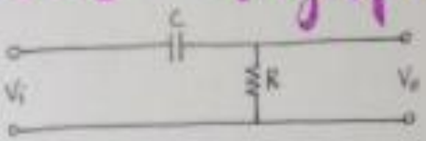
FILTERS

← A CIRCUIT WHOSE OUTPUT VOLTAGE AMPLITUDE VARIES AS A FUNCTION OF FREQUENCY COMPARED TO THE INPUT VOLTAGE AMPLITUDE.

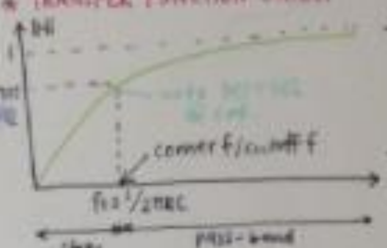
RC - highpass



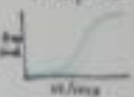
*** RC HIGH-PASS FILTER**

↳ The above circuit is just a V divider.
→ But one of the impedances vary w/ frequency. ∴ V_o must also vary w/ frequency.
→ $V_o = V_i \cdot R / R + 1/j\omega C$
$= \frac{V_i \, j\omega CR}{j\omega CR + 1}$
↳ How does the V_o amplitude of w/ V_i amplitude as f changes?
→ $H(j\omega) = V_o / V_i$ (frequency response)
$= \frac{j\omega CR}{j\omega CR + 1}$
→ At the f extremes:
$\omega = 0$: transfer fn = 0. At low f, circuit behaves like DC.
$\omega \Rightarrow \infty$: transfer fn → 1.
↳ Filter w/ 1 storage element : 1st order filter.

*** TRANSFER FUNCTION GRAPH**

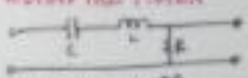


→ cut-off f: f @ which we have ½ of possible power.
→ ∴ for f < cof, filter passes < 50% power.
→ for f > cof, filter passes > 50% power.
∴ HIGH PASS FILTER.
→ cof: $\omega_{co} = 1/RC$
∴ $H(j\omega) = V_o/V_i = \omega/\omega_{co} \Big/ \sqrt{1 + (\omega/\omega_{co})^2}$
→ Plotting ω/ω_{co} in log-scale, we will observe the f response of circuit @ any f rel. to cof.



BAND PASS FILTER

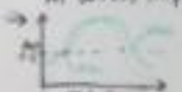
*** BAND PASS FILTER**



→ 2 fn-storing el. ∴ 2nd-order filter.

→ $V_o = V_i \frac{j\omega CR}{j\omega CR + 1 + (j\omega)^2 LC}$ ∴ $H(j\omega) = \frac{j\omega CR}{j\omega CR + 1 + (j\omega)^2 CL}$

↳ At $\omega = 0$, impedance of C is large. ∴ no I.
At $\omega = \infty$, impedance of L is large. ∴ no I.

→ 

↳ Basically a series RCL circuit, minus load.
→ $Z = \sqrt{R^2 + (\omega L - 1/\omega C)^2}$
→ $I = V/R$ @ $\omega_0 = 1/\sqrt{LC}$.
↳ BPF has 2 cof: $\omega_{co1} = 1/RC$ & $\omega_{co2} = R/L$
→ Bandwidth $B = \omega_2 - \omega_1$
→ ∴ ω_0 midway btw 2 cofs.

*** BPF & CUT OFF f**

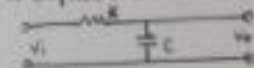
↳ 50% P_{max} @ cof; Also, $I^2 R = \frac{1}{2} I_0^2 R$
→ $I = I_0/\sqrt{2} = V/R\sqrt{2}$
→ $I = V/Z = V/\sqrt{R^2 + (1/\omega C - \omega L)^2}$
→ For $\omega < \omega_0$, $X_L < X_C$; $\omega > \omega_0$, $X_L > X_C$

@ cof.
→ $R\sqrt{2} = \sqrt{R^2 + (\omega L - 1/\omega C)^2}$ OR
$= \sqrt{R^2 + (1/\omega C - \omega L)^2}$
→ ∴ $2R^2 = R^2 \pm (\omega L - 1/\omega C)^2$
→ $\pm 1 = \omega L/R$ ...

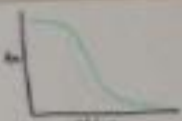
RC LOWPASS

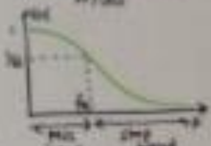
*** RC LOW-PASS FILTER**

↳ Capacitor & resistors ⇌.



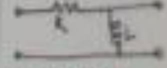
→ $V_o = \frac{V_i \cdot 1}{j\omega CR + 1}$
→ ∴ $H(j\omega) = 1/j\omega CR + 1$
→ $|H(j\omega)| = 1/\sqrt{1 + (\omega/\omega_{co})^2}$
↳ Note: larger f = smaller A & vice versa. ∴ low f passed thru.





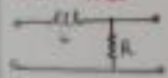
RL-FILTERS

*** HIGH PASS**



$H(j\omega) = j\omega L / j\omega L + R$
$\omega_{co} = R/L$

*** LOW PASS**



$H(j\omega) = R / j\omega L + R$
$\omega_{co} = R/L$

* cross over filters:

↳ filters often used in audio systems w/ 2 or more loudspeakers.
↳