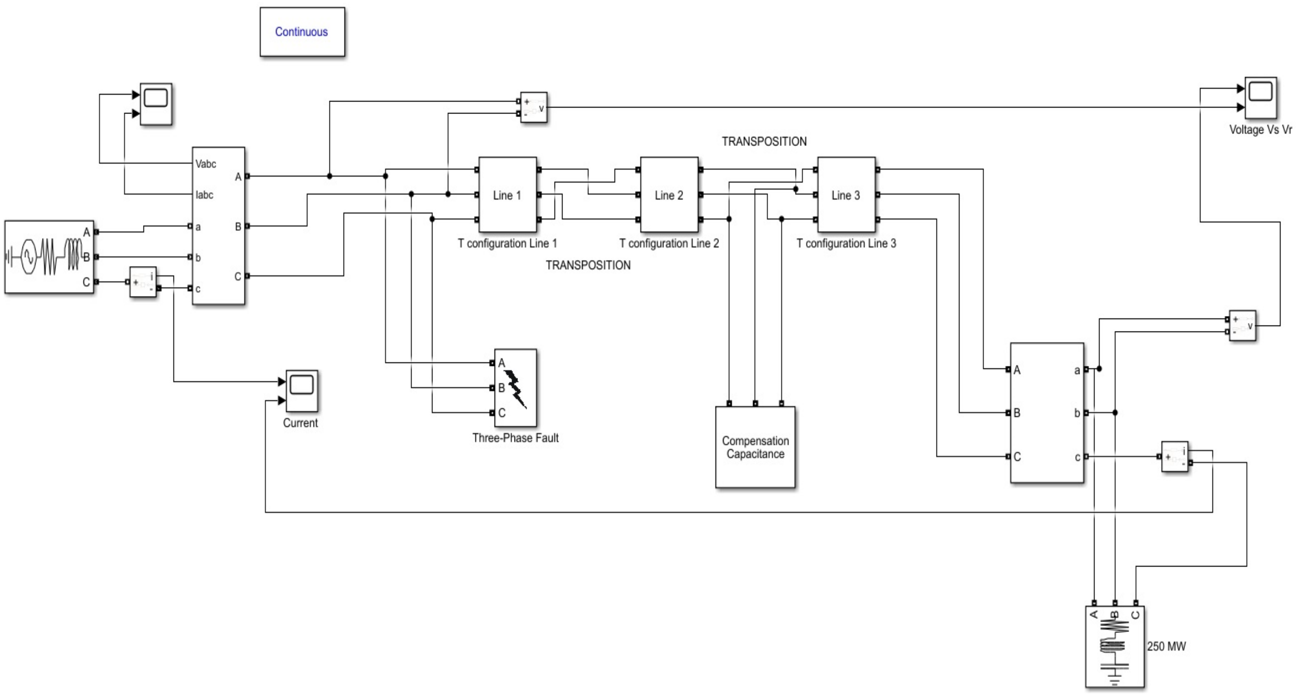
- **Aim:**

To design and analyze extra high voltage transmission line in T-configuration.

