Condition for minimum attenuation

For minimum attenuation, the attenuation constant (α) should be minimum.

Assuming R, G, and C to be constant and L to be variable then, minimum attenuation constant can be found by differentiating α, with respect to L and equating it equal to 0. i.e.

$$\frac{\partial \alpha}{\partial L} = 0$$

$$\alpha = \sqrt{\frac{1}{2}\left\{\sqrt{(R^2+\omega^2L^2)(G^2+\omega^2C^2)} + (RG-\omega^2LC)\right\}}$$

$$\Rightarrow 2\alpha^2 = \sqrt{(R^2+\omega^2L^2)}\sqrt{(G^2+\omega^2C^2)} + (RG-\omega^2LC).$$

differentiating both sides w.r.t. L and equating it to 0.

$$4\alpha \cdot \frac{d\alpha}{dL} = \sqrt{G^2+\omega^2C^2} \cdot \frac{1}{2}(R^2+\omega^2L^2)^{\frac{1}{2}-1}(0+\omega^2 \cdot 2L) - \omega^2C$$

$$4\alpha \frac{d\alpha}{dL} = \frac{\sqrt{G^2+\omega^2C^2}}{\sqrt{R^2+\omega^2L^2}} \times \omega^2 L - \omega^2 C$$

$$\frac{d\alpha}{dL} = \frac{1}{4\alpha}\left[\frac{\sqrt{G^2+\omega^2C^2}}{\sqrt{R^2+\omega^2L^2}} \times \omega^2 L - \omega^2C\right] = 0$$

Equating above equation equal to 0.

$$\frac{\omega^2 L\sqrt{G^2+\omega^2C^2}}{\sqrt{R^2+\omega^2L^2}} - \omega^2 C = 0$$

$$\frac{\sqrt{G^2+\omega^2C^2}}{\sqrt{R^2+\omega^2L^2}} = \frac{C}{L}$$

$$\frac{G^2+\omega^2C^2}{R^2+\omega^2L^2} = \frac{C^2}{L^2}$$

$$G^2L^2 + \omega^2C^2L^2 = C^2R^2 + \omega^2L^2C^2$$

$$LG = CR$$

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

Loading of Transmission Lines

→ The process of ~~artuf~~ artificially increasing the inductance (L) per unit length of the transmission line to reduce attenuation and distortion ~~is~~ is called loading of transmission line.

There are ~~three~~ two methods of loading.

i) Continuous loading.

→ In this method, the inductance is increased by rapping an iron tape or some other magnetic material, such as mumetal, around the conductors.

→ This rapping increases the permeability (μ) of the surrounding medium.

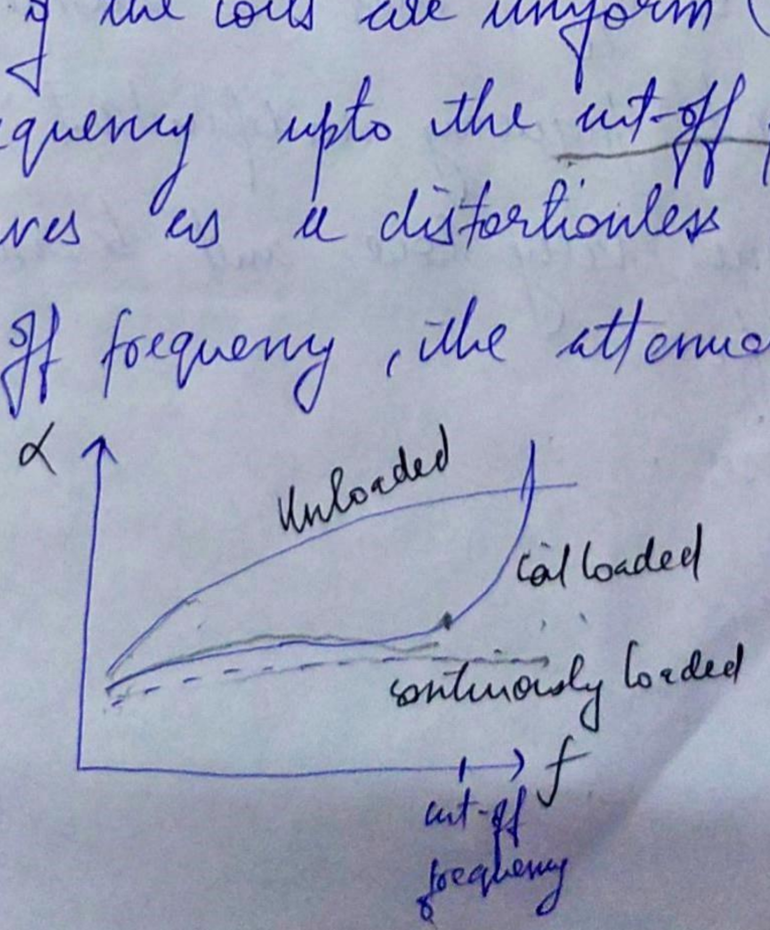
→ The inductance of the conductor is

$$L \simeq \frac{\mu}{\frac{d}{n \cdot t}+1} \text{ mH}$$

where μ = permeability of iron tape
d = diameter of conductor
n = number of layer of iron tape rapping
t = thickness of iron layer

→ One of this disadvantages of this method is the increase in the primary constant R, due to eddy current & hysterisis losses in magnetic material.
→ Irregular variation of pressure between the tape and the material causes large variation in primary consta

② Lumped loading →
→ In this method, the inductance of the transmission line is increased, by introducing inductance coils at regular intervals along the length of the line.
→ If the spacing of the coils are uniform (समान), the at all frequency upto the cut-off frequency, as the line behaves as a distortionless line.
→ Beyond cut-off frequency, the attenuation increases rapidly.



Properties of loading coil:

1)- Low resistance

2)- Low core losses

3)- Maintaining uniform pressure b/w tape and conductor.

4)- Small size.

5)- Should ~~be~~ not create interference with circuit.

Effect of loading:

→ Due to loading of the line, below, the cut-off frequency, the attenuation is very low.

→ Properly loading the line ~~to~~ results in R/L ratio almost equal to the G/C ~~ra~~ ratio, ~~d~~ and the line becomes distortionless.

→ Since $\frac{R}{L} \simeq G/C$, thus Z_0 becomes pure resistive and frequency independant. $Z_0 = \sqrt{\frac{R}{G}}$

→ α, becomes very low and becomes constant below the f_c.

→ β increases.