# POWER SYSTEMS-II
# 20APE0201

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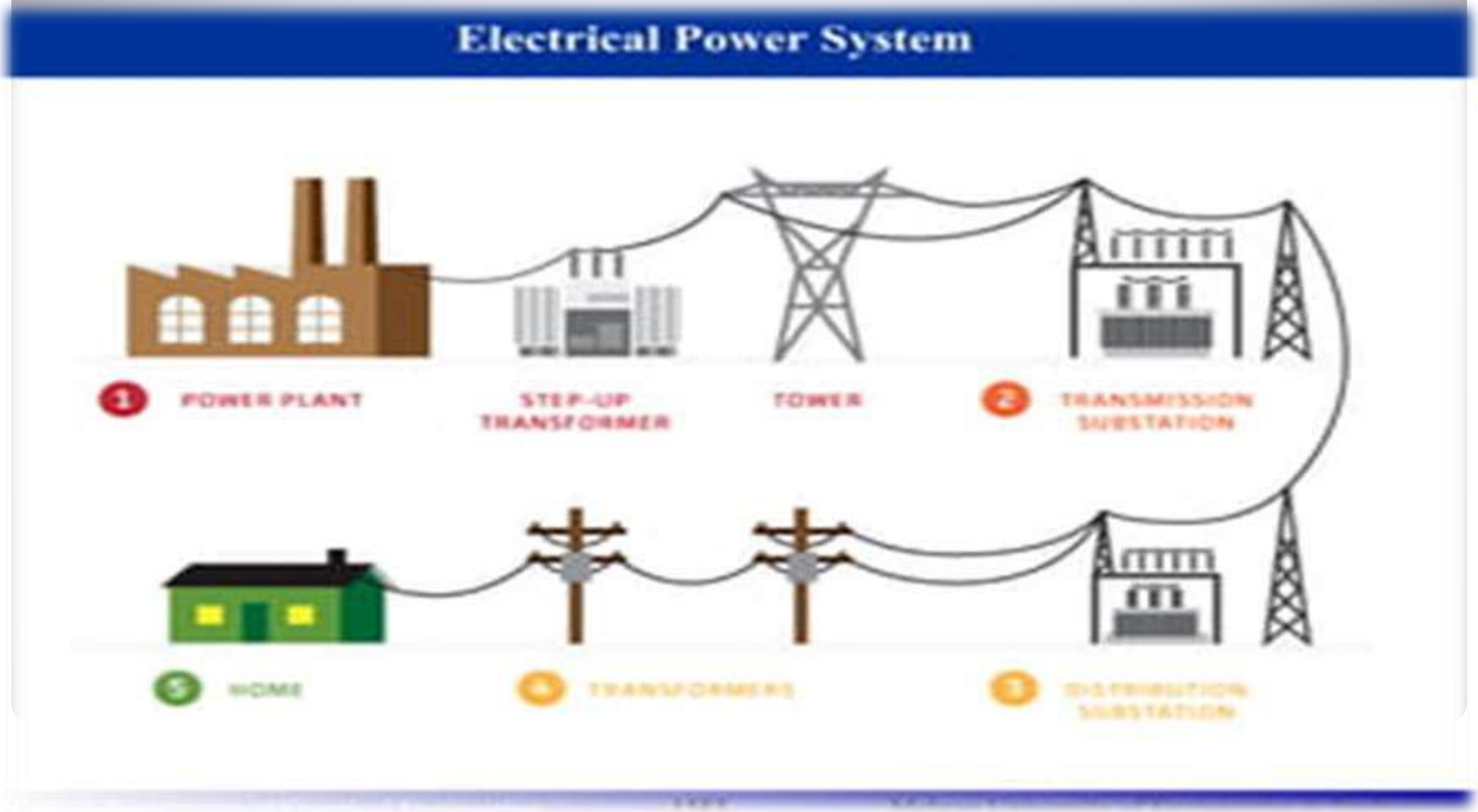
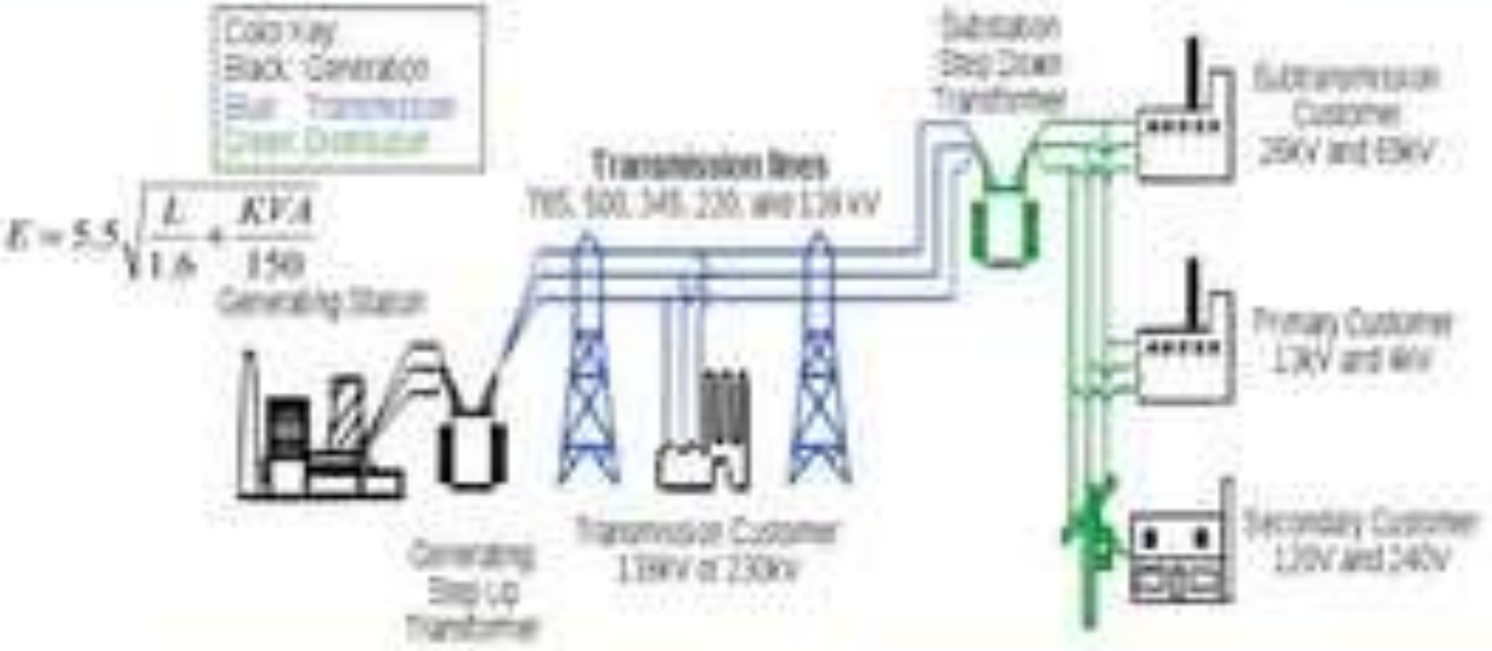
# UNIT-I
# TRANSMISSION LINE PARAMETER

- Types of conductors
- calculation of resistance for solid conductors
- Calculation of inductance for single phase and three phase, single and double circuit lines.
- concept of GMR & GMD
- symmetrical and asymmetrical conductor configuration with and without transposition,
- Calculation of capacitance for 2 wire and3wiresystems
- effect of ground on capacitance, capacitance calculations for symmetrical and asymmetrical single and three phase, single and double circuit lines.

