# LECTURE 7

# DC POWER SUPPLIES

**Analog Electronics**

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*By*

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# Outline and Aim

**After completing this lecture, you should be able to:**

- Describe the operation of power supplies
- Explain the operation of a capacitor-input filter
- Determine the PIV for the diode in a filtered rectifier
- Define ripple voltage and discuss its cause
- Calculate the ripple factor

# The Basic DC Power Supply

The **DC power supply** converts the standard 220 V, 50 Hz AC into a constant DC voltage. The DC voltage produced by a power supply is used to power all types of electronic circuits, such as:

- Television
- Satellite receivers,
- Stereo systems,
- Computers,
- Laboratory equipment.
- Most of the electronic devices

# The Basic DC Power Supply

The general DC power supply consists of the following:
Transformer, Rectifier, Filter, and Regulator

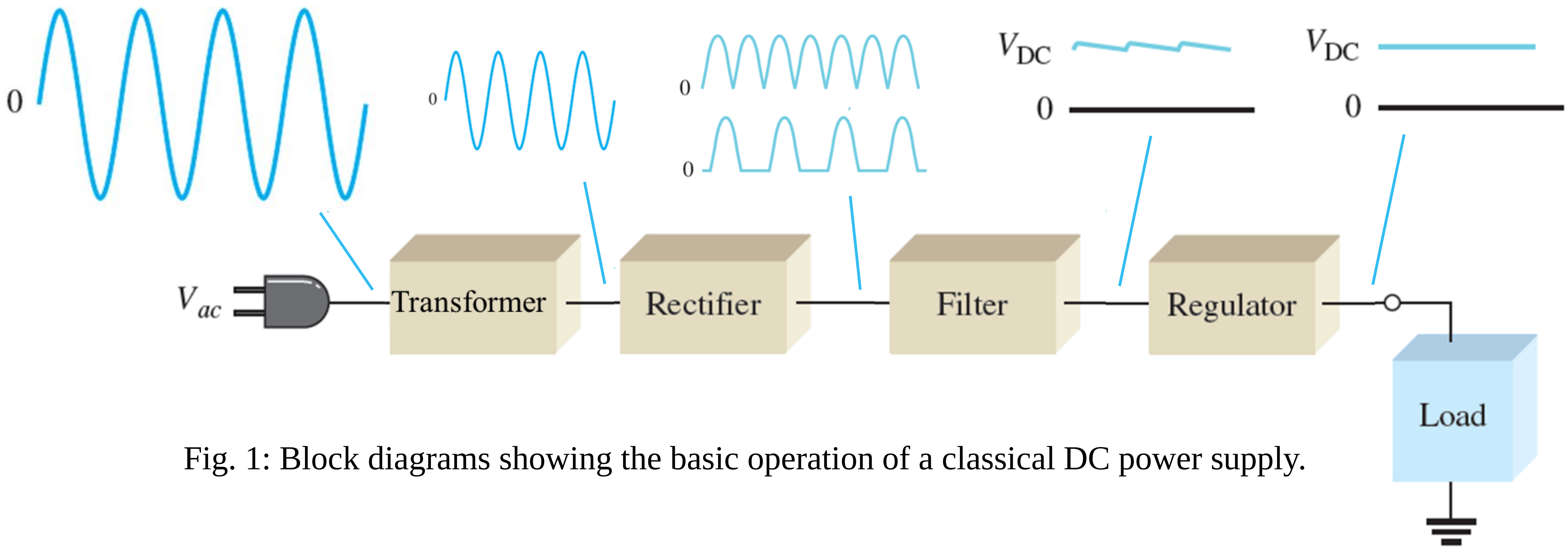



Fig. 1: Block diagrams showing the basic operation of a classical DC power supply.

# Capacitor-Input Filter

During the positive first quarter-cycle of the input,

- The diode is forward-biased, allowing the capacitor to charge to approximately the diode drop of the input peak, as illustrated in Fig.2.

