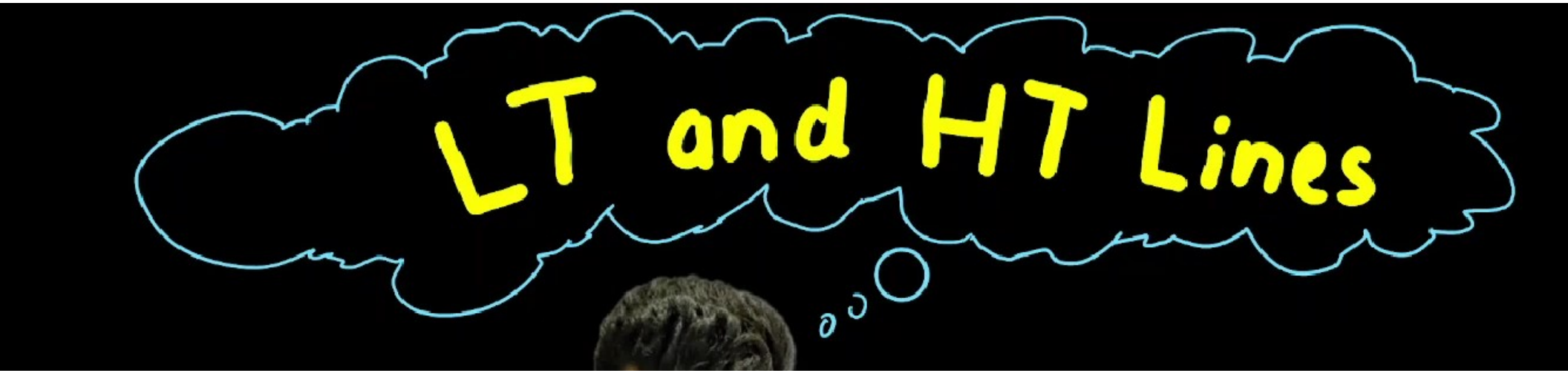
Low tension lines [LT line]

High Tension line [HT Line]

Extra High Tension line [EHT line]


LT and HT Lines

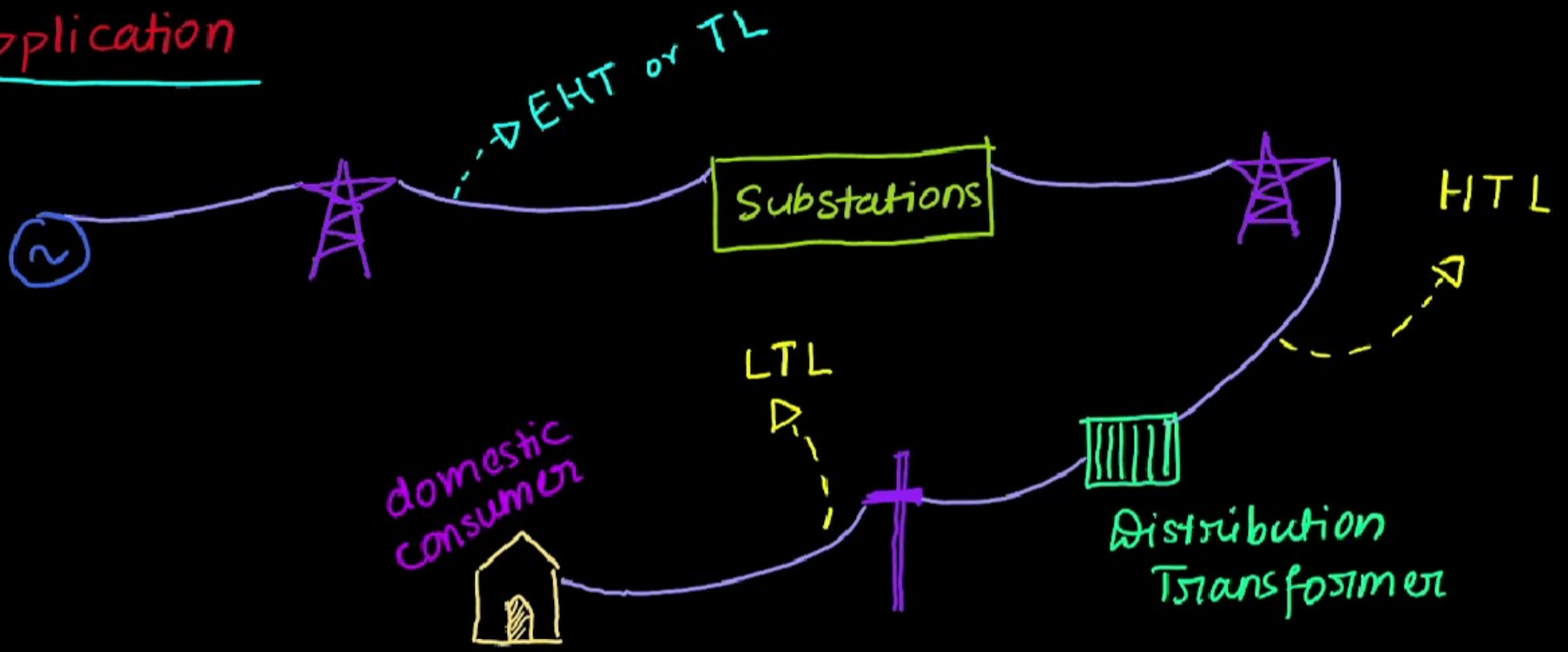
Meaning

Tension ----> french word for voltage

LT line ----> Low tension or Low voltage line

HT line ----> High tension or High voltage line

Application



* EHT or TL :→ Generation to Substation

HT Line :→ Substation to distribution transformer

LT Line :→ Distribution Transformer to consumer

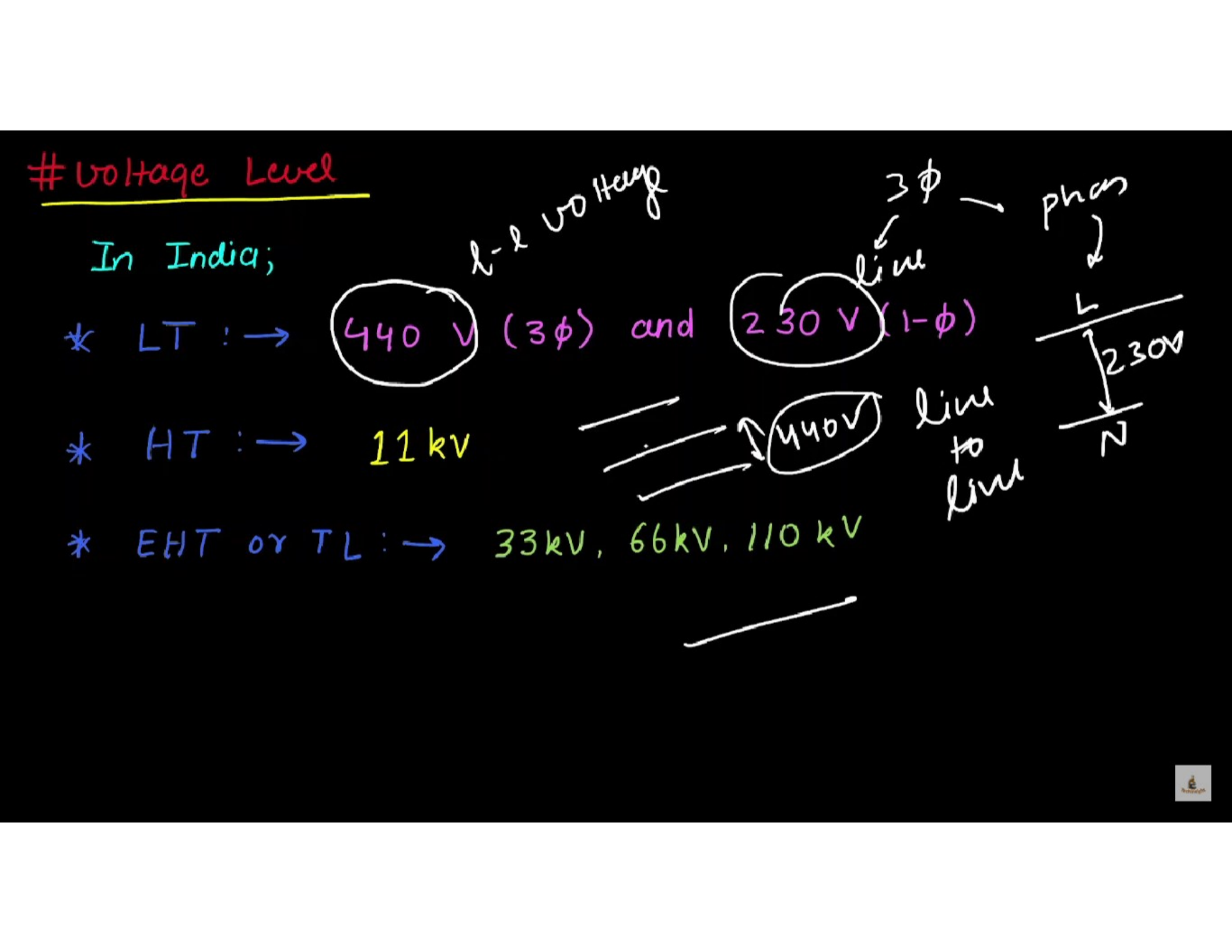
Voltage Level

In India;

* LT :→ 440 V (3ϕ) and 230 V (1-ϕ)

* HT :→ 11 kV

* EHT or TL :→ 33kV, 66kV, 110 kV



No. of conductors used

LT line — Domestic

- 4 conductors
- 3 phase wires
- 1 Neutral

HT Line — Industrie — 3-ϕ 4 M

- 3 conductors
- 3 Phase wires
- No neutral

TL or EHT Line — 3-ϕ syn.

- 3 conductors
- 3 phase wires
- 1 earth wire

Mall

Shield wire

No. of conductors used

LT line

4 conductors

3 phase wires

1 Neutral

HT Line

3 conductors

3 Phase wires

No neutral

Lightning shielding wire

phase

TL or EHT Line

3 conductors

3 phase wires

1 earth wire

No neutral

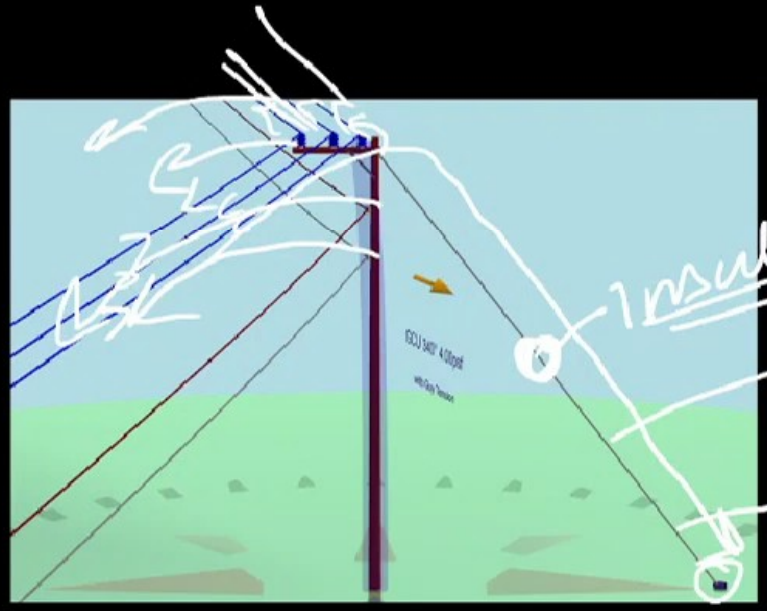
Insulators ⇢ Depends on voltage rating of Line

