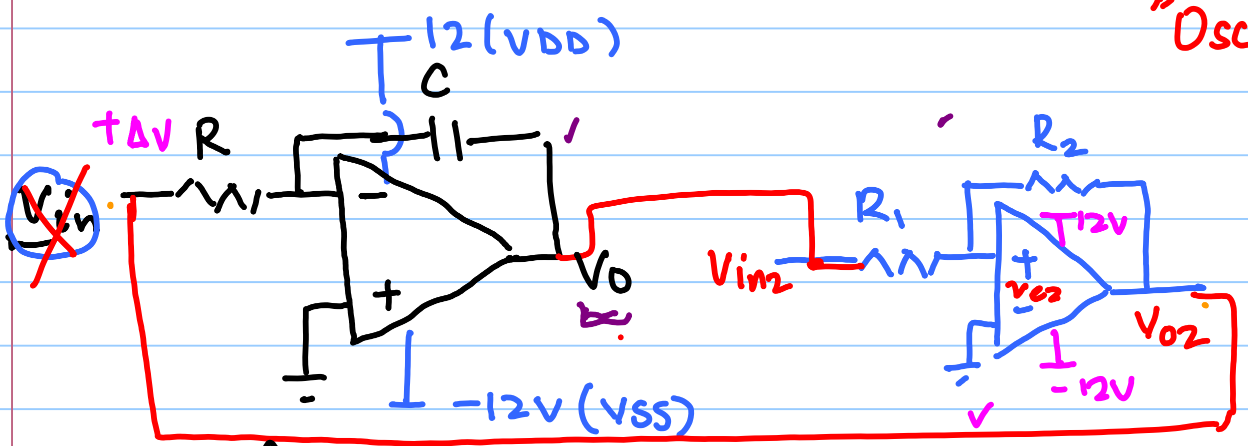
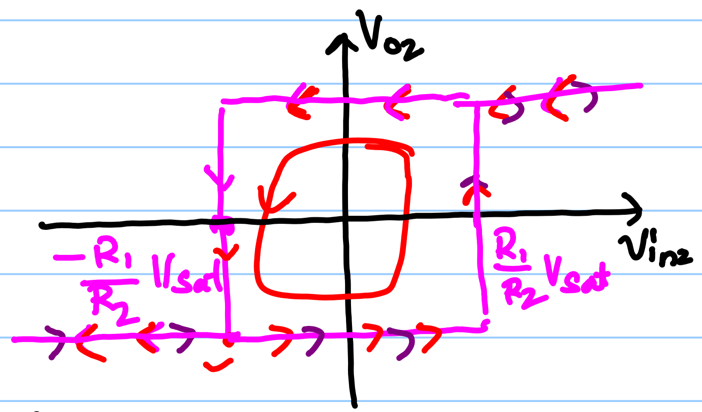
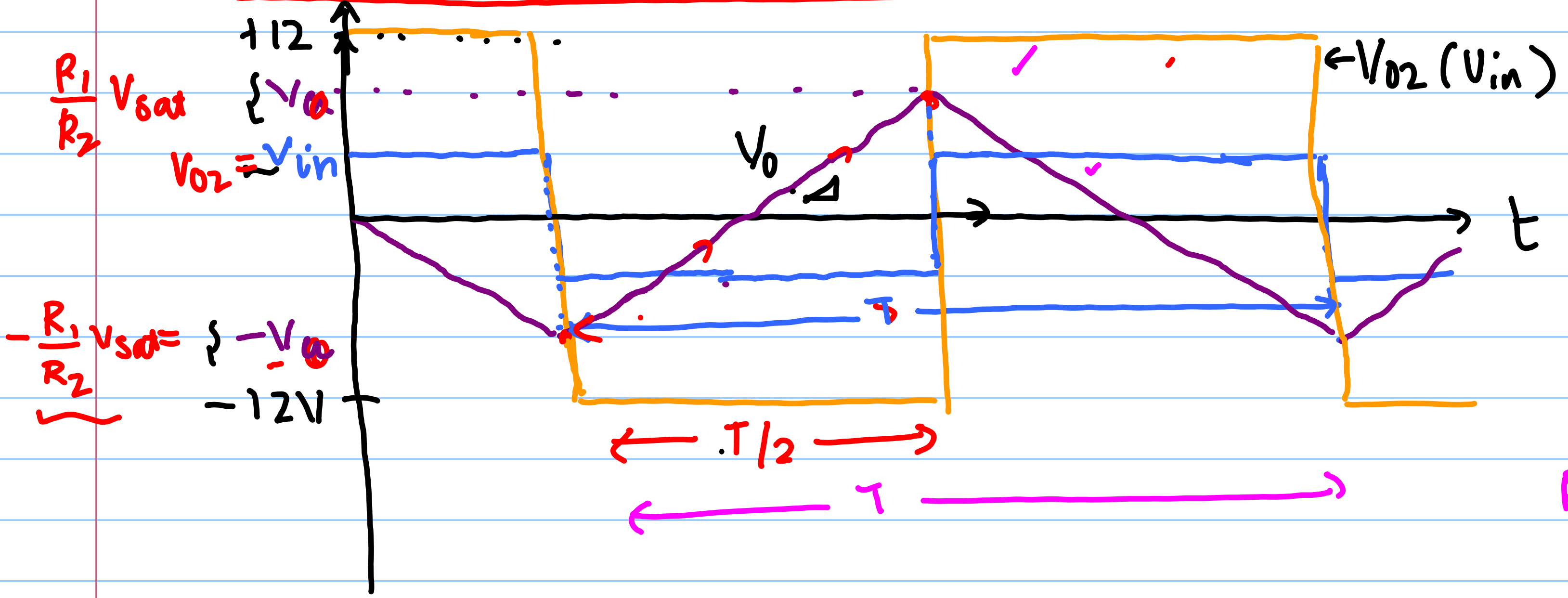
Lecture #14