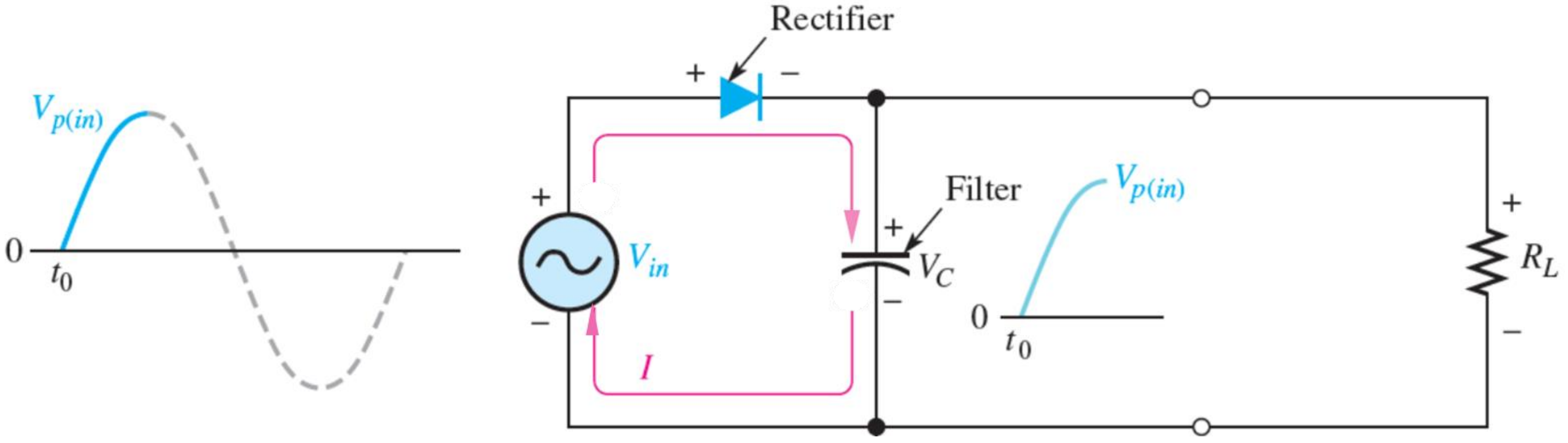



Fig. 2. Initial charging of the capacitor (diode is forward-biased) happens only once when power is turned on.

# Capacitor-Input Filter

During the positive first quarter-cycle of the input,

- When the input begins to decrease below its peak, as shown in Fig. 3, the capacitor retains its charge, and the diode becomes reverse-biased.

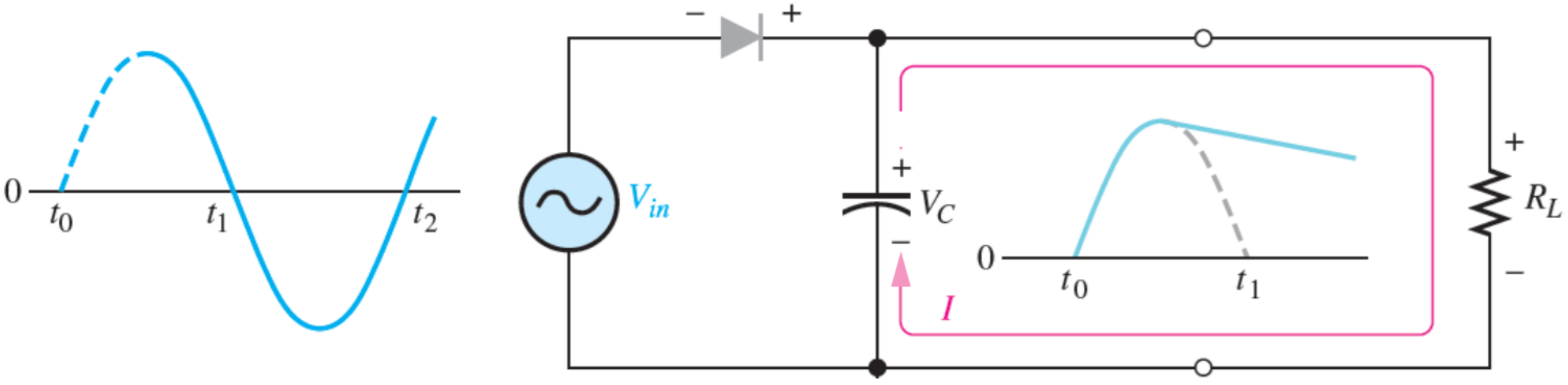



Fig. 3: The capacitor discharges through $R_L$ after peak of positive alternation when the diode is reverse-biased. This discharging occurs during the portion of the input voltage indicated by the solid dark blue curve.

# Capacitor-Input Filter

During the positive first quarter-cycle of the input,

- Because the capacitor charges to a peak value equal to $V_{P(in)}$, the peak inverse voltage of the diode in this application is:

$$PIV = 2V_{p(in)}$$

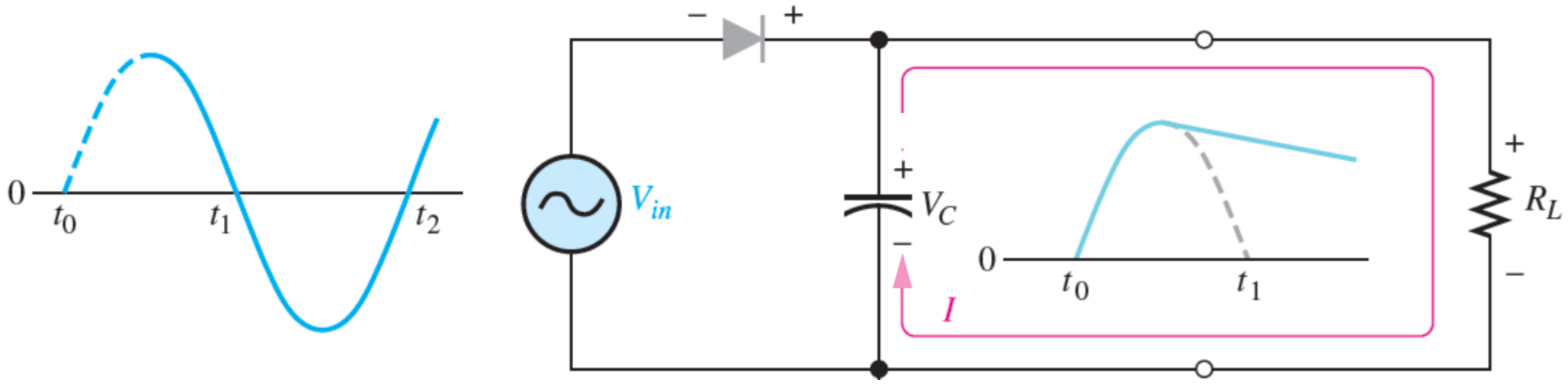



Fig. 3: The capacitor discharges through $R_L$ after peak of positive alternation when the diode is reverse-biased. This discharging occurs during the portion of the input voltage indicated by the solid dark blue curve.

# Capacitor-Input Filter

During the positive first quarter-cycle of the input,

- During the remaining part of the cycle, the capacitor can discharge only through the load resistance at a rate determined by the $R_L C$ time constant. The larger the time constant, the less the capacitor will discharge.

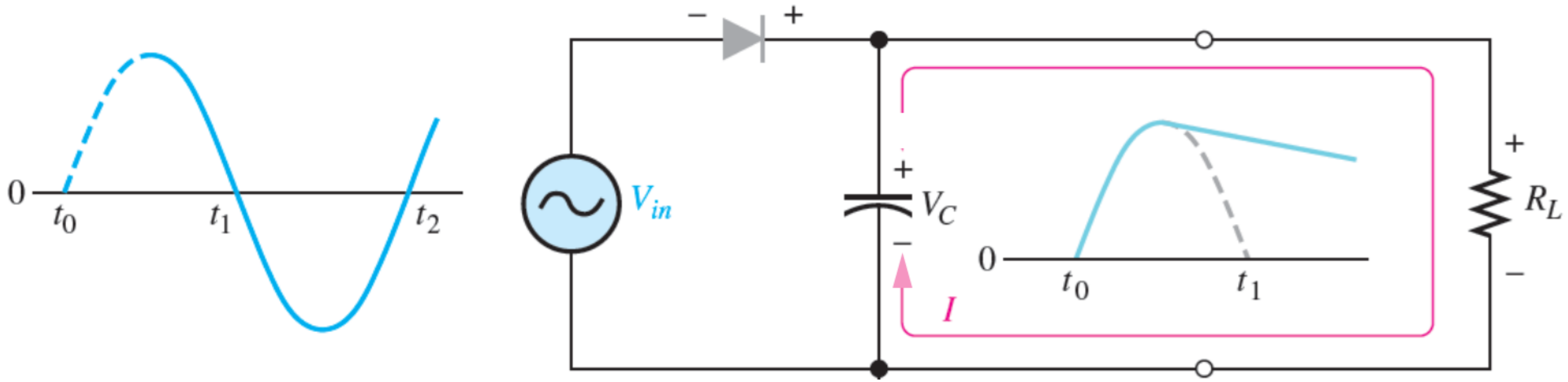



Fig. 3: The capacitor discharges through $R_L$ after peak of positive alternation when the diode is reverse-biased. This discharging occurs during the portion of the input voltage indicated by the solid dark blue curve.

# Capacitor-Input Filter

During the first quarter of the next cycle, as illustrated in Fig. 4, the diode again will become forward-biased when the input voltage exceeds the capacitor voltage.