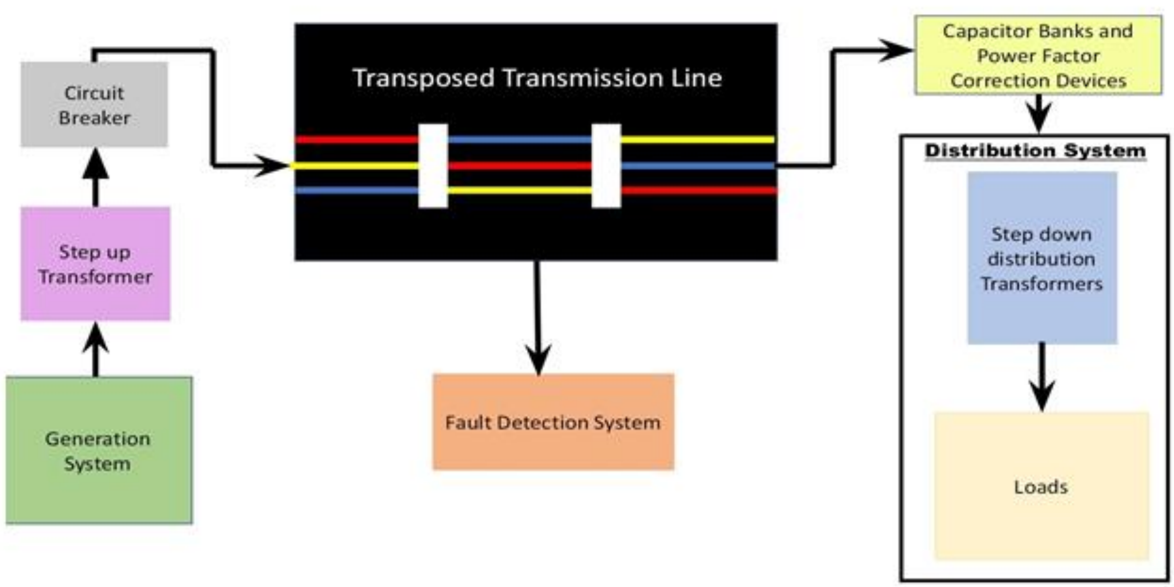
- **Apparatus:**

S.no.	Apparatus	Quantity
1	Step up transformer	1
2	Circuit breaker	1
3	Transposed transmission line	1
4	Capacitor banks	1
5	Load resistance	
6	Power factor correction device:	1
7	Step down transformer	1

➢ Circuit diagram:



➢ Hardware block diagram:



