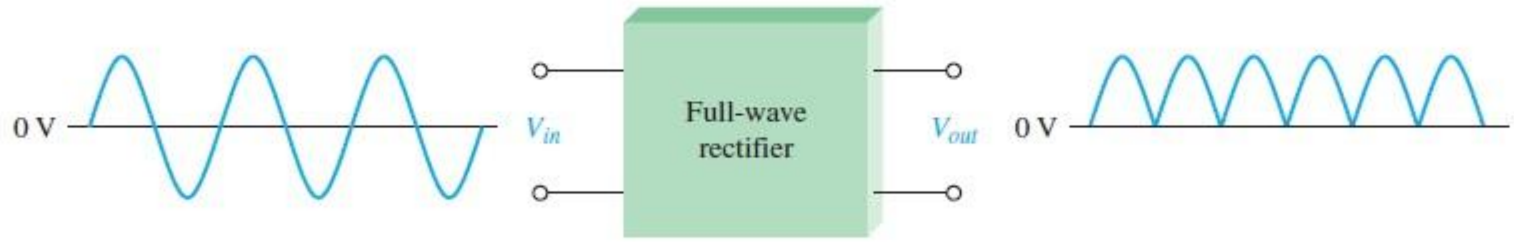
Full Wave Rectifier

A full-wave rectifier allows unidirectional (one-way) 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,



Average value of full wave rectifier

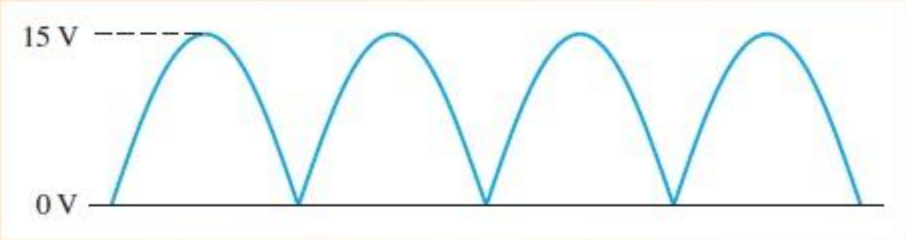
The number of positive alternations that make up the full-wave rectified voltage is twice that of the half-wave voltage for the same time interval. The average value, which is the value measured on a dc voltmeter, for a full-wave rectified sinusoidal voltage is twice that of the half-wave, as shown in the following formula:

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

V_{AVG} is approximately 63.7% of V_p for a full-wave rectified voltage.

EXAMPLE 2–5 Find the average value of the full-wave rectified voltage in Figure 2–30.

