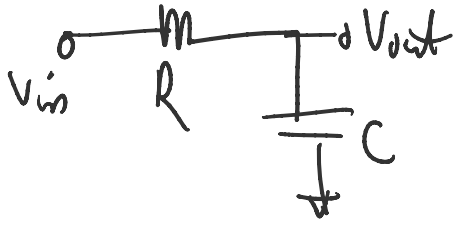
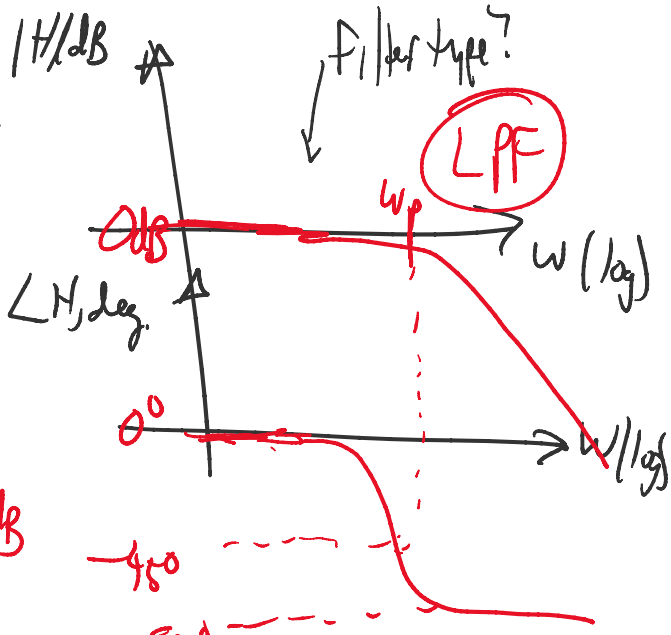
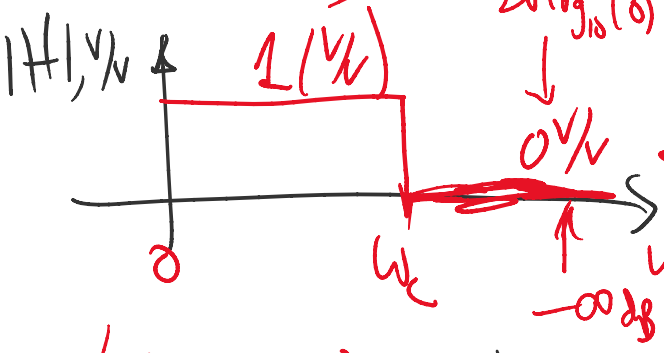
RC filter:





