Boylestad-Electronic Devices and Circuit-Clipper & Clamper Circuits-Module & Solved Problems

Basic Electronics - Lec (De La Salle University – Dasmariñas)

LESSON 6. CLIPPERS AND CLAMPERS CIRCUIT

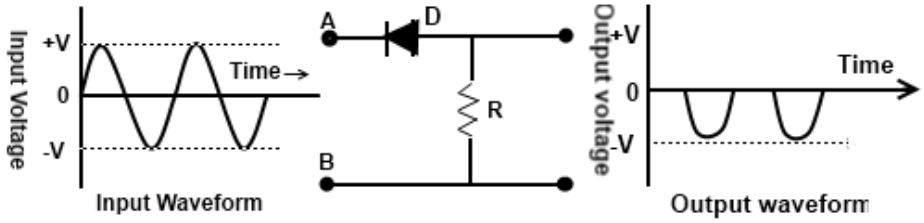
Intended Learning Outcomes

After the completion of the chapter, students will be able to:

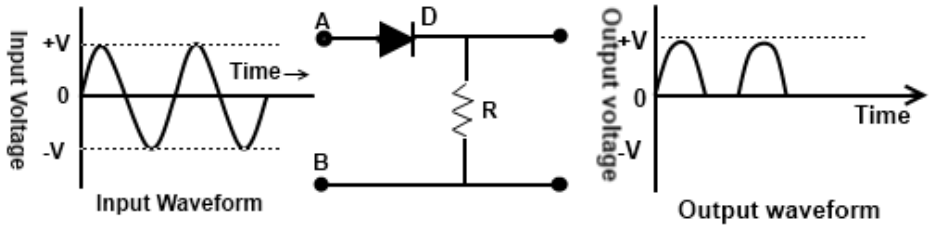
1. Design and analyze a clipper circuit given an output and input.
2. Design and analyze a clamper circuit given an output and input.

Diode Clippers

- Clippers are known as limiters.
- Limiting circuits limit the positive or negative amount of an input voltage to a specific value.
- The desired amount of limitation can be attained by power supply or voltage divider.
- The amount clipped can be adjusted with different levels of V_{bias}.
- A circuit which cutoff voltage above or below voltage are both at specified level is called clipper.
- A clipper which removes a portion of positive half-cycle of the input signal is called positive clipper while a clipper which removes a portion of negative half-cycle of the input signal is called negative clipper.



(a) Positive clipper

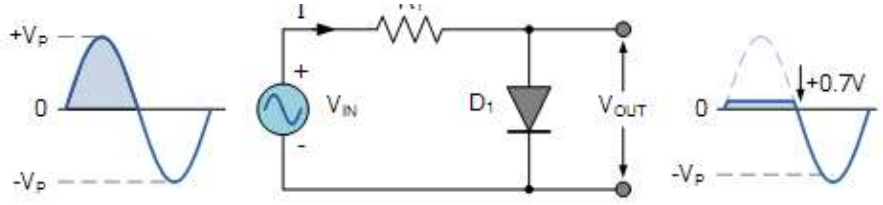


(b) Negative clipper

Type of Clipper Circuits.

1. Clipper

Circuit Problem 1. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diode, input voltage of $20\,V_P$, and a bias voltage of 10V.

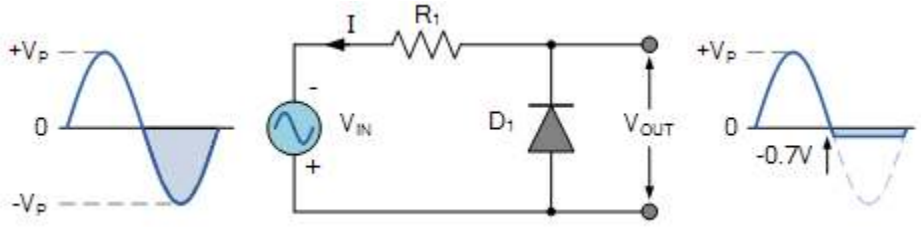


@ Positive Half-Cycle ($V_{in} = 20V$)
Diode is forward-biased (ON-state) and parallel to output
$\boldsymbol{V_o = 0.7V}$

@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is reverse-biased (OFF-state)

$V_{in} - V_o = 0$
$\boldsymbol{V_o = -20V}$

Circuit Problem 2. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diode, input voltage of $20\,V_P$, and a bias voltage of 10V.

