ECE 20100 – Spring 2018
Final Exam

May 1, 2018

Section (include on scantron)

Michelusi (9:30) – 0001 Tan (1:30) – 0004 Li (10:30) – 0005

Hosseini (12:30) – 0006 Cui (11:30) – 0007

Kildishev (12:30) – 0008 Liu (8:30) – 0009 Zhu (3:30) – 0010

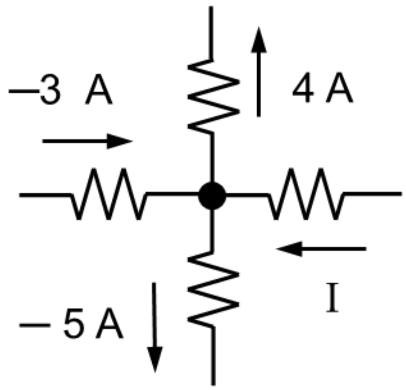
Instructions

1. DO NOT START UNTIL TOLD TO DO SO.
2. Write your name, section, professor, and student ID# on your **Scantron** sheet. We may check PUIDs.
3. This is a CLOSED BOOKS and CLOSED NOTES exam.
4. The use of a TI-30X IIS calculator is allowed.
5. If extra paper is needed, use the back of test pages.
6. Cheating will not be tolerated. Cheating in this exam will result in, at the minimum, an F grade for the course. In particular, **continuing to write after the exam time is up is regarded as cheating**.
7. If you cannot solve a question, be sure to look at the other ones, and come back to it if time permits.

By signing the scantron sheet, you affirm you have not received or provided assistance on this exam.

Question 1

Determine the unknown current, I (in A):



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

(6) 6

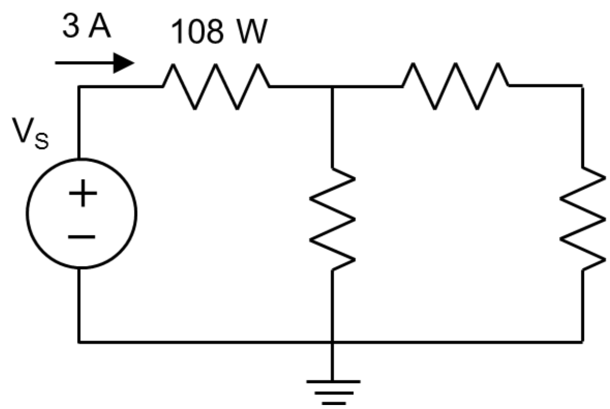
(7) 7

(8) 8

(9) None of the above

Question 2

All resistors in the circuit below have the same resistance. The voltage source supplies a current of 3A to the circuit and the power dissipated by the first resistor is 108 Watts. Find the power (in Watts) delivered by the voltage source to the circuit.



(1) 180

(2) 240

(3) 324

(4) 432

(5) 64

(6) 72

(7) 120

(8) 156

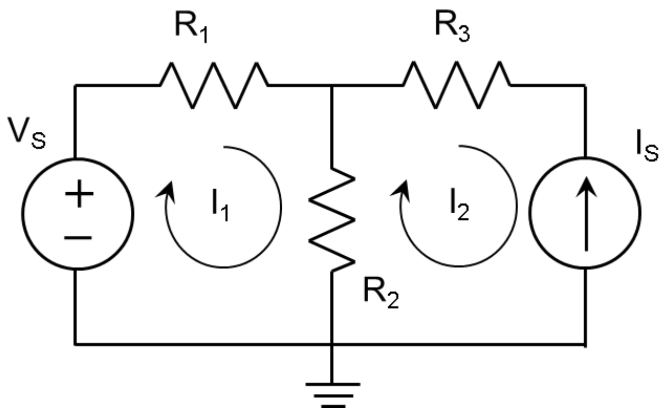
(9) None of the above

Question 3

The loop equations for the circuit shown below are as follows:

$$V_S = 10I_1 - 3I_2$$
$$I_S = -I_2$$

Find the value of R_1 (in Ohms).



