PRINCIPLES AND PRACTICE OF ENGINEERING SAMPLE TEST QUESTIONS FOR POWER EXAM AND ELECTRICAL AND ELECTRONICS EXAM

Created by

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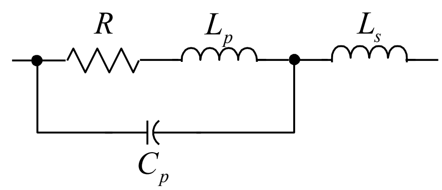
Introduction

Included in this packet are sample PE questions. Unlike the first sample test that I created, these questions are not intended to be a complete sample test or a comprehensive test--they are just topics that happen to be of current interest in the power area and the electrical and electronics area. Since there appears to be a great need for more advanced afternoon questions, many of these problems are challenging. However, all of these problems can be worked in six minutes or less! Unfortunately, I do not have the time to write out solutions as with my older-style morning breadth examination. I have, however, provided the answers. If time is available, I will try to add to this database.

These sample questions are not endorsed by any agency (including NCEES) and are intended as a study aid. They are provided free-of-charge (but may not be sold, modified, or DISTRIBUTED in any form without my written consent). Any relationship of these sample questions to actual test questions is purely coincidental.

1. Shown is a model for a nonideal, wirewound, resistor with long leads where R is the resistance, L_p is the parasitic inductance of the body of the resistor, C_p is the parasitic capacitance of the body of the resistor, and L_s is the (partial) inductance of the long leads. Which of the following statements is most true concerning this *RLC* model for this resistor?

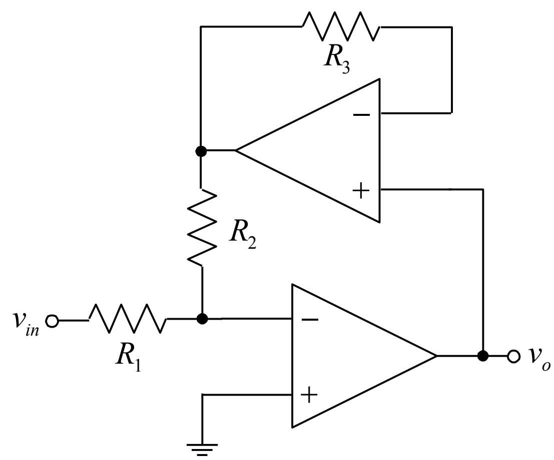


(A) at high frequencies, well above the highest resonant frequency, the impedance of this resistor has both strong resistive and capacitive components
(B) this is a third-order circuit with three resonant frequencies
(C) between two resonant frequencies, the Bode magnitude response of the impedance of this circuit could possibly decrease at a rate of 40 dB/decade
(D) as the parasitic capacitance increases, generally the frequency range that this component is mostly resistive increases

2. A long, straight trace on the top side of a single-layer printed circuit board with a large ground plane on the back side is used as a quarter-wavelength antenna at 900 MHz. The dielectric constant of the printed circuit board's substrate material is 4. Neglecting any trace or substrate resistive losses, the length of the trace is most likely within which of the following ranges?

(A) 1 cm to 4 cm
(B) 4 cm to 8 cm
(C) 8 cm to 12 cm
(D) 12 cm to 16 cm

3. For the given circuit, both op-amps are ideal except that each has an offset voltage equal to V_{os}. The magnitude of the voltage at the output, v_o, due only to these offset voltages is most nearly



(A) $\frac{R_2}{R_1}V_{os}$

(B) $\left(1+\frac{R_2}{R_1}\right)V_{os}$

(C) $\left(2+\frac{R_2}{R_1}\right)V_{os}$

(D) $\frac{R_2+R_3}{R_1}V_{os}$

4. A remote sensor is connected to an instrumentation amplifier through a twisted-pair transmission line. The amplifier has a differential gain equal to 30 and a common-mode rejection ratio (CMRR) equal to 70 dB. The total voltage at the output of the amplifier is described by the following expression

$$v_o(t) = 6\cos\left(2\pi \times 1{,}000t\right) + 0.1\cos\left(2\pi \times 60t + 35^\circ\right) \text{ V}$$

where the 1 kHz component corresponds to the sensor signal and the 60 Hz component corresponds to the undesirable noise term. The peak value of the sensor signal across the input of the amplifier was calculated to be approximately $6/30 = 0.2$ V while the peak value of the noise term at each input relative to the amplifier's reference was calculated to be approximately $0.1/(30/3{,}160) \approx 11$ V. Which of the following statements is most true concerning the assumptions used to obtain these two results?

(A) both the differential-mode component of the sensor signal and the differential-mode component of the noise signal are negligible
(B) both the common-mode component of the sensor signal and the common-mode component of the noise signal are negligible
(C) both the common-mode component of the sensor signal and the differential-mode component of the noise signal are negligible
(D) both the differential-mode component of the sensor signal and the common-mode component of the noise signal are negligible

5. A portable 10 kW, 120V/240 V rms, single-phase, gasoline-powered generator is connected through a transfer switch to the main circuit breaker panel of a house. The neutral of this main panel is connected to a ground-rod system. The generator also has a 120 V rms GFCI outlet. A power cable connecting the generator to the transfer switch contains two hot conductors, one neutral conductor, and one ground conductor. This ground conductor is connected to the main panel's ground at the panel side of the cable and the metal frame of the generator at the generator side of the cable. This generator allows the neutral conductor to be connected or not connected to the frame of the generator, based on the generator's application. Which of the following statements is most true concerning this system?

(A) when the neutral conductor of the cable is not connected to the frame, the generator is far from the main panel, and the power cable is long, connecting the generator's frame to an additional ground-rod system at the generator will decrease the electrical safety of the generator and increase the low-frequency ground loop noise potentially produced by the generator
(B) when the neutral conductor of the cable is connected to the frame and the generator's load is not balanced, the frame's voltage relative to the main panel's ground is generally closer to the main panel's ground potential than when only the ground conductor of the cable is connected to the frame
(C) when the neutral conductor of the cable is not connected to the frame, the hot and neutral for the 120 V rms GFCI should be connected to one hot conductor and the ground conductor of the cable, respectively
(D) when the neutral conductor of the cable is not connected to the frame, the generator is in close proximity to the main panel, and the power cable is short, connecting the generator's frame to an additional ground-rod system at the generator will generally not substantially improve the electrical safety of the generator

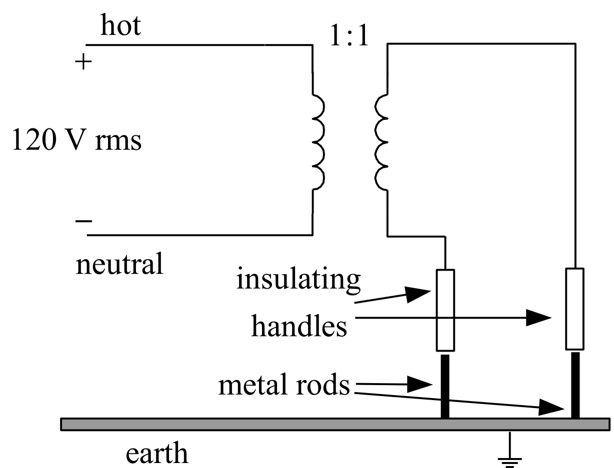
6. A farmer notices that his emus are exceptionally agitated ever since he recently installed power to the emu shed. He asked his daughter, a recent EE Kettering Graduate, to determine why. She suspects that due to improper grounding stray currents might be producing a large step voltages along the ground. After performing many field measurements she determined an approximation for the electric field in the vicinity of the shed at the power frequency:

$$\vec{E} = 80xe^{-y}\hat{a}_x - 40x^2e^{-y}\hat{a}_y + 5e^{-z}\hat{a}_z \text{ V/m}$$

where $\hat{a}_x$, for example, is the unit vector in the x direction. Assume the ground is located in the xy plane ($z = 0$) and the ground is flat. Using this expression, if one leg of a emu is located at the origin (0, 0, 0), the other leg of this same emu is located at (0.3 m, 0.03 m, 0), and both legs are in the vicinity of the shed, the magnitude of the step voltage along the ground between the two legs is closest to

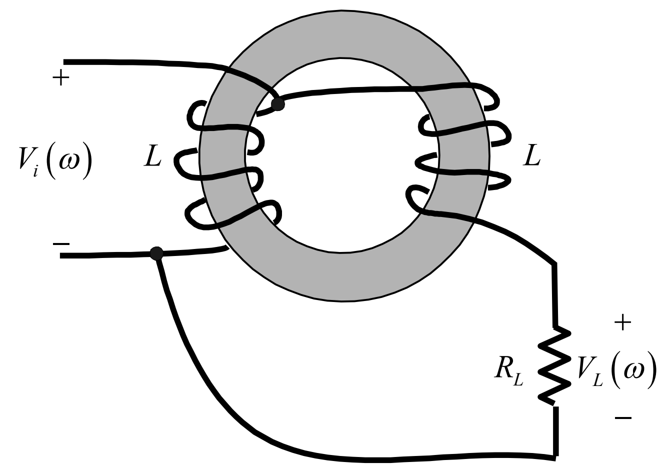
(A) 0.45 V
(B) 20 V
(C) 3.5 V
(D) 23 V

7. A 120 V rms worm harvester is a simple but very dangerous electrical device used to harvest worms. One "safer" version of this device consists of two metal rods both with insulating handles that connect to the power outlet through a 1:1 isolation transformer. The primary side of the 1:1 isolation transformer is connected to the power outlet through the hot and neutral conductors of an extension cord while each of the metallic rods are connected to one of the secondary outputs of the isolation transformer as shown. To operate this device, the metallic rods are first inserted in the earth within a few feet of each other and then the extension cord is plugged into a 120 V rms outlet. Based on the ground conditions, the resultant current into the earth will encourage worms in the vicinity of the two rods to rise slowly to the ground's surface. Which of the following statements is <u>most</u> true concerning this worm harvester?



