SNS COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Subject Code: 19EC502

Subject: Transmission Lines and Antennas

Unit-I

Topic: Reflection Co-efficient, Reflection Loss & Reflection Factor

Line at Zero Dissipation

Reflection Co-efficient

$$K = \frac{\text{REFLECTED VOLTAGE AT LOAD}}{\text{INCIDENT VOLTAGE AT LOAD}}$$

$$V = \frac{V_R}{2}\left[\left(1+\frac{Z_O}{Z_R}\right)e^{\upsilon l} + \left(1-\frac{Z_O}{Z_R}\right)e^{-\upsilon l}\right]$$

Where, $\frac{V_R}{2}\left(1+\frac{Z_O}{Z_R}\right) \rightarrow$ Incident voltage

$\frac{V_R}{2}\left(1-\frac{Z_O}{Z_R}\right) \rightarrow$ Reflected voltage

$$K = \frac{\frac{V_R}{2}\left(1-\frac{Z_O}{Z_R}\right)}{\frac{V_R}{2}\left(1+\frac{Z_O}{Z_R}\right)} = \frac{Z_R - Z_O}{Z_R + Z_O} \Rightarrow K = \frac{Z_R - Z_O}{Z_R + Z_O}$$

CASE i: ($Z_R = Z_O$)

K = 0, no reflection

CASE ii: LINE IS SHORT CIRCUITED ($Z_R = 0$)

$$K = -\frac{Z_O}{Z_O} = -1 = 1\angle 180^\circ$$

REFLECTION IS MAXIMUM

iii: LINE IS OPEN CIRCUITED ($Z_R = \infty$)

$$K = \frac{Z_R\left(1-\frac{Z_O}{Z_R}\right)}{Z_R\left(1+\frac{Z_O}{Z_R}\right)} = 1 \Rightarrow K = 1\angle 0^\circ$$

REFLECTION IS MAXIMUM

Reflection Loss and Reflection Factor

If the line is terminated in Zo then there is no reflection. But in mismatch conditions, the ratio of voltage to current gets disturbed. The part of the energy is rejected and reflected by the load. Thus the energy delivered to the load under a mismatch condition is always less than the energy that would be delivered to the load under a matched condition. This is because of a loss called **reflection loss.**

The reflection loss is determined from the ratio of current which flows under mismatch conditions in the load to that which would flow if the impedance are matched at the terminals of the load.

Reflection Loss and Reflection Factor

The reflection loss is defined as the number of Neper's and Decibel's by which the current in the load under image matched condition would exceed the current actually flowing in the load.

$$\text{Reflection loss} = \left[\frac{|I_2'|}{|I_2|}\right] \text{Neper}$$

I_2' - actual current

I_2 – observed current

$$\text{Reflection loss} = 20\, log\left[\frac{|I_2'|}{|I_2|}\right] \text{Decibel}$$

Where,

I_2' is load current under image matched condition.

I_2 is actual load current under mismatched condition.

P_1 is power at receiving end due to incident wave.

P_2 is power observed by the load

P_3 is power rejected back to the line.

Reflection Loss and Reflection Factor

$P_1 = P_2 + P_3$

$P = I^2 \qquad I \, \alpha \, \sqrt{P} \qquad I = P^{\frac{1}{2}}$

$$\text{Reflection loss} = 20 \, log \left[\frac{P_1}{P_2}\right]^{\frac{1}{2}}$$

$$\text{Reflection loss} = 10 \, log \left[\frac{P_1}{P_2}\right]$$

And also we know,

$$K = \frac{P_2}{P_1}$$

$$\text{Reflection loss} = 10 \, log \left[\frac{1}{K}\right]$$

$$K = \frac{Z_R - Z_o}{Z_R + Z_o}$$

$$\text{Reflection loss} = 10 \, log \left[\frac{Z_R + Z_o}{Z_R - Z_o}\right]$$

If E_R and I_R are the values of voltage and current at the receiving end due to incident wave , then the values of voltage and current at the receiving end to the reflected wave is KE_R and KI_R

