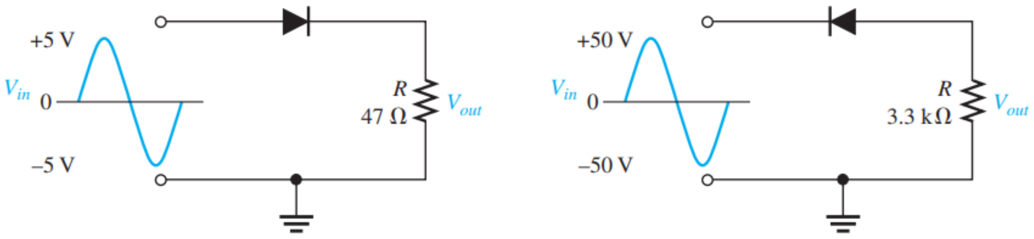
XMUT204 Electronic Design

Tutorial 2: Diode Applications (Answer)

Section A: Half-wave Rectifiers

1. For each circuit in the figures given below:

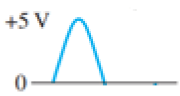


(a) (b)

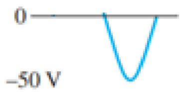
a. Draw the output voltage waveform and include the voltage values. [4 marks]

Solution

- Output voltage waveform of circuit (a):



- Output voltage waveform of circuit (b):



b. What is the peak inverse voltage across each diode? [4 marks]

Solution

- Peak Inverse Voltage (PIV) of diode in circuit (a):

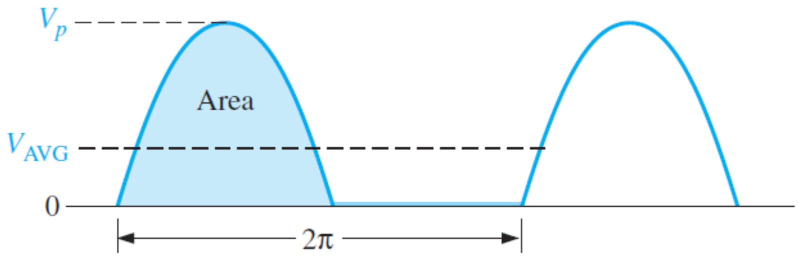
  PIV = $V_{in}(\text{peak})$ = 5 V

- Peak Inverse Voltage (PIV) of diode in circuit (b):

  PIV = $V_{in}(\text{peak})$ = 50 V

c. Derive the average voltage ($V(\text{ave})$) of half-wave rectifier. [10 marks]

The average value of a half-wave rectified sine wave is the area under the curve divided by the period (2π).



The equation for a sine wave is:

$$V = V(\text{peak})\sin\theta$$

Thus, the average voltage is:

$$\begin{aligned} V(\text{ave}) &= \frac{\text{area}}{2\pi} \\ &= \frac{1}{2\pi}\int_0^{\pi} V(\text{peak})\sin\theta\, d\theta \\ &= \frac{V(\text{peak})}{2\pi}(-\cos\theta)\Big|_0^{\pi} \\ &= \frac{V(\text{peak})}{2\pi}[-\cos\pi - (-\cos\theta)] \\ &= \frac{V(\text{peak})}{2\pi}[-(-1) - (-1)] \\ &= \frac{V(\text{peak})}{2\pi}(2) \\ &= \frac{V(\text{peak})}{\pi} \end{aligned}$$

d. Calculate the average value of half-wave rectified voltage with a peak value of 200 V. [2 marks]

Solution

For a peak voltage $V_{out}(\text{peak})$ = 200 V, the average voltage of the half-wave rectifier is:

$$V_{out}(\text{ave}) = \frac{V_{out}(\text{peak})}{\pi} = \frac{200}{\pi} = 63.69\text{ V}$$

e. What is the peak forward current through each diode? [4 marks]

Solution

- Assuming ideal diode, the peak forward current of the diode in circuit (a):

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak})}{R}$$

$$= \frac{5}{47} = 0.106\ \text{A}$$

- Assuming ideal diode, the peak forward current of the diode in circuit (b):

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak})}{R}$$

$$= \frac{50}{3.3 \times 10^3} = 0.0151\ \text{A}$$

f. A power-supply transformer has a turn ratio of 5:1. What is the secondary voltage if the primary is connected to a 120 V rms source? [2 marks]

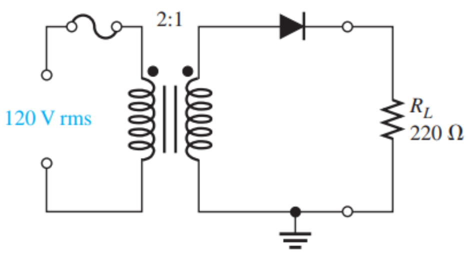
Solution

The RMS voltage at the secondary winding is:

$$V_s(\text{rms}) = V_p(\text{rms})\left(\frac{N_s}{N_p}\right)$$

$$= 120\left(\frac{1}{5}\right) = 24\ \text{V}$$

2. Determine the peak and average power delivered to R_L in the figure given below. [8 marks]



Solution

The RMS voltage at the secondary winding of the rectifier circuit is:

$$V_s(\text{rms}) = V_p\left(\frac{N_s}{N_p}\right)$$

$$= 120\left(\frac{1}{2}\right) = 60\ \text{V}$$

The peak voltage at the secondary is:

$$V_s(\text{peak}) = \frac{V_s(\text{rms})}{0.707} = \frac{60}{0.707} = 84.87\ \text{V}$$

The average voltage at the secondary is:

$$V_s(\text{ave}) = \frac{V_s(\text{peak})}{\pi}$$

$$= \frac{84.87}{\pi} = 27.02\ \text{V}$$

Assuming ideal diode, the peak power delivered to the load resistor is:

$$P_L(\text{peak}) = \frac{V_s(\text{peak})^2}{R} =$$

$$= \frac{(84.87)^2}{220} = 32.7\ \text{A}$$

Assuming ideal diode, the average power delivered to the load resistor is:

$$P_L(\text{ave}) = \frac{V_s(\text{ave})^2}{R}$$

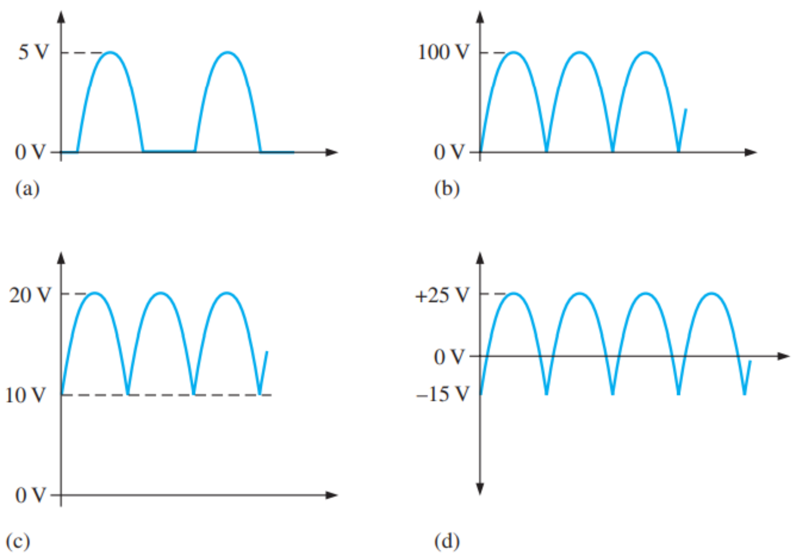
$$= \frac{(27.2)^2}{220} = 3.36\ \text{A}$$