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

(6) 6

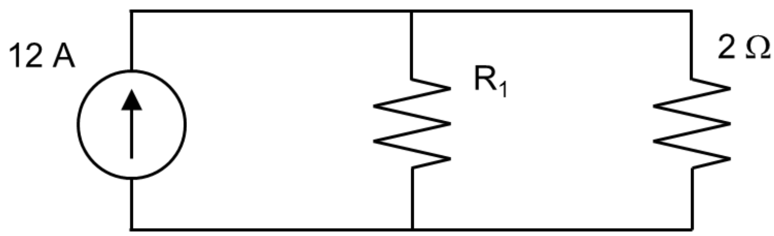
(7) 7

(8) 8

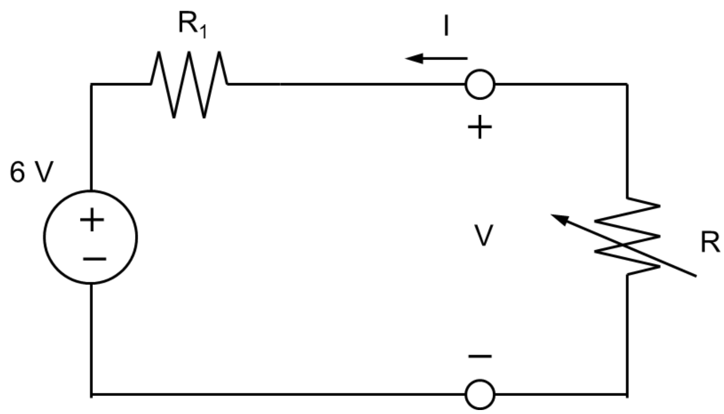
(9) None of the above

Question 4

A resistor of unknown value, R_1, is connected to a 2 Ω resistor and a 12 A independent current source as shown below. In this configuration, the 2 Ω resistor absorbs 32 W.



The same resistor is connected to a variable resistor (R) and voltage source as shown below. Find the correct current-voltage (I-V) relationship for this configuration.



(1) I = 2 V + 1.5

(2) I = 0.33 V + 6

(3) I = 0.25 V + 1.5

(4) I = 3 V + 1.5

(5) I = V – 6

(6) I = 0.33 V – 6

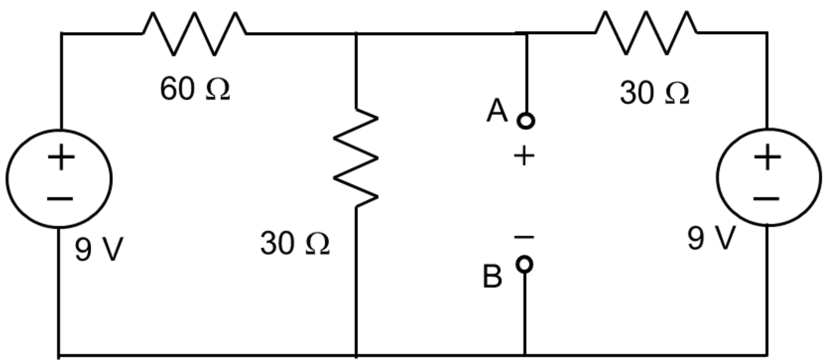
(7) I = 0.25 V – 1.5

(8) I = 3 V – 6

(9) None of the above

Question 5

Find the Thevenin equivalent resistance (R_{TH}) and open circuit voltage (v_{OC}) combination that correctly corresponds to the circuit below ("A" and "B" are external terminals).



(1) $R_{TH} = 9\ \Omega$, $v_{OC} = 5.4$ V

(2) $R_{TH} = 9\ \Omega$, $v_{OC} = 7.2$ V

(3) $R_{TH} = 9\ \Omega$, $v_{OC} = 9.0$ V

(4) $R_{TH} = 12\ \Omega$, $v_{OC} = 5.4$ V

(5) $R_{TH} = 12\ \Omega$, $v_{OC} = 7.2$ V

(6) $R_{TH} = 12\ \Omega$, $v_{OC} = 9.0$ V

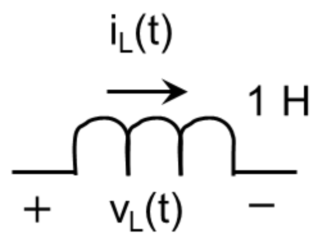
(7) $R_{TH} = 15\ \Omega$, $v_{OC} = 5.4$ V