$H(s) = \frac{1}{1+s/\omega_p}$, $\omega_p = 1/RC$

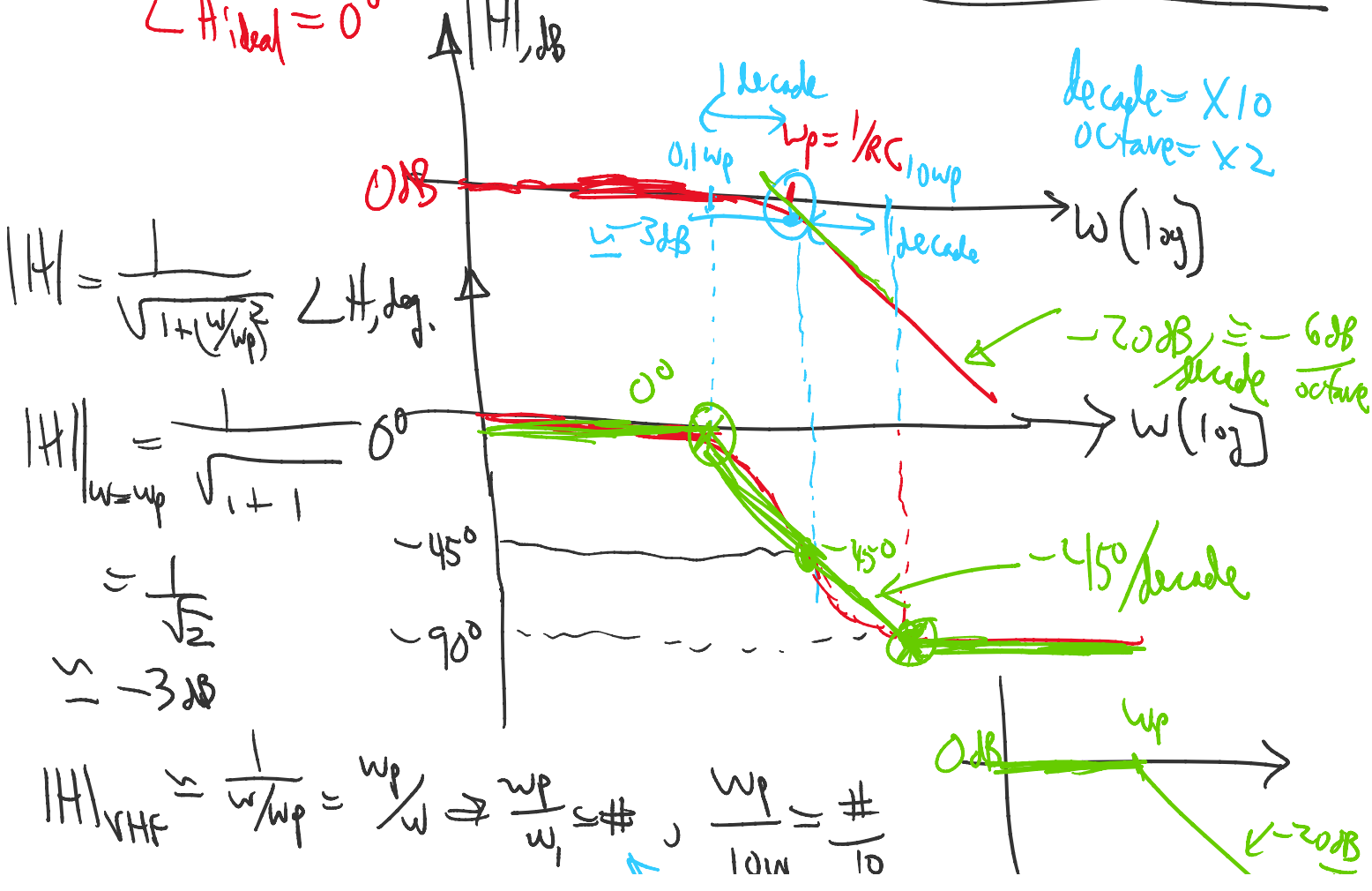


$= 0\,dB$

$20\log_{10}(0) = -\infty\,dB$

$\angle H_{ideal} = 0°$

Bode plot approximations



$$|H| = \frac{1}{\sqrt{1+(\omega/\omega_p)^2}}$$

$$|H|_{\omega=\omega_p} = \frac{1}{\sqrt{1+1}} = \frac{1}{\sqrt{2}} \cong -3\,dB$$

$$|H|_{VHF} \cong \frac{1}{\omega/\omega_p} = \omega_p/\omega \Rightarrow \frac{\omega_p}{\omega_1} = \#, \quad \frac{\omega_p}{10\omega_p} = \frac{\#}{10}$$

$|H|_{VHF} = w/w_p = 1/10 \Rightarrow \frac{w_1}{w_1} = \#$, $\frac{10w_1}{10} = \#$