Section B: Full-wave Rectifiers

1. In terms of energy transfer, full-wave rectifiers are twice more efficient than half-wave rectifiers.

   a. Determine the average voltage ($V(\text{ave})$) of full-wave rectifier. [2 marks]

   b. Find the average value of each voltage in the figures given below. [8 marks]



Solution

a. The average voltage of full-wave rectifier circuit is twice the average voltage of half-wave rectifier circuit. It is:

$$V(\text{ave}) = \frac{2V(\text{peak})}{\pi}$$

That is approximately 63.7% of peak voltage (V(peak) for full-wave rectifier circuit.

b. Average voltage of circuit (a):

$$V(\text{ave}) = \frac{V(\text{peak})}{\pi}$$

$$= \frac{5}{\pi} = 1.59 \text{ V}$$

c. Average voltage of circuit (b):

$$V(\text{ave}) = 2\left[\frac{V(\text{peak})}{\pi}\right]$$

$$= 2\left(\frac{100}{\pi}\right) = 63.69 \text{ V}$$

d. Average voltage of circuit (c):

$$V(\text{ave}) = 2\left[\frac{V(\text{peak}) - V(\text{offset})}{\pi}\right] + V(\text{offset})$$

$$= 2\left(\frac{10}{\pi}\right) + 10 = 16.37 \text{ V}$$

e. Average voltage of circuit (d):

$$V(\text{ave}) = 2\left[\frac{V(\text{peak}) - (-V(\text{offset}))}{\pi}\right] + V(\text{offset})$$

$$= 2\left[\frac{25 - (-15)}{\pi}\right] - 15 = 10.48 \text{ V}$$

2. Full-wave rectifier circuit can be realised as centre-tap or bridge full-wave rectifier circuit.

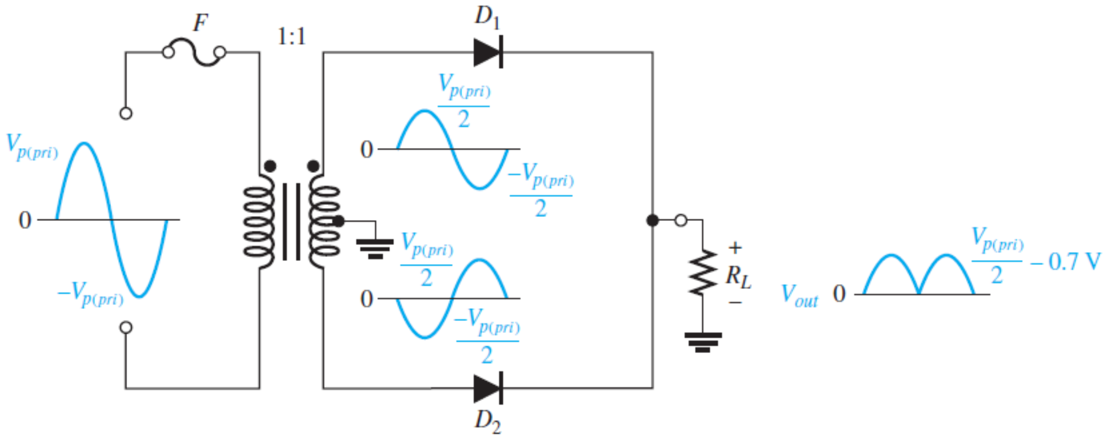
   a. Using ideal diode + voltage source model, determine average voltage from the peak voltage in full-wave rectifier circuit. [2 marks]

   b. Using ideal diode model and ideal diode + voltage source model, determine the voltage across the load at the output for centre-tap full wave rectifier circuit. [4 marks]

Solution

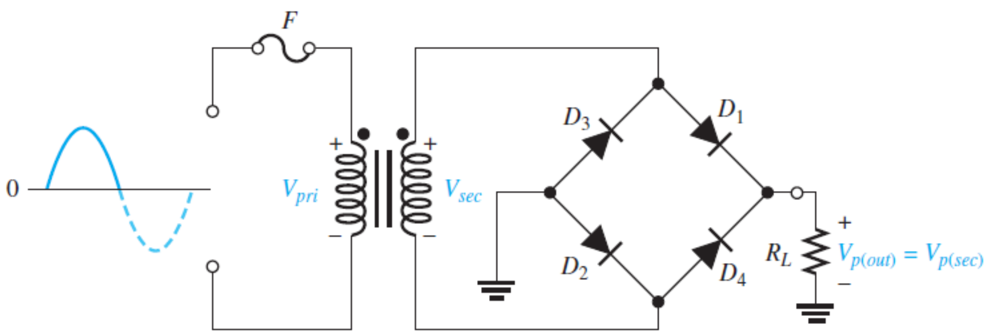
a. The voltage across the load at the output of centre-tap full-wave rectifier is:

$$V_L(\text{peak}) = \frac{V_s(\text{peak})}{2} - V_d$$



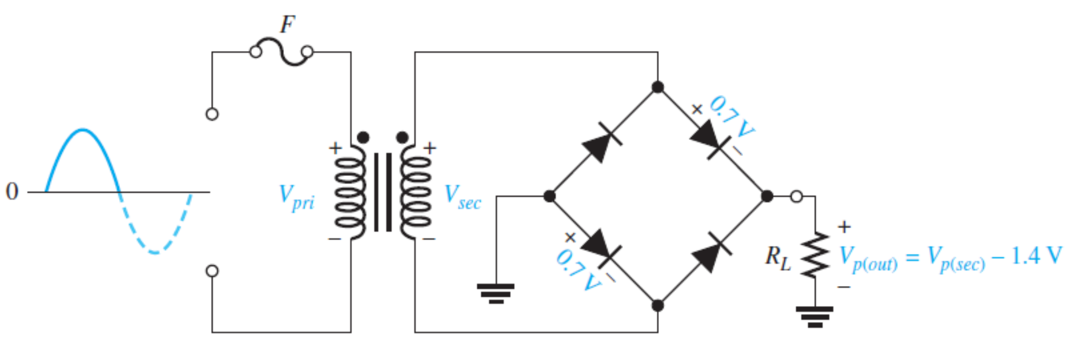
b. For ideal diode model, the voltage across the load at the output of bridge-tap full-wave rectifier is:

$$V_L(\text{peak}) = V_s(\text{peak})$$



For ideal diode + voltage source model, the voltage across the load at the output of bridge full-wave rectifier is:

$$V_L(\text{peak}) = V_s(\text{peak}) - 2(V_d)$$



3. Peak inverse voltage (PIV) is one of the device parameters which is useful for determining rating of the diode during reverse bias condition.