"Oscillators"







$$V_{e2} = \frac{R_2}{R_2+R_1} V_{in2} + \frac{R_1}{R_1+R_2} V_{o2}$$

$$V_{e2} = 0$$

$$R_2 V_{in2} + R_1 V_{o2} = 0$$

$$\frac{V_{o2}}{V_{in2}} = -\frac{R_2}{R_1}$$

$$V_{in2} = -\frac{R_1}{R_2} V_{o2}$$

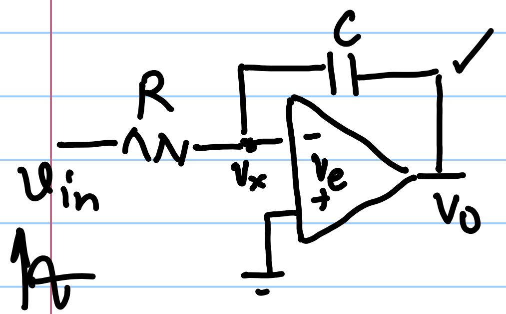
$$\frac{V_{in}}{R} = -C\frac{dV_o}{dt} \Rightarrow \frac{dV_o}{dt} = \frac{-1}{RC} V_{in}$$

$$\frac{\frac{2R_1}{R_2} V_{sat}}{V_{DD}/RC} = \frac{T}{2} \Rightarrow T = \frac{4R_1RC}{R_2} \frac{V_{sat}}{V_{DD}}$$

$$T = \frac{4R_1RC}{R_2} \quad \text{if } V_{sat} = V_{DD}$$

$$f = \frac{1}{T} = \frac{R_2}{4R_1RC}$$

$$\frac{R_1}{R_2} V_{sat} < V_{DD}$$



$V_o = A v_e$, at $t = 0$, $V_o(t) = 0$

$v_{in} = a \sin(\omega_0 t)$

$$\frac{v_{in} - (-V_e)}{R} = C \frac{d(-V_e - V_o)}{dt} \Rightarrow \frac{V_{in} + \frac{V_o}{A}}{R} = -C \frac{d\left(V_o + \frac{V_o}{A}\right)}{dt}$$

$$\frac{dV_o}{dt} + \frac{V_o}{(1+A)RC} = \frac{-V_{in}}{RC\left(1 + \frac{1}{A}\right)}$$

$$V_o(t) = e^{-t/RC(1+A)} \int \frac{-a\sin(\omega_o t)}{\frac{RC(1+A)}{A}} e^{t/RC(1+A)}\,dt + Ke^{-t/RC(1+A)}$$