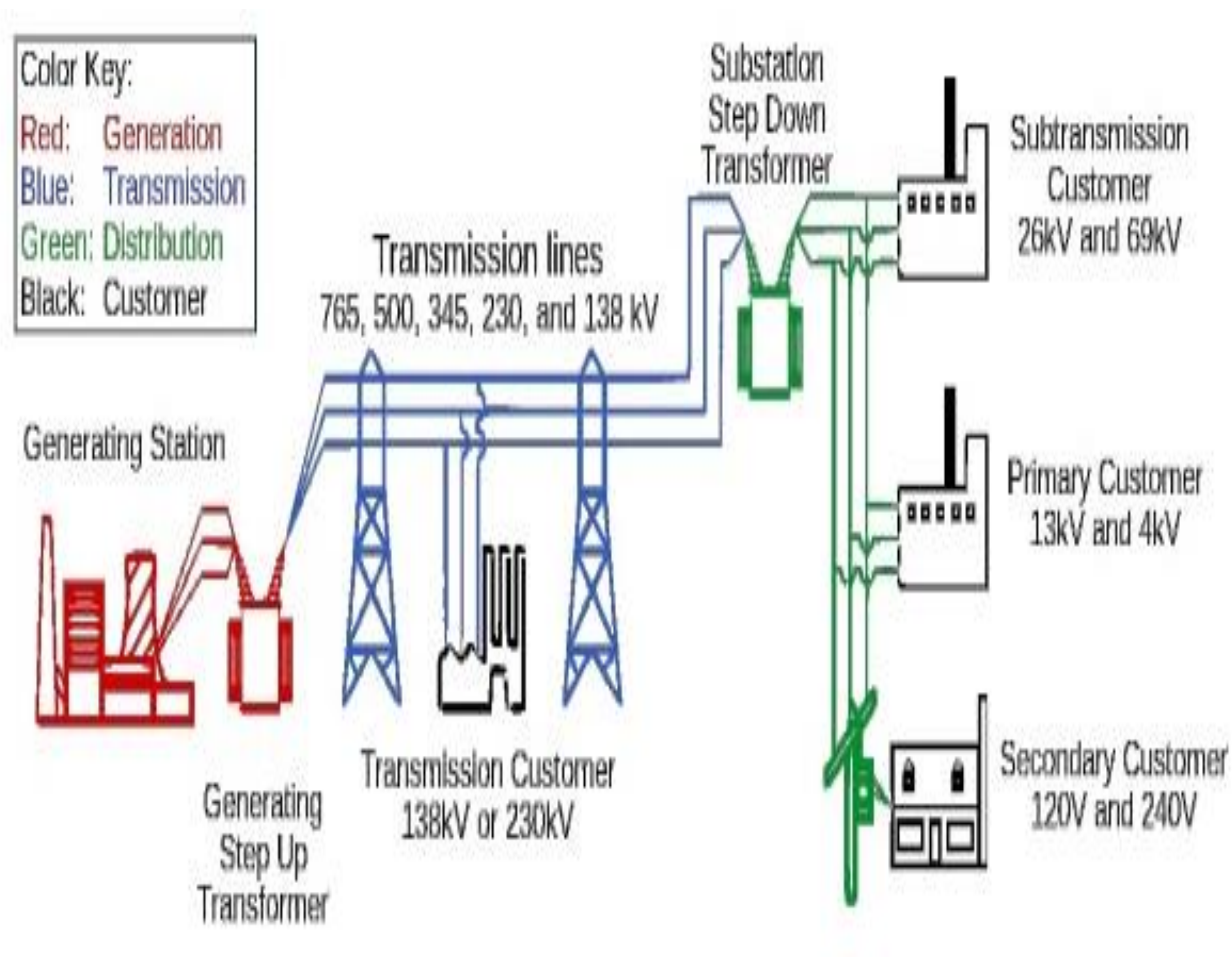
- **Procedure:**

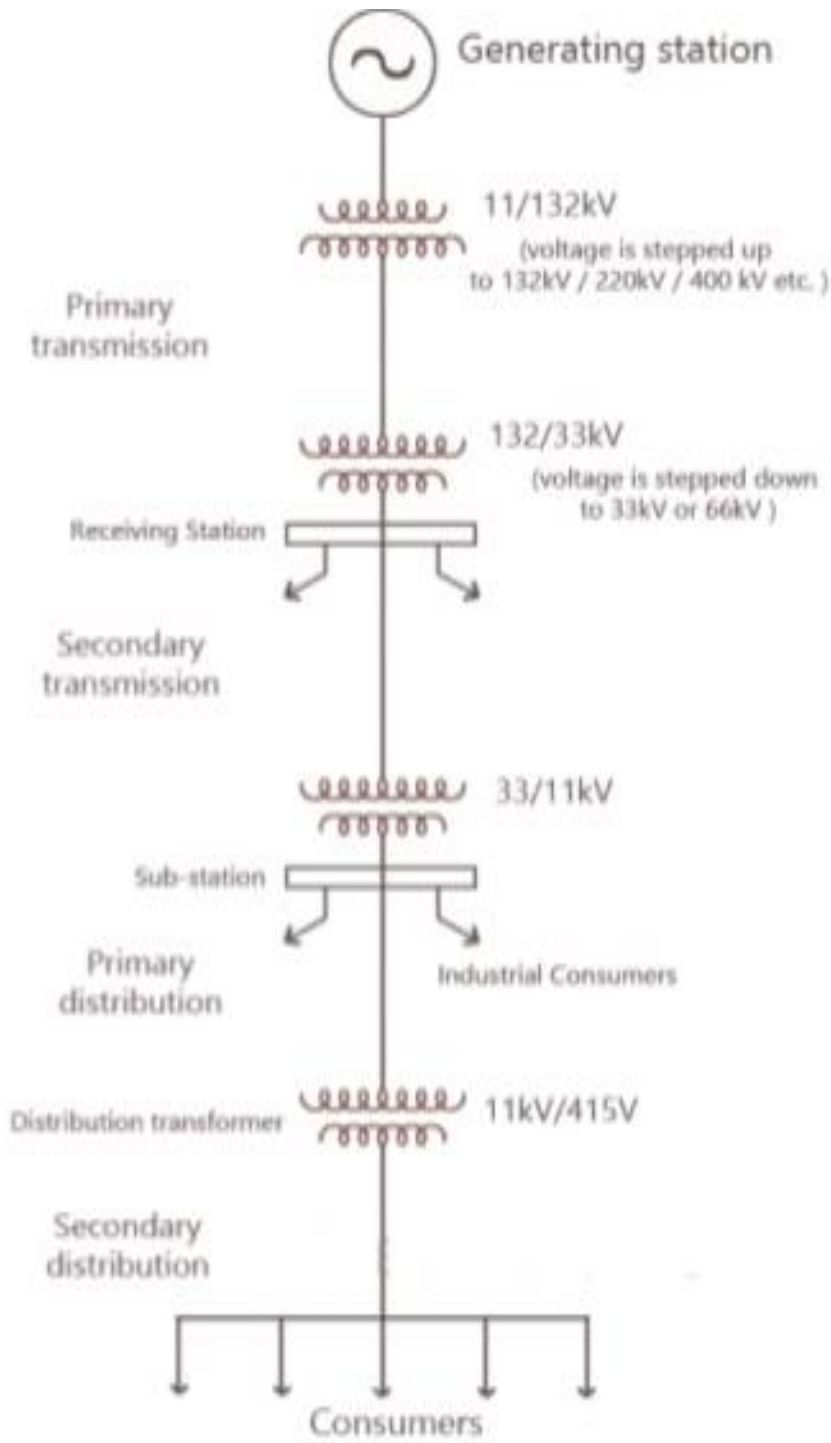
1. The source voltage was set to a rms value of 70KV.
2. The transmission line parameters were set to values of: -
   - Receiving Voltage (Vr)= 75kV arg(0).
   - Receiving Current (Ir)= 322.52 arg(-18).
   - Resistance (R)= 0.013 ohms/km.
   - Inductance (L)= 0.9337mH/km.
   - Capacitance (C)= 12.74 nF/km.
3. The total distance of the transmission line is 300km. With a load of 27MW.
4. The lines are divided into three parts of 100km each.
5. There are three subsystems – Line 1, 2 and 3 consisted of transmission lines with parameters in T – configuration.
6. A **Three Phase Fault detection system** is kept as it helps to detect if any fault is present in the transmission lines and it breaks the circuit. It is used to protect the transmission line.
7. The method of **Transposition** is used to periodically swap the positions of the conductors of a transmission line, in order to reduce crosstalk and otherwise improve transmission.
8. The Modern transmission lines are regulated lines which means that the sending and receiving end voltages are maintained constant at all loads by using shunt capacitors (**Compensation Capacitance**) they are provided to compensate the inductive load that is present in the system and bring the power factor to unity.

