Power Electronics

Single Phase Uncontrolled Full Wave Rectifiers

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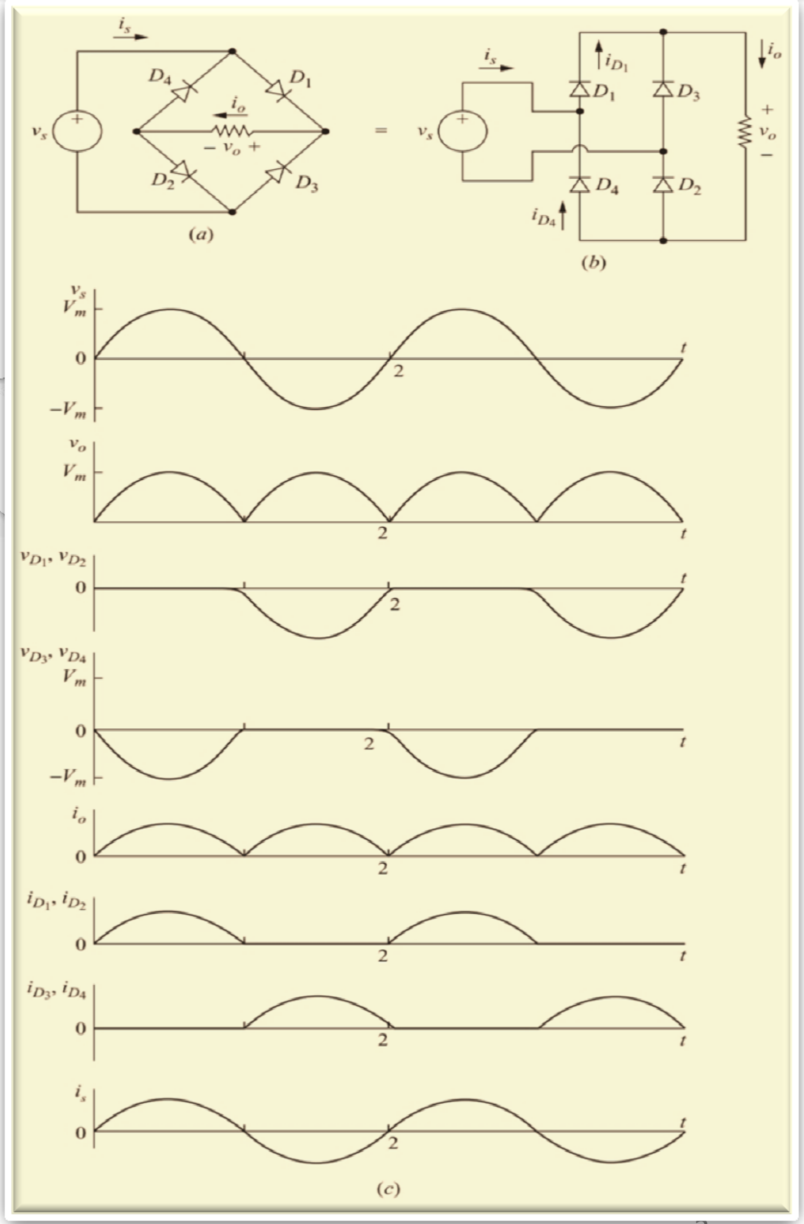
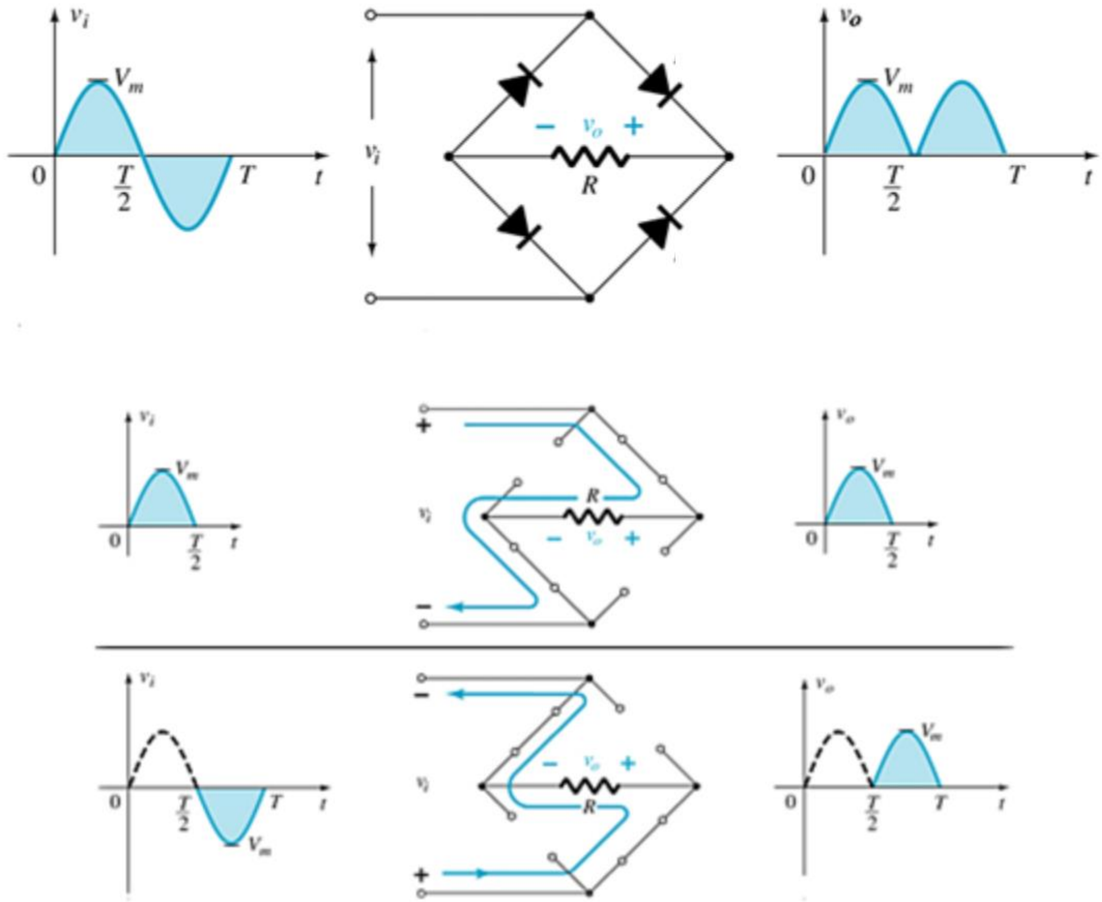
The Bridge Rectifier with Resistive Load