   a. Determine the PIV of centre-tap full-wave rectifier circuit. [6 marks]

   b. Determine the PIV of bridge full-wave rectifier circuit for ideal and ideal + voltage source models. [4 marks]

   c. Compare the PIV of centre-tap full-wave rectifier circuit with the PIV of bridge full-wave rectifier circuit. [4 marks]

Solution

a. For a centre-tap rectifier circuit, referring to the diagram given below, the PIV of each diode in the circuit is calculated from:

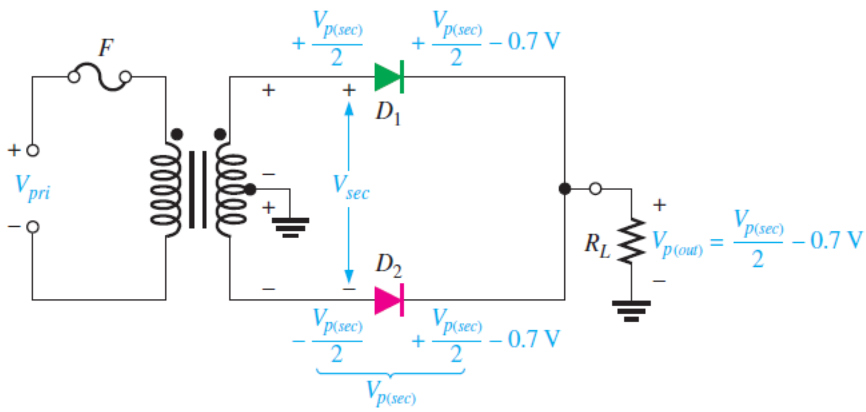
$$\mathrm{PIV} = \left(\frac{V_s(\mathrm{peak})}{2} - 0.7\right) - \left(-\frac{V_s(\mathrm{peak})}{2}\right) = V_s(\mathrm{peak}) - 0.7$$

Since $V_L(\mathrm{peak}) = V_s(\mathrm{peak})/2 - 0.7$, then multiplying each term by 2 and transposing:

$$V_s(\mathrm{peak}) = 2V_L(\mathrm{peak}) + 1.4$$

Therefore, by substitution, the peak inverse voltage across either diode in the centre-tap full-wave rectifier circuit is:

$$\mathrm{PIV} = 2V_L(\mathrm{peak}) + 0.7$$

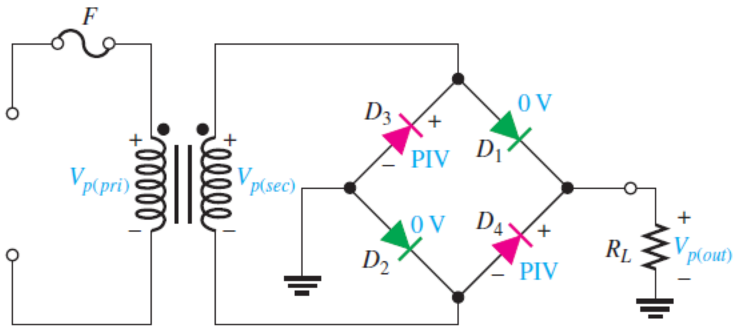


b. For bridge rectifier circuit, in case of an ideal diode model, as shown in the figure (a) below, since the output voltage is ideally equal to the secondary voltage, PIV is:

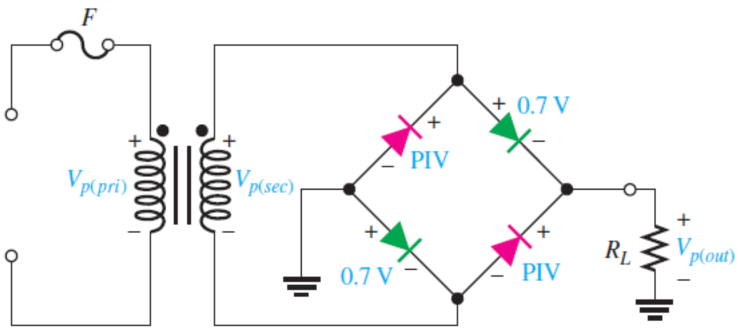
$$PIV = V_L(\mathrm{peak})$$

If the diode drops of the forward-biased diodes are included as shown in the figure (b) below, the peak inverse voltage across each reverse-biased diode is:

$$PIV = V_L(\mathrm{peak}) + V_d$$



(a) For the ideal diode model (forward-biased diodes D_1 and D_2 are shown in green), PIV = $V_{p(out)}$.



(b) For the practical diode model (forward-biased diodes D_1 and D_2 are shown in green), PIV = $V_{p(out)}$ + 0.7 V.

c. The PIV rating of the bridge diodes is less than that required for the centre-tapped configuration. If the diode drop is neglected, the bridge rectifier requires diodes with half the PIV rating of those in a centre-tapped rectifier for the same output voltage.

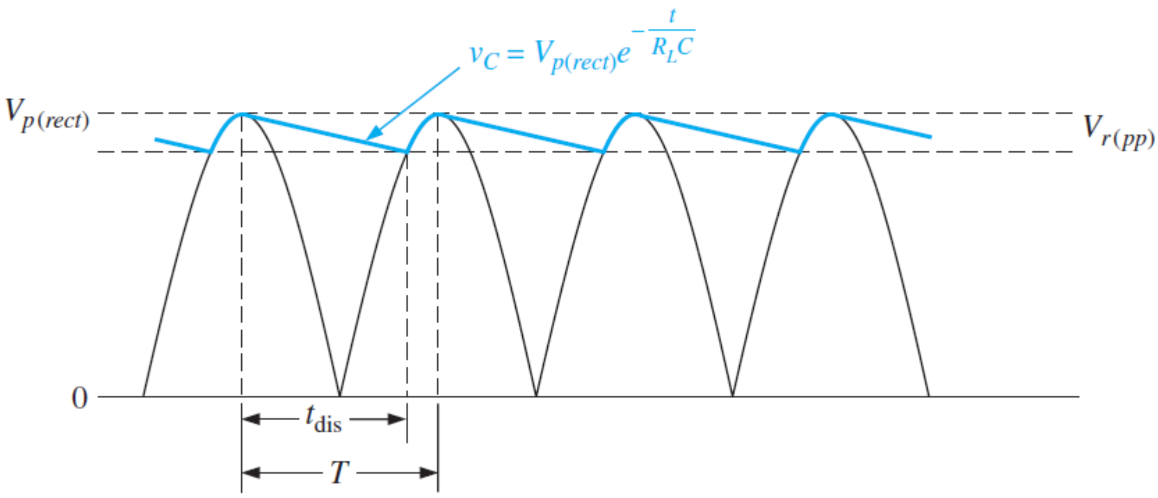
4. For a given diode rectifier circuit, derive the following parameters of the circuit:

   a. Ripple voltage (V_r). [12 marks]

   b. DC voltage (V_{DC}). [6 marks]

