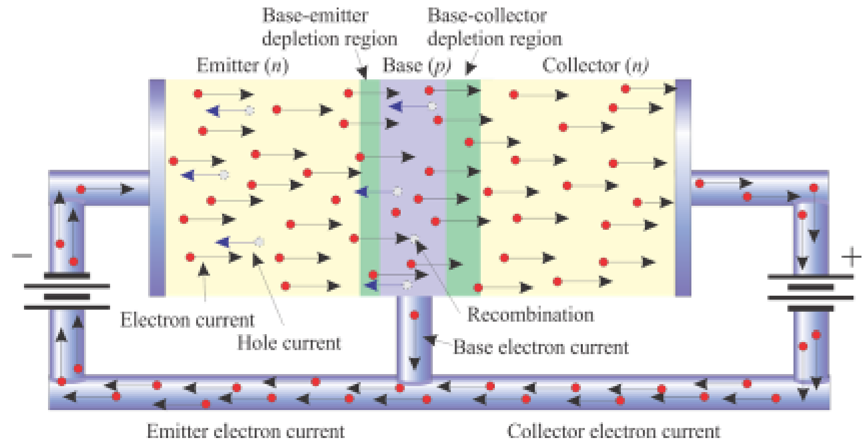
Electronic Devices

Ninth Edition

Floyd

Chapter 2

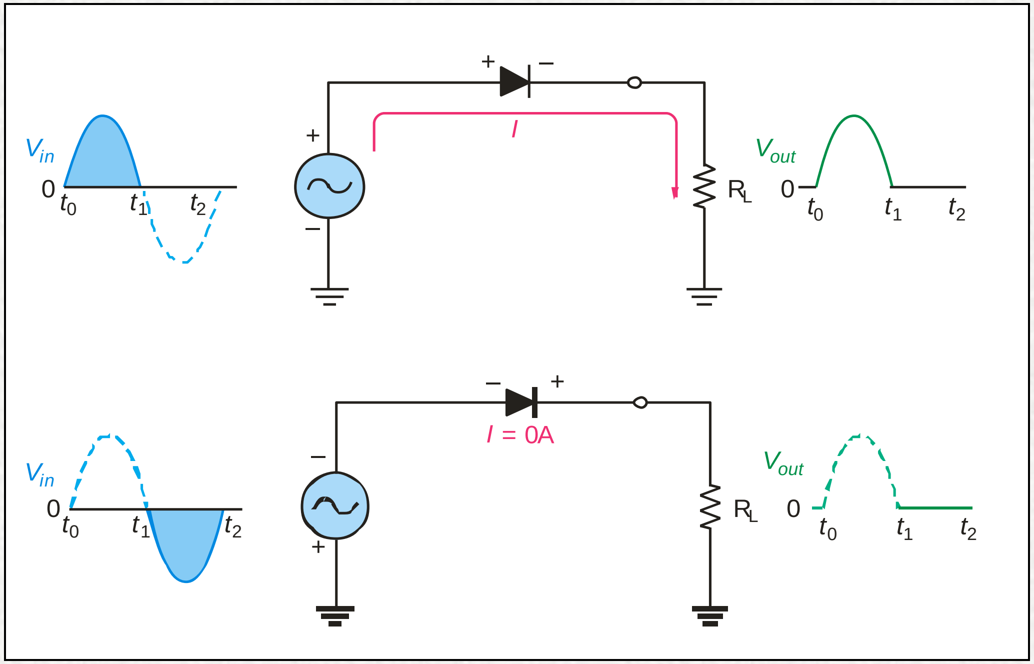


Summary

Half-wave Rectifier

The diode conducts during the positive half cycle.

It does not conduct during the negative half cycle.

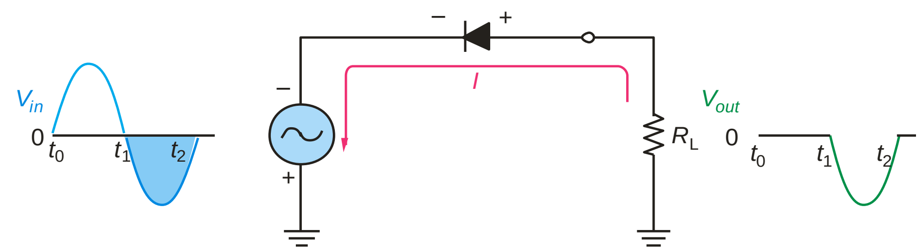


Question:

