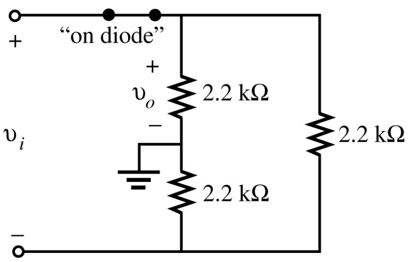
30. Positive half-cycle of v_i:

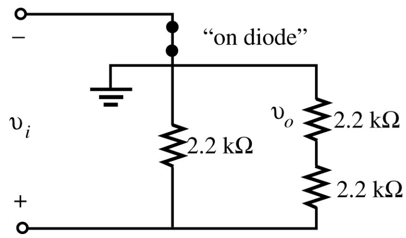
Network redrawn:



Voltage-divider rule:

$$V_{o_{\max}} = \frac{2.2\text{ k}\Omega(V_{i_{\max}})}{2.2\text{ k}\Omega + 2.2\text{ k}\Omega}$$
$$= \frac{1}{2}(V_{i_{\max}})$$
$$= \frac{1}{2}(100\text{ V})$$
$$= \mathbf{50\ V}$$

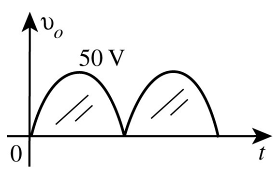
Negative half-cycle of υ_i:



Polarity of v_o across the 2.2 kΩ resistor acting as a load is the same.

Voltage-divider rule:

$$V_{o_{\max}} = \frac{2.2\text{ k}\Omega(V_{i_{\max}})}{2.2\text{ k}\Omega + 2.2\text{ k}\Omega}$$
$$= \frac{1}{2}(V_{i_{\max}})$$
$$= \frac{1}{2}(100\text{ V})$$
$$= \mathbf{50\ V}$$



$$V_{dc} = 0.636V_m = 0.636\ (50\text{ V})$$
$$= \mathbf{31.8\ V}$$

31. Positive pulse of v_i:

Top left diode "off", bottom left diode "on"
2.2 kΩ ∥ 2.2 kΩ = 1.1 kΩ

$$V_{o_{\text{peak}}} = \frac{1.1\text{ k}\Omega(170\text{ V})}{1.1\text{ k}\Omega + 2.2\text{ k}\Omega} = 56.67\text{ V}$$

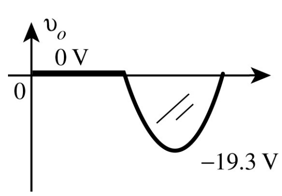
Negative pulse of v_i:

Top left diode "on", bottom left diode "off"

$$V_{o_{\text{peak}}} = \frac{1.1\text{ k}\Omega(170\text{ V})}{1.1\text{ k}\Omega + 2.2\text{ k}\Omega} = 56.67\text{ V}$$

$V_{dc} = 0.636(56.67\text{ V}) = \mathbf{36.04\ V}$

32. (a) Si diode open for positive pulse of v_i and $v_o = \mathbf{0\ V}$
For $-20\text{ V} < v_i \le -0.7\text{ V}$ diode "on" and $v_o = v_i + 0.7\text{ V}$.
For $v_i = -20\text{ V}$, $v_o = -20\text{ V} + 0.7\text{ V} = \mathbf{-19.3\ V}$
For $v_i = -0.7\text{ V}$, $v_o = -0.7\text{ V} + 0.7\text{ V} = \mathbf{0\ V}$



(b) For $v_i \leq 8$ V the 8 V battery will ensure the diode is forward-biased and $v_o = v_i - 8$ V.

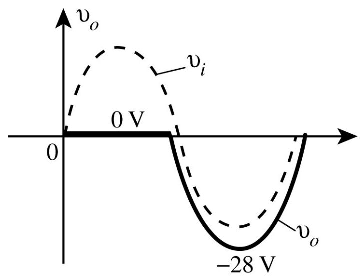
At $v_i = 8$ V

$v_o = 8\text{ V} - 8\text{ V} = \mathbf{0\ V}$

At $v_i = -20$ V

$v_o = -20\text{ V} - 8\text{ V} = \mathbf{-28\ V}$

For $v_i > 8$ V the diode is reverse-biased and $v_o = \mathbf{0\ V}$.