(A) because of the return current from the rods to the main power's earthing system, the worm harvester will often trip when powered through a GFCI protected outlet
(B) using a three-conductor extension cord and connecting the cord's ground/safety conductor to either side of the transformer's secondary might slightly improve the electrical safety of this harvester and still not cause the GFCI to trip
(C) inserting a 100 W, 120 V rms, incandescent light bulb in series with either rod and the secondary will significantly improve the safety of this harvester since the bulb is acting as a fast-acting current "fuse"
(D) if the user of this device touches simultaneously both of the metal rods, not the handles, while the harvester is energized, the isolation transformer will significantly reduce the lethal nature of the resultant shock

8. Two coils of equal inductance are tightly wound around a high-permeability toroidal core as shown. Assume that all leakage inductances are negligible (the coefficient of coupling is one). For sinusoidal steady-state conditions, the ratio $V_L(\omega)/V_i(\omega)$ is closest to

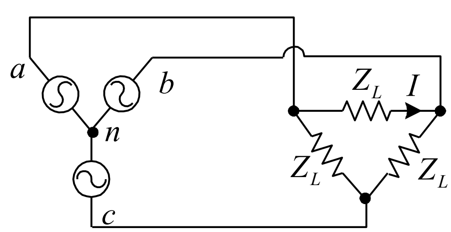


(A) 1
(B) 2
(C) $\dfrac{R_L}{R_L + j\omega L}$
(D) $\dfrac{R_L}{R_L + j\omega 2L}$

9. Rather than obtaining special permission from the FCC to use a jammer to reduce cell-phone communications inside an auditorium with many windows, an engineering consultant recommends attaching adhesive shielding film to all of the windows. According to the product specifications, about 70% of visible light is passed through this film while about 20 dB RF attenuation from 30 MHz to 4 GHz is obtained. The relative permeability of the film is about one, and the film has a conductivity of 25 Ω/□ or Ω/sq. Which of the following statements is most correct concerning this film's application?

   (A) this film provides about a factor of ten reduction in far-field electric fields
   (B) this film provides about a factor of ten reduction in near-field magnetic fields
   (C) this film should be connected to the nearest earth ground, preferably the safety of the nearest wall outlet, to improve significantly far-field radiation shielding
   (D) this film's far-field shielding effectiveness decreases as the window size increases since the film's conductivity per square increases with window size

10. For the balanced Y-Δ configuration shown where $f = 60$ Hz, $V_{an} = 120\angle 120^\circ$ V rms, $V_{bn} = 120\angle 0^\circ$ V rms, $V_{cn} = 120\angle -120^\circ$ V rms, and each load, Z_L, consists of a 2 Ω resistor in series with a 500 mH inductor, the current $i(t)$ is closest to



   (A) $0.9\cos\left(2\pi \times 60t - 120^\circ\right)$ A
   (B) $1.1\cos\left(2\pi \times 60t + 61^\circ\right)$ A
   (C) $1.6\cos\left(2\pi \times 60t + 61^\circ\right)$ A
   (D) $1.6\cos\left(2\pi \times 60t - 120^\circ\right)$ A

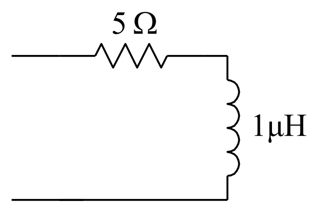
11. An emergency generator is required to power the following appliances:

    personal computer: 250 W, 120 V rms, P.F. = 0.7 capacitive
    refrigerator: 440 VA, 120 V rms, P.F. = 0.8 inductive
    sump pump: 1.2 kVA, 10 A rms, P.F. = 0.65 lagging

    These ratings are for continuous or steady-state operation. The worse-case power this generator must supply if 50% allowance is added for power surges AND only two of these appliances are run simultaneously is closest to

    (A) 1.4 kW
    (B) 1.7 kW
    (C) 2.1 kW
    (D) 2.8 kW

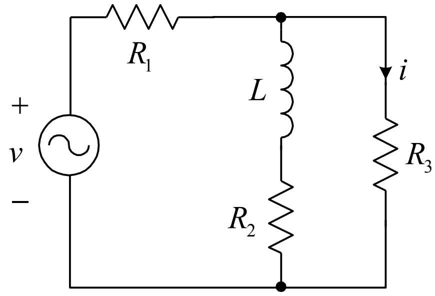
12. At low frequencies and small resistive loads, the input impedance for a lossless, short transmission line is modeled as a series *RL* circuit as shown.



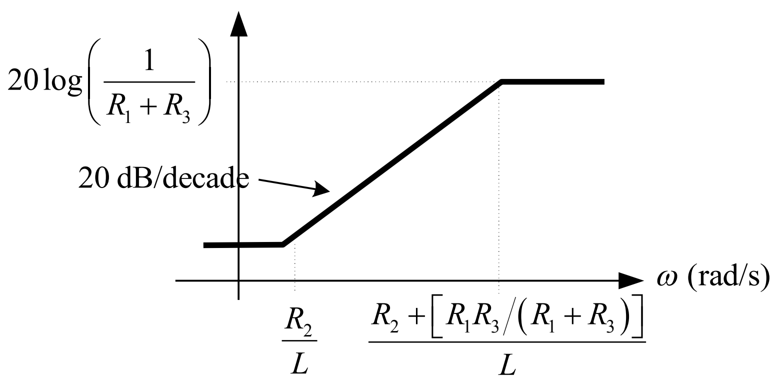
    A capacitor $C = 2\ \mu F$ is placed, in parallel, across the input of this transmission line in attempt to provide a more resistive input impedance from 1 kHz to 10 kHz. Which of the following statements is most true concerning this *RLC* circuit with this added capacitor?

    (A) the power factor for this *RLC* circuit has both lagging and leading values over the given frequency range
    (B) at 10 kHz the ratio of the power factor for this *RLC* circuit to the power factor for the original *RL* circuit is 0.9
    (C) the power factor is lagging for both this *RLC* circuit and for the original *RL* circuit at 1 kHz
    (D) the capacitor has reduced the power factor from about 1 to about 0.85 at 10 kHz

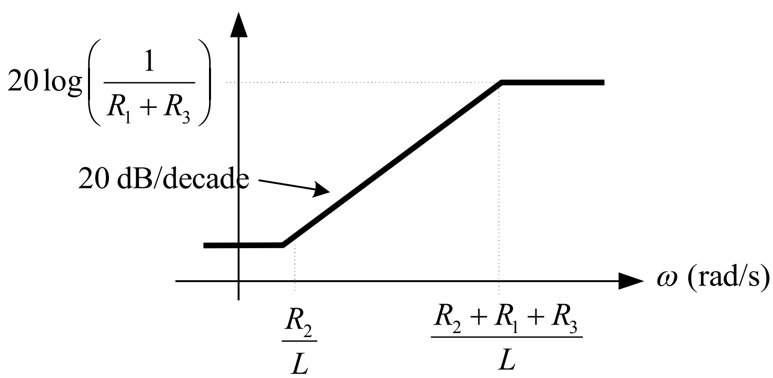
13. The Bode magnitude plot for the transfer function, $I(\omega)/V(\omega)$, for the given filter is closest to:



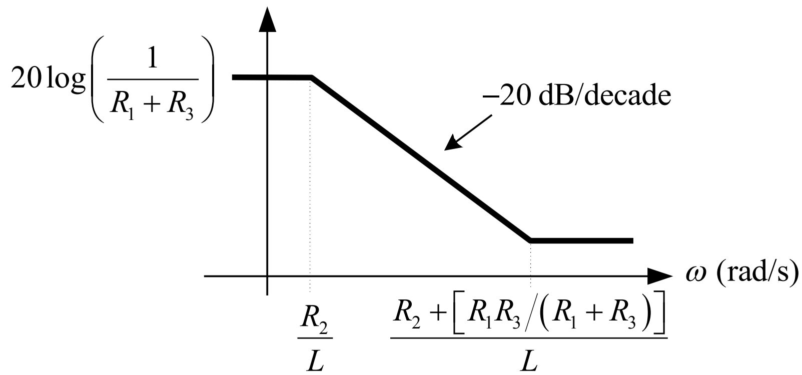
(A)