For the bridge rectifier of fig a (fig. b), these are some basic observations:

- Diodes D_1 and D_2 conduct together, and D_3 and D_4 conduct together. D_1 and D_3 cannot be ON at the same time. Similarly, D_2 and D_4 cannot conduct simultaneously. The load current can be positive or zero but can never be negative.
- The voltage across the load is $+v_s$ when D_1 and D_2 are ON. The voltage across the load is $-v_s$ when D_3 and D_4 are ON.
- The maximum voltage across a reverse-biased diode is the peak value of the source. This can be shown by Kirchhoff's voltage law around the loop containing the source, D_1, and D_3. With D_1 ON, the voltage across D_3 is $-v_s$.
- The current entering the bridge from the source is i_{D1}-i_{D4}, which is symmetric about zero. Therefore, the average source current is zero.
- The *rms* source current is the same as the *rms* load current. The source current is the same as the load current for one-half of the source period and is the negative of the load current for the other half. The squares of the load and source currents are the same, so the *rms* currents are equal.
- The fundamental frequency of the output voltage is 2 ω, where ω is the frequency of the *ac* input since two periods of the output occur for every period of the input.



The Bridge Rectifier with Resistive Load



The Bridge Rectifier with Resistive Load

The voltage across a resistive load for the bridge rectifier of fig. a is expressed as

$$v_o(\omega t) = \begin{cases} V_m \sin \omega t & \text{for } 0 \le \omega t \le \pi \\ -V_m \sin \omega t & \text{for } \pi \le \omega t \le 2\pi \end{cases}$$

The <u>dc component</u> of the output voltage is the average value, and load current is the resistor voltage divided by resistance.

$$V_o = \frac{1}{\pi}\int_0^{\pi} V_m \sin \omega t \, d(\omega t) = \frac{2V_m}{\pi}$$

$$I_o = \frac{V_o}{R} = \frac{2V_m}{\pi R}$$

The *rms* value of the output voltage and current are

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} (V_m sin\omega t)^2 \, d\omega t} = \frac{V_m}{\sqrt{2}} = 0.707 V_m$$

$$I_{rms} = \frac{0.707 V_m}{R} \qquad\qquad I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m$$

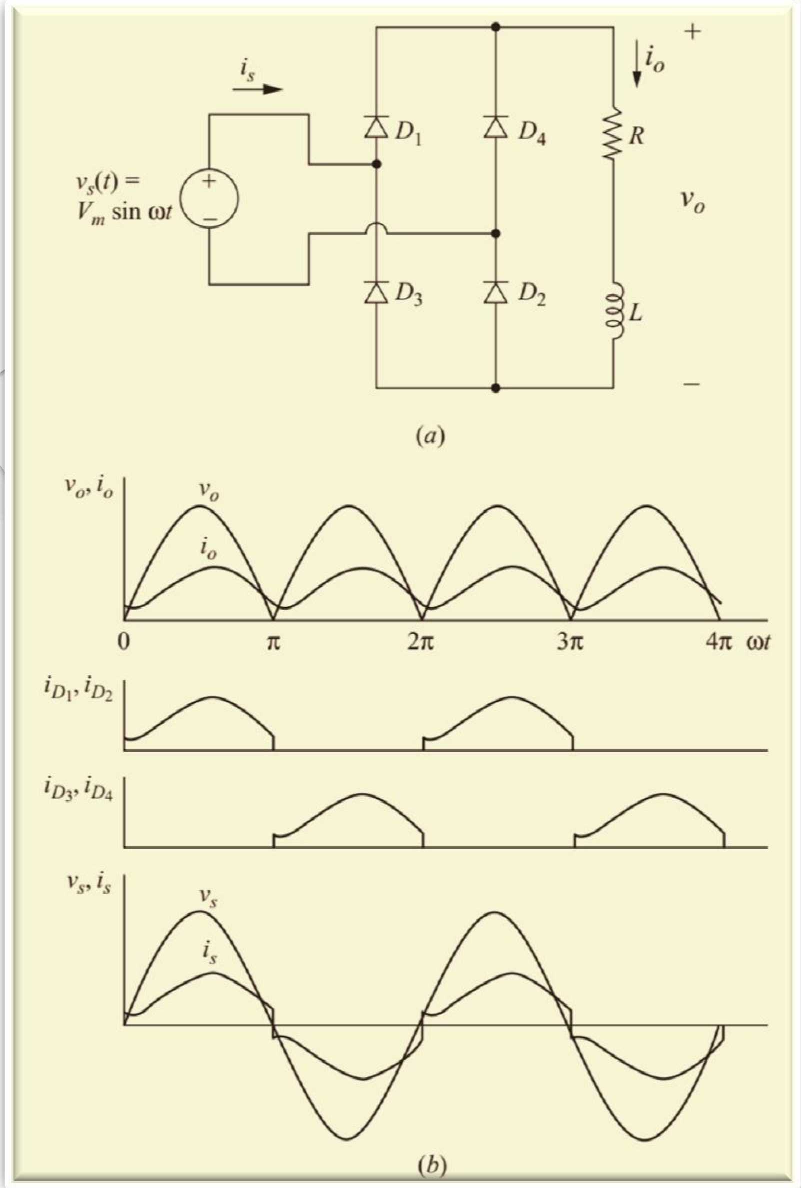
Power absorbed by the load resistor can be determined from $I^2_{rms} R$

The Bridge Rectifier with Highly Inductive Load

For an RL series-connected load in fig. a, the method of analysis is similar to that for the half-wave rectifier with the freewheeling diode.

