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EPE 2165—Analog Electronics

EXERCISE #—1: DIODE CIRCUITS

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Section 4.1: The Ideal Diode

4.1

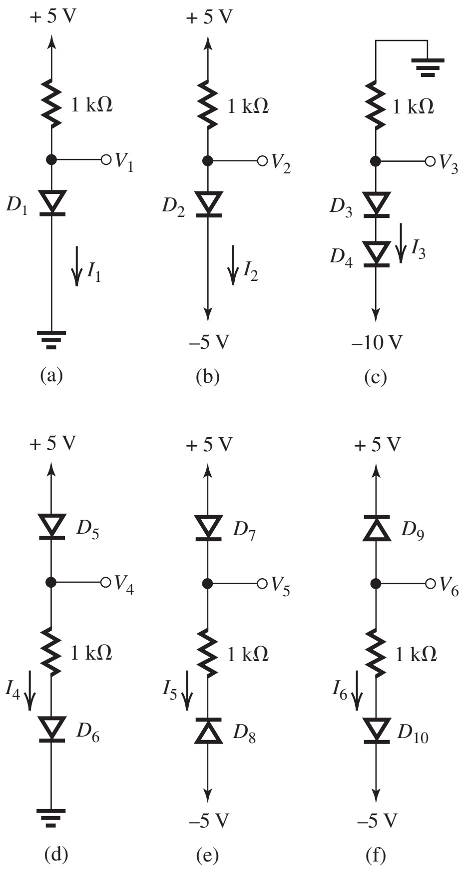


Figure 4.1.1

For the circuits in Fig. 4.1.1 employing ideal diodes, find the labeled currents I and voltages V, measured with respect to ground.

4.2

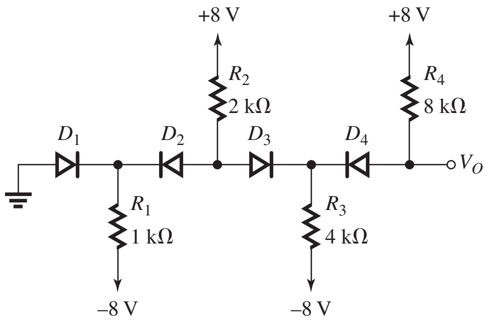


Figure 4.2.1

For the circuit shown in Fig. 4.2.1 employing ideal diodes, find the currents through all branches and determine the voltages at all nodes.

4.3

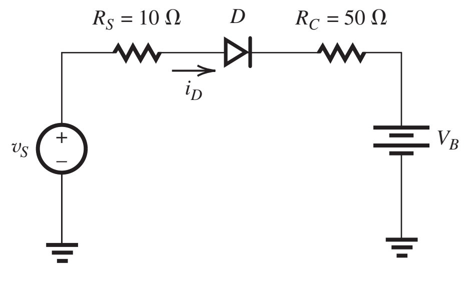


Figure 4.3.1

In the battery-charger circuit shown in Fig. 4.3.1, the sine-wave input v_S is 12 V (rms), while the battery voltage varies from 12 V to 14 V from the discharged to fully charged states. $R_S = 10\ \Omega$ is the charging-source resistance, D is an ideal diode, and $R_C = 50\ \Omega$ is a current-controlling resistor established by the designer. Sketch and label the diode-current waveform for $V_B = 12$ V. What are its peak and average values? What do the peak and average diode currents become when V_B reaches 14 V?

