COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

Power Engineering
EET 305

Lecture 12

- Medium Transmission Lines -
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Medium Transmission Lines

- In short transmission line calculations, the effects of the line capacitance are neglected because such lines have smaller lengths and transmit power at relatively low voltages (< 20 kV).

- However, as the length and voltage of the line increase, the capacitance gradually becomes of greater importance.

Introduction

- Since medium transmission lines have sufficient length (50-150 km) and usually operate at voltages greater than 20 kV, the effects of capacitance cannot be neglected.

- Therefore, in order to obtain reasonable accuracy in medium transmission line calculations, the line capacitance must be taken into consideration.

- The capacitance is uniformly distributed over the entire length of the line.

Introduction

- However, in order to make the calculations simple, the line capacitance is assumed to be lumped or concentrated in the form of capacitors shunted across the line at one or more points.

- Such a treatment of localising the line capacitance gives reasonably accurate results.

- Although the above methods are used for obtaining the performance calculations of medium lines, they can also be used for short lines if their line capacitance is given in a particular problem.

Introduction

- The most commonly used methods (known as localised capacitance methods) for the solution of medium transmissions lines are :

(i) End condenser method.

(ii) Nominal T method.

(iii) Nominal π method.

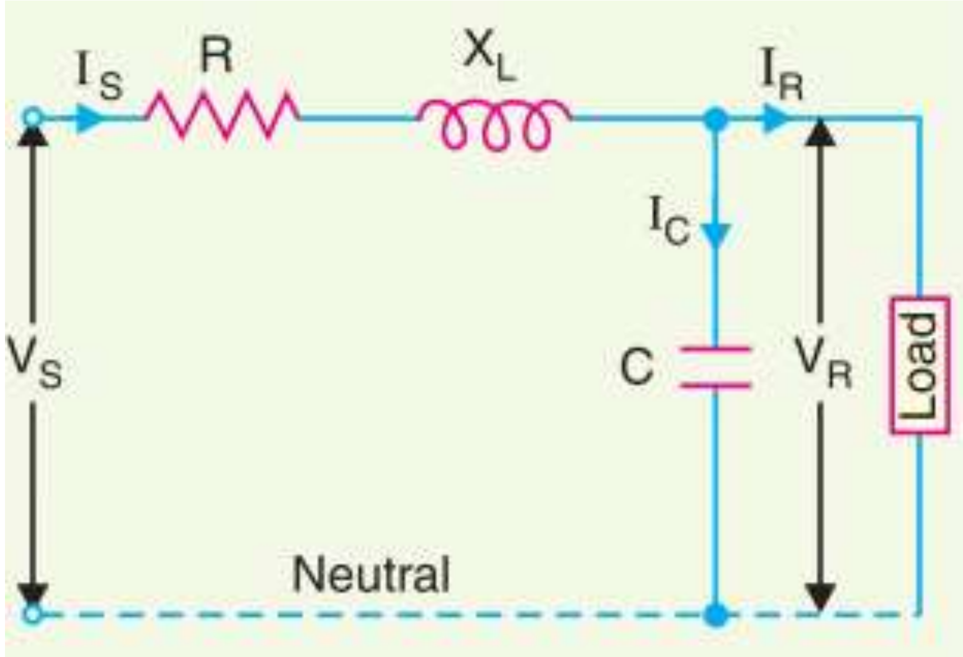
End Condenser Method

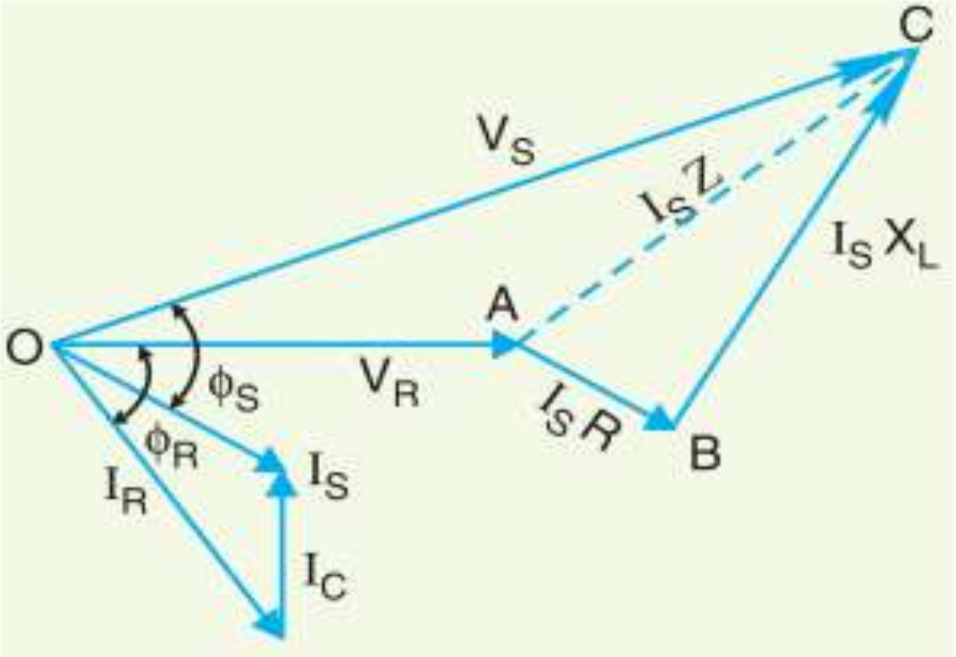
- In this method, the capacitance of the line is lumped or concentrated at the receiving or load end as shown in Figure.