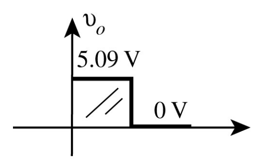


33. (a) Positive pulse of v_i:

$$V_o = \frac{1.8\text{ k}\Omega(12\text{ V} - 0.7\text{ V})}{1.8\text{ k}\Omega + 2.2\text{ k}\Omega} = \mathbf{5.09\ V}$$

Negative pulse of v_i:

diode "open", $v_o = \mathbf{0\ V}$

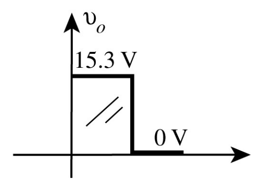


(b) Positive pulse of v_i:

$V_o = 12\text{ V} - 0.7\text{ V} + 4\text{ V} = \mathbf{15.3\ V}$

Negative pulse of v_i:

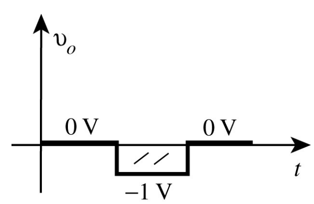
diode "open", $v_o = \mathbf{0\ V}$



34. (a) For $v_i = 20$ V the diode is reverse-biased and $v_o = \mathbf{0\ V}$.
For $v_i = -5$ V, v_i overpowers the 4 V battery and the diode is "on".

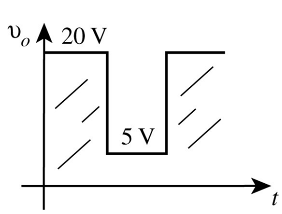
Applying Kirchhoff's voltage law in the clockwise direction:

$$-5\text{ V} + 4\text{ V} - v_o = 0$$
$$v_o = \mathbf{-1\ V}$$

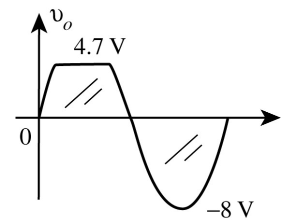


(b) For $v_i = 20$ V the 20 V level overpowers the 5 V supply and the diode is "on". Using the short-circuit equivalent for the diode we find $v_o = v_i = \mathbf{20\ V}$.

For $v_i = -5$ V, both v_i and the 5 V supply reverse-bias the diode and separate v_i from v_o. However, v_o is connected directly through the 2.2 kΩ resistor to the 5 V supply and $v_o = \mathbf{5\ V}$.



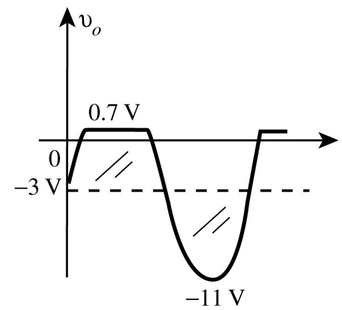
35. (a) Diode "on" for $v_i \geq 4.7$ V
For $v_i > 4.7$ V, $V_o = 4\text{ V} + 0.7\text{ V} = \mathbf{4.7\ V}$
For $v_i < 4.7$ V, diode "off" and $v_o = \boldsymbol{v_i}$



(b) Again, diode "on" for $v_i \geq 3.7$ V but v_o now defined as the voltage across the diode
For $v_i \geq 3.7$ V, $v_o = \mathbf{0.7\ V}$

For $v_i < 3.7$ V, diode "off", $I_D = I_R = 0$ mA and $V_{2.2\text{ k}\Omega} = IR = (0\text{ mA})R = 0$ V

Therefore, $v_o = v_i - 3$ V
At $v_i = 0$ V, $v_o = \mathbf{-3\ V}$
$v_i = -8$ V, $v_o = -8\text{ V} - 3\text{ V} = \mathbf{-11\ V}$

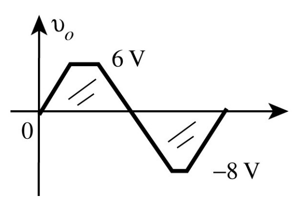


36. For the positive region of v_i:
The right Si diode is reverse-biased.
The left Si diode is "on" for levels of v_i greater than $5.3\text{ V} + 0.7\text{ V} = 6$ V. In fact, $v_o = \mathbf{6\ V}$ for $v_i \geq 6$ V.

For $v_i < 6$ V both diodes are reverse-biased and $v_o = \boldsymbol{v_i}$.

