

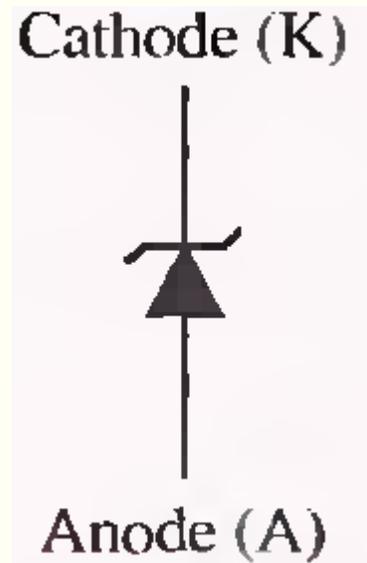
# ZENER DIODE



# Introduction

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- Zener diode is a silicon pn junction device that is designed for operation in the reverse-breakdown region
- It is a properly doped crystal diode which has a sharp breakdown voltage.

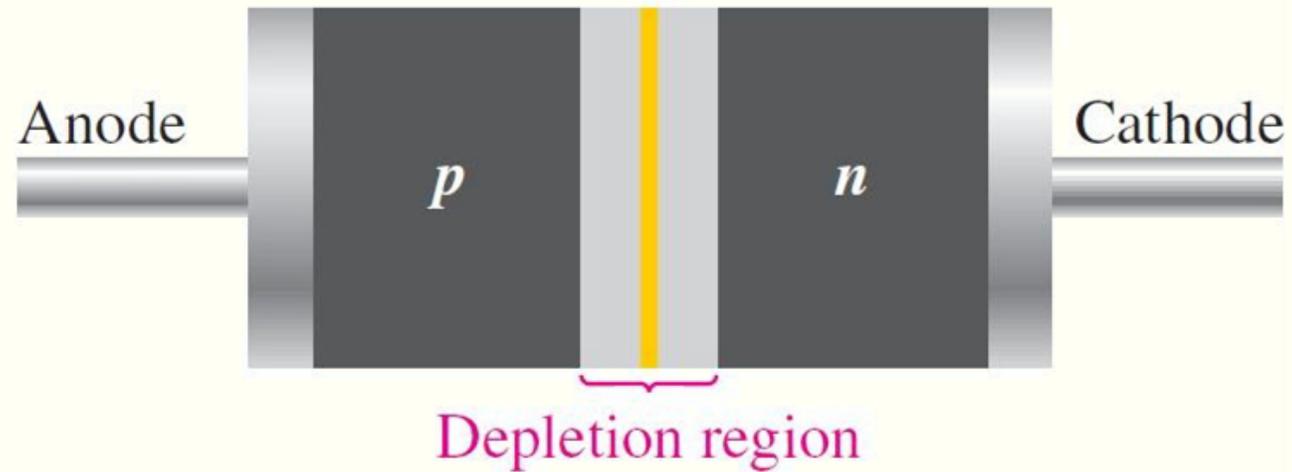


# Construction of Zener

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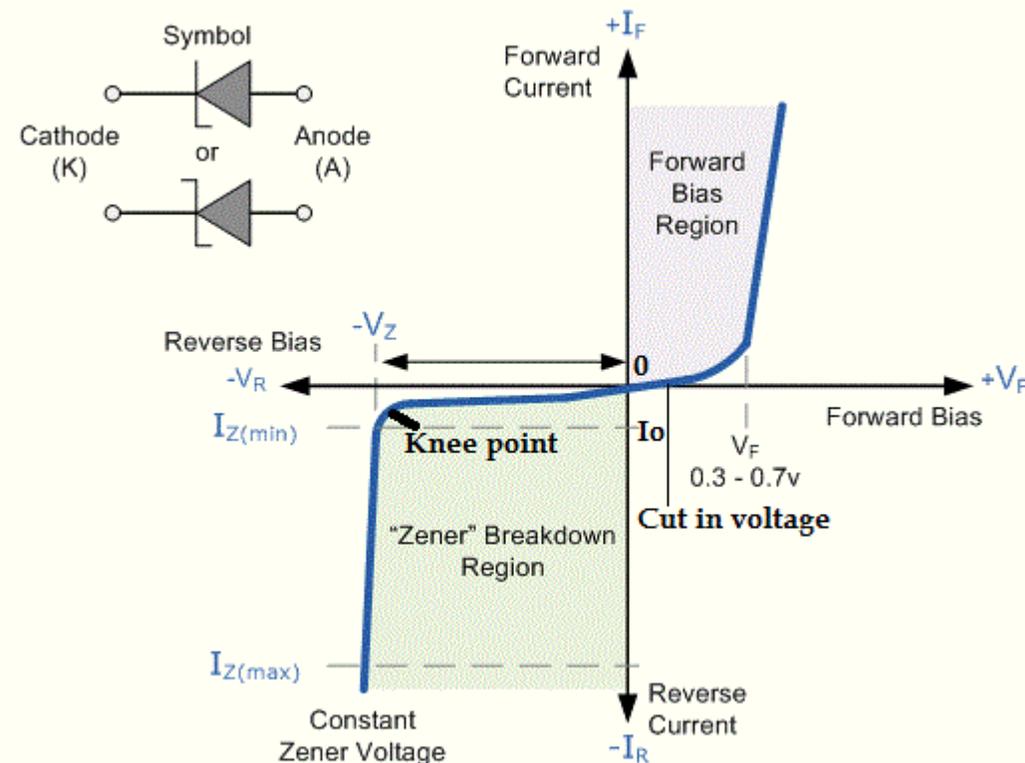
- Zener diodes are special diodes designed to operate in reverse breakdown.
- As we know there are two types of reverse breakdown avalanche and zener. The avalanche break down occurs in both rectifier and zener diodes at a sufficiently high reverse voltage.
- A zener diode is heavily doped to reduced the breakdown voltage. In other words, we can say Zener breakdown occurs in a zener diode at low reverse voltages.
- Zeners are commercially available with voltage breakdowns of 1.8 V to 200 V.
- The zener diodes breakdown characteristics are determined by the doping process

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- Because of heavy doping, zener diodes have a very thin depletion region.