Answer

a. Referring to the diagram given below, the ripple in the waveform is to be derived.



When the filter capacitor discharges through R_L, the voltage is:

$$V_C = V_{rect}(\text{peak})e^{-t/R_L C}$$

Since the discharge time of the capacitor is from one peak to approximately the next peak, $t_{dis} = T$ when V_C reaches its minimum value.

$$V_C(\text{min}) = V_{rect}(\text{peak})e^{-T/R_L C}$$

Since $RC \gg T$, the $T/R_L C$ becomes much less than 1 (which is usually the case); $e^{-T/R_L C}$ approaches 1 and can be expressed as:

$$e^{-T/R_L C} \cong 1 - \frac{T}{R_L C}$$

Therefore,

$$V_C(\text{min}) = V_{rect}(\text{peak})\left(1 - \frac{T}{R_L C}\right)$$

The peak-to-peak ripple voltage is:

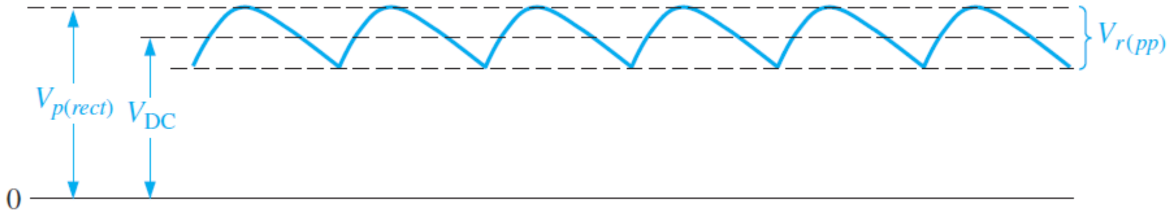
$$V_r(\text{peak} - \text{peak}) = V_{rect}(\text{peak}) - V_C(\text{min})$$

$$= V_{rect}(\text{peak}) - V_{rect}(\text{peak}) + \frac{V_{rect}(\text{peak})T}{R_L C}$$

$$= \frac{V_{rect}(\text{peak})T}{R_L C}$$

$$\cong \left(\frac{1}{fR_L C}\right) v_{rect}(\text{peak})$$

b. To obtain the dc value, one-half of the peak-to-peak ripple is subtracted from the peak value.



$$V_{DC} = V_{rect}(\text{peak}) - \frac{V_r(\text{peak} - \text{peak})}{2}$$

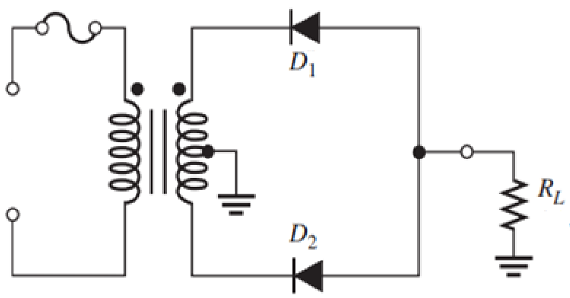
$$= V_{rect}(\text{peak}) - \left(\frac{1}{2fR_LC}\right) V_{rect}(\text{peak})$$

$$= \left(1 - \frac{1}{2fR_LC}\right) V_{rect}(\text{peak})$$

5. Show how to connect the diodes in a centre-tapped rectifier in order to produce a negative-going full-wave voltage across the load resistor. [2 marks]

Solution

It is by reversing the direction of both diodes in the secondary part of the circuit.



6. Calculate the peak voltage across each half of center-tapped transformer used in a full-wave rectifier that has an average output voltage of 120 V. [4 marks]

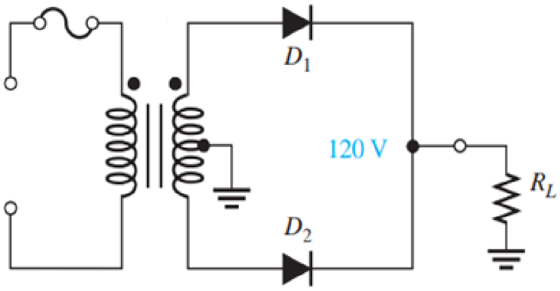
Solution

The peak voltage at the load resistor is calculated from:

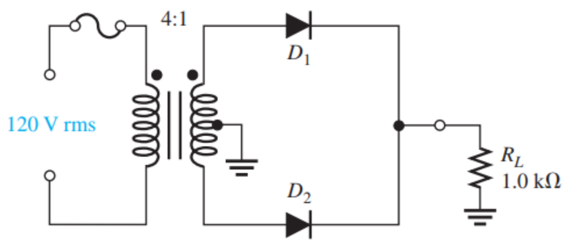
$$V_L(\text{peak}) = \left[\frac{V_L(\text{ave})}{2}\right]\pi = \left(\frac{120}{2}\right)\pi = 188.4\ \text{V}$$

The peak voltage at each half of the secondary winding is:

$$V_s(\text{peak}) = 2V_L(\text{peak}) + 2V_d = 2(188.4) + 2(0.7) = 378.2\text{ V}$$



7. Consider the centre-tap full-wave rectifier circuit given in the figure below.



a. What is the total peak secondary voltage? [2 marks]

b. Find the peak voltage across each half of the secondary. [2 marks]

c. Sketch the voltage waveform across R_L. [4 marks]

d. What is the peak current through each diode? [2 marks]

e. What is the peak inverse voltage for each diode? [2 marks]

