accomplish the task by passing the voltage in half of each cycle and inverting the voltage in the other half-cycle.

- The bridge-rectifier circuit is the preferred full-wave rectifier configuration.
- The variation of the output waveform of the rectifier is reduced considerably by connecting a capacitor C across the output load resistance R. The resulting circuit is the peak rectifier. The output waveform then consists of a dc voltage almost equal to the peak of the input sine wave, V_p, on which is superimposed a ripple component of frequency $2f$ (in the full wave case) and of peak-to-peak amplitude $V_r = V_p/2fCR$. To reduce this ripple voltage further a voltage regulator is employed.
- Combination of diodes, resistors, and possibly reference voltages can be used to design voltage limiters that prevent one or both extremities of the output waveform from going beyond predetermined values, the limiting level(s).
- Applying a time-varying waveform to a circuit consisting of a capacitor in series with a diode and taking the output across the diode provides a clamping function. Specifically, depending on the polarity of the diode either the positive or negative peaks of the signal will be clamped to the voltage at the other terminal of the diode (usually ground). In this way the output waveform has a non zero average or dc component and the circuit is known as a dc restorer.
- By cascading a clamping circuit with a peak-rectifier circuit, a voltage doubler is realized.

PROBLEMS

Computer Simulation Problems

SIM Problems identified by this icon are intended to demonstrate the value of using SPICE simulation to verify hand analysis and design, and to investigate important issues such as allowable signal swing and nonlinear distortion. Instructions to assist in setting up PSpice and Multisim simulations for all the indicated problems can be found in the corresponding files on the disc. Note that if a particular parameter value is not specified in the problem statement, you are to make a reasonable assumption.
* difficult problem; ** more difficult; *** very challenging and/or time-consuming; D: design problem.

Section 4.1: The Ideal Diode

4.1 An AA flashlight cell, whose Thévenin equivalent is a voltage source of 1.5 V and a resistance of 1 Ω, is connected to the terminals of an ideal diode. Describe two possible situations that result. What are the diode current and terminal voltage when (a) the connection is between the diode cathode and the positive terminal of the battery and (b) the anode and the positive terminal are connected?

4.2 For the circuits shown in Fig. P4.2 using ideal diodes, find the values of the voltages and currents indicated.

4.3 For the circuits shown in Fig. P4.3 using ideal diodes, find the values of the labeled voltages and currents

4.4 In each of the ideal-diode circuits shown in Fig. P4.4, v_I is a 1-kHz, 10-V peak sine wave. Sketch the waveform resulting at v_O. What are its positive and negative peak values?