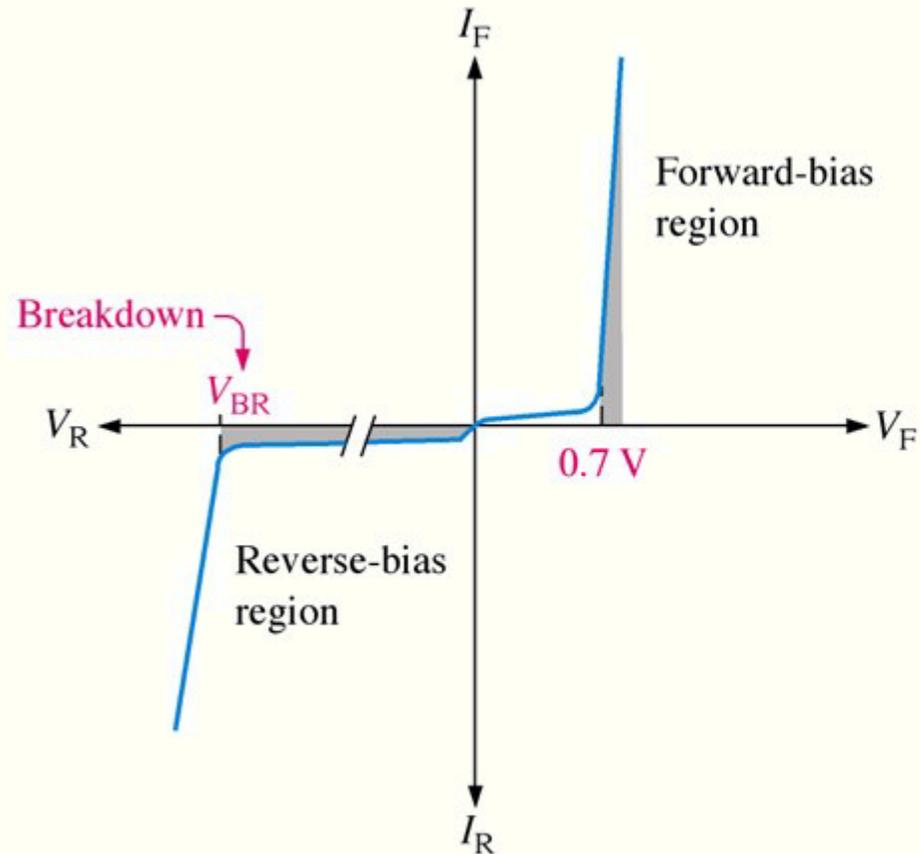


# Working of Zener

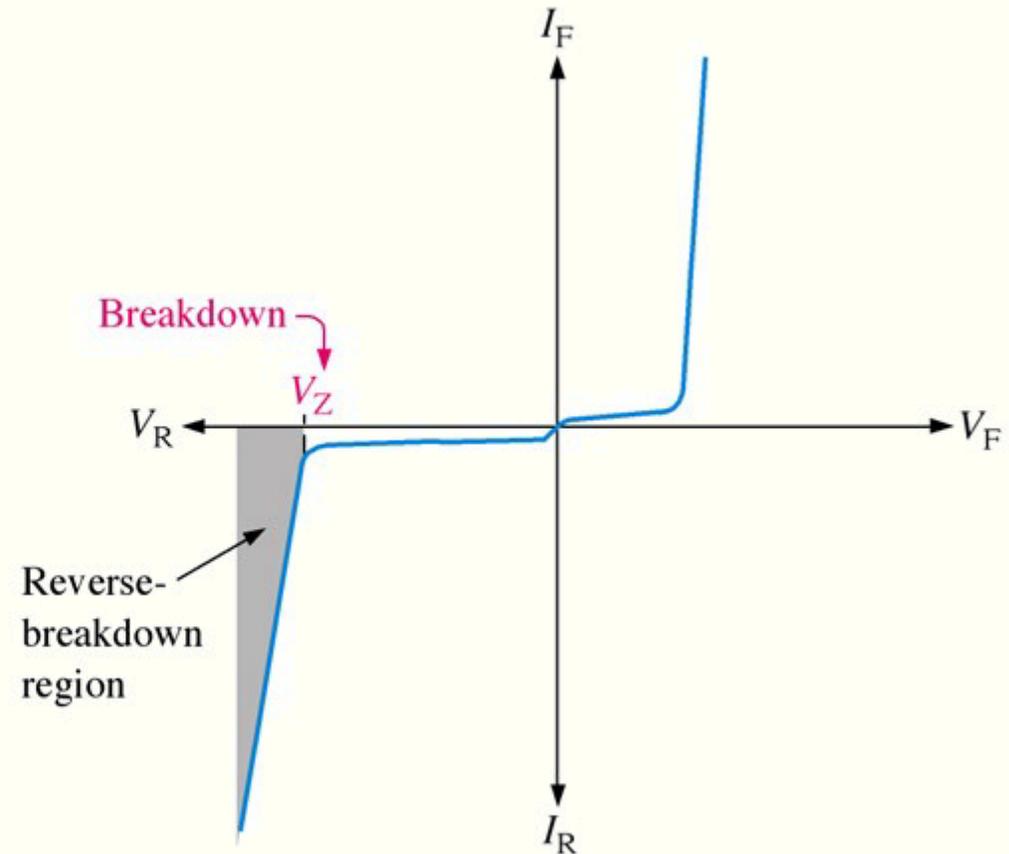
- A zener diode is much like a normal diode. The exception being is that it is placed in the circuit in reverse bias and operates in reverse breakdown.
- Note that it's forward characteristics are just like a normal diode.



