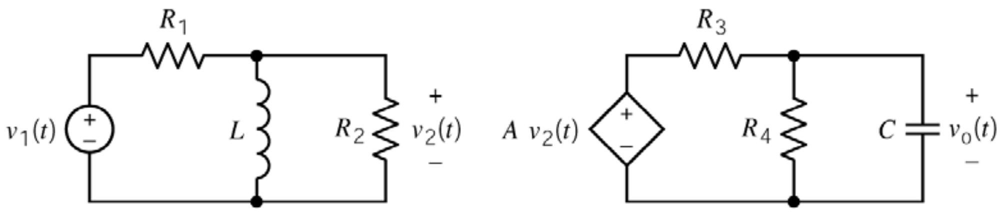
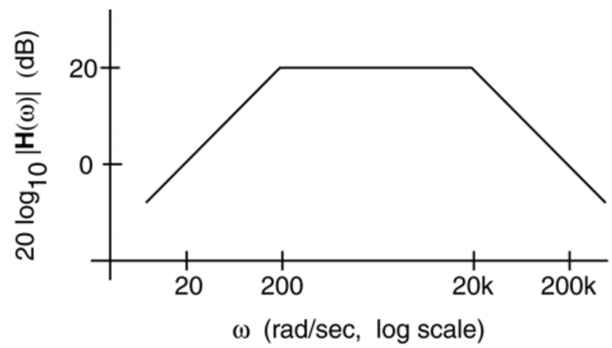
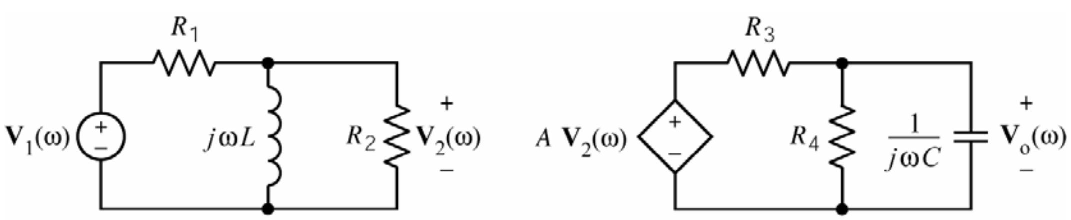
Example:
Consider this circuit and corresponding asymptotic magnitude Bode plot. The input to this circuit is the voltage of the voltage source, $v_1(t)$. The output is the capacitor voltage $v_o(t)$. Design this circuit to have this Bode plot.





Solution:
Represent the circuit in the frequency domain:



Using voltage division twice gives:

$$\frac{\mathbf{V}_2(\omega)}{\mathbf{V}_1(\omega)} = \frac{\dfrac{j\omega L\, R_2}{R_2 + j\omega L}}{R_1 + \dfrac{j\omega L\, R_2}{R_2 + j\omega L}} = \frac{j\omega L\, R_2}{R_1 R_2 + j\omega L\left(R_1 + R_2\right)} = \frac{L}{R_1}\,\frac{j\omega}{1 + j\omega \dfrac{L\left(R_1 + R_2\right)}{R_1 R_2}}$$

and

$$\frac{\mathbf{V}_o(\omega)}{\mathbf{V}_2(\omega)} = \frac{\dfrac{R_4}{1 + j\omega C\, R_4}}{R_3 + \dfrac{R_4}{1 + j\omega C\, R_4}}\, A = \frac{A\, R_4}{R_3 + R_4 + j\omega C\, R_3 R_4} = \frac{\dfrac{A\, R_4}{R_3 + R_4}}{1 + j\omega \dfrac{C\, R_3 R_4}{R_3 + R_4}}$$

Combining these equations gives

$$\mathbf{H}(\omega)=\frac{\mathbf{V}_o(\omega)}{\mathbf{V}_i(\omega)}=\frac{ALR_4}{R_1(R_3+R_4)}\frac{j\omega}{\left(1+j\omega\frac{L(R_1+R_2)}{R_1R_2}\right)\left(1+j\omega\frac{CR_3R_4}{R_3+R_4}\right)}$$

