

$$A = \frac{V_S}{V_R} (I_R = 0)$$

Thus it implies that on applying open circuit condition to ABCD parameters, we get parameter A as the ratio of sending end voltage to the open circuit receiving end voltage. Since dimension wise A is a ratio of voltage to voltage, A is a dimension less parameter.

Applying the same open circuit condition i.e. $I_R = 0$ to equation (2)

$$I_S = CV_R + D0$$

$$I_S = CV_R + 0$$

$$C = \frac{I_S}{V_R} (I_R = 0)$$

Thus its implies that on applying open circuit condition to ABCD parameters of transmission line, we get parameter C as the ratio of sending end current to the open circuit receiving end voltage. Since dimension wise C is a ratio of current to voltage, its unit is mho.

Thus C is the open circuit conductance and is given by $C = I_S/V_R$ mho.

ABCD Parameters (When Receiving End is Short Circuited)

Receiving end is short circuited meaning receiving end voltage $V_R = 0$

Applying this condition to equation (1) we get,

$$V_S = A0 + BI_R$$

$$V_S = 0 + BI_R$$

$$B = \frac{V_S}{I_R} (V_R = 0)$$

Thus its implies that on applying short circuit condition to ABCD parameters, we get parameter B as the ratio of sending end voltage to the short circuit receiving end current. Since dimension wise B is a ratio of voltage to current, its unit is Ω . Thus B is the short circuit resistance and is given by

$$B = V_S/I_R \Omega.$$

Applying the same short circuit condition i.e. $V_R = 0$ to equation (2) we get

$$I_S = C0 + DI_R$$

$$I_S = 0 + DI_R$$

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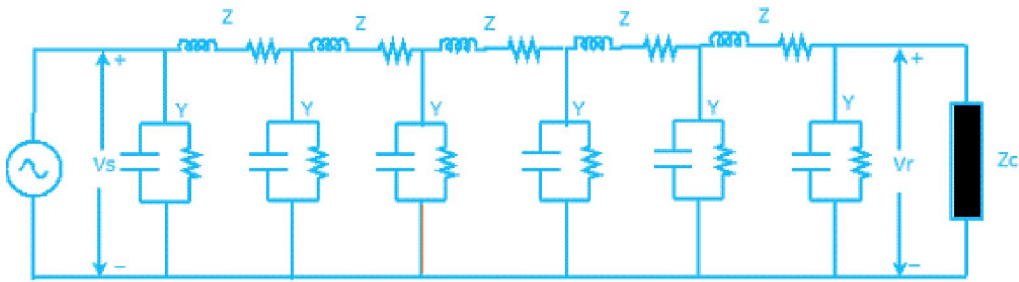


Fig.1.14: Long line model

- a) Ignoring the shunt admittance of the network, like in a small transmission line model.
- b) Considering the circuit impedance and admittance to be lumped and concentrated at a point as was the case for the medium line model.

Rather, for all practical reasons we should consider the circuit impedance and admittance to be distributed over the entire circuit length as shown in the figure below.

The calculations of circuit parameters for this reason are going to be slightly more rigorous as we will see here. For accurate modeling to determine circuit parameters let us consider the circuit of the **long transmission line** as shown in the diagram below.

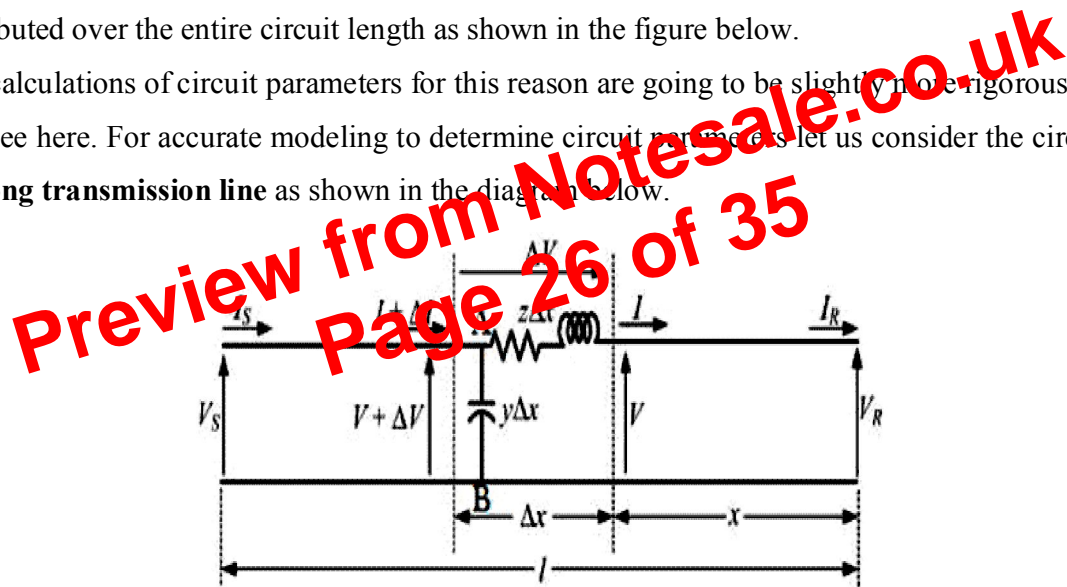


Fig.1.15: Modeling of long transmission line

Here a line of length $l > 250\text{km}$ is supplied with a sending end voltage and current of V_S and I_S respectively, whereas the V_R and I_R are the values of voltage and current obtained from the receiving end. Let us now consider an element of infinitely small length Δx at a distance x from the receiving end as shown in the figure 1.15 where.