(8) $R_{TH} = 15\ \Omega$, $v_{OC} = 7.2$ V

(9) None of the above

Question 6

The voltage drop over the inductor shown is $v_L(t)$ = 2t for $0 \le t \le 2$ sec. If $i_L(0\text{-})$ = 0 A, find the energy stored in the inductor (in J) at time t = 2 sec.



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

(6) 6

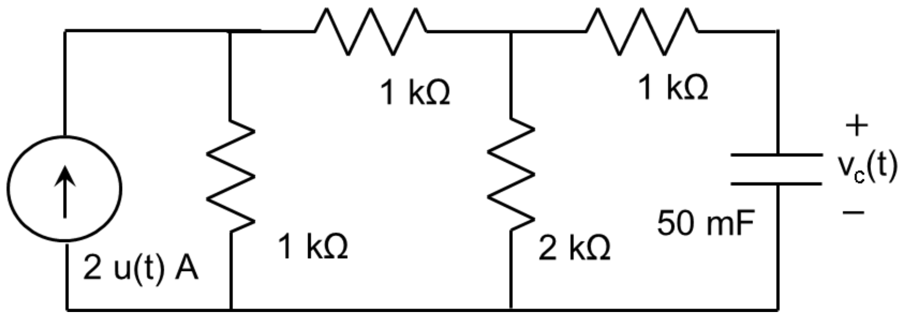
(7) 7

(8) 8

(9) None of the above

Question 7

In the circuit below, $v_c(0^-)$ = 0 V. Find the time constant τ (in sec) for the capacitor voltage $V_C(t)$ after the current source turns on at t = 0 sec.



(1) 0.001

(2) 0.01

(3) 0.1

(4) 1

(5) 10

(6) 100

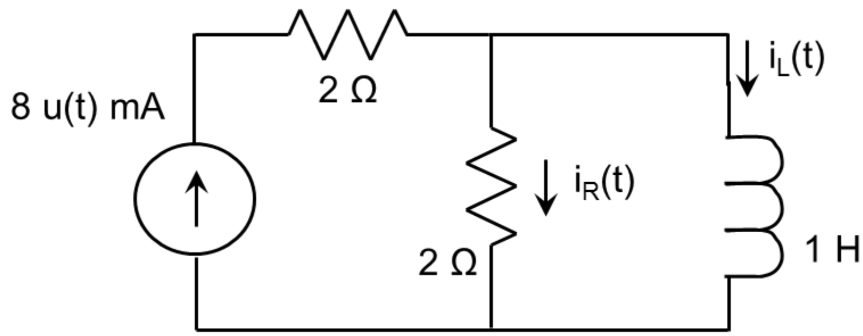
(7) 1,000

(8) 10,000

(9) None of the above

Question 8

Find the current $i_R(t)$ (in mA) as a function of time for $t \geq 0$ if $i_L(0^-) = 0$ A.



(1) $8 - 8\,e^{-t}$

(2) $4 - 4\,e^{-t}$

(3) $8e^{-t}$

(4) $4e^{-t}$

(5) $8 - 8\,e^{-2t}$

(6) $4 - 4\,e^{-2t}$

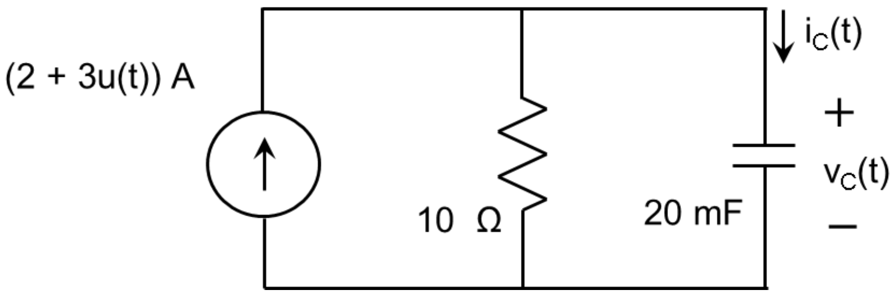
(7) $8e^{-2t}$

(8) $4e^{-2t}$

(9) None of the above

Question 9

Find $i_c(0^+)$ (in A) in the circuit below.



