BPF example, cont'd

< Note that there are many ways to implement a BPF; this is just one way >

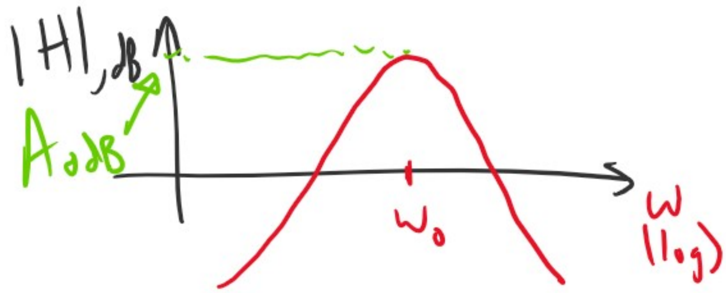
Let's suppose our component values are:

$$R_1 = 49\,k\Omega,\ R_2 = 1\,k\Omega,\ R_5 = 98\,k\Omega,$$
$$C_3 = C_4 = 427.3763\,pF$$

$$H(s) = \underbrace{\frac{-\alpha \omega_0 s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}} = \underbrace{\frac{-\left(\frac{1}{R_1 C_4}\right) s}{s^2 + \left(\frac{C_3 + C_4}{R_5 C_3 C_4}\right) s + \frac{(G_1 + G_2)}{R_5 C_3 C_4}}}$$

$$\omega_0 = \sqrt{\frac{G_1 + G_2}{R_5 C_3 C_4}}, \quad Q = \frac{\sqrt{(G_1 + G_2) R_5 C_3 C_4}}{(C_3 + C_4)}$$

$$A_{o\,dB} = 20\log_{10}(A_o)$$



$A_o = \Rightarrow$

$$|H(j\omega_0)| = \frac{\sqrt{\left[\left(\frac{\alpha}{\cancel{\omega_0}}\right)\cancel{\omega_0}\right]^2}}{\sqrt{\left(1 - \cancel{\left(\frac{\omega_0}{\omega_0}\right)^2}\right)^2 + \frac{1}{Q^2}\left(\cancel{\frac{\omega_0}{\omega_0}}\right)^2}} = \frac{\alpha}{1/Q} = \alpha Q$$

$$\boxed{A_o = \alpha Q} \leftarrow \text{filter gain (V/V) @ } \omega = \omega_0 = 2\pi f_c$$

(V/V) "center freq"

$Q = \frac{1}{\ldots}$

[V/V]

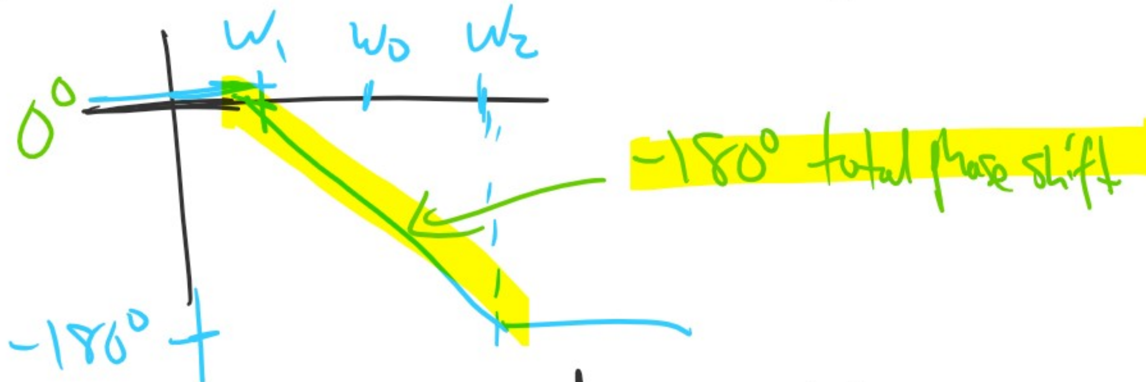
$Q = \frac{1}{2\zeta}$ "center freq."

$W_0 = 2\pi(38\,kHz)$ rps.

$\left[Q = 5 \rightarrow \zeta = \frac{1}{2Q} = 0.1 \right]$

(zeta)

$\frac{A_0}{\zeta} = 1\,V/V \Rightarrow \alpha = A_0/Q = 1/5 = 0.2$



# of decades between w_1 & w_2 $= \log_{10}\left(\frac{w_2}{w_1}\right)$

$-180^\circ / \log_{10}(w_2/w_1) \leftarrow$ deg./decade.

