PRINCIPLES AND PRACTICE OF ENGINEERING ELECTRICAL AND COMPUTER ENGINEERING BREADTH MORNING SAMPLE TEST

Created by

Kenneth L. Kaiser, P.E., Ph.D.

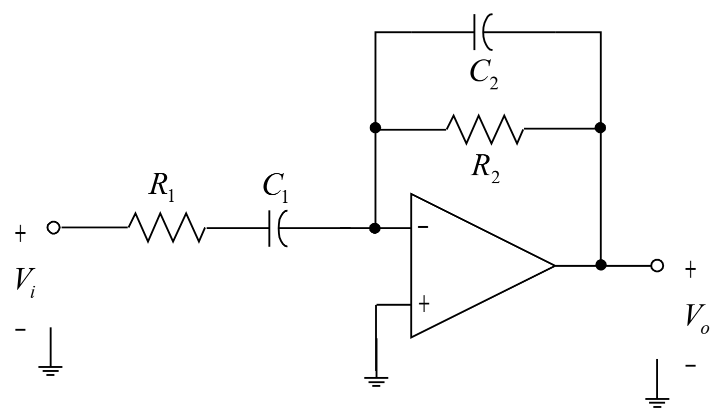
Professor ECE Department
Kettering University
Flint, MI

Introduction

When preparing for the Professional Engineering (PE) test, I found it valuable to work as many sample PE tests as possible (independent of their source, time of creation, or problem style). Having taken and passed the PE test (in 2006), I thought it would be appropriate to add to this pool of tests. The following sample test is my first contribution to this collection. As with the actual PE test that I took, it is in "quick-answer" multiple-choice format. The style, content, and difficulty of the problems are based on the sample test and examination specifications provided by the NCEES (dated 2001). This sample test is not endorsed by any agency (including NCEES) and is intended as a study aid. It is provided free-of-charge (but may not be sold, modified, or DISTRIBUTED in any form without my written consent).

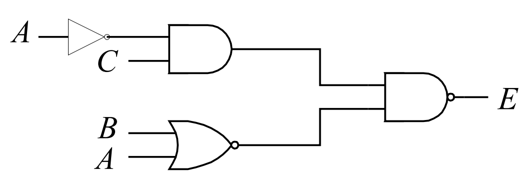
As is stated in NCEES's sample test dated 2001, "No representation is made or intended as to future questions, content, or subject matter." Any relationship of these sample questions to actual test questions is purely coincidental. Study hard and good luck.

101. For the circuit shown, the magnitude of the response $H(\omega) = V_o(\omega)/V_i(\omega)$ is most nearly:



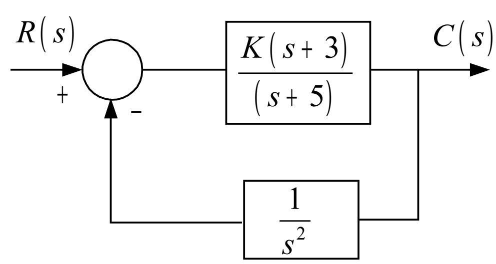
(A) high pass
(B) low pass
(C) band pass
(D) band reject

102. The expression for *E* in the given circuit is (all inputs and output are high asserting):



(A) $\bar{A}C(A+B)$
(B) $A+B+\bar{C}$
(C) $(A+B)(\bar{A}+C)$
(D) $A+B+C$

103. If *K* is restricted to positive values only for the system shown, the range of *K* for the system to be stable is:

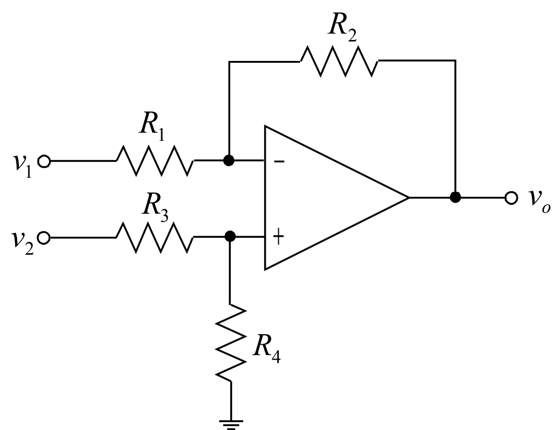


(A) $K < 3/5$
(B) $K > 0$
(C) $K > 3/5$
(D) no positive values of K exist for this system to be stable

104. It is common in industrial plants to place capacitance across large horsepower motors. The most likely reason for this is to:

(A) increase the current on the line leading to the motors
(B) increase the overall reactive power in VARS for the plant
(C) improve the power factor for the plant
(D) reduce the losses inherent in the parasitic capacitance of the motors

