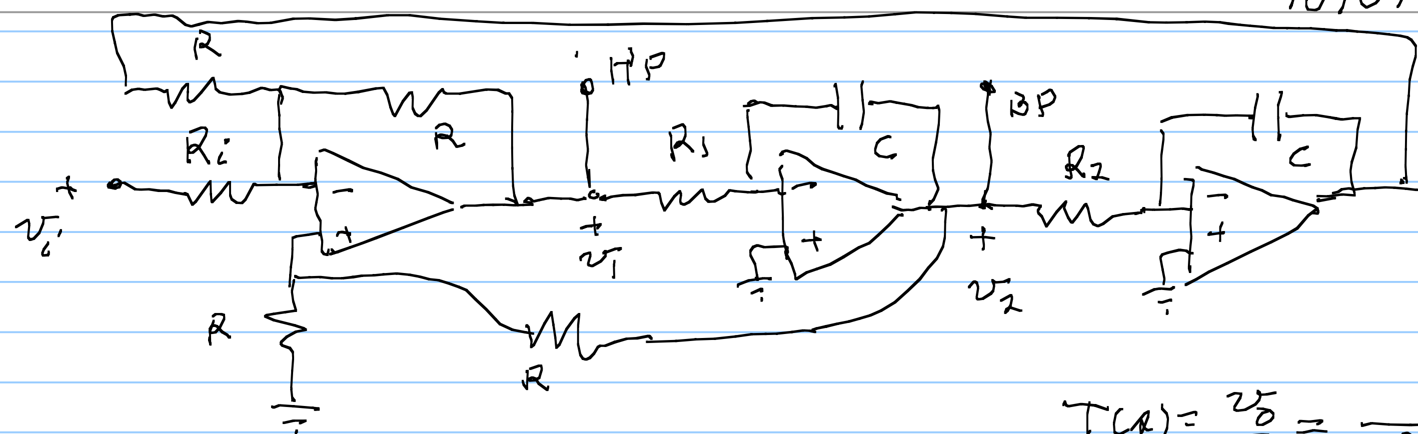
Note Title 10/6/2014

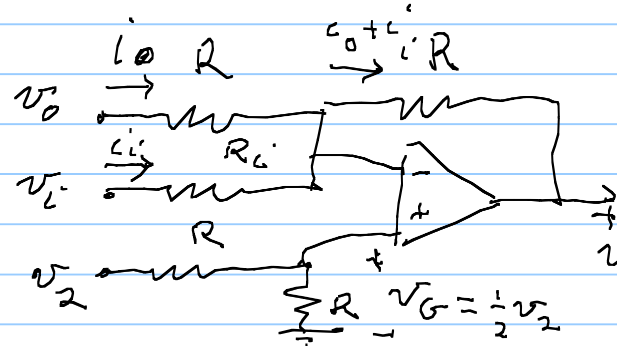
EE 610

10/07/14



LP = low pass

$$T_{LP}(s) = \frac{v_0}{v_i} = \frac{K_0 \times \omega_0}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}$$



$v_1 = -R(i_0 + i_i) + v_G$, $G = 1/R$

$i_0 = G(v_0 - v_G)$, $i_i = G_i(v_i - v_G)$

$v_1 = -v_0 + v_G - RG_i v_i + RG_i v_G + v_G$

$$v_1 = -RG_i \cdot v_i + \left(1 + \tfrac{1}{2} RG_i\right) v_2 - v_0$$

$$v_2 = -\frac{1}{sCR_1} v_1 \;,\; v_0 = -\frac{1}{sC\,R_2} v_2 = \left(\frac{-1}{sCR_1}\right)\left(\frac{-1}{sCR_2}\right) v_1$$

$$v_2 = -\frac{1}{sCR_1}\left[\; s^2 R_1 R_2 C^2 \right] v_0 = -sR_2C\, v_0$$

$$\rightarrow s^2 R_1 R_2 C^2 \cdot v_0 = -RG_i \cdot v_i + (2 + RG_i)\frac{1}{2}(-sCR_2) v_0 - v_0$$

$$\left[s^2 R_1 R_2 C^2 + \tfrac{1}{2}(2 + RG_i) CR_2 \cdot s + 1\right] v_0 = -RG_i \cdot v_i$$