* LT Line :→

Pin insulator

Guy Insulator

Resist



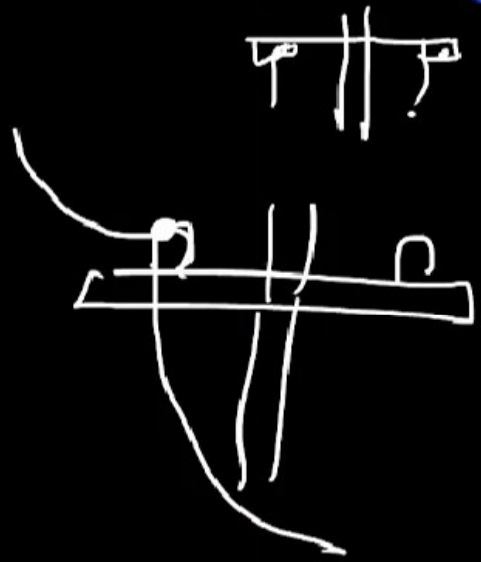
Insulator

guy wire

metal wire

* HT Line :→

Disc Insulator

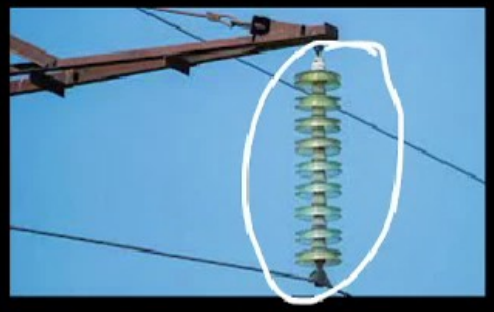


Railway

* EHT or TL :→

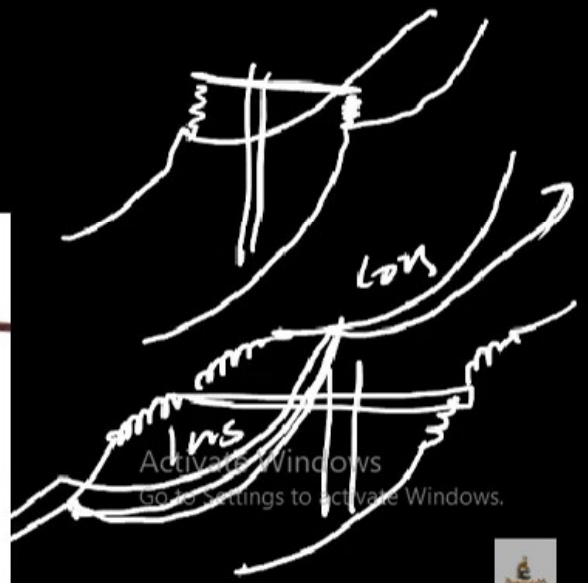
75% 1 dis → 11kV

400 33kV



Suspension Insulator

Strain Insulators



Location

* LT Line :→

City streets

* HT Line :→

Only main roads

* EHT or TL :→

Outside city

Support Structure

* LT and HT Line

Cemented Poles

PCC

Plain Cement Concrete

RCC

Reinforced Cement Concrete

(Pcc)

(RCC)

* EHT or TL :→

cond size ↳ TL > HT > LT

WT

RCC PLC

Tower

Strong

cond. hold

Heavy

current rating

Steel Tower

Types of conductors

Al. cond. steel R

ACSR conductors

* LT Lines :→ Phase :→ weasel conductor

  Neutral :→ Squirrel conductor

* HT Lines :→ Rabbit conductor

* TL or EHT :→ ACSR coyote → 66kV

  ACSR Lynx → 110 kV

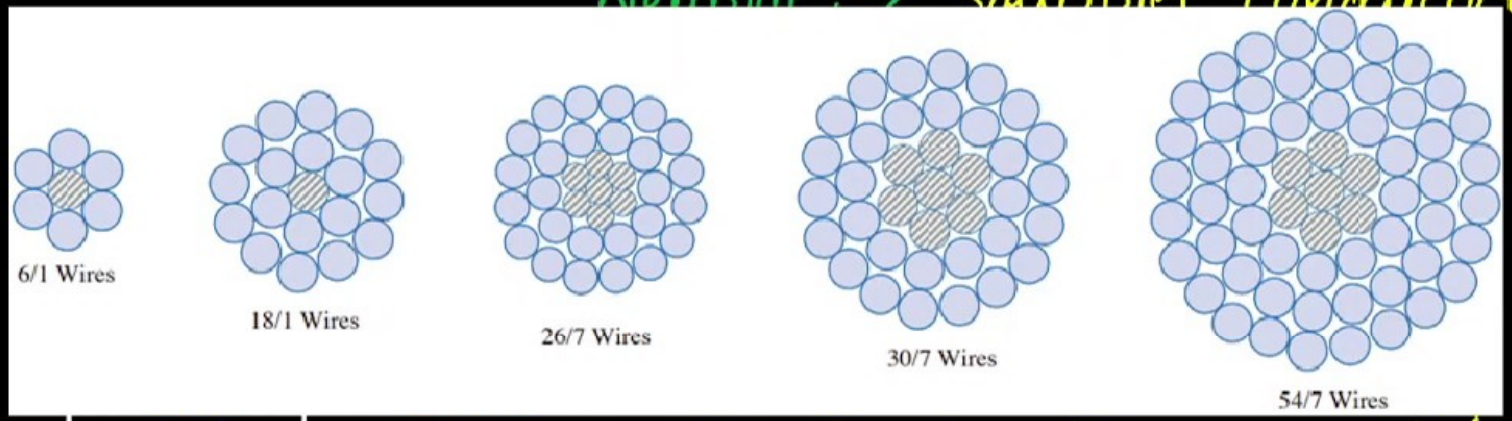
  ACSR Drake → 220kV

Types of conductors

Al. cond. Steel R

* LT Lines :→ Phase :→ weasel conductor

Neutral :→ Squirrel conductor



* TL or EHT :→ ACSR coyote → 66kV

ACSR Lynx → 110 kV

ACSR Drake → 220kV

ACSR conductors

Differ in strands, cross section area, wt. and current carrying capacity

6/1 18/1 26/7

#size of conductor

CODE NAME	AREA (mm2)	SIZE (Aluminum strands/Steel Strands/ Diameter)	WEIGHT	CURRENT CAPACITY
Squirrel	20	6/1/2.11	85	130
Weasel	30	6/1/2.59	128	170
Rabbit	50	6/1/3.35	214	240
Lynx	175	30/7/2.79	842	520
Drake	420	30/7/4.27	972	870

--> LT and HT Line consist; 6 Al. strands + 1 steel strands

* ACSR Coyote :→ Al. strands :→ 30/2.54 mm

Steel strands :→ 7/1.9 mm

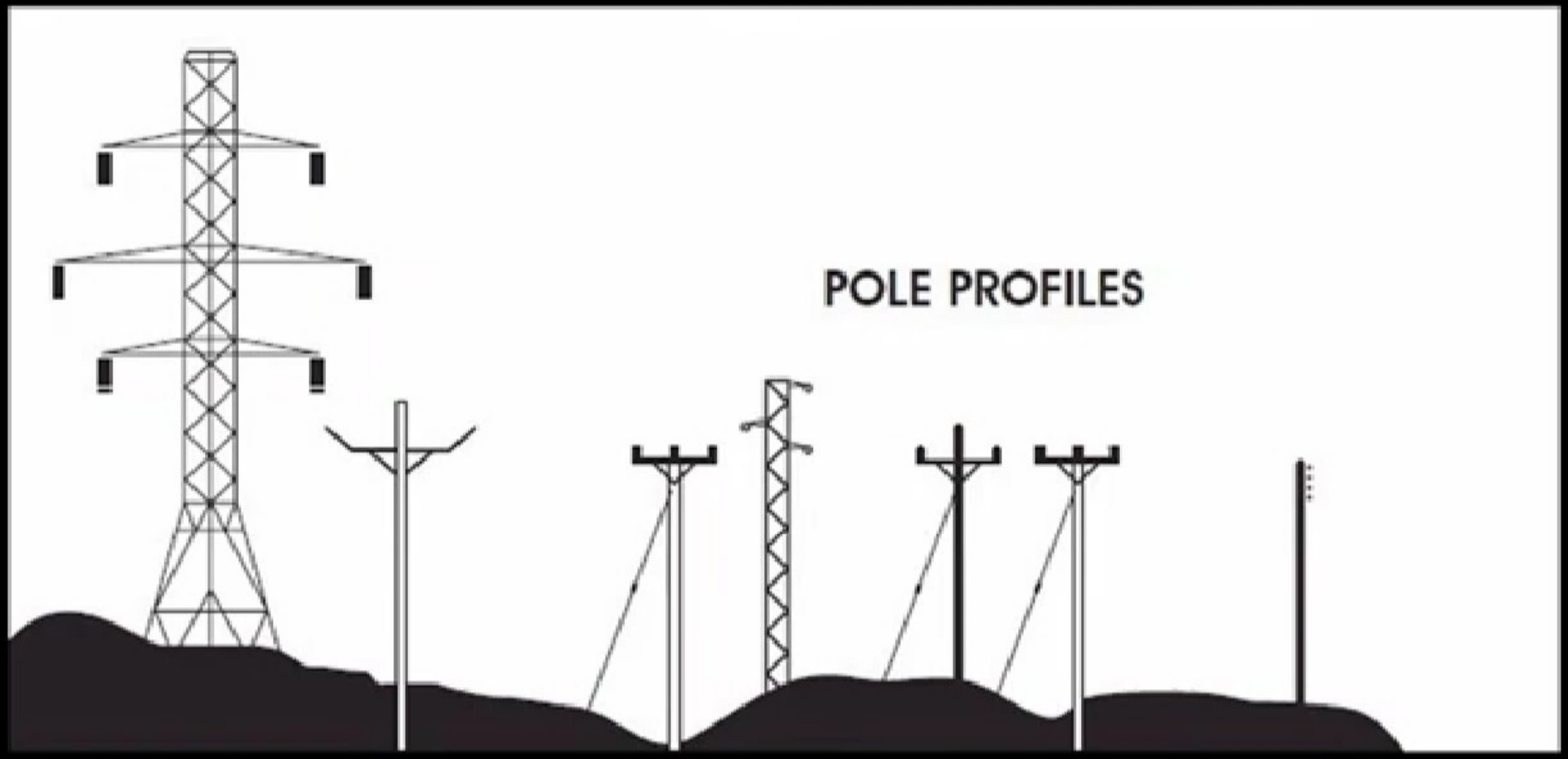
Cost

Cost ∝ Size of conductors ∝ Current rating

LT Line < HT Line < T Line

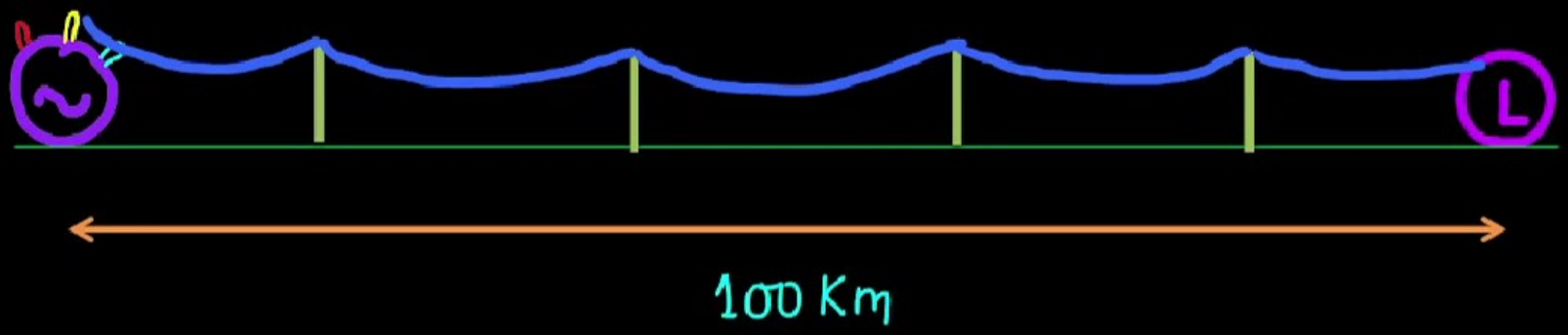
Current Rating

Cost


POLE PROFILES

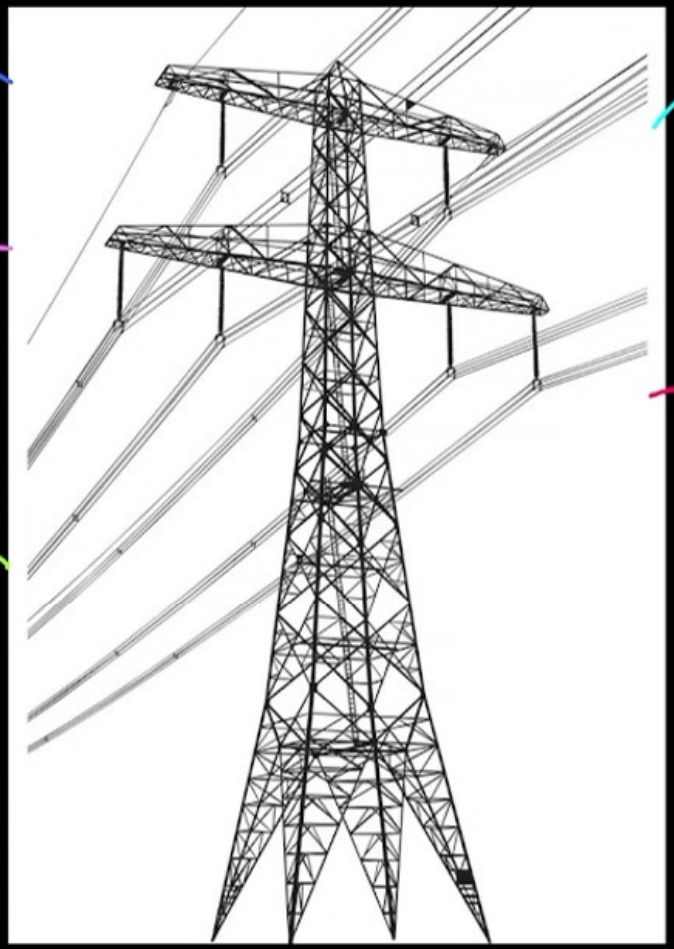

ELECTRIC POLES

Use of electric poles



" To mechanically support lines for transmission and distribution of electric power"