$\Delta dB = -20dB$

$-20dB/dec$

$$H(s) = \frac{1}{1+sRC}$$

$$= \frac{1}{1+s/w_p}, \quad w_p = 1/RC$$

$1+s/w_p$ ↑ pole term

$\frac{K}{1+s/w_p}$ ← gain term

① $H(s) = \frac{K}{1+s/w_p}$ approx & exact

$K = 100 V/V$

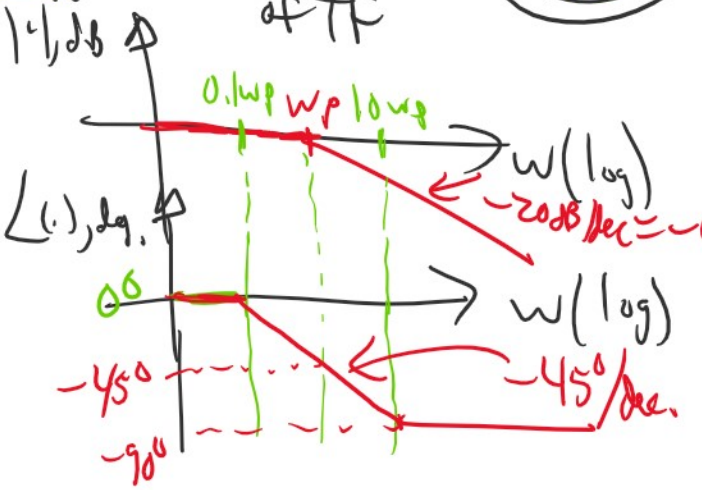
$K_{dB} = 20\log_{10}(K) = 40dB$

Shift the $|H|$ dB response up (or down) by K_{dB}

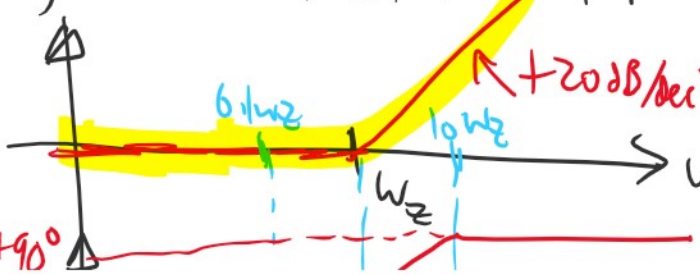
What if $K = -100 V/V = 100 \angle \pm 180°$