The Bode plot corresponds to the network function:

$$\mathbf{H}(\omega)=\frac{k\ j\omega}{\left(1+j\frac{\omega}{p_1}\right)\left(1+j\frac{\omega}{p_2}\right)}=\frac{k\ j\omega}{\left(1+j\frac{\omega}{200}\right)\left(1+j\frac{\omega}{20000}\right)}$$

$$\mathbf{H}(\omega)\approx\begin{cases}\dfrac{k\ j\omega}{1\cdot 1}=k\ j\omega & \omega\le p_1\\ \dfrac{k\ j\omega}{\frac{j\omega}{p_1}\cdot 1}=k\ p_1 & p_1\le\omega\le p_2\\ \dfrac{k\ j\omega}{\frac{j\omega}{p_1}\cdot\frac{j\omega}{p_2}}=\dfrac{k\ p_1\ p_2}{j\omega} & \omega\ge p_2\end{cases}$$

This equation indicates that $|\mathbf{H}(\omega)|=k\ p_1$ when $p_1\le\omega\le p_2$. The Bode plot indicates that $|\mathbf{H}(\omega)|=20\text{ dB}=10$ when $p_1\le\omega\le p_2$. Consequently

$$k=\frac{10}{p_1}=\frac{10}{200}=0.05$$

Finally,

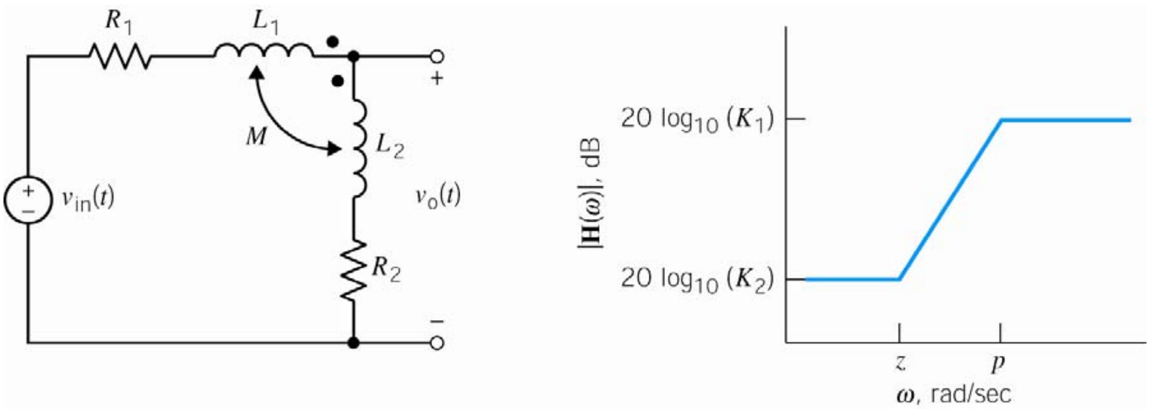
$$\mathbf{H}(\omega)=\frac{0.05\ j\omega}{\left(1+j\frac{\omega}{200}\right)\left(1+j\frac{\omega}{20000}\right)}$$

Comparing the equation for $\mathbf{H}(\omega)$ obtained from the circuit to the equation for $\mathbf{H}(\omega)$ obtained from the Bode plot gives:

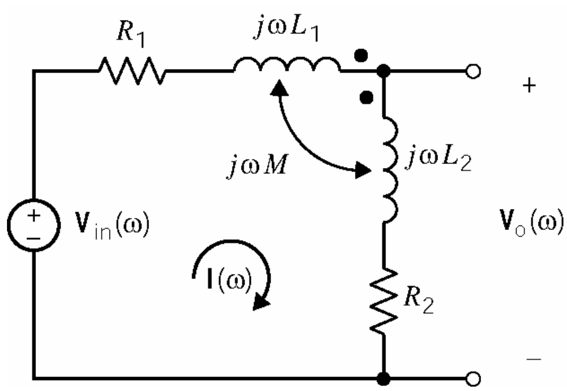
$$0.05=\frac{ALR_4}{R_1(R_3+R_4)},\ 200=\frac{R_1R_2}{L(R_1+R_2)}\text{ and }20000=\frac{R_3+R_4}{C\,R_3R_4}$$

Pick L = 1 H, and $R_1 = R_2$, then $R_1 = R_2$ = 400 Ω. Let C = 0.1 μF and $R_3 = R_4$, then $R_3 = R_4$ = 1000 Ω. Finally, A=40.