V = value of voltage just before entering the element Δx .

$$Z_c = \sqrt{(z/y)} \Omega$$

$$\delta = \sqrt{(yz)}$$

Then the voltage and current equation can be expressed in terms of characteristic impedance and propagation constant as

$$V = A_1 e^{\delta x} + A_2 e^{-\delta x} \quad (7)$$

$$I = A_1 / Z_c e^{\delta x} + A_2 / Z_c e^{-\delta x} \quad (8)$$

Now at $x=0$, $V = V_R$ and $I = I_R$. Substituting these conditions to equation (7) and (8) respectively.

$$V_R = A_1 + A_2 \quad (9)$$

$$I_R = A_1 / Z_c + A_2 / Z_c \quad (10)$$

Solving equation (9) and (10),

We get values of A_1 and A_2 as,

$$A_1 = (V_R + Z_c I_R) / 2$$

$$\text{And } A_2 = (V_R - Z_c I_R) / 2$$

Now applying another extreme condition at $x=l$, we have $V = V_S$ and $I = I_S$

Now to determine V_S and I_S we substitute x by l and put the values of A_1 and

A_2 in equation (7) and (8) we get

$$V_S = (V_R + Z_c I_R) e^{\delta l} / 2 + (V_R - Z_c I_R) e^{-\delta l} / 2 \quad (11)$$

$$I_S = (V_R / Z_c + I_R) e^{\delta l} / 2 - (V_R / Z_c - I_R) e^{-\delta l} / 2 \quad (12)$$

By trigonometric and exponential operators we know

$$\sinh \delta l = (e^{\delta l} - e^{-\delta l}) / 2$$

$$\text{And } \cosh \delta l = (e^{\delta l} + e^{-\delta l}) / 2$$

Therefore, equation(11) and (12) can be re-written as

$$V_S = V_R \cosh \delta l + Z_c I_R \sinh \delta l$$

$$I_S = (V_R \sinh \delta l) / Z_c + I_R \cosh \delta l$$

Thus comparing with the general circuit parameters equation, we get the ABCD parameters of a long transmission line as,

$$A = \cosh \delta l$$

$$B = Z_c \sinh \delta l$$

ratio of actual power consumed by the load, to the total power i.e. vector sum of active and reactive power, of the system becomes quite less. This ratio is alternatively known as electrical power factor, and fewer ratios indicates poor power factor of the system. If the power factor of the system is poor, the ampere burden of the transmission, distribution network, transformers, alternators and other equipments connected to the system, becomes high for required active power. And hence reactive power compensation becomes so important. This is commonly done by capacitor bank.

Let's explain in details,

we know that active power is expressed $=VI\cos\theta$

where, $\cos\theta$ is the power factor of the system. Hence, if this power factor has got less value, the corresponding current (I) increases for same active power P.

As the current of the system increases, the ohmic loss of the system increases. Ohmic loss means, generated electrical power is lost as unwanted heat originated in the system. The cross-section of the conducting parts of the system may also have to be increased for carrying extra ampere burden, which is also not economical in the commercial point of view. Another major disadvantage, is poor voltage regulation of the system, which mainly caused due to poor power factor.

The equipments used to compensate reactive power.

There are mainly two equipments used for this purpose.

- (1) Synchronous condensers
- (2) Static capacitors or Capacitor Bank

Synchronous condensers, can produce reactive power and the production of reactive power can be regulated. Due to this regulating advantage, the synchronous condensers are very suitable for correcting power factor of the system, but this equipment is quite expensive compared to static capacitors. That is why synchronous condensers, are justified to use only for voltage regulation of very high voltage transmission system. The regulation in static capacitors can also be achieved to some extent by split the total capacitor bank in 3 sectors of ratio 1: 2:2. This division enables

capacitive reactance of series capacitor neutralizes the inductive reactance of the line hence, reduces, effective reactance of the line. Thereby, voltage regulation of the system is improved. But series capacitor bank has a major disadvantage. During faulty condition, the voltage across the capacitor maybe raised up to 15 times more than its rated value. Thus series capacitor must have sophisticated and elaborate protective equipments. Because of this, use of-series capacitor is confined in the extra high voltage system only.

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