- **Theory:**

Electrical power system has three principle divisions:

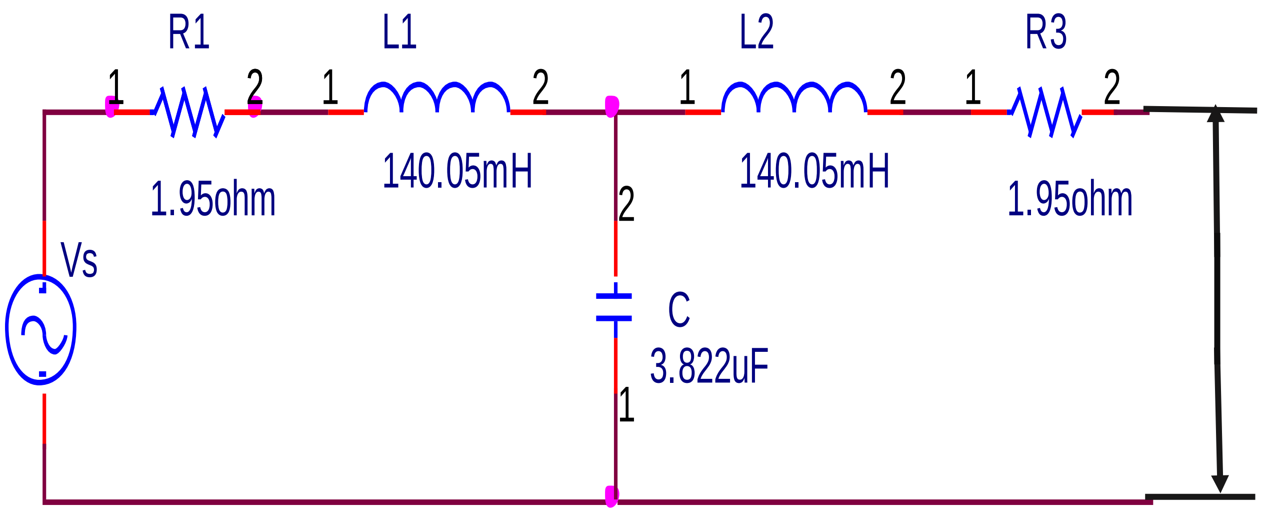
1. Generating station
2. Transmission system
3. Distribution system





