Frequency Response

Lecture 36
\[ p_s = \text{poses} \]
\[ Z_s = \text{crosses} \]
\[ T(S) = \frac{(s - \text{pin}) \cdots (s - \text{pen})}{(s - \text{pin}) \cdots (s - \text{pen})} \]

\[ \begin{align*}
\text{Function} & \quad \text{Input} \\
\text{Current Transfer} & \quad \frac{I_r(s)}{I_o(s)} \\
\text{Transfer Conductance} & \quad \frac{\nu(s)}{I_o(s)} \\
\text{Transfer Transferance} & \quad \frac{I_o(s)}{I_r(s)} \\
\text{Voltage Transfer} & \quad \frac{V_o(s)}{V_i(s)} \\
\end{align*} \]

\[ T(s) = \text{Output (s)} \]

\[ \begin{array}{c}
\text{Input} \\
\text{Output}
\end{array} \]

\[ \text{Transfer Functions} \]
RECALL \[ S = \omega j = 2\pi f j \quad \therefore \quad S = z_i \quad \equiv \quad S = z_{ii} f j \]

That is, \( @ f = f_i \) the output of the circuit will be "0"

\[ T(z_i) = K \frac{(z_i-z_1)(z_i-z_2) \ldots (z_i-z_i) \ldots (z_i-z_m)}{(z_i-p_1)(z_i-p_2) \ldots (z_i-p_N)} \]

\[ T(z_i) = 0 \quad \Rightarrow \quad \text{"Output"}(z_i) = 0 \]

\( \text{"Output"} = V_0(s) \quad \text{or} \quad I_0(s) \)

\[ V_0 = ? \]
\[ \frac{s^2}{\sqrt{s^2 + K_F}} = 2 \]

\[ \left( \frac{s^2}{s + K_F} \right)^2 \times K = \frac{\left( \frac{s}{K_F} \right)^2}{\left( \frac{s + K_F}{K_F} \right)^2} = 0 \]

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\[
\frac{1}{(R_p || R_s) C_p} = \frac{2}{s} + \frac{1}{1} \quad \left[ \begin{array}{c}
\frac{2}{s} + 1 \\
1
\end{array} \right] \quad K = \frac{\frac{v_i(s)}{s}}{v_o(s)}
\]

\[
\left[ \begin{array}{c}
\frac{1 + s (R_p + R_s) C_p}{R_p} \\
1
\end{array} \right] \quad \frac{v_i(s)}{s} = \frac{v_o(s)}{s} \quad v_o(s) = \frac{3}{s}
\]
That is, both the magnitude and phase of $V_o$ are functions of the frequency $\omega$.

$$T(s) = \frac{V_o(s)}{V_i(s)} = K \left( \frac{\frac{\omega_i}{2s}}{1 + \frac{\omega_i}{2s}} \right)$$

$$|T(\omega)| = K \left| \frac{\frac{\omega_i}{2}}{1 + \frac{\omega_i}{2}} \right|$$

$$\phi(\omega) = \arg\left( \frac{\omega_i}{2} \right)$$

Bode Plots

$f = \frac{1}{2\pi}$
\[ T_3 = T_2 + T_1 \]

\[ \log \left( \sqrt{z_{2m+1} + \frac{\sqrt{2m}}{2}} \right) k = 20 \log k + 20 \log w + 20 \log w_s - 20 \log 3 = \frac{80}{10} \left( f_m^T \right) \]

\[ \left( \left\lfloor \frac{z_{2m+1} + \frac{\sqrt{2m}}{2}}{2} \right\rfloor \right) k = \left( f_m^T \right) \]

\[ \left| \frac{z_{2m+1} + \frac{\sqrt{2m}}{2}}{2} \right| k = \left| \left( f_m^T \right) \right| \]

Magnitude
1) \[ \text{Note:} \text{ Slope of } T \rightarrow \frac{T}{2} = \frac{6V_2}{20} = -3 \text{dB} \]

2) For \( T < 1 \), \( V_2 \gg V_m^2 \)

\[ T_2 = -\frac{20 \log \left( \frac{1 + \frac{V_m^2}{V_2}}{1 + \frac{V_m^2}{V_2}} \right)}{L} = 0 \]

\[ 0 = 20 \log (1 + \frac{V_m^2}{V_2}) \]

\[ \text{Note: Frequency increases by a factor of two, and } \frac{V_m^2}{V_2} \text{ increases by a factor of two.} \]

\[ \text{Frequency = Frequency increase by a factor of two.} \]

\[ \text{Note: Two values of } V_2 \text{ are } V_m^2, \text{ and } \frac{V_m^2}{2}, \text{ respectively.} \]
\[ \tan^{-1}\left(\frac{\omega}{\theta}\right) = \Theta \]

\[ \Theta = 90^\circ \]

\[ \theta = 0 \]

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\[ \Theta_\text{is real} \]

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Similarly, for the second circuit, 

\[
\frac{1 + \frac{1}{s}}{1} = K(s)
\]
Note: \( I = 0 \) as \( z \to \infty \)

\[ R = \frac{5}{10} = 0.5 \Omega \]

\[ K = \frac{2\pi f}{R} = \frac{4.309}{10} = 0.4309 \]

\[ f = \frac{2\pi \times 20}{2\pi \times 20} = 1 \frac{1}{s} \]

\[ L = 11 \text{ mH} \]

\[ C = \frac{1}{f} = 1 \text{ nF} \]

\[ R_p = 10 \text{ k}\Omega \]

\[ R_s = 1 \text{ k}\Omega \]
$20 \log (f) = 58.3 \text{ MHz}$

\[ f = \frac{20 \pm 2}{1} = 58.3 \text{ MHz} \]

\[ 2\beta = (R_s || R_p) C_f = (1 \text{ K} || 10 \text{ K}) \times 10 = 2.73 \times 10^{-3} \]

\[ K = -0.828 \text{ DB} \]

\[ C_f = 3 \text{ pF} \]

\[ R_p = 10 \text{ K} \]

\[ R_s = 1 \text{ K} \]

\[ V_0 \]

\[ E_x \]