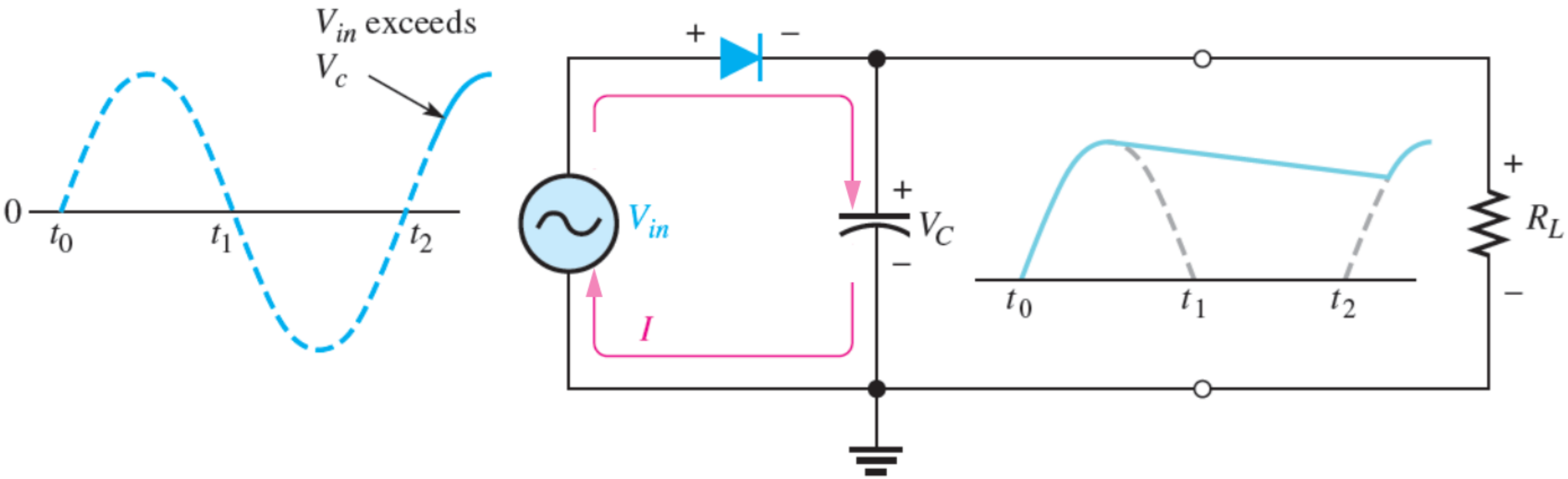



Fig. 4: The capacitor charges back to peak of input when the diode becomes forward-biased. This charging occurs during the portion of the input voltage indicated by the solid dark blue curve.

# Ripple Voltage ($V_r$)

The variation in the output voltage of a DC power supply due to the charging and discharging of the capacitor is called the **ripple voltage**. The smaller the ripple, the better the filtering action, as illustrated in Fig. 5.

