EE 322 Advanced Analog Electronics, Spring 2010
Homework #8 solution

HH 9.5. Show that these choices of filter components actually give a loop gain of magnitude 1.0 at $f_2 = 2.0\,\mathrm{Hz}$.

The magnitude of the loop gain expression on page 649 is

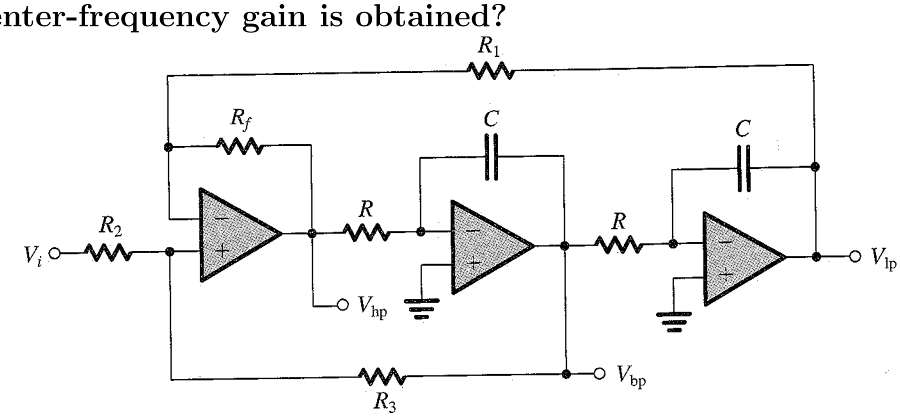
$$|G_{\mathrm{loop}}| = K_P \sqrt{\frac{1+\omega^2 R_4^2 C_2^2}{1+\omega^2\left(R_3 C_2 + R_4 C_2\right)^2}}\frac{K_{\mathrm{VCO}}}{\omega}K_{\mathrm{div}}$$

Using $K_P = 1.59$, $\omega = 2\pi f_2 = 4\pi$, $R_4 = 330\,\mathrm{k\Omega}$, $C_2 = 1\,\mu\mathrm{F}$, $R_3 = 4.3\,\mathrm{M\Omega}$, $K_{\mathrm{VCO}} = 1.13\times 10^5$, and $K_{\mathrm{div}} = \frac{1}{1024}$ we get

$$\begin{aligned}|G_{\mathrm{loop}}| =& 1.59 \times \sqrt{\frac{1+\left(4\pi\times 330\times 10^3\times 1\times 10^{-6}\right)^2}{1+\left[4\pi\times\left(4.3\times 10^6\times 1\times 10^{-6}+330\times 10^3\times 1\times 10^{-6}\right)\right]^2}} \times \frac{1.13\times 10^5}{4\pi}\times\frac{1}{1024}\\ =& 1.02\end{aligned}$$

Close enough given that we are specifying most quantities to two significant digits.

SS 12.49. Design the KHN circuit of Fig. 12.24(a) to realize a bandpass filter with a center frequency of $1\,\mathrm{kHz}$ and a $3-\mathrm{dB}$ bandwidth of $50\,\mathrm{Hz}$. Use $10\,\mathrm{nF}$ capacitors. Give the complete circuit and specify all component values. What value of center-frequency gain is obtained?



The center frequency is $\omega = \frac{1}{RC}$. Given that $C = 10\,\mathrm{nF}$, we get $R = \frac{1}{\omega C} = \frac{1}{2\pi\times 10^3\times 10\times 10^{-9}} = 15.9\,\mathrm{k\Omega}$. We also know that $R_f = R_1$, so let's choose $R_f = R_1 = 100\,\mathrm{k\Omega}$. Lastly we need to choose R_2 and R_3 which sets the bandwidth. First we find Q, which is the inverse of the fractional bandwidth,

$$Q = \frac{\omega_0}{\Delta\omega} = \frac{10^3}{50} = 20$$

Next, choose $R_2 = 10\,\mathrm{k\Omega}$, and we have
and we have

$$R_3 = R_2\left(2Q-1\right) = 39\,R_2 = 390\,\mathrm{k\Omega}$$

The K gain parameter is then

$$K = 2 - \frac{1}{Q} = 2 - \frac{1}{20} = 1.95$$

Finally, the gain function is

$$T_{\mathrm{bp}}(s) = -\frac{K\omega_0 s}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}$$

For $s = j\omega_0$ we get

$$T_{\mathrm{bp}}(j\omega_0) = -\frac{jK\omega_0^2}{-\omega_0^2 + j\frac{\omega_0^2}{Q} + \omega_0^2} = -KQ = -1.95 \times 20 = -39$$