105. For the circuit shown, the expression for the output voltage is (assuming the amplifier is operated in its linear range)



(A) $v_o = -v_1\left(\frac{R_2}{R_1}\right) + v_2\left(1+\frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3+R_4}\right)$

(B) $v_o = -v_1\left(\frac{R_2}{R_1}\right) + v_2\left(1+\frac{R_2}{R_1}\right)$

(C) $v_o = -v_1\left(1+\frac{R_2}{R_1}\right) + v_2\left(\frac{R_2}{R_1}\right)$

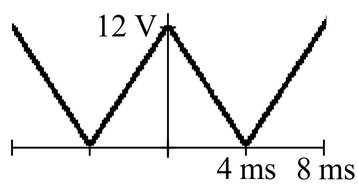
(D) $v_o = (v_2 - v_1)\left(\frac{R_2}{R_1}\right) + (v_2 - v_1)\left(\frac{R_2}{R_3}\right)$

106. To increase the electrical safety of an outlet located near water, a ground fault circuit interrupter (GFCI) is used. In this situation, which of the following is the <u>least</u> likely reason a typical circuit breaker provides inadequate protection for individuals using this outlet:

(A) circuit breakers trip too quickly

(B) circuit breakers do not necessarily open when there is an imbalance in current in the hot and neutral wires
(C) circuit breakers are typically used to protect equipment and help prevent conductors from overheating not to protect humans from electrical shock
(D) circuit breakers usually break at a current level much greater than the “let-go” current

107. The signal shown, which has a period of 8 ms, is applied across the series combination of a 5 Ω resistor and 2 Ω resistor. If a wattmeter is used to measure the power absorbed by just the 2 Ω resistor, it would most nearly indicate a power of:



(A) 8.0 W
(B) 2.0 W
(C) 0.74 W
(D) 0.35 W

108. A new spectrum analyzer for an EMC facility costs $55K and will be sold at the end of 5 years for $20K. If the interest rate is 6%, the average annual cost to own this analyzer is most nearly:

(A) $11K
(B) $7K
(C) $15K
(D) $9K

109. Each month a diamond drill bit for a printed circuit board mill must be replaced at a cost of $300. In addition, ever year there are additional $1,500 maintenance costs. Assume the salvage value of the mill after 7 years is negligible, and the annual interest rate is 6%. If the mill initially cost $20,000, the present cost of the mill to operate for 7 years is most nearly:

(A) $56,000
(B) $33,000
(C) $49,000
(D) $46,000

110. A 4 pole induction motor is supplied by a 50 Hz synchronous generator. The motor is running with a 3% slip. The full-load speed of the motor is mostly nearly:

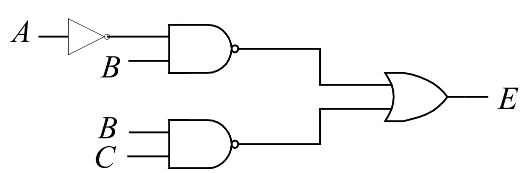
(A) 1,750 rpm
(B) 1,460 rpm
(C) 1,500 rpm
(D) 1,800 rpm

111. The truth table for a combinational logic circuit with three inputs (A, B, and C) and one output (E) is

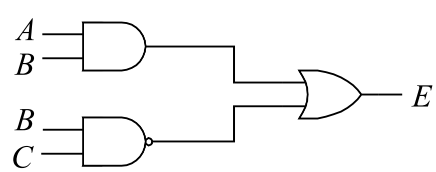
A	B	C	E
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Assuming all the inputs and the one output are high asserting, this truth table can be implemented by which of the following circuits?

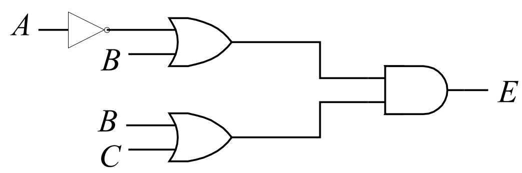
(A)



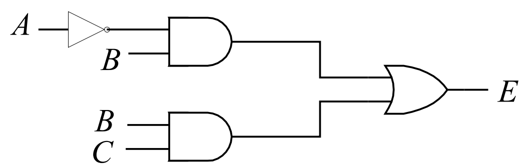
(B)



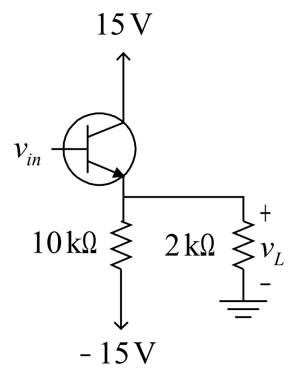
(C)



(D)