After a transient that occurs during start-up, the load current i_o reaches a periodic steady-state condition similar to that in fig. b.

For the bridge circuit, current is transferred from one pair of diodes to the other pair when the source changes polarity. The voltage across the RL load is a full-wave rectified sinusoid, as it was for the resistive load.



The Bridge Rectifier with Highly Inductive Load

If L >> R

In some applications, the load inductance may be relatively large or made large by adding external inductance.

The <u>dc component</u> of the output voltage is the average value, and load current is the resistor voltage divided by resistance.

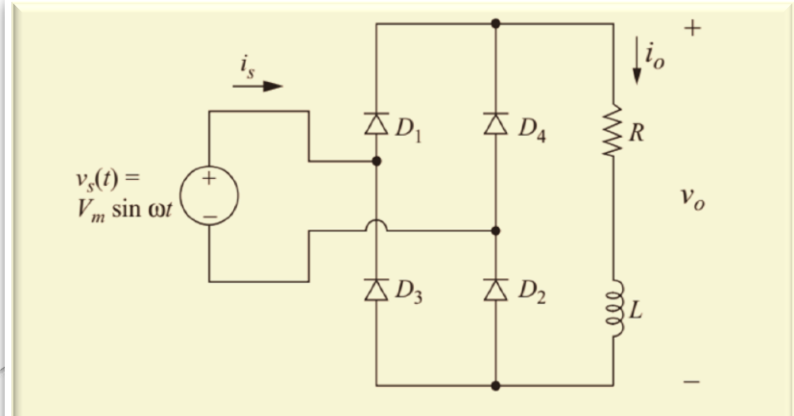
$$V_o = \frac{1}{\pi}\int_0^{\pi} V_m \sin \omega t \, d(\omega t) = \frac{2V_m}{\pi}$$

$$I_o = \frac{V_o}{R} = \frac{2V_m}{\pi R}$$

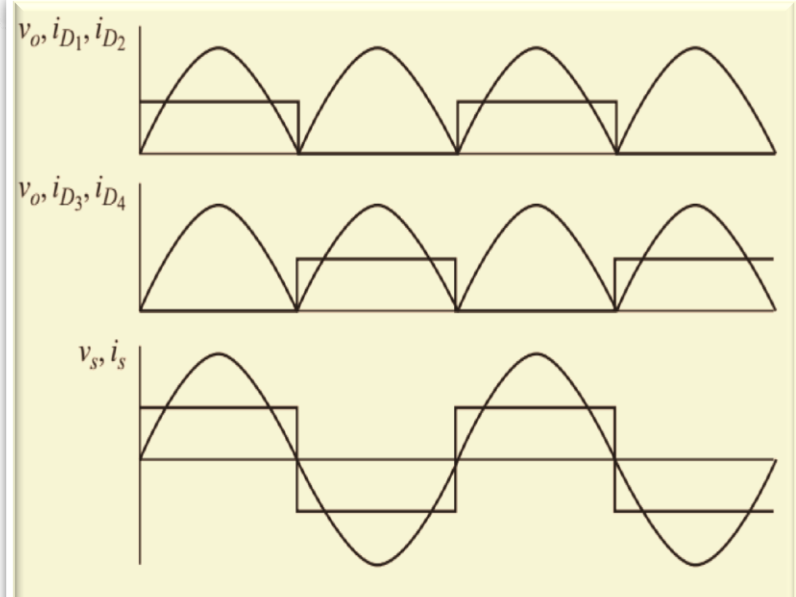
The *rms* value of the output voltage and current are

