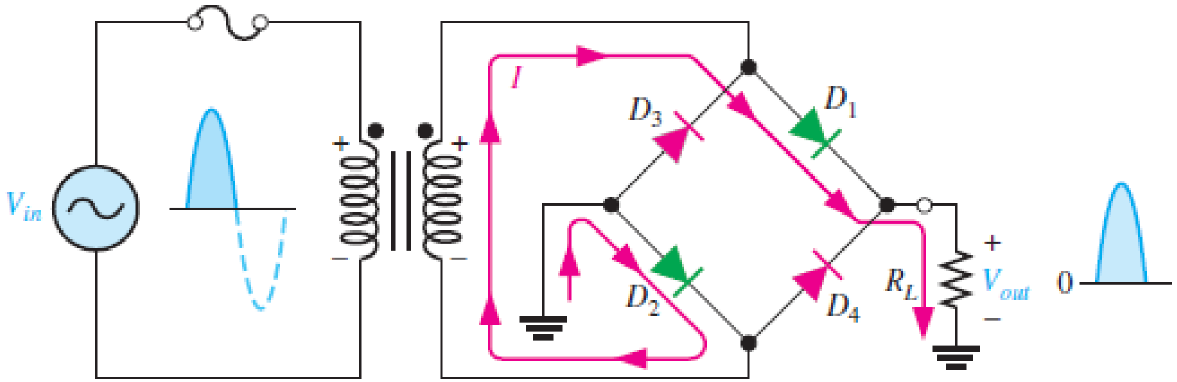
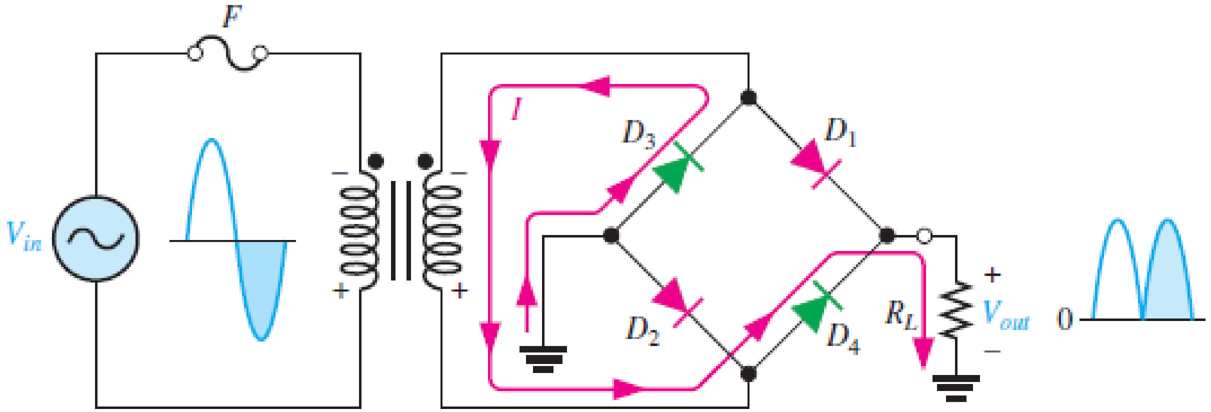
2–5 **Full-Wave Rectifiers**

b) Bridge Full-Wave Rectifier Operation



(a) During the positive half-cycle of the input, D_1 and D_2 are forward-biased and conduct current. D_3 and D_4 are reverse-biased.



(b) During the negative half-cycle of the input, D_3 and D_4 are forward-biased and conduct current. D_1 and D_2 are reverse-biased.

Ideally	$V_{p(out)} = V_{p(sec)}$
Practically	$V_{p(out)} = V_{p(sec)} - 1.4\ \text{V}$

2–5 Full-Wave Rectifiers (Bridge)

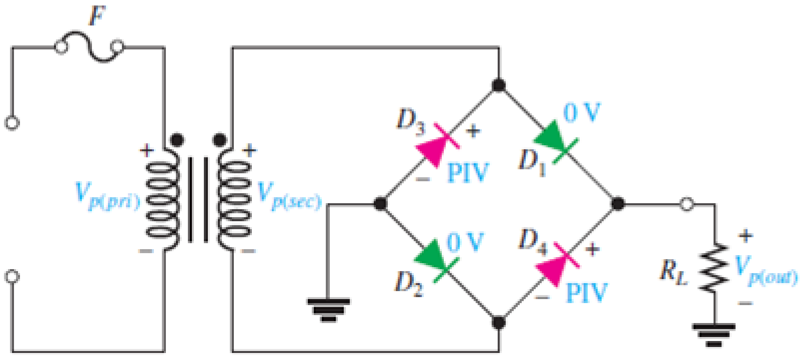
Peak Inverse Voltage (PIV)

using ideal diodes models

$$PIV = V_{p(out)}$$

using practical diode models

$$PIV = V_{p(out)} + 0.7\ V$$



(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.