FIGURE 2–30



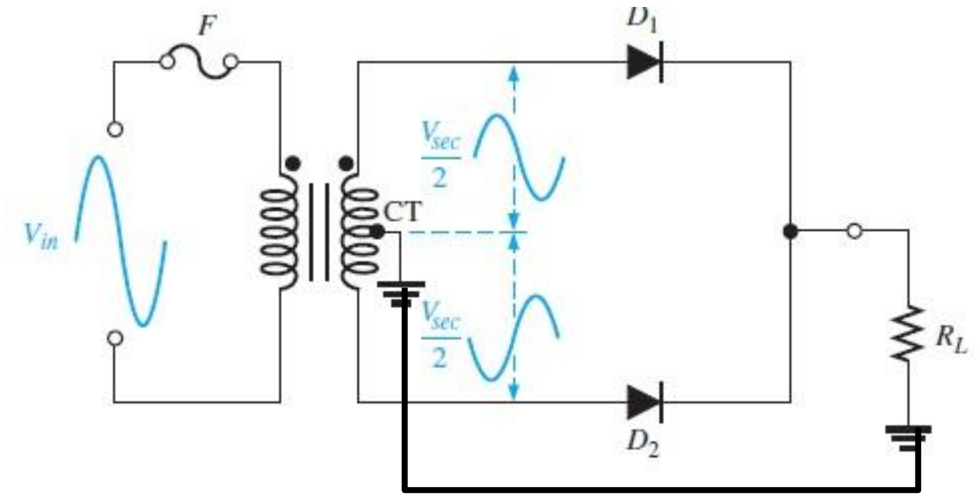
Solution

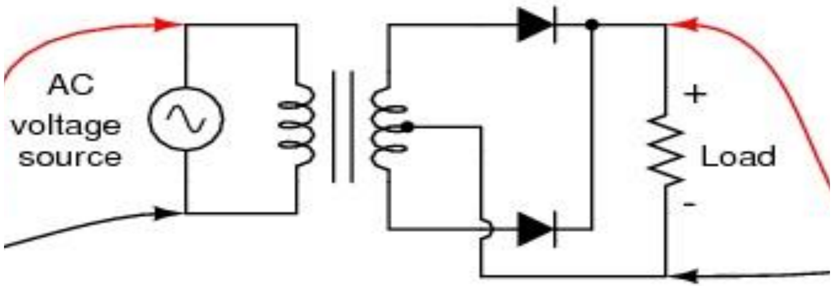
$$V_{AVG} = \frac{2V_p}{\pi} = \frac{2(15\text{ V})}{\pi} = \mathbf{9.55\text{ V}}$$

V_{AVG} is 63.7% of V_p.

Related Problem Find the average value of the full-wave rectified voltage if its peak is 155 V.

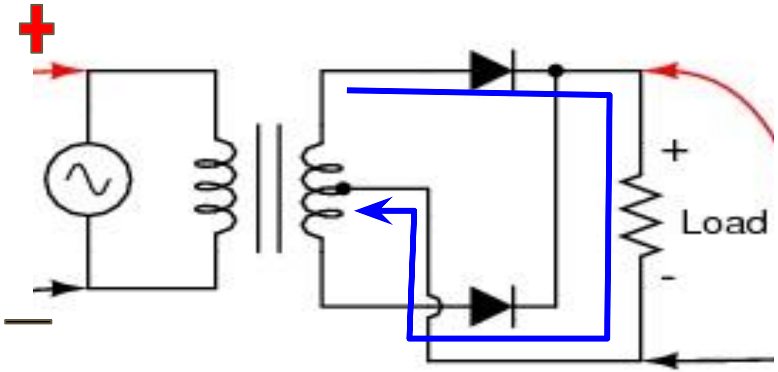
Center-Tapped Full-Wave Rectifier Operation





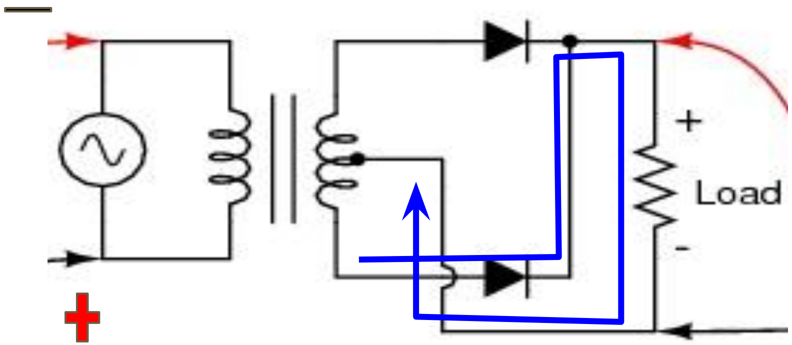
During Positive half cycle

For a positive half-cycle of the input voltage, the polarities of the secondary voltages are as shown in Figure. This condition forward-biases diode D1 and reverse-biases diode D2