"Integration by parts"

$$V_o(t) = \frac{-aA}{RC(1+A)} \left[\frac{RC(1+A)}{1+(\omega_o RC(1+A))^2} \sin(\omega_o t) - \frac{\omega_o (RC(1+A))^2}{1+(\omega_o RC(1+A))^2} \cos(\omega_o t) \right]$$

$$+ Ke^{-t/RC(1+A)}$$

$$V_o(t) = \frac{-aA\sin(\omega_o t)}{1+(\omega_o RC(1+A))^2} + \frac{aA\omega_o (RC(1+A))^2}{1+(\omega_o RC(1+A))^2} \frac{1}{(1+A)} \frac{1}{RC}$$

$$\times \left\{ \cos(\omega_o t) - e^{-t/RC(1+A)} \right\}$$

$A \to \infty$

$V_o(t) = 0$

$$H(s) = \frac{V_o}{V_{in}} = \frac{-1}{sRC} = -\frac{1}{j\omega RC}$$

$$V_{in} - \boxed{H(s)} - V_o$$

$$V_o = V_{in}\,H(s)$$

$$v_{in}(t) = a\sin(\omega_0 t)$$

$$\measuredangle H(j\omega_0) = \measuredangle\left(\frac{-1}{j\omega_0 RC}\right)$$

$$= \mp 180^\circ - 90^\circ = 90^\circ$$

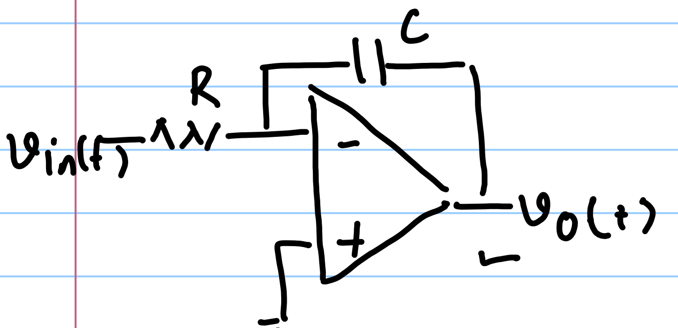
$$v_o(t) = a\,|H(j\omega_0)|\,\sin(\omega_0 t + \angle H(j\omega_0))$$

$$\measuredangle\left(\frac{-j}{j^2\omega_0 RC}\right) = \measuredangle\left(\frac{j}{\omega_0 RC}\right)$$

$$= \frac{a}{\omega_0 RC}\sin(\omega_0 t + 90^\circ)$$

$$= \frac{a}{\omega_0 RC}\left(\sin(\omega_0 t)\cdot\cos 90^\circ + \sin 90^\circ\cdot\cos(\omega_0 t)\right)$$

$$= \frac{a}{\omega_0 RC}\cos(\omega_0 t)$$



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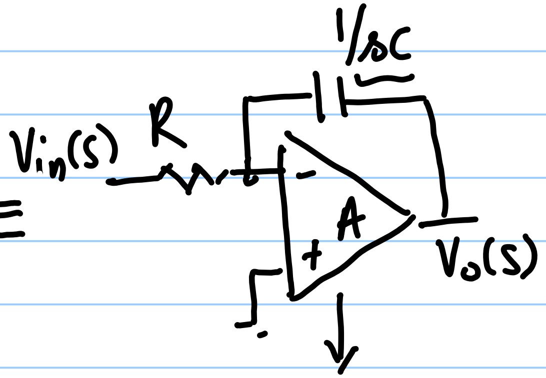
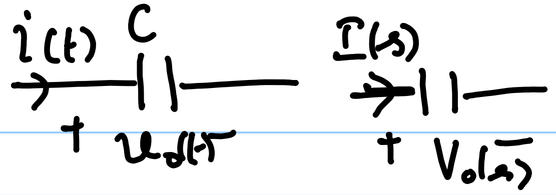


$$\frac{v_{in}(t)}{R} = -C\frac{dv_o}{dt}$$

$$\frac{V_{in}(s)}{R} = -\frac{V_o(s)}{1/sC}$$

$$\frac{V_o}{V_{in}} = \frac{-1}{sRC}$$



$$V_o(s) = \int v_o(t) \cdot e^{-st} \, dt$$

$$I(s) = \int i(t) \, e^{-st} \, dt$$

$$i(t) = C \frac{dv_o}{dt}$$

$$I(s) = C \left(s V_o(s) \right)$$

$$V_o(s) = \frac{1}{sC} \cdot I(s)$$

$$\frac{V_{in}(s) + V_e(s)}{R} = \frac{-V_e(s) - V_o(s)}{1/sC}$$

$$\frac{V_{in}(s) + \frac{V_o(s)}{A}}{R} = - \frac{V_o(s) \left(1 + \frac{1}{A}\right)}{1/sC}$$

$$V_{in}(s) = -V_o(s)\left\{sRC\left(1+\frac{1}{A}\right)+\frac{1}{A}\right\}$$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{-1}{sRC\left(1+\frac{1}{A}\right)+\frac{1}{A}} \xrightarrow{A\to\infty} \frac{-1}{sRC}$$