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

(6) 6

(7) 7

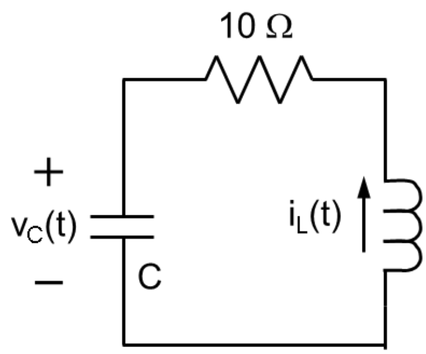
(8) 8

(9) None of the above

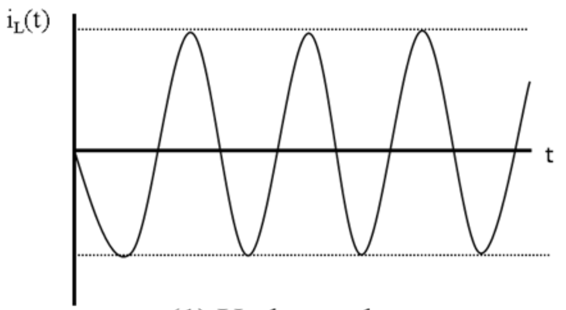
Question 10

In the circuit below, the inductor current, $i_L(t)$, for $t \geq 0$ is known to be,

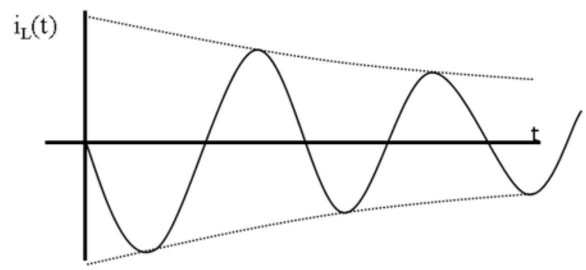
$$i_L(t) = 1e^{-10t} sin\left(10\sqrt{3}t\right) \text{ A}$$



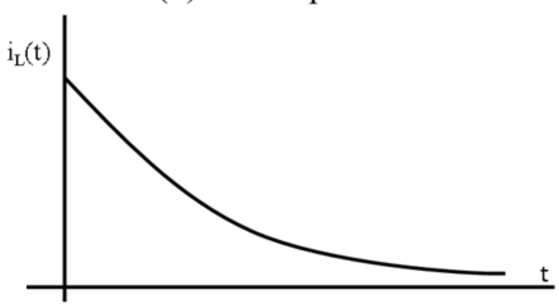
Find the response curve that best represents the inductor current above.



