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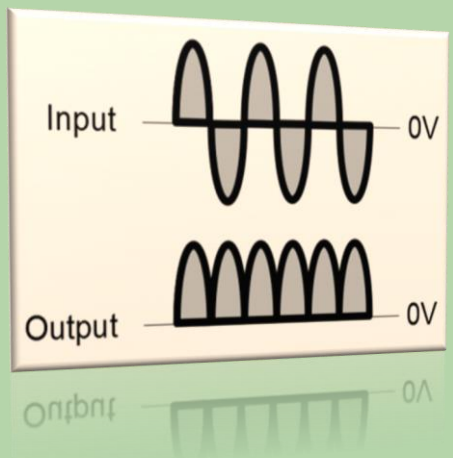


Electronic Fundamentals

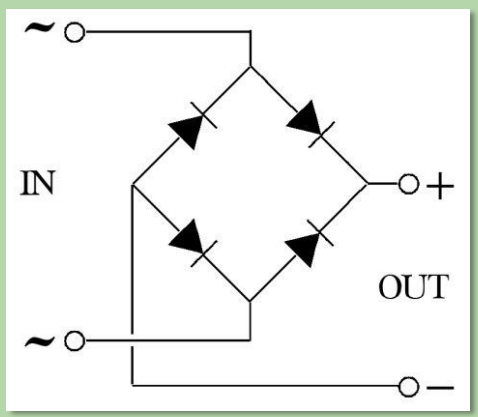
Circuits, Devices, and Applications

Diodes and Applications

Half-Wave and Full-Wave Rectifiers

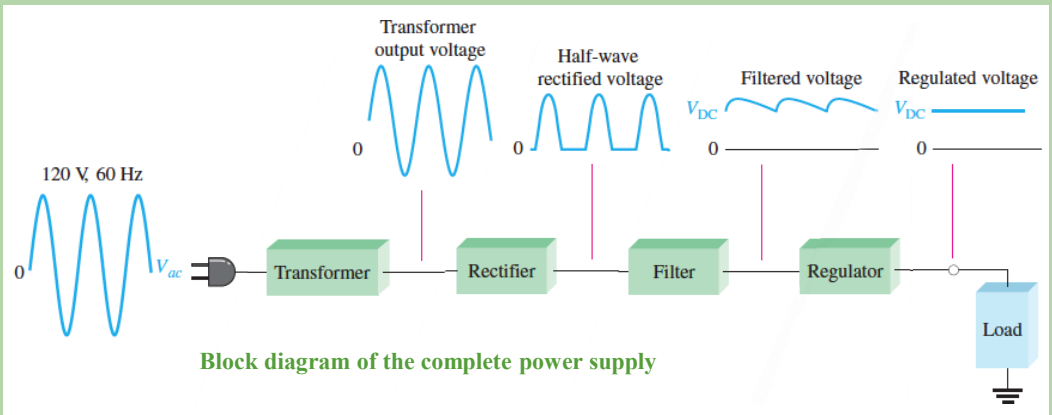
Unit 3: Diodes and Applications

- Diode Operation
- *V-I* Characteristics of a Diode
- Diode Models
- Half-Wave and Full-Wave Rectifiers
- Power Supply Filters and Regulators
- Diode Limiters and Clampers
- Voltage Multipliers



The Basic DC Power Supply

The **dc power supply** converts the standard 220 V, 60 Hz ac voltage available at wall outlets into a constant dc voltage.



Block diagram of the complete power supply

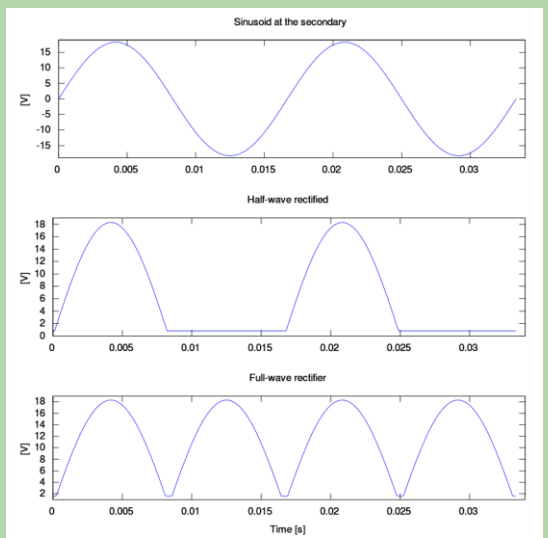
Rectifier

Rectifier are circuit that convert ac to dc.