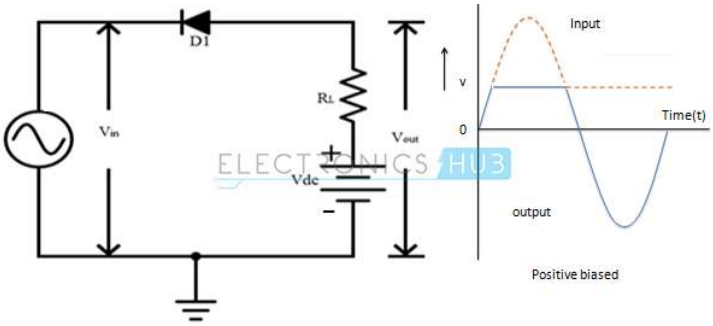


@ Positive Half-Cycle ($V_{in} = 20V$)
Diode is reverse-biased (OFF-State)
$V_{in} - V_o = 0$
$\boldsymbol{V_o = 20V}$

@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is forward-biased (ON-state) and parallel to V_o
$\boldsymbol{V_o = -0.7V}$

2. Series Clipper with Bias Voltage

Circuit Problem 3. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diode, input voltage of $20\,V_P$, and a bias voltage of 10V.

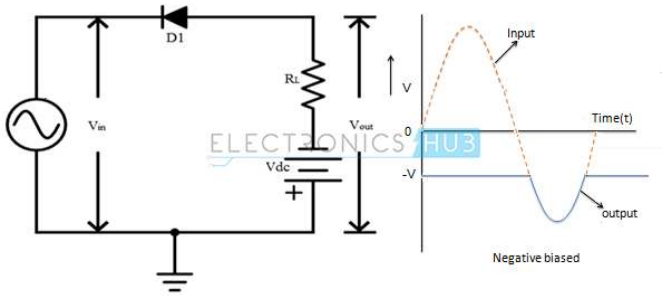


@ Positive Half-Cycle ($V_{in} = 20V$)
Current will start at higher potential. Since V_{in} is greater than V_{bias}, no current flow due to reverse biased condition of diode (open).

$V_o - V_{dc} = 0$
$\boldsymbol{V_o = 10V}$

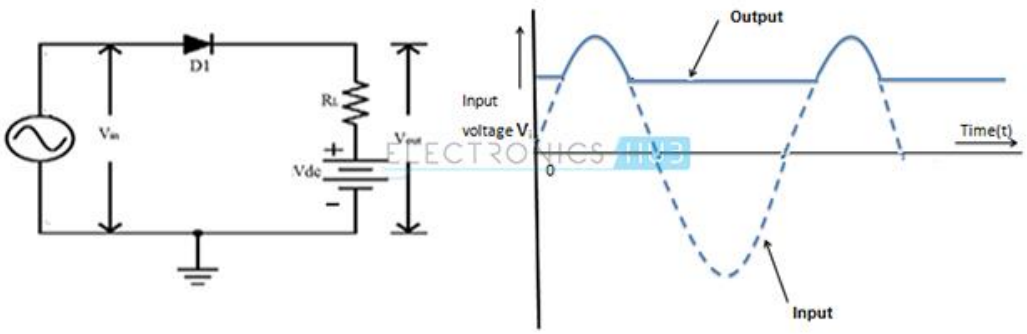
@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is now forward-biased condition due to the negative input.
$$V_{in} + V_D - V_o = 0$$
$$-20V + 0.7V - V_o = 0$$
$$\boldsymbol{V_o = -19.3V}$$

Circuit Problem 4. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diode, input voltage of $20\,V_P$, and a bias voltage of 10 V.