112. For the BJT-based circuit shown, assume $h_{FE} = 100$, $V_{CESAT} = 0.2$ V, and the dc base voltage is adjusted so that the dc emitter voltage is about zero volts. For unloaded conditions, the maximum possible voltage swing or range is about from −15 V to 14.8 V. If distortion is acceptable in the load voltage, for the 2 kΩ load shown the maximum possible swing of the load voltage, v_L, for a sinusoidal input signal, v_{in}, is most nearly:



(A) $-2.5 \text{ V} \le v_L \le 14.8 \text{ V}$
(B) $-12.5 \text{ V} \le v_L \le 14.8 \text{ V}$
(C) $-15 \text{ V} \le v_L \le 14.8 \text{ V}$
(D) $0 \text{ V} \le v_L \le 14.8 \text{ V}$

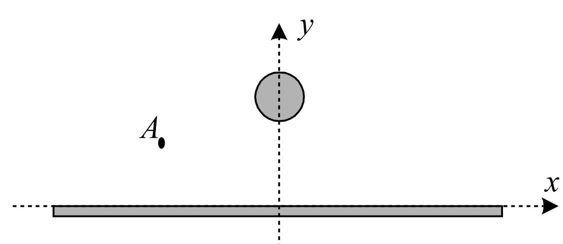
113. There is a 3% chance that a certain HF transmitter will malfunction over a rated lifetime. The HF receiver, which is a separate piece of equipment and not influenced by the transmitter, has a 5% chance of malfunctioning over this same rated lifetime. The probability that both the transmitter and receiver will not malfunction over this lifetime is most nearly:

(A) 0.02
(B) 0.92
(C) 0.99
(D) 0.08

114. In the last stage of a high-power audio amplifier, the probability that the final power transistor will fail during the amplifier's five year lifetime (causing an amplifier malfunction) is 0.001. The probability that the high-voltage capacitor used in the output's harmonic filter will fail during this same lifetime (causing the amplifier to malfunction) is 0.002. The overall probability that the amplifier will malfunction over this lifetime due to either (or both) the power transistor or the filter capacitor failing is 0.0025. Therefore, the probability that both the transistor and the capacitor will fail over this lifetime is most nearly:

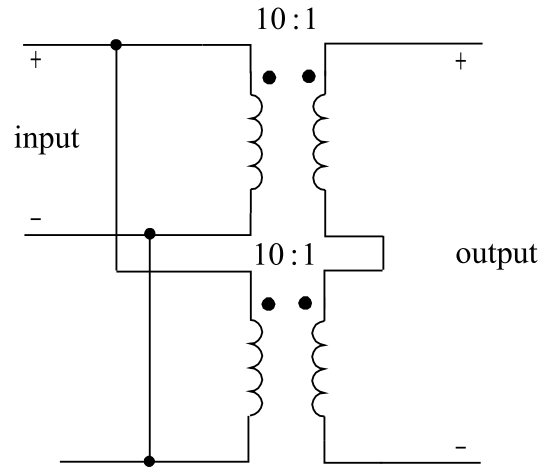
(A) 0.0055
(B) 0.0025
(C) 0.003
(D) 0.0005

115. Shown is the cross-sectional view of a long circular conductor parallel to a large flat ground plane. Free space exists everywhere around the conductors. A negative dc voltage, relative to the ground plane, is applied to the circular conductor. Assuming the electric field is two dimensional (i.e., does not vary in the *z* direction), the electric field at point *A* is in the:



(A) positive *x* and positive *y* direction
(B) positive *x* and negative *y* direction
(C) negative *x* and positive *y* direction
(D) negative *x* and negative *y* direction

116. Two, identical, ideal transformers with 10:1 turn ratios are connected as shown. If a sinusoidal signal with 340 V peak-to-peak amplitude and +30 V dc offset is applied to the input, the <u>rms</u> voltage that would be measured across the output is most nearly:

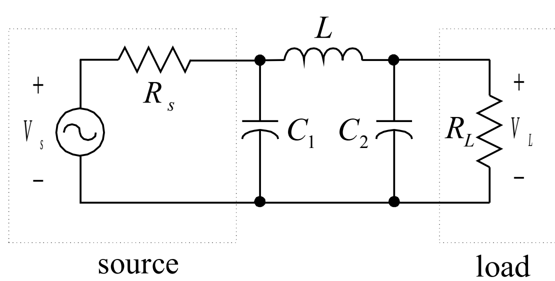


(A) 25 V
(B) 13 V
(C) 12 V
(D) 24 V

117. Which of the following statements is <u>least</u> likely to be true for an autotransformer:

(A) a winding is shared (or is common) between the input and output
(B) the output voltage can be either additive (a "booster") or subtractive (a "bucker")
(C) conduction current can pass between the input and output
(D) dc isolation exists between the input and output