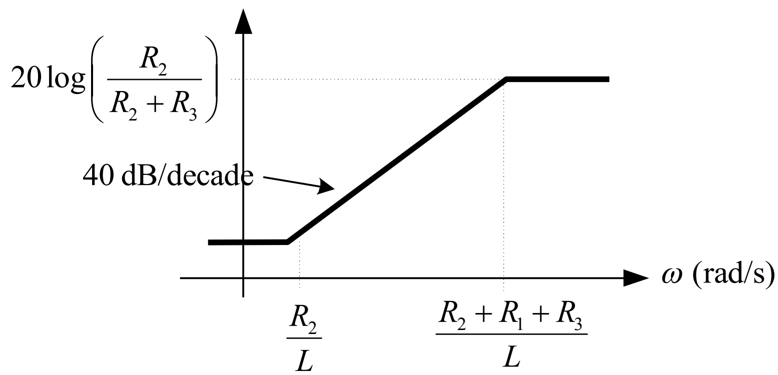
(B)



(C)


$20\log\left(\frac{1}{R_1+R_3}\right)$
−20 dB/decade
ω (rad/s)
$\frac{R_2}{L}$
$\frac{R_2+\left[R_1R_3/\left(R_1+R_3\right)\right]}{L}$

(D)


$20\log\left(\frac{R_2}{R_2+R_3}\right)$
40 dB/decade
ω (rad/s)
$\frac{R_2}{L}$
$\frac{R_2+R_1+R_3}{L}$

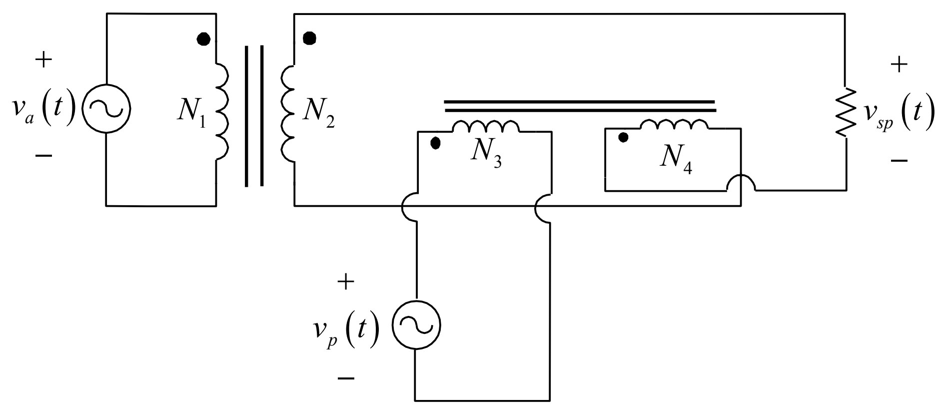
14. A simplified schematic of the audio stage of a vintage radio is shown. Assume that the two transformers are ideal and there is no coupling between these two transformers. As indicated, the corresponding number of turns for the primary and secondary sides of one transformer is N_1 and N_2, respectively, and the corresponding number of turns for the primary and secondary sides of the other transformer is N_3 and N_4, respectively. The source $v_a(t)$ represents the audio signal and the source $v_p(t)$ represents the partially filtered power supply signal. The total voltage, $v_{sp}(t)$, across the speaker is most nearly

(A) $v_a(t)\dfrac{N_2}{N_1} - v_p(t)\dfrac{N_4}{N_3}$

(B) $v_a(t)\dfrac{N_2}{N_1} + v_p(t)\dfrac{N_4}{N_3}$

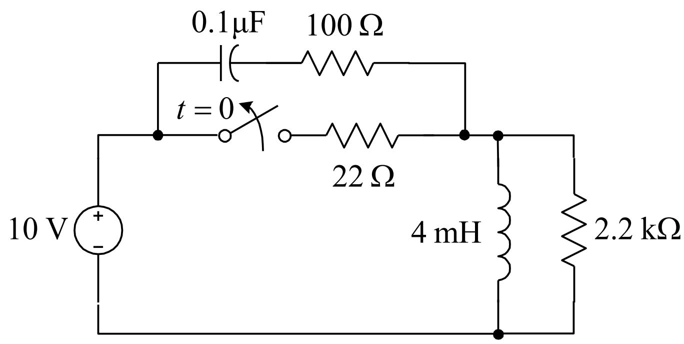
(C) $-v_a(t)\dfrac{N_2}{N_1} - v_p(t)\dfrac{N_4}{N_3}$

(D) $-v_a(t)\dfrac{N_2}{N_1} + v_p(t)\dfrac{N_4}{N_3}$

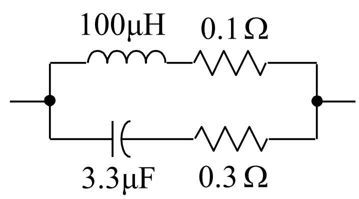


15. The following circuit has been sitting for a long time when suddenly at $t = 0$ the switch is opened. The magnitude of the voltage across the 4 mH inductor immediately after the switch is opened is closest to

(A) 21 μV
(B) 9.6 V
(C) 43 V
(D) 1000 V



16. Which of the following statements is most true concerning the given *RLC* circuit?



(A) if this circuit is inserted in series between a 100 MHz voltage source, with a 1 Ω equivalent resistance, and a 10 kΩ resistive load, then the resultant voltage attenuation due to this filter is greater than 10 dB (or a factor of about 3.2)
(B) the cutoff or break frequencies for the Bode magnitude of this circuit's impedance are approximately 160 Hz, 8.8 kHz, and 160 kHz
(C) the magnitude of this circuit's impedance much less than the lowest cutoff frequency is about 0.3 Ω and much greater than the highest cutoff frequency is about 0.1 Ω
(D) if the 0.1 Ω resistor in this circuit represents the resistance of the 100 μH inductor, then the *Q*, or quality factor, of this inductor would be considered high at 100 Hz

17. After a switch between an independent supply and a passive circuit closes at $t = 0$, the current through one element in the circuit is given by

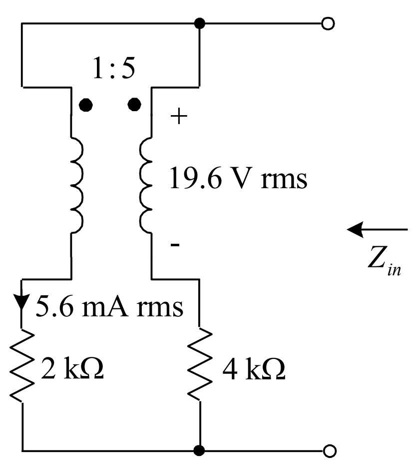
$$i_z(t) = \left(100e^{-5t} - 50e^{-100t} + 25\right) \text{ mA}$$

Which of the following statements in most true concerning this circuit and current?

(A) the circuit must contain at least one capacitor and one inductor to obtain this overdamped response
(B) after a long time, which would correspond to about 50 msec, the current is within 5% of its steady-state value
(C) this second-order circuit must contain at least one resistor and two energy storage elements
(D) there are two time constants for this current response, and the dominate time constant corresponds to the term $-50e^{-100t}$

18. For the given circuit the transformer is ideal with a 1:5 turns ratio. When energized by an external source, one measured voltage and current at 60 Hz is as shown. For this circuit, the input impedance, Z_{in}, is closest to

(A) 1.3 kΩ
(B) 3.4 kΩ
(C) 6.0 kΩ
(D) 22.4 kΩ



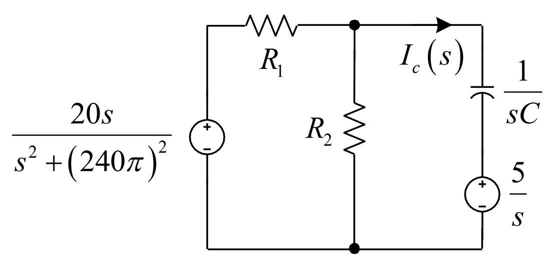
19. The frequency domain version of a circuit using Laplace transforms is shown. (The 5/*s* supply represents the capacitor's initial 5 V "charge.") The magnitude of the current through the capacitor at $t = 0^+$ is closest to

(A) $\frac{20}{R_1} - 5\left(\frac{R_1 + R_2}{R_1 R_2}\right)$

(B) $20\left(\frac{R_1 + R_2}{R_1 R_2}\right) - 5\left(\frac{R_1 + R_2}{R_1 R_2}\right)$

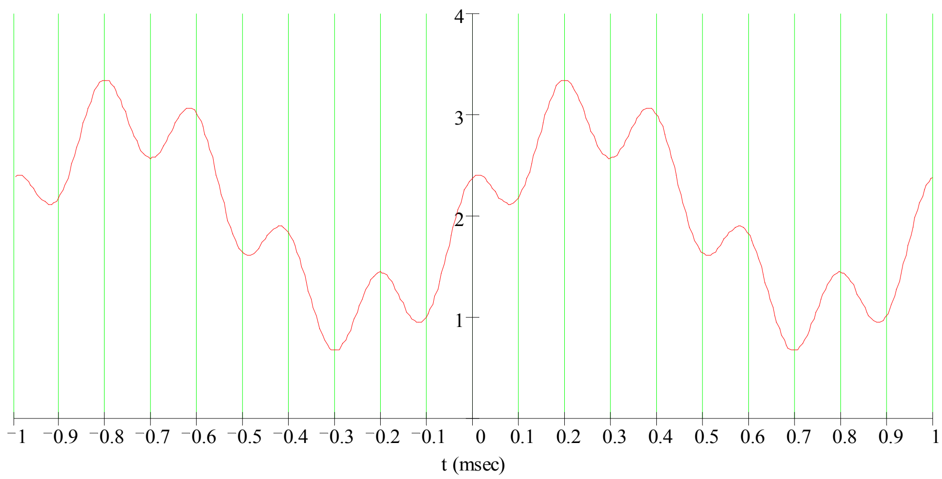
(C) $\frac{20}{R_1 + \frac{R_2 C}{R_2 + C}} - \frac{5}{C}$