Section 4.2: Terminal Characteristics of Junction Diodes

D4.4

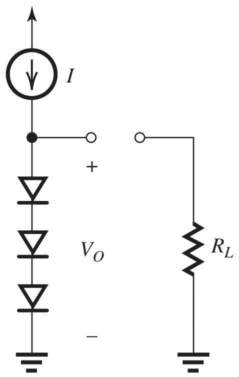
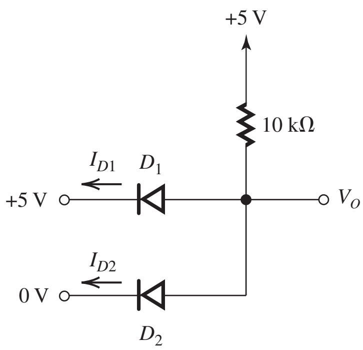


Figure 4.4.1

The diodes in the circuit in Fig. 4.4.1 have $I_S = 10^{-16}$ A. Find the value of the current I that results in $V_O = +2.4$ V. If a resistance R_L is connected to V_O and it draws a current of 1 mA, find the change in V_O. Without R_L connected, find the change V_O that results when the temperature increases by 20°C.

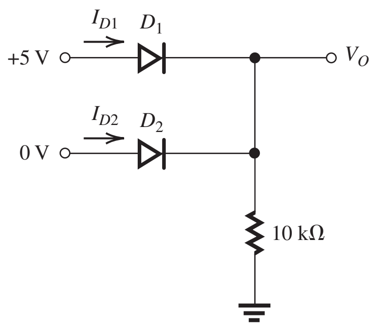
Section 4.3: Modeling the Diode

4.5



(a)

Figure 4.5.1



(b)

Figure 4.5.1 ***continued***

For the diode logic circuits shown in Fig. 4.5.1, find the output voltage and the diode currents for the particular input values shown. Model a conducting diode as a constant voltage drop of 0.7 V.

4.6

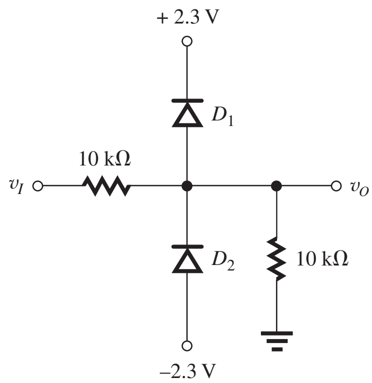


Figure 4.6.1

For the limiter circuit shown in Fig. 4.6.1, find the upper and lower limiting levels, the transmission v_O/v_I in the linear region, and the upper- and lower-input threshold levels. Sketch v_o vs v_I. What is the input current required from an input which is twice the upper threshold value? Assume that when a diode conducts it exhibits a voltage drop of 0.7 V.

Section 4.4: The Small-Signal Model

4.7

For the circuit in Fig. 4.7.1, assume that v_i is a small signal and that C_1 and C_2 are large coupling capacitors. Use the small-signal model for each of D_1 and D_2 to find v_o/v_i. For $I = 1$ mA, what must I_x be to obtain $v_o/v_i = 0$, 0.2, 0.5, or 1?

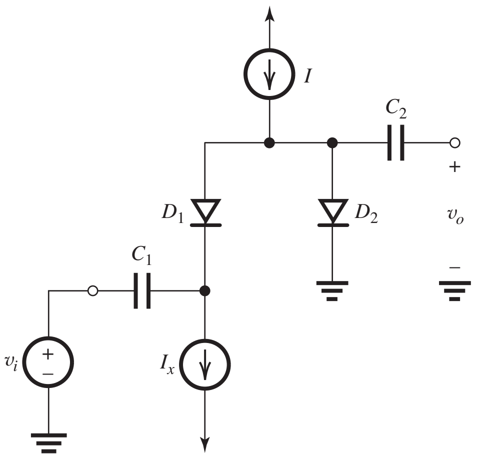


Figure 4.7.1

Section 4.5: Voltage Regulation

D4.8

Given the availability of diodes that exhibit a voltage drop of 0.7 V at a current of 0.1 mA, use four diodes connected in series and fed from a +5-V supply through a resistance R to obtain a voltage $V_O = 3.0$ V across the diode string. What value of R is required? If the supply voltage changes by ±10%, use the small-signal diode model to find the corresponding absolute and percentage changes in V_O? If a load resistance $R_L = 15$ kΩ is connected across the diode string, what do you estimate the absolute and percentage changes of V_O to be? Whenever you use the small-signal diode model, verify that such use is justified.

