**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 $\omega_c$ are positive values, find the values of A and $\omega_c$;

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)



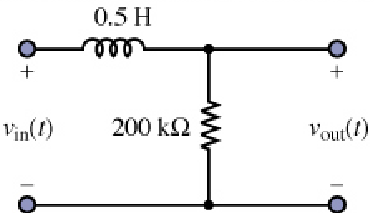


Fig P6.1

**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 $\omega_c$ are positive values, find the values of A and $\omega_c$;

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)



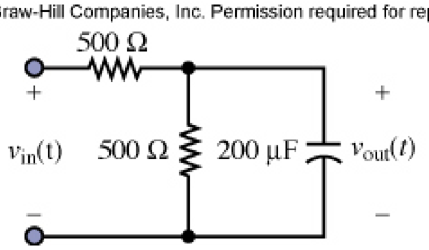


Fig P6.2

**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 $\omega_c$ are positive values, find the values of A and $\omega_c$;

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?



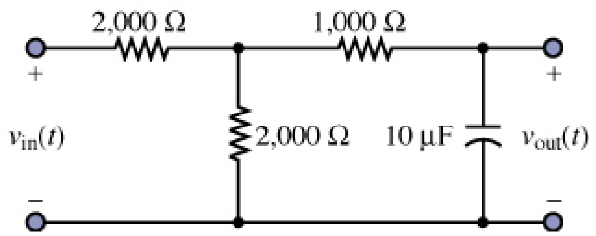


Fig P6.3

**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 $\omega_c$ are positive, find expressions for A and $\omega_c$ 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)



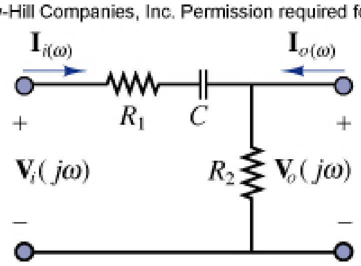


Fig P6.11

## 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, $\omega_c$ = 400 krad/s

b) Magnitudes

At ω = 0, $|V_{out}/V_{in}| = 1$;

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

At ω → ∞, $|V_{out}/V_{in}| = 0$;

c) Phases

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

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

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, $\omega_c$ = 20 rad/s

b) Magnitudes

At ω = 0, $|V_{out}/V_{in}| = 0.5$;

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

At ω → ∞, $|V_{out}/V_{in}| = 0$;

c) Phases

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

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

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, $\omega_c$ = 50 rad/s

b) Magnitudes

At ω = 0, $|V_{out}/V_{in}| = 0.5$;

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

At ω → ∞, $|V_{out}/V_{in}| = 0$;

c) Phases

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

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

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