② $(1+s/w_p)$ in denom. of TF $\Rightarrow$ pole <See above>

Approx

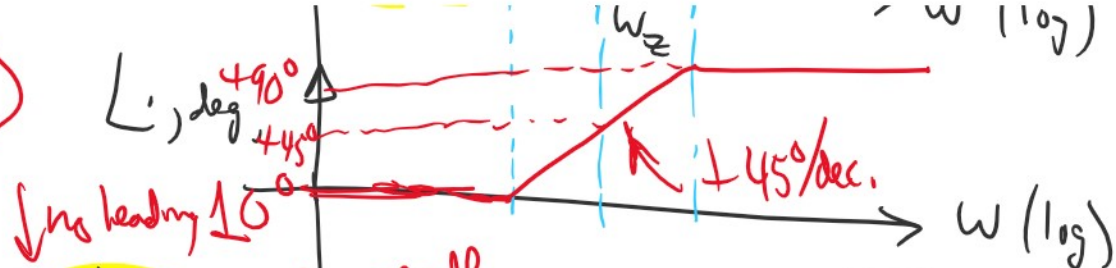


③ $(1+s/w_z)$ in numerator of TF $\Rightarrow$ zero



Approx

approx



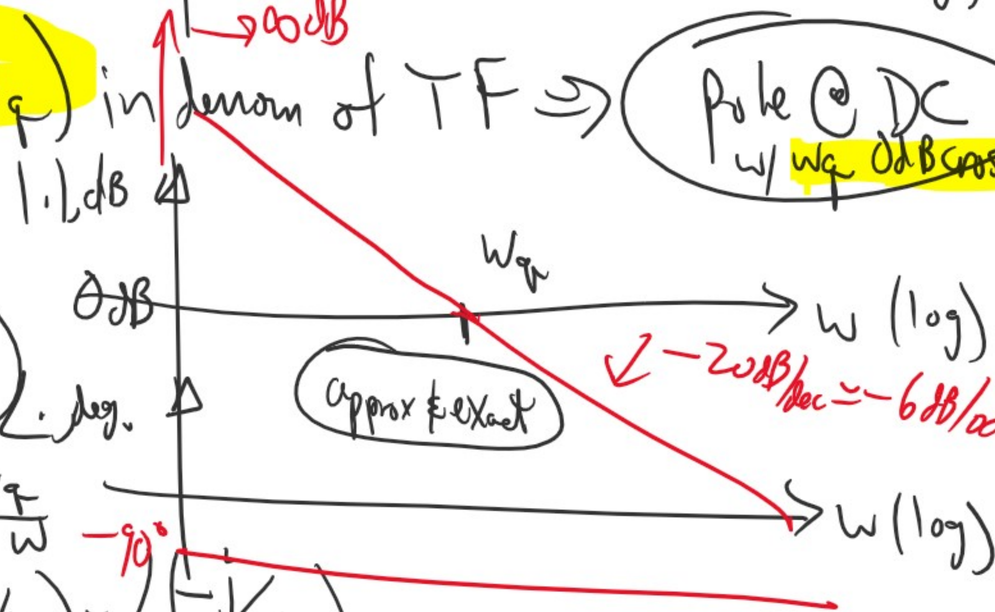
④ (s/ω_q) in denom of TF ⇒ Pole @ DC w/ ω_q 0dB crossing

$s = j\omega$

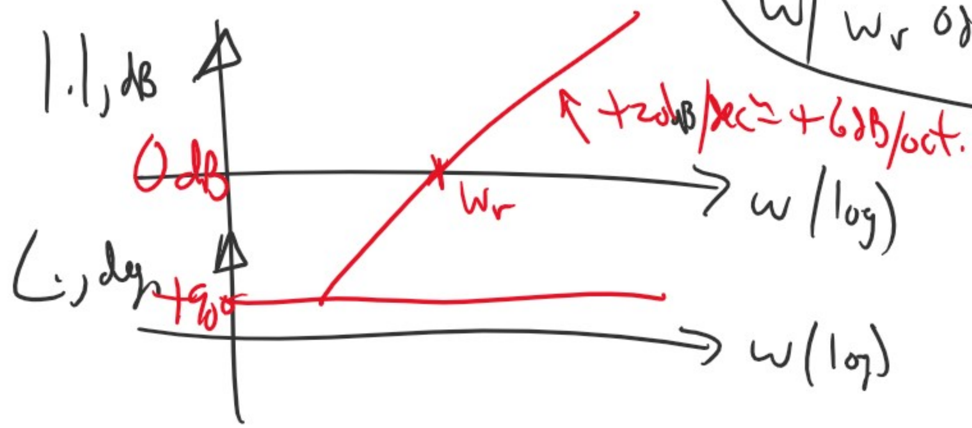
$H(j\omega) = \frac{1}{j\omega/\omega_q}$

$|H| = \frac{1}{\omega/\omega_q} = \frac{\omega_q}{\omega}$

$\angle H = \angle\left(\frac{1}{j\omega/\omega_q}\right) = \angle\left(\frac{-j}{\omega/\omega_q}\right)$



⑤ (s/ω_r) in numerator of TF ⇒ Zero @ DC w/ ω_r 0dB crossing.



$\frac{1}{s^2 + as + b}$ $s_{1,2} = \omega_{p_1}, \omega_{p_2}$

$\frac{1}{(s+\omega_{p_1})(s+\omega_{p_2})} = \frac{1}{\omega_{p_1}(1+s/\omega_{p_1})\,\omega_{p_2}(1+s/\omega_{p_2})}$

$$(A+\omega_{p_1})(A+\omega_{p_2}) = \omega_{p_1}(1+A/\omega_{p_1})\,\omega_{p_2}(1+A/\omega_{p_2})$$

$$= \frac{(1/\omega_{p_1}\omega_{p_2})\,K}{(1+A/\omega_{p_1})(1+A/\omega_{p_2})}$$

← 2 poles.