# INTRODUCTION



# Transmission & Distribution Systems

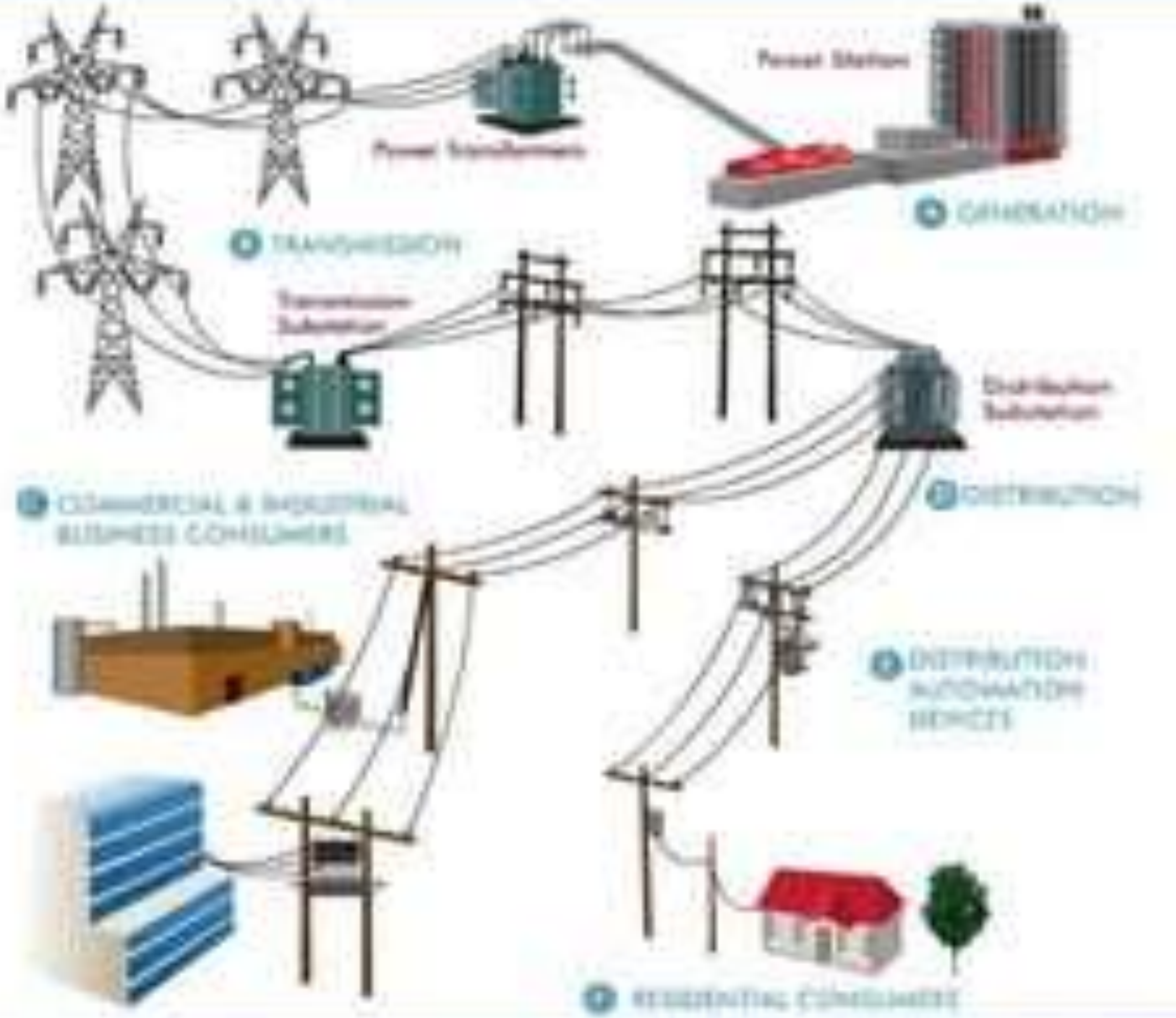


$$E = 5.5\sqrt{\frac{L}{1.6} + \frac{KVA}{150}}$$

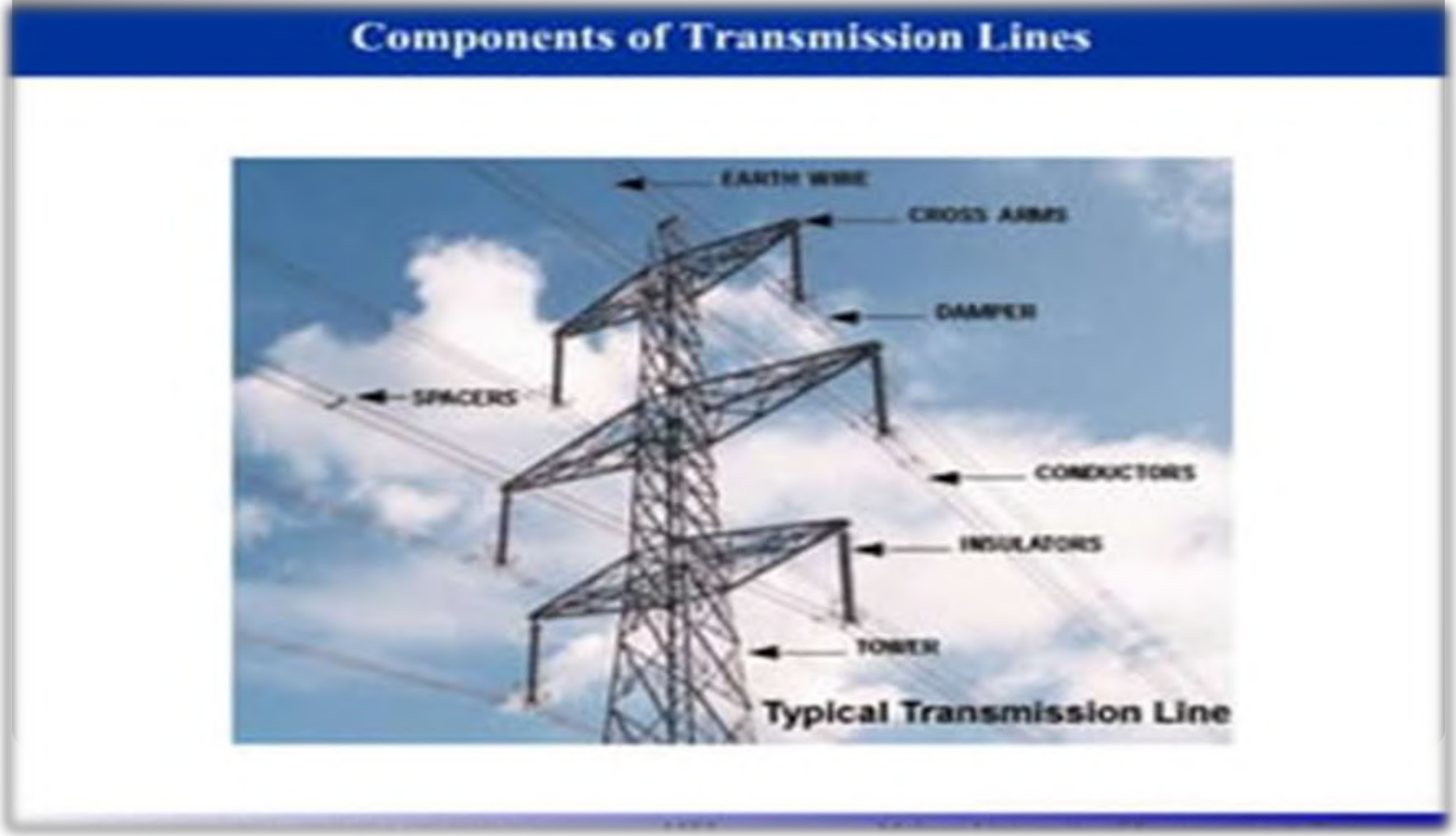
1. Power station
2. Set of transformers
3. Transmission lines
4. Substations
5. Distribution lines
6. Supplementary Equipment

1. Choice of System Voltage
2. Voltage Variations
3. Voltage Drop
4. Reliability
5. Loading Capacity
6. Location and Load Growth

# Electrical Power System



# COMPONENTS OF TRANSMISSION SYSTEM



## Components of Transmission Lines

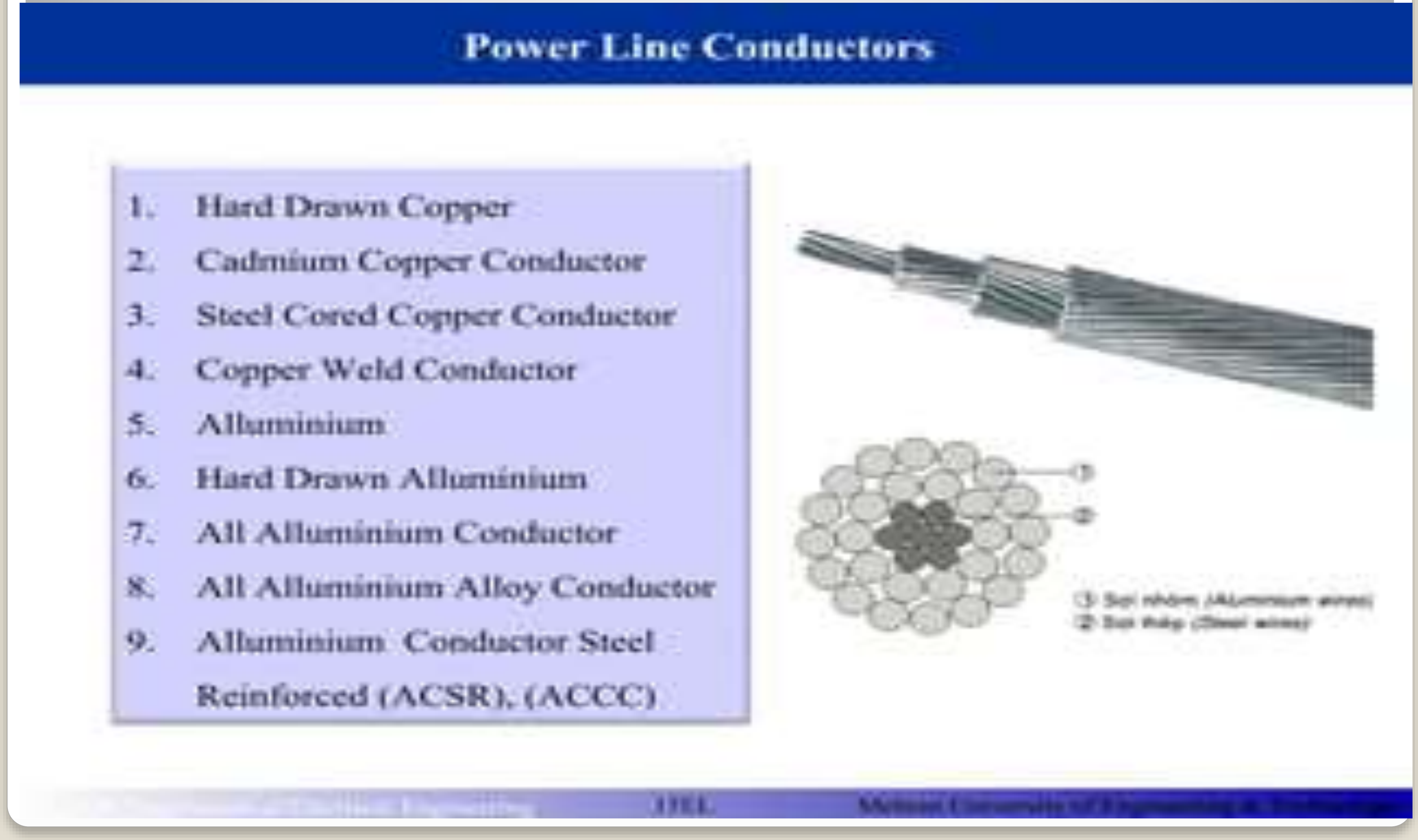
Typical Transmission Line

# CONDUCTORS

## Power Line Conductors

1. Hard Drawn Copper
2. Cadmium Copper Conductor
3. Steel Cored Copper Conductor
4. Copper Weld Conductor
5. Alluminium
6. Hard Drawn Alluminium
7. All Alluminium Conductor
8. All Alluminium Alloy Conductor
9. Alluminium Conductor Steel Reinforced (ACSR), (ACCC)

# CONDUCTORS



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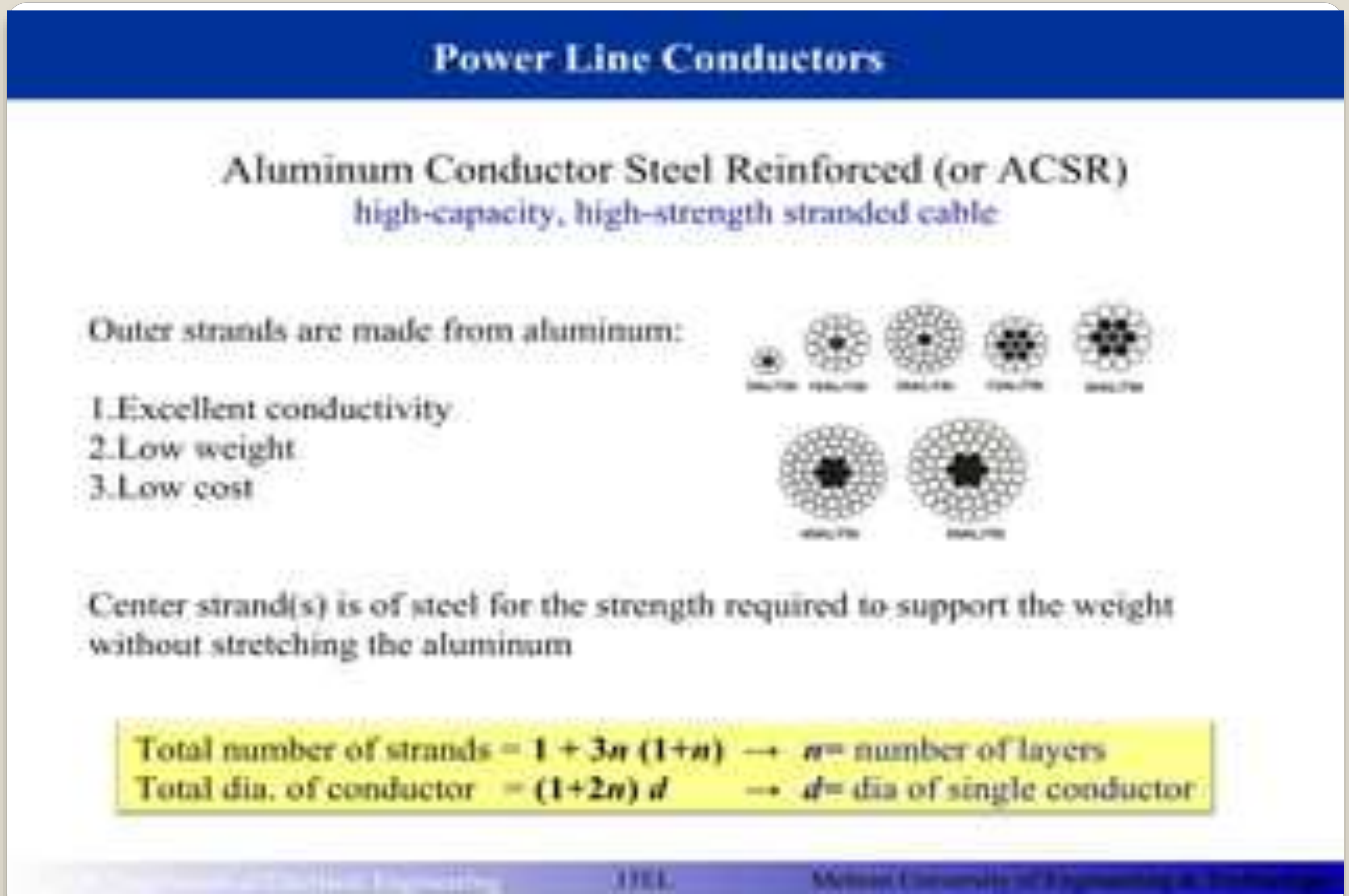
1. Cost
2. Life
3. Brittle
4. Weight
5. Resistance
6. Power loss
7. Tensile Strength
8. Low specific-gravity
9. Temerature Co-efficient
10. Shorter Sag



## Power Line Conductors

### Aluminum Conductor Steel Reinforced (or ACSR)

high-capacity, high-strength stranded cable

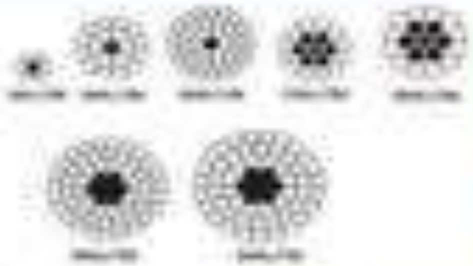
Outer strands are made from aluminum:

1. Excellent conductivity
2. Low weight
3. Low cost

Center strand(s) is of steel for the strength required to support the weight without stretching the aluminum