Special diodes, called rectifier diodes, are designed to handle the higher current requirements in these circuits.

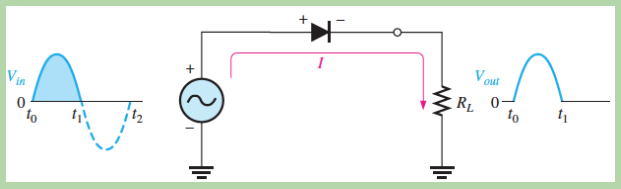
Half-Wave Rectifier

Full-Wave Rectifier

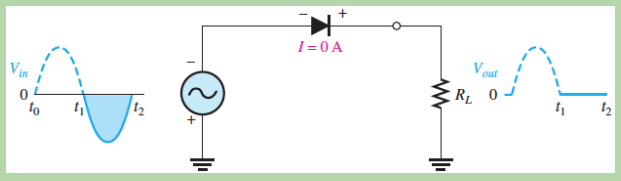


Half-Wave Rectifier Operation

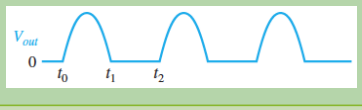
During the positive alternation of the 60 Hz input voltage, the output voltage looks like the positive half of the input voltage.



During the negative alternation of the input voltage, the current is 0, so the output voltage is also 0.



60 Hz half-wave output voltage for three input cycles.



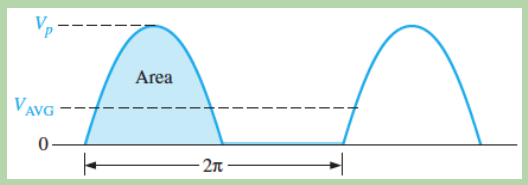
The net result is that only the positive half-cycles of the ac input voltage appear across the load.

Average Value of the Half-Wave Output Voltage

- The average value of the half-wave rectified output voltage is the value you would measure on a dc voltmeter.
- Mathematically, it is determined by finding the area under the curve over a full cycle, and then dividing by 2∏, full cycle.

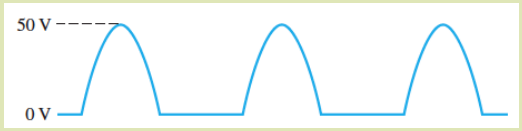
$$V_{AVG} = \frac{V_p}{\pi}$$

V_{AVG} is approximately 31.8% of V_p



Example: What is the average value of the half-wave rectified voltage

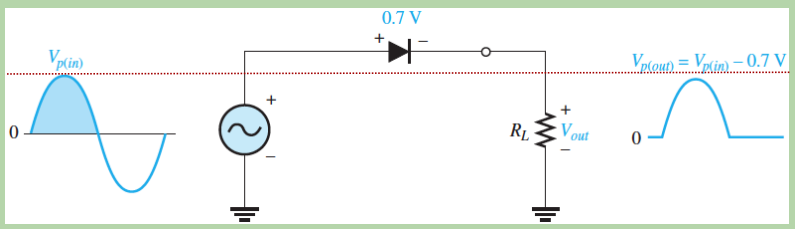
$$V_{AVG} = \frac{V_p}{\pi} = \frac{50\text{ V}}{\pi} = 15.9\text{ V}$$



Effect of the Barrier Potential on the Half-Wave Rectifier Output

- In the previous discussion, the diode was considered ideal.
- Now consider the practical diode model with the barrier potential of 0.7 V taken into account.
- This results in a half-wave output with a peak value (V_p) that is 0.7 V less than the peak value of the input.

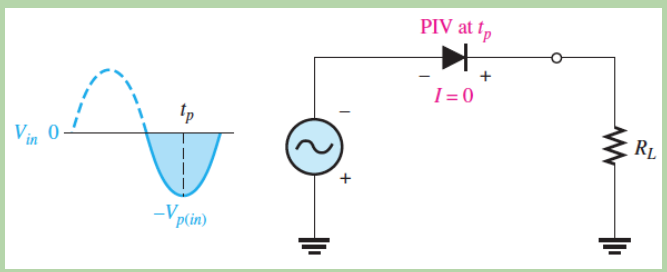
$$V_{p(out)} = V_{p(in)} - 0.7\,\text{V}$$



Peak Inverse Voltage (PIV)