@ Positive Half-Cycle ($V_{in} = 20V$)
Since V_{in} is greater than V_{dc}, no current flow due to reverse biased.
$$V_o + V_{dc} = 0$$
$$\boldsymbol{V_o = -10V}$$
@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is now forward-biased condition due to the negative input.
$$V_{in} + V_D - V_o = 0$$
$$-20V + 0.7V - V_o = 0$$
$$\boldsymbol{V_o = -19.3V}$$

Circuit Problem 5. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diode, input voltage of $20\,V_P$, and a bias voltage of 10 V.

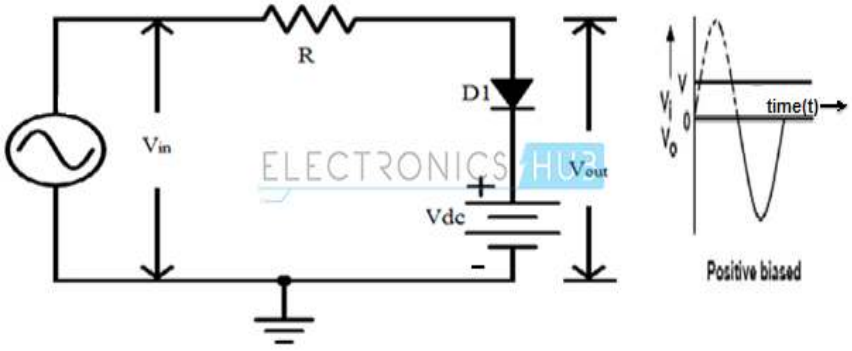


@ Positive Half-Cycle ($V_{in} = 20V$)
Diode is forward biased.
$$20V - 0.7 - V_o = 0$$
$$V_o = 19.3V$$

@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is reversed biased
$V_o - V_{dc} = 0$
$V_o = 10V$

3. Parallel Clipper with Bias Voltage

Circuit Problem 6. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diode, 1 kilo-ohms resistor, input voltage of $20\,V_P$, and a bias voltage of 10 V.



@ Positive Half-Cycle ($V_{in} = 20V$)
$20V - I(1k) - 0.7V - 10V = 0$
$I = 9.3mA$

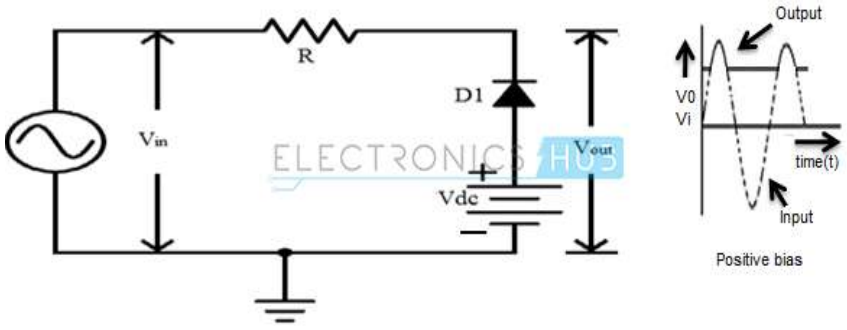
$20V - (9.3mA)(1k) - V_o = 0$
$\boldsymbol{V_o = 10.7V}$

@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is reversed-biased, clipper circuit is open.

$V_{in} - V_o = 0$
$\boldsymbol{V_o = -20V}$

Vin - Vdc
Vo = 10V

Circuit Problem 7. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diode, 1 kilo-ohms resistor, input voltage of $20\,V_P$, and a bias voltage of 10 V.