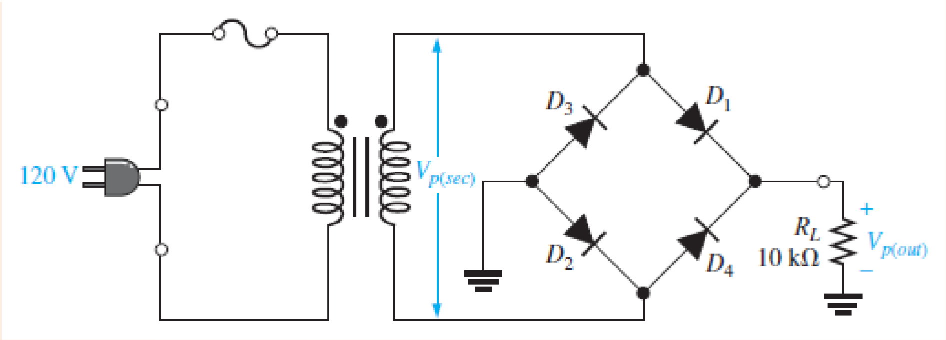
▲ FIGURE 2–40

Peak inverse voltages across diodes D_3 and D_4 in a bridge rectifier during the positive half-cycle of the secondary voltage.

EXAMPLE 2–7

Determine the peak output voltage for the bridge rectifier in Figure 2–41. Assuming the practical model, what PIV rating is required for the diodes? The transformer is specified to have a 12 V rms secondary voltage for the standard 120 V across the primary.

▶ FIGURE 2–41



Solution The peak output voltage (taking into account the two diode drops) is

$$V_{p(sec)} = 1.414V_{rms} = 1.414(12\text{ V}) \cong 17\text{ V}$$

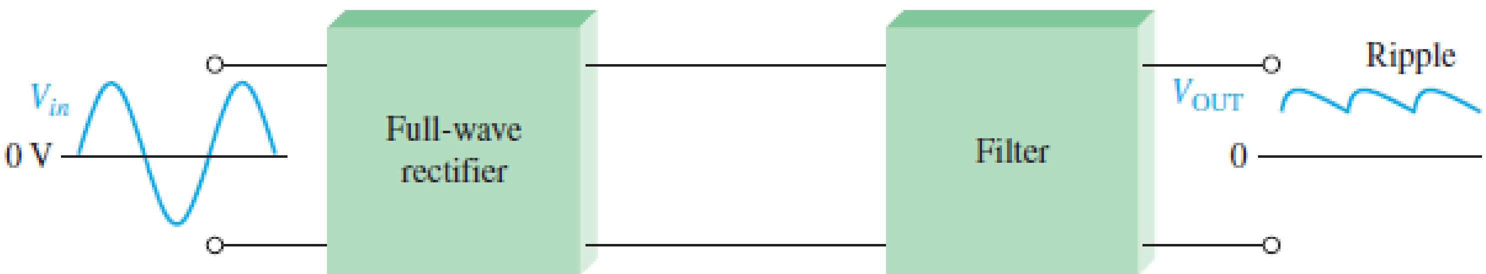
$$V_{p(out)} = V_{p(sec)} - 1.4\text{ V} = 17\text{ V} - 1.4\text{ V} = \mathbf{15.6\text{ V}}$$

The PIV rating for each diode is

$$\text{PIV} = V_{p(out)} + 0.7\text{ V} = 15.6\text{ V} + 0.7\text{ V} = \mathbf{16.3\text{ V}}$$

2–6 **Power Supply Filters & Regulators**

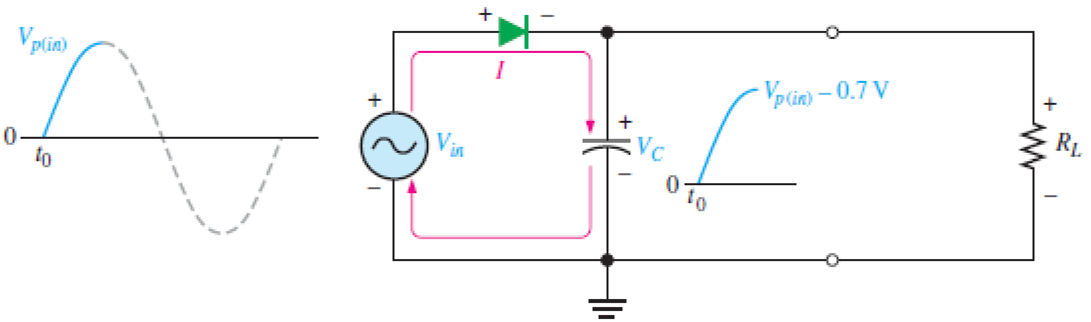
Filter: ideally eliminates the fluctuations in the output voltage of a half wave or full-wave rectifier and produces a constant-level dc voltage.