# Operating regions of zener & rectifier diodes



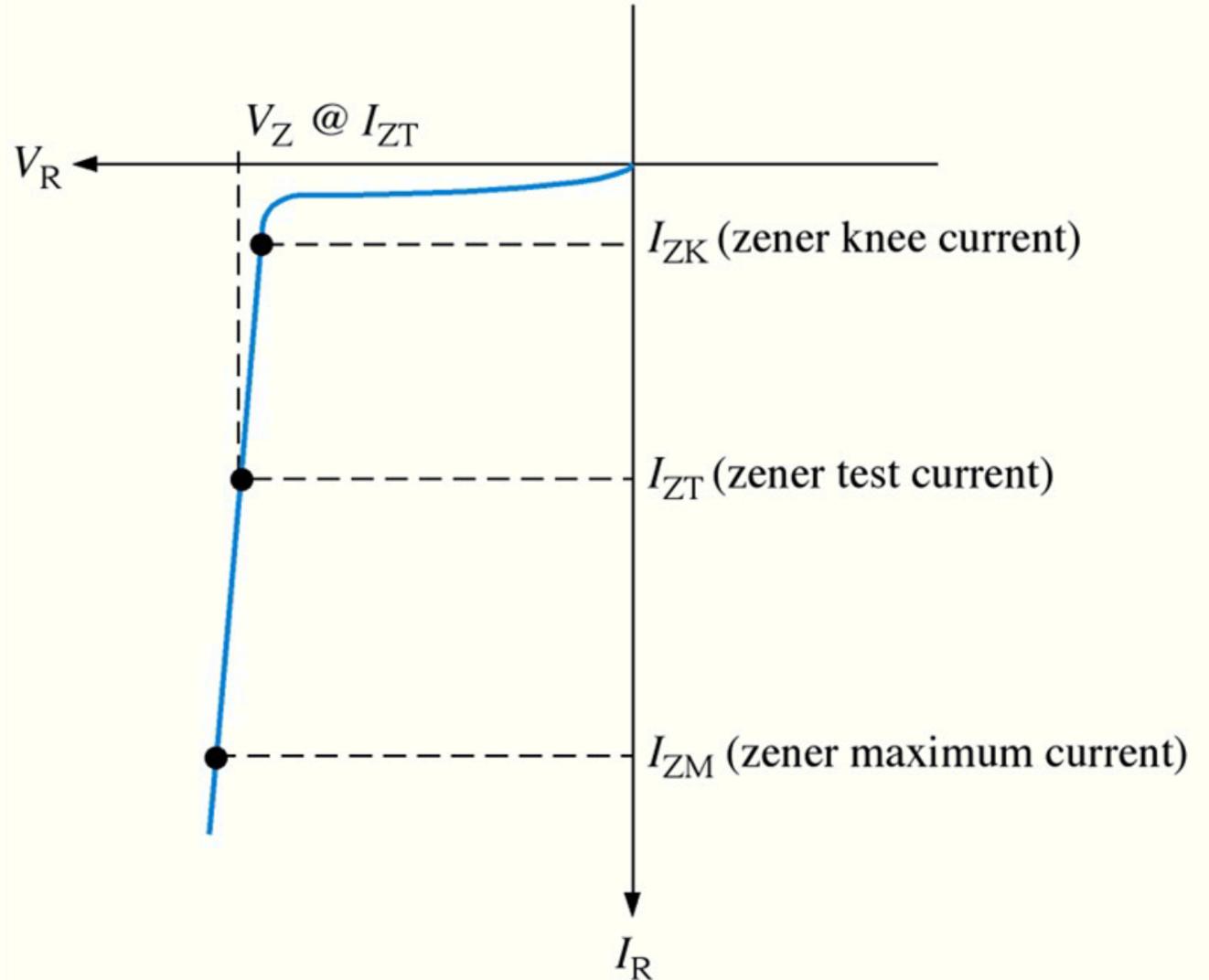
(a) The normal operating regions for a rectifier diode are shown as shaded areas.



(b) The normal operating region for a zener diode is shaded.

# Breakdown Characteristics

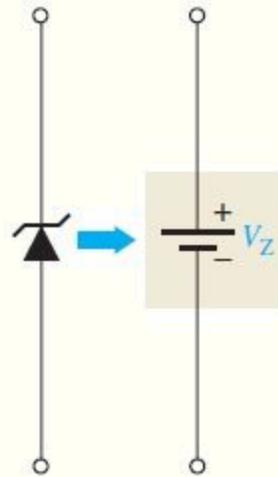
Figure shows the reverse portion of a zener diode's characteristic curve. As the reverse voltage ( $V_R$ ) is increased, the reverse current ( $I_R$ ) remains extremely small up to the "knee" of the curve. The reverse current is also called the zener current,  $I_Z$ . At this point, the breakdown effect begins; the internal zener resistance, also called zener impedance ( $Z_Z$ ), begins to decrease as reverse current increases rapidly.