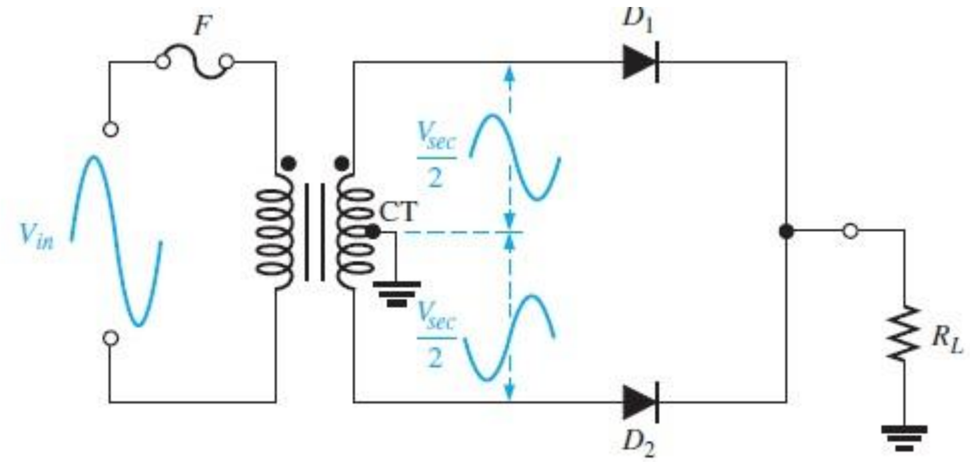


During Negative half cycle

For a negative half-cycle of the input voltage, the polarities of the secondary voltages are as shown in Figure. This condition forward-biases diode D2 and reverse-biases diode D1



PIV



$$\text{PIV} = \left(\frac{V_{p(sec)}}{2} - 0.7\text{ V}\right) - \left(-\frac{V_{p(sec)}}{2}\right) = \frac{V_{p(sec)}}{2} + \frac{V_{p(sec)}}{2} - 0.7\text{ V}$$

$$= V_{p(sec)} - 0.7\text{ V}$$

Since $V_{p(out)} = V_{p(sec)}/2 - 0.7\text{ V}$, then by multiplying each term by 2 and transposing,

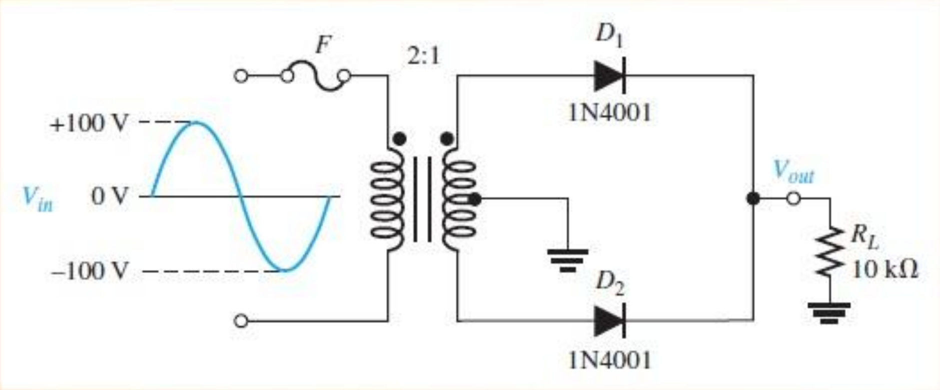
$$V_{p(sec)} = 2V_{p(out)} + 1.4\text{ V}$$

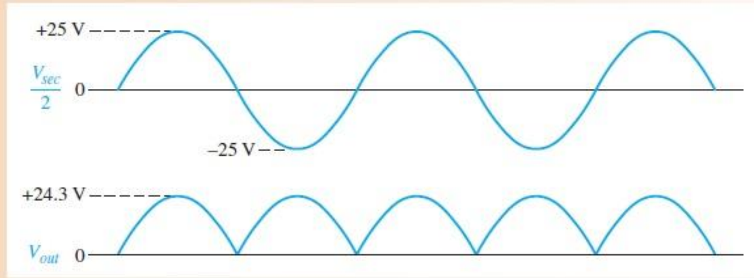
Therefore, by substitution, the peak inverse voltage across either diode in a full-wave center-tapped rectifier is

$$\textbf{PIV} = \mathbf{2}\boldsymbol{V_{p(out)}} + \textbf{0.7 V}$$

(a) Show the voltage waveforms across each half of the secondary winding and across R_L when a 100 V peak sine wave is applied to the primary winding in Figure 2–36.

(b) What minimum PIV rating must the diodes have?