Solution

a. The peak voltage at the centre-tap transformer's secondary winding is:

$$V_s(\text{peak}) = V_p(\text{peak})\left(\frac{N_s}{N_p}\right)$$

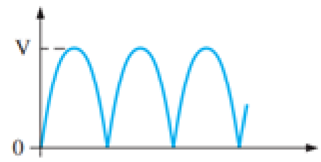
$$= \left[\frac{V_p(\text{rms})}{0.707}\right]\left(\frac{N_s}{N_p}\right)$$

$$= \left(\frac{120}{0.707}\right)\left(\frac{1}{4}\right) = 42.43\text{ V}$$

b. The peak output voltage of the diode at each half of the centre-tap transformer's secondary winding (V_s') is:

$$V_s'(\text{peak}) = \frac{V_s(\text{peak})}{2}$$
$$= \frac{42.43}{2} = 21.22\ \text{V}$$

c. The waveform of the output voltage is as shown in the figure below



Voltage across load resistor (V_L):

$$V_L(\text{peak}) = V_s'(\text{peak}) - V_d = 21.22 - 0.7 = 20.52\ \text{V}$$

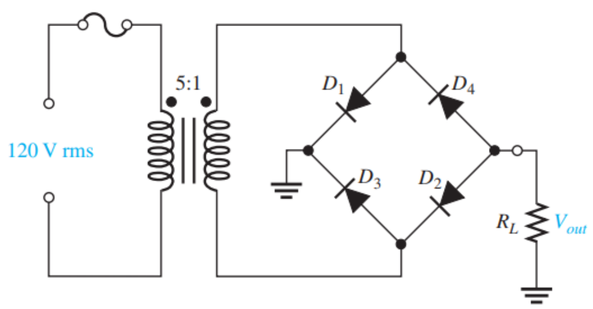
d. The peak current that flows through each diode is:

$$I_d(\text{peak}) = \frac{V_L(\text{peak})}{R}$$
$$= \frac{20.52}{1000} = 20.52\ \text{mA}$$

e. The peak inverse voltage of each diode is:

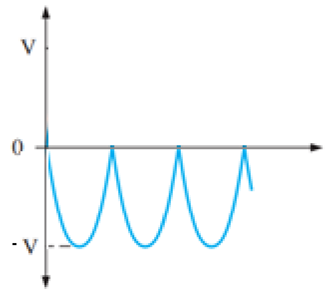
$$\text{PIV} = 2V_L(\text{peak}) + V_d$$
$$= 2(20.52) + 0.7 = 41.73\ \text{V}$$

8. Draw the output voltage waveform for the bridge rectifier given in the figure below. Notice that all the diodes are reversed from circuits shown earlier in the lecture. Determine also the peak output voltage of the rectifier circuit. [10 marks]



Solution

The waveform across the load resistor, $V_{out}(\text{peak})$ is as shown below:



In the output, we will see negative voltage of the full-wave bridge rectifier.

The peak output voltage of the rectifier circuit is:

$$V_{out}(\text{peak}) = -\left[\frac{V_{in}(\text{rms})}{0.707}\right]\left(\frac{N_s}{N_p}\right) + 2V_d$$

$$= -\left(\frac{120}{0.707}\right)\left(\frac{1}{5}\right) + [2(0.7)] = -32.55\text{ V}$$

9. What peak inverse voltage rating is required for diodes in a bridge rectifier that produces an average output voltage of 50 V? [4 marks]

Solution

The peak voltage at the secondary is determined from:

$$V_s(\text{peak}) = \left[\frac{V_s(\text{ave})}{2}\right]\pi$$

$$= \left[\frac{50}{2}\right]\pi = 78.5\text{ V}$$

The peak inverse voltage of the diode in the full-bridge rectifier is:

$$\text{PIV} = V_s(\text{peak}) + V_d$$

$$= 78.5 + 0.7 = 79.2\text{ V}$$

10. The rms output voltage of a bridge rectifier is 20 V. What is the peak inverse voltage across the diodes? [4 marks]

Solution

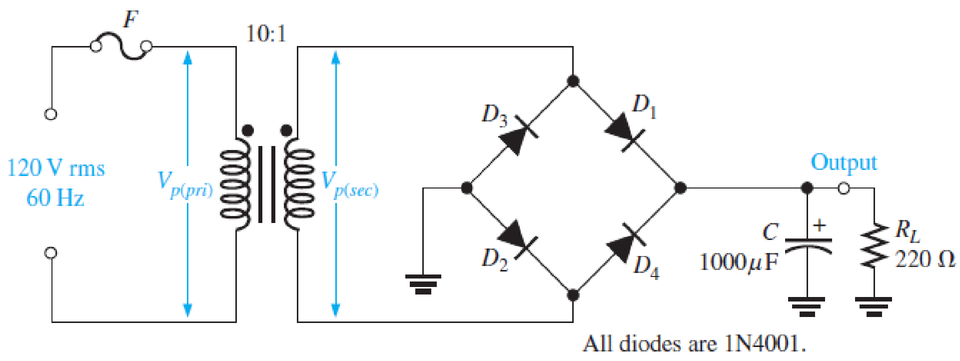
The peak voltage at the secondary is determined from:

$$V_s(\text{peak}) = \frac{V_s(\text{rms})}{0.707}$$
$$= \frac{20}{0.707} = 28.29\ \text{V}$$

The peak inverse voltage of the diode in the full-bridge rectifier is:

$$\text{PIV} = V_s(\text{peak}) + V_d$$
$$= 28.29 + 0.7 = 28.99\ \text{V}$$

11. Determine the following circuit parameters for the filtered bridge rectifier with a load as indicated in the figure given below.



a. Peak primary voltage. [2 marks]

b. Peak secondary voltage. [2 marks]

c. Unfiltered peak full-wave rectified voltage. [2 marks]

d. Peak-to-peak ripple voltage at the output. [2 marks]

e. Approximate DC value of the output voltage. [2 marks]

f. Ripple factor (in percentage). [2 marks]

Solution

a. For a full-wave rectifier as shown above, the peak primary voltage is:

$$V_p(\text{peak}) = \sqrt{2}\, V_p(\text{rms})$$
$$= 1.414(120) = 170\ \text{V}$$

b. When the transformer turns ratio is n = 0.1., the peak secondary voltage is:

$$V_s(\text{peak}) = nV_p(\text{peak})$$

$$= (0.1)(170) = 17 \text{ V}$$

c. The unfiltered peak full-wave rectified voltage is:

$$V_L(\text{peak}) = V_s(\text{peak}) - 2V_d$$
$$= 17 - (2)(0.7) = 15.6 \text{ V}$$

d. If the frequency of a full-wave rectified voltage is 120 Hz, the approximate peak-to-peak ripple voltage at the output is:

$$V_{r(peak-peak)} \cong \left(\frac{1}{fR_LC}\right) V_L(\text{peak})$$
$$= \left[\frac{1}{(120)(220)(1000 \times 10^{-6})}\right] 15.6 = 0.591 \text{ V}$$

e. The approximate dc value of the output voltage is determined as follows:

$$V_{DC} = \left(1 - \frac{1}{2fR_LC}\right) V_L(\text{peak})$$
$$= \left[1 - \frac{1}{(120)(220)(1000 \times 10^{-6})}\right] 15.6 = 15.3 \text{ V}$$

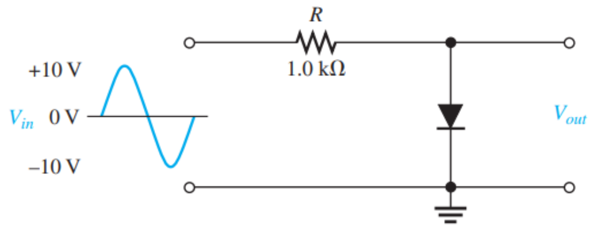
f. The resulting ripple factor is:

$$r = \frac{V_{r(peak-peak)}}{V_{DC}}$$
$$= \frac{0.591}{15.3} = 0.039$$

As a result, the percent ripple for the given rectifier circuit is 3.9%.