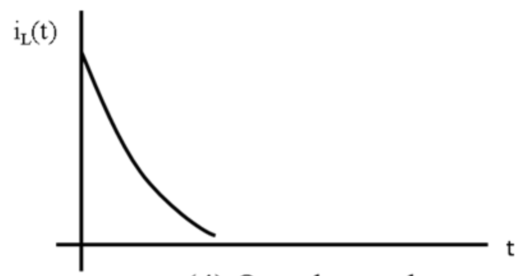
(1) Undamped



(2) Underdamped



(3) Critically damped

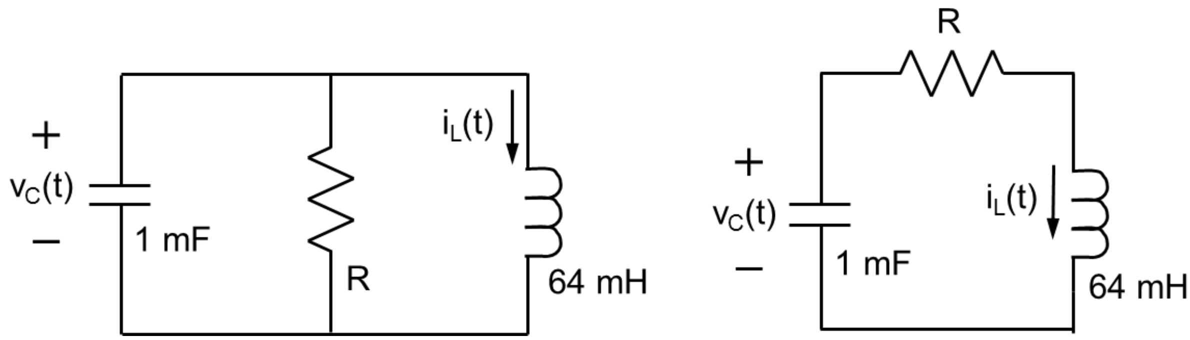


(4) Overdamped

(5) None of the above

Question 11

Find the resistance, R (in Ω), which makes the roots of the characteristic equation $s^2 + bs + c = 0$ the same for the two circuits below.



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

(6) 6

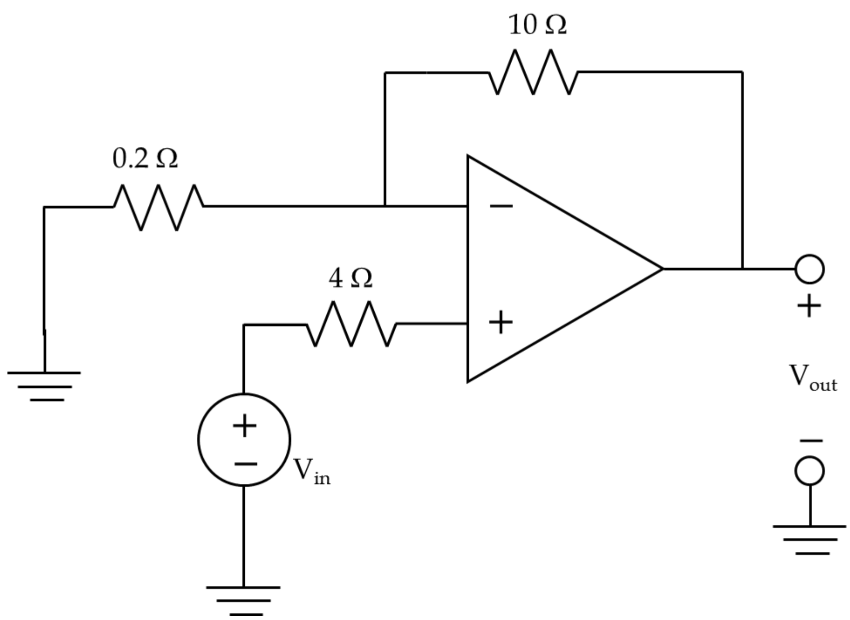
(7) 7

(8) 8

(9) None of the above

Question 12

For the circuit below, V_{out} = 10.2 V. Find V_{in} (in mV).