(a) The transformer turns ratio $n = 0.5$. The total peak secondary voltage is

$$V_{p(sec)} = nV_{p(pri)} = 0.5(100\text{ V}) = 50\text{ V}$$

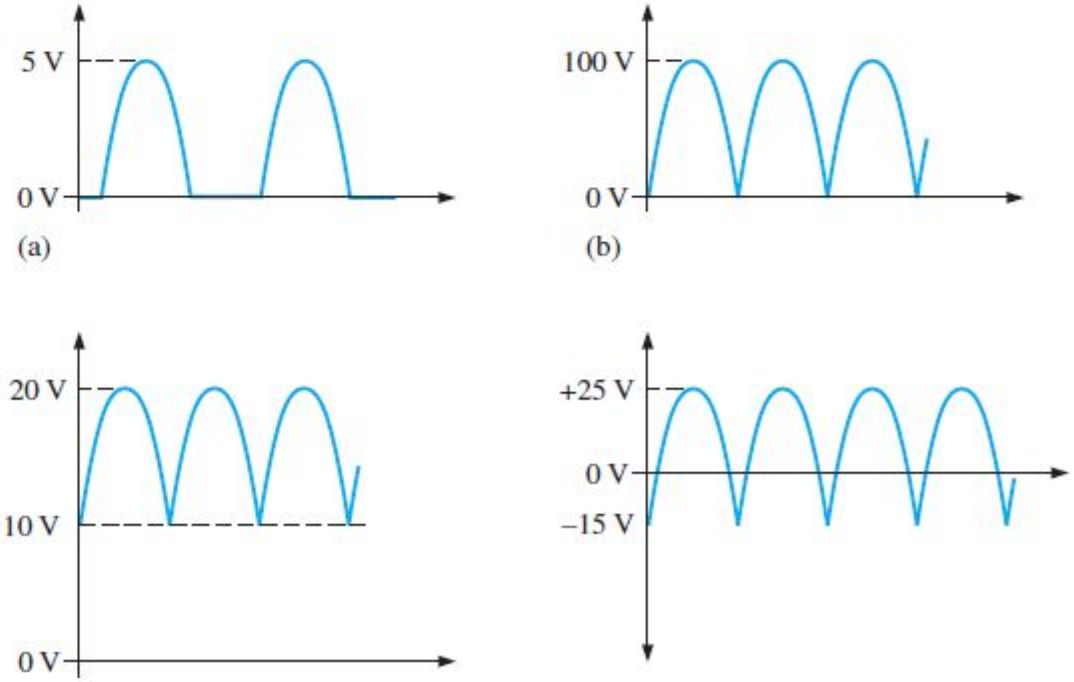
There is a 25 V peak across each half of the secondary with respect to ground. The output load voltage has a peak value of 25 V, less the 0.7 V drop across the diode. The waveforms are shown in Figure 2–37.

(b) Each diode must have a minimum PIV rating of

$$\text{PIV} = 2V_{p(out)} + 0.7\text{ V} = 2(24.3\text{ V}) + 0.7\text{ V} = \mathbf{49.3\text{ V}}$$

Full-Wave Rectifiers

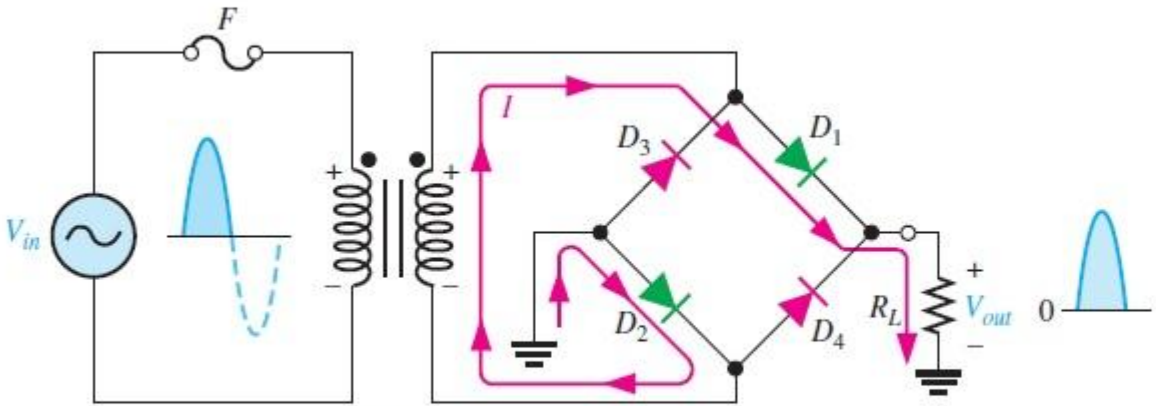
15. Find the average value of each voltage in Figure 2–95.