Section C: Diode Limiters and Clampers

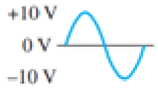
1. Determine the output waveform for the circuit given in the figure below. [4 marks]



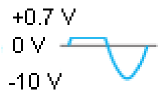
Solution

V+: V_{out} = 0.7 V

V-: V_{out} = -10 V



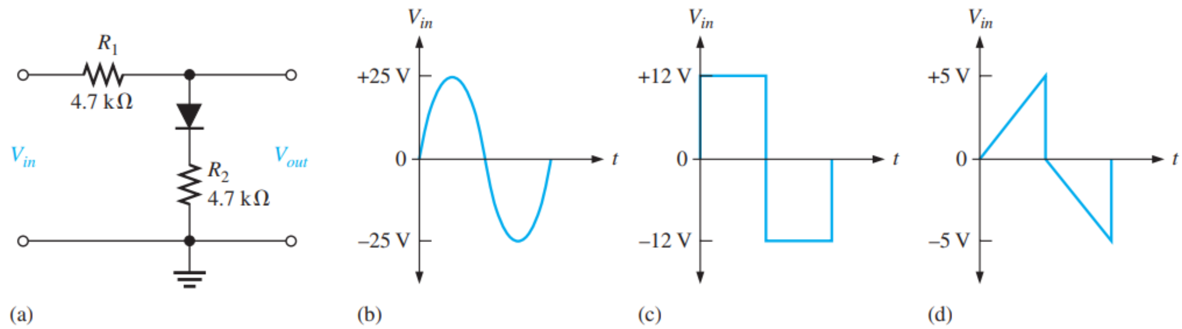
input



output

2. Determine the output voltage for the circuit in (a) for each input voltage in (b), (c), and (d).

[6 marks]

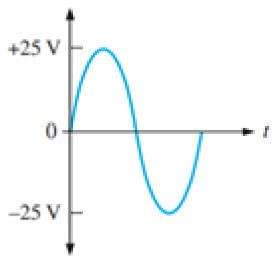


Solution

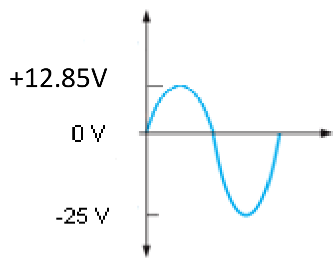
For wave form in (b)

V+: V_{out} = (25-0.7/2) +0.7 = 12.85 V

V-: V_{out} = -25 V



input

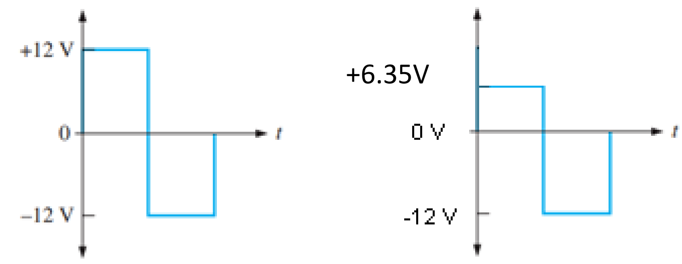


output

For waveform in (c)

V+: V_{out} = (12-0.7/2) + 0.7 = 6.35 V

V-: V_{out} = -12 V



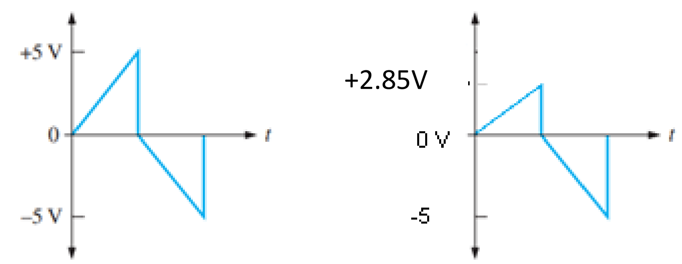
input

output

For waveform in (d)

V+: V_{out} = (5-0.7/2) + 0.7 = 2.85 V

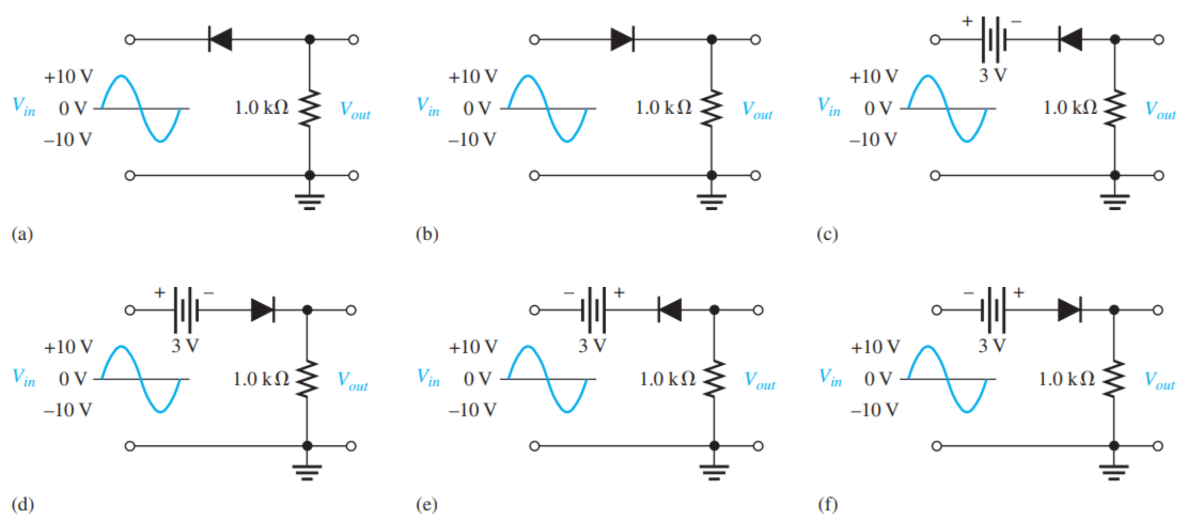
V-: V_{out} = -5 V



input

output

3. Determine the output voltage waveform for each circuit in the figure given below. [12 marks]

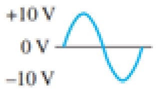


Solution

For circuit in (a)