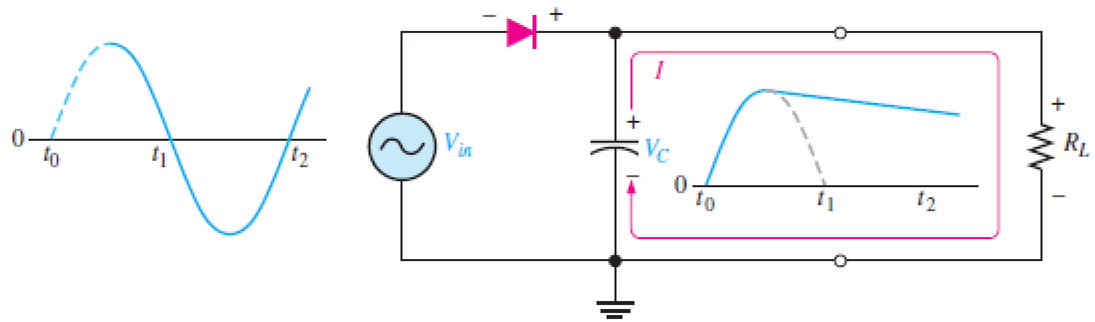
Power supply filtering. Rectifier with a filter

Capacitor-Input Filter

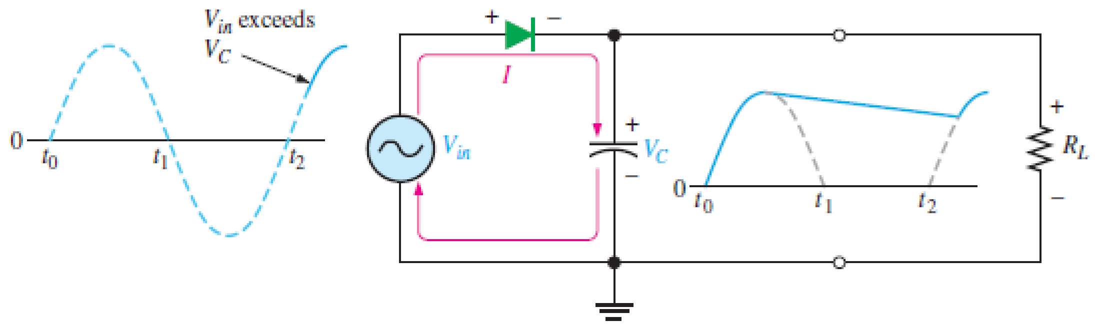
► **Operation of a half-wave rectifier with a capacitor-input filter.**



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



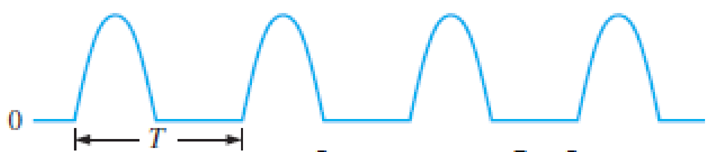
The capacitor discharges through R_L after peak of positive half-cycle when the diode is reverse-biased. This discharging occurs during the portion of the input voltage indicated by the solid dark blue curve.



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.