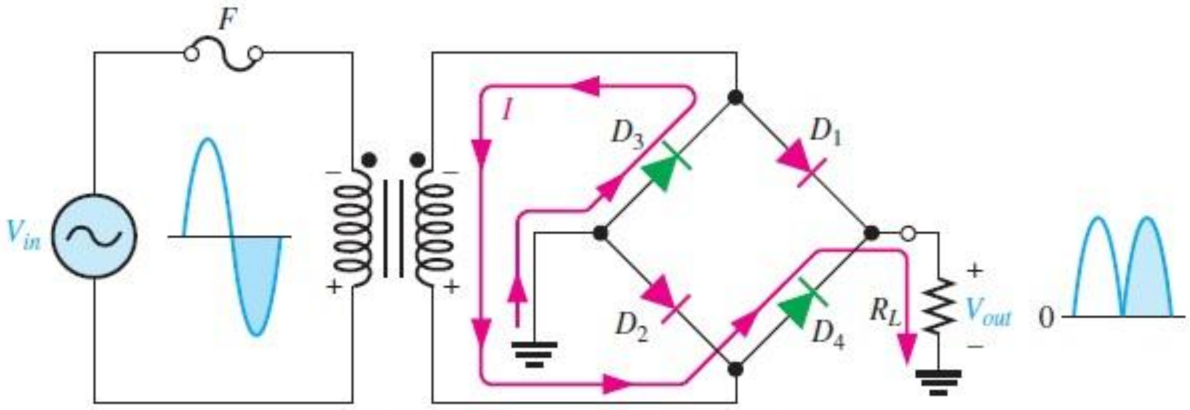
Example: **Calculate the peak voltage across each half of a center-tapped transformer used in a full-wave rectifier that has an average output voltage of 120 V.**

Solution in class

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.

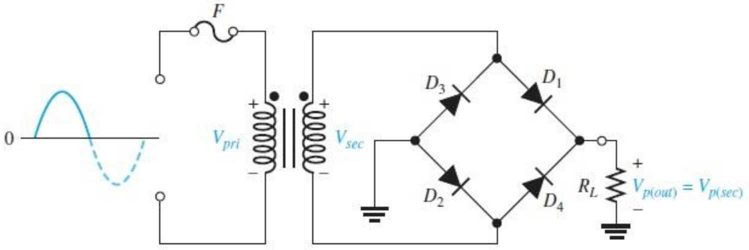


(b) During the negative half-cycle of the input, D_3 and D_4 are forward-biased and conduct current. D_1 and D_2 are reverse-biased.

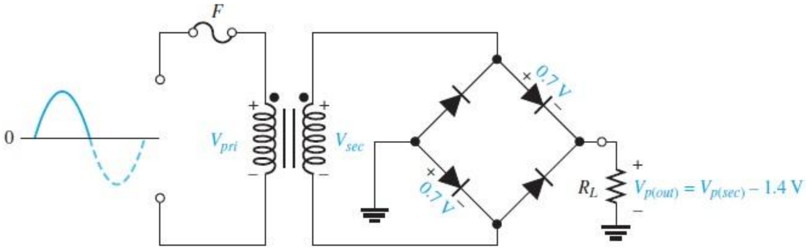
Bridge Output Voltage

As you can see in Figure two diodes are always in series with the load resistor during both the positive and negative half-cycles. If these diode drops are taken into account, the output voltage is

