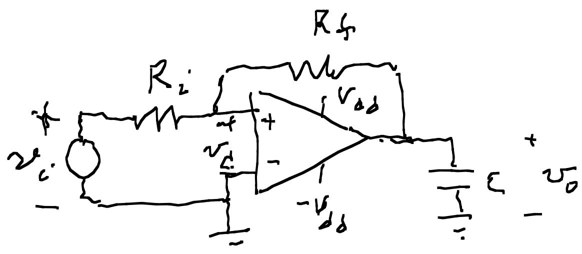
ENEE 610
11/10/20

Note Title 9/19/2020

presentations
homeworkn10
op-amp loaded

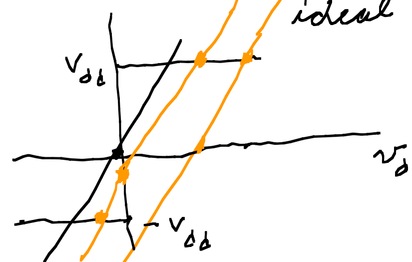
Synthesis from state equations



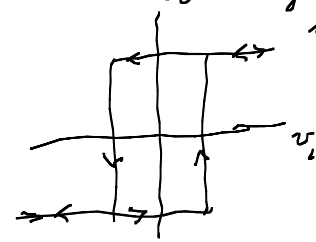
$\Rightarrow$

$v_i = 1$ is v_i gives this by R_s/R_i

ideal

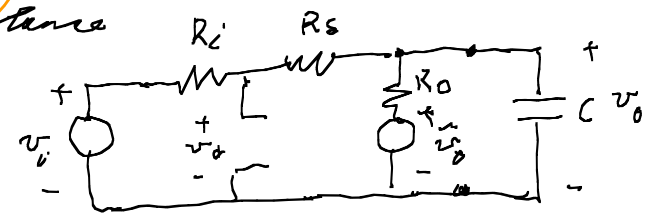


hysteresis
no load c



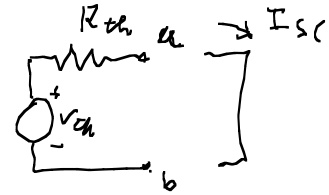
practical op-amp need R_o = output resistance

$\hat{v}_o = k v_d \quad k \sim 10^6$



for small time when $\hat{v}_o = k v_d$

$\Rightarrow$



$v_{th} = V_{oc}$ between nodes a - b

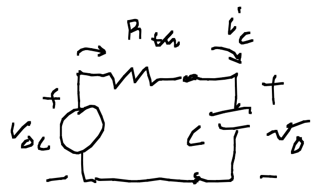
$$R_{th} = \frac{V_{oc}}{I_{sc}}$$

$$= \frac{R_o(R_i + R_f)\left[G_i(R_o + kR_f)\right]}{(R_o + kR_f)\left[(1-k) + G_i(R_o + R_f)\right]} \approx \frac{-G_i R_f}{k R_f}\left(R_o(R_i + R_f)\right) = -R_{eq}.$$

$$V_{oc} = \frac{\left[G_i(R_o + kR_f)\right]}{\left[(1-k) + G_i(R_o + R_f)\right]} v_i \sim -G_i R_f v_i$$

$k \to$ large

$$I_{sc} = \frac{R_o + kR_f}{R_o(R_i + R_f)} v_i \sim \frac{kR_f}{R_o(R_i + R_f)} v_i$$



Thevenin equivalent

$$C\dot{v}_o = i_c = \frac{V_{oc} - v_o}{R_{th}} \Rightarrow C\dot{v}_o + \frac{1}{R_{th}} v_o = \frac{1}{R_{th}} V_{oc}$$

$$\Rightarrow \dot{v}_o + \frac{1}{R_{th}C} \cdot v_o = \frac{1}{C R_{th}} \cdot v_{oc}$$ after $t=0$ & before op amp saturates

$$\dot{v}_o - \frac{1}{R_{eq}C} v_o \approx \frac{-1}{C R_{eq}} v_{oc} \times 1(t)$$ $-\infty < t <$ time to saturate