@ Positive Half-Cycle ($V_{in} = 20V$)

Diode is reverse-biased (OFF-state)
Current starts to flow at higher potential which is V_{in}.

$$V_{in} - V_o = 0$$
$$V_o = 20V$$

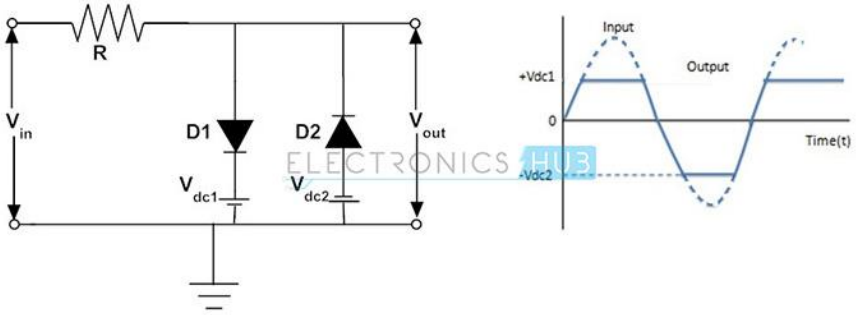
@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is forward-biased (ON-state). Compute for the current at resistor.

$$-20V - I(1k) + 0.7 - 10V = 0$$
$$\boldsymbol{I = -29.3\ mA}$$

$$\boldsymbol{-20V - (-29.3mA)(1k) - V_o = 0}$$
$$\boldsymbol{V_o = 9.3V}$$

4. Double Clipper with Bias Voltage

Circuit Problem 8. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diodes, 1 kilo-ohms resistor, input voltage of $20\ V_P$, and bias voltages of 10 V.



@ Positive Half-Cycle ($V_{in} = 20V$)
D_1 is forward-biased.

$$20V - I(1k) - 0.7 - 10V = 0$$
$$I = 9.3\ mA$$

$$20V - (1k)(9.3\ mA) - V_o = 0$$
$$\boldsymbol{V_o = 10.7\ V}$$

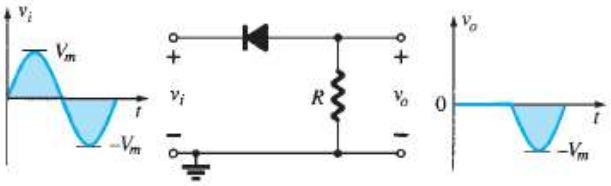
@ Negative Half-Cycle ($V_{in} = -20V$)
D_2 is forward-biased

$$-20V - I(1k) + 0.7V + 10V = 0$$
$$I = -9.3\ mA$$

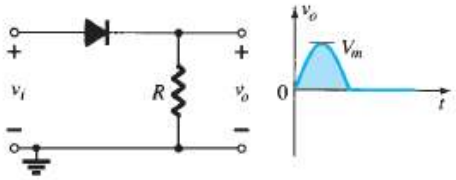
$$-20V - (-9.3\ mA)(1k) - V_o = 0$$
$$\boldsymbol{V_o = -10.7\ V}$$

Simple Series Clipper Circuits (Ideal Diodes)