$$\frac{v_0}{v_i}(s) = \frac{-RG_i/(R_1R_2C^2)}{s^2 + \frac{\frac{1}{2}(2+RG_i)CR_2\, s}{R_1R_2C^2} + \frac{1}{R_1C \cdot R_2C}} = \frac{-RG_i/(R_1R_2C^2)}{s^2 + \frac{1}{2}\frac{(2+RG_i)}{R_1C} s + \frac{1}{R_1C \cdot R_2C}}$$

$$\omega_0^2 = \frac{1}{R_1 C \cdot R_2 C} \Rightarrow \omega_0 = \frac{1}{C}\frac{1}{\sqrt{R_1 R_2}}$$

$$\frac{\omega_0}{Q} \Rightarrow \quad Q = \frac{\omega_0 \cdot 2 R_1 C}{(2 + R G_i)}$$

all-pass ; $$T(s) = \frac{N(s)}{D(s)} = \frac{D(-s)}{D(s)} = \frac{s^2 - \frac{\omega_0}{Q}s + \omega_0^2}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}$$

$$|T(j\omega)|^2 = T(j\omega)\,T(-j\omega)$$

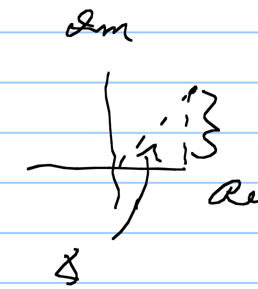
$$= \frac{D(-j\omega)}{D(j\omega)} \times \frac{D(j\omega)}{D(-j\omega)} = 1 \; ; \quad T(j\omega) = |T(j\omega)|\, e^{j\measuredangle T(j\omega)}$$

$$= 1 \times \frac{e^{j\angle N(j\omega)}}{e^{j\angle D(j\omega)}}$$

$$\measuredangle N(j\omega) = \arctan\left(-\omega \cdot \frac{\omega_0}{Q} \Big/ (\omega_0^2 - \omega^2)\right) \qquad = e^{2j\measuredangle N(j\omega)}$$

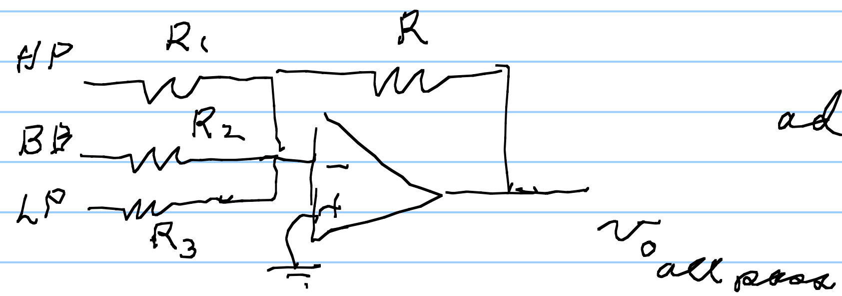
$$\measuredangle D(j\omega) = \arctan\left(\omega\omega_0/Q \big/ (\omega_0^2 - \omega^2)\right) = -\measuredangle N(j\omega)$$

$$\measuredangle T(j\omega) = 2\measuredangle N(j\omega) = -2\arctan\left[\frac{\omega\omega_0}{Q} \Big/ (\omega_0^2 - \omega^2)\right]$$



UAF = universal active filter
(state variable filter)

To get all pass from UAF42 of TI

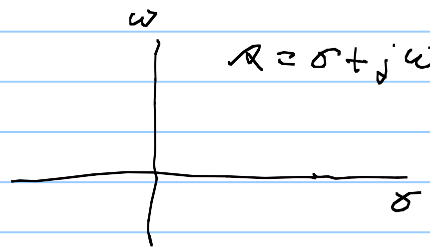


adjust R's to give desired numerator

PR functions = positive real & rational

$Y(s) = \frac{N(s)}{D(s)}$

$s = \sigma + j\omega$



Positive real definition

1. real for s real in $\mathrm{Re}\, s > 0$ = RHP open
   (real coefficients if PR) $\Rightarrow$ real devices

2. analytic in $\mathrm{Re}\, s > 0$ (stable circuit)
   (no poles or zeroes in $\sigma > 0$ if PR)

3.