Exam Review

Ch.1 V, I, Circuit Elements

Ch.2 Vs, Is, KVL, KCL, Dependent Sources

Ch.3 R Circuits

Ch.4 Analysis Techniques: Node Voltage, Loop Current, Source Transformation, Thevenin & Norton, Max Power transfer

Ch.5 Op Amp

Ch.6 L, C (not 6.4, 6.5)

Ch.7 1^{st} order RL & RC
Natural response
Step → DC driven/complete response

Ch.8 2^{nd} order RLC
Natural Response
→ DC driven/complete response

Ch.9 Sinusoidal Steady State (not 9.11)
COMPLETE RESPONSE for sinusoidally driven circuits
↳ (not in book, done in class)

Ch.14 Frequency Response - Transfer functions

Ch.15 Active (op amp) filters (not 15.2)

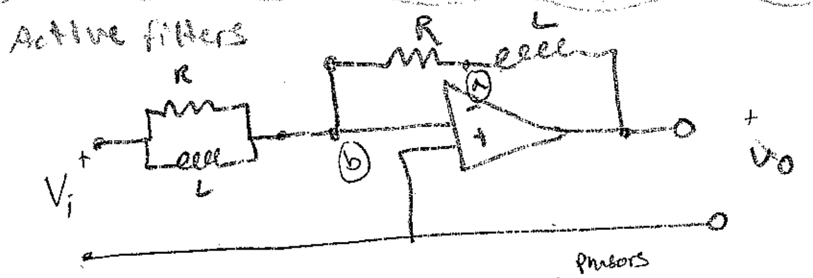
Appendix B Complex Numbers

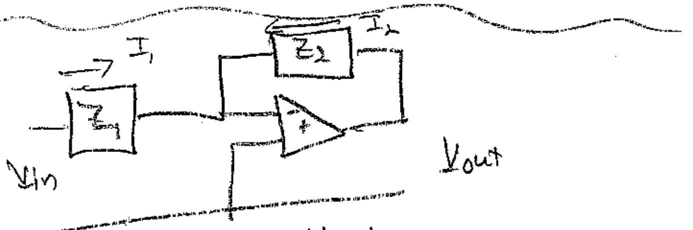
Appendix E Bode Plots

Not in book:

- Diodes
- Digital Logic
- Duals
- Pole-Zero diagrams
- Impulse
- Finding natural response using Z(s)

Active filters





$\frac{V_o}{V_i}$ ⇒ Frequency Response < Phasors, $Z(j\omega)$

$v_o(t)$ ⇒ Complete Response as f(time)

$$\frac{V_{in}}{Z_1} + \frac{V_{out}}{Z_2} = 0$$

$$\frac{V_{out}}{V_{in}} = \frac{-Z_2}{Z_1} = \frac{-(R+j\omega L)}{\frac{j\omega LR}{R+j\omega L}}$$

$$= \frac{-(R+j\omega L)^2}{j\omega LR} = -\frac{R^2-(\omega L)^2+j2\omega LR}{j\omega LR}$$

$$\left|\frac{V_o}{V_{in}}\right| = \frac{\sqrt{[R^2-(\omega L)^2]^2+(2\omega RL)^2}}{\omega RL}$$

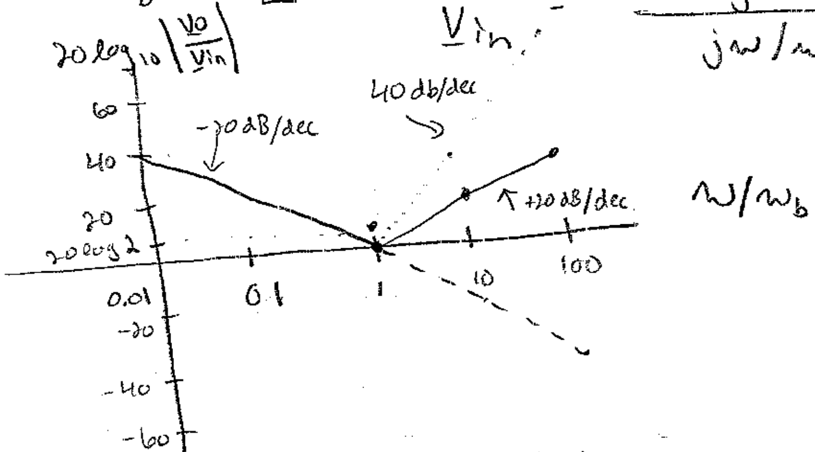
$$\angle\frac{V_o}{V_{in}} = \pi + \tan^{-1}\left[\frac{2\omega LR}{R^2-(\omega L)^2}\right] - \frac{\pi}{2}$$