For the negative region of v_i:
The left Si diode is reverse-biased.
The right Si diode is "on" for levels of v_i more negative than $7.3\text{ V} + 0.7\text{ V} = 8$ V. In fact, $v_o = \mathbf{-8\ V}$ for $v_i \leq -8$ V.

For $v_i > -8$ V both diodes are reverse-biased and $v_o = \boldsymbol{v_i}$.



i_R: For $-8\text{ V} < v_i < 6$ V there is no conduction through the 10 kΩ resistor due to the lack of a complete circuit. Therefore, $i_R = 0$ mA.

For $v_i \geq 6$ V

$v_R = v_i - v_o = v_i - 6$ V

For $v_i = 10$ V, $v_R = 10\text{ V} - 6\text{ V} = 4$ V

and $i_R = \dfrac{4\text{ V}}{10\text{ k}\Omega} = \mathbf{0.4\ mA}$

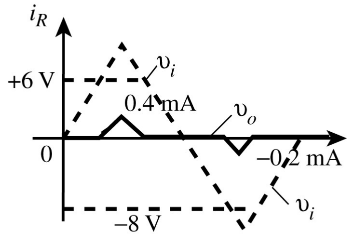
For $v_i \leq -8$ V

$v_R = v_i - v_o = v_i + 8$ V

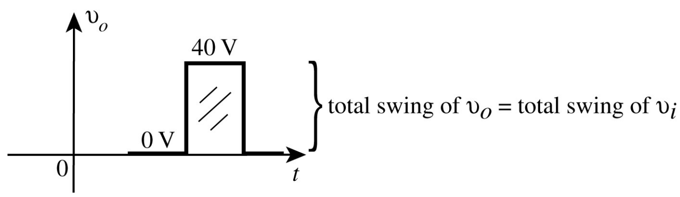
For $v_i = -10$ V

$$v_R = -10 \text{ V} + 8 \text{ V} = -2 \text{ V}$$

$$\text{and } i_R = \frac{-2 \text{ V}}{10 \text{ k}\Omega} = \mathbf{-0.2 \text{ mA}}$$

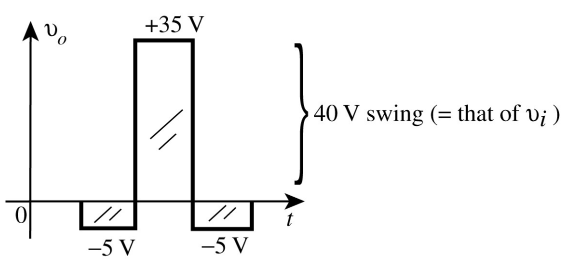


37. (a) Starting with $v_i = -20$ V, the diode is in the "on" state and the capacitor quickly charges to −20 V+. During this interval of time v_o is across the "on" diode (short-current equivalent) and $v_o = 0$ V.
When v_i switches to the +20 V level the diode enters the "off" state (open-circuit equivalent) and $v_o = v_i + v_C = 20 \text{ V} + 20 \text{ V} = +40 \text{ V}$

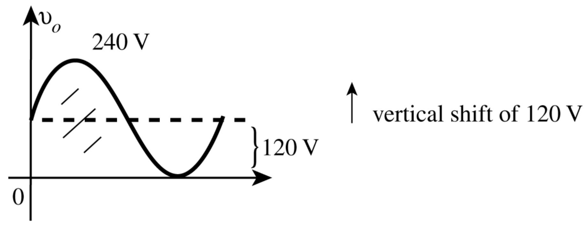


(b) Starting with $v_i = -20$ V, the diode is in the "on" state and the capacitor quickly charges up to −15 V+. Note that $v_i = +20$ V and the 5 V supply are additive across the capacitor. During this time interval v_o is across "on" diode and 5 V supply and $v_o = -5$ V.

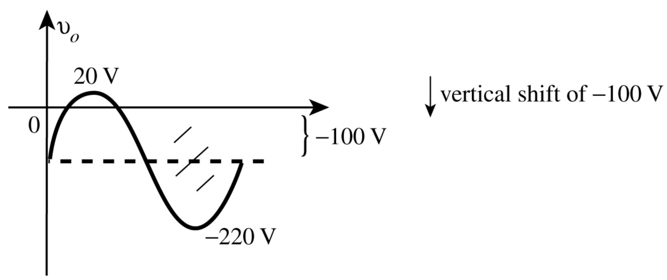
When v_i switches to the +20 V level the diode enters the "off" state and $v_o = v_i + v_C = 20 \text{ V} + 15 \text{ V} = 35 \text{ V}$.