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



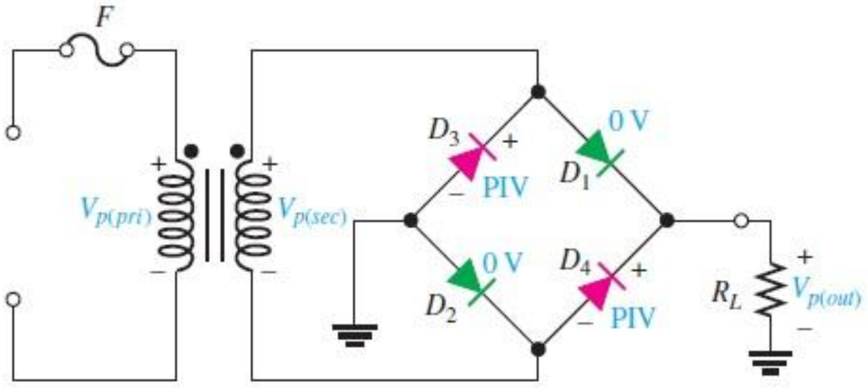
(a) Ideal diodes



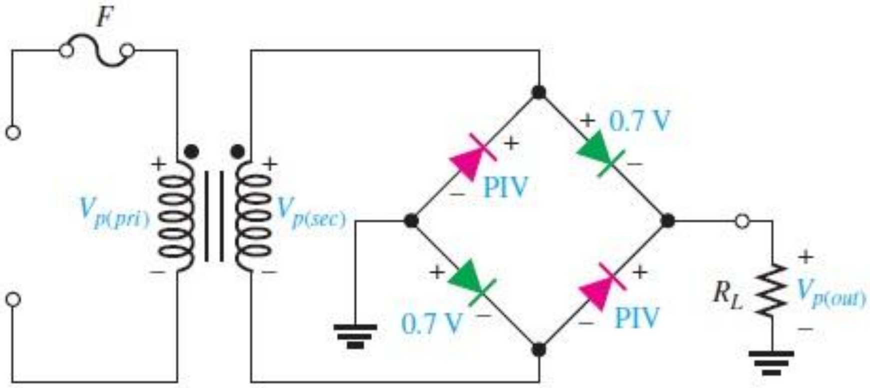
(b) Practical diodes (Diode drops included)

Peak Inverse Voltage of bridge Rectifier

If the diode drops of the forward-biased diodes are included as shown in , the peak inverse voltage across each reverse-biased diode in terms of Vp(out) is



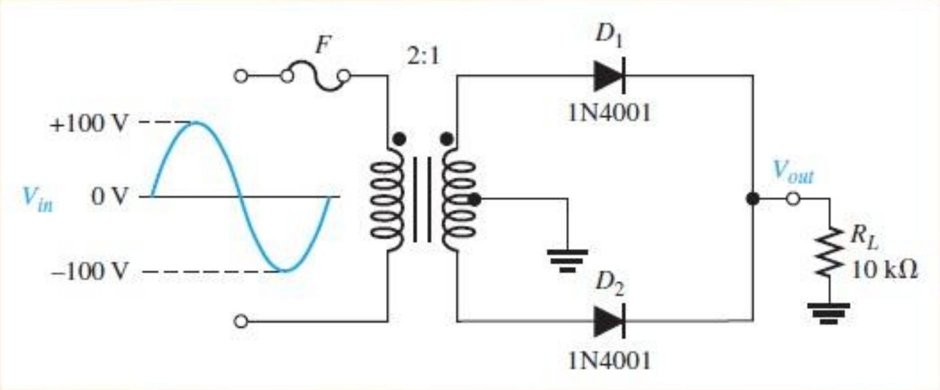
(a) For the ideal diode model (forward-biased diodes D_1 and D_2 are shown in green), PIV = $V_{p(out)}$.



(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.

(a) Show the voltage waveforms across each half of the secondary winding and across R_L when a 100 V peak sine wave is applied to the primary winding in Figure 2–36.

(b) What minimum PIV rating must the diodes have?



(a) The transformer turns ratio $n = 0.5$. The total peak secondary voltage is

$$V_{p(sec)} = nV_{p(pri)} = 0.5(100\text{ V}) = 50\text{ V}$$

There is a 25 V peak across each half of the secondary with respect to ground. The output load voltage has a peak value of 25 V, less the 0.7 V drop across the diode. The waveforms are shown in Figure 2–37.

(b) Each diode must have a minimum PIV rating of

$$\text{PIV} = 2V_{p(out)} + 0.7\text{ V} = 2(24.3\text{ V}) + 0.7\text{ V} = \mathbf{49.3\text{ V}}$$

Example: What PIV rating is required for the diodes in a bridge rectifier that produces an average output voltage of 50 V?

Example: The rms output voltage of a bridge rectifier is 20 V. What is the peak inverse voltage across the diodes?