Important features of Electric Poles



Long Lifespan

Low maintainance

Easy to access transmission lines for maintainance

To withstand with weight of conductor

Low cot. without compromising strength

Types of electric poles

Wooden poles

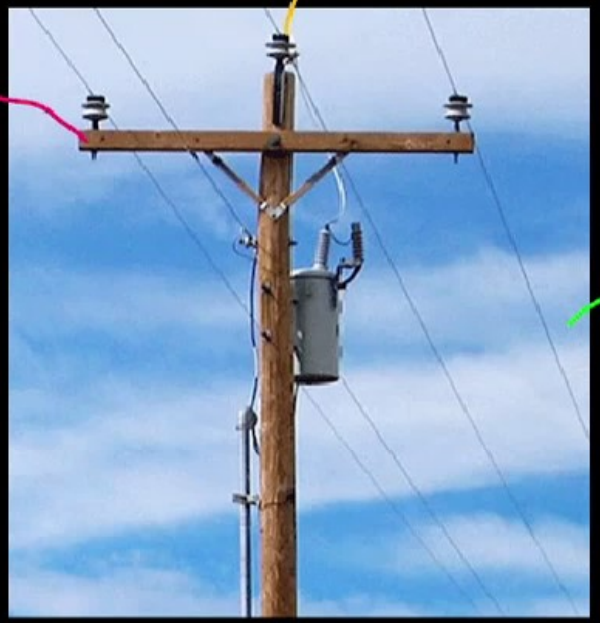
Rail electric poles

Lattice steel

Steel tubular

Concrete poles

Wooden Poles



Used during the early stages of power system

Used for LT Lines

Division

On the basis of wt. of conductor

Shaal wood

Garjan wood

Steel Tubular Poles

Have high load bearing capacity

Higher than wood poles

Demand

due to high cost

Generally used in both HT and LT Lines

Types

Stepped pole (1STP)

Swaged pole (1SWP)

Concrete Electric Poles

RCC
(Reinforced
Cement concrete)

Cement with steel → iron
Reinforcement

Strength ↑
Durability ↑

Used in
LT and
HT lines

PCC
(Plain Cement Concrete)

made of plain cement
without steel
Reinforcement

Strength ↓
Durability ↓

Comparison

LT and HT poles

1. Strength :


<

<


2. Cost :


<

<


Lattice steel (EHT or Transmission lines poles)

