UNIT - II

THE LINE AT RADIO FREQUENCIES

Standing waves and standing wave Ratio on a line

Introduction The assumptions made in the analysis of the transmission line at radio frequencies (MHz and above) are

1) very considerable skin effect, so that the current is assumed to flow on conductor surfaces, internal inductance is zero.

2) $\omega L >> R$ when computing Z.

3) The lines are well enough constructed so that $G = 0$.

Constants for the line of zero dissipation

$Z = j\omega L$, $Y = j\omega C$ (since R & $G = 0$)

1) $Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{j\omega L}{j\omega C}} = \sqrt{\frac{L}{C}}$

2) $\gamma = \sqrt{ZY} = \alpha + j\beta$
$= j\omega\sqrt{LC}$ $\Rightarrow$ $\alpha = 0$, $\beta = \omega\sqrt{LC}$

3) $Z_0 = R_0$

4) $V = \frac{\omega}{\beta} = \frac{\omega}{\omega\sqrt{LC}} = \frac{1}{\sqrt{LC}}$

Voltages and currents on dissipationless line

The voltage at any point distant s units from the receiving end of the transmission line is

$$E = \frac{E_R (Z_R + Z_0)}{2Z_R} \left[e^{\gamma s} + K e^{-\gamma s} \right] \rightarrow ①$$

$$K = \text{reflection factor} = \frac{Z_R - Z_0}{Z_R + Z_0}$$

Since $Z_0 = R_0$, $\gamma = j\beta$ for dissipationless line,

$$E = \frac{E_R (Z_R + R_0)}{2Z_R} \left(e^{j\beta s} + K e^{-j\beta s} \right) \rightarrow ②$$

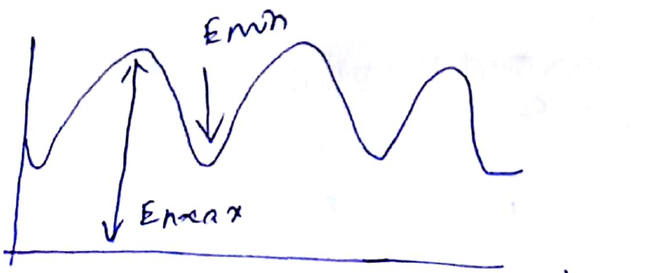
The term varying with $e^{j\beta s}$ → wave progressing from source to load.

The term varying with $e^{-j\beta s}$ → wave reflected from load to source

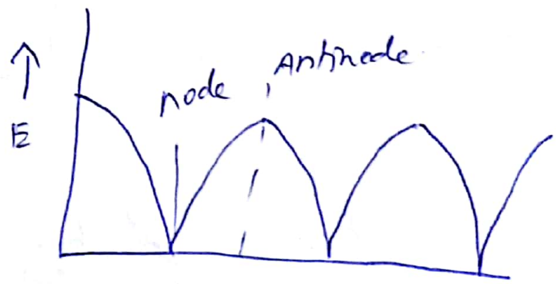
The actual voltage at any point on the transmission line is the sum of incident and reflected wave voltages at that point.

The resultant total voltage appears to stand still on the line oscillating in magnitude but having fixed positions of maxima and minima. Such a wave is known as a standing wave.

SWR



i) standing waves on a line terminated in a load ≠ R_0



standing waves on a line have open (or) short circuited termination

Nodes:

Nodes are the points of zero voltage or current in the standing wave systeme.

Antinodes (or) loops

Antinodes are the points of maximum voltage or current.

Smooth line

A line terminated in R_o has no standing waves and thus no nodes or loops and is called a smooth line.

standing wave Ratio (SWR)

The ratio of maximum to minimum magnitudes of voltage (or) current on a line having standing waves is called the standing wave ratio (S).

$$S = \left| \frac{E_{max}}{E_{min}} \right| = \left| \frac{I_{max}}{I_{min}} \right| \rightarrow (1)$$

The maxima of voltage occurs at points at which incident & reflected waves are in phase and add directly.

$$E_{max} = \frac{E_R(Z_R + Z_0)}{2Z_R}\left(e^{j\beta s} + K e^{-j\beta s}\right) \rightarrow (2)$$

$$E_{max} = \frac{E_R(Z_R + Z_0)}{2Z_R}(1 + |K|)$$

at the points of voltage minima, the incident & reflected waves are out of phase.

$$E_{min} = \frac{E_R (Z_R + Z_0)}{2 Z_R} (1 - |K|)$$

$$S = \frac{1 + |K|}{1 - |K|}$$

$$|K| = \frac{S - 1}{S + 1} = \frac{|E_{max}| - |E_{min}|}{|E_{max}| + |E_{min}|}$$

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