What is the output if the diode is reversed? See next slide…

Summary

Half-wave Rectifier



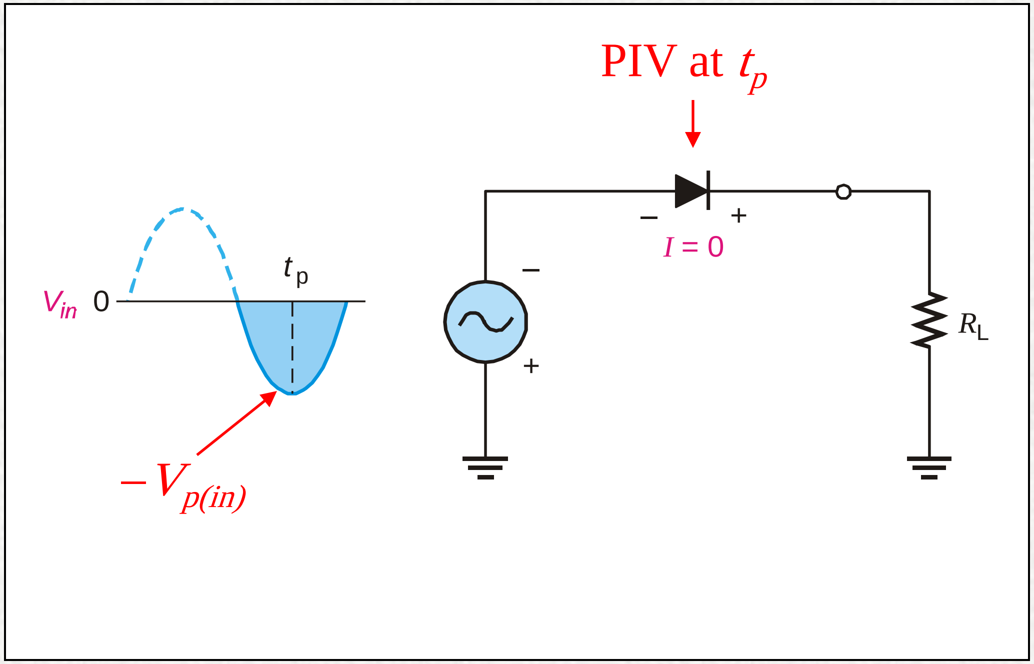
Question:

What is the output if the diode is reversed?

Summary

Half-wave Rectifier

The **peak inverse voltage** (PIV) is equal to the peak input voltage and is the maximum voltage across the diode when it is not conducting.

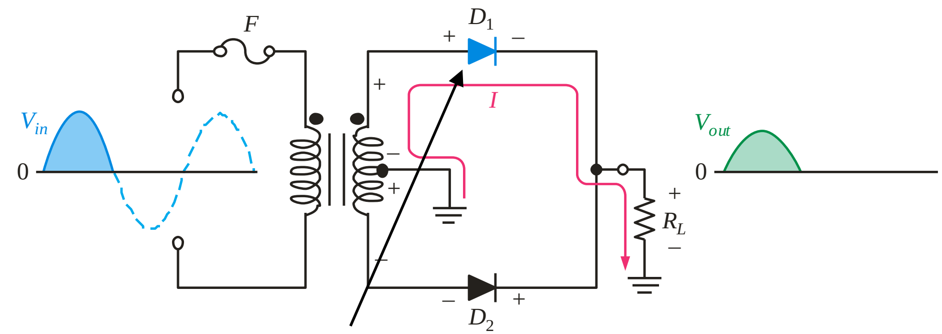


Notice that the PIV can be found by applying Kirchhoff's Voltage Law. The load voltage is 0 V, so the input voltage is across the diode at t_p.

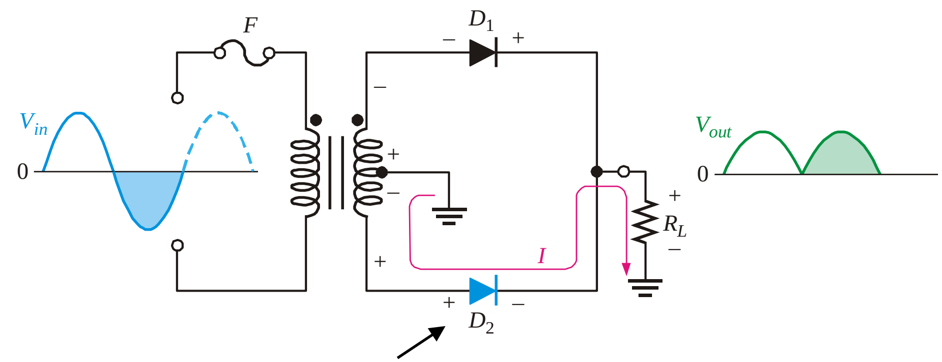
Summary

Full-wave Rectifier

A center-tapped transformer is used with two diodes that conduct on alternating half-cycles.