4.9

A 6.8-V Zener diode specified at 5 mA to have $V_Z = 6.8$ V and $r_z = 20\ \Omega$ with $I_{ZK} = 0.2$ mA is operated in a regulator circuit using a 200-Ω resistor and a 9-V supply. Estimate the knee voltage of the zener. For no load, what is the lowest supply voltage for which the zener remains in breakdown operation? For the nominal supply voltage, what is the maximum load current for which the zener remains in breakdown operation? For half this load current, what is the lowest supply voltage for breakdown operation? What are the line regulation and load regulation?

Section 4.6: Rectifier Circuits

D4.10

The circuit in Fig. 4.10.1 (refer Figure below) implements a complementary-output peak rectifier. Assume that the diodes available exhibit a 0.7-V drop when conducting. Design the circuit to provide a ±10-V dc output voltages with a peak-to-peak ripple no greater than 0.8 V. Each supply should be capable of providing 50-mA dc current to its load resistor R. Completely specify the capacitors, diodes, and the transformer.

4.11

The op amp in the precision rectifier circuit of Fig. 4.11.1 is ideal with output that saturates at ±5 V. Assume that when conducting the diode exhibits a constant voltage drop of 0.7 V. Find v_-, v_O, v_A, and i_D for:

(a) $v_I = +0.1$ V
(b) $v_I = +1.0$ V
(c) $v_I = -0.1$ V
(d) $v_I = -1.0$ V

Also, find the average output voltage obtained when v_I is a symmetrical square wave of 1-kHz frequency, 2-V amplitude, and zero average.

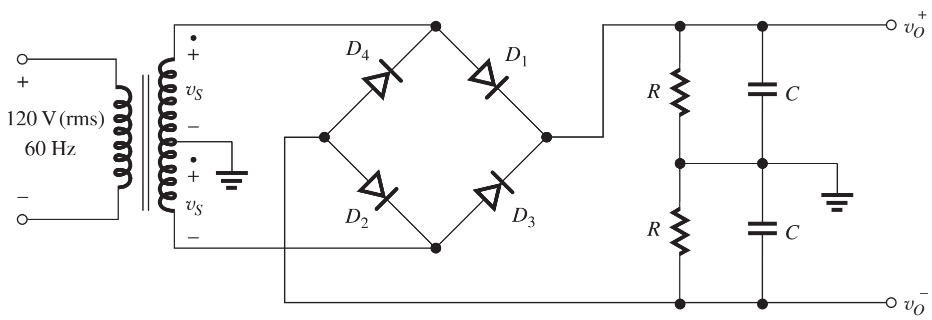


Figure 4.10.1

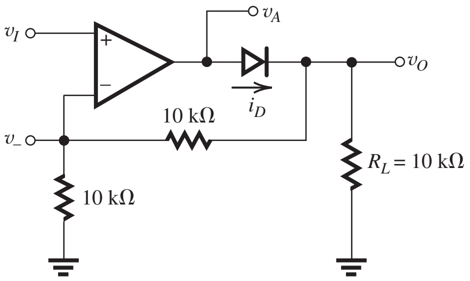


Figure 4.11.1

Section 4.7: Diode Applications

4.12
The clamped-capacitor circuit shown in Fig. 4.12.1 has a square-wave input of 10-V and 100-V levels.

(a) Describe the resulting output for a very high-resistance load R and a diode that has 0.5-V drop at very low currents.
(b) What happens when the load resistance R is reduced such that $CR = 2T$, where T is the period of the square-wave input.

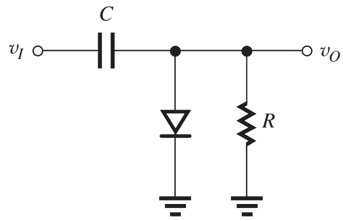


Figure 4.12.1