Electronics
Zener Diodes and Photodiodes

Terry Sturtevant

Wilfrid Laurier University

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Basic Diode Operation

forward bias
Basic Diode Operation

reverse bias
The diode will conduct when it is *forward biased* when the input voltage goes above about 0.7V.
The diode will conduct when it is *forward biased* when the input voltage goes above about 0.7V.

The diode will not conduct when it is *reverse biased* until the input voltage goes above about the *reverse breakdown voltage*, which is typically large.
Application: Clamping

It may sometimes be necessary to ensure that a signal does not become negative. For instance, a sensor inside the engine of a car may pick up electrical noise. A negative voltage due to noise could destroy a microprocessor. To avoid this, the signal may be clamped so that it never goes below zero. This can be done using a diode.
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- To avoid this, the signal may be clamped so that it never goes below zero.
- This can be done using a diode.
Clamping a signal
Diodes
Zener diodes
Photodiodes
Optical Isolation

Basic Diode Operation
Application: Clamping

\[ V_i \]
\[ R_d \]
\[ V_o \]
The diode will conduct once it is forward biased.
The diode will conduct once it is forward biased.

The output voltage will follow the input until the input goes below about $-0.7V$. 

(This slight negative voltage will not be a problem for most electronics.)

The resistor should be chosen so that the maximum current through the diode is within the specified limits.
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• From then on the output will not decrease.
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From then on the output will not decrease. (This slight negative voltage will not be a problem for most electronics.)

The resistor should be chosen so that the maximum current through the diode is within the specified limits.
Zener diodes

The Zener diode will conduct in reverse bias once the voltage exceeds the Zener voltage, $V_Z$. The output voltage will follow the input until the input exceeds $V_Z$. From then on the output will not increase. It is usually placed in a voltage divider with a resistor chosen so that the maximum current through the diode is within the specified limits.
Zener diodes

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Diodes
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Application: Clipping
Calculating Resistance

reverse bias
Diodes

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Application: Clipping
Calculating Resistance

$V_Z$

reverse bias

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Electronics Zener Diodes and Photodiodes
Here's the typical circuit.
Here’s the typical circuit.
Here's a Zener diode circuit simulation drawing.

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$V_{in}$ $V_{out1}$ $V_{out2}$
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Application: Clipping
Calculating Resistance

$V_{in}$  $V_{out}$

$V_{in001}$  $V_{out002}$

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For a 10V Zener diode, the output voltage range is much less than the input range.
Diodes
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Application: Clipping
Calculating Resistance

\[ V_{in} \quad V_{imm} \quad V_{out} \quad V_{out} \]

\[ 0\text{ms} \quad 1\text{ms} \quad 2\text{ms} \quad 3\text{ms} \quad 4\text{ms} \quad 5\text{ms} \quad 6\text{ms} \quad 7\text{ms} \quad 8\text{ms} \quad 9\text{ms} \quad 10\text{ms} \]

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The output range is smaller if the input range is smaller.
Often it's necessary to ensure that a signal does not exceed a certain voltage in order to avoid harming circuitry which follows. Again, using the car sensor example, a sensor inside the engine of a car may pick up electrical noise of hundreds of volts occasionally which could destroy a microprocessor. To avoid this, the signal may be clipped so that it never goes above a fixed voltage. This can be done using a Zener diode.
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Again, using the car sensor example, a sensor inside the engine of a car may pick up electrical noise of hundreds of volts occasionally which could destroy a microprocessor.

To avoid this, the signal may be clipped so that it never goes above a fixed voltage.

This can be done using a Zener diode.
Clipping a signal
Application: Clipping
Calculating Resistance

\[ V_i \]

\[ R_z \]

\[ V_o \]
Calculating Resistance

Three parameters are needed to calculate the required resistance for a Zener diode:

1. Supply voltage, \( V_S \)
2. Zener voltage, \( V_Z \)
3. Recommended Zener current, \( I \)

The ideal value for the resistance, \( R \), is given by:

\[
R = V_S - V_Z / I
\]
Calculating Resistance

Three parameters are needed to calculate the required resistance for a Zener diode:

1. Supply voltage, $V_S$
2. Zener voltage, $V_Z$
3. Recommended Zener current, $I_T$

The ideal value for the resistance, $R$, is given by:

$$R = V_S - V_Z I_T$$
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2. Zener voltage, $V_Z$
3. recommended Zener current, $I$

The ideal value for the resistance, $R$, is given by:

$$R = \frac{V_S - V_Z}{I}$$
Photodiodes

Photodiodes are diodes which operate differently when exposed to light. They can operate in two modes:

1. Forward-biased; a.k.a. photovoltaic mode
2. Reverse-biased; a.k.a. photocurrent mode

LEDs can also be used as photodiodes.
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Photodiode symbol
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photocurrent
mode

photovoltaic
mode

dark

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increasing light

photocurrent mode

photovoltaic mode
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Calculating Resistance

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Calculating Resistance

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Electronics Zener Diodes and Photodiodes
To use a photodiode in photovoltaic mode:

Measure the forward-biased voltage which changes with light.

To use a photodiode in photocurrent mode:

Put it reverse-biased in a voltage divider like a Zener diode and measure the reverse-biased voltage which changes with light.
To use a photodiode in photovoltaic mode:
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Measure the forward-biased voltage which changes with light

To use a photodiode in photocurrent mode:
Put it reverse-biased in a voltage divider like a Zener diode and measure the reverse-biased voltage which changes with light
Calculating Resistance

Three parameters are needed to calculate the required resistance for a photodiode:

1. supply voltage, \( V_S \)
2. photocurrent, \( I_p \)
3. desired voltage change with light, \( V_o \)

The ideal value for the resistance, \( R \), is given by:

\[
R = \frac{V_S - V_o}{I_p}
\]
Calculating Resistance

Three parameters are needed to calculate the required resistance for a photodiode:

1. Supply voltage, \( V_S \)
2. Photocurrent, \( I_p \)
3. Desired voltage change with light, \( V_o \)

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\]
Optical Isolation

Optical isolation using an LED and a phototransistor or photodiode can transmit DC (i.e. steady-state values) only one way. It cannot transmit power. The above two conditions mean that there is no danger of voltage spikes as there is with inductive isolation.
Optical Isolation

*Optical* isolation using an LED and a phototransistor or photodiode
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Optical isolation using an LED and a phototransistor or photodiode

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The values chosen for the resistors should be consistent with the current specifications for the device.

The amount of DC isolation provided by an optoisolator is usually in the range of kV.

At some point the insulation will break down and arcs can occur.
Whenever sensors are in a place where it is possible for high voltages to be induced, optical isolation should be used to protect electronic devices which follow.