$-1 = 1\angle\pi$

$$\left.\begin{array}{l} \omega L \ll R \\ \text{or} \\ \frac{\omega L}{R} \ll 1 \end{array}\right\} \Rightarrow \frac{\underline{V}_o}{\underline{V}_{in}} = \frac{1}{j\omega L/R} = \frac{R}{\omega L} \angle -\frac{\pi}{2}$$

$$\left.\begin{array}{l} \omega L \gg R \\ \frac{\omega L}{R} \gg 1 \end{array}\right\} \Rightarrow \frac{\underline{V}_o}{\underline{V}_{in}} = j\frac{\omega L}{R} = \frac{\omega L}{R} \angle \frac{\pi}{2}$$

Let $\omega_b = \frac{R}{L} \Rightarrow \frac{\underline{V}_o}{\underline{V}_{in}} = \frac{(1 + j\,\omega/\omega_b)^2}{j\omega/\omega_b}$

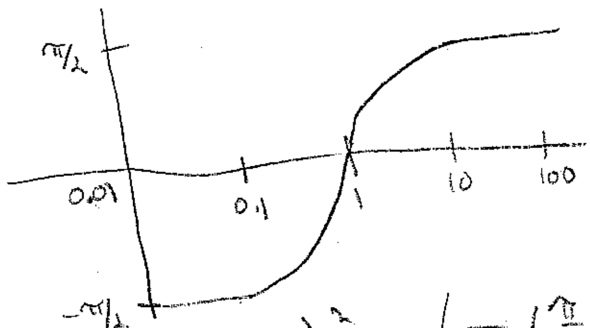


@ $\omega = \omega_b$, $40\log|\sqrt{2}| - 20\log 1$

$\downarrow \qquad \downarrow$

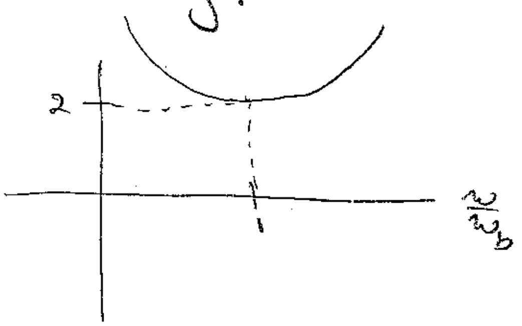
$20\log 2 \; - \; 0$

$$20\log\left|\frac{\underline{V}_o}{\underline{V}_{in}}\right| = \underbrace{40\log_{10}\left|1 + j\frac{\omega}{\omega_b}\right|}_{\text{kicks in when } \frac{\omega}{\omega_b} > 1} - \underbrace{20\log_{10}\left|\frac{\omega}{\omega_b}\right|}_{\text{active at all } \omega/\omega_b}$$



$$\left[\sqrt{2}\, e^{j\frac{\pi}{4}}\right]^2 = 2e^{j2\left(\frac{\pi}{4}\right)}$$

$$\frac{\omega}{\omega_b}: \quad \frac{(1+j1)^2}{j1} = \frac{\left(\sqrt{2}\angle\frac{\pi}{4}\right)^2}{1\angle\frac{\pi}{2}} = 2\angle 0$$



$V_o(t)$:

$$\sum_b i = 0 = \frac{V_{in}}{R} + \frac{1}{L}\int (V_{in} - 0)\,dt + \frac{V_a}{R}$$

$$\sum_a i = 0 = \frac{0 - V_a}{R} + \frac{1}{L}\int (V_{out} - V_a)\,dt$$

V_a - don't need

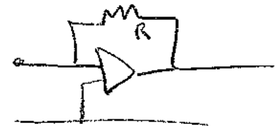
$$\left.\begin{aligned} \frac{1}{R}\frac{dV_{in}}{dt} + \frac{1}{L}V_{in} + \frac{1}{R}\frac{dV_a}{dt} &= 0 \\ -\frac{1}{R}\frac{dV_a}{dt} + \frac{1}{L}(V_{out} - V_a) &= 0 \end{aligned}\right\} + \frac{1}{R}\frac{dV_a}{dt} + \frac{1}{L}V_{in} + \frac{1}{L}(V_{out}) - \frac{1}{L}\left[-V_{in} - \frac{R}{L}\int V_{in}dt\right] = 0$$

$$\frac{1}{R}\frac{dV_{in}}{dt} + \frac{2}{L}V_{in} + \frac{R}{L^2}\int V_{in}dt = -\frac{1}{L}V_{out}$$

$$-\frac{R}{L}V_{out} = \frac{dV_{in}}{dt} + \frac{2R}{L}V_{in} + \left(\frac{R}{L}\right)^2\int V_{in}dt$$