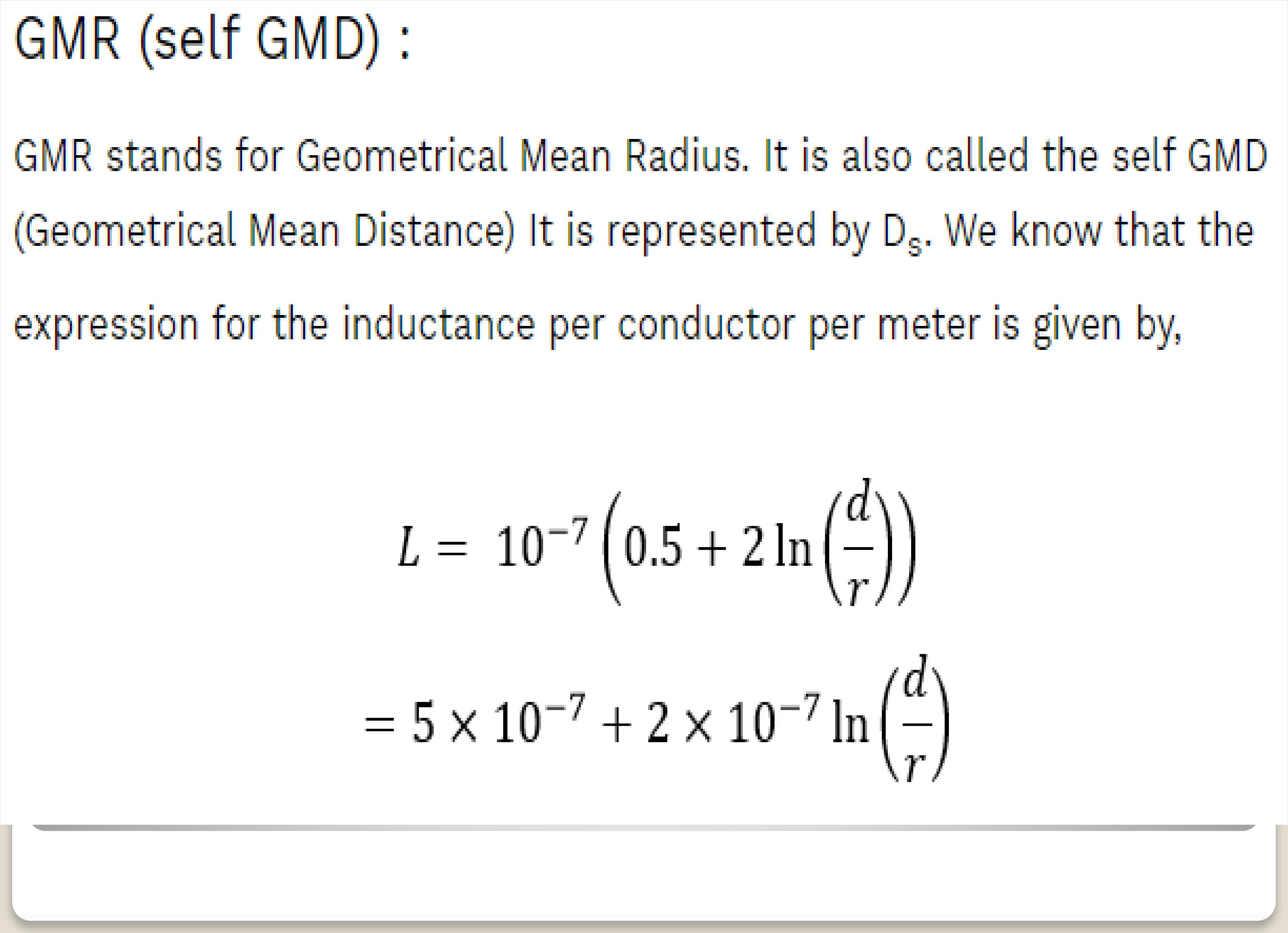
Total number of strands = **1 + 3*n* (1+*n*)** → ***n***= number of layers
Total dia. of conductor = **(1+2*n*) *d*** → ***d***= dia of single conductor

# Power Line Conductors



**More amps on the same size**

**Aluminum Conductor Composite Reinforced (ACCR)**

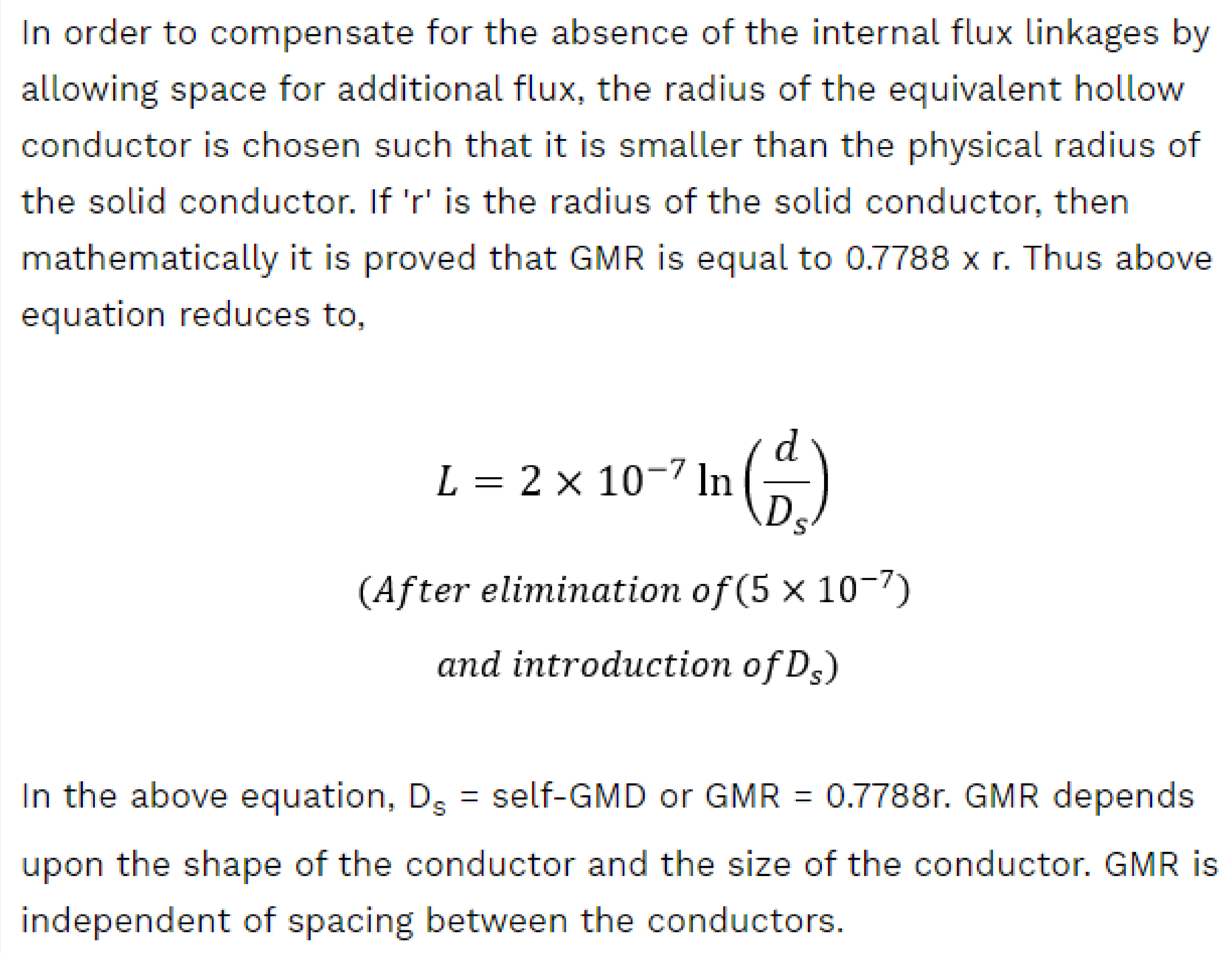


## GMR (self GMD) :

GMR stands for Geometrical Mean Radius. It is also called the self GMD (Geometrical Mean Distance) It is represented by $D_S$. We know that the expression for the inductance per conductor per meter is given by,

$$L = 10^{-7}\left(0.5 + 2\ln\left(\frac{d}{r}\right)\right)$$

$$= 5 \times 10^{-7} + 2 \times 10^{-7}\ln\left(\frac{d}{r}\right)$$



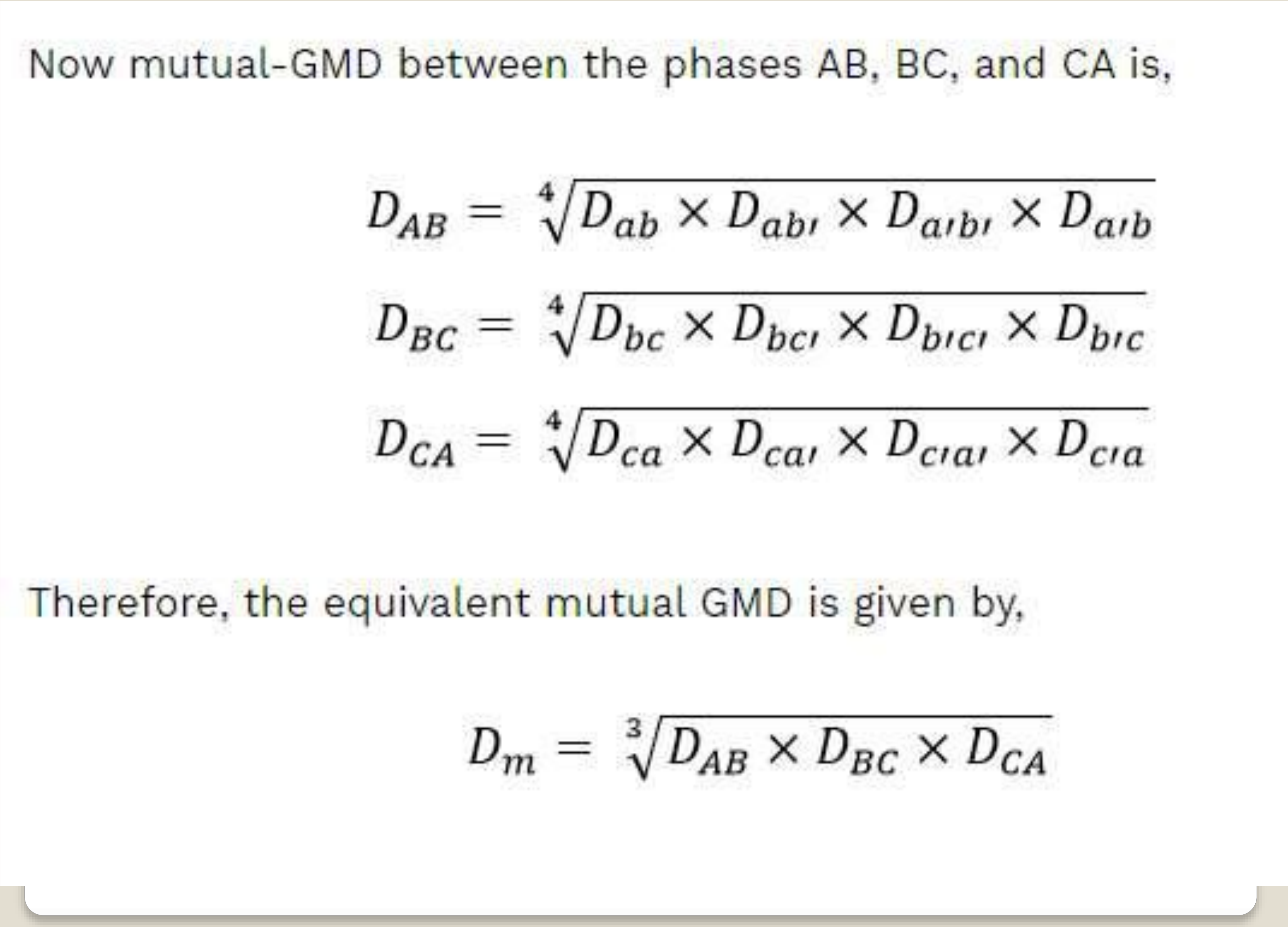
In order to compensate for the absence of the internal flux linkages by allowing space for additional flux, the radius of the equivalent hollow conductor is chosen such that it is smaller than the physical radius of the solid conductor. If 'r' is the radius of the solid conductor, then mathematically it is proved that GMR is equal to 0.7788 x r. Thus above equation reduces to,

$$L = 2 \times 10^{-7} \ln\left(\frac{d}{D_s}\right)$$

*(After elimination of* $(5 \times 10^{-7})$

*and introduction of* $D_s$*)*

In the above equation, $D_s$ = self-GMD or GMR = 0.7788r. GMR depends upon the shape of the conductor and the size of the conductor. GMR is independent of spacing between the conductors.