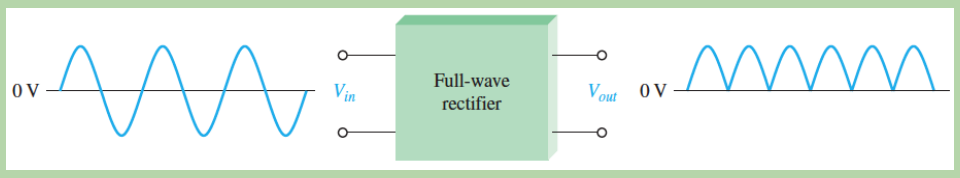
- The **peak inverse voltage (PIV)** equals the peak value of the input voltage, and the diode must be capable of withstanding this amount of repetitive reverse voltage.
- A diode should be rated at least 20% higher than the PIV.

$$\text{PIV} = V_{p(in)}$$



Full-wave rectifiers

A **full-wave rectifier** allows unidirectional current through the load during the entire 360° of the input cycle, whereas a half-wave rectifier allows current through the load only during one-half of the cycle. The result of full-wave rectification is an output voltage with a **frequency twice** the input frequency and that pulsates every half-cycle of the input.



The average value (V_{AVG}), which is the value measured on a dc voltmeter, for a full-wave rectified sinusoidal voltage is twice that of the half-wave,

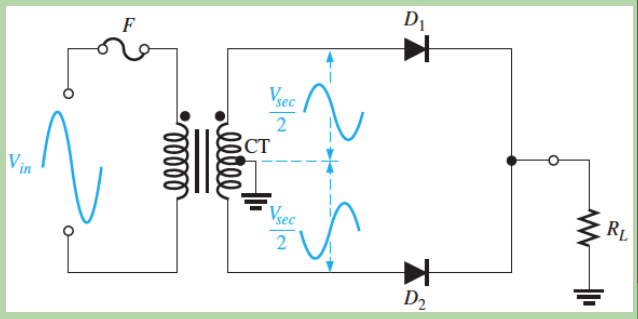
$$V_{AVG} = \frac{2V_p}{\pi}$$

V_{AVG} is approximately 63.7% of V_p

Center-Tapped Full-Wave Rectifier Operation

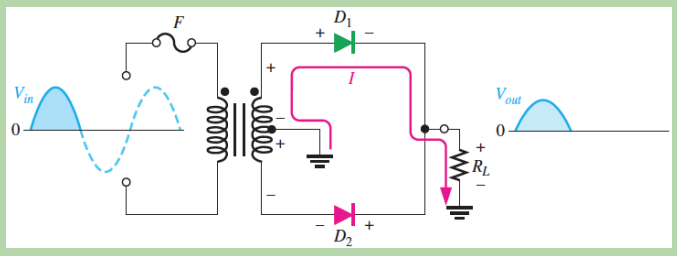
- A **center-tapped rectifier** is a type of full-wave rectifier that uses two diodes connected to the secondary of a center-tapped transformer.
- The ac on each side of the center-tap is 1⁄2 of the total secondary voltage. Only one diode will be biased on at a time.

For a positive half-cycle of the input voltage, the polarities of the secondary voltages are as shown

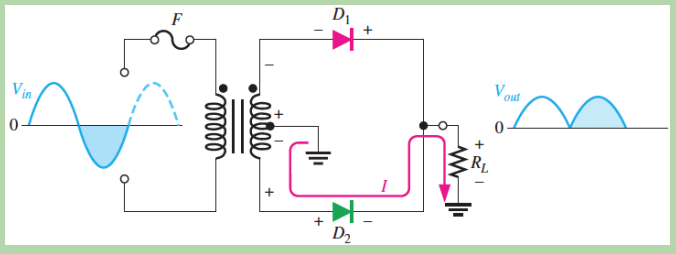


A center-tapped full-wave rectifier.

During positive half-cycles, D_1 is forward-biased and D_2 is reverse-biased.



During negative half-cycles, D_2 is forward-biased and D_1 is reverse-biased.



Effect of the Turns Ratio on the Output Voltage

- The output voltage is determine by the turns ratio, n of the transformer.
- If you do not know the voltage, but do know the turns ratio of the transformer, you can calculate the peak output voltage for a full-wave rectifier from the following equation:

$$V_{p(out)} = \frac{nV_{p(in)}}{2}$$

Where n is the number of turns in the secondary (N_{sec}) divided by the number of turns in the primary (N_{pri})

Example

Specify the **turns ratio** and **type of transformer** required for a full-wave rectifier if the input voltage is 120 V rms and the required output is 17 V peak?