118. A low-pass π filter used for filtering high-frequency noise is shown. The frequency domain expression for the voltage across the load, V_L, assuming V_s is a sinusoidal signal with an amplitude of *A* and zero dc offset, is:



(A) $$A\frac{\dfrac{R_L}{R_s+R_L}}{\left\{\begin{array}{l}1+j\omega\left[\dfrac{L}{R_s+R_L}+(C_1+C_2)\dfrac{R_sR_L}{R_s+R_L}\right]-\omega^2L\left(\dfrac{C_1R_s+C_2R_L}{R_s+R_L}\right)\\-j\omega^3LC_1C_2\left(\dfrac{R_sR_L}{R_s+R_L}\right)\end{array}\right\}}$$

(B) $$A\frac{\dfrac{R_s}{R_s+R_L}}{\left\{\begin{array}{l}1+j\omega\left[\dfrac{L}{R_s+R_L}+(C_1+C_2)\dfrac{R_sR_L}{R_s+R_L}\right]-\omega^2L\left(\dfrac{C_1R_s+C_2R_L}{R_s+R_L}\right)\\-j\omega^3C_1C_2\left(\dfrac{R_sR_L}{R_s+R_L}\right)\end{array}\right\}}$$

(C) $$A\frac{\dfrac{R_L}{R_s+R_L}\omega}{\left\{\begin{array}{l}1+j\omega\left[\dfrac{L}{R_s+R_L}+\dfrac{R_sR_L}{R_s+R_L}\right]-\omega^2L\left(\dfrac{C_1R_s+C_2R_L}{R_s+R_L}\right)\\-j\omega^3LC_1C_2\left(\dfrac{R_sR_L}{R_s+R_L}\right)\end{array}\right\}}$$

(D) $$A\frac{\dfrac{R_L}{R_s+R_L}}{\left\{1+j\omega\left[\dfrac{L}{R_s+R_L}+(C_1+C_2)\dfrac{R_sR_L}{R_s+R_L}\right]-\omega^2L\left(\dfrac{C_1R_s+C_2R_L}{R_s+R_L}\right)\right\}}$$

119. Four mathematical representations of a carrier signal of frequency f_c modulated by a signal $m(t)$ are given as

$$x(t)=Am(t)\cos[2\pi f_ct],\quad y(t)=A\cos[2\pi f_ct+km(t)]$$

$$z(t)=A[1+km(t)]\cos[2\pi f_ct],\quad s(t)=A\cos\left[2\pi f_ct+k\int_0^t m(\lambda)\,d\lambda\right]$$

where k and A are constants. In the sequence $x(t)$, $y(t)$, $z(t)$, and $s(t)$, the best description for the corresponding modulation methods is:

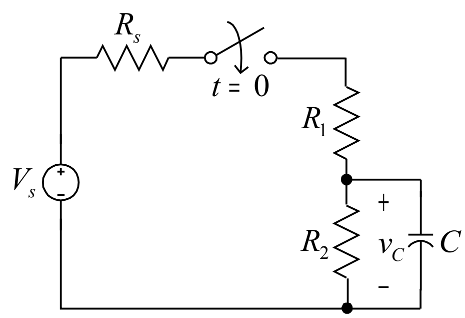
(A) DSB, FM, AM, PM
(B) SSB, PM, AM, FM
(C) SSB, PM, DSB, FM

(D) DSB, PM, AM, FM

120. In an FM system with a frequency deviation constant of k_f, a 200 MHz signal is modulated by a 10 kHz sinusoid resulting in a bandwidth of almost 25 kHz. If the frequency of the sinusoid is decreased to 5 kHz and its amplitude is doubled for this 200 MHz signal with the same k_f, the bandwidth for this new modulated signal is most nearly:

(A) 5 kHz
(B) 13 kHz
(C) 20 kHz
(D) 35 kHz

121. Assuming V_s is a dc voltage source, the initial voltage across the capacitor is zero, and the switch closes at $t = 0$, the expression for the voltage v_C after $t = 0$ is:



(A) $V_s\left(1-e^{-\frac{t}{\tau}}\right)$ where $\tau = \dfrac{(R_1+R_s)R_2}{R_1+R_2+R_s}C$

(B) $\dfrac{V_sR_2}{R_1+R_2+R_s}\left(1-e^{-\frac{t}{\tau}}\right)$ where $\tau = \dfrac{(R_1+R_s)R_2}{R_1+R_2+R_s}C$

(C) $\dfrac{V_sR_2}{R_1+R_2+R_s}\left(1-e^{-\frac{t}{\tau}}\right)$ where $\tau = R_2C$

(D) $\dfrac{V_sR_2}{R_1+R_2+R_s}\left(1-e^{-\frac{t}{\tau}}\right)$ where $\tau = (R_1+R_2+R_s)C$

122. The Thevenin equivalent and Norton equivalent for a signal generator are provided at one particular frequency. Which of the following statements is most true concerning these equivalents?