During the positive half-cycle, the upper diode is forward-biased and the lower diode is reverse-biased.

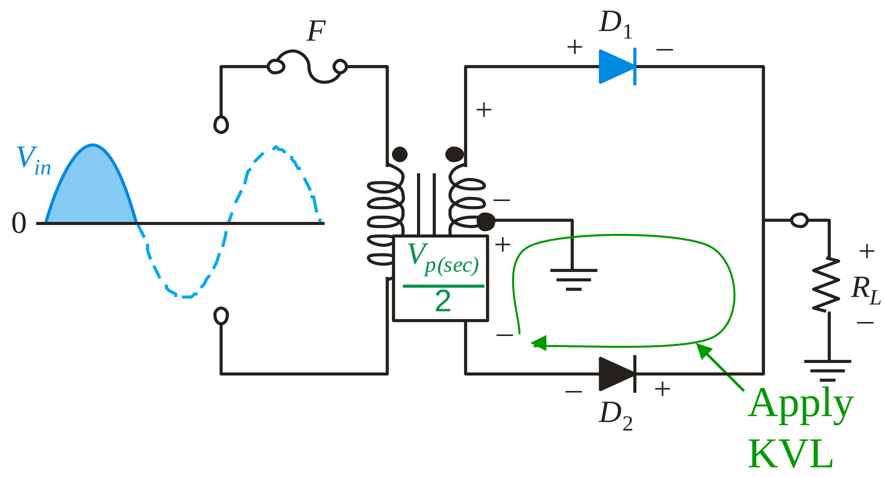


During the negative half-cycle, the lower diode is forward-biased and the upper diode is reverse-biased.

Summary

Full-wave Rectifier

The PIV can be shown by applying KVL around the green loop shown for the reverse-biased diode.

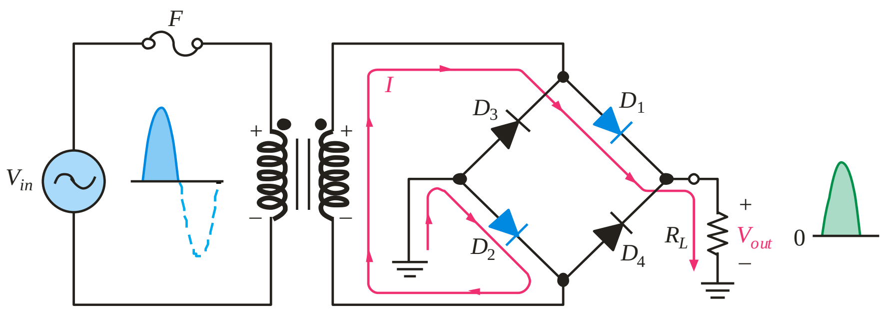


Notice that one-half of the peak secondary voltage will be across the reverse-biased diode.

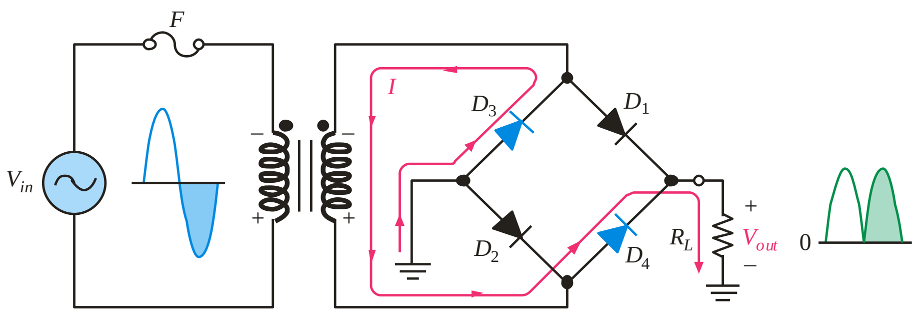
Summary

The Bridge Full-Wave Rectifier

The Bridge Full-Wave rectifier uses four diodes connected across the entire secondary as shown.



Conduction path for the positive half-cycle.



Conduction path for the negative half-cycle.

Question:

Ideally, what is the PIV equal to?

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

Summary

The Bridge Full-Wave Rectifier

Example:

Determine the peak output voltage and current in the 3.3 kΩ load resistor if V_{sec} = 24 V_{rms}. Use the practical diode model.

