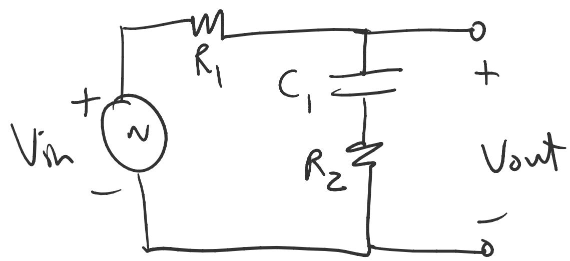
Tuesday, November 10, 2020 6:42 PM

More on Bode example #1 ... how to check our result?

→ could simulate ckt; what else?, ⇒ perform a few phasor analyses at some key frequencies of operation.

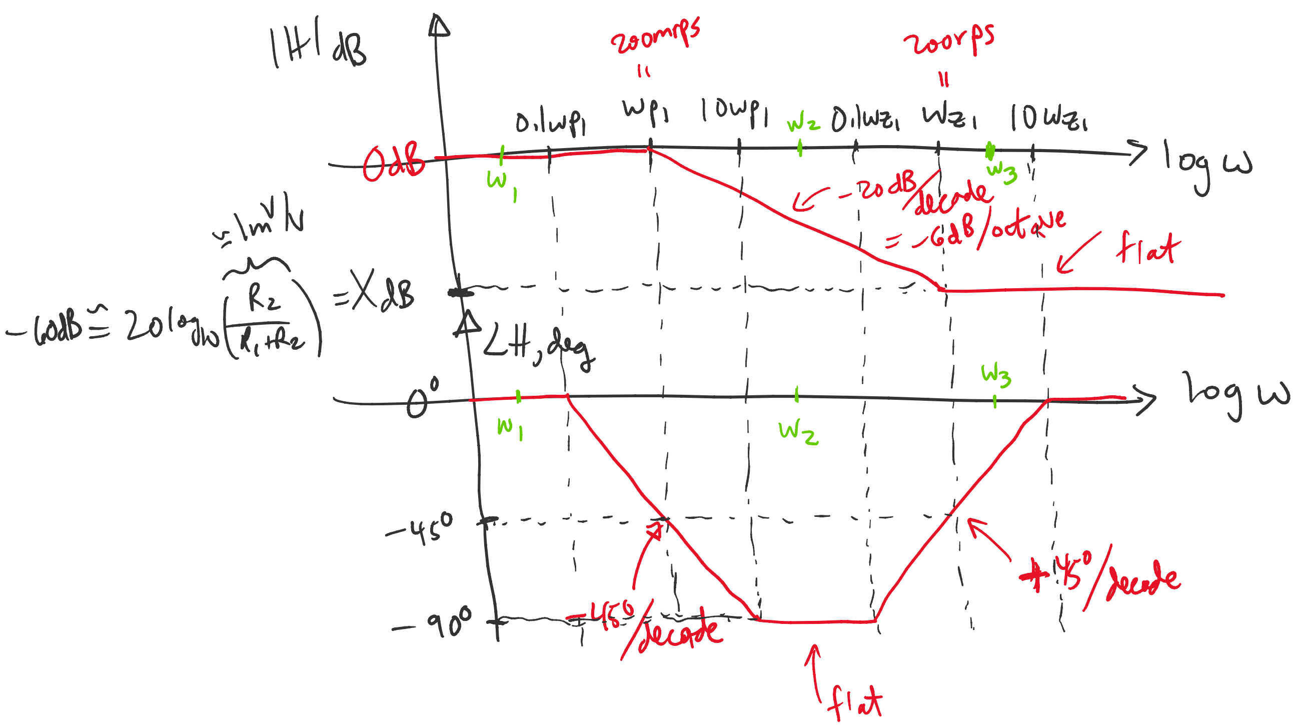
Let's choose some numerical component values;

$R_1 = 5M\Omega,\ R_2 = 5k\Omega,\ C_1 = 1\mu F$



$$w_{z_1} = \frac{1}{R_2 C_1} = \frac{1}{(5k)(1\mu)} = 200\,rps$$

$$\& \quad w_{p_1} = \frac{1}{(R_1+R_2)C_1} = \frac{1}{(5M+5k)(1\mu)} \cong 200\,mrps$$ ⇒ our Bode plot approximation is shown below:



3 frequencies are chosen to spot-check our work: w_1, w_2, w_3

→ $w_1 < 0.1 w_{p_1}$ ⇒ $0.1 w_{p_1} = 20\,mrps$ ⇒ so, choose $\underline{\underline{w_1 = 10\,mrps}}$

$\rightarrow \omega_2 > 10\omega_{p1}$ & $\omega_2 < 0.1\omega_{z1} \Rightarrow 10\omega_{p1} = 2\,rps$ & $0.1\omega_{z1} = 20\,rps$