its mechanical strength is higher than rest of the pole

Long Life

Can withstand with harsh climatic condition

Rail Electric Poles

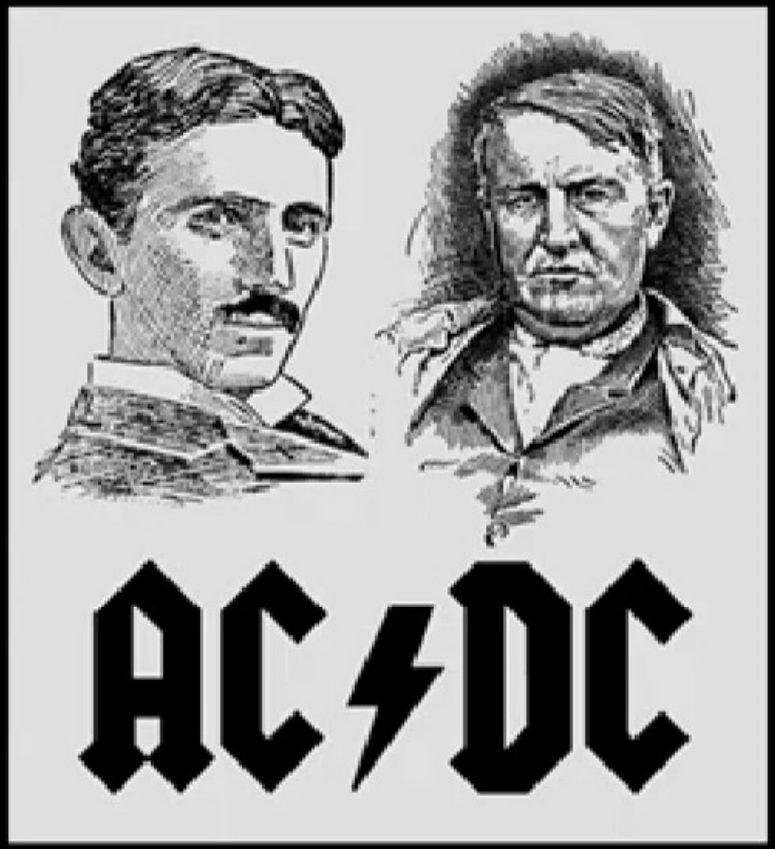
Height → 9 m to 13m

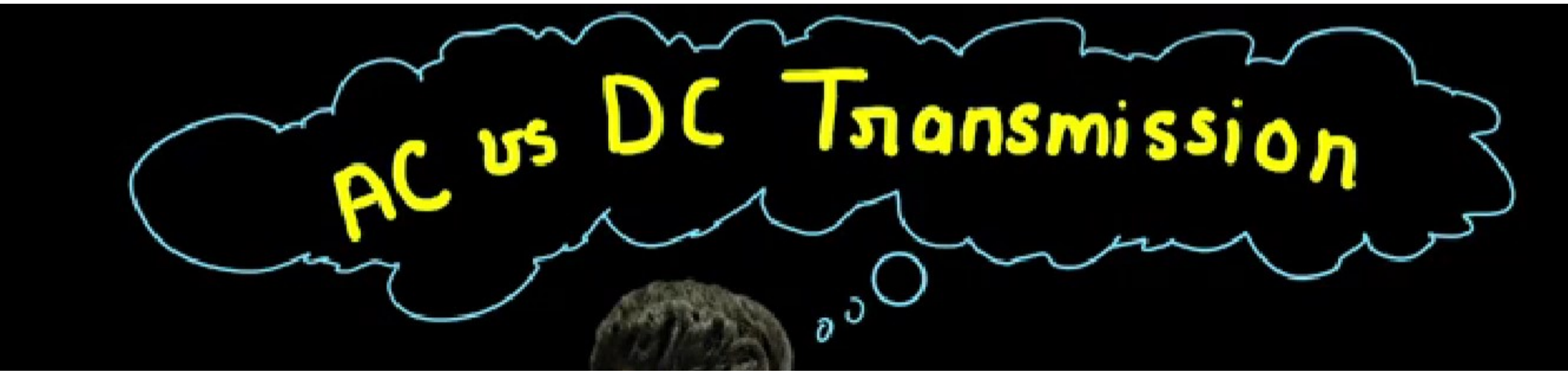
Carry 25kV Line

has more Strength

Maximum Strength
maximum cost

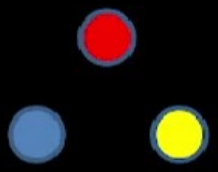
Size: 30 kg/m
37 kg/m
45 kg/m


AC/DC


AC vs DC Transmission

#DC system Advantages

1. Only 2 conductors

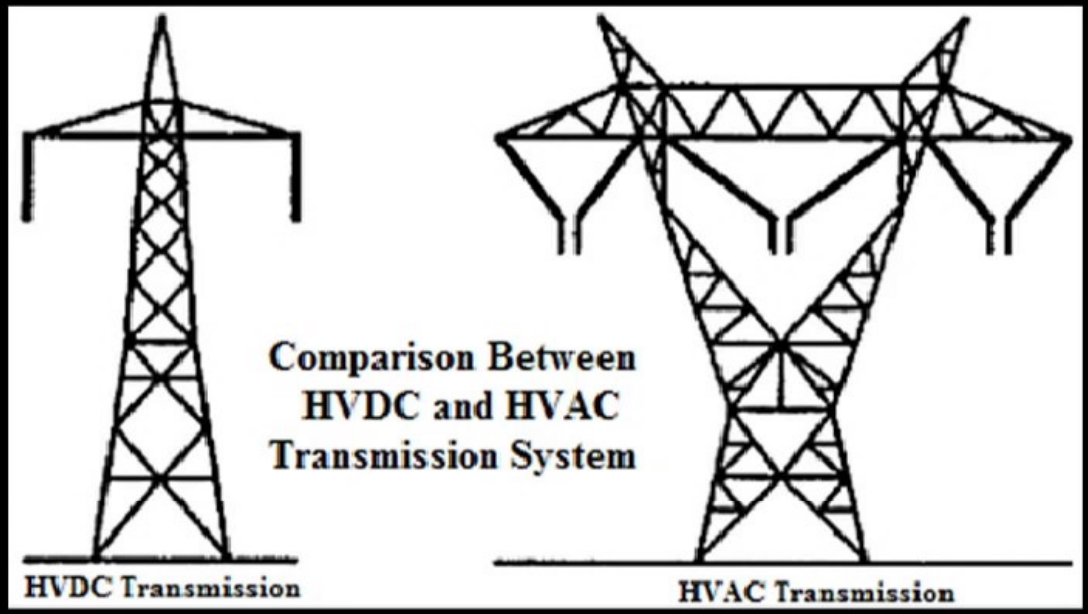


3-ϕ AC system

DC system

Neutral wire

2. Simplified structure



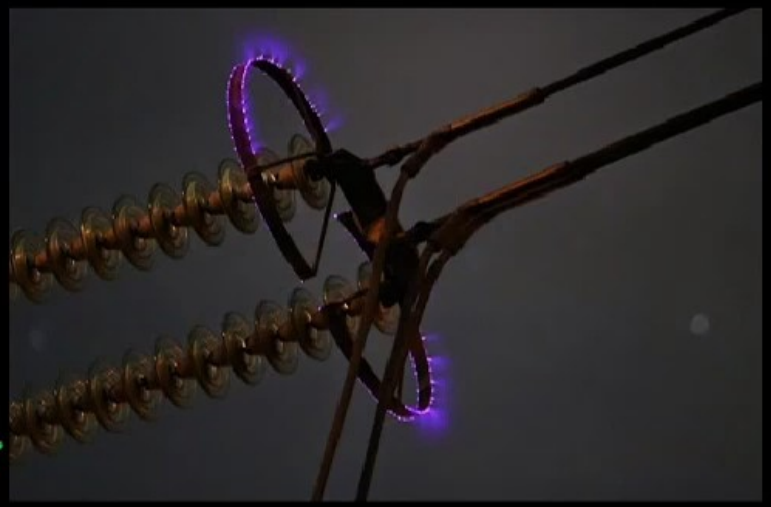
3. No L or C

AC ≡ DC

Transients
Surge
Skin effect
Proximity effect

} Due to L and C = zero in DC system

4. Low Corona Effect



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

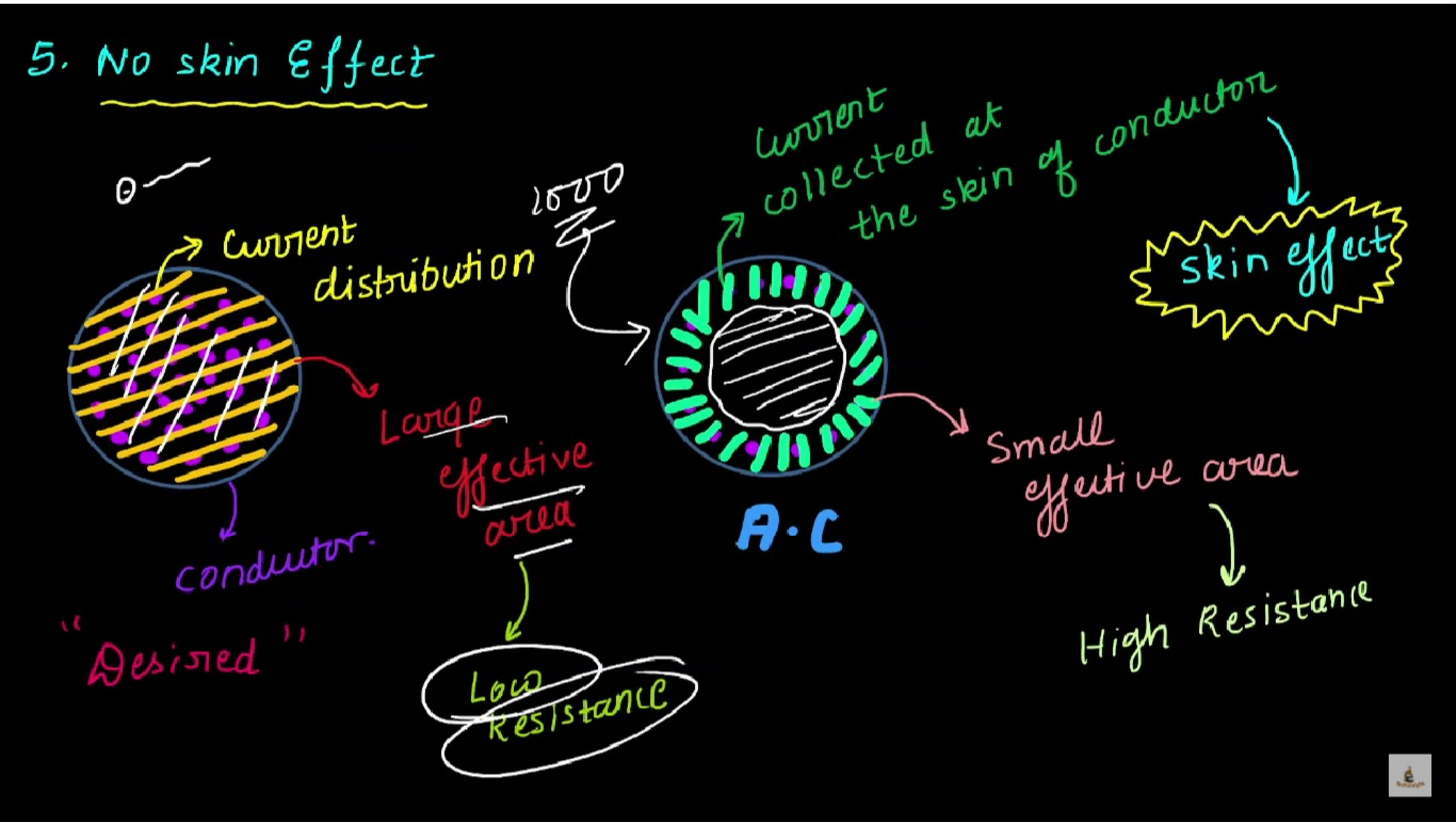
$$\text{Power Loss} = \frac{242.2}{\delta}\left[f + 25\right]\sqrt{\frac{r}{d}}\,.\,(V - V_c)^2 \times 10^{-5}\ \text{kW/km/}\phi$$

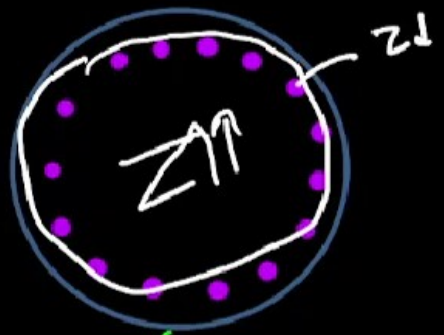
(AC)

(f = 0 in dC)

for 50Hz AC;

$$P_{corona_{AC}} \simeq 3\, P_{corona_{DC}}$$

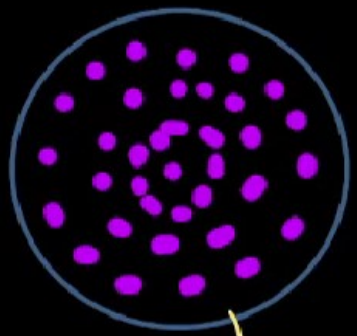

5. No skin Effect
0
Current distribution
conductor.
"Desired"
Large effective area
Low Resistance
2000
Current collected at the skin of conductor
A·C
skin effect
Small effective area
High Resistance



Skin effect is due to variable AC flux

DC

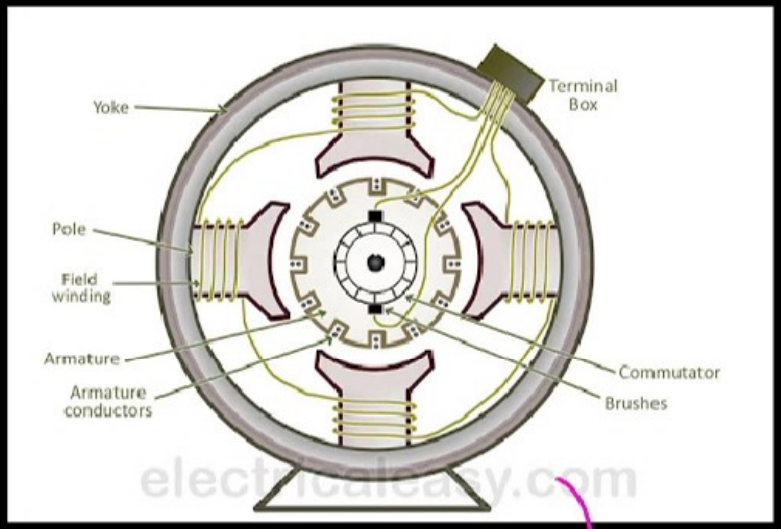
Constant flux



No skin effect in DC

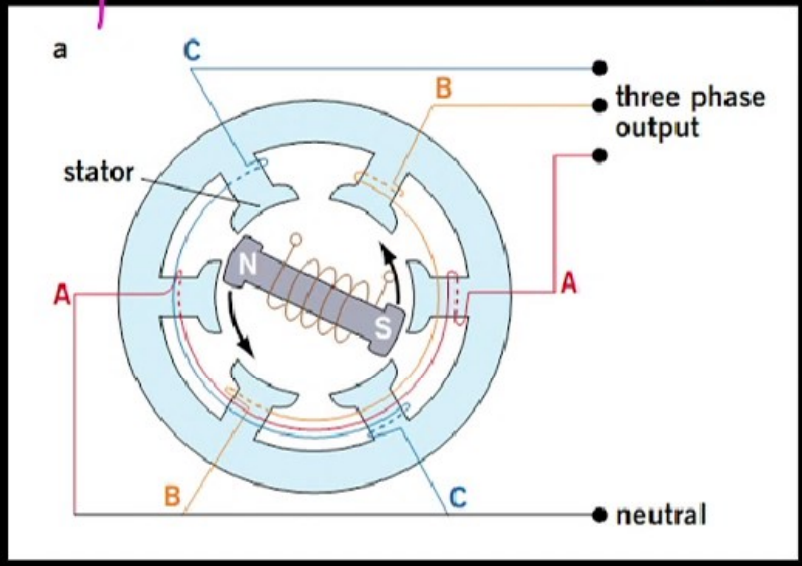
Advantages of AC system

1. High voltage generation

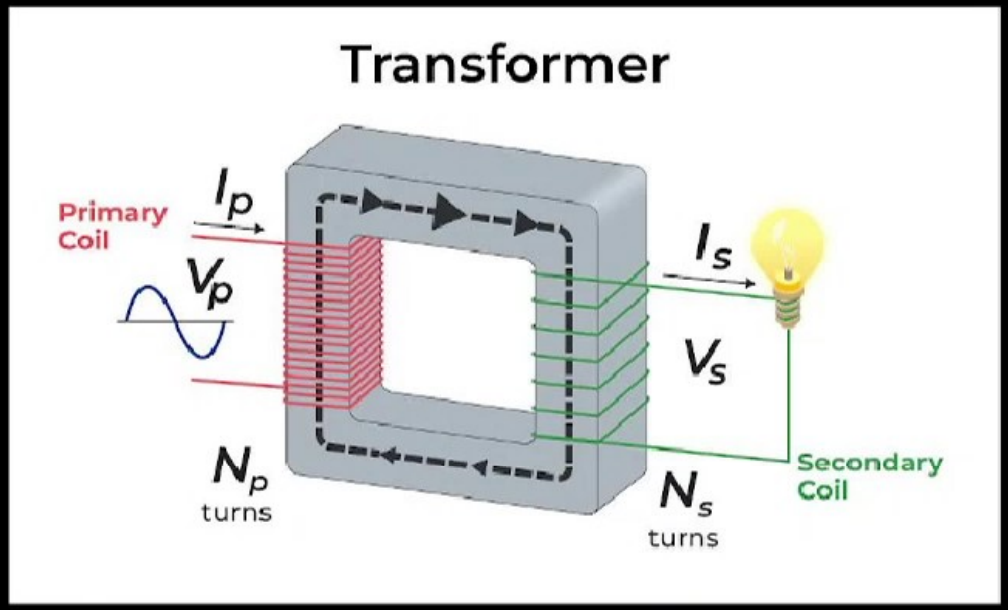


Low voltage generation ← Commutation Problem

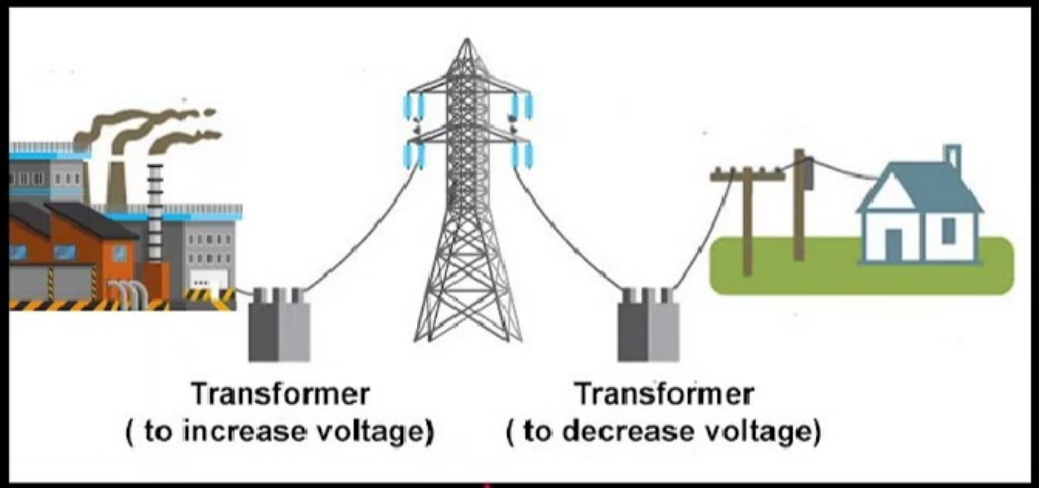
No commutation problem → High voltage generation