Example:
Consider this circuit and corresponding asymptotic magnitude Bode plot. The input to this circuit is the voltage of the voltage source, $v_{\text{in}}(t)$. The output is the voltage $v_{\text{o}}(t)$. Design this circuit to have this Bode plot.



Solution:
Represent the circuit in the frequency domain:



Mesh equations:

$$\mathbf{V}_{\text{in}}(\omega) = \mathbf{I}(\omega)\,[R_1 + (j\omega L_1 - j\omega M) + (-j\omega M + j\omega L_2) + R_2]$$
$$\mathbf{V}_{\text{o}}(\omega) = \mathbf{I}(\omega)\,[(-j\omega M + j\omega L_2) + R_2]$$

Solving yields:

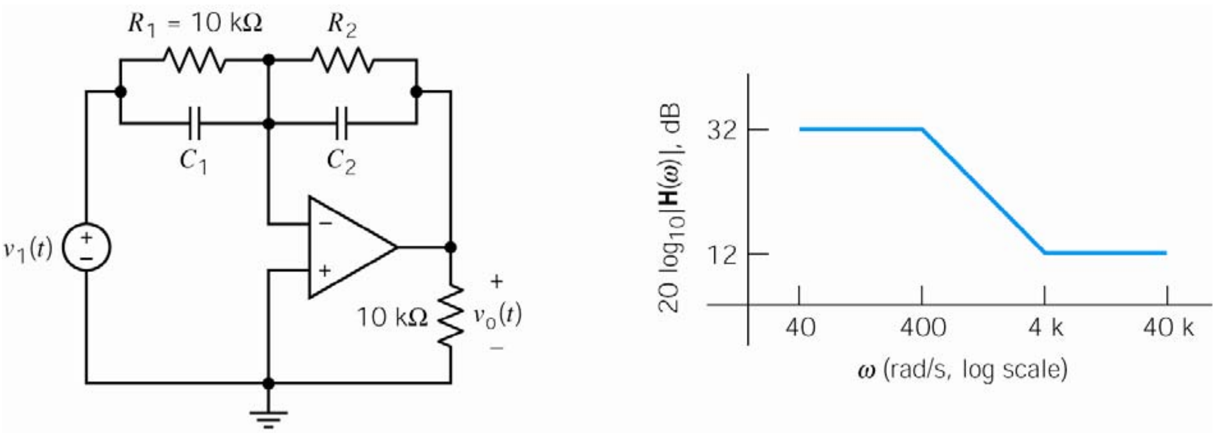
$$\mathbf{H}(\omega) = \frac{\mathrm{V}_{\text{o}}(\omega)}{\mathrm{V}_{\text{in}}(\omega)} = \frac{R_2 + j\omega(L_2 - M)}{R_1 + R_2 + j\omega(L_1 + L_2 - 2M)}$$

Comparing to the given Bode plot yields:

$$K_1 = \lim_{\omega\to\infty} |\mathbf{H}(\omega)| = \frac{L_2 - M}{L_1 + L_2 - 2M} = 0.75 \quad \text{and} \quad K_2 = \lim_{\omega\to 0} |\mathbf{H}(\omega)| = \frac{R_2}{R_1 + R_2} = 0.2$$

$$z = \frac{R_2}{L_2 - M} = 333 \text{ rad/s} \quad \text{and} \quad p = \frac{R_1 + R_2}{L_1 + L_2 - 2M} = 1250 \text{ rad/s}$$

Example:
Consider this circuit and corresponding asymptotic magnitude Bode plot. The input to this circuit is the voltage of the voltage source, $v_1(t)$. The output is the capacitor voltage $v_o(t)$. Design this circuit to have this Bode plot.



Solution:
From Table 13.3-2:

$$\frac{R_2}{R_1} = k = 32\text{ dB} = 40 \quad R_2 = 40\left(10\times10^3\right) = 400\text{ k}\Omega$$

$$\frac{1}{C_2 R_2} = p = 400\text{ rad/s} \quad \Rightarrow \quad C_2 = \frac{1}{(400)\left(400\times10^3\right)} = 6.25\text{ nF}$$

$$\frac{1}{C_1 R_1} = z = 4000\text{ rad/s} \quad \Rightarrow \quad C_1 = \frac{1}{(4000)\left(10\times10^3\right)} = 25\text{ nF}$$