4.5 The circuit shown in Fig. P4.5 is a model for a battery charger. Here v_I is a 10-V peak sine wave, D_1 and D_2 are

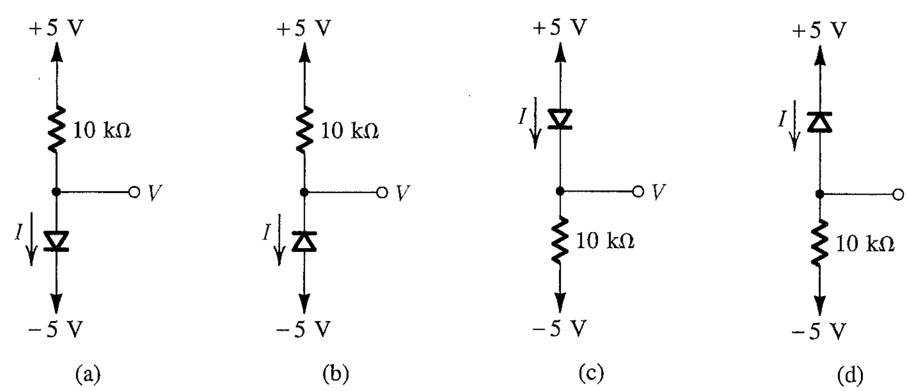

Figure P4.2

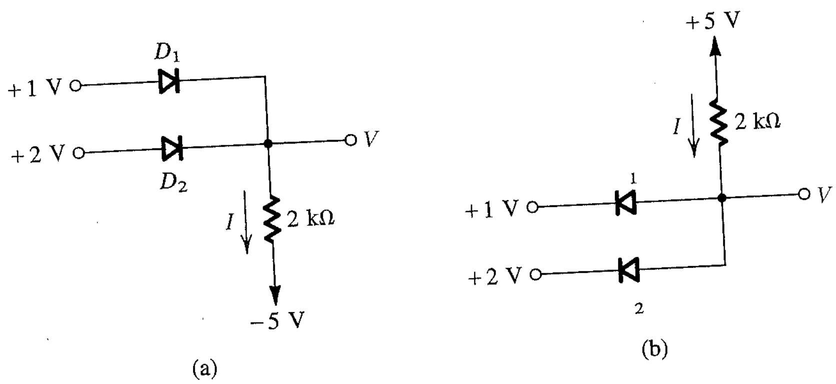

Figure P4.3

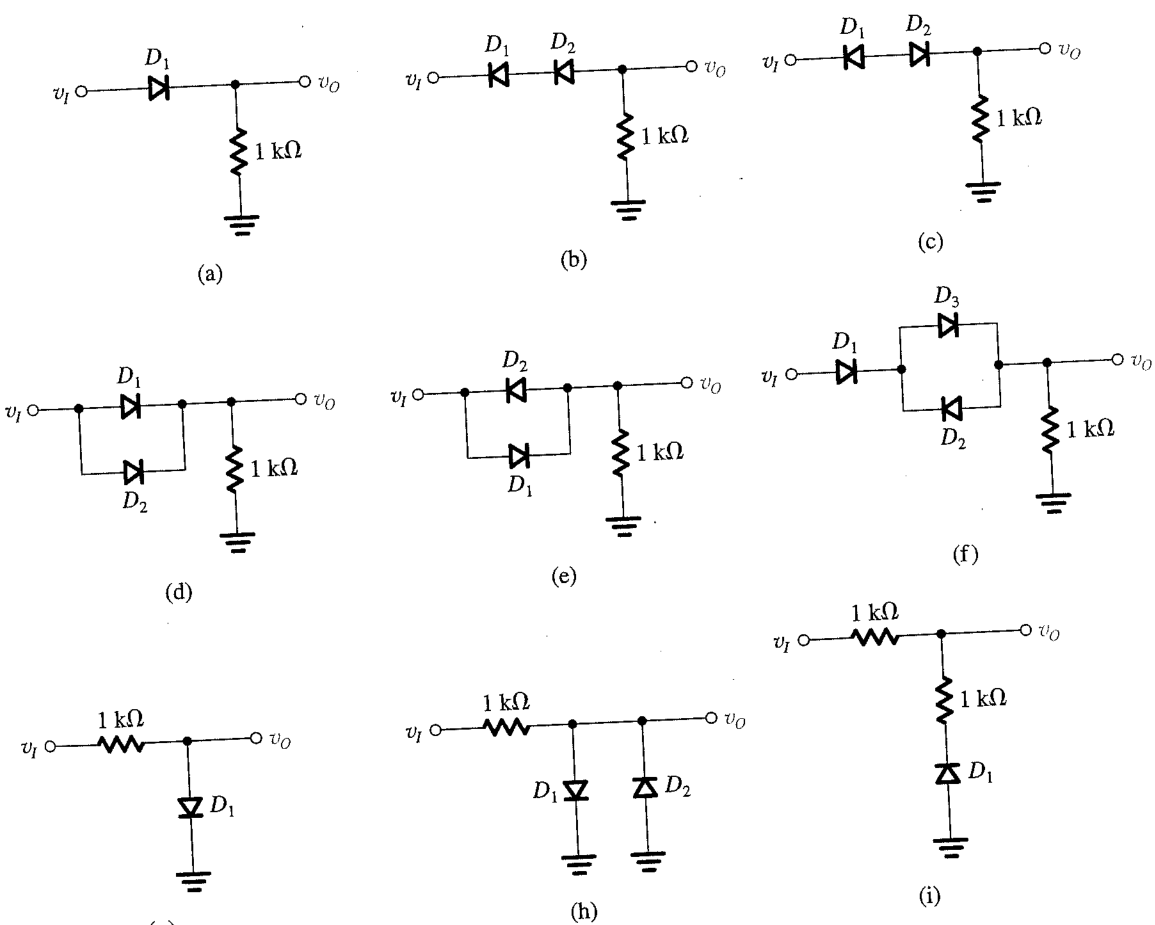

Figure P4.4

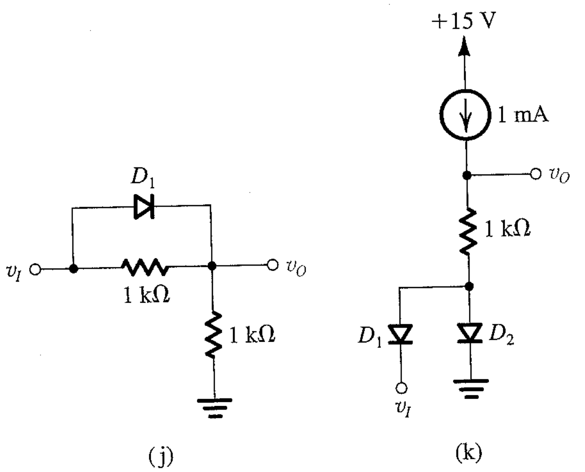

Figure P4.4 *(Contd.)*

ideal diodes, I is a 60-mA current source, and B is a 3-V battery. Sketch and label the waveform of the battery current i_B. What is its peak value? What is its average value? If the peak value of v_I is reduced by 10%, what do the peak and average values of i_B become?

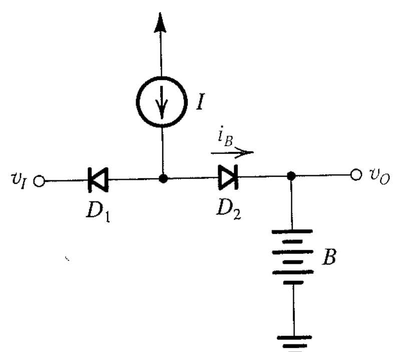

Figure P4.5

4.6 The circuits shown in Fig. P4.6 can function as logic gates for input voltages that are either high or low. Using "1" to denote the high value and "0" to denote the low value, prepare a table with four columns including all possible input combinations and the resulting values of X and Y. What logic function is X of A and B? What logic function is Y of A and B? For what values of A and B do X and Y have the same value? For what values of A and B do X and Y have opposite values?