Solution:

The peak output voltage is:

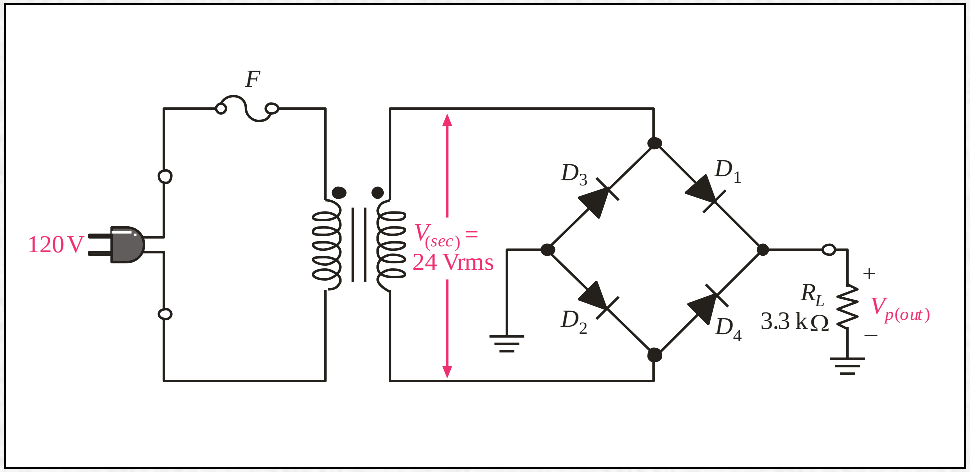
$$V_{p(sec)} = 1.41V_{rms} = 33.9\text{ V}$$

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

$$= 32.5\text{ V}$$

Applying Ohm's law,

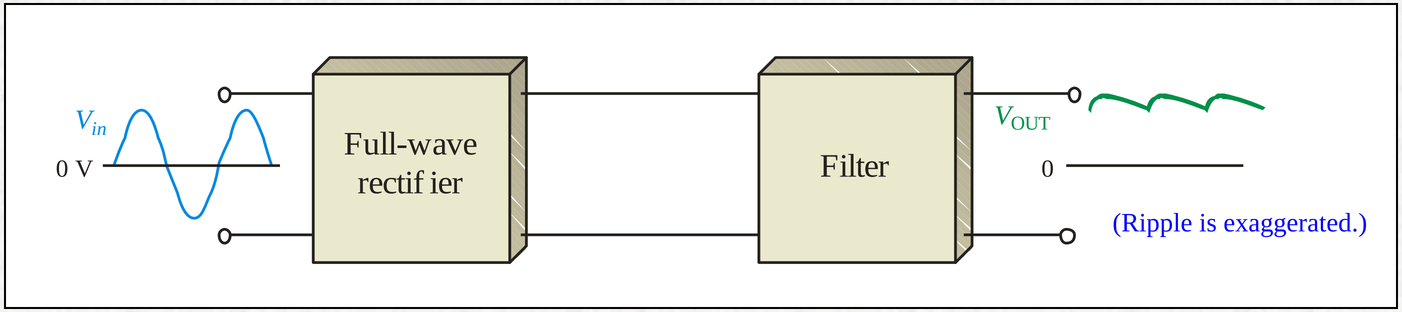
$$I_{p(out)} = 9.8\text{ mA}$$



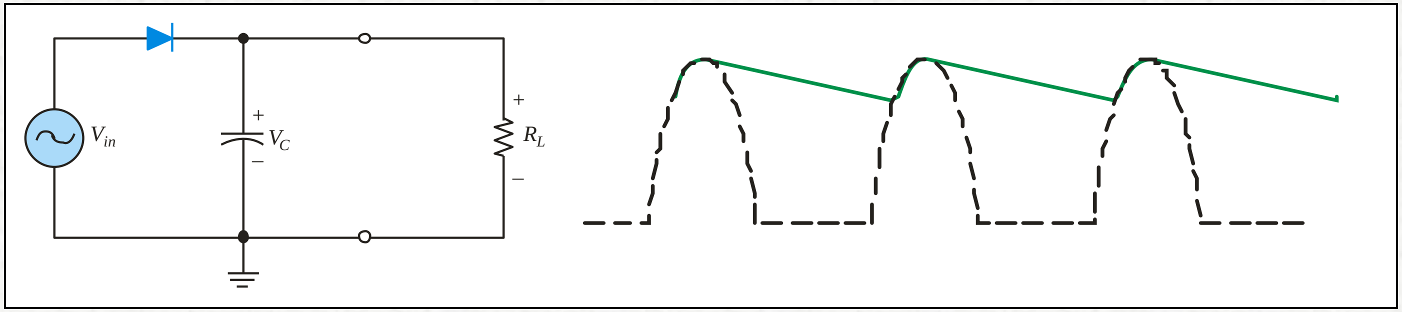
Summary

Power Supply Filters

Filtering is the process of smoothing the ripple from the rectifier.