- This method of localising the line capacitance at the load end overestimates the effects of capacitance.

- In Figure below, one phase of the 3-phase transmission line is shown as it is more convenient to work in phase instead of line-to-line values.

Introduction





Introduction

Let I_R = load current per phase

R = resistance per phase

X_L = inductive reactance per phase

C = capacitance per phase

$\cos \phi_R$ = receiving end power factor (*lagging*)

V_S = sending end voltage per phase

we have, $\vec{V_R} = V_R + j\,0$

Load current, $\vec{I_R} = I_R(\cos\phi_R - j\sin\phi_R)$

Capacitive current, $\vec{I_C} = j\,\vec{V_R}\,\omega C = j\,2\pi f C\,\vec{V_R}$

$$\begin{aligned}\vec{I_S} &= \vec{I_R} + \vec{I_C}\\ &= I_R(\cos\phi_R - j\sin\phi_R) + j\,2\pi f C\,V_R\\ &= I_R\cos\phi_R + j(-I_R\sin\phi_R + 2\pi f C V_R)\end{aligned}$$

Voltage drop/phase $= \vec{I_S}\,\vec{Z} = \vec{I_S}\,(R + jX_L)$

Introduction

Sending end voltage, $\vec{V}_S = \vec{V}_R + \vec{I}_S \vec{Z} = \vec{V}_R + \vec{I}_S (R + j X_L)$

Thus, the magnitude of sending end voltage V_S can be calculated.

$$\% \text{ Voltage regulation} = \frac{V_S - V_R}{V_R} \times 100$$

$$\% \text{ Voltage transmission efficiency} = \frac{\text{Power delivered / phase}}{\text{Power delivered / phase} + \text{losses / phase}} \times 100$$

$$= \frac{V_R I_R \cos \phi_R}{V_R I_R \cos \phi_R + I_S^2 R} \times 100$$

Limitations

- Although end condenser method for the solution of medium lines is simple to work out calculations, yet it has the following drawbacks :

(i) There is a considerable error (about 10%) in calculations because the distributed capacitance has been assumed to be lumped or concentrated.

(ii) This method overestimates the effects of line capacitance.

Example

A (medium) single phase transmission line 100 km long has the following constants :

Resistance/km = 0·25 Ω, Reactance/km = 0·8 Ω, Susceptance/km = 14 Micro siemens, Receiving end line voltage = 66,000 V

Assuming that the total capacitance of the line is localised at the receiving end alone, determine

(i) the sending end current (ii) the sending end voltage and (iii) voltage regulation.

The line is delivering 15,000 kW at 0.8 power factor lagging.