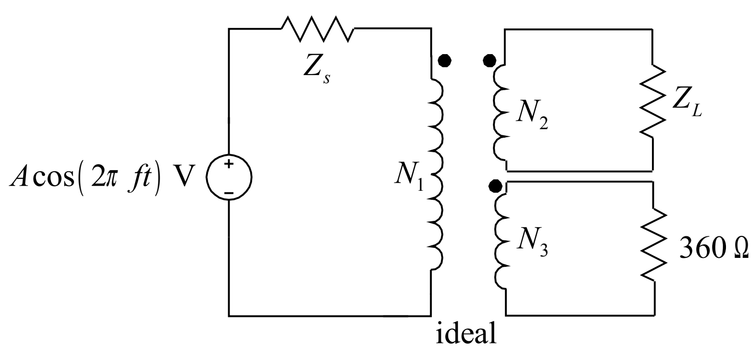
(A) the power dissipated by the Norton equivalent circuit is usually equivalent to power dissipated by the actual signal generator when connected to the same load

(B) the power dissipated by the Norton equivalent circuit is usually equivalent to power dissipated by the Thevenin equivalent when connected to the same load
(C) if the signal generator is linear in nature, the Thevenin and Norton equivalent models present to a load exactly what the network presents
(D) even if the signal generator was nonlinear and the output voltage swing was large, a reasonable single Thevenin equivalent could be obtained for the generator

123. Which of the following statements concerning (or implied by) the maximum power transfer theorem is most true:

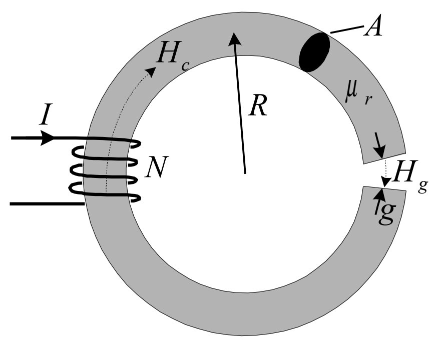
(A) when a load is connected across a typical battery, the load impedance is usually selected to be equal to the conjugate of the impedance of the battery
(B) when determining *S* parameters (for a device), commonly used in high-frequency modeling, 50 Ω (or some other typical value) is often selected for the source and load impedance to the device in order to maximize the power transfer in and out of the device during the testing
(C) for high-speed communications along an electrically-long lossy transmission line, the load impedance at the end of the line is usually selected to be equal to the conjugate of the impedance of the characteristic impedance of the line
(D) the maximum power transfer theorem's importance is mostly limited to the academic arena

124. The split-secondary transformer shown is ideal. Your boss insists that the maximum power transfer theorem be used to maximize the power delivered to the net load (as seen by the primary side of the transformer) from the sinusoidal source shown, ignoring all other considerations of engineering consequence. If $Z_L = 16 - j320\ \Omega$, $N_1 = 50$, $N_2 = 200$, and $N_3 = 300$, then Z_s should be selected (or adjusted) to have a value most nearly equal to:



(A) $11 + j20\ \Omega$
(B) $13{,}000 + j5{,}100\ \Omega$
(C) $380 + j320\ \Omega$
(D) $7.9 + j3.8\ \Omega$

125. An N-turn coil is tightly wrapped around a high-permeability toroidal core with a cross-sectional area of A. There is a small air gap of average length g in the core. A sinusoidal voltage source is connected across the coil, and the amplitude of the resultant current in the coil is I. The average magnitudes of the magnetic fields in the core and air gap are H_c and H_g, respectively. Which is the following statements is <u>least</u> likely to be true?