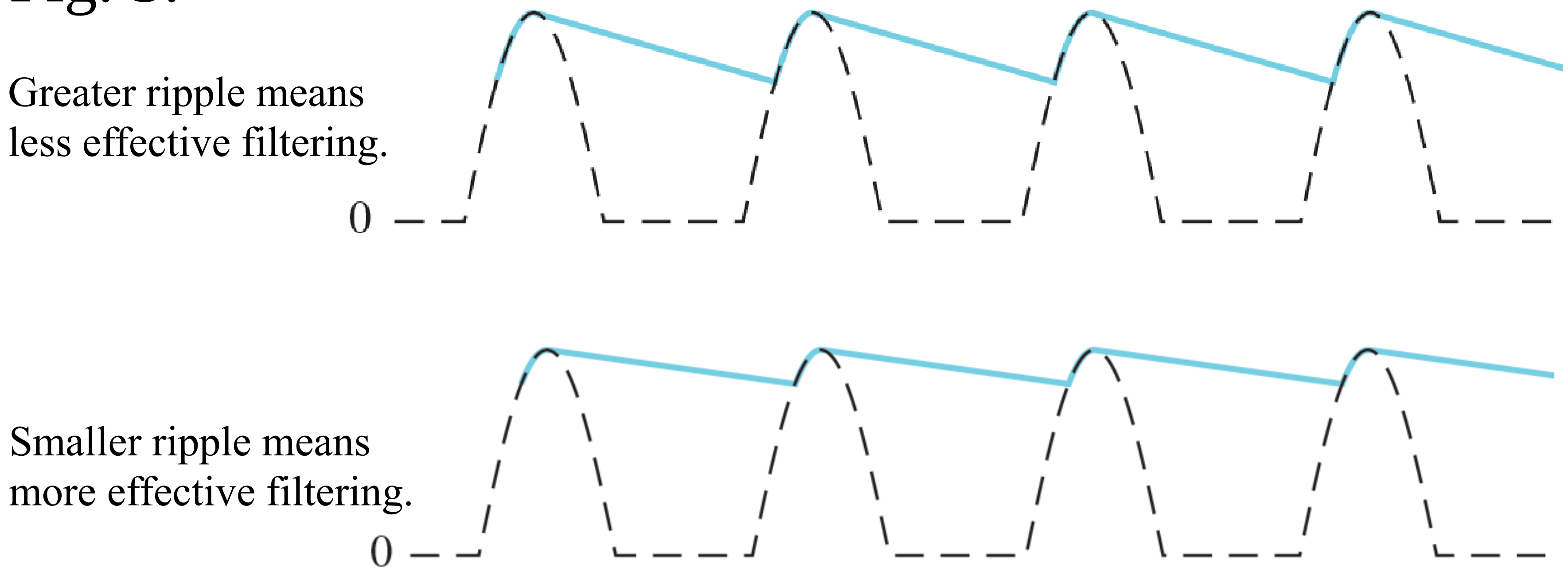
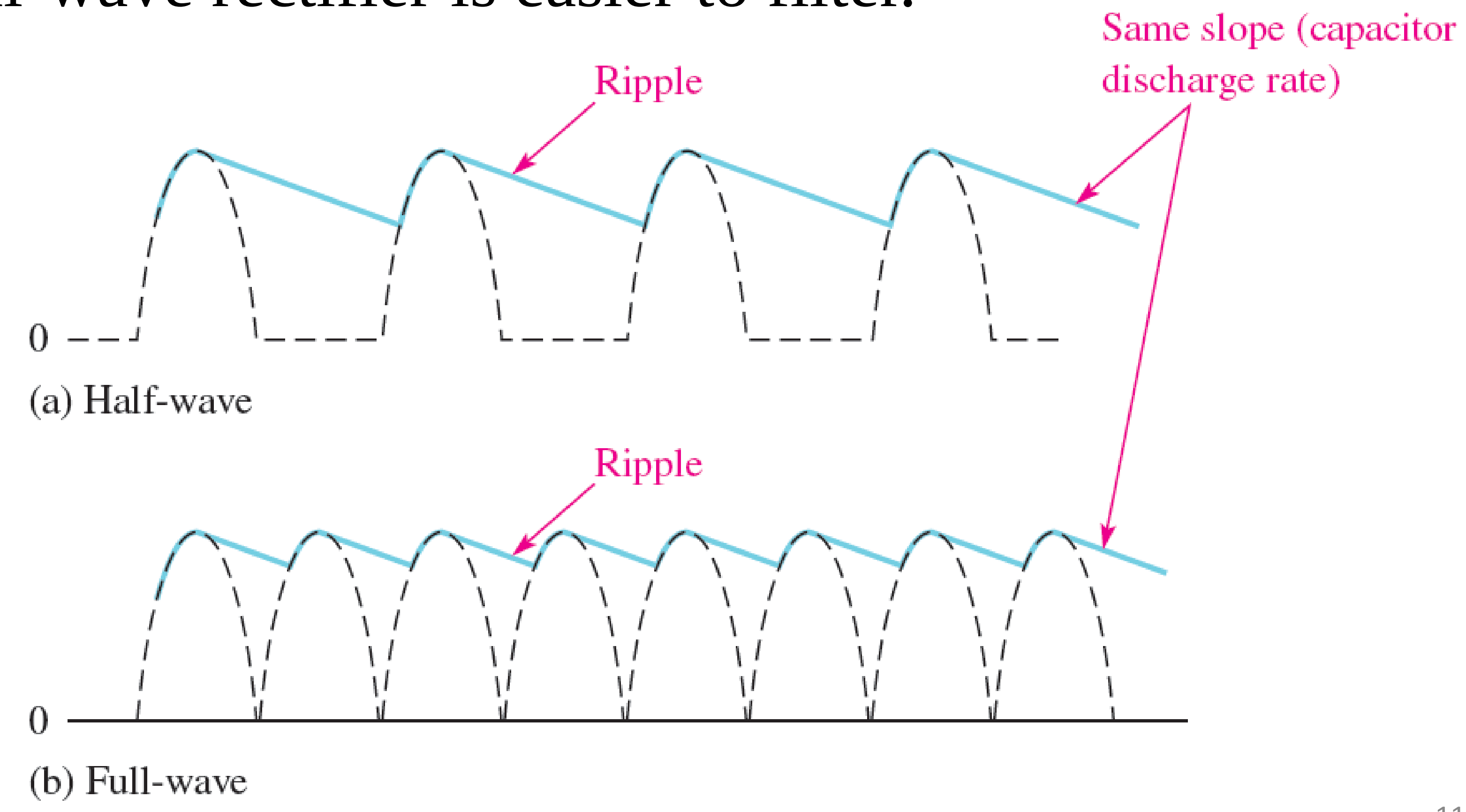



Fig. 5: Half-wave ripple voltage (blue line).

# Ripple Voltage ($V_r$)

- For a given input frequency, the output frequency of a full-wave rectifier is twice that of a half-wave rectifier.
- As a result, a full-wave rectifier is easier to filter.

Fig. 6: Comparison of ripple voltages for half-wave and full-wave signals with the same filter and same input frequency.



# Ripple Voltage ($V_r$)

- When filtered, the full-wave rectified voltage has a smaller ripple than does a half-wave signal for the same load resistance and capacitor values.