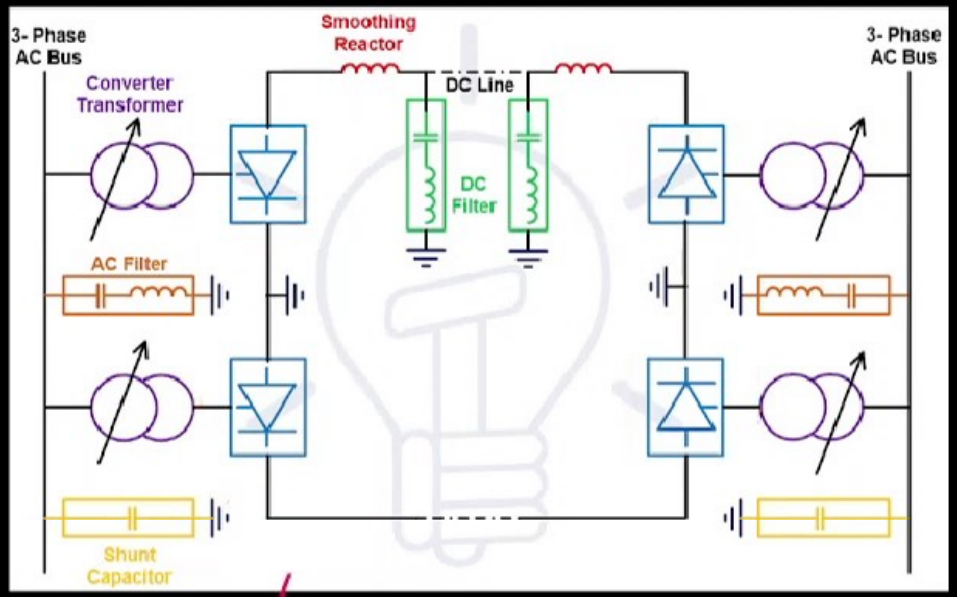
2. Can be easily step up - step down



3. Maintainance is easy and cheap



HVAC

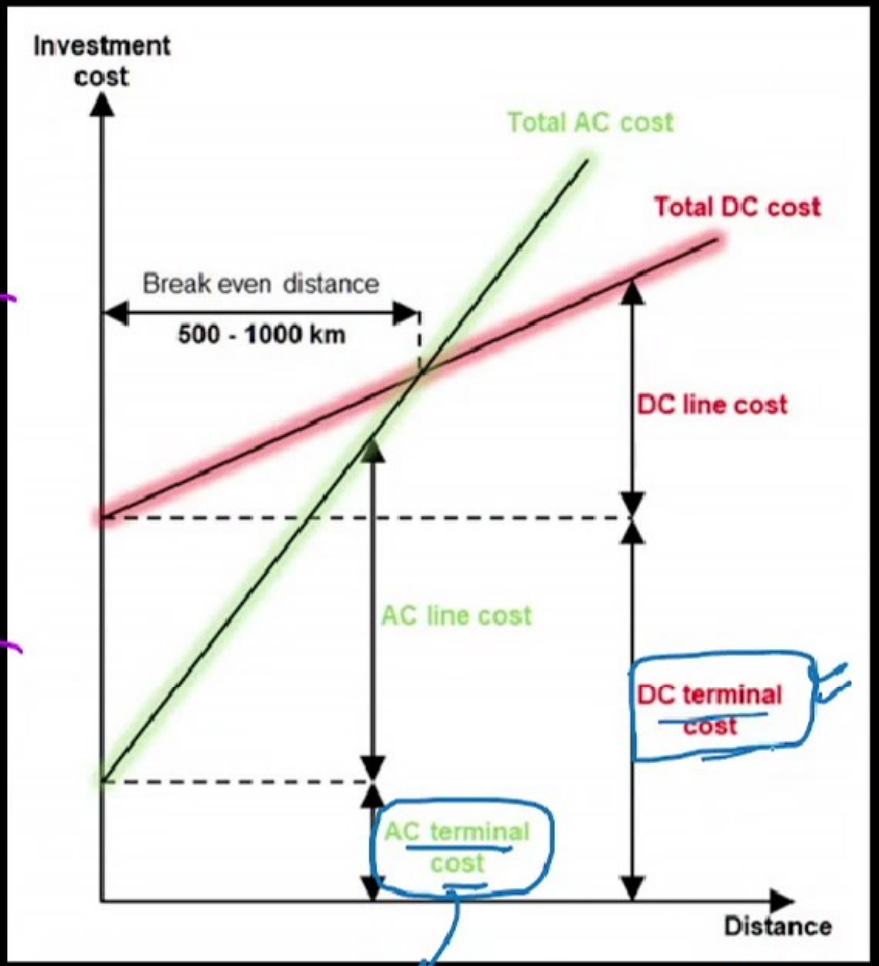


HVDC

4. Cost Effectiveness

DC system is economical for long distance transmission

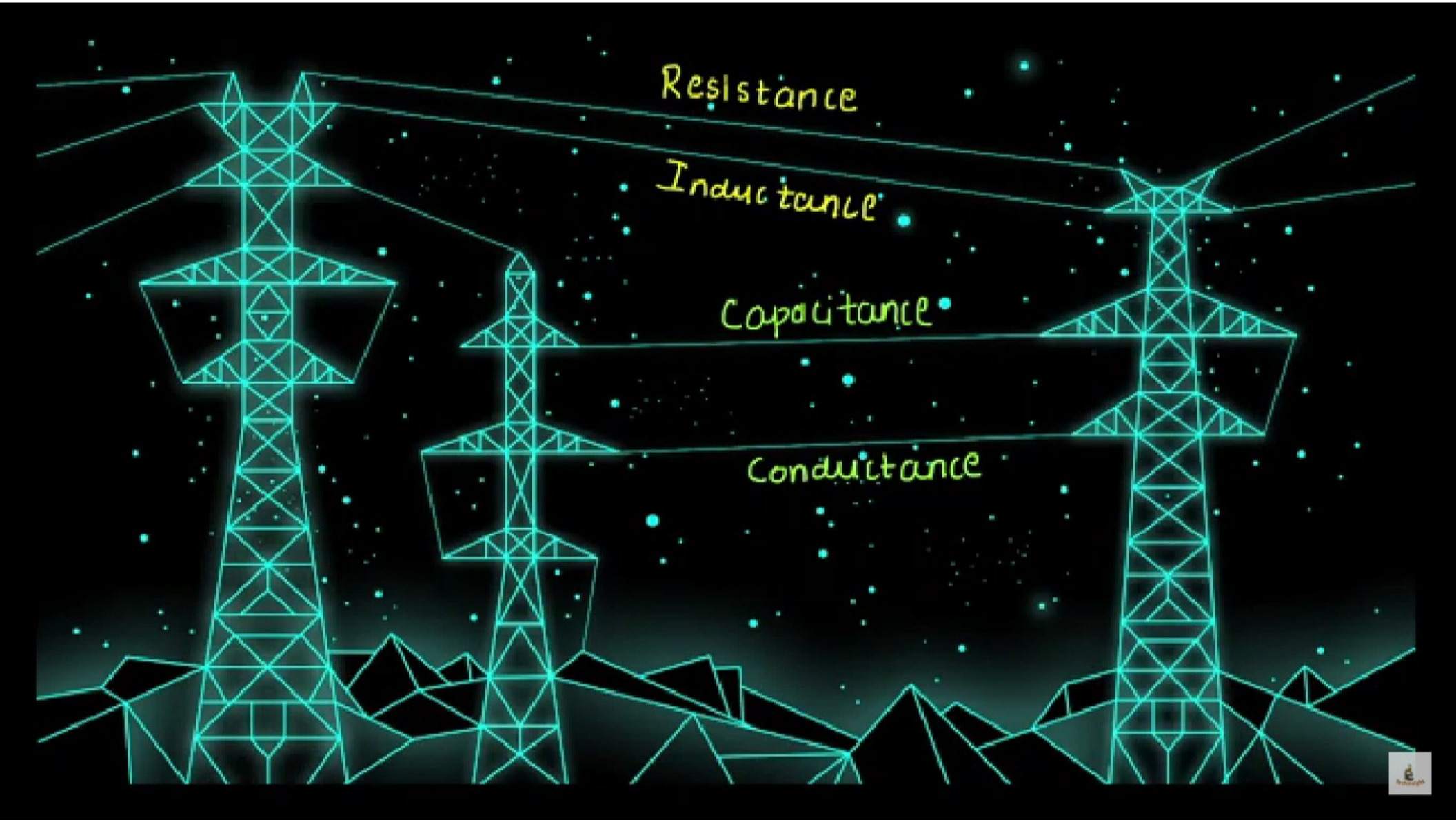
AC system is economical for short distance transmission

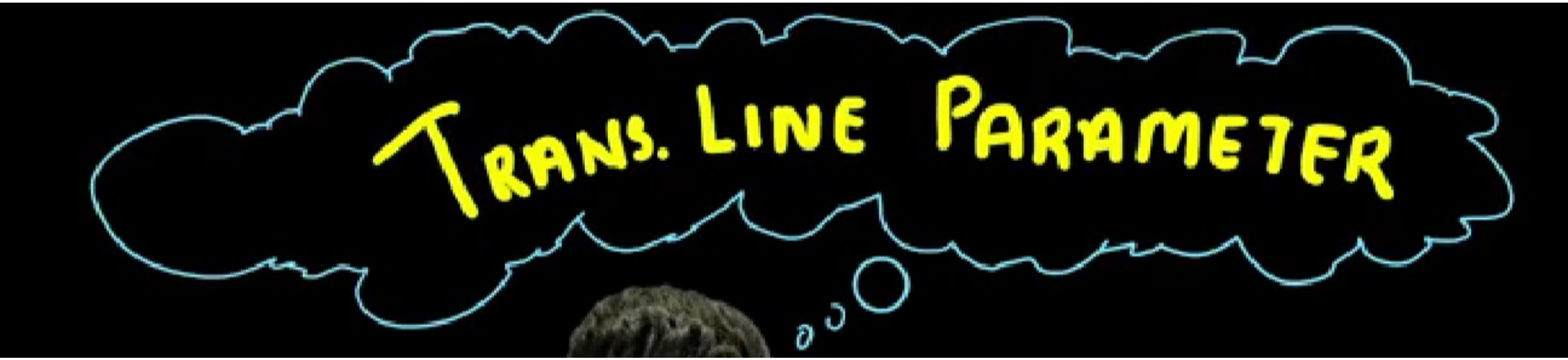


HVAC

HVDC

HVAC


Resistance
Inductance
Capacitance
Conductance


TRANS. LINE PARAMETER

Transmission Line Parameters

(1) Resistance

Every electric conductor offers some opposition to the flow of electric current through it.

(2) Inductance

When alternating current flows in the transmission lines, the conductors produce alternating magnetic flux, results in induced voltage. This induced EMF is nothing but inductance present in the line.

(3) Capacitance

There exists a capacitance between two conductors of a transmission line or between a conductor and earth.

(4) Conductance

It is the flow of leakage current between conductors or between a conductor and earth at the insulators of the transmission line.

Lumped and Distributed Parameters

In a power transmission line;
parameters like resistance, conductance,
inductance and capacitance
are uniformly distributed over the
length of the line.

Therefore ideally, they should be
expressed on per unit length basis.