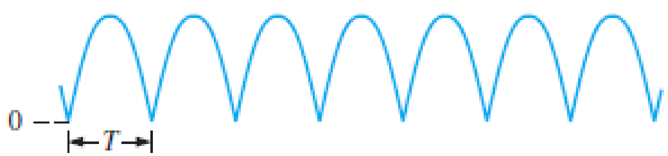
Capacitor-Input Filter

▶ **Ripple Factor (r)** is an indication of the effectiveness of the filter

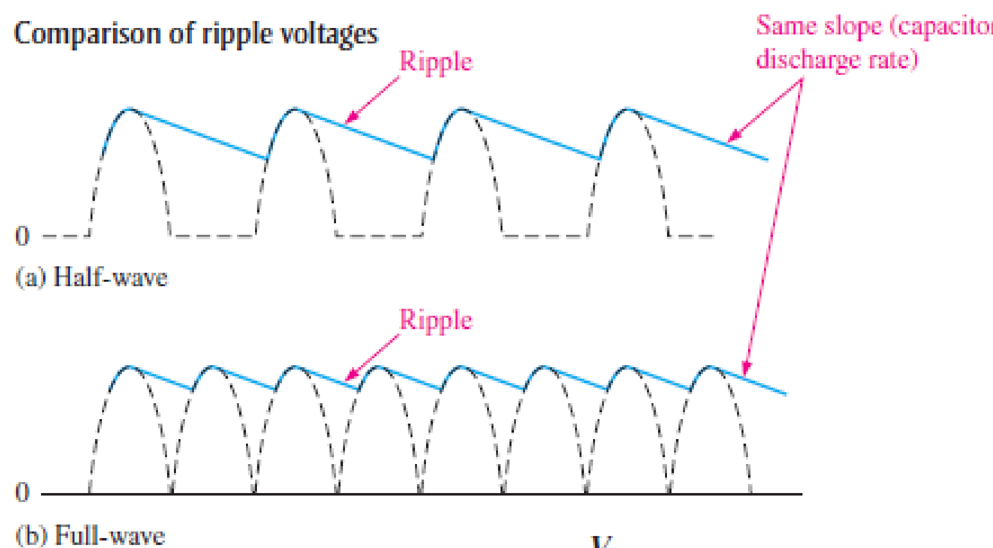


(a) Half-wave

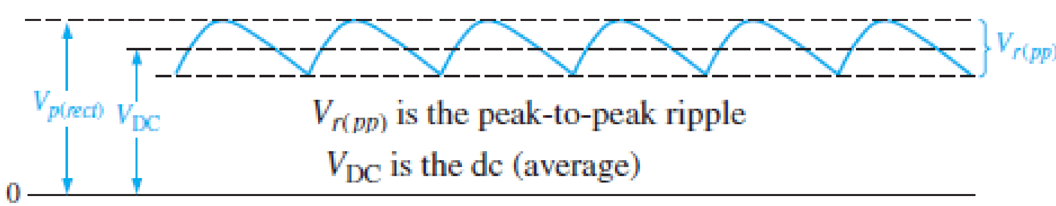
$$f_{(full)} = 2\,f_{(half)}$$



(b) Full-wave



ripple factor $r = \dfrac{V_{r(pp)}}{V_{DC}}$



$$V_{r(pp)} \cong \left(\frac{1}{fR_LC}\right)V_{p(rect)}$$

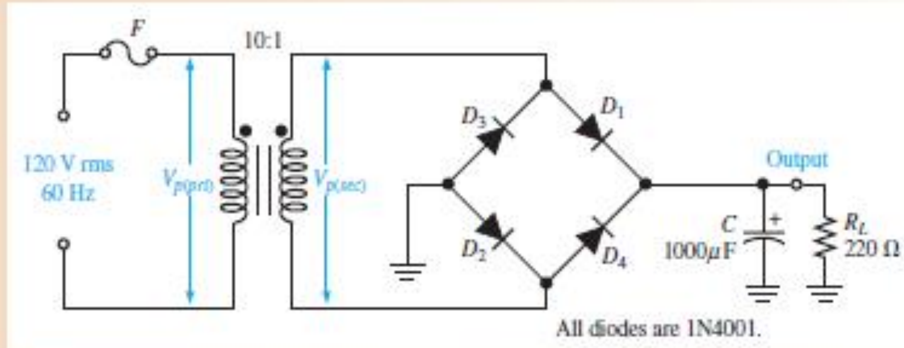
$$V_{DC} \cong \left(1 - \frac{1}{2fR_LC}\right)V_{p(rect)}$$

Note: the above equations are derived for **full-wave rectifier**

EXAMPLE 2–8

Determine the ripple factor for the filtered bridge rectifier with a load as indicated in Figure 2–48.