The capacitor input filter is widely used. A half-wave rectifier and capacitor-input filter are shown:

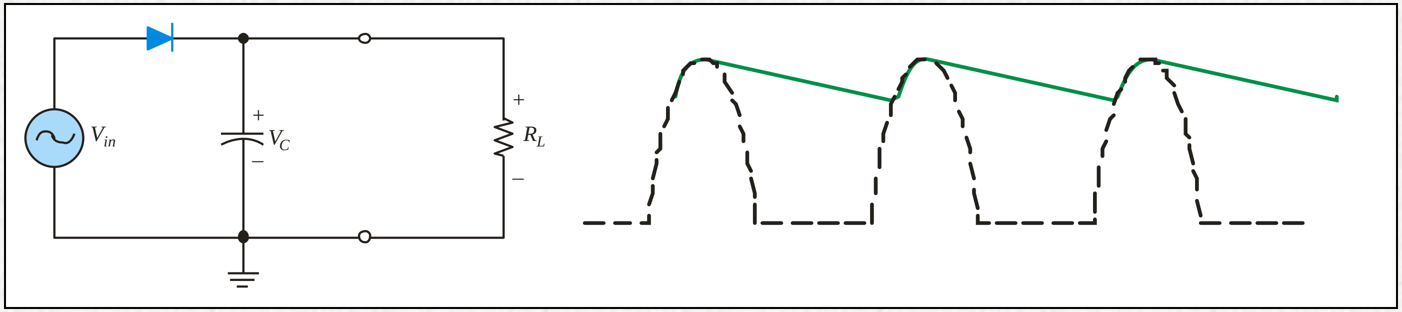


Summary

Power Supply Filters

Question:

How is the ripple affected by the *RC* time constant?



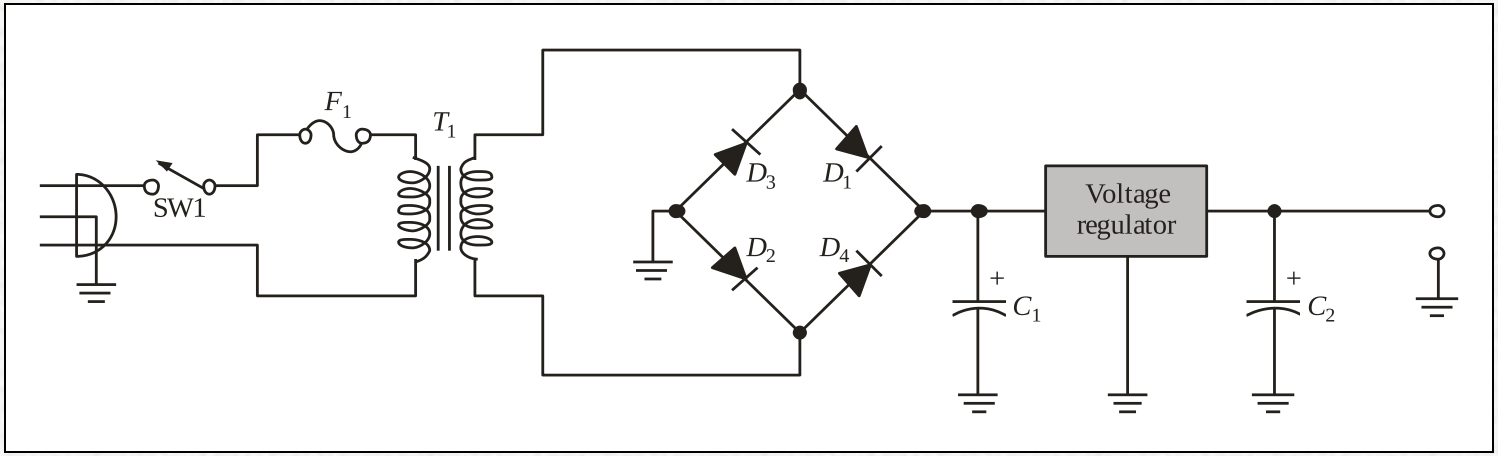
Answer:

A longer time constant will have less ripple for the same input voltage and frequency.

Summary

Power Supply Regulators

A voltage regulator can furnish nearly constant output with excellent ripple rejection. Three-terminal regulators are require only external capacitors to complete the regulation portion of the circuit.



Summary

Power Supply Regulators

Regulation performance is specified in two ways. **Line regulation** specifies how much the dc output changes for a given change in regulator's input voltage. The text formula is based on a *dc* input voltage change to the regulator due to a change in the *ac line* voltage.

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

Question:

Assume the dc input to a regulator changes by 1.0 V due to a change in the ac line voltage. If the output changes by 1.5 mV due to the change, what is the line regulation?