Now mutual-GMD between the phases AB, BC, and CA is,

$$D_{AB} = \sqrt[4]{D_{ab} \times D_{ab'} \times D_{a'b'} \times D_{a'b}}$$

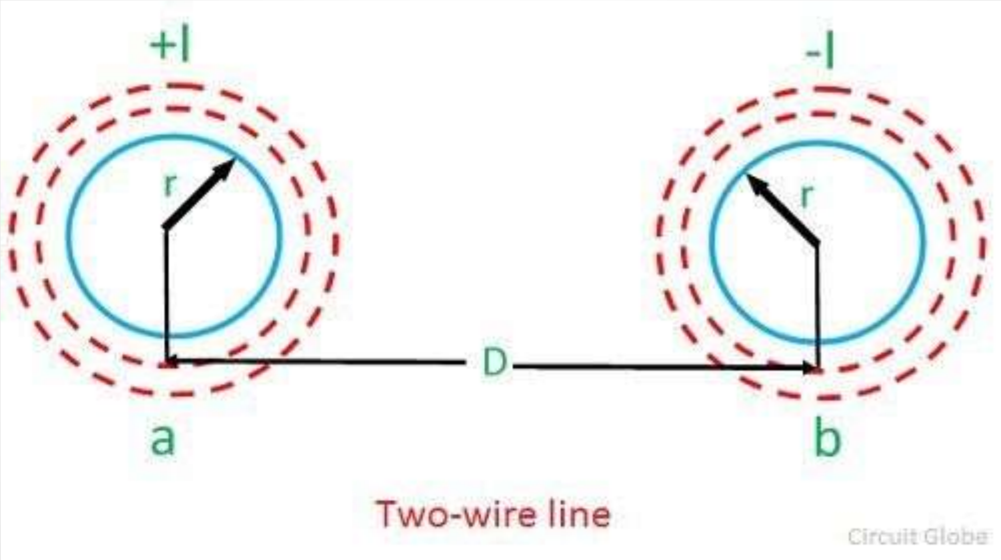
$$D_{BC} = \sqrt[4]{D_{bc} \times D_{bc'} \times D_{b'c'} \times D_{b'c}}$$

$$D_{CA} = \sqrt[4]{D_{ca} \times D_{ca'} \times D_{c'a'} \times D_{c'a}}$$

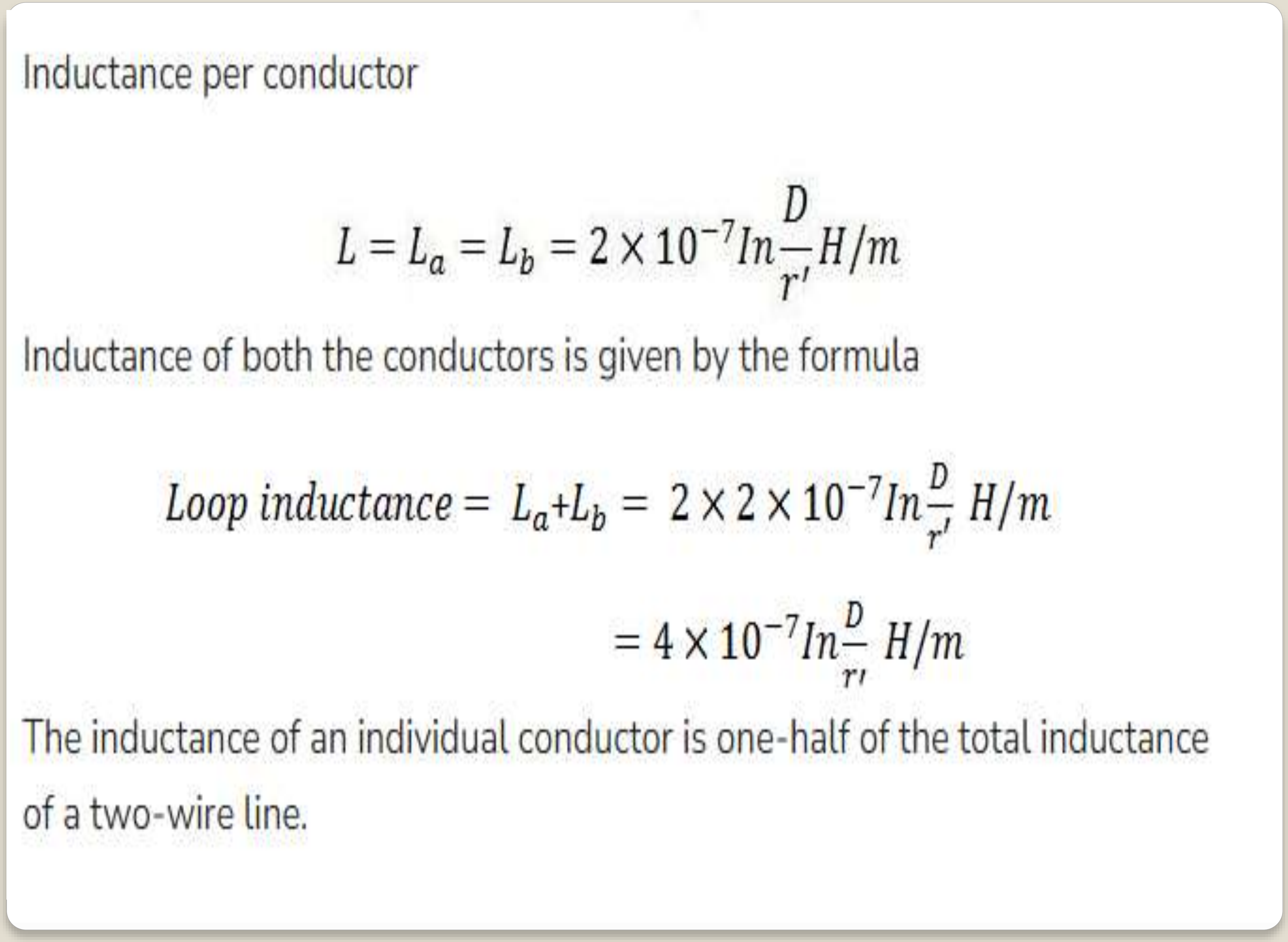
Therefore, the equivalent mutual GMD is given by,

$$D_m = \sqrt[3]{D_{AB} \times D_{BC} \times D_{CA}}$$

# Calculation of inductance for single phase and three phase



Two-wire line



Inductance per conductor

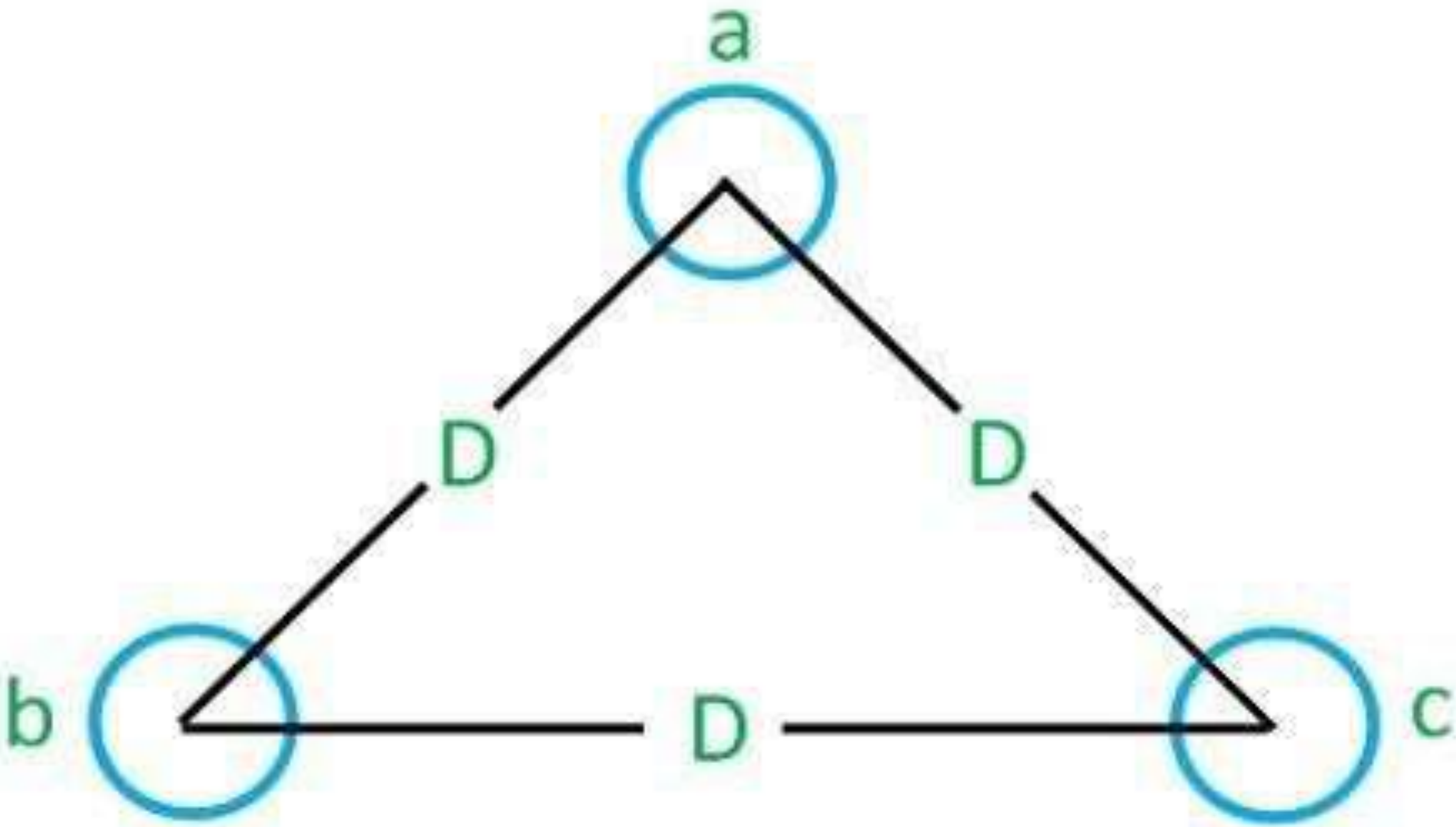
$$L = L_a = L_b = 2 \times 10^{-7} In \frac{D}{r'} H/m$$

Inductance of both the conductors is given by the formula

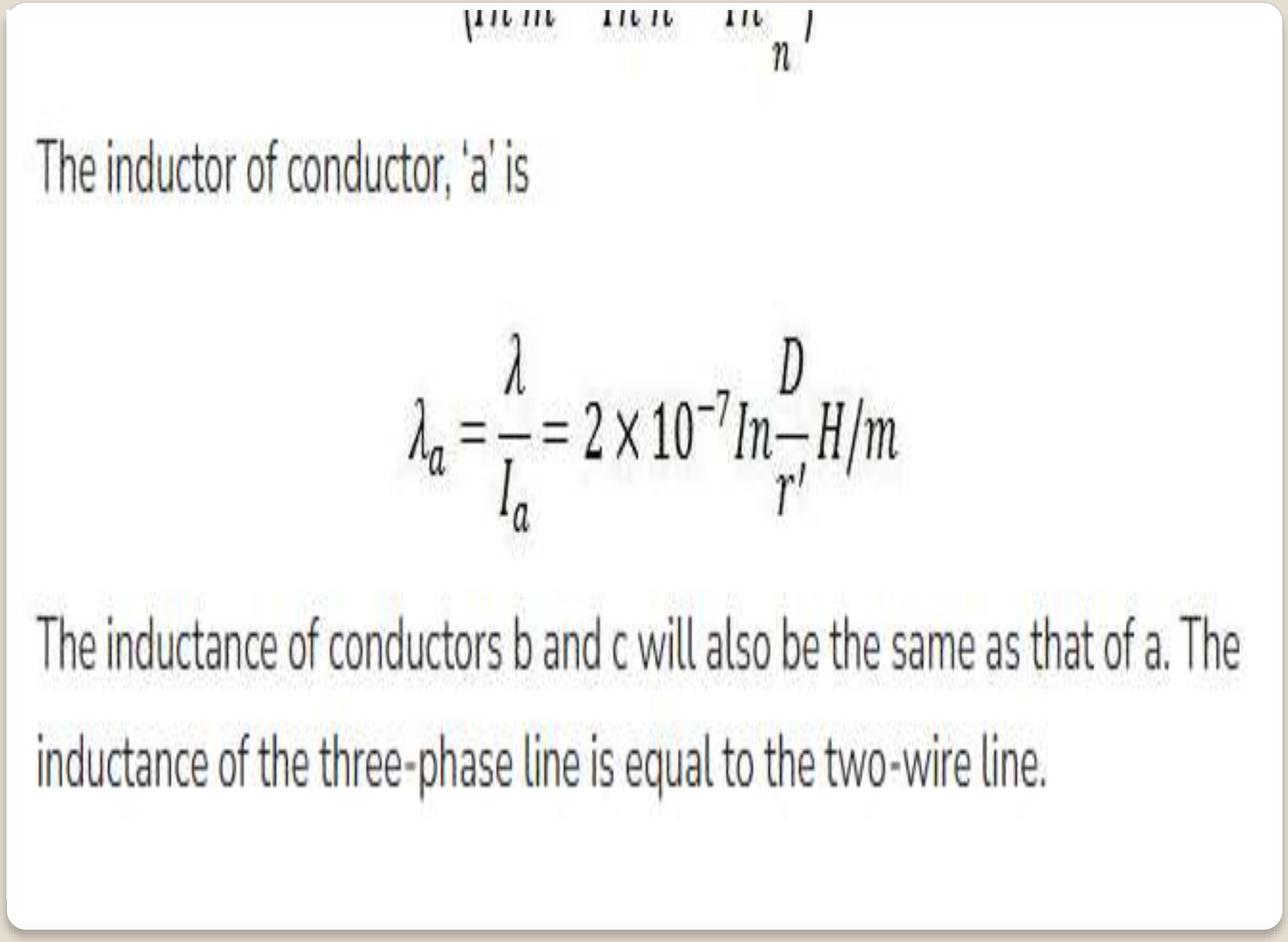
$$Loop\ inductance = \ L_a + L_b = \ 2 \times 2 \times 10^{-7} In \frac{D}{r'}\ H/m$$

$$= 4 \times 10^{-7} In \frac{D}{r'}\ H/m$$

The inductance of an individual conductor is one-half of the total inductance of a two-wire line.