D 4.7 For the logic gate of Fig. 4.5(a), assume ideal diodes and input voltage levels of 0 V and +5 V. Find a suitable value for R so that the current required from each of the input signal sources does not exceed 0.2 mA.

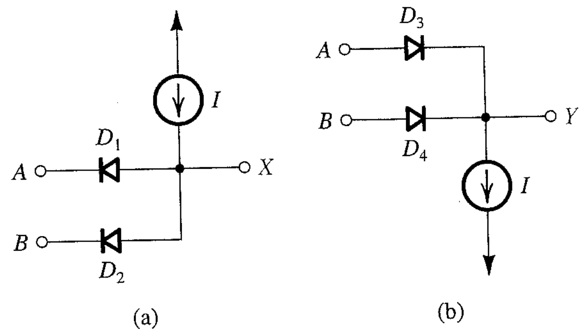

Figure P4.6

D 4.8 Repeat Problem 4.7 for the logic gate of Fig. 4.5(b).

4.9 Assuming that the diodes in the circuits of Fig. P4.9 are ideal, find the values of the labeled voltages and currents.

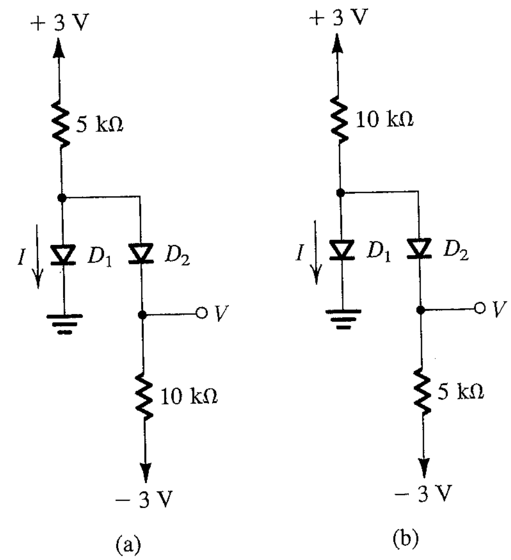

Figure P4.9

4.10 Assuming that the diodes in the circuits of Fig. P4.10 are ideal, utilize Thévenin's theorem to simplify the circuits and thus find the values of the labeled currents and voltages.

D 4.11 For the rectifier circuit of Fig. 4.3(a), let the input sine wave have 120-V rms value and assume the diode to be ideal. Select a suitable value for R so that the peak diode current does not exceed 50 mA. What is the greatest reverse voltage that will appear across the diode?