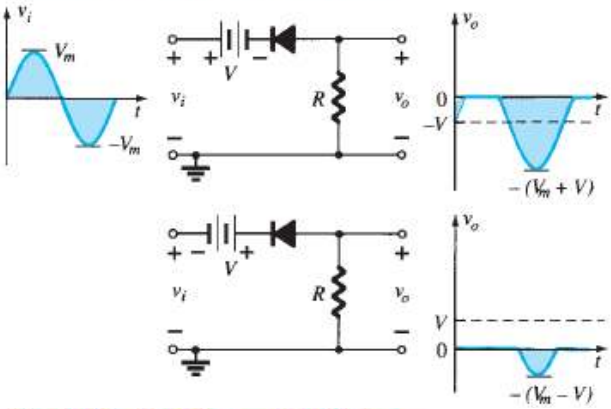
POSITIVE

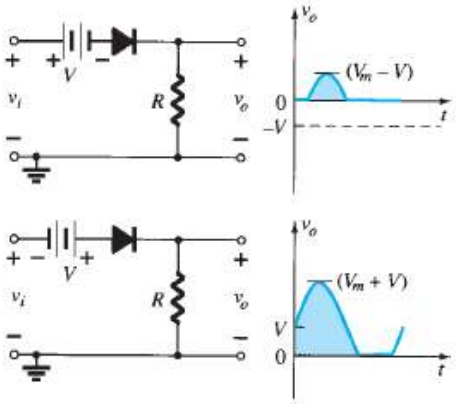


NEGATIVE

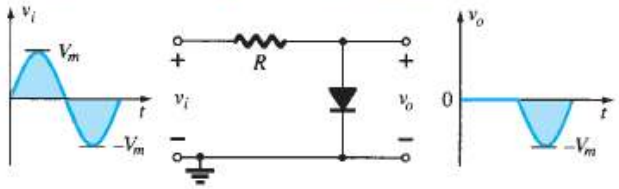


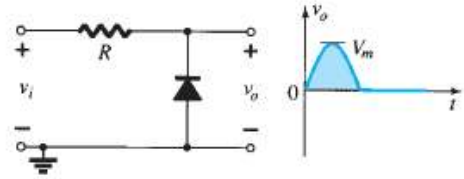
Biased Series Clippers (Ideal Diodes)



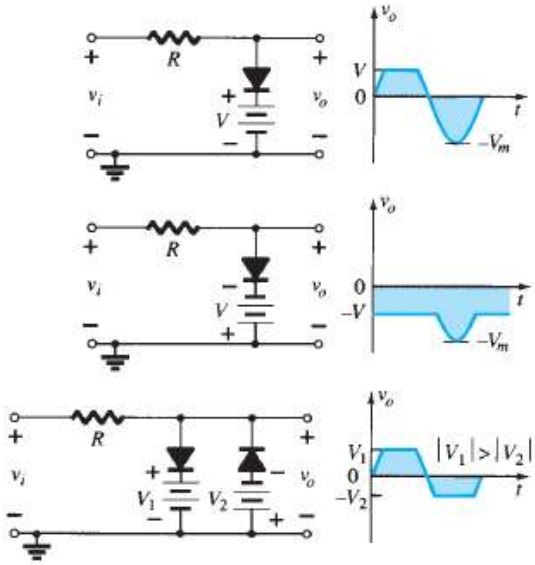


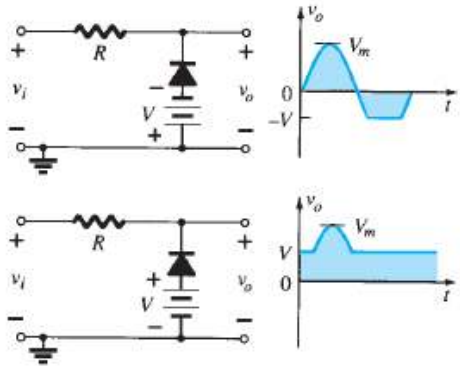
Simple Parallel Clippers (Ideal Diodes)





Biased Parallel Clippers (Ideal Diodes)



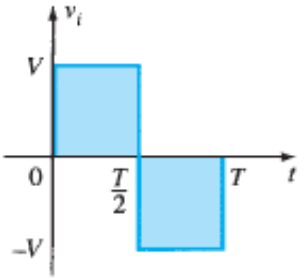


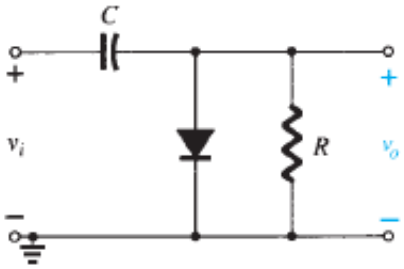
Diode Clampers

- Clampers are referred to as DC restorers.
- Clamper is also called level shifter.
- Diode clamper adds a DC level to an AC voltage
- The AC voltage will “ride” along with the DC voltage.
- A diode and capacitor can be combined to “clamp” an AC signal to a specific DC level.
- During the positive half cycle, at the peak value, the capacitor gets charged with positive on one plate and negative on the other.
- During the negative half cycle, at the peak value, the capacitor gets charged with negative on one plate and positive on the other.