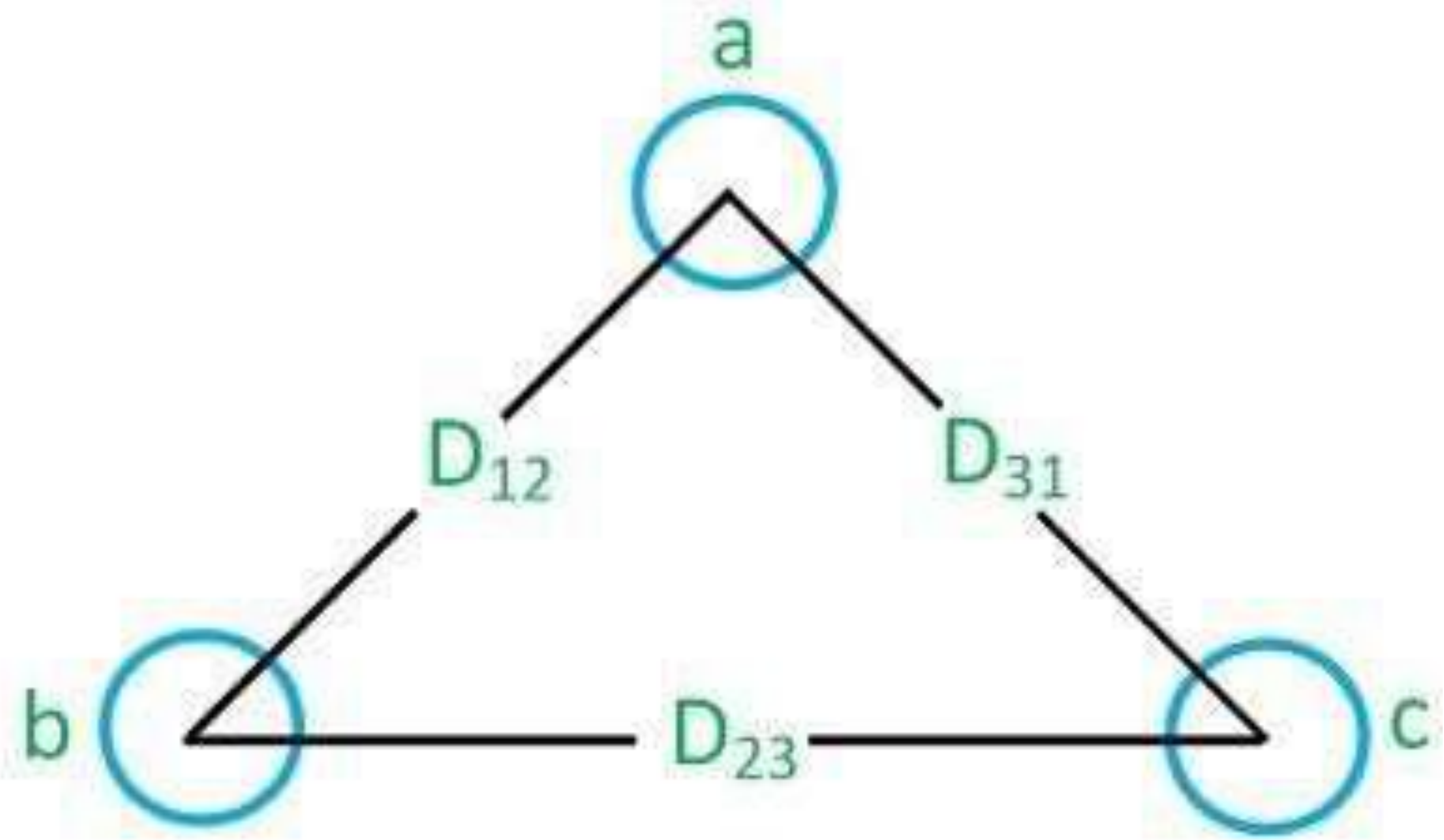
Symmetrical three-phase line



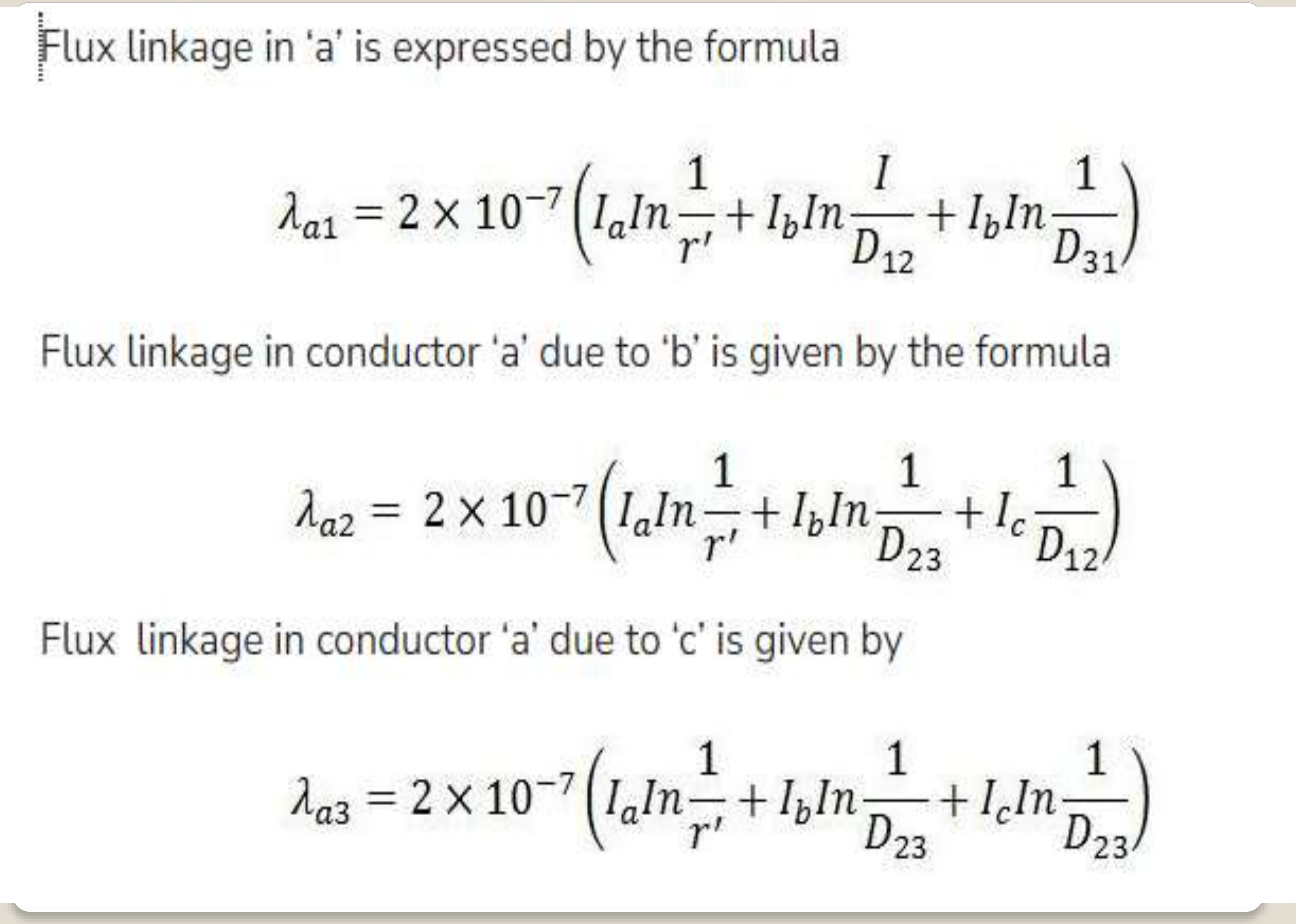
The inductor of conductor, 'a' is

$$\lambda_a = \frac{\lambda}{I_a} = 2 \times 10^{-7} In \frac{D}{r'} H/m$$

The inductance of conductors b and c will also be the same as that of a. The inductance of the three-phase line is equal to the two-wire line.



Unsymmetrical three-phase line



Flux linkage in 'a' is expressed by the formula

$$\lambda_{a1} = 2 \times 10^{-7}\left(I_a In\frac{1}{r'} + I_b In\frac{I}{D_{12}} + I_b In\frac{1}{D_{31}}\right)$$

Flux linkage in conductor 'a' due to 'b' is given by the formula

$$\lambda_{a2} = 2 \times 10^{-7}\left(I_a In\frac{1}{r'} + I_b In\frac{1}{D_{23}} + I_c\frac{1}{D_{12}}\right)$$

Flux linkage in conductor 'a' due to 'c' is given by

$$\lambda_{a3} = 2 \times 10^{-7}\left(I_a In\frac{1}{r'} + I_b In\frac{1}{D_{23}} + I_c In\frac{1}{D_{23}}\right)$$