Solution:

- The input peak voltage is

$$V_{p(in)} = \frac{V_{rms(in)}}{0.707} = \frac{120V}{0.707} = 170V$$

- Rearranging Equation and substituting

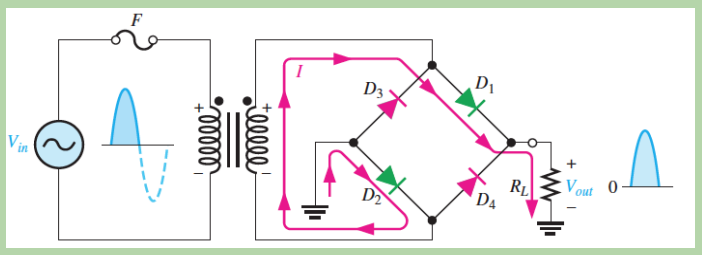
$$V_{p(out)} = \frac{nV_{p(in)}}{2}$$

$$n = \frac{2V_{p(out)}}{V_{p(in)}} = \frac{2(17V)}{170V} = 0.200$$

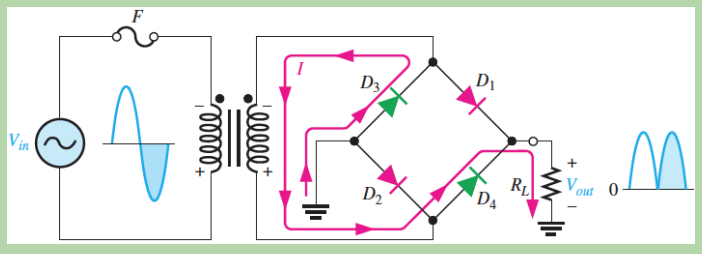
A center-tapped step-down transformer with a turns ration of 0.2 is required.

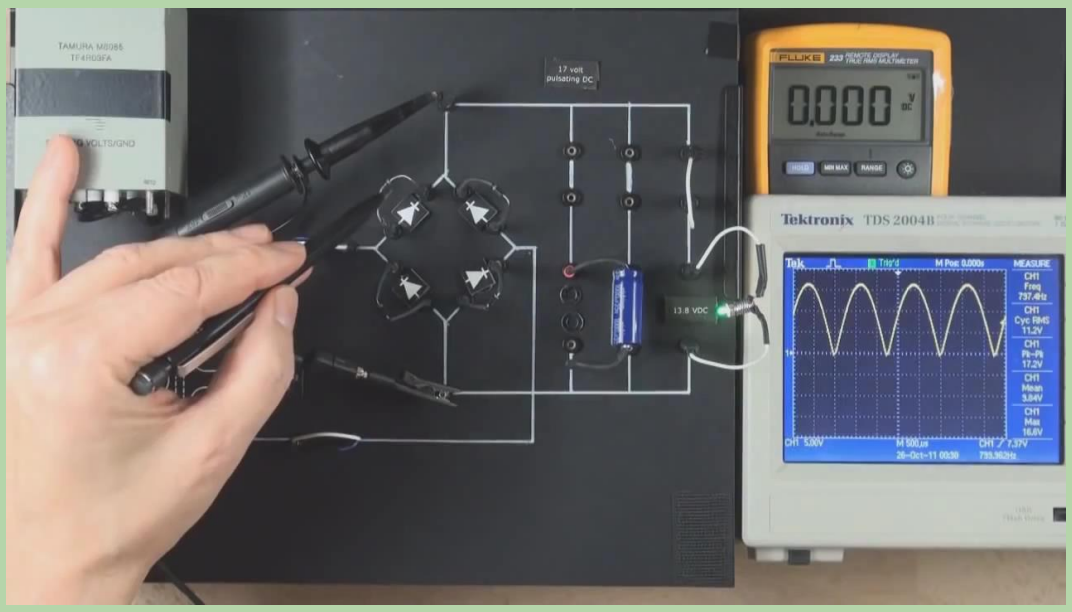
Bridge Full-Wave Rectifier Operation

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.



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.





Review Questions

1. At what point on the input cycle does the PIV occur?
2. For a half-wave rectifier, there is current through the load for approximately what percentage of the input cycle?
3. What is the average of a half-wave rectified voltage with a peak value of 10V?
4. What is the peak value of the output voltage of a half-wave rectifier with a peak sine wave input of 25 V?
5. What PIV rating must a diode have to be used in a rectifier with a peak out put voltage of 50 V?
6. How does a full-wave voltage differ from a half-wave voltage?
7. What is the average value of a full-wave rectified voltage with a peak value of 60V?