(D) $\frac{20}{R_1}\left(\frac{C}{C + R_2}\right) - 5\left(\frac{R_1 + R_2}{R_1 R_2}\right)$



20. A specialized digitizer samples at nine (9) times the highest frequency of the input signal. Two periods of one particular input signal are shown. For this input signal, the sampling frequency for this digitizer is closest to

(A) 9 kHz
(B) 18 kHz
(C) 30 kHz
(D) 45 kHz



21. The voltage across a 2.2 kΩ resistor is given by

$$v(t) = -3 + 4\sqrt{2}\cos(120\pi t) - 6\cos(120\pi t + 30^\circ) + 2\cos(240\pi t + 45^\circ)\ \text{V}$$

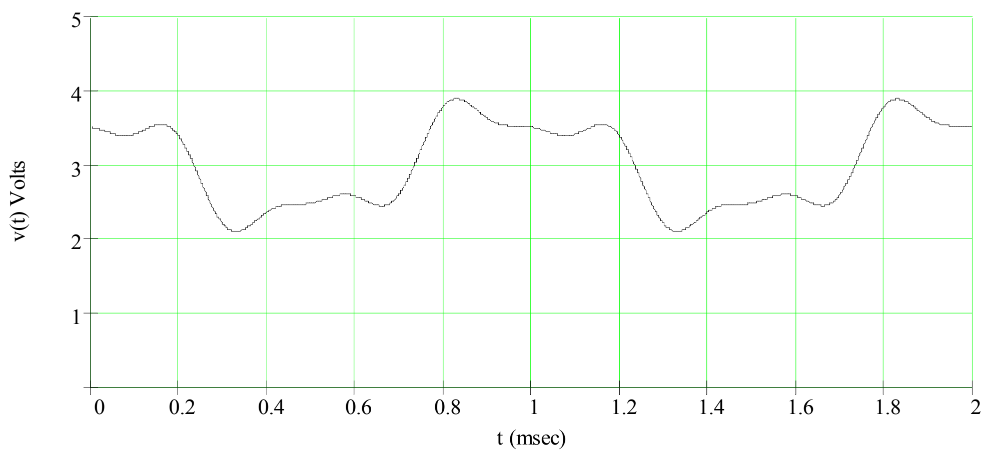
The total power absorbed by this resistor is closest to

(A) 5 mW
(B) 7 mW
(C) 10 mW
(D) 20 mW

22. The rating plate on a appliance indicates that for a supply voltage of 120 V rms at 60 Hz, 1.5 kVA is required. A wattmeter indicates that the actual power used by this appliance is 1.3 kW with the 120 V rms applied. Based on these specifications and this wattmeter reading, which of the following statements is <u>least</u> correct concerning this appliance?

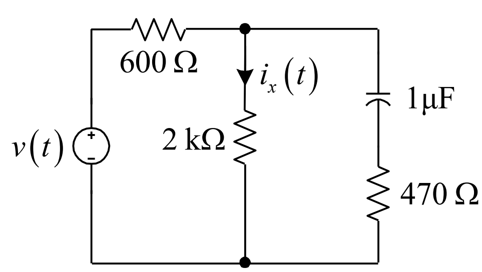
(A) the current drawn by this appliance is about 12.5 A rms
(B) the power required to operate this appliance is less than 1.5 kW since the appliance has a significant resistive component
(C) the power factor of this appliance is about 0.87
(D) the real power is less than the apparent power and the appliance is mostly resistive in nature

23. For the periodic source voltage $v(t)$ shown,



the average value for the current through the 2 kΩ resistor, $i_x(t)$, is closest to

(A) 0.07 mA
(B) 0.3 mA
(C) 1 mA
(D) 4 mA



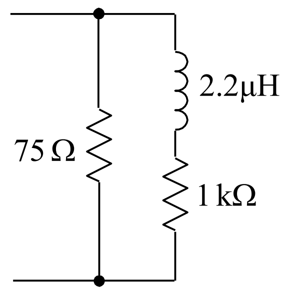
24. Two microminiature, shellac-insulated, copper conductors are uniformly twisted together to created an unshielded twisted-pair cable. The gauge of each copper conductor is 32 AWG and the thickness of the shellac coating is 2 mil. The high-frequency characteristic impedance of this twisted wire, neglecting losses, when surrounded by air is 100 Ω. This twisted-wire cable is used in an electronic surveillance system operating around 200 MHz. In order to help conceal this cable during this operation, it is inserted inside a long, straight, drywall crack with a depth of 25 mil. Which of the following statements is most true concerning this cable inside the dry wall?

    (A) the characteristic impedance of the cable inside the wall is greater than 100 Ω since the inductance per unit length has increased
    (B) the characteristic impedance of the cable inside the wall is greater than 100 Ω since the capacitance per unit length has decreased
    (C) the characteristic impedance of the cable inside the wall is less than 100 Ω since the capacitance per unit length has increased
    (D) the characteristic impedance of the cable inside the wall has not changed significantly since both the inductance and capacitance per unit length have increased by the same amount

25. A 12 inch long, 22 AWG copper wire is used as an antenna operating at 5 MHz. Which of the following statements is least true concerning this antenna?

    (A) plating the copper wire with 1 mil of gold will decrease the efficiency of the antenna
    (B) the skin depth for this copper wire is (essentially) the same if the wire size is increased to 20 AWG
    (C) the resistance of the antenna will increase if the wire length is increased to 16 inches and the wire size changed to 24 AWG
    (Δ) the ratio of the ac resistance to the dc resistance of this wire is about 50

26. Due to a strong electrostatic discharge, a transient surge with a peak value of 300 V is created across the input of low-loss transmission line with a characteristic impedance of 75 Ω, capacitance of 60 pF/m, and length of 11 m. This transient voltage surge has the shape of a double exponential with an approximate rise time of 1 ns, fall time of 20 ns, and pulse width of 0.2 ms. The output of this transmission line is connected to a load that can be modeled by the following circuit:



For this situation, assuming the breakdown strength of the cable is much greater than 300 V, which of the following statements is most true?

(A) the peak current to the entire load is about 4 A and the time required for the surge to appear at the load is about 50 ns
(B) the minimum current through the 1 kΩ portion of the load is about 0.3 A and for this transient surge the magnitude of the transmission coefficient for the entire load is about 1
(C) the reflection of the surge off the load is substantial with a peak voltage magnitude of about 300 V
(D) the rms value of the voltage across the entire load is about 212 V

27. The voltage of a 20 MHz signal across a 1 kΩ resistor on a printed circuited board is measured using a portable, differential, dc-powered oscilloscope. The low-loss cable used to connect the oscilloscope to the board is labeled as 50 Ω, with a nominal velocity of 84% of the speed of light. The input of the oscilloscope can be modeled as a 1 MΩ resistor in parallel with a 20 pF capacitor. Assume the lead lengths on both ends of the cable are very short compared to the length of the cable. For this situation, which of the following statements is most true?

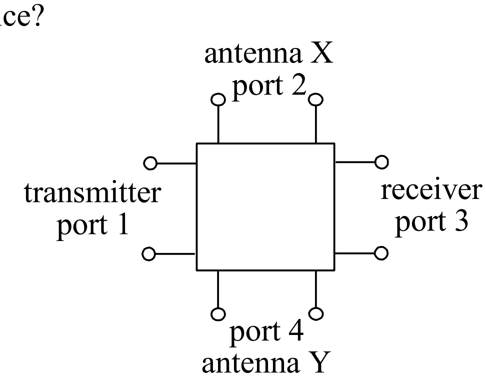
(A) the voltage measured by the oscilloscope is essentially the same as the actual voltage across the 1 kΩ resistor for lead lengths less than 6 m
(B) the loading effect of the cable and oscilloscope on this measurement is negligible for line lengths less than 1.26 m
(C) if the cable length is 6.3 m, the input impedance of the cable, seen by the 1 kΩ resistor, is approximately -*j*400 Ω

(D) if the capacitance of the oscilloscope is neglected, for cable lengths up to 12.6 m the input impedance of the cable is approximately 50 Ω in parallel with 1 MΩ

28. Shown is a reciprocal, 4-port, microwave device designed to connect a transmitter and receiver to two antennas. For matched loads with this device

1) the insertion loss between the transmitter and both antennas is 0.8 dB
2) the isolation between the transmitter and receiver is 25 dB
3) the insertion loss between the receiver and antenna X is 0.8 dB
4) the isolation between the receiver and antenna Y is 14 dB
5) the isolation between antennas X and Y is 10 dB

The VSWR for each port is 1.3 for a 50 Ω reference impedance. Which of the following matrices best describes the magnitude of the *s* parameters for this microwave device?