Answer:

$$\text{Line regulation} = \left(\frac{\Delta V_{OUT}}{\Delta V_{IN}}\right)100\% = \left(\frac{1.5\text{ mV}}{1.0\text{ V}}\right)100\% = 0.15\%$$

Summary

Power Supply Regulators

Load regulation specifies how much change occurs in the output voltage for a given range of load current values, usually from no load (NL) to full load (FL).

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

Question:

Assume the dc output of a regulator changes from 5.00 V to 4.96 V when the output is varies from no load to full load. What is the load regulation?

Answer:

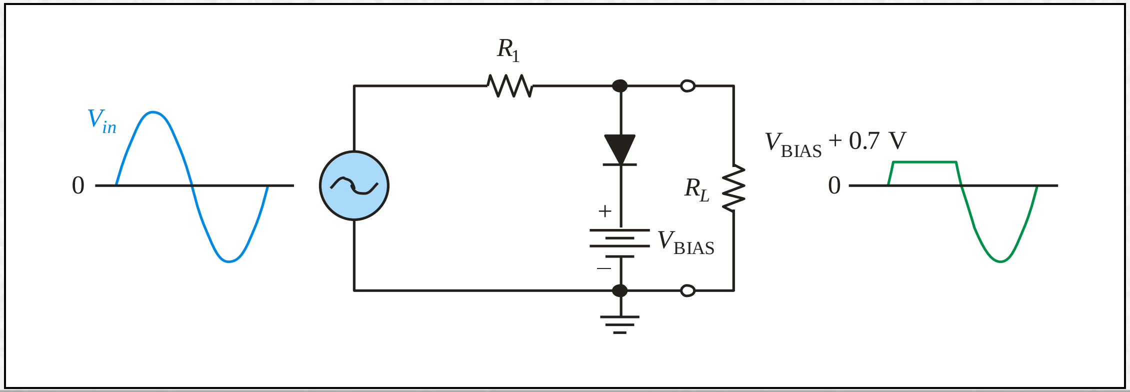
$$\text{Load regulation} = \left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right)100\% = \left(\frac{5.00\text{ V} - 4.96\text{ V}}{4.96\text{ V}}\right)100\% = 0.8\ \%$$

Summary

Diode Limiting Circuits

A diode **limiter** is a circuit that limits (or *clips*) either the positive or negative part of the input voltage. A **biased limiter** is one that has a bias voltage in series with the diode, so that a specific voltage level can be selected for limiting.

A positive limiter is shown. R_L is normally >> R_1 to avoid loading effects. The output will be clipped when the input voltage overcomes the bias voltage and the forward voltage of the diode.

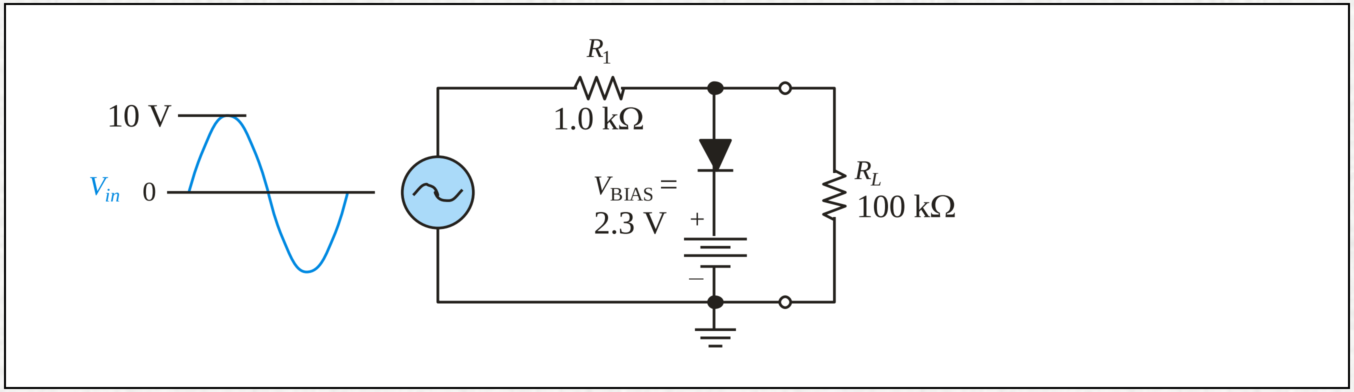


Summary

Diode Limiting Circuits

Example-1:

What is the output of positive limiter shown?