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} (V_m sin\omega t)^2 \, d\omega t} = \frac{V_m}{\sqrt{2}} = 0.707V_m$$

$$I_{rms} \approx I_o = I_{dc}$$



(a)

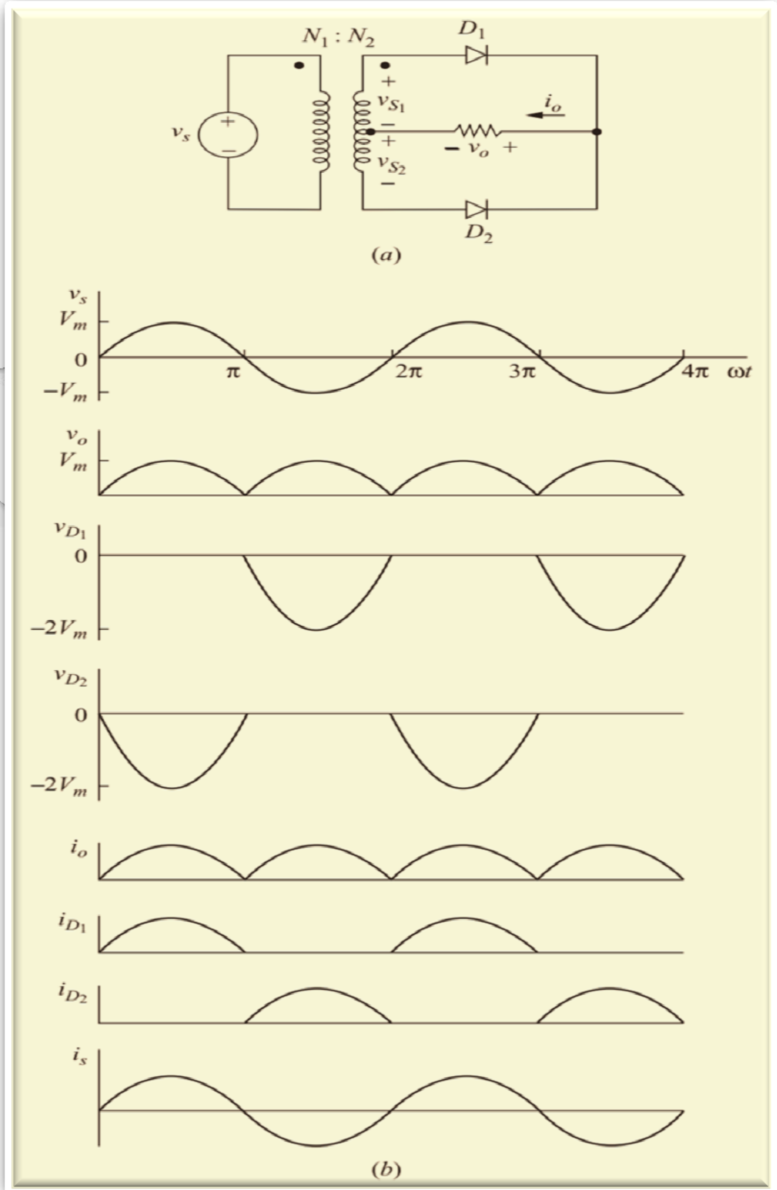


(c)