(A) $\begin{bmatrix} 0.13 & 1.1 & 18 & 1.1 \\ 1.1 & 0.13 & 1.1 & 3.2 \\ 18 & 1.1 & 0.13 & 5 \\ 1.1 & 3.2 & 5 & 0.13 \end{bmatrix}$

(B) $\begin{bmatrix} 1.3 & 1.1 & 18 & 1.1 \\ 1.1 & 1.3 & 1.1 & 3.2 \\ 18 & 1.1 & 1.3 & 5 \\ 1.1 & 3.2 & 5 & 1.3 \end{bmatrix}$

(C) $\begin{bmatrix} 0.13 & 18 & 18 & 18 \\ 1.1 & 0.13 & 5 & 3.2 \\ 18 & 1.1 & 0.13 & 5 \\ 1.1 & 3.2 & 5 & 0.13 \end{bmatrix}$

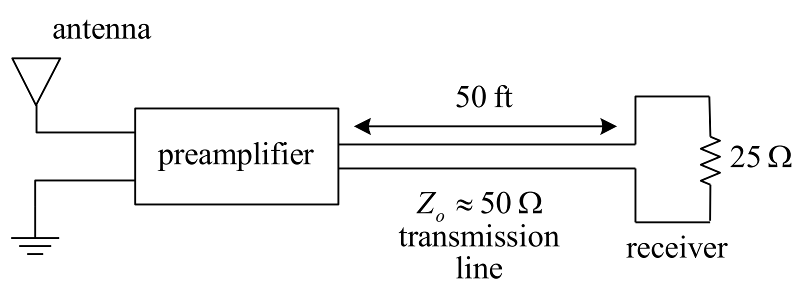
(D) $\begin{bmatrix} 0 & 1.1 & 18 & 1.1 \\ 1.1 & 0 & 1.1 & 3.2 \\ 18 & 1.1 & 0 & 5 \\ 1.1 & 3.2 & 5 & 0 \end{bmatrix}$

29. A preamplifier is connected between an antenna and a receiver as shown. The receiver is connected to the preamplifier via a transmission line with an approximate characteristic impedance of 50 Ω, length of 50 ft, nominal velocity of 79% of the speed of light, and matched loss of 20 dB/100 ft. The input impedance of the receiver is about 25 Ω. The *s* parameters for the preamplifier, based on a 50 Ω reference impedance, are given by

$$\begin{bmatrix} 0.08\angle -18^\circ & 0.049\angle 52^\circ \\ 12\angle 140^\circ & 0.91\angle -4.1^\circ \end{bmatrix}$$

Assuming the operating frequency is 0.9 GHz, if the voltage across the input of the preamplifier is 0.01 mV rms, the voltage across the receiver is closest to

(A) 0.25 μV rms
(B) 2.5 μV rms
(C) 25 μV rms
(D) 250 μV rms



30. A two-conductor cable, 30 ft in length, is used to connect a sensor to an amplifier. The measured total capacitance of this cable is 182 pF while the measured surge or characteristic impedance of this cable at 5 kHz is 282 − *j*282 Ω. If the input impedance of the amplifier is 10 kΩ, the input impedance seen by the sensor looking into the cable at 5 kHz is closest to

(A) 282 − *j*282 Ω
(B) 282 − *j*175,000 Ω

(C) $10{,}000 - j570\ \Omega$
(D) $10{,}282 - j282\ \Omega$

31. An antenna with an impedance of $30 - j20\ \Omega$ at 30 MHz is connected to a 30 MHz transmitter through a low-loss transmission line with a characteristic impedance of 75 Ω and nominal velocity of $2.2\text{x}10^8$ m/s. In order for the transmitter to function properly, the magnitude of the input impedance of the transmission line seen by the transmitter must be greater than 40 Ω but less than 250 Ω. Which of the following statements is most true concerning this scenario?

(A) for line lengths less than 7.4 m, the magnitude of the input impedance is always greater than 40 Ω and less than 250 Ω
(B) for line lengths greater than 7.4 m, the magnitude of the input impedance is always greater 40 Ω but possibly greater than 250 Ω
(C) for line lengths less than 3.7 m, the magnitude of the input impedance is always greater than 40 Ω and always less than 250 Ω
(D) for line lengths greater than 3.7 m, the magnitude of the input impedance is possibly less than 40 Ω but always less than 250 Ω

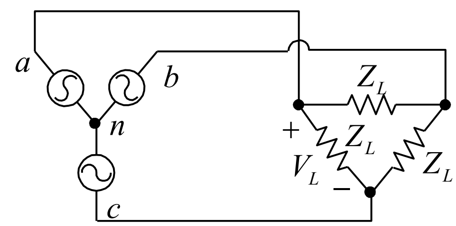
32. A portable compressor is connected to an outlet with a measured voltage of 117 V rms through a two-conductor extension cord with a total 60 Hz impedance of $0.1 + j\,0.05\ \Omega$. The compressor is rated at 1 kW with a power factor is 0.84. During steady-state operation, the line voltage at the compressor dips or sags by 12% relative to the measured outlet voltage. The real power dissipated by the extension cord during steady-state operation, assuming the compressor draws 1 kW, is most nearly

(A) 7 W
(B) 9 W
(C) 13 W
(D) 15 W

33. The measured current to and voltage across a product with a 500 W rating are 5 A rms and 120 V rms, respectively. After a 20 μF capacitor is connected across the hot and neutral power inlet of this product, the new current to the product including this additional capacitor is 4.6 A rms. Based on this information, and assuming the power line frequency is 60 Hz, the power factor of the product with this added capacitor is closest to

(A) 0.83 lagging or 0.83 leading
(B) 0.75 lagging or 0.75 leading
(C) 0.91 lagging
(D) 0.91 leading

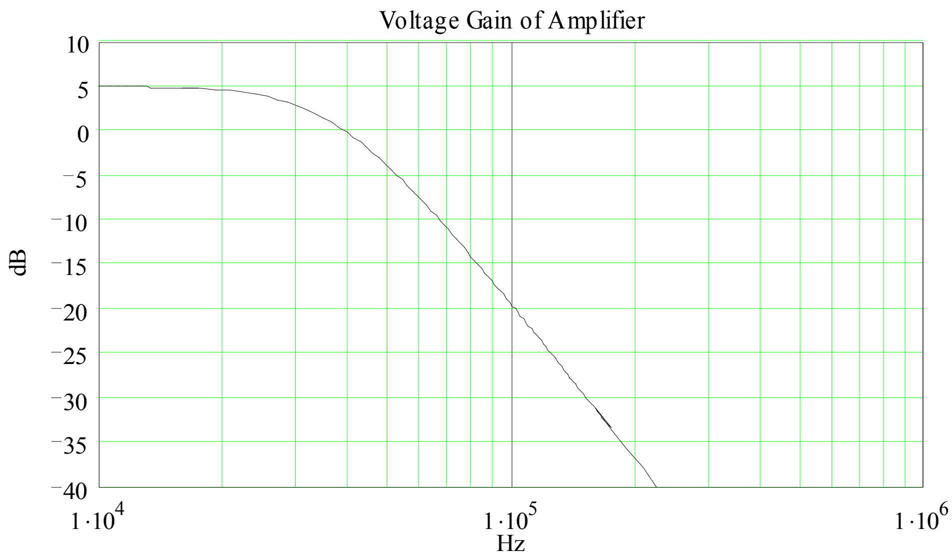
34. For the Y-Δ configuration shown where $f = 60$ Hz, $V_{an} = 120\angle 120^\circ$ V rms, $V_{bn} = 120\angle 0^\circ$ V rms, $V_{cn} = 120\angle -120^\circ$ V rms, and each load, Z_L, consists of a 1 kΩ resistor in parallel with a 22 mF capacitor.



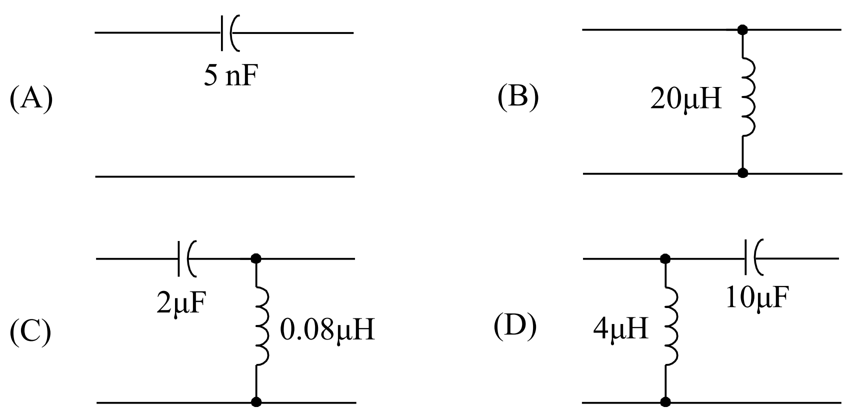
Due to a blown fuse, a winding failure occurs with V_{cn} resulting in an open circuit for this phase of the Y. The ratio of the the rms voltage of V_L, shown in the figure, before the failure to the rms voltage of V_L after the failure is closest to

(A) $1/\sqrt{3}$
(B) 1
(C) $\sqrt{3}$
(D) 2

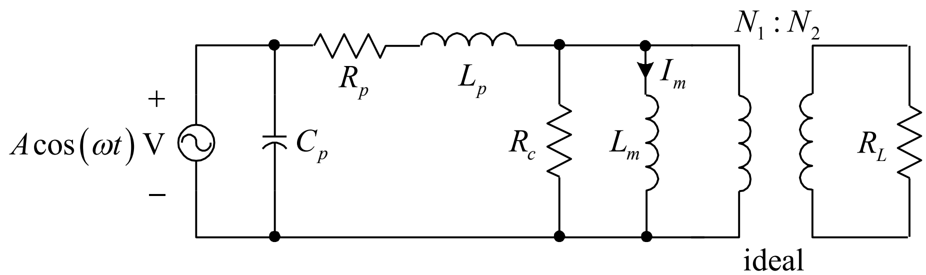
35. The Bode magnitude plot for the voltage gain of an amplifier with a Thevenin output impedance of approximately 2 Ω when connected to a 10 kΩ load is shown.



