Unit 2: Diodes and Applications

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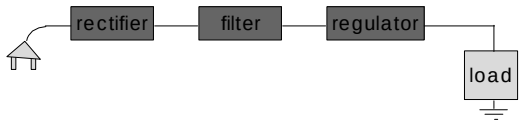
Text: *Electronic Devices* by Floyd

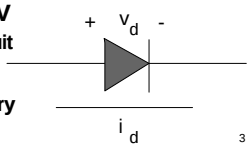
DC Power Supply

- **converts standard ac (110V, 60Hz) to a constant dc voltage**
- **used to power all types of electronics circuits, such as TVs, VCRs, etc...**
- **block diagram:**



Diode Circuit Models

- **ideal diode model**
  - **→diode is off when v_d<0**
    - » **appears as an open circuit**
  - **→diode is on when i_d>0**
    - » **appears as a short circuit**
- **practical diode model**
  - **→diode is off when v_d<0.7V**
    - » **appears as an open circuit**
  - **→diode is on when i_d>0**
    - » **appears as 0.7V dc battery**



Half-Wave Rectification

- **see Floyd, fig. 2-2**
- **assuming an ideal diode model**
  - **→ apply a sinusoidal voltage to a load through a series connected diode**
  - **→ when the input voltage is positive, the diode is forward biased, thus appearing as a short circuit, and all of the source voltage appears across the load**
  - **→ when the input voltage is negative, the diode is reverse biased, thus appearing as an open circuit, and none of the source voltage appears across the load**

Average Value of Periodic Functions

- the average value of any periodic function is found by finding the area under the curve over one period and then dividing that value by the period
- the average value of a sinusoidal voltage over one period is ZERO!
- the average value of a half-wave rectified voltage is

$$V_{avg} = \frac{V_p}{p}$$

Practical Concerns

- Assuming a practical model for the diode, the rectifier output voltage is reduced by the barrier potential.
- The peak inverse voltage (PIV), is the maximum value of reverse voltage and must be less than the breakdown voltage for the diode.
- A transformer is used to couple the ac input voltage from the source to the rectifier circuit.
  - → allows source voltage to be stepped up or down as needed
  - → provides electrical isolation, thus reducing the shock hazard

The Transformer

- Turns ratio sets the amount of step down or up:
  N_{pri}:N_{sec} where *pri* and *sec* stand for primary and secondary.
- The primary voltage, V_{pri}, is to N_{pri} as the secondary voltage, V_{sec}, is to N_{sec}.
  → $(V_{pri}/N_{pri}) = (V_{sec}/N_{sec})$
- Phasing dots indicate the phase alignment between primary and secondary windings.

Half-Wave Rectifier with Transformer-Coupled Input

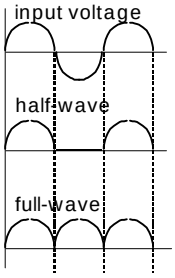
- See Floyd, Figure 2-9
- The output peak voltage is
  $$V_{p(out)} = V_{p(sec)} - 0.7\ V$$
- $f_{out}=f_{in}$
- Let's look at example 2-3 and fig. 2-10

Full-Wave Rectification

- produces an output greater than zero for the full sinusoidal cycle
- output voltage is at a frequency twice the input voltage
- the average value of the full-wave rectified voltage is twice the half-wave rectified result:

$$V_{avg} = \frac{2V_p}{p}$$

- Note that $f_{out}=f_{in}$ for half-wave but $f_{out}=2*f_{in}$ for full-wave.



Full-Wave Center-Tapped Rectifier

- See Floyd, Figure 2-13
- Due to the grounded center tap, only one diode is ON at a time.
  - ➔See fig. 2-14 and 2-15
- The output peak voltage is
  $V_{p(out)} = (V_{p(sec)}/2) - 0.7\ V$
  - ➔See fig. 2-17
- Let's look at example 2-5 and fig. 2-18.
  - ➔Find the average (dc) output voltage.

Full-Wave Bridge Rectifier

- See Floyd, Figure 2-20
- The peak output voltage is
  $V_{p(out)} = V_{p(sec)} - 1.4\ V$
- Note that the bridge circuit produces significantly larger peak output than the center-tapped.
- Let's look at example 2-6 and fig. 2-23.
  - ➔Find the average (dc) output voltage.

Power Supply Filters

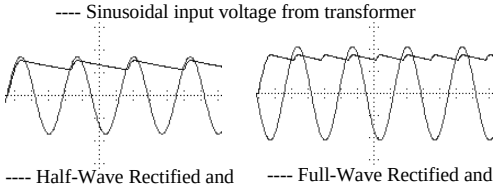
- Ideally, eliminates the fluctuations in voltage from the rectifier circuitry.
- The ripple voltage is the variation in the output voltage about the DC value.
- Filter Types
  - → capacitor-input filter
  - → LC filter
  - → PI and T-type filters
- The various filters result in varying ripple factors and DC voltage levels, $V_{DC(OUT)}$

The Capacitor-Input Filter

- **Ideally, all that the capacitor-input filter does is charge the capacitor to the peak voltage in the first quarter cycle.**
  - **➔See fig. 2-25.**
- **Due to the dissipation in the load resistor, there is a ripple effect at the output.**
  - **➔the amplitude of the ripple can be reduced using full-wave rectification (see fig. 2-28)**
  - **➔For the experimental ripple factor formula, see equation 2-10 and fig. 2-29**
  - **➔For the theoretical ripple and dc voltage, see equations 2-11 and 2-12**

Oscilloscope Traces for Filtered Half- and Full-Wave Rectifiers

---- Sinusoidal input voltage from transformer



---- Half-Wave Rectified and Filtered Output Voltage

---- Full-Wave Rectified and Filtered Output Voltage

The peak-to-peak ripple voltage, V_R, is measured between the peak and valley of the output voltage (blue trace).

The DC output voltage is approximately equal to the peak output voltage less half the ripple voltage.

Peak Inverse Voltage and Surge Current

- **PIV - maximum voltage across non-conducting diode (must be less than the breakdown voltage)**
- **Surge Current - initial rush of current when the power is turned on because the capacitor is uncharged**
  - ***➔may use a surge resistor to limit current***
  - ***➔see Fig. 2-31***

Diodes to Use for These Applications

- **Section 2-6 discusses the diode data sheet**
- **Diode information can be found in Table 2-1 and figures 2-54, 55, and 56.**

Related Assignments

Floyd: Read Chapter 2
HW:chapter 2
Self-test: 1-6, 11-13
problems: 4, 5, 12, 15
Lab Activity: Rectifier Circuits