Generating station
11/132kV
(voltage is stepped up
to 132kV / 220kV / 400 kV etc.)
Primary
transmission
132/33kV
(voltage is stepped down
to 33kV or 66kV)
Receiving Station
Secondary
transmission
33/11kV
Sub-station
Primary
distribution
Industrial Consumers
Distribution transformer
11kV/415V
Secondary
distribution
Consumers

- **Equivalent circuit diagram:**



- The equivalent circuit diagram of the transmission line model simulated is shown above. The equivalent circuit has resistance, inductance and capacitance in T configuration.
- The receiving end voltage and receiving end current has been fixed along with the output power and receiving end power factor.
- Sending voltage, sending end current, sending end power factor, voltage regulation, percentage efficiency has been calculated and transmission parameters are analyzed.

- **Calculations:**

$V_r = 55\,kV$ (line) $\Rightarrow 31.75\,kV$ (per phase).

$I_r = 322.52 \angle -21$

$R = 0.013\,\Omega/km.$

$l = 0.9337\,mH/km.$

$c = 12.74\,nF/km.$

load = 10 kW.

$Z = [R + j(2\pi f l)](300\,km)$

$Z = 88.08 \angle 87.46\,\Omega.$

$Y = j2\pi f c$

$Y = 1.2 \times 10^{-3} \angle 90$ mho.

$\left.\begin{matrix} Z \\ Y \end{matrix}\right\} \rightarrow ZY = 0.105 \angle 177.46.$

Using approximate model of long transmission lines;

A, B, C, D parameters are;

$$A = D = 1 + \frac{ZY}{2}, \quad B = Z\left(1 + \frac{ZY}{6}\right), \quad C = Y\left(1 + \frac{ZY}{6}\right).$$

$$\therefore \begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_r \\ I_r \end{bmatrix}$$

$A = D = 0.947 \angle 0.141$

$B = 85.57 \angle 87.47\,\Omega$

$C = 1.79 \times 10^{-3} \angle 90.04$ mho.

Hence $V_s = 48294.09 \angle 31.70$ (per phase) $\Rightarrow 83647.82 \angle 31.74\,V$ (line).

$I_s = 294.158 \angle -14.03\,A$

Recieving end power (active) $= \sqrt{3}\, V_L I_L \cos\phi$

$$= \sqrt{3}.55\times10^3 \times 322.52 \cos(21)$$

$$P_r = 28.68\,\text{MW}.$$

Sending end power (active) $= \sqrt{3}\, V_L I_L \cos\phi$

$$= \sqrt{3}\times 83647.82\angle 31.44 \times 294.158 \cos(45.47)$$

$$= 29.72\,\text{MW}.$$

$$\therefore \text{Efficiency} = \frac{28.68\,\text{MW}}{29.72\,\text{MW}} \times 100 = 0.9647\times100$$

$$\therefore \eta = 96.47\%$$

$$\text{Voltage regulation} = \frac{V_{NL} - V_{FL}}{V_{NL}}$$

$$V_r(NL) = |V_s/A| = |88329.27\angle 31.59| = 88.33\,\text{kV}$$

$$V_r(FL) = 55\times10^3$$

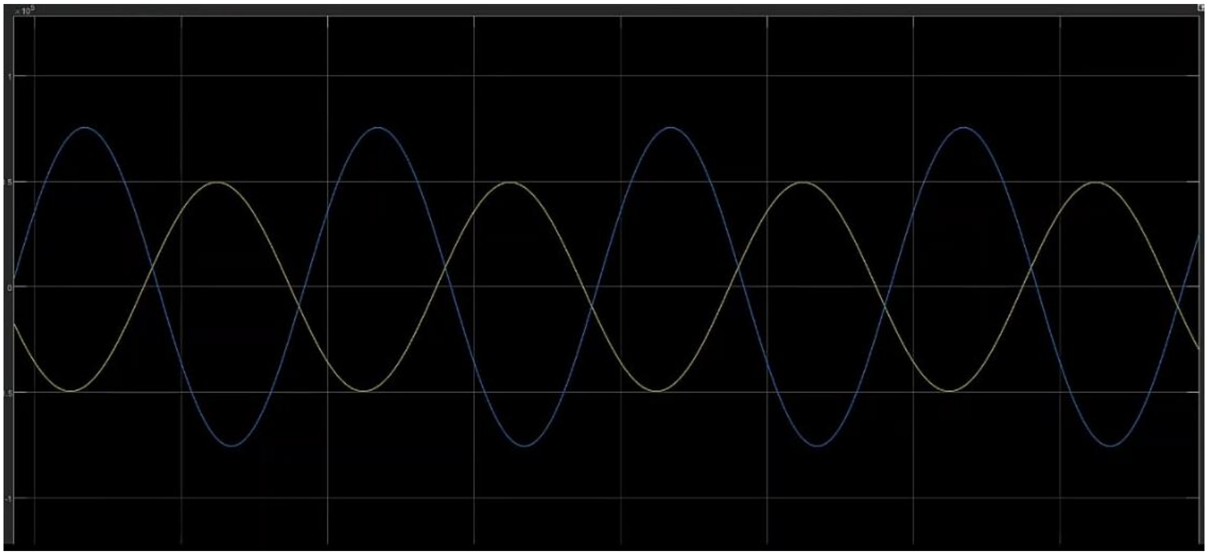
$$\therefore VR = \frac{(88.33-55)\times10^3}{88.33\times10^3} = 0.377$$