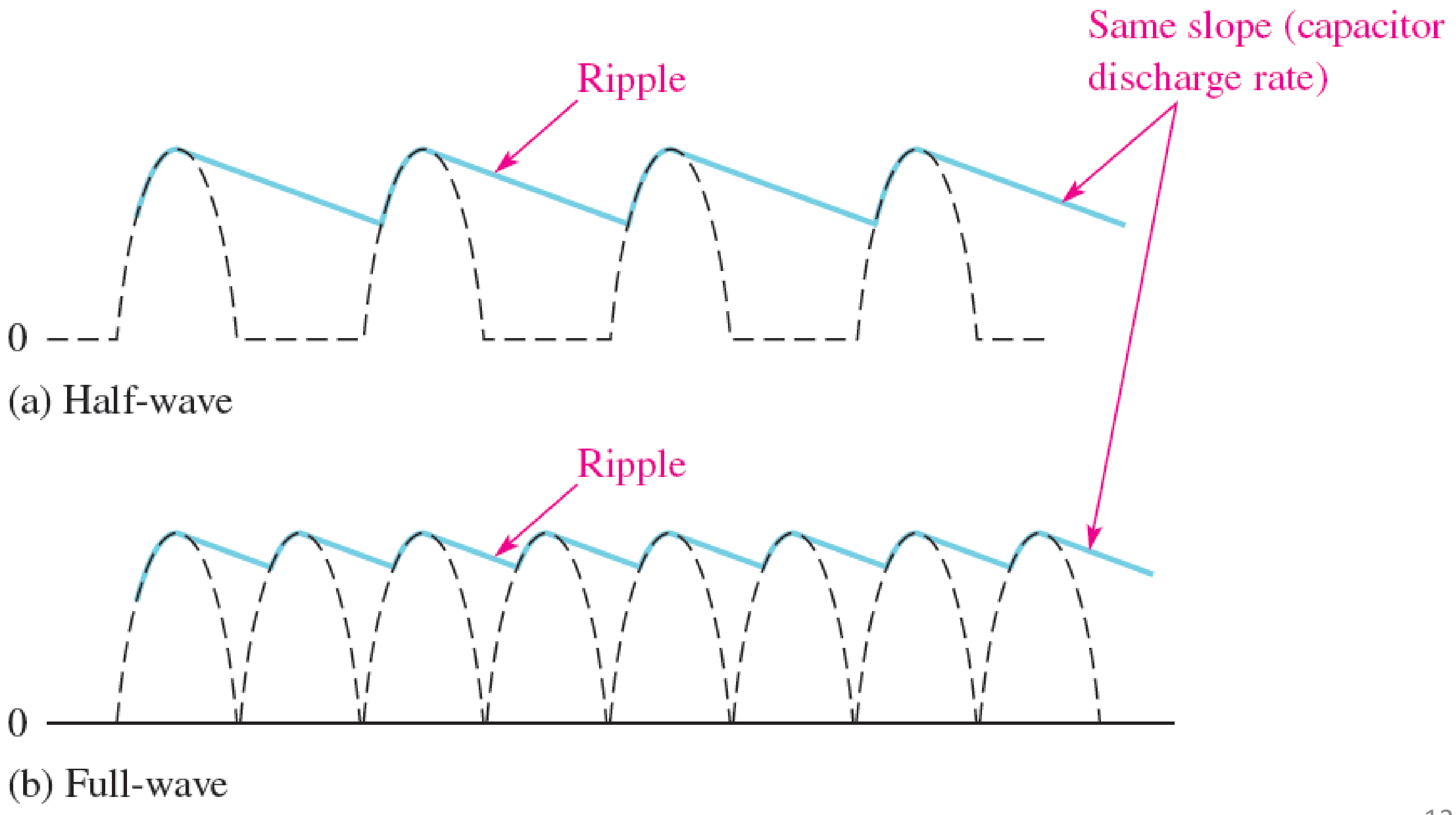