(A) the net reluctance of the closed path of the corresponding magnetic circuit will increase as the permeability of the core decreases
(B) the inductance seen by the source will decreases as the gap length increases (but still remains small),
(C) for a given source voltage, the current I will increase as the cross-sectional area of the core, A, increases
(D) as the current I increases, the magnetic fields H_c and H_g, which are not equal, will increase and the core losses will increase

126. The power delivered to a paper mill is 2 MW at a lagging power factor of 0.7. A –1.2 MVAR reactive parallel load is then added to improve the power factor. The improved power factor is most nearly:

(A) 0.53 lagging
(B) 0.80 lagging
(C) 0.92 lagging
(D) 0.98 lagging

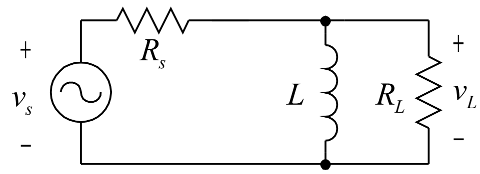
127. A balanced 230 V rms three-phase Δ load is absorbing 150 kW at 0.85 PF leading. The magnitude of the line current to this load is most nearly:

(A) 260 A rms
(B) 440 A rms
(C) 650 A rms
(D) 770 A rms

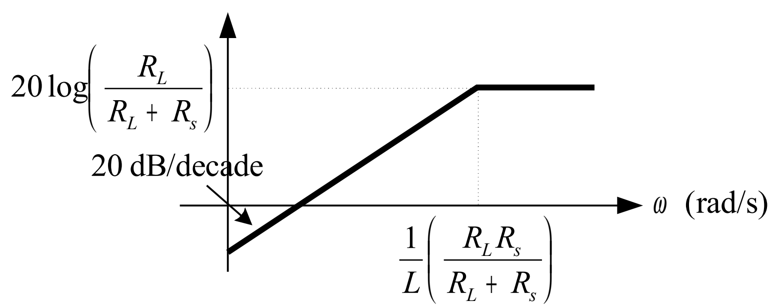
128. A 60 Hz, 3 phase, 20 HP motor is operated at full load with a PF = 0.78 lagging. The motor's efficiency is 88%. The impedance of each line from the supply transformer to the motor is 0.4 + *j*5.4 Ω. If the line-to-line voltage at the motor is 240 V rms, the rms line current to this motor is most nearly:

(A) 46 A
(B) 52 A
(C) 80 A
(D) 91 A

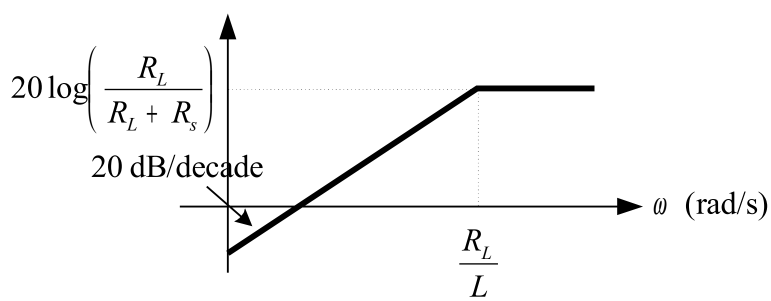
129. The Bode magnitude plot for the voltage transfer function, $V_L(\omega)/V_s(\omega)$, for the following filter is given by:



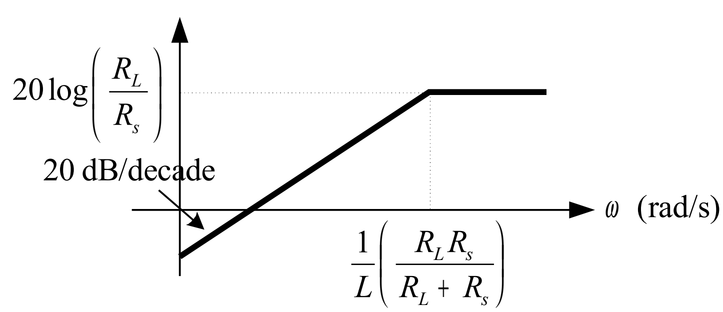
(A)



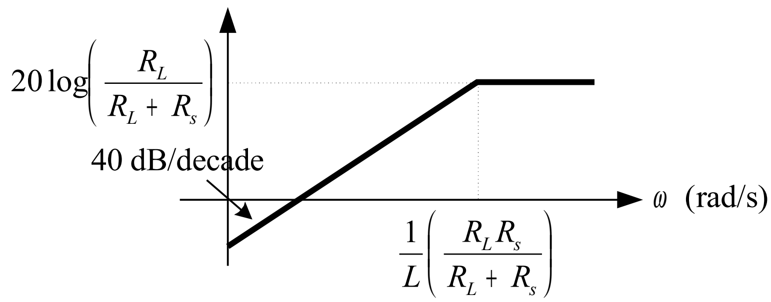
(B)



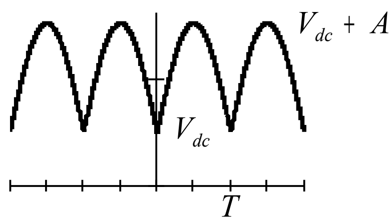
(C)



(D)



130. A full-rectified sine wave with added dc offset is shown. Its period is T. The Fourier series representation of this periodic signal is (or is probably best described by):