$$\therefore \%\ \text{Voltage regulation} = 37.7\%$$

➢ Observations:

- We observed receiving end voltage to be 31.75kV per phase, receiving end current with the magnitude of 322.52 A and a lag of 21 degrees.

- Equivalent resistance of transmission line is observed to be 0.013 ohms/km, inductance is observed to be 0.9337 mH/km and capacitance is 12.74 nF/km.



Receiving end voltage and receiving end current plotted

- **Result:**

- Sending end voltage is 48.29 kV leading by 31.7 degrees and obtained value of sending end current is 294.15 A lagging by 14.07 degrees with receiving end voltage as reference.
- The efficiency of transmission line is calculated and is observed to be 96.47%, thus the system is economically feasible.
- Voltage regulation is the system is observed as 37.7%.

- **Advantages of EHV transmission line:**

- The voltages in the range of 300 kV to 765 kV are known as Extra High Voltages (EHV). The voltages which are 765 kV are termed as Ultra High Voltage (UHV). In India, transmission voltage ranges from 66 kV to 400 kV (RMS value of line to line voltage in three phase system). There are several advantages of **extra high voltage transmission**.

In EHV AC lines additional parallel three-phase line is always provided to ensure continuity of power supply and stability of line. A long EHV AC line is always double circuit line with intermediate substations at an interval of 250 km to 400 km for compensating reactive power.

Power transmitted is given by

$P = \sqrt{3}\ V\ I \cos\varphi$

Where, V = transmission voltage, I = load current, $\cos\varphi$ = load power factor.

Or **Load current,** $\mathbf{I = P/(\sqrt{3}\ V \cos\varphi)}$

From above expression, it is clear that for a constant power and power factor, the load current is inversely proportional to the transmission voltage. In simple words, **as we increase the transmission voltage, the load current decreases**.

This decrease in load current results in following advantages:

- As current gets reduced, size and volume of conductor required also reduces for transmitting the same amount of power.
- Voltage drop in line (3IR) reduces and hence voltage regulation of the line is improved.
- Line losses ($3I^2R$) gets reduced which results in the increase in transmission line efficiency.
- Power handling capacity of the line increases as we increase the transmission voltage. It is proportional to the square of operating voltage. The cost related to tower, insulators and different types of equipment are proportional to voltage rather than the square of voltage. Thus the net capital cost of transmission line decreases as voltage increases. Therefore, a large power can be transmitted with high voltage transmission lines economically.
- The total line cost of per MW per km decreases considerably.

- The operation of EHV AC system is simple, reliable and can be adopted easily.
- The lines can be easily tapped and extended.

➢ **Disadvantages of EHV transmission line:**

- Corona loss is a big problem at higher voltages. This may further increase in bad weather conditions.
- It increases radio interference.
- The height of towers and insulation increases with increase in transmission voltage.
- The cost of different types of equipment and switchgear required for transmission increases with increase in transmission voltage.
- The high voltage lines produce electrostatic effects which are injurious to human beings and animals.

References:

https://www.slideshare.net/gsgindia/construction-ehv-transmission-line

http://www.irjabs.com/

Power System Engineering – DP Kothari

THANK YOU