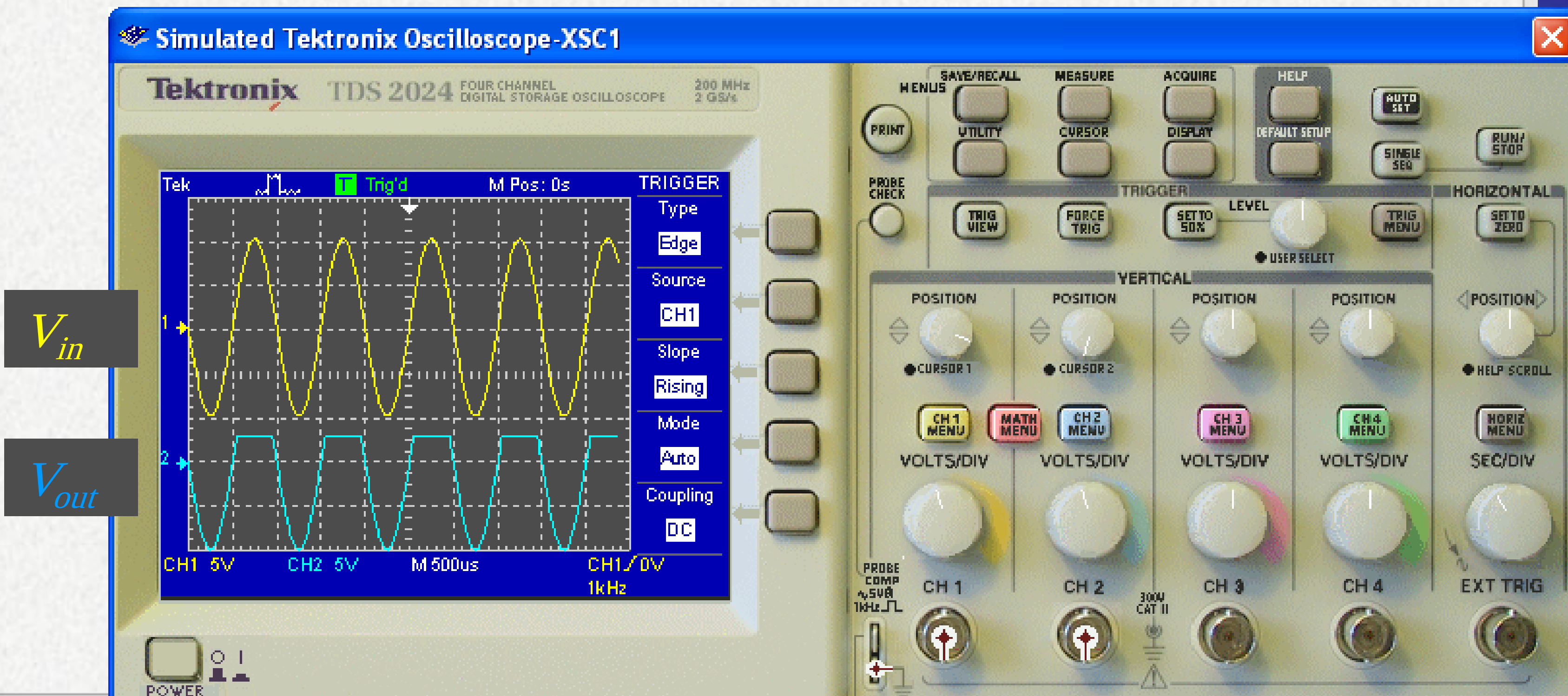
Solution:

The diode is forward-biased when the output tries to go *above* +3.0 V. This causes the output to be limited to voltages *less* than +3.0 V.

Summary

Diode Limiting Circuits

As a check, you can simulate the circuit with Multisim. The scope shows the input and output voltage for the positive limiter circuit.



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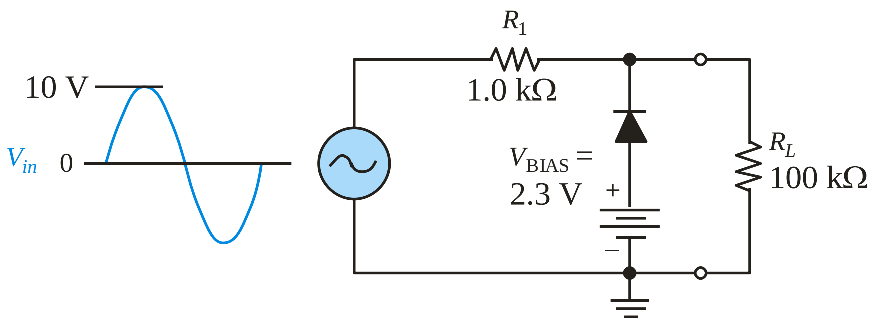
Summary

Diode Limiting Circuits

Example-2:

What happens in the previous circuit if the diode is reversed?