Reflection Loss and Reflection Factor

Reflection Loss can be obtained as,

$P_1 = E_R\, I_R$

$P_3 = KE_R \, . \, KI_R$

$P_3 = K^2 E_R\, I_R$

$P_3 = K^2 P_1$

$P_2 = P_1 - P_3$

$P_2 = P_1 - K^2 P_1$

$P_2 = P_1(1 - K^2)$

Wkt,

$$\text{Reflection loss} = 10\, log \left[\frac{P_1}{P_1(1-K^2)}\right]$$

$$\text{Reflection loss} = 10\, log \left[\frac{1}{(1-K^2)}\right]$$

$$K = \frac{Z_R - Z_o}{Z_R + Z_o}$$

$$\text{Reflection loss} = 10\, log \left[\frac{1}{1-\left(\frac{Z_R - Z_o}{Z_R + Z_o}\right)^2}\right]$$

$$\text{Reflection loss} = 10\, log \left[\frac{1}{\frac{(Z_R + Z_o)^2 - (Z_R - Z_o)^2}{(Z_R + Z_o)^2}}\right]$$

Reflection Loss and Reflection Factor

$$\text{Reflection loss} = 20\,log\left[\frac{Z_R + Z_o}{2\sqrt{Z_R\,Z_o}}\right]$$

$$\text{Reflection loss} = 20\,log\left[\frac{1}{|K|}\right]$$

$|K|$ is reflection factor

The ratio in which indicate the change in current with the load due to reflection at the mismatched junction is called reflection factor.

It is given by,

$$|K| = \frac{2\sqrt{Z_R\,Z_o}}{Z_R + Z_o}$$

Reflection Loss and Reflection Factor

It is defined as the ratio of actual power to the reflected power.

$$\text{Return loss} = 10\ log\left[\frac{P_1}{P_3}\right]$$

$$\text{Return loss} = 10\ log\left[\frac{P_1}{K^2 P_1}\right]$$

$$\text{Return loss} = 10\ log\left[\frac{1}{K^2}\right]$$

$$\text{Return loss} = 10\ log\left[\frac{1}{K}\right]^2$$

$$\text{Return loss} = 20\ log\left[\frac{1}{K}\right]$$

Wkt,

$$K = \frac{Z_R - Z_o}{Z_R + Z_o}$$

$$\text{Return loss} = 20\ log\left[\frac{Z_R + Z_o}{Z_R - Z_o}\right]$$

Line of Zero Dissipation (Dissipation Less Line)

Characteristic Impedance (z_0) and propagation constant (γ) *of a line are given by,*

$$Z_o = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{R+j\omega L}{G+j\omega C}} \text{ ---------------(1)}$$

$$\gamma = \sqrt{ZY} = \sqrt{(R + j\omega L)(G + j\omega C)} \text{ ----- -(2)}$$

At a high frequency, $j\omega L \gg R$ and $j\omega C \gg G$

$$Z_o = \sqrt{\frac{j\omega L}{j\omega C}} = \sqrt{\frac{L}{C}} = \text{ -------------(3)}$$

Characteristic impedance is real and resistive , represented by Z_o

$$Z_o = R_o = \sqrt{\frac{L}{C}} \text{ -------------(4)}$$

similarly *the propagation* constant (γ) is given by,

$$\gamma = \sqrt{(j\omega L)(j\omega C)} = j\omega\sqrt{LC} \text{ ----- -(5)}$$

$$\gamma = 0 + j\omega\sqrt{LC}$$

$$\gamma = \alpha + j\beta$$

But, At a high frequency,

$$\alpha = 0 \text{ and } \beta = \omega\sqrt{LC} \text{ radian/m ----(6)}$$

The velocity of propagation is given by,

$$\vartheta = \frac{\omega}{\beta} = \frac{\omega}{\omega\sqrt{LC}} \text{ m/sec ------(7)}$$

From equation (7) , the velocity of propagation for open wire dissipation less line, separated by air

The distance corresponding to the phase shift of 2π radians is called wavelength (λ) is given by,

$$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{\omega\sqrt{LC}} \; m \text{ ----- -(8)}$$