

Formulae for further electrical and electronic principles

A.c. theory

$$T = \frac{1}{f} \quad \text{or} \quad f = \frac{1}{T}$$

$$I = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + \dots + i_n^2}{n}}$$

For a sine wave: $I_{AV} = \frac{2}{\pi} I_m$ or $0.637 I_m$

$$I = \frac{1}{\sqrt{2}} I_m \quad \text{or} \quad 0.707 I_m$$

Form factor = $\frac{\text{r.m.s.}}{\text{average}}$ Peak factor = $\frac{\text{maximum}}{\text{r.m.s.}}$

General sinusoidal voltage: $v = V_m \sin(\omega t \pm \phi)$

Single-phase circuits

$$X_L = 2\pi fL \quad X_C = \frac{1}{2\pi fC}$$

$$Z = \frac{V}{I} = \sqrt{(R^2 + X^2)}$$

$$\text{Series resonance: } f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = \frac{V_L}{V} \quad \text{or} \quad \frac{V_C}{V} = \frac{2\pi f_r L}{R} = \frac{1}{2\pi f_r C R} = \frac{1}{R} \sqrt{\frac{L}{C}}$$

$$Q = \frac{f_r}{f_2 - f_1} \quad \text{or} \quad (f_2 - f_1) = \frac{f_r}{Q}$$

Parallel resonance (LR-C circuit):

$$f_r = \frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$I_r = \frac{VRC}{L} \quad R_D = \frac{L}{CR}$$

$$Q = \frac{2\pi f_r L}{R} = \frac{I_C}{I_r}$$

$$P = VI \cos \phi \quad \text{or} \quad I^2 R \quad S = VI \quad Q = VI \sin \phi$$

$$\text{power factor} = \cos \phi = \frac{R}{Z}$$

Filter networks

Low-pass T or π :

$$f_C = \frac{1}{\pi \sqrt{LC}} \quad R_0 = \sqrt{\frac{L}{C}}$$

$$C = \frac{1}{\pi R_0 f_C} \quad L = \frac{R_0}{\pi f_C}$$

See Fig. F1.

High-pass T or π :

$$f_C = \frac{1}{4\pi \sqrt{LC}} \quad R_0 = \sqrt{\frac{L}{C}}$$

$$C = \frac{1}{4\pi R_0 f_C} \quad L = \frac{R_0}{4\pi f_C}$$

See Fig. F2.

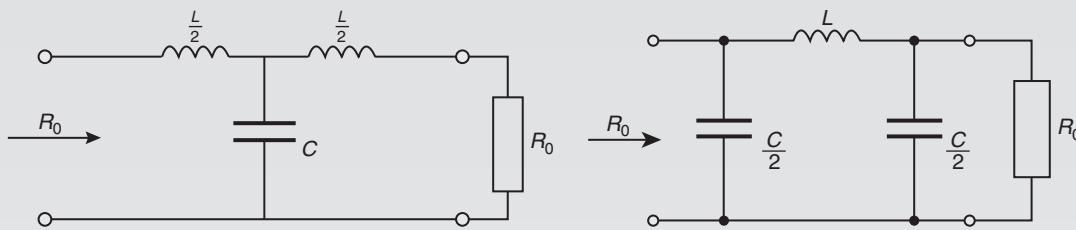


Figure F1

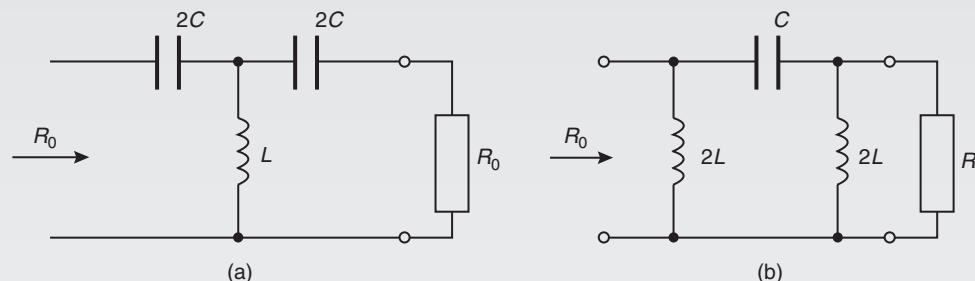


Figure F2

D.c. transientsC-R circuit $\tau = CR$ Charging: $v_C = V(1 - e^{-t/CR})$

$$v_r = Ve^{-t/CR}$$

$$i = Ie^{-t/CR}$$

Discharging: $v_C = v_R = Ve^{-t/CR}$

$$i = Ie^{-t/CR}$$

L-R circuit $\tau = \frac{L}{R}$ Current growth: $v_L = Ve^{-Rt/L}$

$$v_R = V(1 - e^{-Rt/L})$$

$$i = I(1 - e^{-Rt/L})$$

Current decay: $v_L = v_R = Ve^{-Rt/L}$

$$i = Ie^{-Rt/L}$$

Operational amplifiers

$$\text{CMRR} = 20 \log_{10} \left(\frac{\text{differential voltage gain}}{\text{common-mode gain}} \right) \text{dB}$$

$$\text{Inverter: } A = \frac{V_o}{V_i} = \frac{-R_f}{R_i}$$

$$\text{Non-inverter: } A = \frac{V_o}{V_i} = 1 + \frac{R_f}{R_i}$$

$$\text{Summing: } V_o = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right)$$

$$\text{Integrator: } V_o = -\frac{1}{CR} \int V_i dt$$

Differential:

$$\text{If } V_1 > V_2 : V_o = (V_1 - V_2) \left(-\frac{R_f}{R_1} \right)$$

$$\text{If } V_2 > V_1 : V_o = (V_2 - V_1) \left(\frac{R_3}{R_2 + R_3} \right) \left(1 + \frac{R_f}{R_1} \right)$$