Which of the following filters inserted between the amplifier and load will best equalize the magnitude response (i.e., approach a uniform or flat response with frequency) from 30 kHz to 200 kHz? The influence of the filter on the phase response of the amplifier should be neglected.



36. A model for a real transformer is shown. It contains an ideal transformer with the given turns ratio, parasitic capacitance, leakage inductance, core losses, winding losses, and magnetizing inductance. For sinusoidal steady-state conditions, the frequency-domain expression for the current, I_m, through the magnetizing inductance, L_m, is best described by



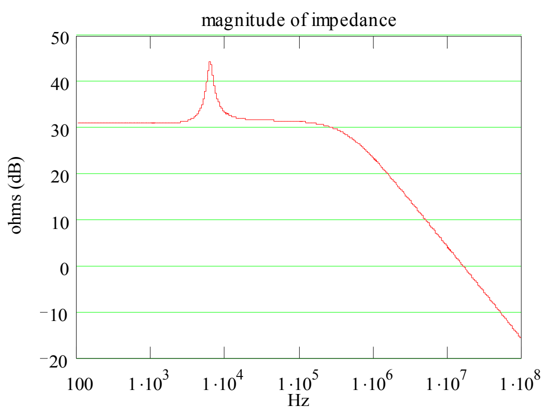
(A) $$\frac{-jR_pR_cA}{\left\{\left[\omega L_mR_LR_c+\omega L_pR_LR_c+\omega L_mR_pR_c\left(\frac{N_2}{N_1}\right)^2+\omega L_mR_pR_L\right]+j\left[\omega^2L_pL_mR_c\left(\frac{N_2}{N_1}\right)^2+\omega^2L_pL_mR_L-R_pR_cR_L\right]\right\}}$$

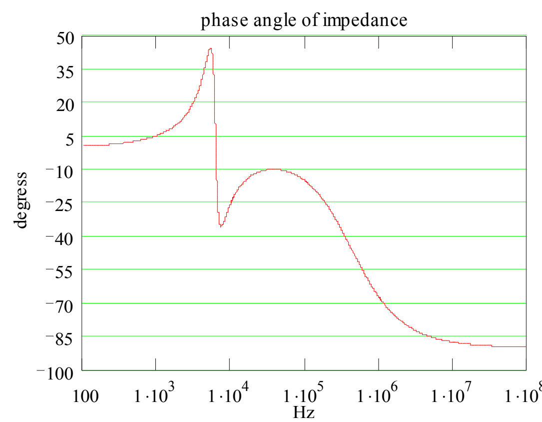
(B) $$\frac{-jC_pR_cR_LA}{\left\{\left[\omega L_mR_LR_c+\omega L_pR_LR_c+\omega L_mR_pR_c\left(\frac{N_2}{N_1}\right)^2+\omega L_mR_pR_L\right]+j\left[\omega^2L_pL_mR_c\left(\frac{N_2}{N_1}\right)^2+\omega^2L_pL_mR_L-R_pR_cR_L\right]\right\}}$$

(C) $$\frac{-j\omega R_LR_cA}{\left\{\left[\omega L_mR_LR_c+\omega L_pR_LR_c+\omega L_mR_pR_c\left(\frac{N_2}{N_1}\right)^2+\omega L_mR_pR_L\right]+j\left[\omega^2L_pL_mR_c\left(\frac{N_2}{N_1}\right)^2+\omega^2L_pL_mR_L-R_pR_cR_L\right]\right\}}$$

(D) $$\frac{-jR_cR_LA}{\left\{\left[\omega L_mR_LR_c+\omega L_pR_LR_c+\omega L_mR_pR_c\left(\frac{N_2}{N_1}\right)^2+\omega L_mR_pR_L\right]+j\left[\omega^2L_pL_mR_c\left(\frac{N_2}{N_1}\right)^2+\omega^2L_pL_mR_L-R_pR_cR_L\right]\right\}}$$

37. The magnitude in dB (using the definition $20\log|Z(f)|$) and phase in degrees of the impedance, $Z(f)$, for one element in a passive bandpass filter are provided from 100 Hz to 100 MHz. Based on these two plots over the given frequency range, which of the following statements concerning this element is least correct?





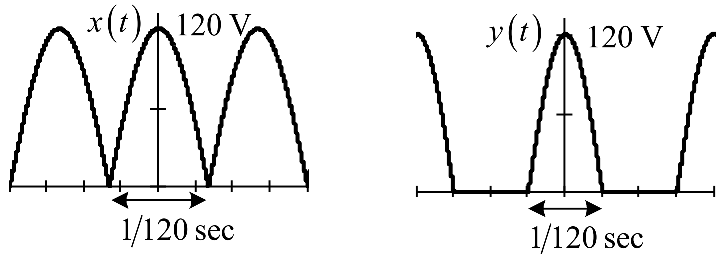
(A) this circuit model for this element is at least third order with inductance, capacitance, and resistance but with only one resonant frequency at about 6 kHz

(B) the bandwidth of the response near the maximum value of the impedance's magnitude is less than 5 kHz

(C) for frequencies less than about 1 kHz the element can be reasonably modeled as a 35 Ω resistor and for frequencies greater than about 10 MHz this element can be reasonably modeled as a 0.01 μF capacitor

(D) the quality factor or Q for this element away from resonance at 1 MHz is about 10

38. The full-wave rectified 60 Hz signal of a power supply is shown as $x(t)$. To reduce the amplitude of one or more harmonic components of this rectified signal that are a source of interference, the half-wave rectified version of this signal shown as $y(t)$ is suggested. Which of the following statements is most correct concerning these two signals:



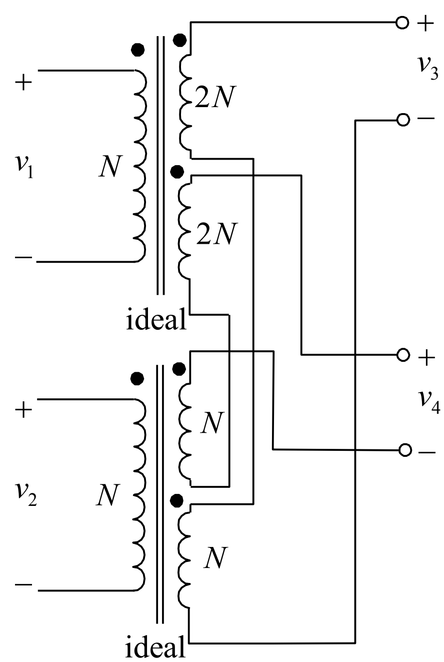
(A) $x(t)$'s 180 Hz harmonic component is greater than $y(t)$'s 180 Hz harmonic component
(B) the fundamental frequency of $x(t)$ is 60 Hz while the fundamental frequency of $y(t)$ is 120 Hz
(C) the average value of $x(t)$ is less than the average value of $y(t)$
(D) the amplitude of $y(t)$'s 120 Hz harmonic component is less than the amplitude of $x(t)$'s 120 Hz fundamental component

39. The measured low-frequency values of three inductors in isolation are 1.6 mH, 0.8 mH, and 0.5 mH. When these three inductors are connected in series with the polarity positions shown, with any separation and orientation relative to each other, the maximum possible total low-frequency measured inductance, L_{tot}, is closest to (neglecting the inductance of the leads and connecting wire)

(A) 0.11 mH
(B) 0.3 mH
(C) 2.9 mH
(D) 4.2 mH

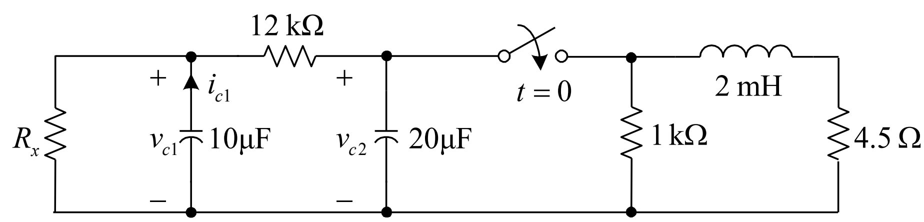
40. The given circuit, which involves ideal transformers, is used to combine two low-frequency sensor signals. The relationship between these input sensor voltages, v_1 and v_2, and the output voltages v_3 and v_4 is given by