Let find impulse response: $v_o(t)_\delta = e^{+\frac{1}{R_{eq}C}t} 1(t)$ satisfies $\dot{v}_o - \frac{1}{R_{eq}C} v_o = \delta(t)$

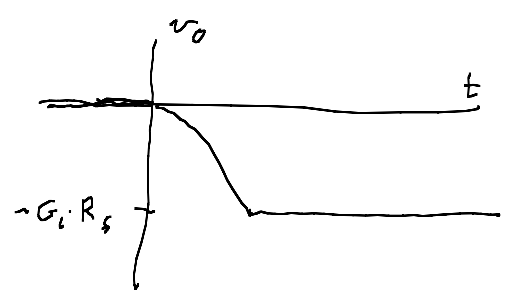
to find $v_o^-(t)$ $\quad$:- v_{oc} applied $\Rightarrow$ $v_o(t) = v_o(t)\Big|_\delta * \frac{-1}{CR_{eq}} v_{oc} \cdot 1(t)$

$$v_o(t) = \int_{-\infty}^{\infty} v_o(\tau)_\delta \left(\frac{-1}{R_{eq}C} V_{oc}\, 1(t-\tau) \right) d\tau = \int_{-\infty}^{\infty} e^{+\frac{1}{R_{eq}C}\tau}\, 1(\tau) \cdot \left(\frac{-V_{oc}}{R_{eq}C} \right) 1(t-\tau)\, d\tau$$

$$= \left(\int_0^t e^{\frac{1}{R_{eq}C}\tau} \left(\frac{-V_{oc}}{R_{eq}C} \right) d\tau \right) 1(t) = \left(\frac{-V_{oc}}{R_{eq}C} \right) \cdot \frac{1}{R_{eq}C} \cdot e^{+\frac{1}{R_{eq}C}\tau} \Bigg|_0^t 1(t) = \left(\frac{-V_{oc}}{(R_{eq}C)^2} \right) \left[e^{+\frac{1}{RC}t} - 1 \right] 1(t)$$

& here $\hat{v}_o = V_{dd}$ or $-V_{dd}$

v_o

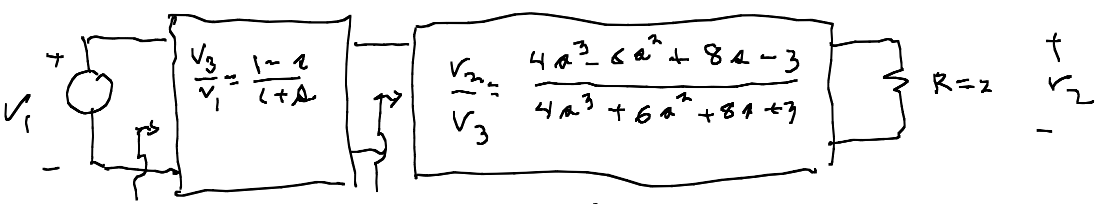


$$\frac{1-x^2}{(1+x)^2} = \frac{(1-x)(1+x)}{(1+x)(1+x)} = \frac{1-x}{1+x}$$

Draw the circuit which is the cascade of two constant R lattices, with R=2, to give

V2/V1=[(1-3s)(4s^3-6s^2+8s-3)]/[(1+3s)(4s^3+6s^2+8s+3)]

Does it matter which section comes first? Why?



$$\frac{V_2}{V_3} = \frac{1-\frac{6s^2+3}{4s^3+8s}}{1+\frac{6s^2+3}{4s^3+8s}} = \frac{1-z_a/R}{1+z_a/R} \Rightarrow z_a/2 = \frac{6s^2+3}{4s^3+8s} = \frac{6(s^2+1/2)}{4s(s^2+2)} \Rightarrow$$

$z_a/2 = 3s$, $L=2$

$y_a = \frac{1}{z_a}$: $6s^2+3 \,\big)\, 4s^3+8s$ $\;\frac{2}{3}s \leftarrow y$; $4s^3+2s$; $6s \,\big)\, 6s^2+3$ $\;s \leftarrow z$; $6s^2$; $3 \,\big)\, 6s$ $\;2s \leftarrow y$; 0