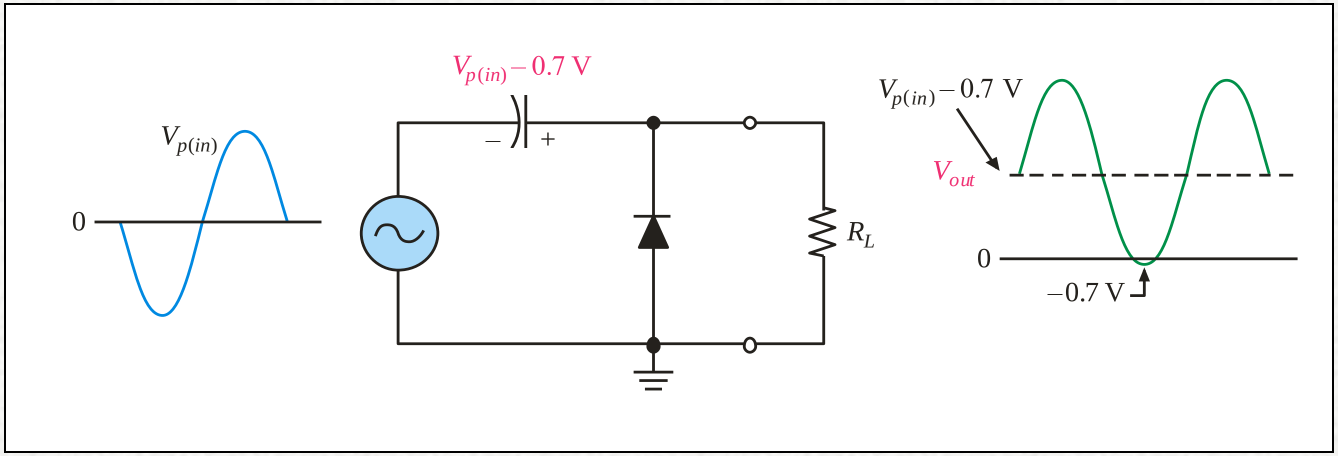
Solution:

The diode is forward-biased when the output tries to go *below* +1.6 V. This causes the output to be limited to voltages *greater* than +1.6 V.

Summary

Diode Clamping Circuits

A **clamper** (dc restorer) is a circuit that adds a dc level to an ac signal. A capacitor is in series with the load. A positive clamper is shown. The capacitor is charged to a voltage that is one diode drop less than the peak voltage of the signal.

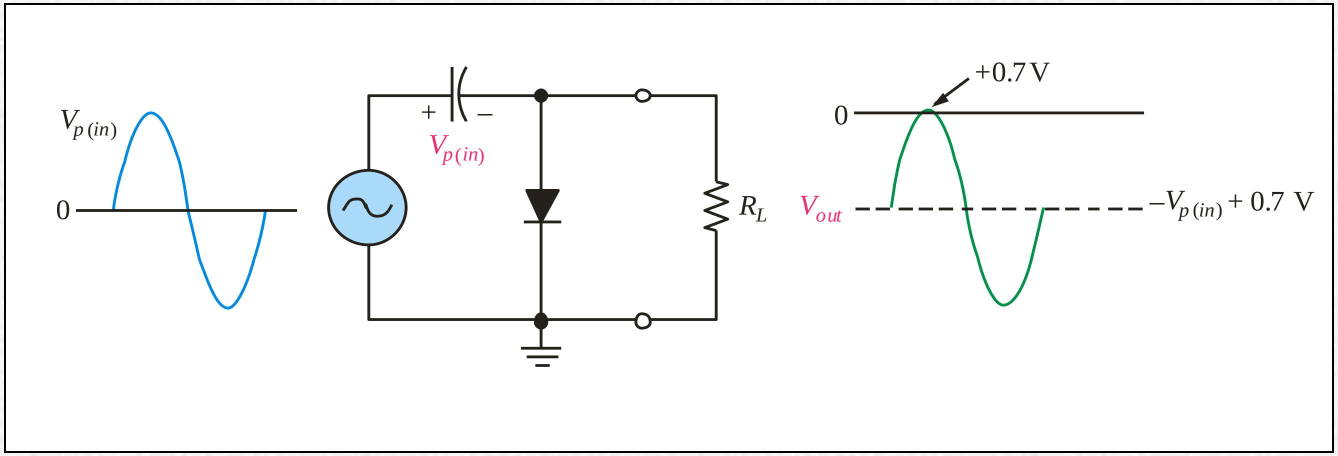


Question: What happens if the diode and capacitor are reversed?

Diode Clamping Circuits

Solution:

Reversing the diode and capacitor forms a negative clamper.



Summary

Voltage Multipliers

Voltage multipliers use clamping action to increase peak rectified voltages. The **full-wave** voltage doubler works by charging a capacitor to the positive peak voltage on one cycle of the sine wave and a second capacitor on the negative peak voltage. The output is (ideally) doubled by taking it across both capacitors in series.