(1) 10

(2) 20

(3) 40

(4) 50

(5) 60

(6) 80

(7) 100

(8) 200

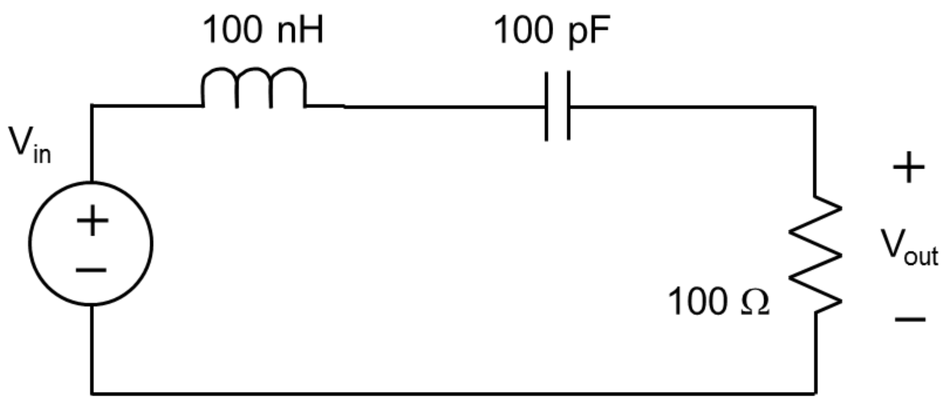
(9) None of the above

Question 13

The frequency response (transfer function) is defined as,

$$H(j\omega) = V_{out} / V_{in}$$

Find the frequency, ω (in rad/s), that maximizes the magnitude $H(j\omega)$.
[Hint: 1 nH = 10^{-9} H; 1 pF = 10^{-12} F]



(1) 0.01×10^{10}

(2) 0.03×10^{10}

(3) 0.10×10^{10}

(4) 0.32×10^{10}

(5) 1.00×10^{10}

(6) 3.16×10^{10}

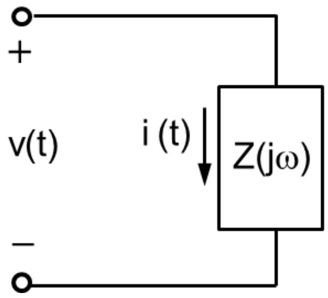
(7) 10.00×10^{10}

(8) 31.62×10^{10}

(9) None of the above

Question 14

Given the current through, *i(t)*, and voltage across, *v(t)*, a group of passive elements with impedance $Z(j\omega)$, find the instantaneous power absorbed by the impedance (in W) at $t = \pi/4$.



$i(t) = 2\cos(4t)$ A

$v(t) = 8\sin(4t + 150°)$ V

(1) 0

(2) 3.46

(3) 4

(4) 8

(5) 16

(6) –3.46

(7) –4

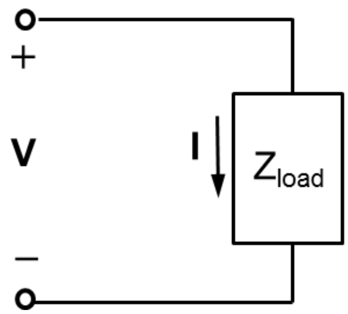
(8) –8

(9) –16

(10) None of the above

Question 15

An effective phasor voltage, $\boldsymbol{V_{eff}} = 200\ \angle 0^{o}$ V, is applied to a load with impedance Z_{load} = (4 + j3) Ω. Find the average power delivered to the load (in W).



(1) 0

(2) 1000

(3) 2500

(4) 4000

(5) 4800

(6) 6400

(7) 7200

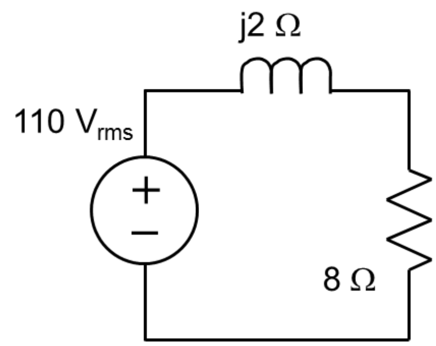
(8) 8000

(9) 10000

(10) None of the above

Question 16

Find the apparent power (in VA) supplied by the source with an effective voltage of 110 V.



(1) 733.7

(2) 756.3

(3) 915.2

(4) 1248.0

(5) 1467.4

(6) 1512.5

(7) 1800

(8) 6050

(9) None of the above

Question 17

Find the complex power (in VA) delivered to a load that absorbs 1 kW average power with a power factor (pf) that is equal to 0.91 lagging.