V+: V_{out} = 0 V

V-: V_{out} = -10 + 0.7 = -9.3 V



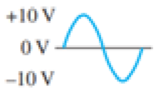
input

output

For circuit in (b)

V+: V_{out} = 10 - 0.7 = 9.3 V

V-: V_{out} = 0 V



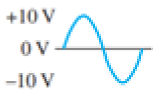
input

output

For circuit in (c)

V+: V_{out} = 0 V

V-: V_{out} = -10 - 3 + 0.7 = - 12.3 V



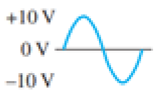
input

output

For circuit in (d)

V+: V_{out} = 10 - 3 – 0.7 = 6.3 V

V-: V_{out} = 0 V



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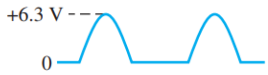


output

For circuit in (e)

V+: V_{out} = 0 V

V-: V_{out} = -10 + 3 + 0.7 = -6.3 V

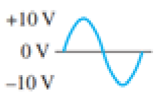
input

output

For circuit in (f)

V+: V_{out} = 10 + 3 - 0.7 = 12.3 V

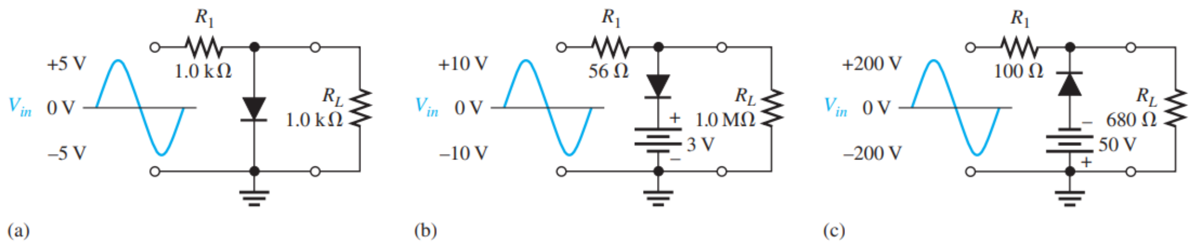
V-: V_{out} = 0 V



input

output

4. Determine the R_L voltage waveform for each circuit in the figure below. [6 marks]

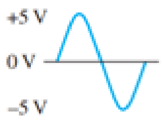


Solution

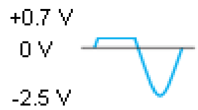
For circuit in (a)

V+: V_{out} = 0.7 V

V-: V_{out} = (5/2) = 2.5 V



input

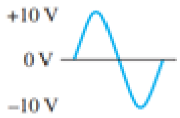


output

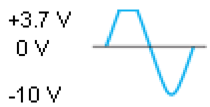
For circuit in (b)

V+: V_{out} = 3 + 0.7 = 3.7 V

V-: V_{out} = -5 – 5 = -10 V



input

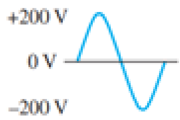


output

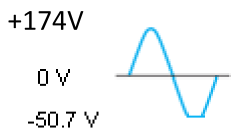
For circuit in (c)

V+: V_{out} = [680/(100+680)](200) = 174V

V-: V_{out} = -50 – 0.7 = -50.7 V

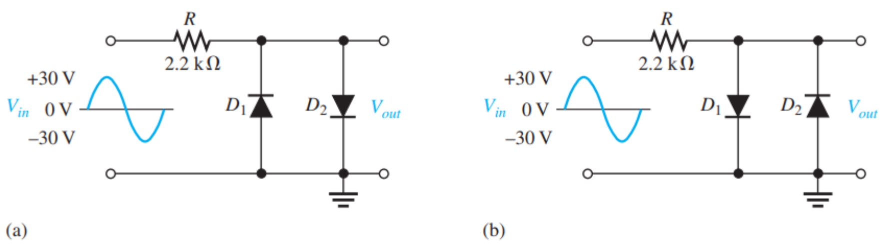


input



output

5. For each circuit in the figure below, determine:



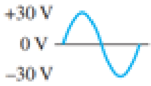
a. The output voltage waveform. [4 marks]

Solution

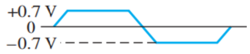
For circuit in (a)

V+: V_{out} = 0.7 V

V-: V_{out} = -0.7 V



input

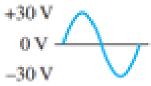


output

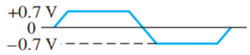
For circuit in (b)

V+: V_{out} = 0.7 V

V-: V_{out} = -0.7 V



input



output

b. The peak forward current through each diode. [4 marks]

Solution

For circuit in (a), the peak forward current is:

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak}) - V_d}{R}$$

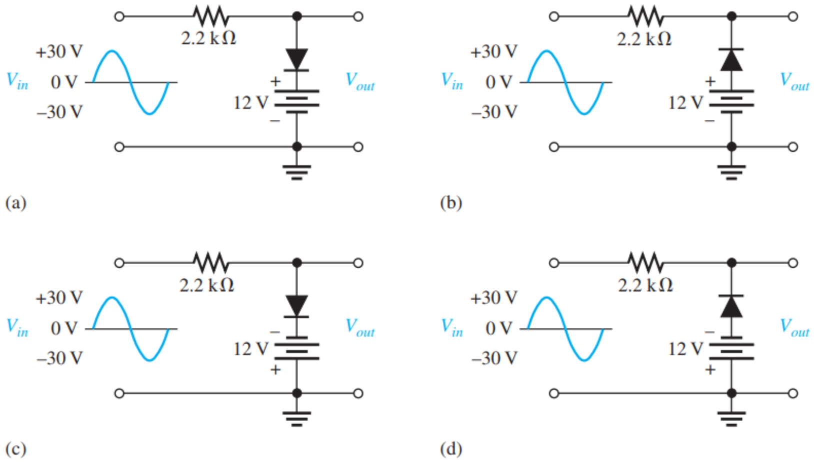
$$= \frac{30 - 0.7}{2.2 \times 10^3} = 13.3 \text{ mA}$$

For circuit in (b), the peak forward current is:

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak}) - V_d}{R}$$

$$= \frac{30 - 0.7}{2.2 \times 10^3} = 13.3 \text{ mA}$$

6. For each of the circuit given below, determine:



a. The peak forward current through each diode. [8 marks]