(A) $v_3 = 2v_1 - v_2,\ v_4 = 2v_1 - v_2$
(B) $v_3 = 2v_1 + v_2,\ v_4 = 2v_1 + v_2$
(C) $v_3 = 2v_1 + v_2,\ v_4 = 2v_1 - v_2$
(D) $v_3 = 2v_1 - v_2,\ v_4 = 2v_1 + v_2$

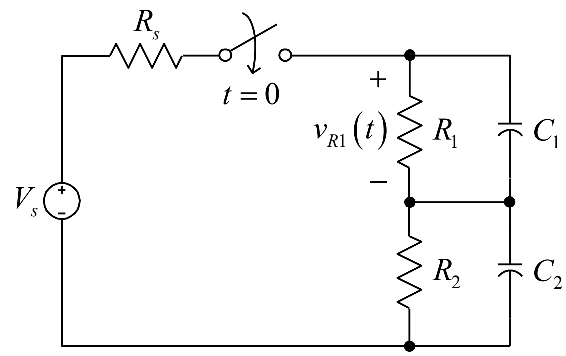


41. Immediately before the switch closes at $t = 0$, the current through the 2 mH inductor is zero and the voltages across the two capacitors are $v_{c1}(0^-) = 80$ V and $v_{c2}(0^-) = 100$ V. The closest value for the resistor R_x so that the current i_{c1} is between 2 mA and 2.5 mA immediately after the switch closes is

(A) 7.5 kΩ
(B) 20 kΩ
(C) 35 kΩ
(D) 150 kΩ



42. In the given figure, the insulation or dielectric resistance of the capacitors C_1 and C_2 are modeled by the resistors R_1 and R_2, respectively. If the voltage across each of these capacitors is zero before the switch closes at $t = 0$, the voltage across the dielectric resistance R_1, $v_{R1}(t)$, for $t > 0$ and the given parameters, is closest to



$V_s = 12$ V
$R_s = 120\ \Omega$
$R_1 = 100$ kΩ
$C_1 = 20\mu$F
$R_2 = 200$ kΩ
$C_2 = 50\mu$F

(A) $v_{R1}(t) = 4 - 4e^{-\frac{t}{2}}$ V

(B) $v_{R1}(t) = 4.6e^{-\frac{t}{4.7}} - 8.6e^{-580t} + 4$ V

(C) $v_{R1}(t) = -12e^{-0.5t}\cos(290t) + 8.6e^{-0.1t}\sin(290t) + 12$ V

(D) $v_{R1}(t) = -4e^{-0.5t}\cos(290t) - 8.6e^{-0.1t}\sin(290t) + 4$ V

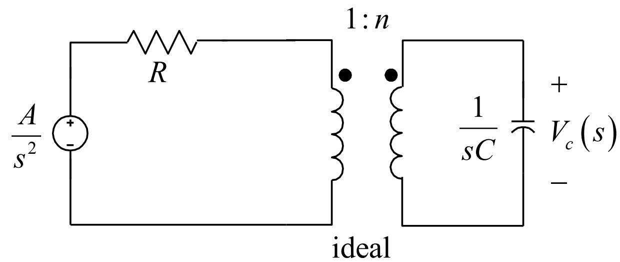
43. The frequency-domain version of a circuit using Laplace transforms is shown. (The transformer is ideal, and the initial voltage across the capacitor is zero.) The time-domain voltage across the capacitor, $v_c(t)$, is best described by

(A) $v_c(t) = Antu(t)$

(B) $v_c(t) = Ant\left(1 - e^{-RCn^2t}\right)u(t)$

(C) $v_c(t) = ARCn^2\left(e^{-RCnt} + \dfrac{1}{RCn}t - 1\right)u(t)$

(D) $v_c(t) = ARCn^3\left(e^{-\frac{t}{RCn^2}} + \dfrac{1}{RCn^2}t - 1\right)u(t)$


1 : n
R
A/s^2
1/sC
+
V_c(s)
−
ideal

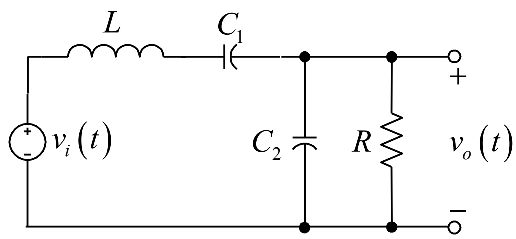
44. A model for piezoelectric sensor for a guitar pickup is shown where $v_i(t)$ is the pickup voltage from one string of the guitar and $v_o(t)$ is the output voltage to be amplified. This sensor is normally used below the highest resonant frequency of this circuit, as viewed from the unloaded output. This highest resonant frequency in Hz is equal to

(A) $f_o = \frac{1}{2\pi\sqrt{LC_1}}$

(B) $f_o = \frac{1}{2\pi\sqrt{LC_2}}$

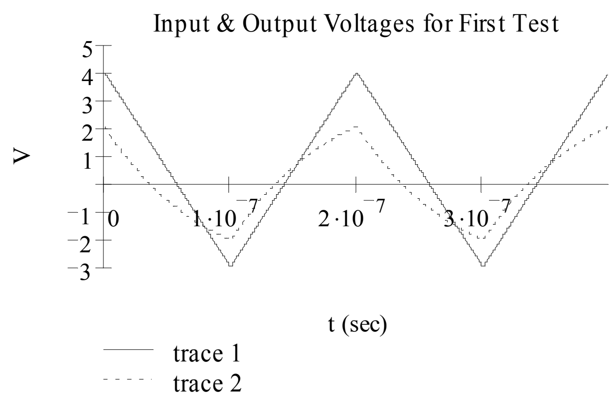
(C) $f_o = \frac{1}{2\pi}\sqrt{\frac{C_1 + C_2}{LC_1C_2}}$

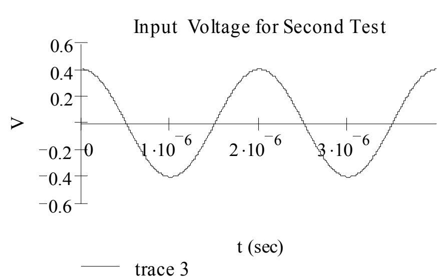
(D) $f_o = \frac{1}{2\pi}\sqrt{\frac{1}{L(C_1 + C_2)} - \frac{1}{RC_2}}$

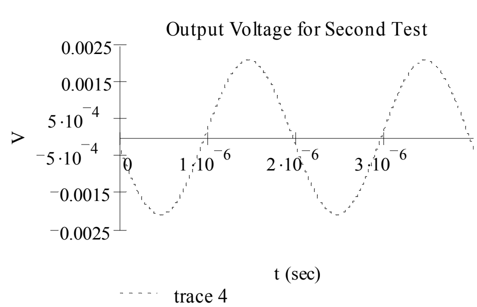


45. A two-port, sealed passive filter with unknown properties has one port labeled "input" and the other port labeled "output." To help determine some of the properties of this filter, the periodic voltage signal (trace 1) is applied across the input and the corresponding output voltage (trace 2) is measured using an oscilloscope. Then, a new periodic voltage signal (trace 3) with a different fundamental frequency is applied across the input and the corresponding output voltage (trace 4) is measured using the same oscilloscope. Assuming the Thevenin impedance of the input voltage source is 0.1 Ω and the input impedance of the oscilloscope is 1 MΩ, which of the following statements concerning this filter is most true based on these limited test results?

(A) low-pass filter with an attenuation rate of 20 dB/dec above the mean cutoff frequency and an insertion loss of 5 dB dB at 5 MHz
(B) low-pass filter with an attenuation rate of 40 dB/dec above the mean cutoff frequency and an insertion loss of 200 dB at 500 kHz
(C) high-pass filter with an attenuation rate of 20 dB/dec below the mean cutoff frequency and an insertion loss of 1.8 dB dB at 5 MHz
(D) high-pass filter with an attenuation rate of 40 dB/dec below the mean cutoff frequency and an insertion loss of 46 dB at 500 kHz







46. A 2.4 GHz wireless router with an output power of 50 mW (when connected to a 50 Ω load) is connected to a remote 95% efficient, antenna through 5 meters of 50 Ω transmission line. The internal impedance of the router is 0.3 Ω. Assume the antenna at this frequency has an input impedance of 50 Ω with a directivity of 2.3 dB. At 2.4 GHz, the 50 Ω transmission line between the router and antenna has an attenuation loss of 0.3 dB/m and a leakage loss (power loss through the braiding of the outer conductor) of 0.1 dB/m. The maximum ERP (relative to an isotropic antenna) from the antenna is most close to

