

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,

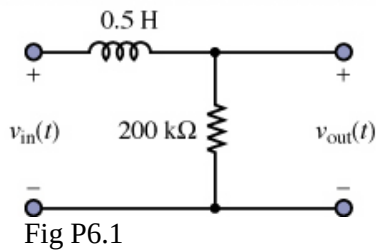
- a) Determine the frequency response of V_{out}/V_{in} expressed in the form:

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

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

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Q2 Problem 6.2

For the circuit in Fig P6.2,

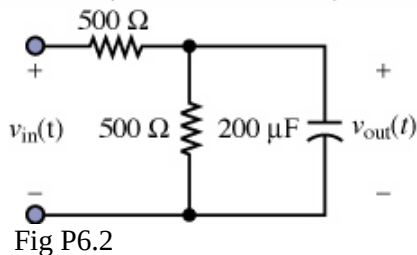
- a) Determine the frequency response of V_{out}/V_{in} expressed in the form:

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

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

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

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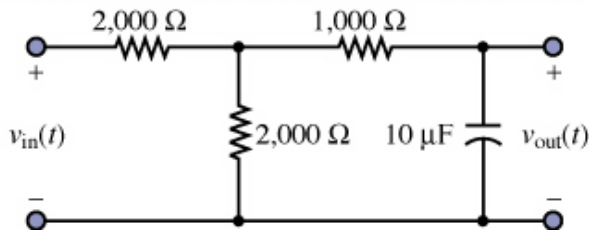


Fig P6.3

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

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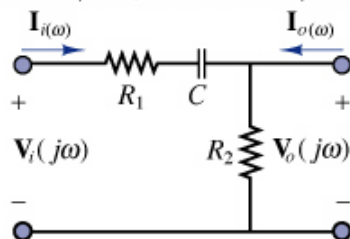


Fig P6.11

Numerical answers

Q1 Problem 6.1

$$a) \frac{V_{out}}{V_{in}} = \frac{1}{1 + j(2.5 \times 10^{-6} \omega)}$$

$$A = 1, \omega_c = 400 \text{ krad/s}$$

b) Magnitudes

$$\text{At } \omega = 0, |V_{out}/V_{in}| = 1;$$

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

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

c) Phases

$$\text{At } \omega = 0, \angle(V_{out}/V_{in}) = 0^\circ;$$

$$\text{At } \omega = \omega_c, \angle(V_{out}/V_{in}) = -45^\circ;$$

$$\text{At } \omega \rightarrow \infty, \angle(V_{out}/V_{in}) = -90^\circ;$$

d) Low pass filter**Q2 Problem 6.2**

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

$$A = 0.5, \omega_c = 20 \text{ rad/s}$$

b) Magnitudes

$$\text{At } \omega = 0, |V_{out}/V_{in}| = 0.5;$$

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

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

c) Phases

$$\text{At } \omega = 0, \angle(V_{out}/V_{in}) = 0^\circ;$$

$$\text{At } \omega = \omega_c, \angle(V_{out}/V_{in}) = -45^\circ;$$

$$\text{At } \omega \rightarrow \infty, \angle(V_{out}/V_{in}) = -90^\circ;$$

d) Low pass filter**Q3 Problem 6.3**

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

$$A = 0.5, \omega_c = 50 \text{ rad/s}$$

b) Magnitudes

$$\text{At } \omega = 0, |V_{out}/V_{in}| = 0.5;$$

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

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

c) Phases

$$\text{At } \omega = 0, \angle(V_{out}/V_{in}) = 0^\circ;$$

$$\text{At } \omega = \omega_c, \angle(V_{out}/V_{in}) = -45^\circ;$$

$$\text{At } \omega \rightarrow \infty, \angle(V_{out}/V_{in}) = -90^\circ;$$

d) Low pass filter

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

Q4 Problem 6.11

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

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

b) Magnitudes

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

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

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

c) Phases

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

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

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

d) High pass filter