Clamper Circuit

Circuit Problem 9. Determine the output voltage and input-output waveform of the figure below. Assuming ideal diodes, 1 kilo-ohms resistor and input voltage of $1\ V_P$



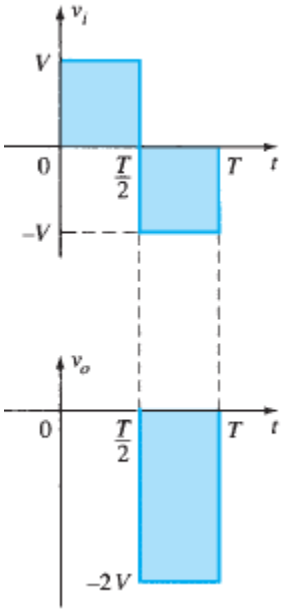


@ Positive Half-Cycle ($V_{in} = 1V$)
Diode is forward-biased (ON-state)
Positive on the left plate and negative on right plate of capacitor.

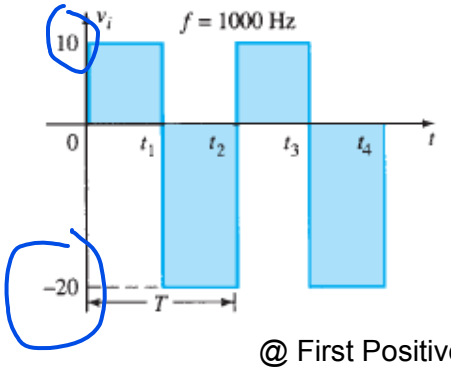
$$V_{in} - V_C - V_D = 0$$
$$1V - V_C - 0V = 0$$
$$\boldsymbol{V_C = 1V}$$

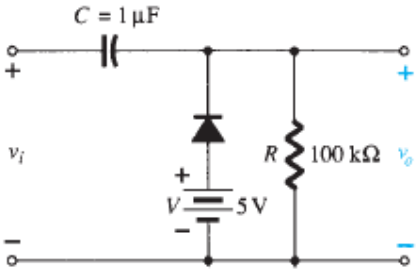
$$V_{in} - V_c - V_o = 0$$
$$1V - 1V - V_o = 0$$
$$\boldsymbol{V_o = 0V}$$

@ Negative Half-Cycle ($V_{in} = -1V$)
Diode is reverse-biased (OFF-state)
$$V_{in} - V_C - V_o = 0$$
$$-1V - 1V - V_o = 0$$
$$\boldsymbol{V_o = -2V}$$



Circuit Problem 10. Determine the output voltage and input-output waveform of the figure below. Assuming silicon diodes. Bias Volt : 5V





@ First Positive Half-Cycle ($V_{in} = 10V$)
Diode is reverse-biased (OFF-state)

$$V_o + V_D - 5V = 0$$
$$V_o + 0V - 5V = 0$$
$$V_o = 5V$$

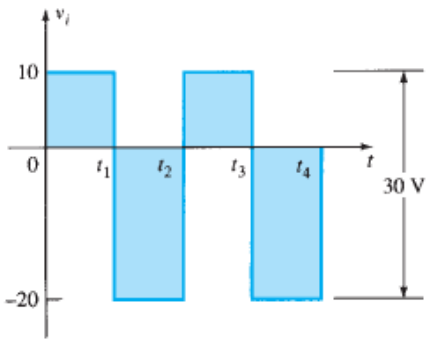
@ Negative Half-Cycle ($V_{in} = -20V$)
Diode is forward-biased (ON-state).
Negative on the left plate and positive on the right plate of capacitor