$w_2 = w_0 10^{\zeta}$, $w_1 = w_0 10^{-\zeta}$

$w_2/w_1 = \frac{\cancel{w_0} 10^{\zeta}}{\cancel{w_0} 10^{-\zeta}} = 10^{2\zeta}$?

$\log_{10}(10^{2\zeta}) = 2\zeta \cancel{\log_{10}(10)}^{1} = 2\zeta$

$H(A) = \frac{-\alpha w_0 A}{A^2 + 2\zeta w_0 A + w_0^2} = \frac{-\alpha w_0 A}{A^2 + \frac{w_0}{Q} A + w_0^2}$ zero @ DC

$$\frac{\quad}{s^2+2\zeta\omega_0 s+\omega_0^2} \qquad \frac{\quad}{s^2+\frac{\omega_0}{Q}s+\omega_0^2}$$

Zero @ DC

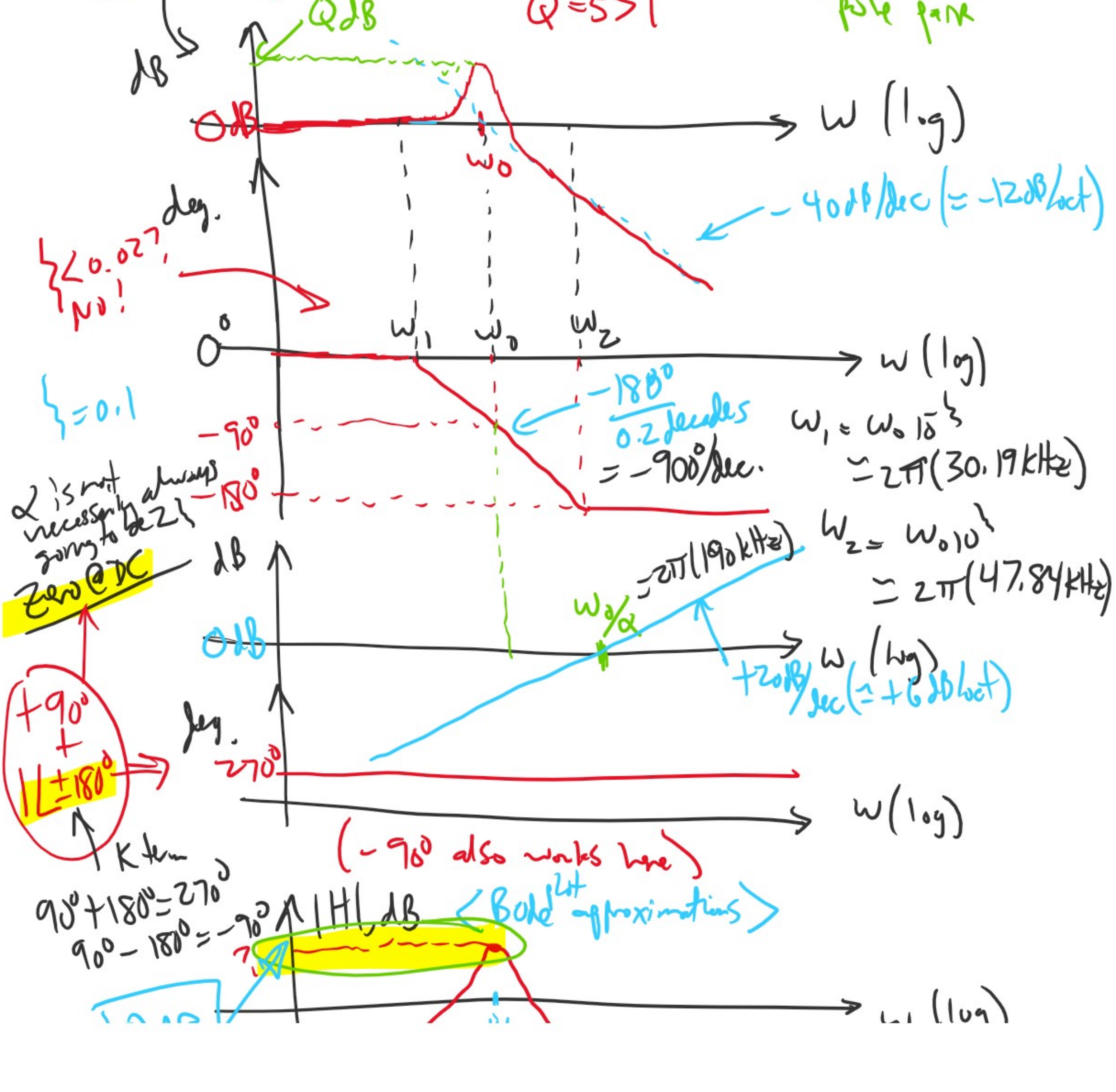
$K=1\angle\pm180^\circ$

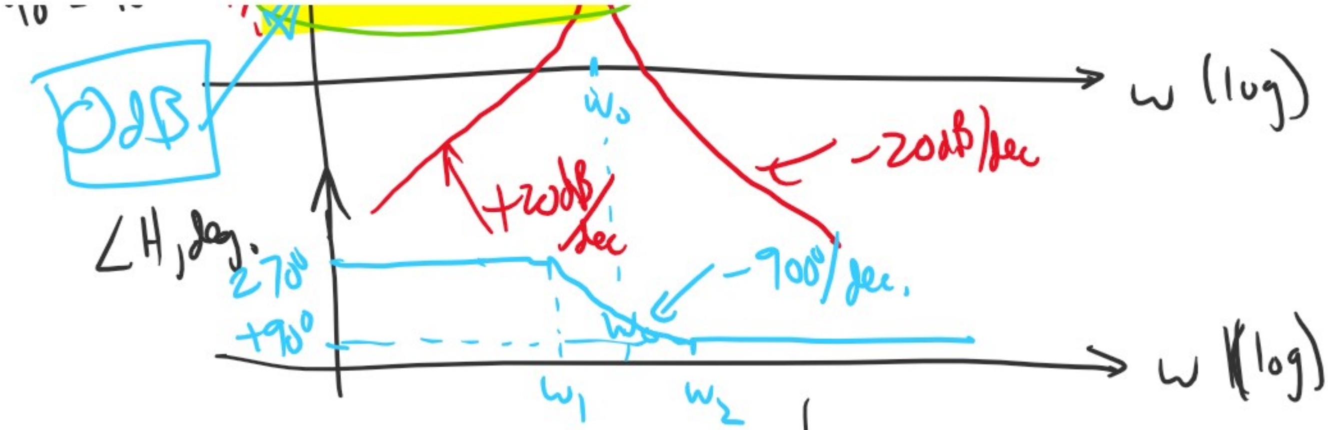