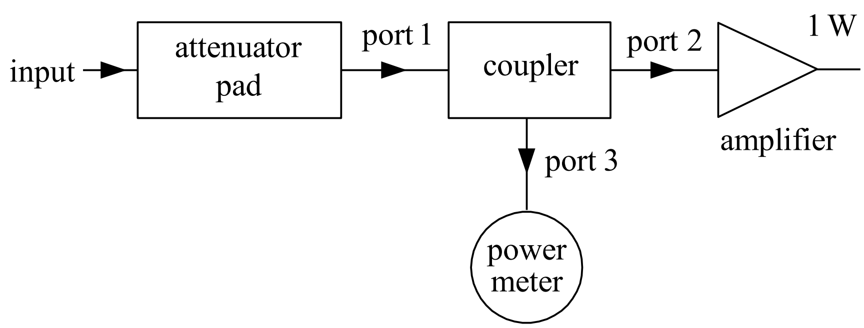
(A) 50 mW
(B) 74 mW
(C) 81 mW
(D) 85 mW

47. A 200 MHz signal source is connected directly to a transmitting antenna with a directivity of 4 dBi and an efficiency of 85%. A receiving antenna, located 100 m away in free space, has a directivity of 9 dBi with a high efficiency (assume 100%). This receiving antenna is connected to a repeater via a 20 m long 50 Ω transmission line with a loss of 5 dB/100 m. The repeater is matched to the 50 Ω transmission line. The gain of the repeater is 40 dB at 200 MHz. The output of the repeater when connected to a wattmeter reads 2 mW for this 200 MHz signal. Assuming the antennas are oriented for maximum signal transmission and reception, and the effects of any reflections are neglected, the output power transmitted by the 200 MHz signal source is closest to

(A) 6.6 nW
(B) 0.59 mW
(C) 6.6 mW
(D) 11 mW

48. The measured power at the output of the given amplifier with a gain of 25 dB at 200 MHz is 1 W as shown. At this same frequency, the insertion loss between port 1 and port 2 of the unidirectional coupler is 1.3 dB while the insertion loss between port 1 and port 3 of the unidirectional coupler is 6.3 dB. The attenuator pad shown has a loss of 3.7 dB. From this information, the best estimates for the input power to the attenuator pad and the power at the meter (port 3), assuming matched conditions, are

(A) "input" = 0.1 mW, "power meter" = 10 mW
(B) "input" = 1.0 mW, "power meter" = 0.74 mW
(C) "input" = 10 mW, "power meter" = 1.0 mW
(D) "input" = 100 mW, "power meter" = 32 mW

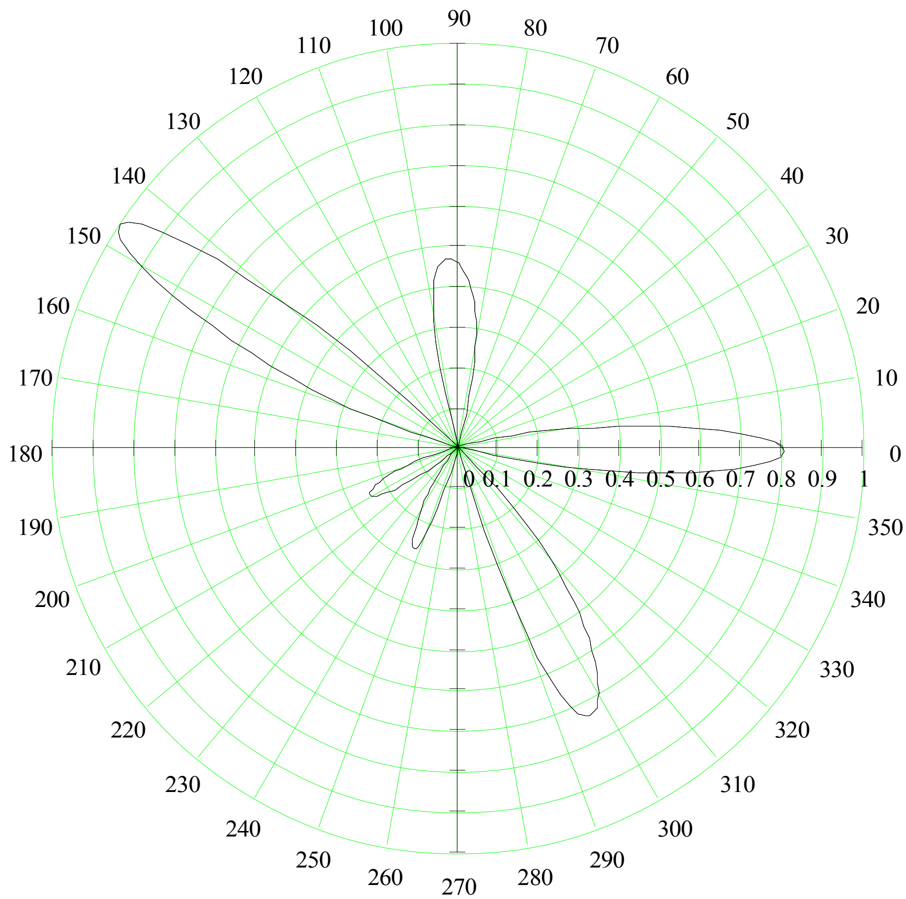


49. A small loop antenna designed for a 200 MHz receiver has a radius of 3 inches and is constructed with #18 AWG copper wire. This loop has an inductance of 0.5 μH, a shunt capacitance of 2 pF, and total resistance, including both ohmic and radiation resistances, of 4 Ω. Which of the following statements is least correct concerning this antenna when unloaded?

(A) the quality factor of this antenna is considered high with a value of about 90 at 200 MHz
(B) adding 4 pF of capacitance across (or in shunt with) this loop will decrease the loop's lowest resonant frequency
(C) assuming that the total resistance does not significantly change, the input impedance at 100 MHz is mainly capacitive in nature
(D) at the lowest resonant frequency, the impedance bandwidth of this antenna will decrease if the loop is constructed of #16 AWG wire instead of #18 AWG wire

50. The normalized, measured, horizontal, radiation pattern, in V/m, of a transmitting antenna operating at 145 MHz is shown. At the center of the major lobe, the measured maximum value of the electric field is 0.5 V/m rms at a distance of 300 m from the antenna and in the same horizontal plane as the antenna. At a distance of 40 m from the antenna and in the same horizontal plane as the antenna, the maximum magnitude of the electric field at either of the half-power beamwidth locations of the lobe centered at $\phi = 0^\circ$ is closest to

(A) 2.2 V rms
(B) 2.7 V rms
(C) 3.0 V rms
(D) 3.8 V rms

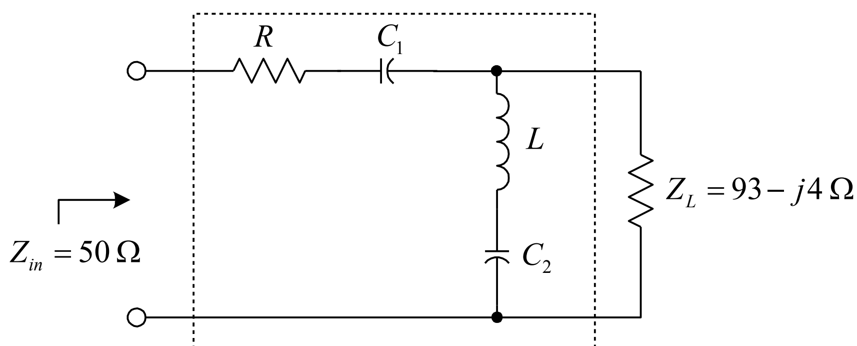


51. A 2 GHz transmitter with an output power of 120 W is connected to a transmitting antenna with a directivity of 9 dBd and an efficiency of 95%. The receiving antenna has a directivity of 12 dBi with an efficiency of 97%. Assuming free-space conditions between these two antennas, the path loss between these two antennas is calculated to be 82 dB. If the distance between these two antennas is halved, the new path loss between these two antennas is closest to

(A) 41 dB
(B) 59 dB
(C) 76 dB
(D) 80 dB

52. The following lossless impedance matching network is used to cause the input impedance, Z_{in}, to be purely real and equal to 50 Ω at 13 MHz when a complex load impedance, $Z_L = 93 - j4\,\Omega$, is connected to the network's output as shown. Assume C_1 = 0.5 μF. Which of the following statements is least true concerning this matching network?

(A) the sum of L and C_2's reactances must be greater than zero
(B) the value of L will decrease when R increases from 0 Ω to 20 Ω
(C) compared to an R value of 0 Ω, an R value of 20 Ω will have a "flatter" input impedance magnitude frequency response around 13 MHz
(D) if L is zero, then there is at least one real value for R and C_2 that will provide the required 50 Ω input impedance



impedance matching network

PRINCIPLES AND PRACTICE OF ENGINEERING SAMPLE TEST ANSWERS FOR POWER EXAM AND ELECTRICAL AND ELECTRONICS EXAM

Created by

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Reasonable efforts have been made to publish reliable answers for the sample test questions, but the author cannot assume responsibility for the validity of all answers and for the consequence of their use.

Answer Sheet

1. C, 2. B, 3. A, 4. C,5. D, 6. C, 7. B, 8. B, 9. A, 10. C, 11. B, 12. D, 13. A, 14. A, 15. C, 16. B, 17. C, 18. B, 19. A, 20. D, 21. B, 22. B, 23. C, 24. C, 25. D, 26. A, 27. C, 28. A, 29. C, 30. C, 31. D, 32. C, 33. C, 34. D, 35. C, ,36. D, 37. D, 38. D, 39. D, 40. C, 41. B, 42. B, 43. D, 44. C, 45. D, 46. A, 47. D, 48. C, 49. C, 50. A, 51. C, 52 D