38. (a) For negative half cycle capacitor charges to peak value of 120 V = 120 V with polarity (− —||— +). The output v_o is directly across the "on" diode resulting in v_o = **0 V** as a negative peak value.
For next positive half cycle $v_o = v_i + 120$ V with peak value of
v_o = 120 V + 120 V = **240 V**.



(b) For positive half cycle capacitor charges to peak value of 120 V − 20 V = 100 V with polarity (+ —||— −). The output v_o = 20 V = **20 V**
For next negative half cycle $v_o = v_i - 100$ V with negative peak value of
v_o = −120 V − 100 V = **−220 V**.

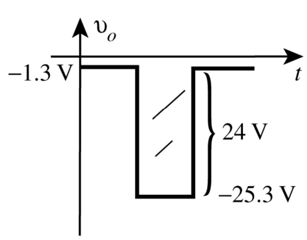


39. (a) $\tau = RC = (56\ \text{k}\Omega)(0.1\ \mu\text{F}) = 5.6$ ms
5τ = **28 ms**

(b) $5\tau = 28\text{ ms} \gg \dfrac{T}{2} = \dfrac{1\text{ ms}}{2}$ = **0.5 ms**, 56:1

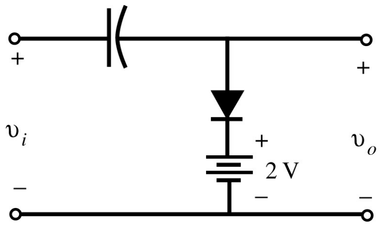
(c) Positive pulse of v_i:
Diode "on" and v_o = −2 V + 0.7 V = −1.3 V
Capacitor charges to 12 V + 2 V − 0.7 V = 13.3 V

Negative pulse of v_i:
Diode "off" and v_o = −12 V − 13.3 V = −25.3 V



40. Solution is network of Fig. 2.181(b) using a 10 V supply in place of the 5 V source.

41. Network of Fig. 2.178 with 2 V battery reversed.



42. (a) In the absence of the Zener diode

$$V_L = \frac{180\ \Omega(20\ \text{V})}{180\ \Omega + 220\ \Omega} = 9\ \text{V}$$

$V_L = 9$ V < $V_Z = 10$ V and diode non-conducting

Therefore, $I_L = I_R = \dfrac{20\ \text{V}}{220\ \Omega + 180\ \Omega}$ = **50 mA**

with I_Z = **0 mA**
and V_L = **9 V**

(b) In the absence of the Zener diode

$$V_L = \frac{470\ \Omega(20\ \text{V})}{470\ \Omega + 220\ \Omega} = 13.62\ \text{V}$$

$V_L = 13.62$ V > $V_Z = 10$ V and Zener diode "on"

Therefore, V_L = **10 V** and $V_{R_s} = 10$ V

$I_{R_s} = V_{R_s} / R_s = 10$ V/220 Ω = **45.45 mA**

$I_L = V_L/R_L = 10$ V/470 Ω = **21.28 mA**

and $I_Z = I_{R_s} - I_L = 45.45$ mA − 21.28 mA = **24.17 mA**

(c) $P_{Z_{\max}} = 400$ mW $= V_Z I_Z = (10\ \text{V})(I_Z)$

$$I_Z = \frac{400\ \text{mW}}{10\ \text{V}} = 40\ \text{mA}$$

$$I_{L_{\min}} = I_{R_s} - I_{Z_{\max}} = 45.45\ \text{mA} - 40\ \text{mA} = 5.45\ \text{mA}$$

$$R_L = \frac{V_L}{I_{L_{\min}}} = \frac{10\ \text{V}}{5.45\ \text{mA}} = \mathbf{1{,}834.86\ \Omega}$$

Large R_L reduces I_L and forces more of I_{R_s} to pass through Zener diode.

(d) In the absence of the Zener diode

$$V_L = 10\ \text{V} = \frac{R_L(20\ \text{V})}{R_L + 220\ \Omega}$$

$10R_L + 2200 = 20R_L$

$10R_L = 2200$

R_L = **220 Ω**