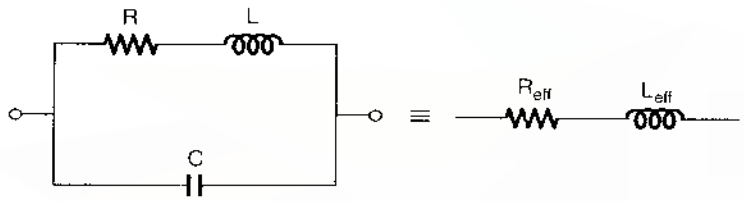
Circuit Components (Resistors, Inductors, Capacitors)

2

Frequency Errors in Resistors



(Equivalent circuit of a resistor at low and medium frequencies)

- Effective resistance

$$R_{eff} = \frac{R}{1+\omega^2 C(CR^2 - 2L)}$$

- Effective inductance or residual inductance

$$L_{eff} = \frac{L - CR^2}{1+\omega^2 C(CR^2 - 2L)}$$

$$\tan\phi = \frac{X_{eff}}{R_{eff}} = \frac{\omega L_{eff}}{R_{eff}} = \frac{\omega(L - CR^2)}{R} = \omega\left(\frac{L}{R} - CR\right)$$

where, ϕ = Phase deflection angle

- Time constant

$$\tau = \frac{L_{eff}}{R_{eff}} = \frac{L - CR^2}{R} = \frac{L}{R} - CR$$

- Condition for resistance to remain independent of frequency

$$CR^2 = 2L$$

- Condition for resistance to show no inductive effect

$$CR^2 = L$$

- Effective resistance for zero effective inductance

$$R_{eff} = \frac{R}{1-\omega^2 LC}$$

- Quality factor

$$Q = \frac{\omega L}{R}$$

Frequency Errors in Inductors

- Effective resistance

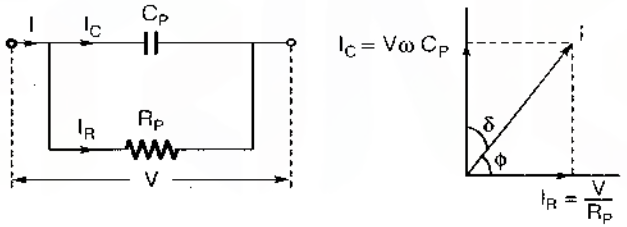
$$R_{eff} = \frac{R}{(1-\omega^2 LC)^2}$$

- Effective inductance

$$L_{eff} = L(1+\omega^2 LC)$$

Capacitor

1. Parallel Representation



- Dielectric loss

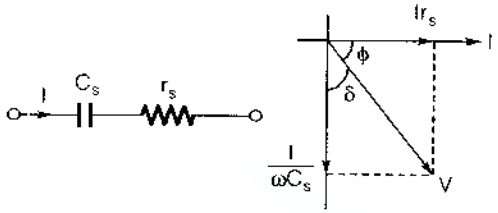
$$P_L = \omega C_P V^2 \tan\delta$$

- Dissipation factor

$$D = \tan\delta = \frac{1}{\omega C_P R_P}$$

where, δ = loss angle of the capacitor.

2. Series Representation



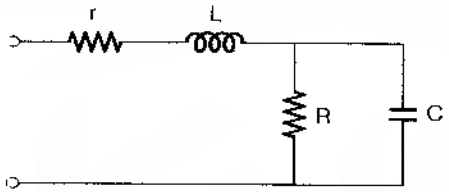
- Dielectric loss

$$P_L = \frac{I^2}{\omega C_s}\tan\delta$$

- Dissipation factor

$$D = \tan\delta = \omega C_s r_s$$

Frequency Errors in Capacitors



Equivalent Circuit of a Capacitor

- Effective capacitance

$$C_{eff} = \frac{C}{1-\omega^2 LC}$$

1. For Medium Frequency

- Effective capacitance

$$C_{eff} = C(1+\omega^2 LC)$$

- Effective series resistance

$$R_{eff} = r + \frac{R}{1+\omega^2 R^2 C^2}$$

where, r = resistance of lead

- Loss angle

$$\tan\delta = \frac{1-\omega^2 LC}{\omega r + \frac{1}{\omega CR}}$$

2. For Low Frequency

- Effective capacitance

$$C_{eff} = C + \frac{1}{\omega^2 CR^2}$$

- Effective series resistance

$$R_{eff} = \frac{R}{1+\omega^2 C^2 R^2}$$

- Loss angle

$$\tan\delta = \omega C r + \frac{1}{\omega CR}$$

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