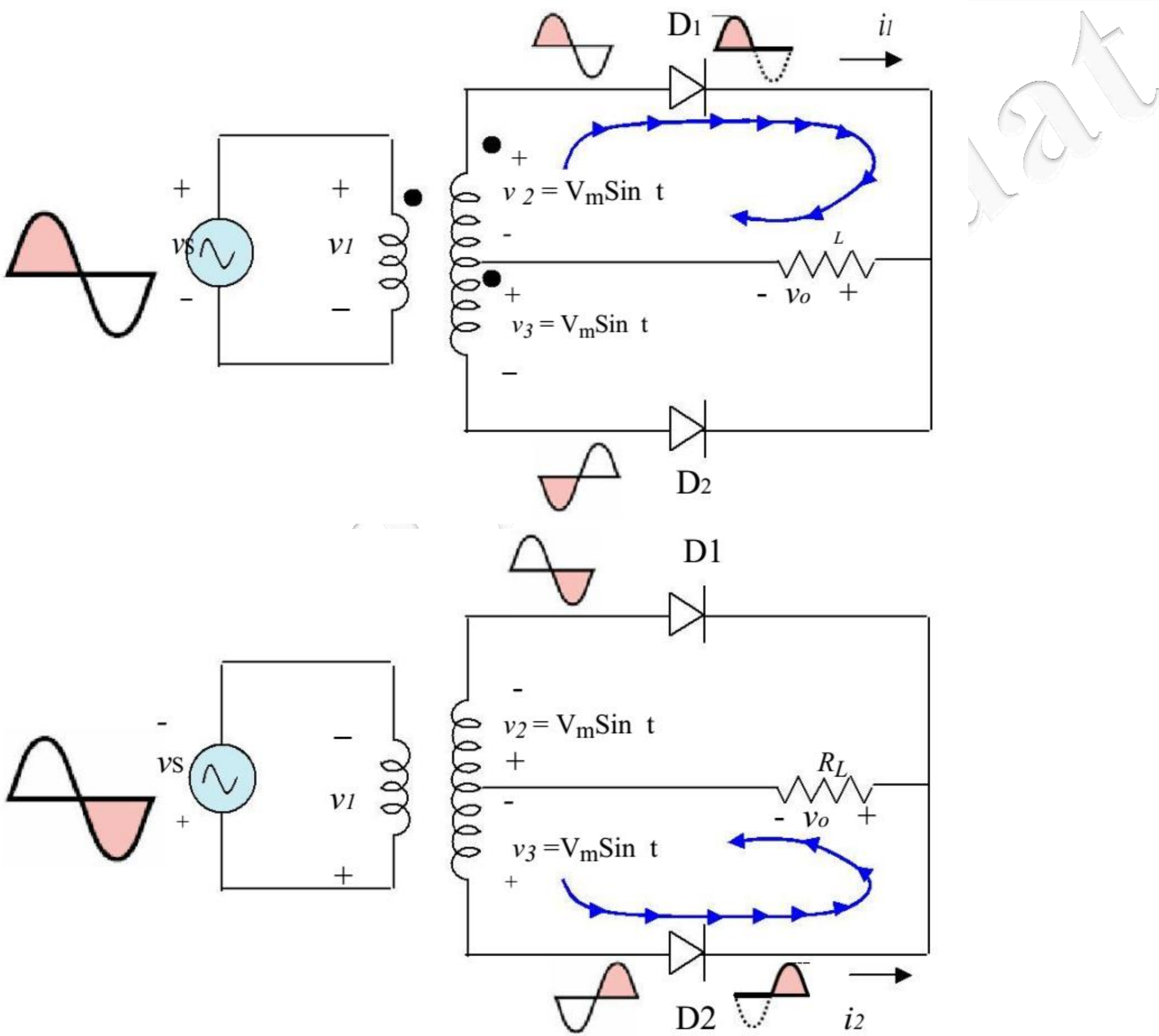
The Center-Tapped Transformer Rectifier

For The Center-Tapped Transformer Rectifier of fig a, these are some basic observations:

- **Kirchhoff's voltage law shows that only one diode can conduct at a time. Load current can be positive or zero but never negative.**
- **The output voltage is $+v_{s1}$ when D_1 conducts and is $-v_{s2}$ when D_2 conducts. The transformer secondary voltages are related to the source voltage by $v_{s1}=v_{s2}=v_s(N_2/2N_1)$.**
- **Kirchhoff's voltage law around the transformer secondary windings, D_1, and D_2 shows that the maximum voltage across a reverse-biased diode is twice the peak value of the load voltage.**
- **Current in each half of the transformer secondary is reflected to the primary, resulting in an average source current of zero.**
- **The transformer provides electrical isolation between the source and the load.**
- **The fundamental frequency of the output voltage is 2ω since two periods of the output occur for every period of the input.**