▸ FIGURE 2–48



Solution The transformer turns ratio is $n = 0.1$. The peak primary voltage is

$$V_{p(pri)} = 1.414V_{rms} = 1.414(120\text{ V}) = 170\text{ V}$$

The peak secondary voltage is

$$V_{p(sec)} = nV_{p(pri)} = 0.1(170\text{ V}) = 17.0\text{ V}$$

The unfiltered peak full-wave rectified voltage is

$$V_{p(rect)} = V_{p(sec)} - 1.4\text{ V} = 17.0\text{ V} - 1.4\text{ V} = 15.6\text{ V}$$

The frequency of a full-wave rectified voltage is 120 Hz. The approximate peak-to-peak ripple voltage at the output is

$$V_{r(pp)} \cong \left(\frac{1}{fR_LC}\right)V_{p(rect)} = \left(\frac{1}{(120\text{ Hz})(220\ \Omega)(1000\ \mu\text{F})}\right)15.6\text{ V} = 0.591\text{ V}$$

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

$$V_{DC} = \left(1 - \frac{1}{2fR_LC}\right)V_{p(rect)} = \left(1 - \frac{1}{(240\text{ Hz})(220\ \Omega)(1000\ \mu\text{F})}\right)15.6\text{ V} = 15.3\text{ V}$$

The resulting ripple factor is

$$r = \frac{V_{r(pp)}}{V_{DC}} = \frac{0.591\text{ V}}{15.3\text{ V}} = \mathbf{0.039}$$

The percent ripple is 3.9%.

Power Supply Regulators

- **Voltage regulation**: prevents changes in the filtered dc voltage due to variations in **input voltage** or **load**.

- Connected to the output of a filtered rectifier and maintains a constant output voltage (or current) despite changes in the input, the load current, or the temperature.

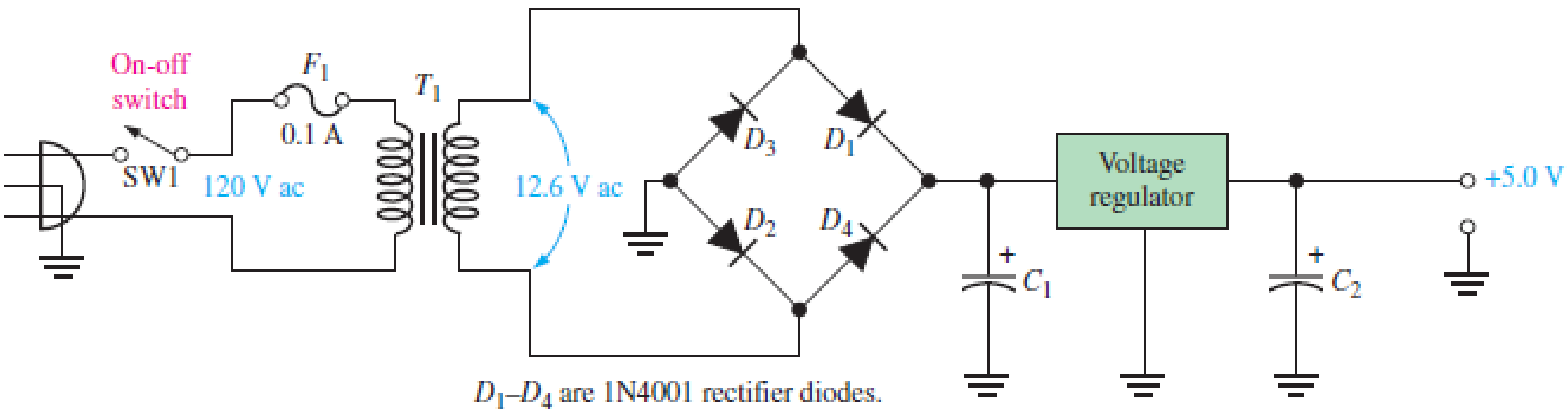


FIGURE 2–51

A basic +5.0 V regulated power supply.

Example: Three-terminal regulators IC: designed for fixed output voltages require only external capacitors to complete the regulation portion of the power supply. Filtering is accomplished by a large-value capacitor between the input voltage and ground. An output capacitor is connected from the output to ground to improve the transient response.

Power Supply Regulators

Percent Regulation:

- Specify the performance of a voltage regulator.
- It can be in terms of input (line) regulation or load regulation.

a) Line Regulation: specifies how much change occurs in the **output voltage** for a given change in the **input voltage.**

$$\text{Line regulation} = \left(\frac{\Delta V_{OUT}}{\Delta V_{IN}}\right)100\%$$

b) Load Regulation: specifies how much change occurs in the **output voltage** over a certain range of **load current** values, usually from minimum current (no load, NL) to maximum current (full load, FL).

$$\text{Load regulation} = \left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right)100\%$$

EXAMPLE 2–9 A certain 7805 regulator has a measured no-load output voltage of 5.18 V and a full-load output of 5.15 V. What is the load regulation expressed as a percentage?

Solution

$$\text{Load regulation} = \left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right)100\% = \left(\frac{5.18\text{ V} - 5.15\text{ V}}{5.15\text{ V}}\right)100\% = \mathbf{0.58\%}$$