WAVEFORM DISTORTION & DISTORTIONLESS TRANSMISSION LINE

Determination of α & β

W.K.T $\quad Z = R + jwL$

$$Y = G + jwC$$

$$\gamma = \sqrt{ZY}$$

$$\gamma = \alpha + j\beta = \sqrt{(R+jwL)(G+jwC)} \rightarrow (1)$$

Squaring both sides,

$$(\alpha + j\beta)^2 = (R+jwL)(G+jwC)$$

$$\alpha^2 - \beta^2 - j2\alpha\beta = RG + jwRC + jwLG - w^2LC \rightarrow (2)$$

Equating real terms,

$$\alpha^2 - \beta^2 = RG - w^2LC$$

$$\alpha^2 = \beta^2 + RG - w^2LC \rightarrow (3)$$

Equating imaginaries & squaring

$$4\alpha^2\beta^2 = w^2(LG+RC)^2 \rightarrow (4)$$

Subs eq (3) in eq (4) & solving,

$$\beta = \sqrt{\frac{w^2LC - RG + \sqrt{(RG - w^2LC)^2 + w^2(LG+CR)^2}}{2}}$$

$$\alpha = \sqrt{\frac{RG - w^2LC + \sqrt{(RG - w^2LC)^2 + w^2(LG+CR)^2}}{2}}$$

WAVE FORM DISTORTION

* Signals transmitted over lines are normally complex and consists of many frequency components.

* For ideal transmission, the wave form at the receiving end must be same as the waveform of the original input signal.

* This requires that all frequencies have same attenuation and the same delay caused by a finite phase velocity or velocity of propagation.

* when these conditions are not satisfied distortion exists. The distortions occuring in the transmission line are called waveform distortion or ~~delay~~ line distortion.

Two types

(i) Frequency distortion

(ii) phase or delay distortion.

(i) Frequency distortion

* when a signal having many frequency components are transmitted along the line, all the frequencies will not have equal attenuation.

* Ex: Voice signal is a complex waveform consists of many frequencies, will not have all frequencies transmitted with equal attenuation.

* And the received waveform will not be identical

with the input waveform at the sending end.

* This variation is known as frequency distortion.

* Frequency distortion is reduced in the transmission line of high quality radio broadcast programme over wire lines by the uses of equalizers at the line terminals.

* These circuits are networks whose frequency and phase characteristics are adjusted to be inverse to those of the lines, resulting in an over-all uniform frequency response over the desired frequency band.

(ii) Phase (or) delay distortion

* When a signal having many frequency components are transmitted along the line, all the frequencies will not have same time of transmission.

* Some frequencies being delayed more than the others.

* So the received end waveform will not be identical with the input waveform at the sending end because some frequency components will be delayed more than those of other frequencies.

* This type of distortion is called phase or delay distortion.

The distortionless line

If a line is to have neither frequency nor delay distortion, then α and the velocity of propagation can not be functions of frequency.

ie α & v $\rightarrow$ independant of frequency

β $\rightarrow$ dependant on frequency.

Expression for β,

$$\beta = \sqrt{\frac{(\omega^2LC - RG) + \sqrt{(RG-\omega^2LC)^2 + \omega^2(LG+RC)^2}}{2}}$$

The term under the second radical is equated to $(RG+\omega^2LC)^2$ then the required condition for β is obtained.

$$\therefore (RG-\omega^2LC)^2 + \omega^2(LG+RC)^2 = (RG+\omega^2LC)^2$$

$$R^2G^2 + \omega^4L^2C^2 - 2RG\omega^2LC + \omega^2L^2G^2 + \omega^2R^2C^2 + 2\omega^2 GRC$$

$$= R^2G^2 + \omega^4L^2C^2 + 2RG\omega^2LC$$

$$\omega^2(L^2G^2 + R^2C^2 - 2LGRC) = 0$$

$$L^2G^2 + R^2C^2 - 2LGRC = 0$$

$$(LG-RC)^2 = 0$$

$$LG - RC = 0$$

$$LG = RC$$

$$\boxed{\frac{L}{C} = \frac{R}{G}}$$

This is the condition for distortionless transmission line.

Subs $(RG+w^2LC)^2$ in the expression β instead of the term inside the second square root,

$$\beta = \sqrt{\frac{(w^2LC-RG)+\sqrt{(RG+w^2LC)^2}}{2}}$$

$$= \sqrt{\frac{w^2LC-\cancel{RG}+\cancel{RG}+w^2LC}{2}}$$

$$= \sqrt{\frac{\cancel{2}w^2LC}{\cancel{2}}}$$

$$\boxed{\beta = w\sqrt{LC}}$$

$$v = \frac{w}{\beta} = \frac{\cancel{w}}{\cancel{w}\sqrt{LC}} = \frac{1}{\sqrt{LC}}$$

$\therefore$ $v \rightarrow$ independant of frequency.

Subs $(RG+w^2LC)^2 \rightarrow$ in α expression,

$$\alpha = \sqrt{\frac{RG-w^2LC+\sqrt{(RG+w^2LC)^2}}{2}}$$

$$= \sqrt{\frac{RG-\cancel{w^2LC}+RG+\cancel{w^2LC}}{2}}$$

$$= \sqrt{\frac{\cancel{2}RG}{\cancel{2}}} = \sqrt{RG}$$

$$\boxed{\alpha = \sqrt{RG}}$$

$\alpha \rightarrow$ independant of frequency.