Solution

For circuit in (a), the peak forward current of the diode is:

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak}) - V_d - V_{offset}}{R} = \frac{30 - (0.7 + 12)}{2.2 \times 10^3} = 7.86 \text{ mA}$$

For circuit in (b), the peak forward current of the diode is:

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak}) + V_d - V_{offset}}{R} = \frac{30 - (-0.7 + 12)}{2.2 \times 10^3} = 8.5 \text{ mA}$$

For circuit in (c), the peak forward current of the diode is:

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak}) - V_d + V_{offset}}{R} = \frac{30 - (0.7 - 12)}{2.2 \times 10^3} = 18.8 \text{ mA}$$

For circuit in (d), the peak forward current of the diode is:

$$I_d(\text{peak}) = \frac{V_{in}(\text{peak}) + V_d + V_{offset}}{R} = \frac{30 - (-0.7 - 12)}{2.2 \times 10^3} = 19.4 \text{ mA}$$

b. The output voltage waveform for each circuit. [8 marks]

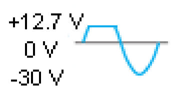
Solution

For circuit in (a)

V+: V_{out} = 12 + 0.7 = 12.7 V

V-: V_{out} = -30 V

input

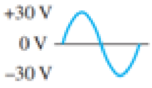


output

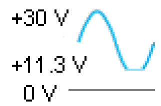
For circuit in (b)

V+: V_{out} = 30 V

V-: V_{out} = 12 – 0.7 = 11.3 V



input

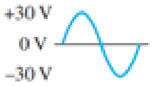


output

For circuit in (c)

V+: V_{out} = -12 + 0.7 = -11.3 V

V-: V_{out} = -30 V



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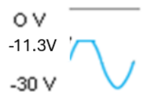
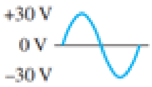


output

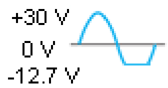
For circuit in (d)

V+: V_{out} = 30 V

V-: V_{out} = -12 – 0.7 = -12.7 V

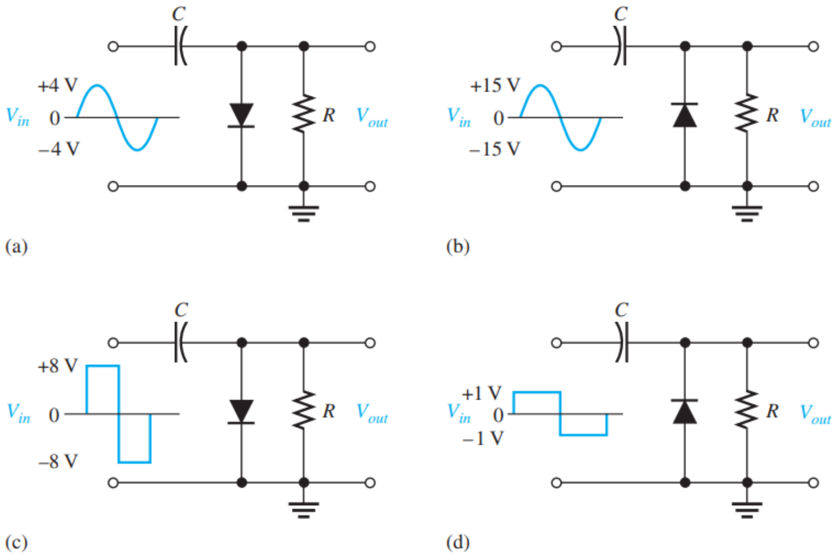


input



output

7. For each circuit given in the figure below:



a. Describe the output waveform of each circuit. Assume the RC time constant is much greater than the period of the input. [8 marks]

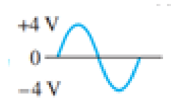
Solution

For circuit in (a)

V+: V_{out} = 0.7 V

V-: V_{out} = -4 - 4 + 0.7 = -7.3 V

DC Voltage: (0.7 - 7.3)/2 = -3.3 V



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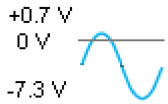


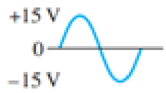
output

For circuit in (b)

V+: V_{out} = 15 + 15 - 0.7 = 29.3 V

V-: V_{out} = -0.7 V

DC Voltage: (29.3 - 0.7)/2 = 14.3 V



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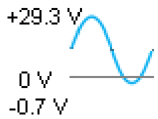


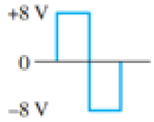
output

For circuit in (c)

V+: V_{out} = 0.7 V

V-: V_{out} = -8 - 8 + 0.7 = -15.3 V

DC Voltage: (0.7 - 15.3)/2 = -7.3 V



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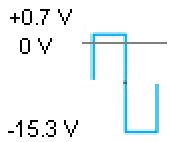


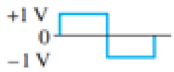
output

For circuit in (d)

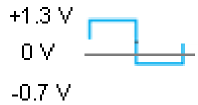
V+: V_{out} = 1 + 1 - 0.7 = 1.3 V

V-: V_{out} = -0.7 V

DC Voltage: (1.3 - 0.7)/2 = 0.3 V



input



output

b. Repeat (a) with the diodes turned around. [8 marks]

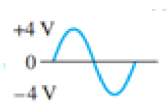
Solution

For circuit in (a)

V+: V_{out} = 4 + 4 – 0.7 = 7.3 V

V-: V_{out} = -0.7 V

DC Voltage: (7.3 - 0.7)/2 = 3.3 V



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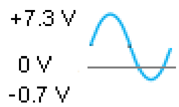


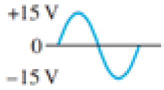
output

For circuit in (b)

V+: V_{out} = 0.7 V

V-: V_{out} = -15 -15 + 0.7 = -29.3 V

DC Voltage: (0.7 - 29.3)/2 = 14.3 V



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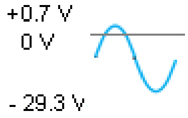


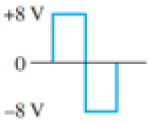
output

For circuit in (c)

V+: V_{out} = 8 + 8 – 0.7 = 15.3 V

V-: V_{out} = -0.7 V

DC Voltage: (15.3 - 0.7)/2 = 7.3 V



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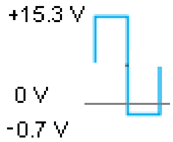


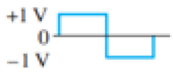
output

For circuit in (d)

V+: V_{out} = +0.7 V

V-: V_{out} = -1 - 1 + 0.7 = -1.3 V

DC Voltage: -0.3 V



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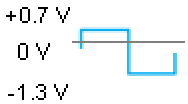

output