$\Rightarrow$ So, choose $\underline{\underline{\omega_2 = 10\,rps}}$

$\rightarrow \omega_3 > \omega_{z1}$ & $\omega_3 < 10\omega_{z1} \Rightarrow \omega_{z1} = 200\,rps$ & $10\omega_{z1} = 2\,krps$

$\Rightarrow$ So, choose $\underline{\underline{\omega_3 = 1\,krps}}$

From Bode plot approximation:

1) $\omega_1 = 10\,mrps \Rightarrow |H|_{dB} = 0\,dB \Rightarrow |H| = 10^{0/20} = 1\,V/V$

& $\angle H = 0^\circ \Rightarrow \underline{H(j\omega_1) \cong 1\angle 0^\circ\ V/V}$

2) $\omega_2 = 10\,rps \Rightarrow |H|_{dB} \cong 0\,dB + (-20\,dB/dec)(\#\text{ of decades from } \omega_{p1} \text{ to } \omega_2)$

$$= \left(-20\frac{dB}{\cancel{dec}}\right)\log_{10}\left(\frac{\omega_2}{\omega_{p1}}\right)\cancel{dec} = -20\log_{10}\underbrace{\left(\frac{10\,\cancel{rps}}{200\,m\cancel{rps}}\right)}_{50} dB$$

$$\cong (-20)(1.6990)\,dB = -33.98\,dB$$

$\Rightarrow |H| = 10^{-33.98/20} = 20\,mV/V$

$\angle H \cong -90^\circ \Rightarrow \underline{H(j\omega_2) \cong 20m\angle -90^\circ\ V/V}$

3) $\omega_3 = 1\,krps \Rightarrow |H|_{dB} \cong -60\,dB \Rightarrow |H| = 10^{-60/20} = 1\,mV/V$

$\angle H = -90^\circ + (45^\circ/dec)(\#\text{ of decades between } 0.1\omega_{z1} \text{ to } \omega_3)$

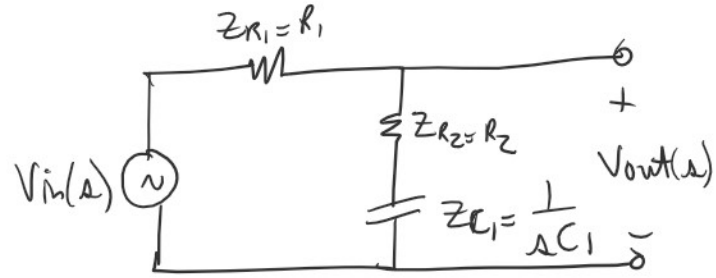
$$= -90^\circ + \left(\frac{45^\circ}{\cancel{dec}}\right)\log_{10}\left(\frac{\omega_3}{0.1\omega_{z1}}\right)\cancel{dec} = -90^\circ + 45\log_{10}\underbrace{\left(\frac{1\,k\cancel{rps}}{20\,\cancel{rps}}\right)}_{50} \text{degrees}$$

$$\cong -90^\circ + (45)(1.6990)\,deg. \cong -13.55^\circ$$

$\Rightarrow H(j\omega_3) \cong 1m\angle -13.55^\circ\ V/V$

$$\Rightarrow H(j\omega_3) \cong 1m \angle -13.55^\circ \ V/V$$

Now, perform a phasor analysis at ω_1, ω_2, ω_3 and compare to the above:



By voltage division,

$$H(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{Z_{C1} + Z_{R2}}{Z_{R_1} + Z_{R_2} + Z_{C1}} = \frac{\frac{1}{sC_1} + R_2}{R_1 + R_2 + \frac{1}{sC_1}}$$

transfer-function

let $s = j\omega \Rightarrow H(j\omega) = \frac{\tilde{V}_{out}}{\tilde{V}_{in}} = \frac{R_2 - \frac{j}{\omega C_1}}{R_1 + R_2 - \frac{j}{\omega C_1}}$ ⇐ now, evaluate at ω_1, ω_2, ω_3

frequency response

④ @ $\omega = \omega_1 = 10$ mrps, $H = 998.75m \angle -2.86^\circ \ V/V$

⟨compare to Bode approx: $H \cong 1 \angle 0^\circ \ V/V$⟩ ✓

④ @ $\omega = \omega_2 = 10$ rps, $H = 20m \angle -85.99^\circ \ V/V$

⟨compare to Bode approx: $H \cong 20m \angle -90^\circ \ V/V$⟩ ✓

④ @ $\omega = \omega_3 = 1$ Krps, $H = 1.02m \angle -11.30^\circ \ V/V$

⟨compare to Bode approx: $H \cong 1m \angle -13.55^\circ \ V/V$⟩ ✓