Solution

Total resistance, $R = 0{\cdot}25 \times 100 = 25\ \Omega$

Total reactance, $X_L = 0{\cdot}8 \times 100 = 80\ \Omega$

Total susceptance, $Y = 14 \times 10^{-6} \times 100 = 14 \times 10^{-4}\ S$

Receiving end voltage, $V_R = 66{,}000\ \text{V}$

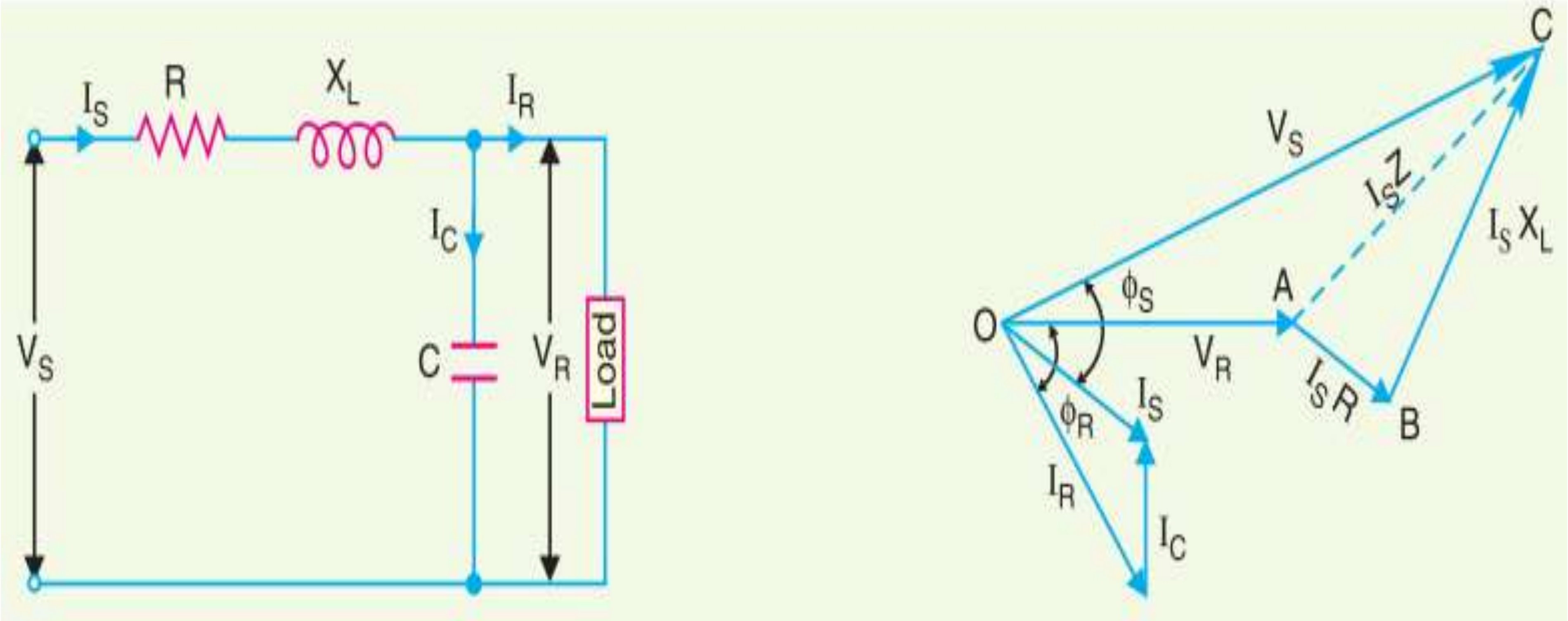
$\therefore$ Load current, $I_R = \dfrac{15{,}000 \times 10^3}{66{,}000 \times 0 \cdot 8} = 284\ \text{A}$

$$\cos \phi_R = 0{\cdot}8\ ; \qquad \sin \phi_R = 0{\cdot}6$$

$$\vec{V_R} = V_R + j\,0 = 66{,}000V$$

Load current, $\vec{I_R} = I_R\,(\cos \phi_R - j \sin \phi_R) = 284\,(0{\cdot}8 - j\,0{\cdot}6) = 227 - j\,170$

Solution



Solution

Capacitive current, $\vec{I_C} = j\,Y \times V_R = j\,14 \times 10^{-4} \times 66000 = j\,92$

(*i*) Sending end current, $\vec{I_S} = \vec{I_R} + \vec{I_C} = (227 - j\,170) + j\,92$

$= 227 - j\,78$

Magnitude of $I_S = \sqrt{(227)^2 + (78)^2} =$ **240 A**

(*ii*) Voltage drop $= \vec{I_S}\,\vec{Z} = \vec{I_S}(R + j\,X_L) = (227 - j\,78)\,(25 + j\,80)$

$= 5{,}675 + j\,18,160 - j\,1950 + 6240$

$= 11{,}915 + j\,16{,}210$

Sending end voltage, $\vec{V_S} = \vec{V_R} + \vec{I_S}\,\vec{Z} = 66{,}000 + 11{,}915 + j\,16{,}210$

$= 77{,}915 + j\,16{,}210$

Magnitude of $V_S = \sqrt{(77915)^2 + (16210)^2} =$ **79583V**

(*iii*) % Voltage regulation $= \dfrac{V_S - V_R}{V_R} \times 100 = \dfrac{79{,}583 - 66{,}000}{66{,}000} \times 100 =$ **20·58%**