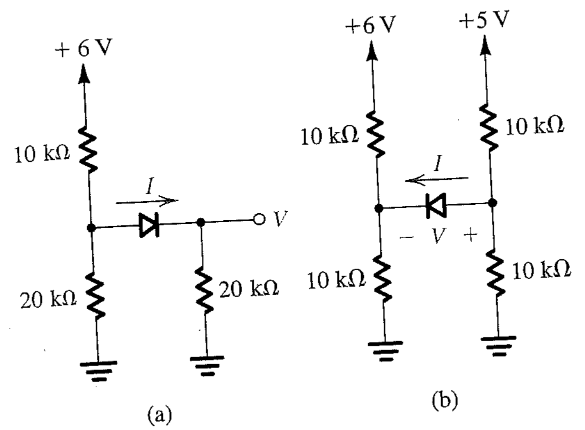

Figure P4.10

4.12 Consider the rectifier circuit of Fig. 4.3 in the event that the input source v_I has a source resistance R_s. For the case $R_s = R$ and assuming the diode to be ideal, sketch and clearly label the transfer characteristic v_O versus v_I.

4.13 A symmetrical square wave of 4-V peak-to-peak amplitude and zero average is applied to a circuit resembling that in Fig. 4.3(a) and employing a 100-Ω resistor. What is the peak output voltage that results? What is the average output voltage that results? What is the peak diode current? What is the average diode current? What is the maximum reverse voltage across the diode?

4.14 Repeat Problem 4.13 for the situation in which the average voltage of the square wave is 1 V, while its peak-to-peak value remains at 4 V.

D *4.15 Design a battery-charging circuit, resembling that in Fig. 4.4 and using an ideal diode, in which current flows to the 12-V battery 20% of the time with an average value of 100 mA. What peak-to-peak sine-wave voltage is required? What resistance is required? What peak diode current flows? What peak reverse voltage does the diode endure? If resistors can be specified to only one significant digit, and the peak-to-peak voltage only to the nearest volt, what design would you choose to guarantee the required charging current? What fraction of the cycle does diode current flow? What is the average diode current? What is the peak diode current? What peak reverse voltage does the diode endure?

4.16 The circuit of Fig. P4.16 can be used in a signalling system using one wire plus a common ground return. At any moment, the input has one of three values: +3 V, 0 V, −3 V. What is the status of the lamps for each input value? (Note that the lamps can be located apart from each other and that there may be several of each type of connection, all on one wire!)

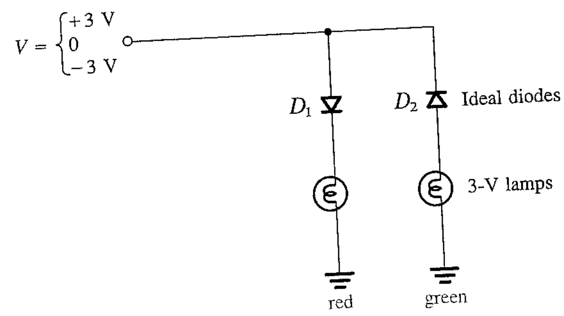

Figure P4.16

Section 4.2: Terminal Characteristics of Junction Diodes

4.17 Calculate the value of the thermal voltage, V_T, at −40°C, 0°C, +40°C, and +150°C. At what temperature is V_T exactly 25 mV?

4.18 At what forward voltage does a diode conduct a current equal to $1000I_S$? In terms of I_S, what current flows in the same diode when its forward voltage is 0.7 V?

4.19 A diode for which the forward voltage drop is 0.7 V at 1.0 mA is operated at 0.5 V. What is the value of the current?

4.20 A particular diode is found to conduct 0.5 mA with a junction voltage of 0.7 V. What is its saturation current I_S? What current will flow in this diode if the junction voltage is raised to 0.71 V? To 0.8 V? If the junction voltage is lowered to 0.69 V? To 0.6 V? What change in junction voltage will increase the diode current by a factor of 10?

4.21 The following measurements are taken on particular junction diodes for which V is the terminal voltage and I is the diode current. For each diode, estimate values of I_S and the terminal voltage at 10% of the measured current.

(a) $V = 0.700$ V at $I = 1.00$ A
(b) $V = 0.650$ V at $I = 1.00$ mA
(c) $V = 0.650$ V at $I = 10$ μA
(d) $V = 0.700$ V at $I = 10$ mA

4.22 Listed below are the results of measurements taken on several different junction diodes. For each diode, the data provided are the diode current I and the corresponding diode voltage V. In each case, estimate I_S, and the diode voltage at $10I$ and $I/10$.