The Center-Tapped Transformer Rectifier



The Center-Tapped Transformer Rectifier

For Resistive Load

The voltage across a resistive load for the bridge rectifier of fig. a is expressed as

$$v_o(\omega t) = \begin{cases} V_m \sin \omega t & \text{for } 0 \leq \omega t \leq \pi \\ -V_m \sin \omega t & \text{for } \pi \leq \omega t \leq 2\pi \end{cases}$$

The dc component of the output voltage is the average value, and load current is the resistor voltage divided by resistance.

$$V_o = \frac{1}{\pi}\int_0^{\pi} V_m \sin \omega t \, d(\omega t) = \frac{2V_m}{\pi}$$

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The *rms* value of the output voltage and current are

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$$I_{rms} = \frac{0.707V_m}{R} \qquad \textbf{Or} \qquad I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707I_m$$

Power absorbed by the load resistor can be determined from $I^2_{rms}R$

The Bridge Rectifier with Highly Inductive Load

If L >> R

The dc component of the output voltage is the average value, and load current is the resistor voltage divided by resistance.

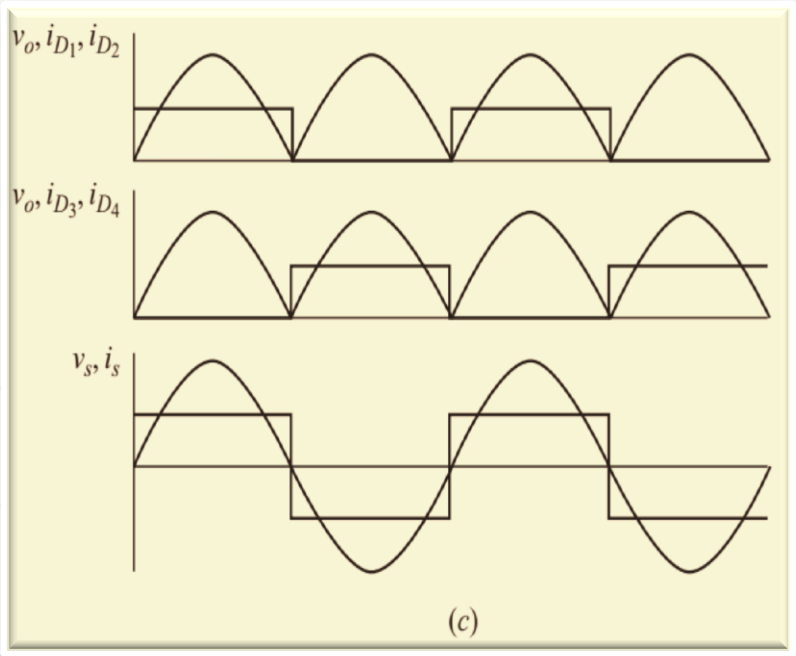
$$V_o = \frac{1}{\pi}\int_0^{\pi} V_m \sin \omega t \, d(\omega t) = \frac{2V_m}{\pi}$$

$$I_o = \frac{V_o}{R} = \frac{2V_m}{\pi R}$$

The *rms* value of the output voltage and current are

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} (V_m sin\omega t)^2 \, d\omega t} = \frac{V_m}{\sqrt{2}} = 0.707V_m$$

$$I_{rms} \approx I_o = I_{dc}$$



The lower peak diode voltage in the bridge rectifier makes it more suitable for high-voltage applications. The center-tapped transformer rectifier, in addition to include electrical isolation, has only one diode voltage drop between the source and load, making it desirable for low-voltage, high-current applications.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&
A