(A) $V_{dc} - \frac{A}{\pi} - \frac{4A}{3\pi}\cos\left(\frac{3\pi}{T}t\right) - \frac{4A}{15\pi}\cos\left(\frac{5\pi}{T}t\right) - \frac{4A}{35\pi}\cos\left(\frac{7\pi}{T}t\right) - \cdots$

(B) $V_{dc} - \frac{A}{\pi} - \frac{4A}{3\pi}\cos\left(\frac{2\pi}{T}t\right) - \frac{4A}{15\pi}\cos\left(\frac{4\pi}{T}t\right) - \frac{4A}{35\pi}\cos\left(\frac{6\pi}{T}t\right) - \cdots$

(C) $V_{dc} + \frac{2A}{\pi} - \frac{4A}{3\pi}\cos\left(\frac{2\pi}{T}t\right) - \frac{4A}{15\pi}\cos\left(\frac{4\pi}{T}t\right) - \frac{4A}{35\pi}\cos\left(\frac{6\pi}{T}t\right) - \cdots$

(D) $V_{dc} + \frac{2A}{\pi} - \frac{4A}{3\pi}\sin\left(\frac{2\pi}{T}t\right) - \frac{4A}{15\pi}\sin\left(\frac{3\pi}{T}t\right) - \frac{4A}{35\pi}\sin\left(\frac{4\pi}{T}t\right) - \cdots$

131. Silicon is doped with boron. Each boron atom accepts one electron from the silicon crystal. The resulting doped silicon would most likely be classified as:

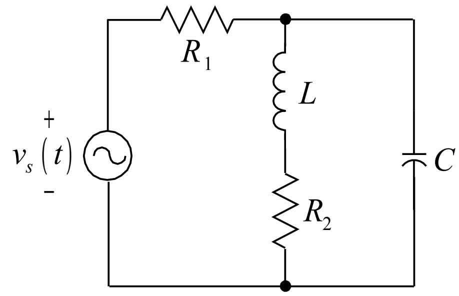
(A) an *n*-type semiconductor
(B) a *p*-type semiconductor
(C) an insulator
(D) a superconductor

132. A strain gauge with a nominal resistance of 350 Ω is attached to a delicate arm of a robot. This gauge, which has a gauge factor (or strain sensitivity) of 3, is one element in a Wheatstone Bridge. When the arm is under no strain, the gauge has a length of 0.2 inch. If the bridge indicates a change of resistance of 0.014 Ω under a specific strain, the corresponding change in the length of the gauge is most nearly:

(A) 8 microinches

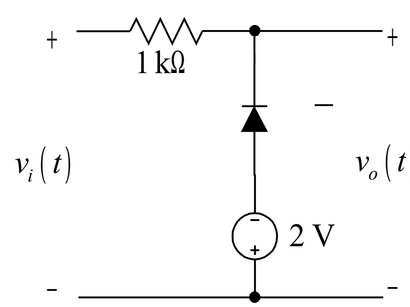
(B) 24 microinches
(C) 2.7 microinches
(D) 0.6 microinches

133. Which of the following statements is most true concerning the following circuit?



(A) the resonant frequency of the circuit (as seen by the voltage source) is $1/\sqrt{LC}$
(B) the maximum current through the inductor and maximum voltage across the capacitor occur at the resonant frequency of the circuit
(C) at very high frequencies (well above any resonant or break frequencies), the current from the source mainly passes through the series combination of L and R_2 rather than through the capacitor, C
(D) at very low frequencies (well below any resonant or break frequencies), the current from the source mainly passes through L and R_2 rather than through the capacitor, C

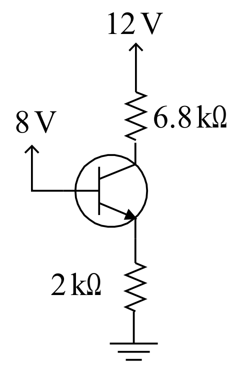
134. For the following circuit, the signal $v_i(t)$ is a 5 V amplitude sinusoid with zero dc offset. Assume the turn-on voltage of the diode is 0.65 V and the frequency of the input signal is sufficiently low so that high-frequency effects do not need to be considered. The output voltage, $v_o(t)$, is then best described as:



(A) a sinusoid clipped only during its positive (i.e., "top") cycle at 1.35 V
(B) a sinusoid clipped only during its negative (i.e., "bottom") cycle at −2.65 V