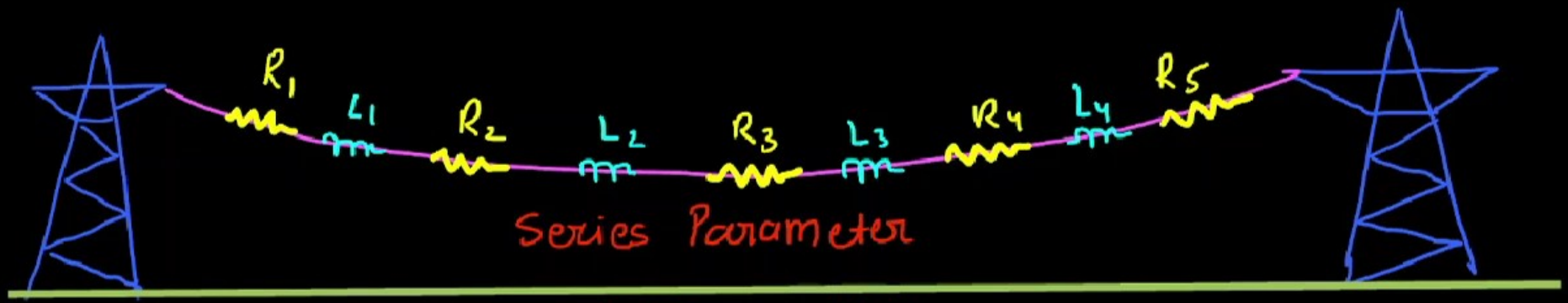
R → ohm per meter

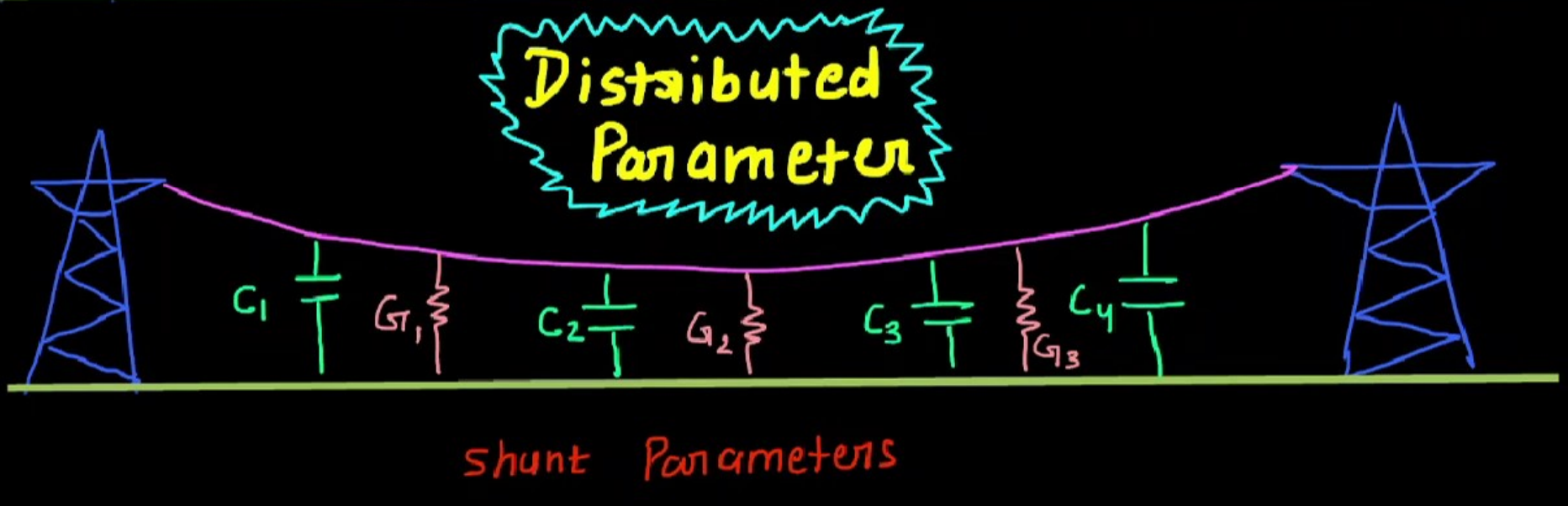
L → Henry per meter

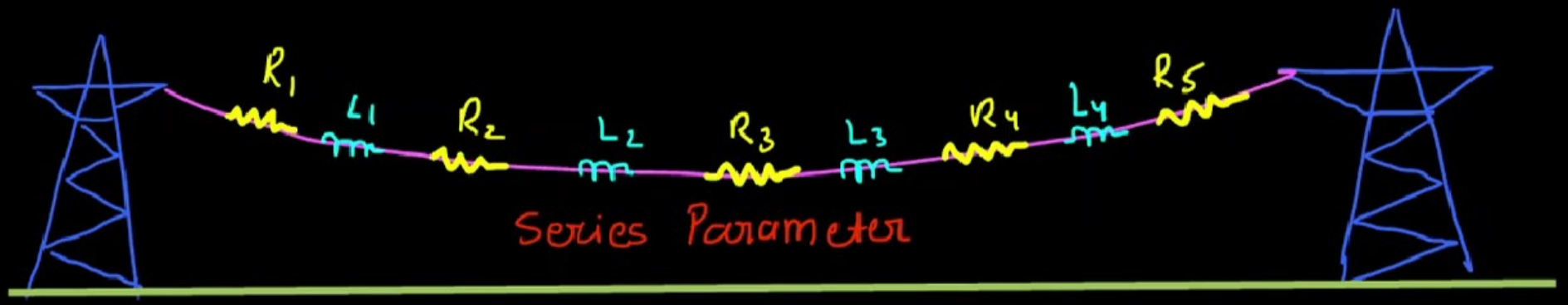
C → Farad per meter

G → mho per meter

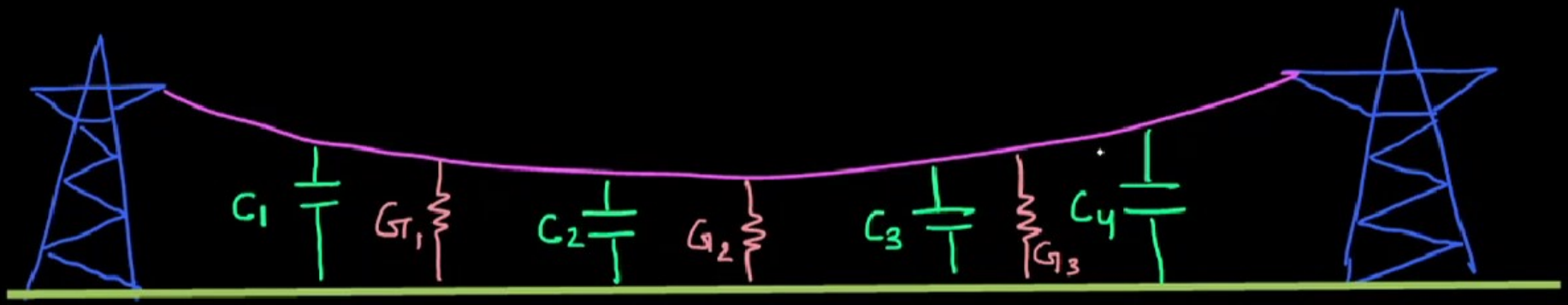
Lumped and Distributed Parameters



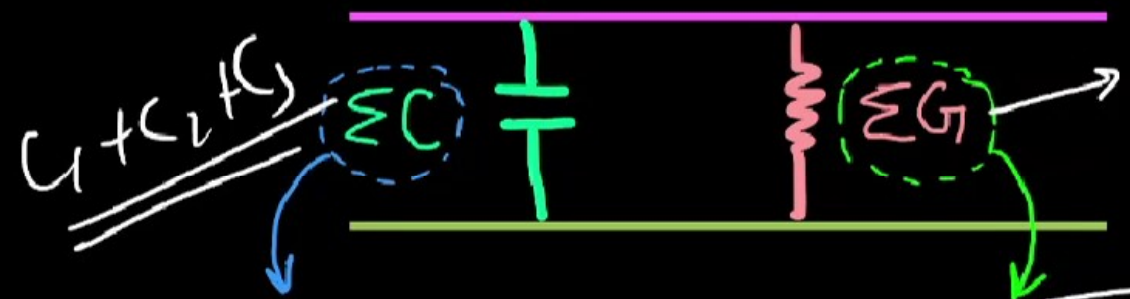



R1
L1
R2
L2
R3
L3
R4
L4
R5
Series Parameter


ΣR
ΣL
Lumped Resistance
Lumped Inductance



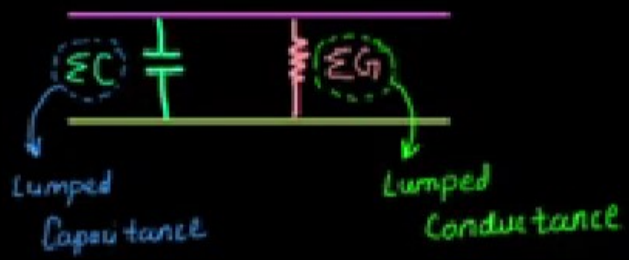
Shunt Parameters



$G_1 + G_2 + G_3$

Lumped Capacitance

Lumped Conductance



When to use lumped and when Distributed Parameter?


Lumped Vs. Distributed

Where we use Lumped Parameter

Lumped

* Ignore some parameter
  - Results in Error
  - Simplify calculation

Simplicity

Distributed

* Include all parameter
  - Provide High accuracy
  - complicate computation

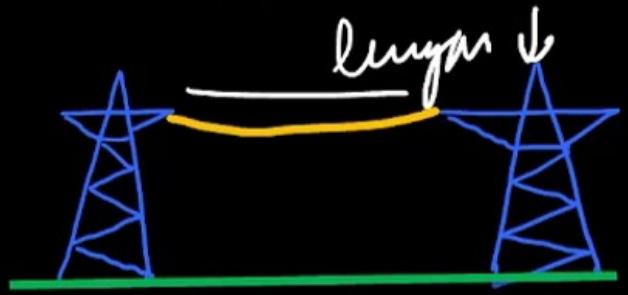
Accuracy

Where we use Lumped Parameter

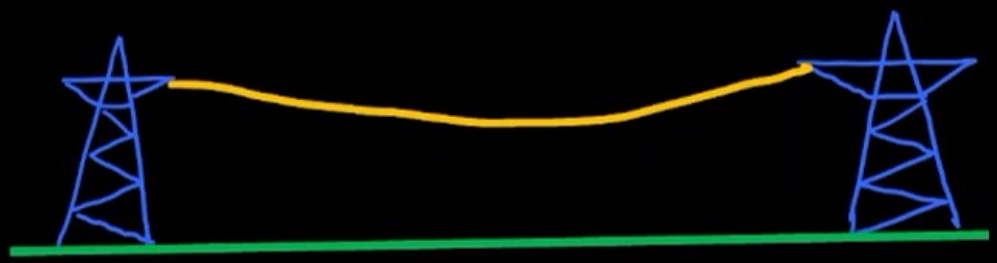
Simplicity
+
Small Error
↓
Lumped Parameter