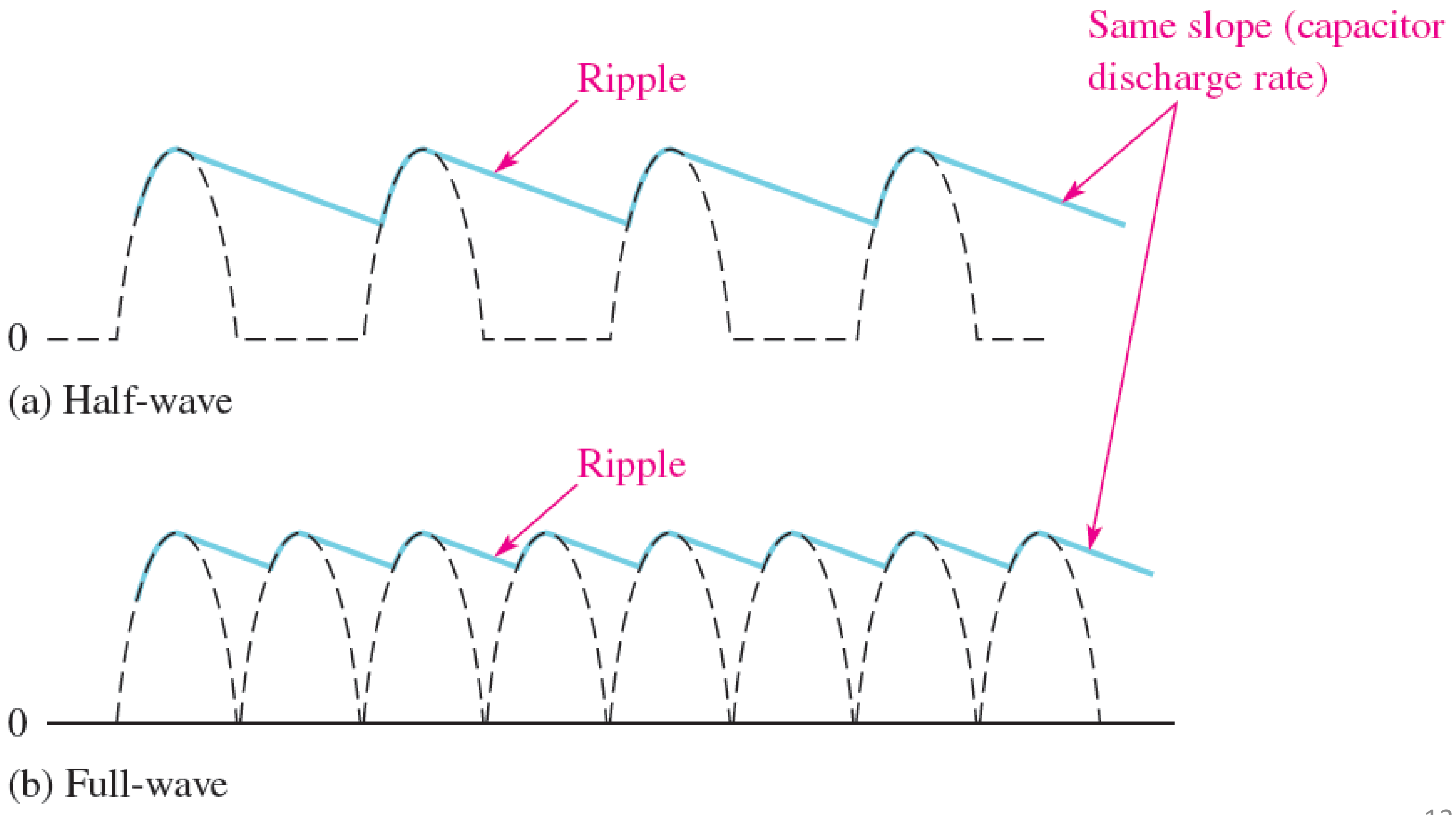