(1) 1000 – j118.4

(2) 1000 – j237.1

(3) 1000 – j314.5

(4) 1000 – j455.6

(5) 1000 + j118.4

(6) 1000 + j237.1

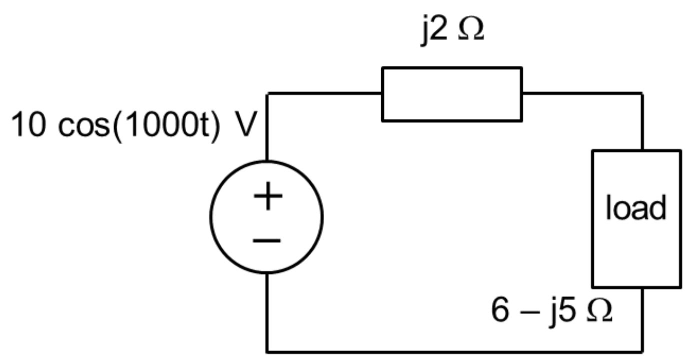
(7) 1000 + j314.5

(8) 1000 + j455.6

(9) None of the above

Question 18

In the circuit below, find the average power absorbed by the load (in W).



(1) 5.00

(2) 6.67

(3) 7.20

(4) 8.00

(5) 10.00

(6) 12.50

(7) 13.33

(8) 15.00

(9) None of the above

Question 19

The voltage across and the current through a passive two-terminal network are listed below. Find the power factor (pf) for the network.

$$v(t) = 100 \sin(\omega t + 105^o) \text{ V}, \quad i(t) = 4 \cos(\omega t + 75^o) \text{ A}$$

(1) 0.1

(2) 0.2

(3) 0.3

(4) 0.4

(5) 0.5

(6) 0.6

(7) 0.7

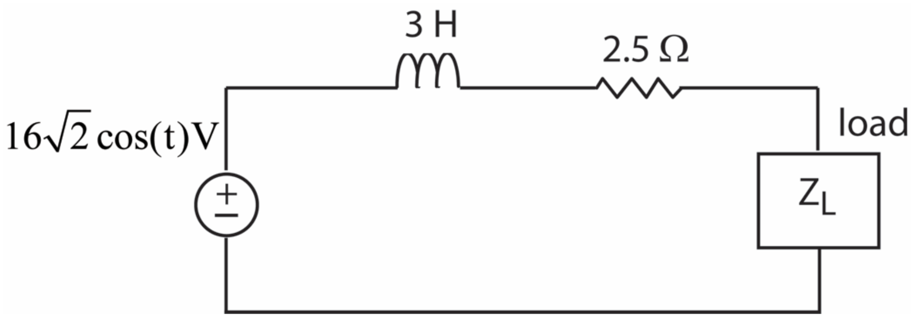
(8) 0.8

(9) 0.9

(10) None of the above

Question 20

Find the effective current $\boldsymbol{I_{eff}}$ (in A) that flows through the load if maximum average power is transferred to the load.



(1) 1.18

(2) 2.00

(3) 3.20

(4) 4.00

(5) 5.60

(6) 6.25

(7) 7.50

(8) 8.00

(9) None of the above

Potentially Useful Formulas (2nd Midterm)

$$x(t) = x(\infty) + \left[x(t_0^+) - x(\infty) \right] e^{-(t-t_0)/\tau} \text{ , where } \tau = R_{TH}C \text{ or } \tau = \frac{L}{R_{TH}}$$

$$v_L(t) = L\frac{di_L(t)}{dt} \qquad\qquad i_C(t) = C\frac{dv_C(t)}{dt}$$

$$i_L(t) = i_L(t_0) + \frac{1}{L}\int_{t_0}^{t} v_L(t')dt' \qquad\qquad v_C(t) = v_C(t_0) + \frac{1}{C}\int_{t_0}^{t} i_C(t')dt'$$

$$W_L(t_0,t_1) = \frac{L}{2}\left[\left(i_L(t_1)\right)^2 - \left(i_L(t_0)\right)^2 \right] \qquad\qquad W_C(t_0,t_1) = \frac{C}{2}\left[\left(v_C(t_1)\right)^2 - \left(v_C(t_0)\right)^2 \right]$$

$$-\ln x = \ln\frac{1}{x}$$

Elapsed time formula: $t_2 - t_1 = \tau \ln[(X_1 - x(\infty))/(X_2 - x(\infty))]$

Potentially Useful Formulas (3rd midterm)