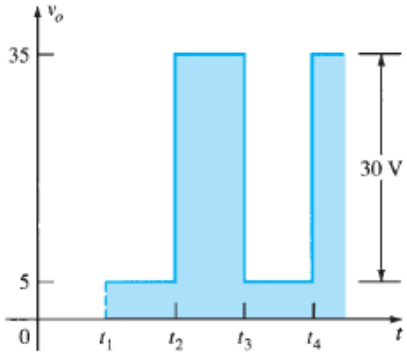
$$-20V + V_C - V_D - 5V = 0$$
$$-20V + V_C - 0V - 5V = 0$$
$$V_C = 25V$$

$$V_{in} + V_C - V_o = 0$$
$$-20V + 25V - V_o = 0$$
$$V_o = 5V$$

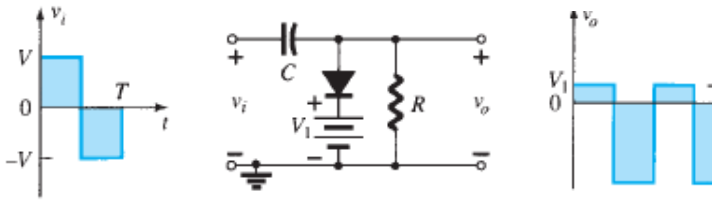
@ Positive Half-Cycle ($V_{in} = 10V$)
$$10V + 25V - V_o = 0$$
$$V_o = 35\ V$$

Input-Output Waveform





Circuit Problem 11. Determine the output voltage and input-output waveform of the figure below. Assuming germanium diodes, input voltage of $15V_P$, and dc voltage of $7V$.



@ Positive Half-Cycle ($V_{in} = 15V$)
Diode is forward-biased (ON-state)
Positive on the left plate and negative on right plate of capacitor.

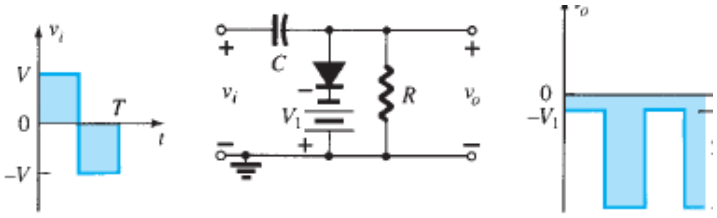
$$15V - V_C - 0.7 - 7V = 0$$
$$V_C = 7.3V$$

$$V_{in} - V_C - V_o = 0$$
$$15V - 7.3V - V_o = 0$$
$$\boldsymbol{V_o = 7.7V}$$

@ Negative Half-Cycle ($V_{in} = -15V$)
Diode is reverse biased (OFF-state)

$$-15V - 7.3V - V_o = 0$$
$$\boldsymbol{V_o = -22.3V}$$

Circuit Problem 12. Determine the output voltage and input-output waveform of the figure below. Assuming germanium diodes, input voltage of $15V_P$, and dc voltage of $7V$.



@ Positive Half-Cycle ($V_{in} = 15V$)
Diode is forward-biased (ON-state)
Positive on the left plate and negative on right plate of capacitor.

$$15V - V_C - 0.3V + 7V = 0$$
$$V_C = 21.7V$$

$$15V - V_C - V_o = 0$$
$$15 - 21.7 - V_o = 0$$
$$\boldsymbol{V_o = -6.7V}$$

@ Negative Half-Cycle ($V_{in} = 15V$)
Diode is reverse-biased (OFF-state)
$$-15V - 21.7V - V_o = 0$$
$$\boldsymbol{Vo = -36.7\ V}$$