Fig. 6: Comparison of ripple voltages for half-wave and full-wave signals with the same filter and same input frequency.

# Ripple Voltage ($V_r$)

- A smaller ripple occurs because the capacitor discharges less during the shorter interval between full-wave pulses, as shown in Fig. 6.

Fig. 6: Comparison of ripple voltages for half-wave and full-wave signals with the same filter and same input frequency.



# Ripple Voltage ($V_r$)

- A good rule of thumb for effective filtering is to make:

$$R_L C \geq 10T$$ where T is the period of the rectified voltage.

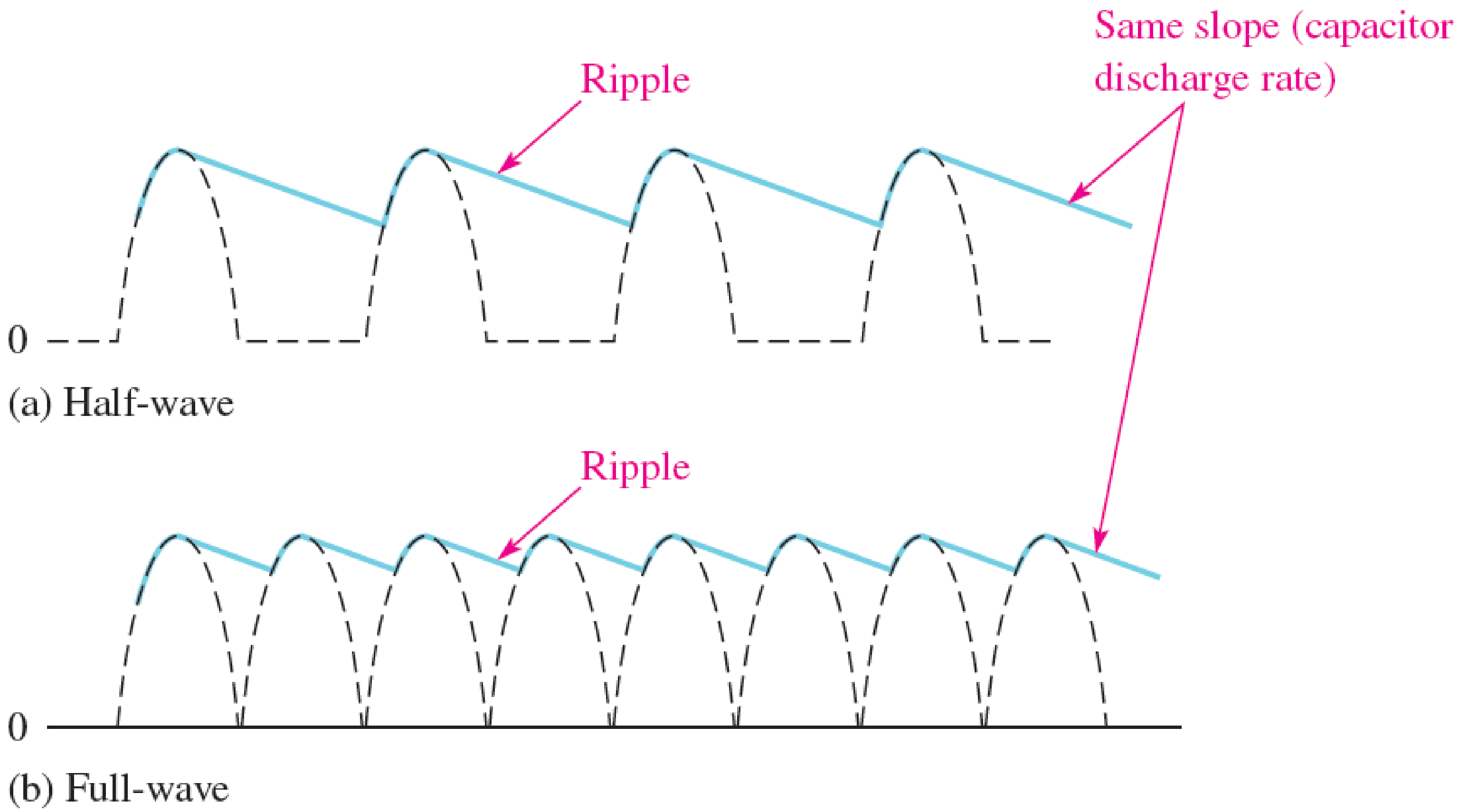



Fig. 6: Comparison of ripple voltages for half-wave and full-wave signals with the same filter and same input frequency.

# Ripple Factor ($r$)

The **ripple factor ($r$)** is an indication of the effectiveness of the filter and is defined as the ratio of the ripple voltage ($V_r$) to the DC (average) value ($V_{AVG}$) of the filter output voltage.

$$r = \frac{V_r}{V_{AVG}} \times 100\%$$

The lower the ripple factor, the better the filter. The ripple factor can be decreased by increasing the value of the filter capacitor.

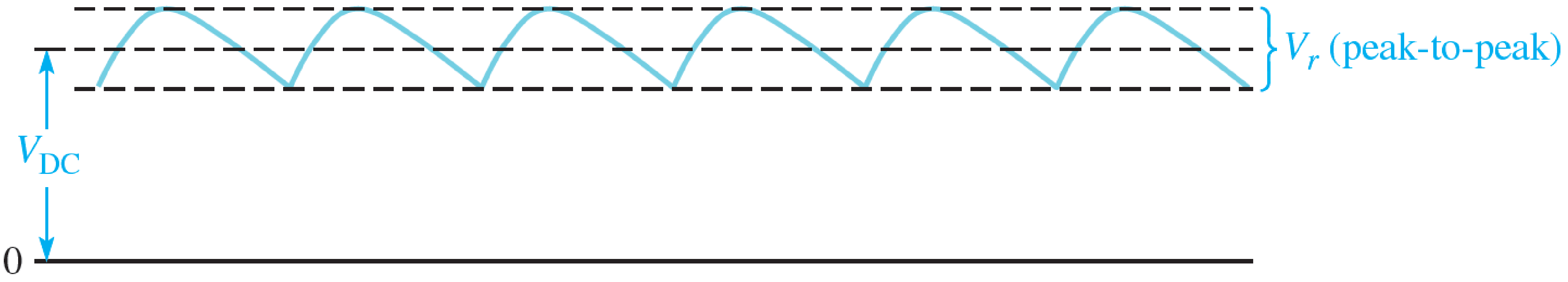



Fig. 7: $V_r$ and $V_{AVG}$ determine the ripple factor.