$$= \frac{\left(-\alpha \cancel{\omega_0}/\omega_0^{\cancel{2}}\right)s}{\boxed{\left(s/\omega_0\right)^2+2\zeta\left(s/\omega_0\right)+1}} \qquad \boxed{-}\,\boxed{s/\left(\omega_0/\alpha\right)}$$

$Q_{dB} = 20\log_{10}(\underset{\simeq 5}{Q}) \simeq 13.98\,dB$

Complex-conjugate pole pair

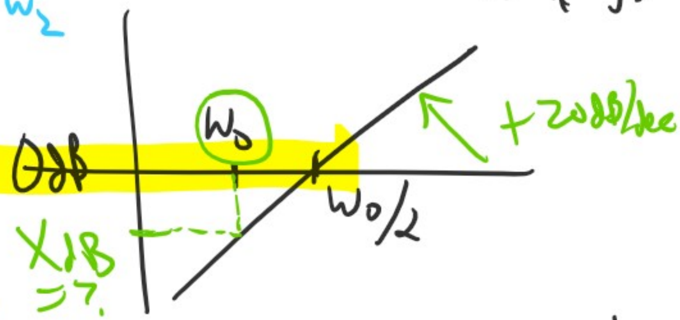
$Q=5>1$





$$X\,\text{dB} = 0\,\text{dB} - \left(+20\,\frac{\text{dB}}{\text{dec}}\right)\underbrace{\log_{10}\left(\frac{\cancel{\omega_0}/2}{\cancel{\omega_0}}\right)}_{\log_{10}(1/2)}$$

$= -13.98\,\text{dB}$



⇒ Monday: go over Bode demo in LTSpice!
(for the example above)

⇒ Also cover the design eqns for this filter, if time permits!