Accuracy
+
Complicated Calculation
↓
Distributed Parameter

Practical Implementation

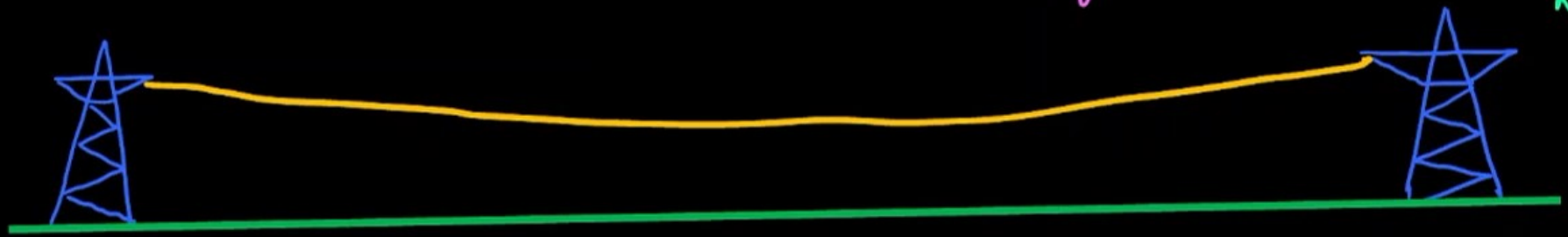


Short TL → Use lumped R, L
Ignore C, G

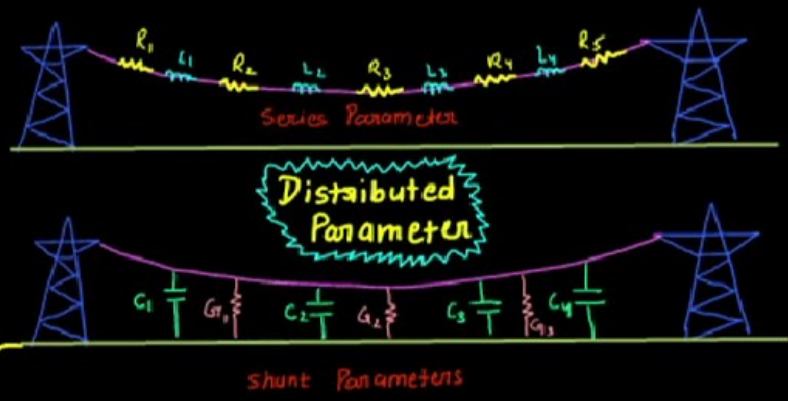


Medium TL → Use lumped
C, R, L ignore G

Long TL → Use distributed
R, L, C, G



Lumped and Distributed Parameters

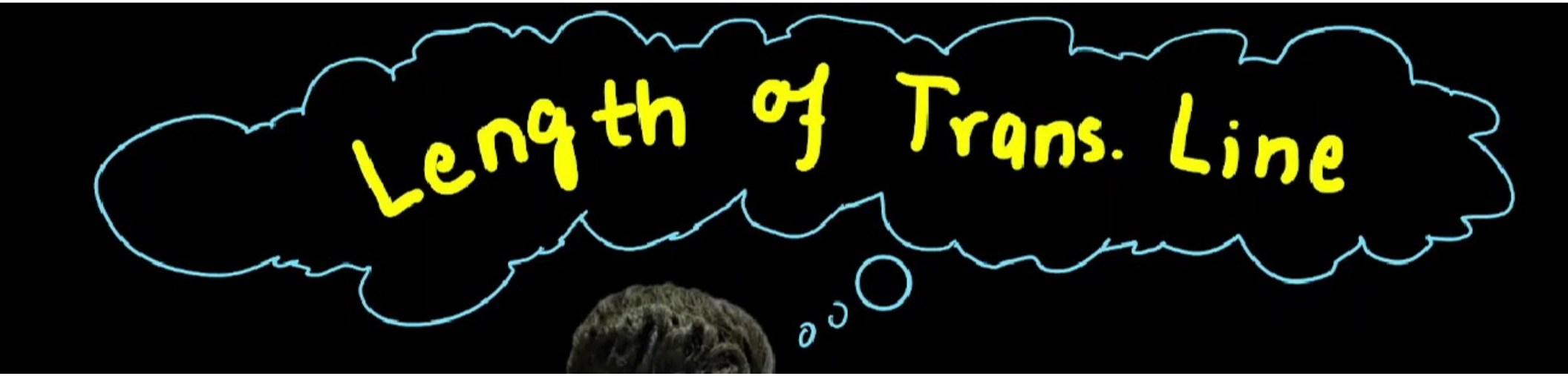


Effective in both short and long wise length

Short, medium and Long T L

To simplify calculations, we can neglect C and G in short length wires

Effective only in large length of wires


Length of Trans. Line

Length of Transmission Line

1. Short → Totally neglect C, G
2. Medium → Take small C and neglect G
3. Long → Consider all parameters (R, L, C, G)

Length deciding factor

Length ⟷ Capacitive effect

Length → decided by → Voltage of TL

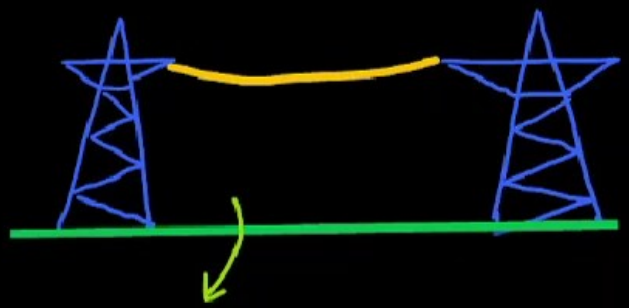
decided by → f . l product

$I_c = V\omega C$

$= V\,2\pi f\,C$

$= V \cdot 2\pi f \cdot \frac{\epsilon l}{d}$

$I_c = V \cdot fl \cdot \frac{2\pi\epsilon}{d}$ → constant



Negligible capacitance

Voltage of TL < 20kV

$f \cdot L < 4000$ Hz-km ⟶ Short Transmission Line

$100Hz \cdot L < 4000$

$L < 40km$

$50Hz \cdot L \leq 4000$

$L \leq \frac{4000}{50} = 80Km$

∴ for 50Hz,

$L \leq 80$ km

Short TL

Length of Transmission Line

80 < L < 200 Km

50 Hz
Z

20kV < U < 100 kV

4000 < f.L ≤ 10,000

fL

< 4000
10,000

Medium TL

U > 100 kV

f.L > 10,000

L > 200 Km

for 50 Hz
f
Z

Long TL

Length of Transmission Line

$20kV < U < 100\ kV$

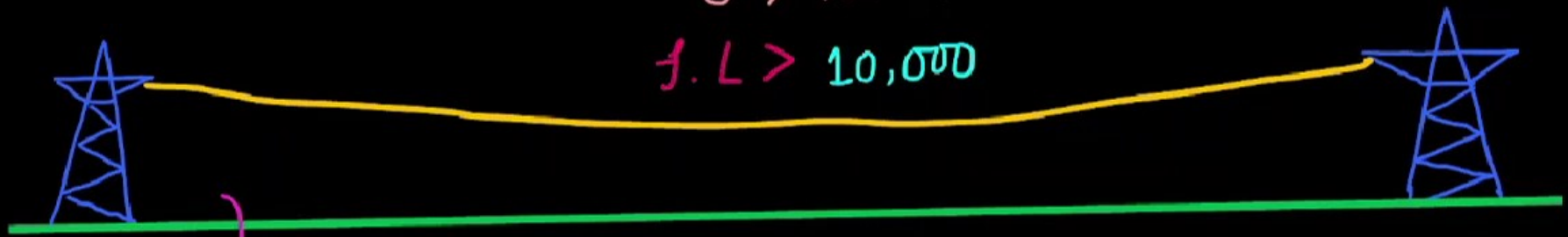
$4000 < f.L \leq 10,000$

Medium capacitance

Medium TL

$U > 100\ kV$

$f.L > 10,000$

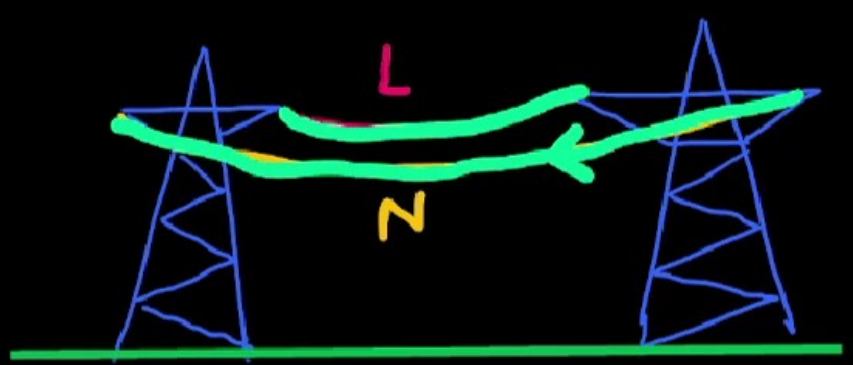


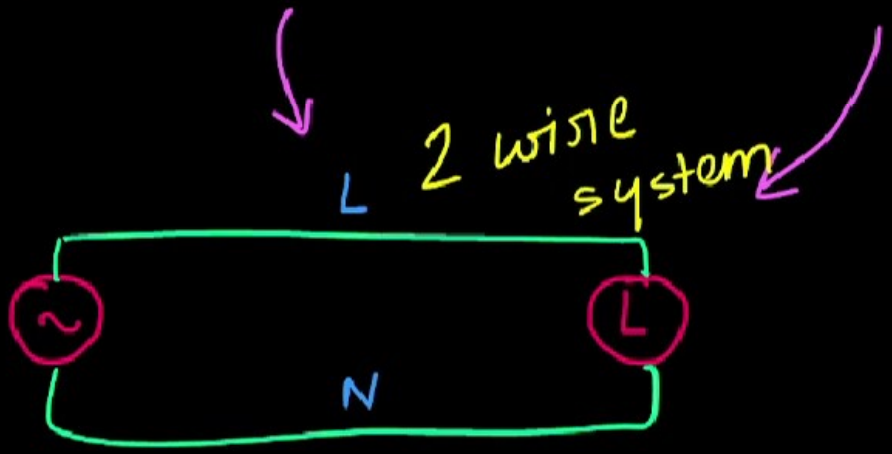
Large capacitance

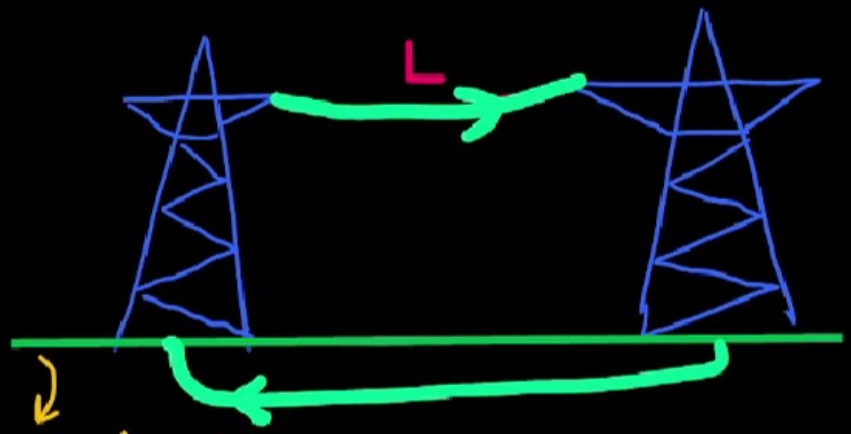
Long TL


EQUIVALENT CKT OF TL

Equivalent ckt of transmission Line → 2 wire system







Ground as neutral

This equivalent circuit consider ;