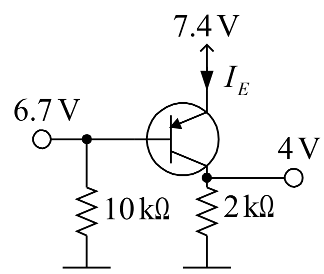
(C) a sinusoid clipped only during its negative (i.e., "bottom") cycle at −1.35 V
(D) a sinusoid clipped during both its positive (i.e., its top) and negative (i.e., "bottom") cycles at 2.65 V and –2.65 V, respectively

135. For the BJT-based circuit shown, assume $\beta = 100$ and $V_{CESAT} = 0.2$ V. The dc power dissipated by the collector resistor is most nearly:



(A) 2.4 mW
(B) 63 mW
(C) 20 mW
(D) 3 mW

136. For the BJT-based circuit shown, assume $\beta = 3$ and $V_{CESAT} = 0.2$ V. The voltage measured at the base is 6.7 V, and the voltage measure at the collector is 4 V. The emitter current, I_E, is most nearly:

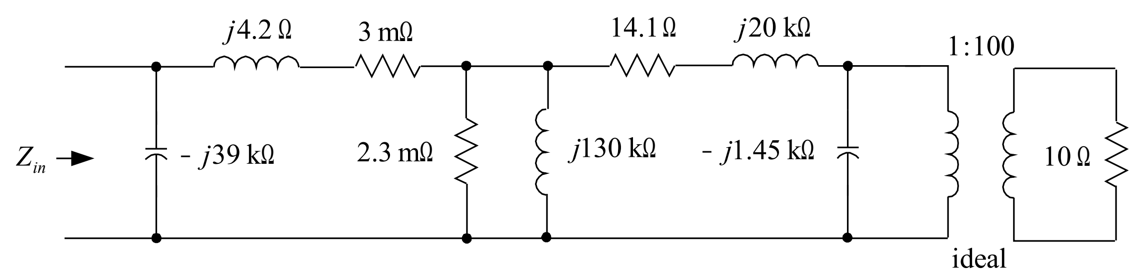


(A) 2.0 mA
(B) 2.7 mA
(C) 0.67 mA
(D) 2.4 mA

137. The main service panel for residential service is located in the home's basement. A subpanel is locate in the attached garage. The two panels are connected using #6 AWG cable, containing two hot wires, a neutral, and one ground wire. From the standpoint of safety, the best grounding method is to:

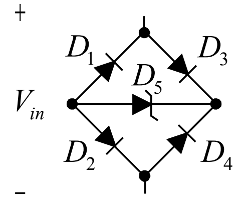
(A) separately and locally earth ground both the main panel and subpanel, and then connect the corresponding end of the cable's ground wire to these local earth grounds
(B) provide the connections as given in (A) and, for added safety, splice the cable midway and locally ground the cable's ground wire at this splice location
(C) locally earth ground the main panel and connect the corresponding end of the ground wire to this main panel's chassis, however, do not locally earth ground the subpanel but connect the corresponding end of the cable's ground wire to the subpanel's chassis
(D) do not earth ground either the main panel or the subpanel but instead connect the corresponding end of the cable's ground wire to the nearest hot water pipe and use a GFCI at both the main panel and the subpanel

138. In the following circuit, which includes an ideal transformer, the impedance Z_{in} is most nearly:



(A) $8 + j4\ \Omega$
(B) $0.005 + j4\ \Omega$
(C) $0.003 - j40{,}000\ \Omega$
(D) $14 + j110{,}000\ \Omega$

139. In the following transient protection circuit, D_5 is a zener diode with a reversed-biased breakdown voltage of -10 V. The remaining switching diodes have forward-biased turn-on voltages of 0.7 V. All of the diodes have fast response times with negligible high-frequency capacitor and inductance. If a transient voltage appears across the entire circuit with a peak value, V_{in}, of 14 V, which of the following statements is most true at the time of this voltage peak:



(A) D_3 and D_2 will be forward biased, D_1 and D_4 will be reversed biased, and D_5 will be reversed biased and conducting

(B) D_3 and D_2 will be reversed biased, D_1 and D_4 will be forward biased, and D_5 will be forward biased
(C) D_3 and D_4 will be forward biased, D_1 and D_2 will be reversed biased, and D_5 will be reversed biased and not conducting
(D) D_1 and D_2 will be forward biased, D_3 and D_4 will be reversed biased, and D_5 will be forward biased

140. Single-phase 60 Hz power lines supply 120 V rms to an electric heater and a sump pump. The electric heater absorbs 1.4 kW with a 0.98 power factor lagging. The sump pump absorbs 23 kVAR at 0.45 power factor lagging. Capacitance is to be added across the hot and neutral conductors to increase the net power factor to 0.95 lagging. This capacitance is most nearly equal to:

(A) 4.3 mF
(B) 3.5 mF
(C) 7.0 mF
(D) 2 mF