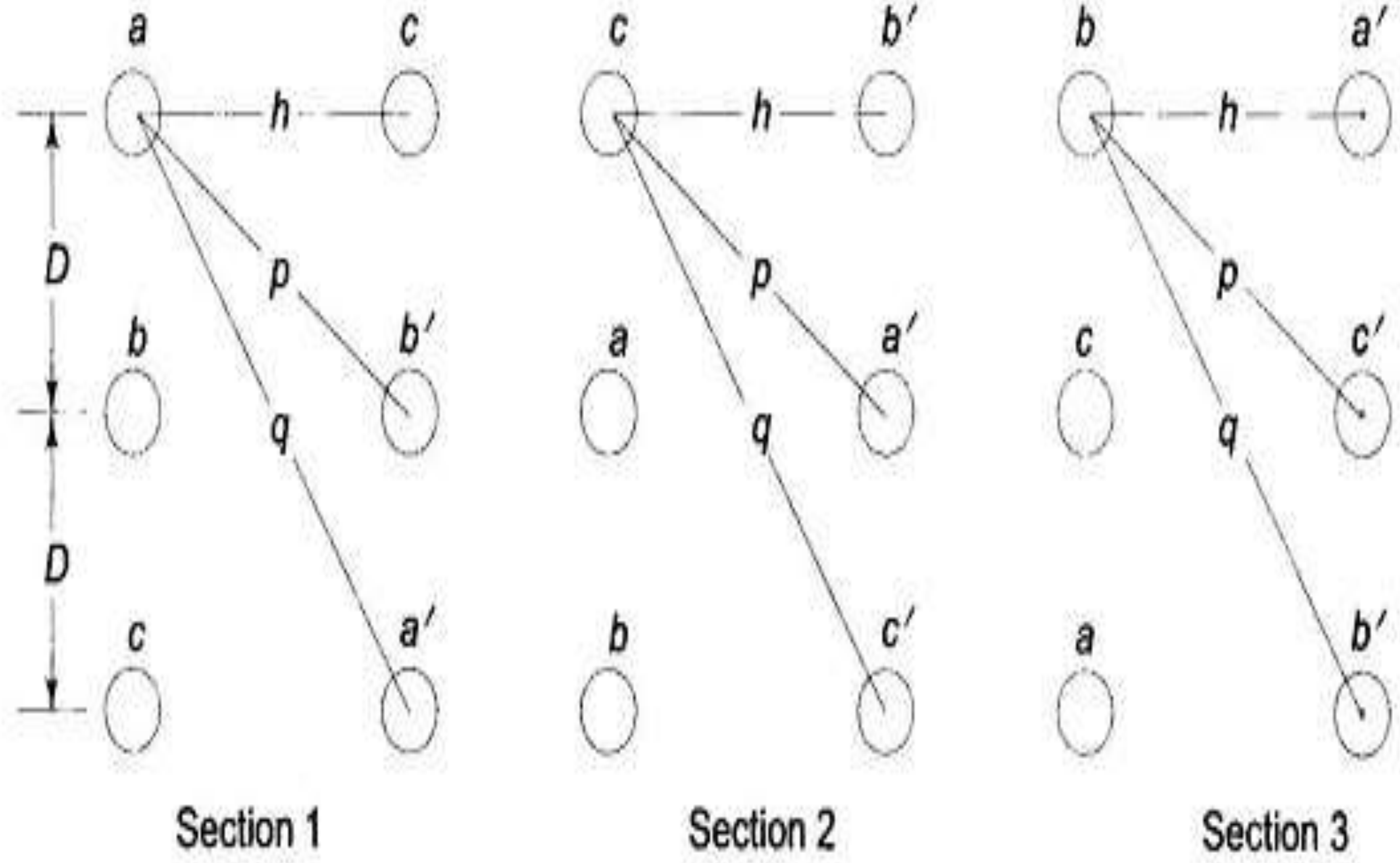
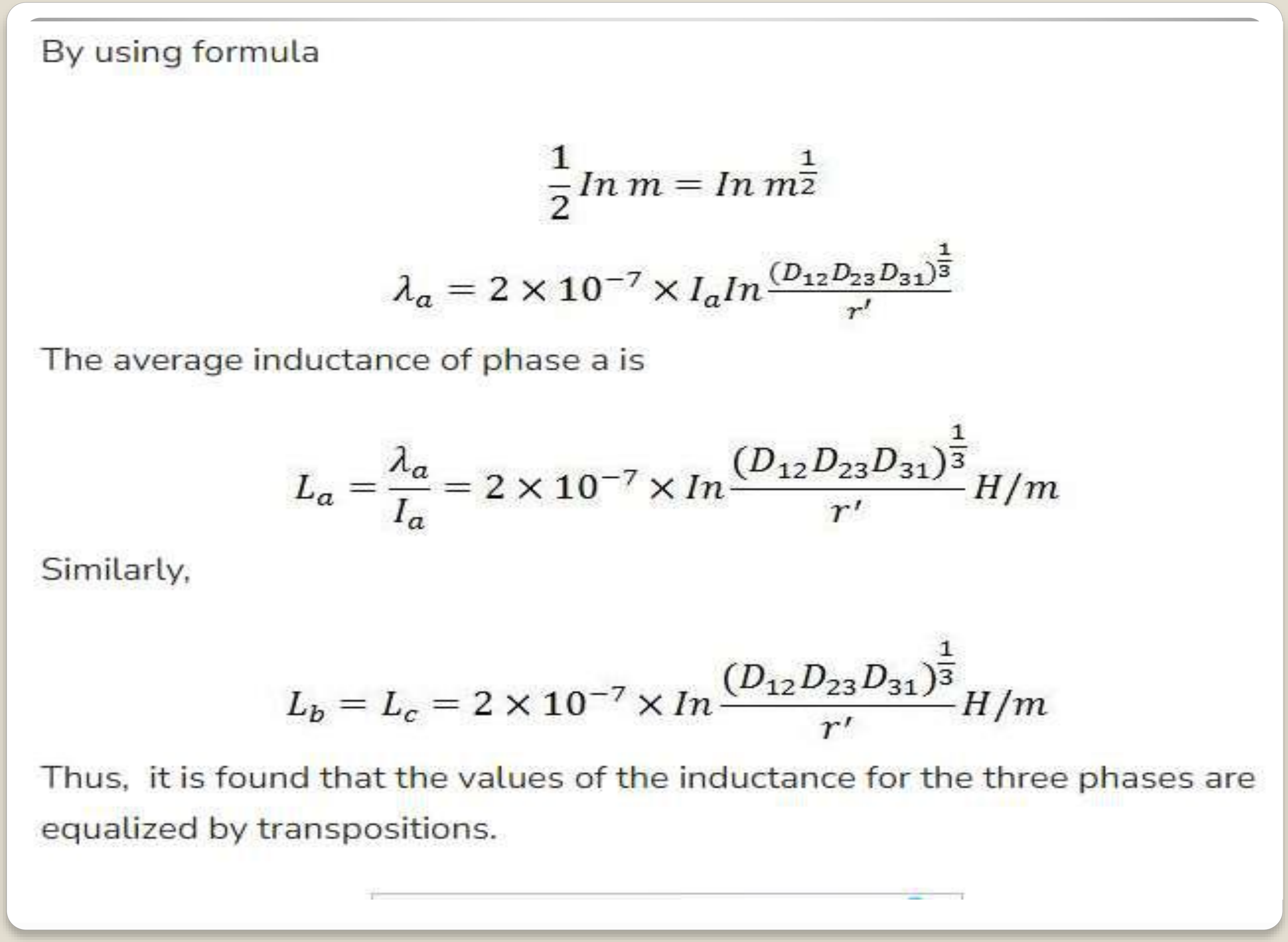


**Fig. 2.15** Arrangement of conductors of a double-circuit three-phase line



By using formula

$$\frac{1}{2} In\, m = In\, m^{\frac{1}{2}}$$

$$\lambda_a = 2 \times 10^{-7} \times I_a In \frac{(D_{12} D_{23} D_{31})^{\frac{1}{3}}}{r'}$$

The average inductance of phase a is

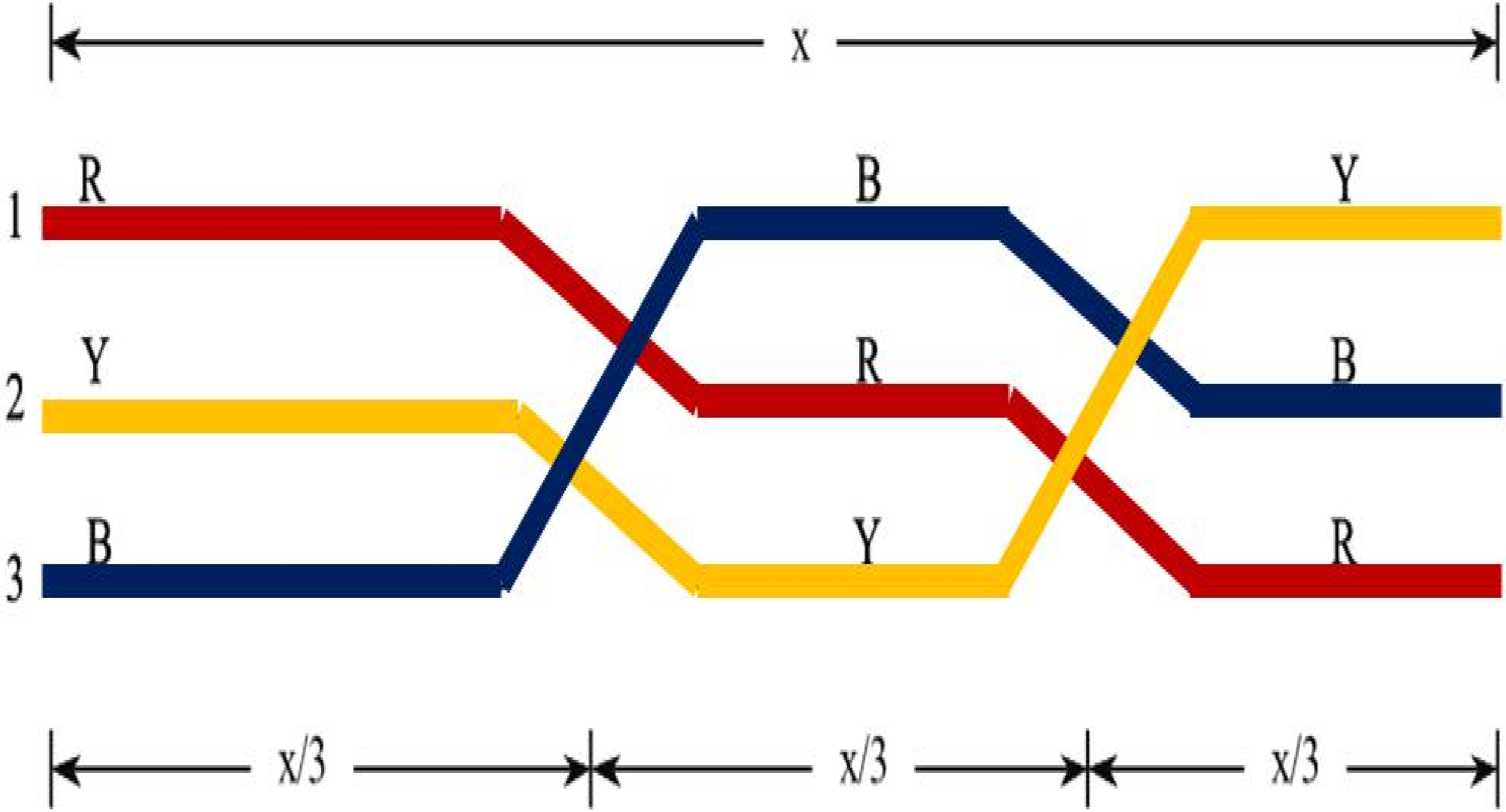
$$L_a = \frac{\lambda_a}{I_a} = 2 \times 10^{-7} \times In \frac{(D_{12} D_{23} D_{31})^{\frac{1}{3}}}{r'} H/m$$

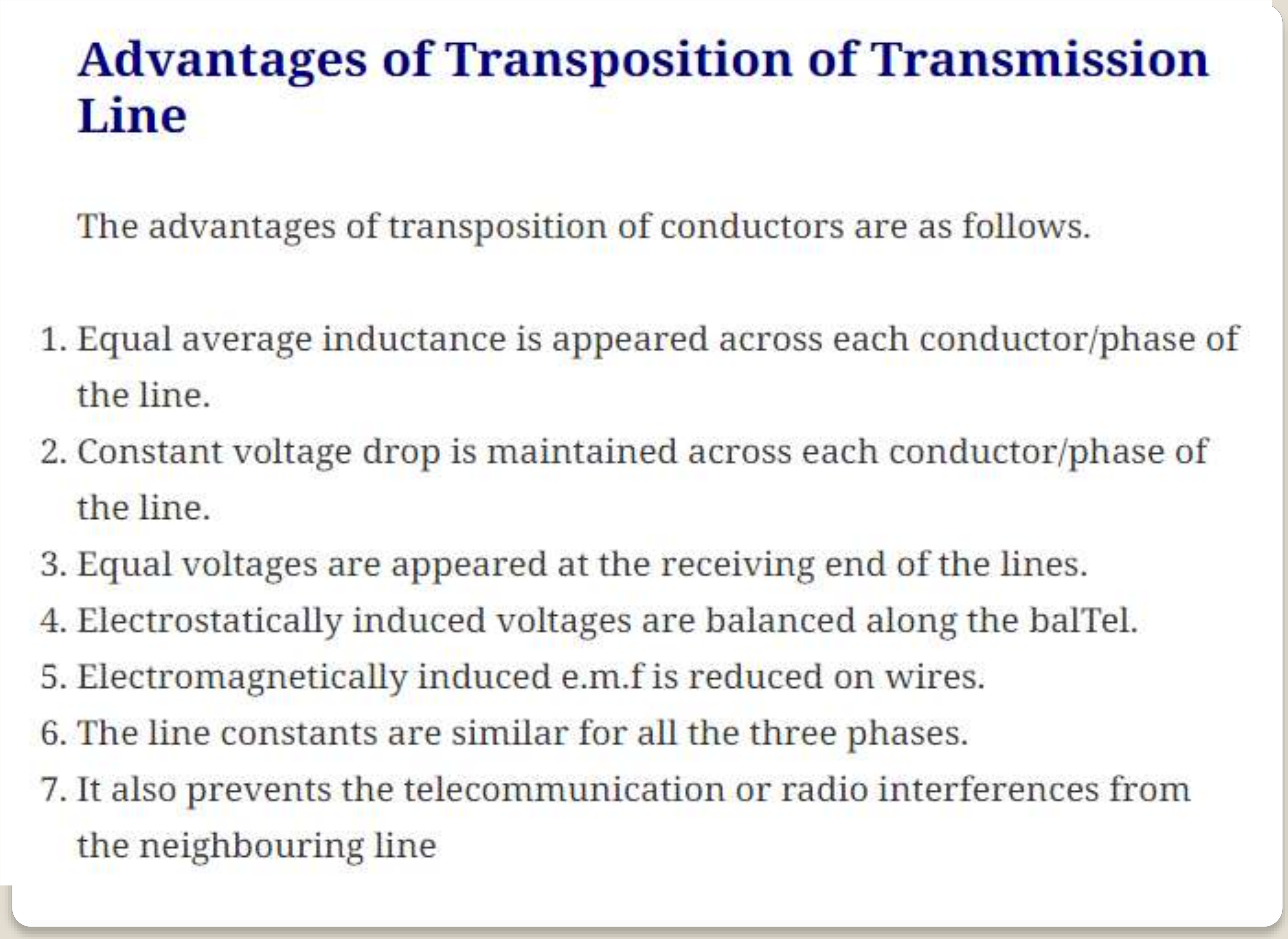
Similarly,

$$L_b = L_c = 2 \times 10^{-7} \times In \frac{(D_{12} D_{23} D_{31})^{\frac{1}{3}}}{r'} H/m$$

Thus, it is found that the values of the inductance for the three phases are equalized by transpositions.