First order circuit: $x(t) = x(\infty) + \left[x(t_o^+) - x(\infty)\right]e^{-\left(t-t_o^+\right)/\tau}$, $\tau = L/R$ or $\tau = RC$

Series RLC: $s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$

Parallel RLC: $s^2 + \frac{1}{RC}s + \frac{1}{LC} = 0$

$$x(t) = x(\infty) + \left(A\cos\omega_d t + B\sin\omega_d t\right)e^{-\sigma t}$$

$$x(t) = x(\infty) + \left(A + Bt\right)e^{-\sigma t}$$

$$x(t) = x(\infty) + \left(Ae^{s_1 t} + Be^{s_2 t}\right)$$

$s_1, s_2 = \dfrac{-b \pm \sqrt{b^2 - 4c}}{2}$ for $s^2 + bs + c = 0$, where $c = \left(LC\right)^{-1}$

$$\sigma = \frac{b}{2} = \begin{cases} R/2L & \text{(series)} \\ \dfrac{1}{2RC} & \text{(parallel)} \end{cases}$$

$$\omega_o = 1/\sqrt{LC}$$

$$s_{1,2} = -\sigma \pm \sqrt{\sigma^2 - \omega_o^2}$$

$$\omega_d = \frac{\sqrt{4c - b^2}}{2} = \sqrt{\omega_o^2 - \sigma^2}$$

TABLE 9.2 General Solutions for Constant-Source Second-Order Networks

General solution of the driven differential equation

$$\frac{d^2x}{dt^2} + b\frac{dx}{dt} + cx = F$$

having characteristic equation $s^2 + bs + c = (s - s_1)(s - s_2) = 0$, with roots

$$s_1, s_2 = \frac{-b \pm \sqrt{b^2 - 4c}}{2}$$

Case 1. Real and distinct roots; $b^2 - 4c > 0$:

$$x(t) = K_1 e^{s_1 t} + K_2 e^{s_2 t} + X_F$$

where $X_F = F/c$, and

$$x(0^+) = K_1 + K_2 + X_F$$
$$x'(0^+) = s_1 K_1 + s_2 K_2$$

Case 2. The roots $s_1 = -\sigma + j\omega_d$ and $s_2 = -\sigma - j\omega_d$ of the characteristic equation are distinct but complex; $b^2 - 4c < 0$:

$$x(t) = e^{-\sigma t}[A\cos(\omega_d t) + B\sin(\omega_d t)] + X_F$$

where again $X_F = F/c$, and

$$x(0^+) = A + X_F$$
$$x'(0^+) = -\sigma A + \omega_d B$$

Case 3. The roots are real and equal; $s_1 = s_2$ and $b^2 - 4c = 0$:

$$x(t) = (K_1 + K_2 t)e^{s_1 t} + X_F$$

where again $X_F = F/c$, and

$$x(0^+) = K_1 + X_F$$
$$x'(0^+) = s_1 K_1 + K_2$$

Potentially Useful Formulas (since Exam 3)

$$P_{ave} = \frac{1}{T}\int_0^T p(t)dt = \frac{V_m I_m}{2}\cos(\theta_V - \theta_I) = V_{eff} I_{eff} \cos(\theta_V - \theta_I) = V_{rms} I_{rms} \cos(\theta_V - \theta_I)$$

$$\mathbf{S} = \frac{1}{2}\mathbf{V}_m \mathbf{I}_m^* = \mathbf{V}_{eff}\mathbf{I}_{eff}^* = \mathbf{V}_{rms}\mathbf{I}_{rms}^* = P + jQ \ \text{VA}$$

$$pf = \frac{P}{|\mathbf{S}|} = \frac{P}{\sqrt{P^2 + Q^2}} = \cos(\theta_V - \theta_I)\ , \ pfa = (\theta_V - \theta_I)$$

Final Exam
May 1, 2018
Answer Key:

1. (2)
2. (1)
3. (7)
4. (5)
5. (4)
6. (8)
7. (6)
8. (7)
9. (3)
10. (2)
11. (8)
12. (8)
13. (2)
14. (4)
15. (6)
16. (5)
17. (8)
18. (2)
19. (5)
20. (3)