V_{in} = ac or dc or any signal

If V_{in} is DC,



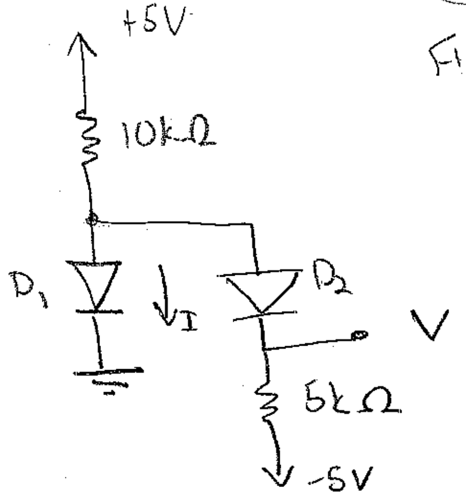
$$\frac{V_o}{V_{in}} = \frac{-R}{0}$$

$V_{in} = V_m \cos \omega t$

$$= -\omega V_m \sin \omega t + \frac{2R}{L}V_m \cos \omega t + \left(\frac{R}{L}\right)^2 \frac{V_m}{\omega}\sin \omega t \Big|_{-\infty}^{t}$$

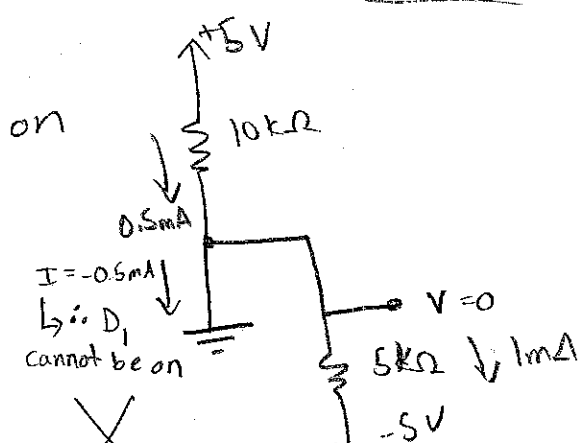
* need initial conditions

Diode

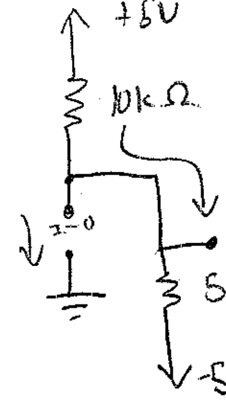


Find I, V

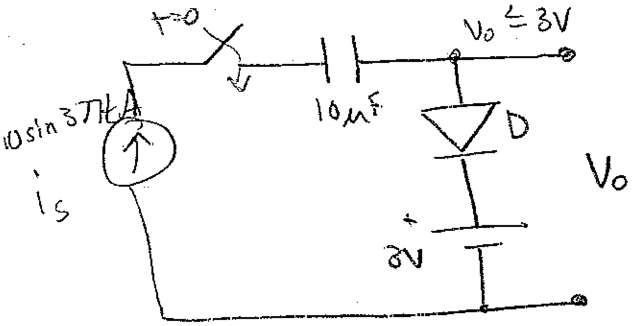
D_1 on, D_2 on

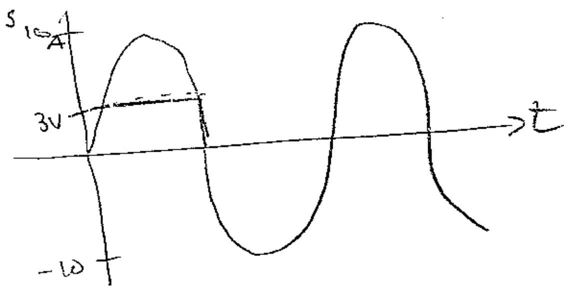


D_1 off



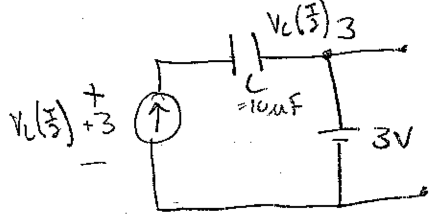
$$V = -5 + \tfrac{2}{3}(5) = -\tfrac{15}{3} + \tfrac{10}{3} = \boxed{\tfrac{-5}{3}}$$





@ $t=0,\ V_c=0$

$$V_c(t) = \frac{1}{C}\int i_s\,dt \quad (\text{for D on})$$



$$V_c(t) = \frac{1}{C}\int_0^{T/2} = -\frac{1}{C}\frac{10}{377}\cos 377t\Big|_0^{T/2}$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega} = \frac{2\pi}{2(377)} = \frac{T}{2}$$

$$V_c(t) = -\frac{10}{377C}\left[\cos 377\left(\frac{2\pi}{2\cdot 377}\right) - 1\right]$$

$$= \frac{20}{377C} = \frac{2(10^6)}{377}\text{ V}$$ whenever i_s is positive