# TRANSPOSITION





# Advantages of Transposition of Transmission Line

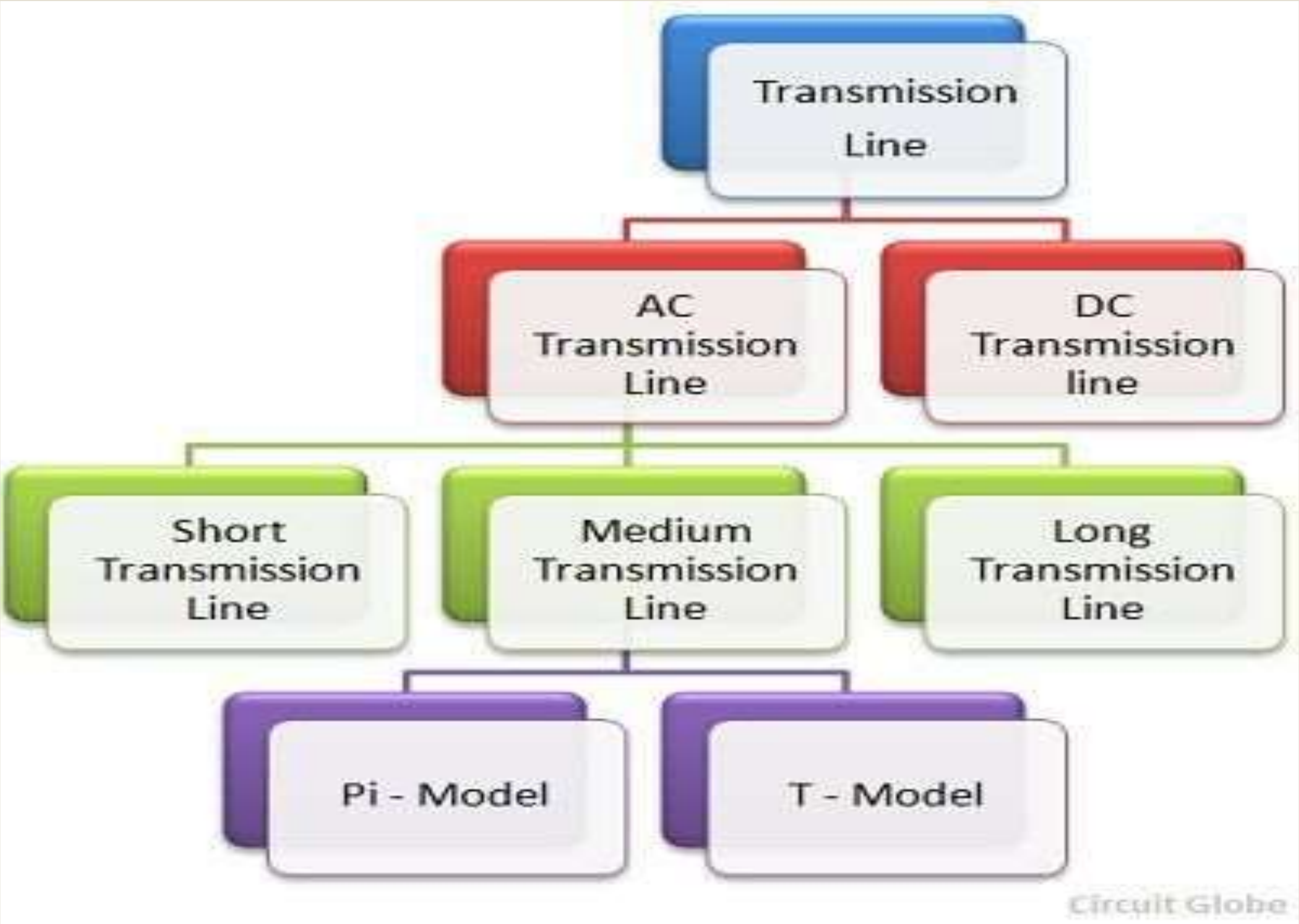
The advantages of transposition of conductors are as follows.

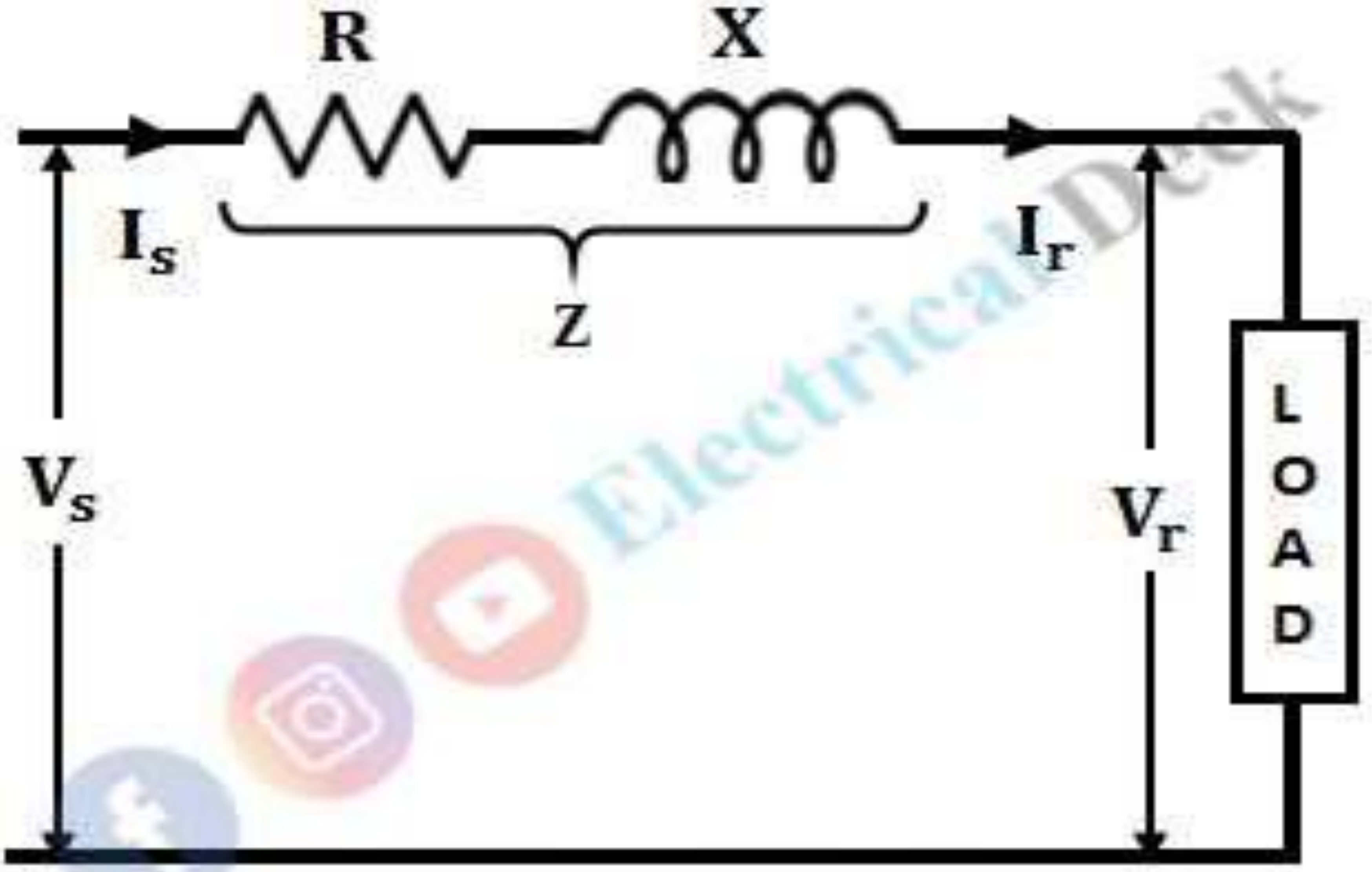
1. Equal average inductance is appeared across each conductor/phase of the line.
2. Constant voltage drop is maintained across each conductor/phase of the line.
3. Equal voltages are appeared at the receiving end of the lines.
4. Electrostatically induced voltages are balanced along the balTel.
5. Electromagnetically induced e.m.f is reduced on wires.
6. The line constants are similar for all the three phases.
7. It also prevents the telecommunication or radio interferences from the neighbouring line

# UNIT-II

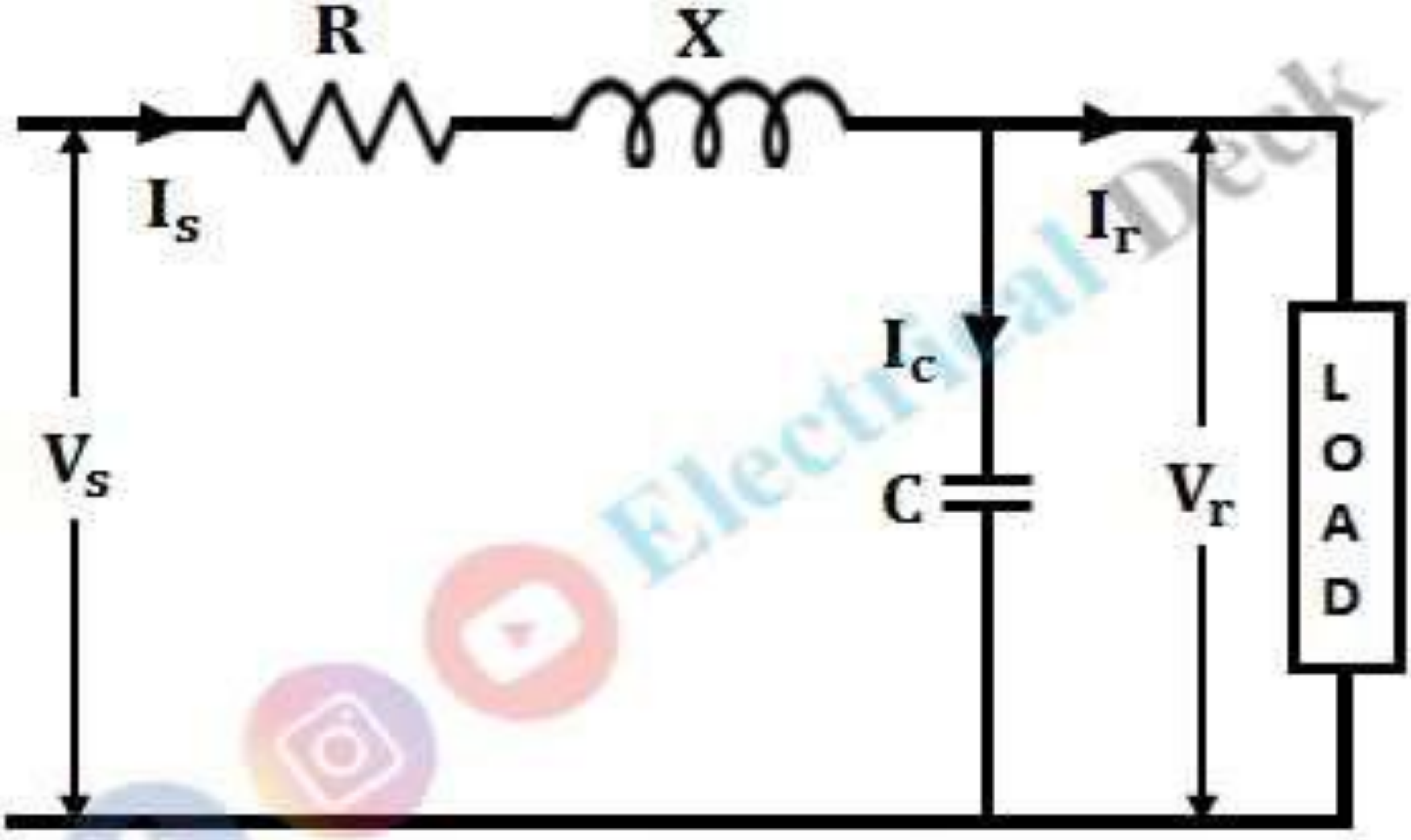
## PERFORMANCE OF SHORT, MEDIUM AND LONG LENGTH TRANSMISSION LINES

- Classification of Transmission Lines - Short, medium and long line and their model representations
- Nominal-T, Nominal-Pie and A, B, C, D Constants for symmetrical &Asymmetrical Networks.
- Long Transmission Line- Rigorous Solution, evaluation of A, B, C, D Constants
- Interpretation of the Long Line Equations Surge Impedance and SIL of Long Lines.
- Wave Length and Velocity of Propagation of Waves.