1-phase AC line
3-phase AC line on phase- neutral basis

Parameter representation

* Series parameter :
  - Resistance → R
  - Inductance → jX = jωL

] → Z

Series Impedance

* Shunt Parameter
  - Conductance → G
  - Capacitance → jωC

] → Y

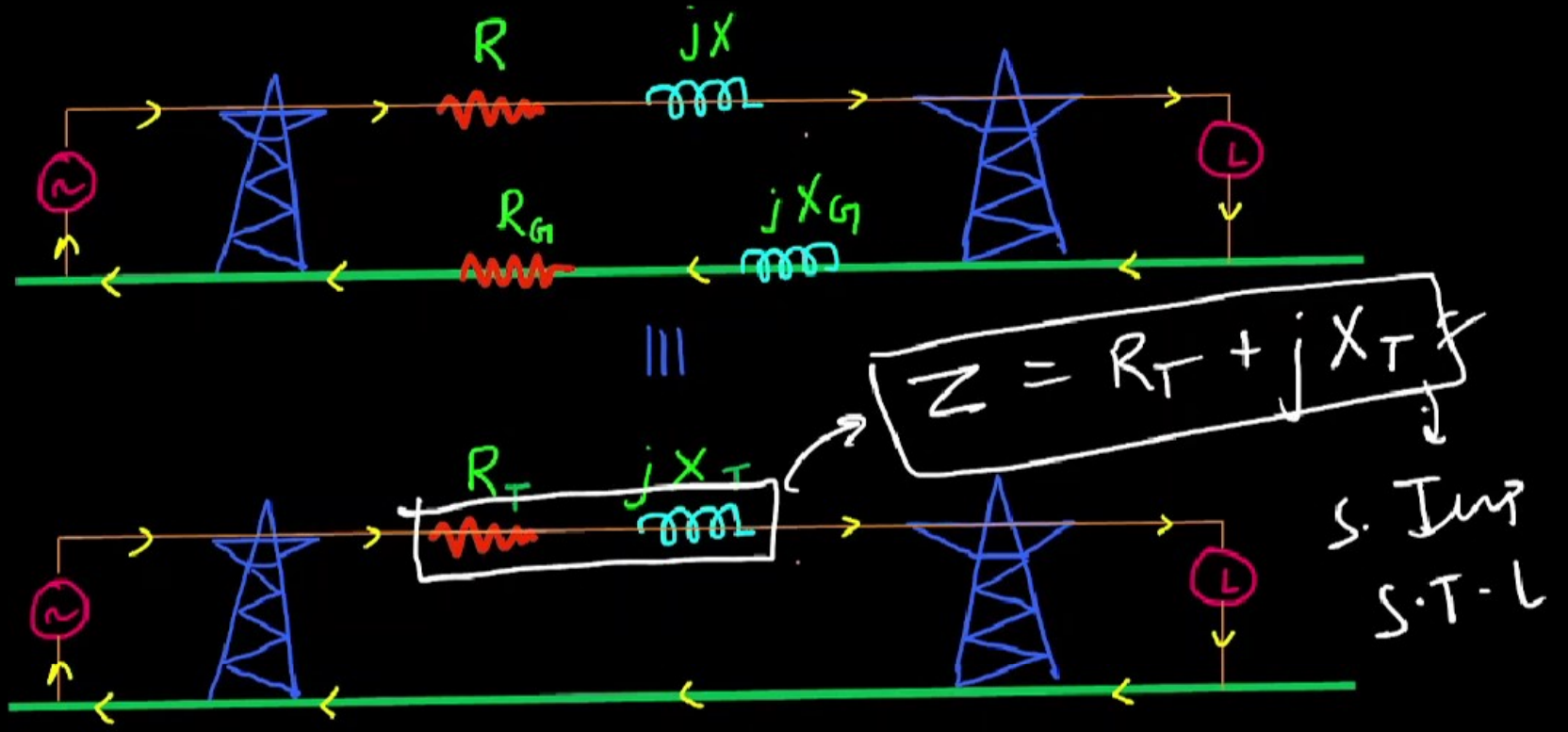
Shunt Admittance

Equivalent ckt of short TL

* Parameters: R, L {C, G → Negligible}

R, X → Live wire

Resistance and Inductance of Return path



R_T → closed loop Resistance

X_T → closed loop Inductance

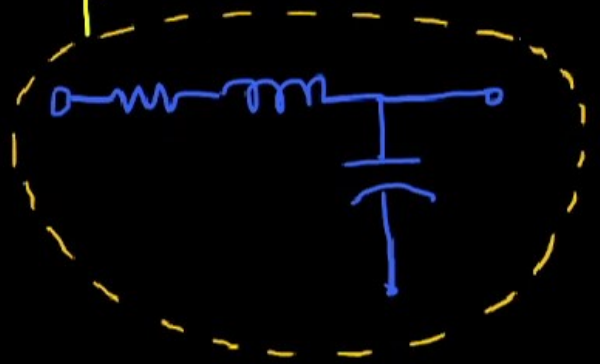
Equivalent ckt of Medium TL

Medium Length : $4000 < f \cdot L \leq 10,000$

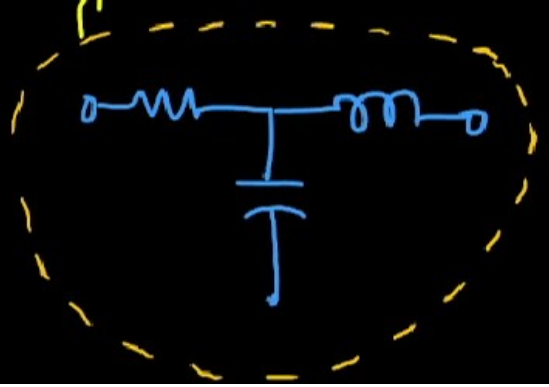
for 50 Hz ; $80\ Km < L \leq 200\ Km$

R, L, and C are effective

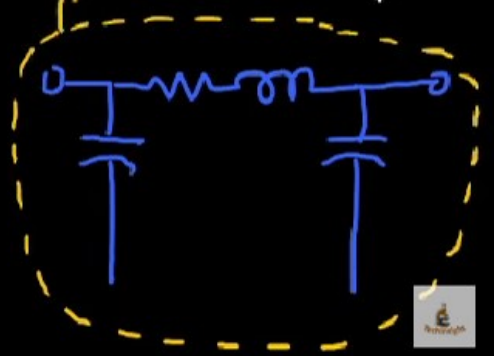
End condenser method



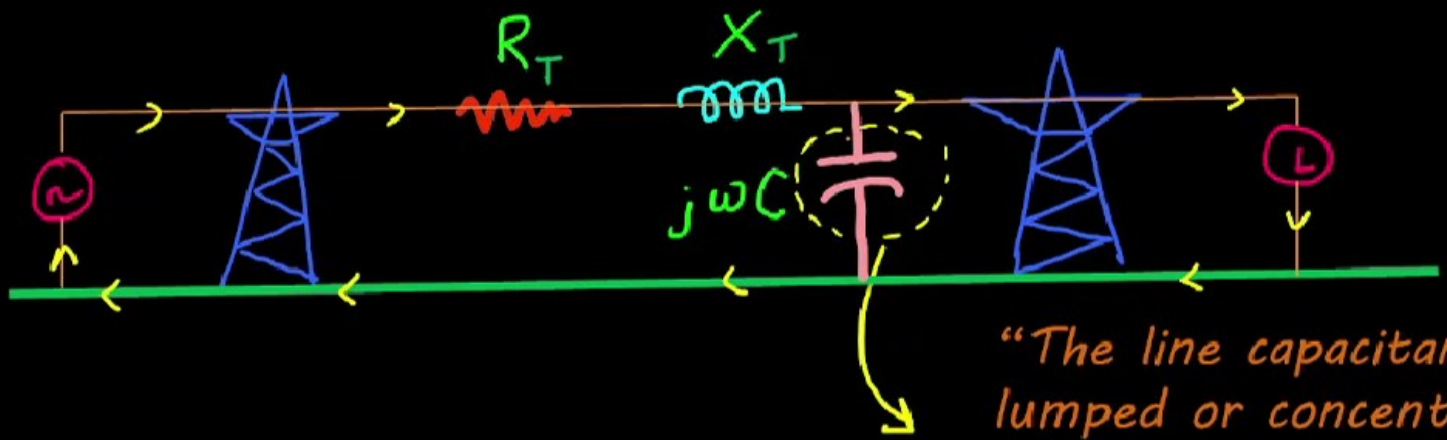
Nominal T method



Nominal π method



End Condenser Method

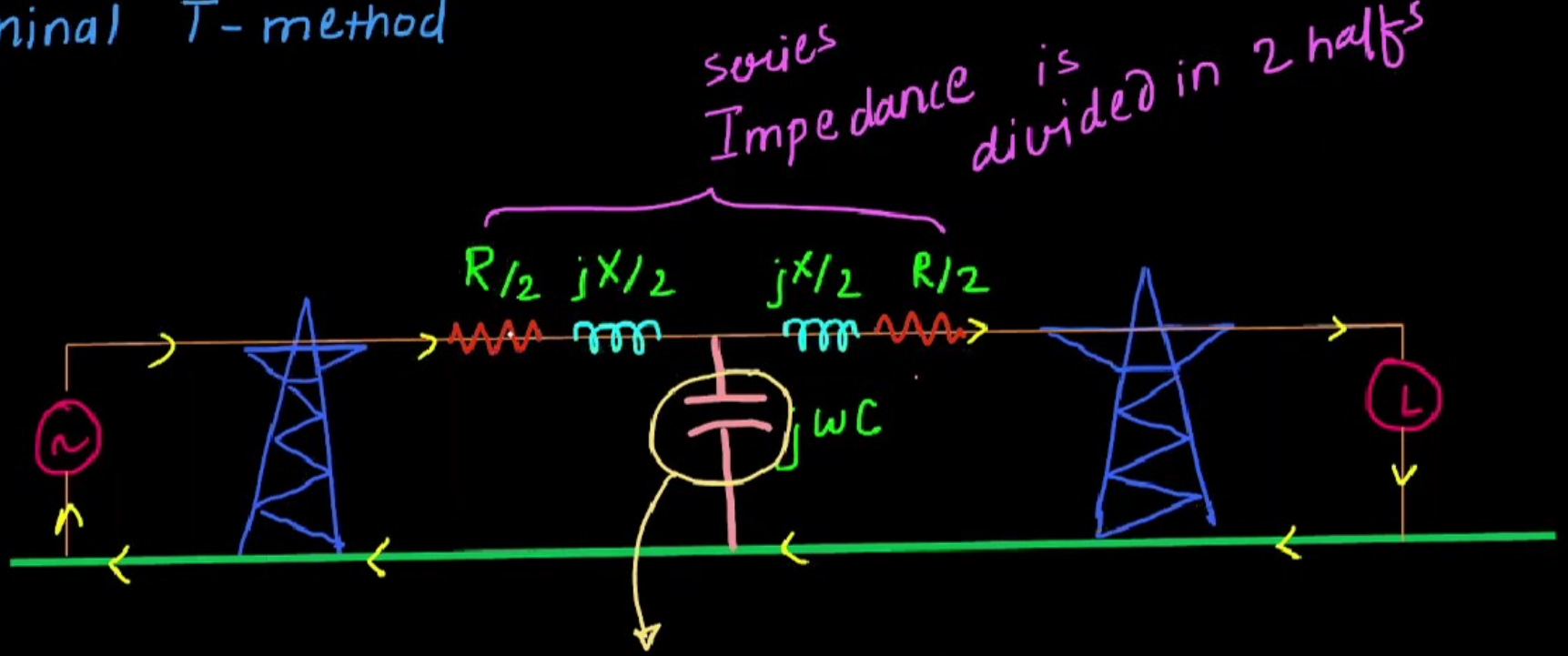


"The line capacitance is lumped or concentrated near the load or at the receiving end"

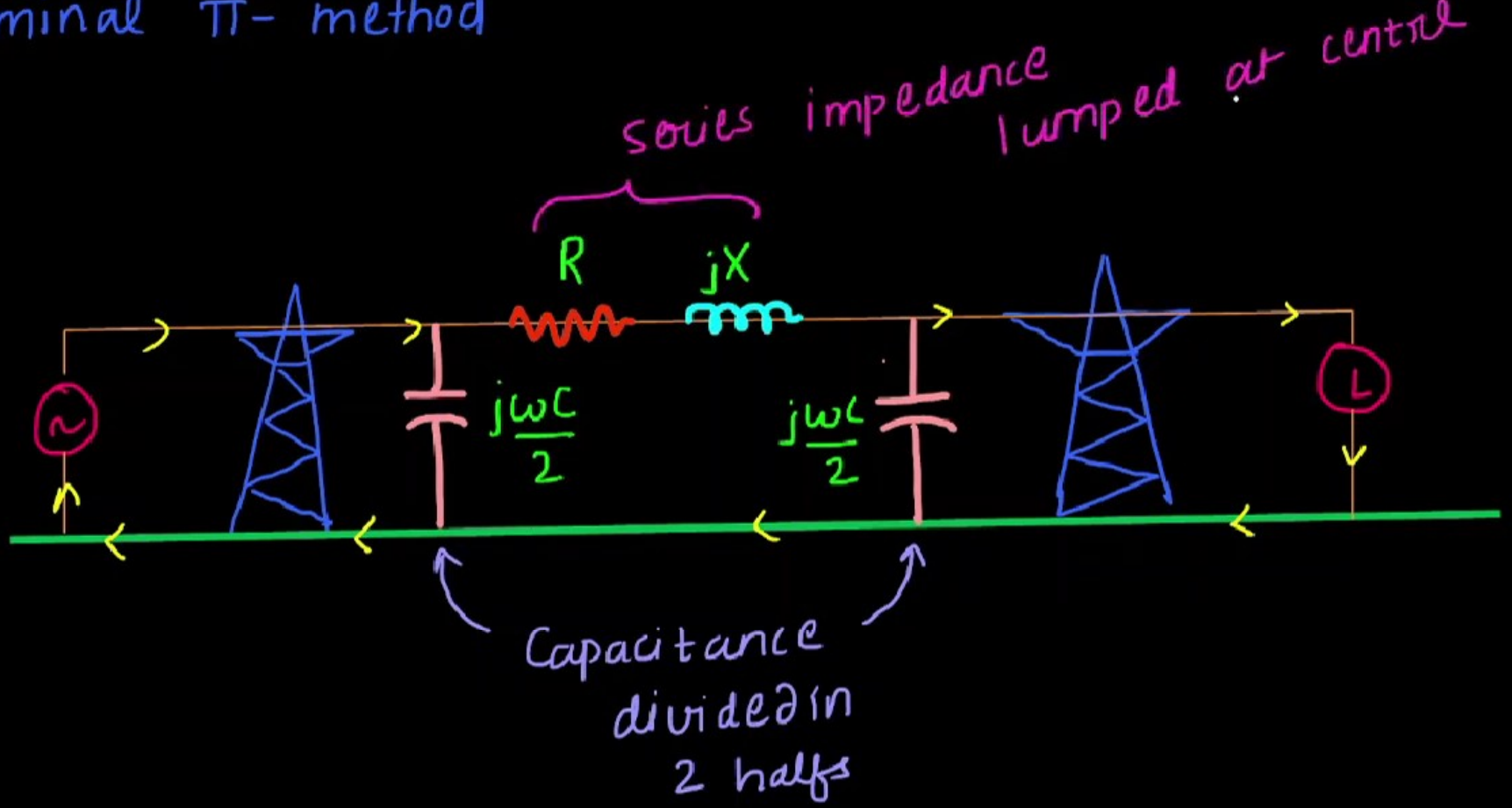
* Issues

- This method assume the capacitance to be lumped at the receiving end, however in actual the capacitance is distributed along the line. Thus an error of 10% will occur in calculation.
- This method overestimates the effect of line capacitance

Nominal T-method



Nominal π- method



Equivalent ckt of Long TL

$L < 200$ Km ⟶ Lumped parameters prefer

$L < 160$ Km
(I J Nagrath)
(C L Wadhwa)

$L > 200$ Km ⟶ Distribution Parameter used

As lumped parameter generates large error

Equivalent ckt of Large TL

- The whole length of line is divided into n-sections.
- Each section having 1/nth value of complete line constant