All the expressions for V_{out}/V_{in} in this problem set can be derived by applying voltage divider rule.

Q1 Problem 6.1

For the circuit in Fig P6.1,

a) Determine the frequency response of V_{out}/V_{in} expressed in the form:
$$\frac{v_{out}}{v_{in}} = \frac{A}{1+j\omega/\omega_c}$$
Given that A and ω_c are positive values, find the values of A and ω_c;

b) Find $|V_{out}/V_{in}|$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

c) Find $\angle(V_{out}/V_{in})$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

d) Hence determine if the circuit is a high pass or low pass filter

e) Sketch the frequency response of V_{out}/V_{in} (log-log plot for magnitude and semi-log plot for phase)

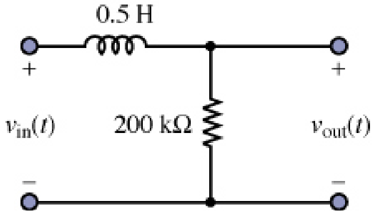

Fig P6.1

Q2 Problem 6.2

For the circuit in Fig P6.2,

a) Determine the frequency response of V_{out}/V_{in} expressed in the form:
$$\frac{v_{out}}{v_{in}} = \frac{A}{1+j\omega/\omega_c}$$
Given that A and ω_c are positive values, find the values of A and ω_c;

b) Find $|V_{out}/V_{in}|$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

c) Find $\angle(V_{out}/V_{in})$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

d) Hence determine if the circuit is a high pass or low pass filter

e) Sketch the frequency response of V_{out}/V_{in} (log-log plot for magnitude and semi-log plot for phase)

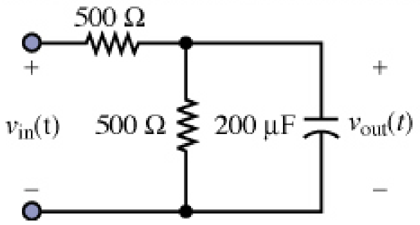

Fig P6.2

Q3 Problem 6.3

For the circuit in Fig P6.3,

a) Determine the frequency response of V_{out}/V_{in} expressed in the form:

$$\frac{V_{out}}{V_{in}} = \frac{A}{1 + j\omega/\omega_c}$$

Given that A and ω_c are positive values, find the values of A and ω_c;

b) Find $|V_{out}/V_{in}|$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

c) Find $\angle(V_{out}/V_{in})$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

d) Hence determine if the circuit is a high pass or low pass filter

e) Draw the frequency response of V_{out}/V_{in} (log-log plot for magnitude and semi-log plot for phase)

f) What is similar and different in the frequency response between the circuit in Fig P6.3 and Fig P.6.2?

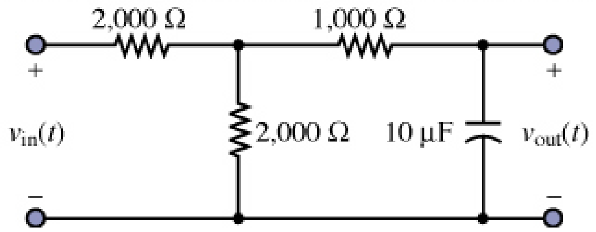

Fig P6.3

Q4 Problem 6.11

For the circuit in Fig P6.11,

a) Determine the frequency response of V_o/V_i expressed in the form:

$$\frac{V_o}{V_i} = \frac{A}{1 + \omega_c / j\omega}$$

Given that A and ω_c are positive, find expressions for A and ω_c in terms of the component symbols given;

b) Find $|V_o/V_i|$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

c) Find $\angle(V_o/V_i)$ when $\omega = 0$, $\omega = \omega_c$, and $\omega \to \infty$;

d) Hence determine if the circuit is a high pass or low pass filter

e) Draw the frequency response of V_o/V_i (log-log plot for magnitude and semi-log plot for phase)

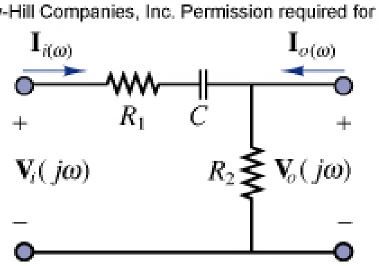

Fig P6.11

Numerical answers

Q1 Problem 6.1

a) $\frac{v_{out}}{v_{in}} = \frac{1}{1 + j\left(2.5\times10^{-6}\omega\right)}$

A = 1, ω_c = 400 krad/s

b) Magnitudes

At ω = 0, $|V_{out}/V_{in}| = 1$;

At ω = ω_C, $|V_{out}/V_{in}| = 1/\sqrt{2}$;

At ω → ∞, $|V_{out}/V_{in}| = 0$;

c) Phases

At ω = 0, $\angle(V_{out}/V_{in}) = 0°$;

At ω = ω_C, $\angle(V_{out}/V_{in}) = -45°$;

At ω → ∞, $\angle(V_{out}/V_{in}) = -90°$;

d) Low pass filter

Q2 Problem 6.2

a) $\frac{v_{out}}{v_{in}} = \frac{0.5}{1 + j\left(0.05\omega\right)}$

A = 0.5, ω_c = 20 rad/s

b) Magnitudes

At ω = 0, $|V_{out}/V_{in}| = 0.5$;

At ω = ω_C, $|V_{out}/V_{in}| = 0.5/\sqrt{2}$;

At ω → ∞, $|V_{out}/V_{in}| = 0$;

c) Phases

At ω = 0, $\angle(V_{out}/V_{in}) = 0°$;

At ω = ω_C, $\angle(V_{out}/V_{in}) = -45°$;

At ω → ∞, $\angle(V_{out}/V_{in}) = -90°$;

d) Low pass filter

Q3 Problem 6.3

a) $\frac{v_{out}}{v_{in}} = \frac{0.5}{1 + j\left(0.02\omega\right)}$

A = 0.5, ω_c = 50 rad/s

b) Magnitudes

At ω = 0, $|V_{out}/V_{in}| = 0.5$;

At ω = ω_C, $|V_{out}/V_{in}| = 0.5/\sqrt{2}$;

At ω → ∞, $|V_{out}/V_{in}| = 0$;

c) Phases

At ω = 0, $\angle(V_{out}/V_{in}) = 0°$;

At ω = ω_C, $\angle(V_{out}/V_{in}) = -45°$;

At ω → ∞, $\angle(V_{out}/V_{in}) = -90°$;

d) Low pass filter

f) Same in all aspects except for the value of the cut off radian frequency

Q4 Problem 6.11

a) $\frac{V_o}{V_i} = \left[\frac{R_2}{R_1+R_2}\right]\left[\frac{1}{1-j/\omega C\left(R_1+R_2\right)}\right]$

A = $R_2/(R_1+R_2)$, $\omega_c = 1/[C(R_1+R_2)]$

b) Magnitudes

At $\omega = 0$, $|V_{out}/V_{in}| = 0$;

At $\omega = \omega_c$, $|V_{out}/V_{in}| = R_2/[\sqrt{2}\,(R_1+R_2)]$;

At $\omega \rightarrow \infty$, $|V_{out}/V_{in}| = R_2/(R_1+R_2)$;

c) Phases

At $\omega = 0$, $\angle(V_{out}/V_{in}) = 90°$;

At $\omega = \omega_c$, $\angle(V_{out}/V_{in}) = 45°$;

At $\omega \rightarrow \infty$, $\angle(V_{out}/V_{in}) = 0°$;

d) High pass filter