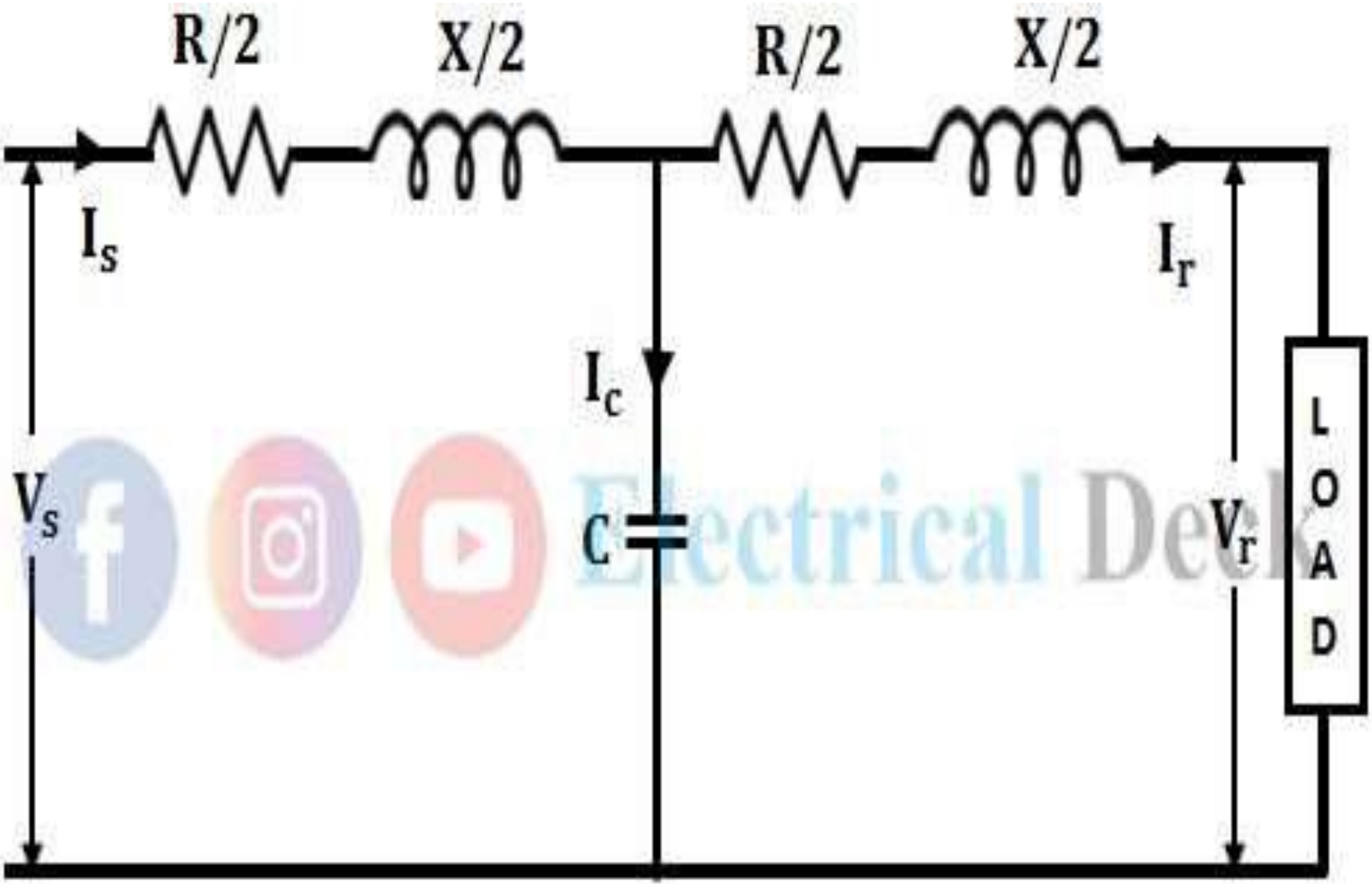

Transmission Line
AC Transmission Line
DC Transmission line
Short Transmission Line
Medium Transmission Line
Long Transmission Line
Pi - Model
T - Model
Circuit Globe



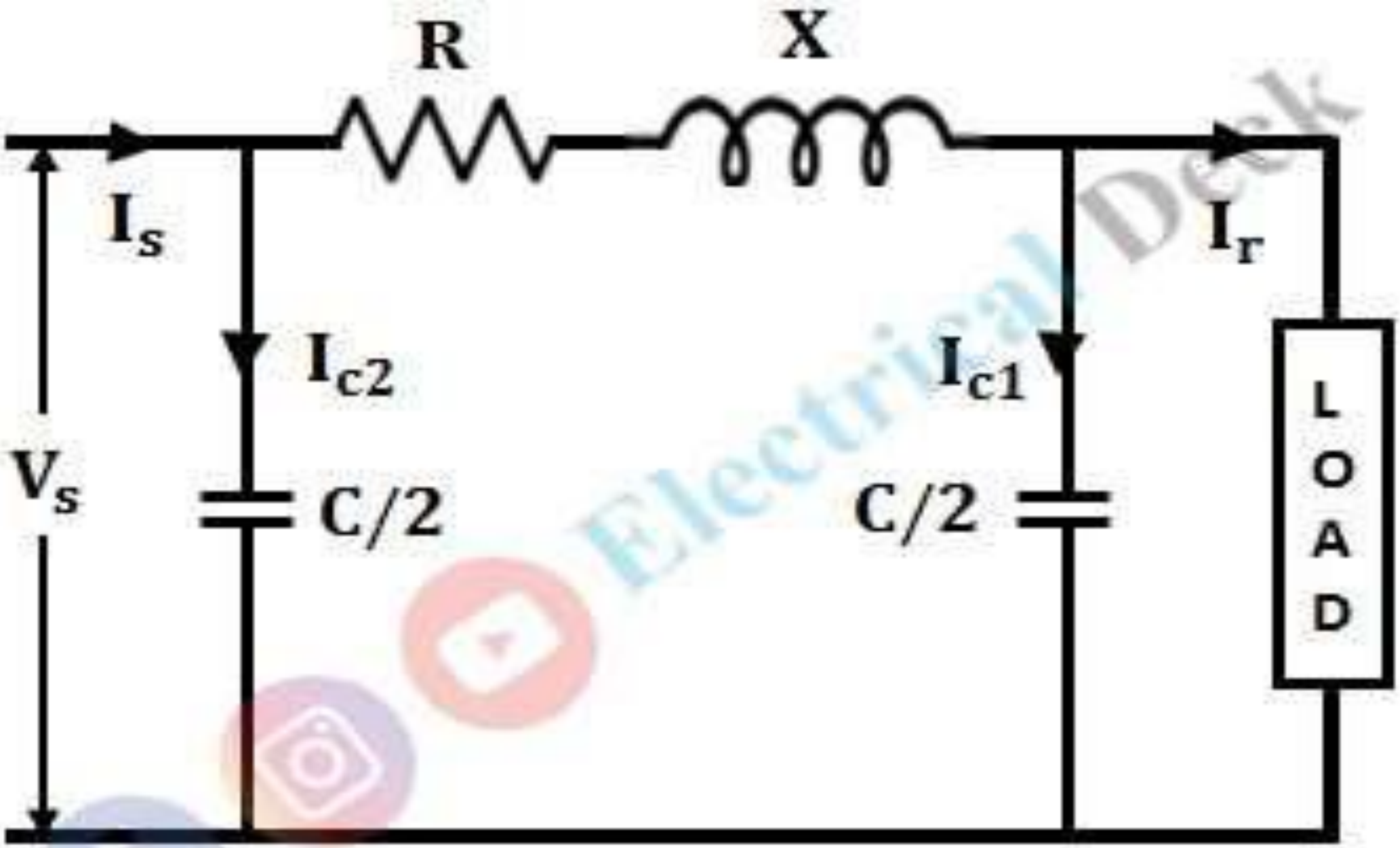
Short Transmission Line



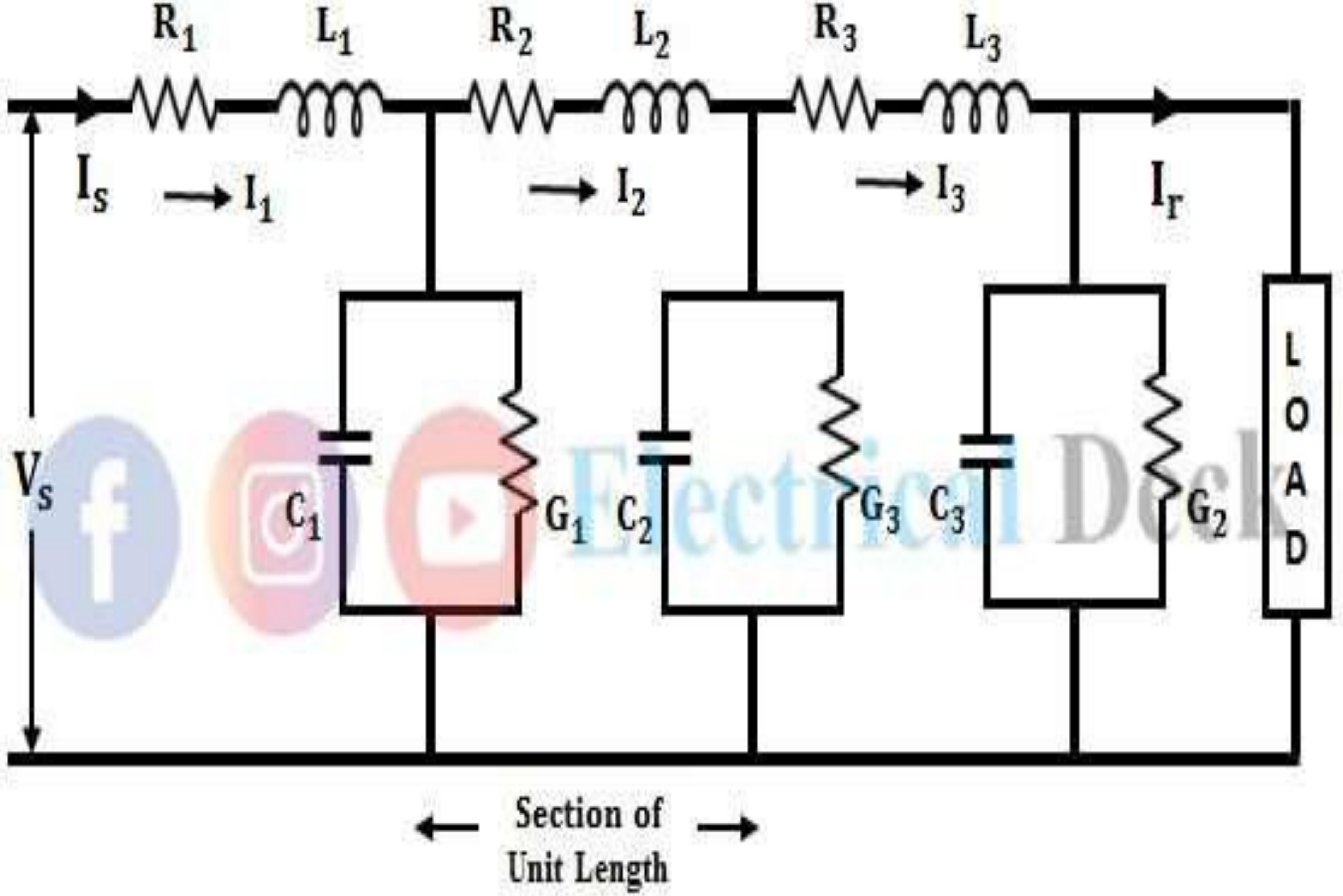
End Condenser Method of Medium Transmission Line



Nominal-T Method of Medium Transmission Line



Nominal-π Method of Medium Transmission Line



Long Transmission Line

# UNIT-II

## POWER SYSTEM TRANSIENTS & FACTORS GOVERNING THE PERFORMANCE OF TRANSMISSIONLINES