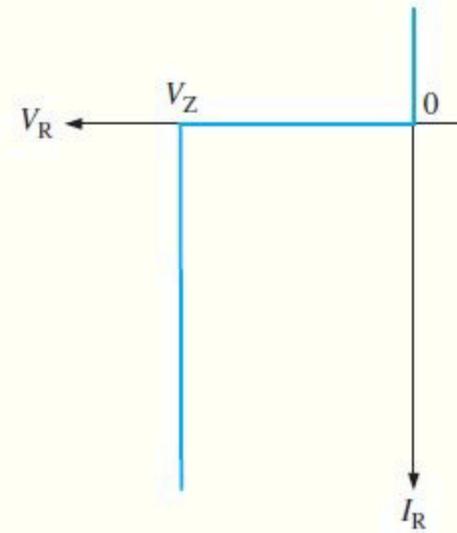
# Ideal Model & Ideal Characteristic Curve of Zener Diode

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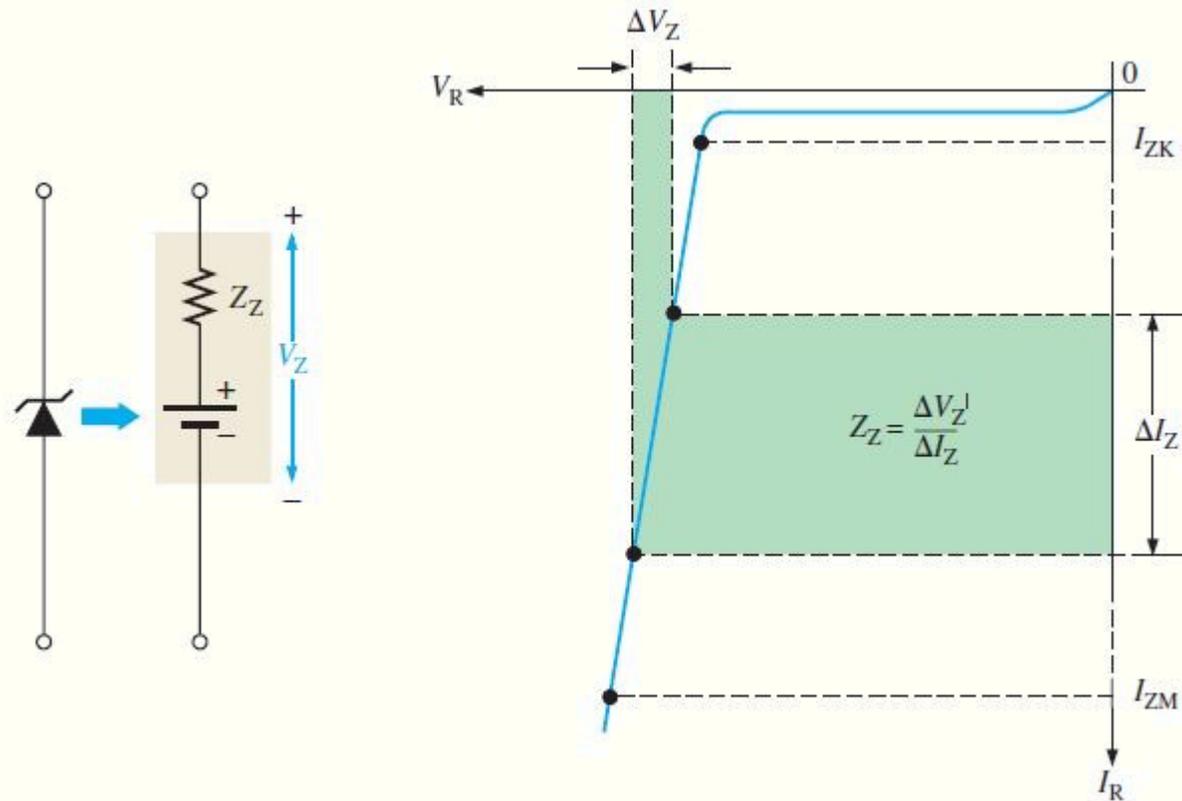
(a) Ideal model



(b) Ideal characteristic curve

# Practical Model & Characteristic Curve of Zener Diode

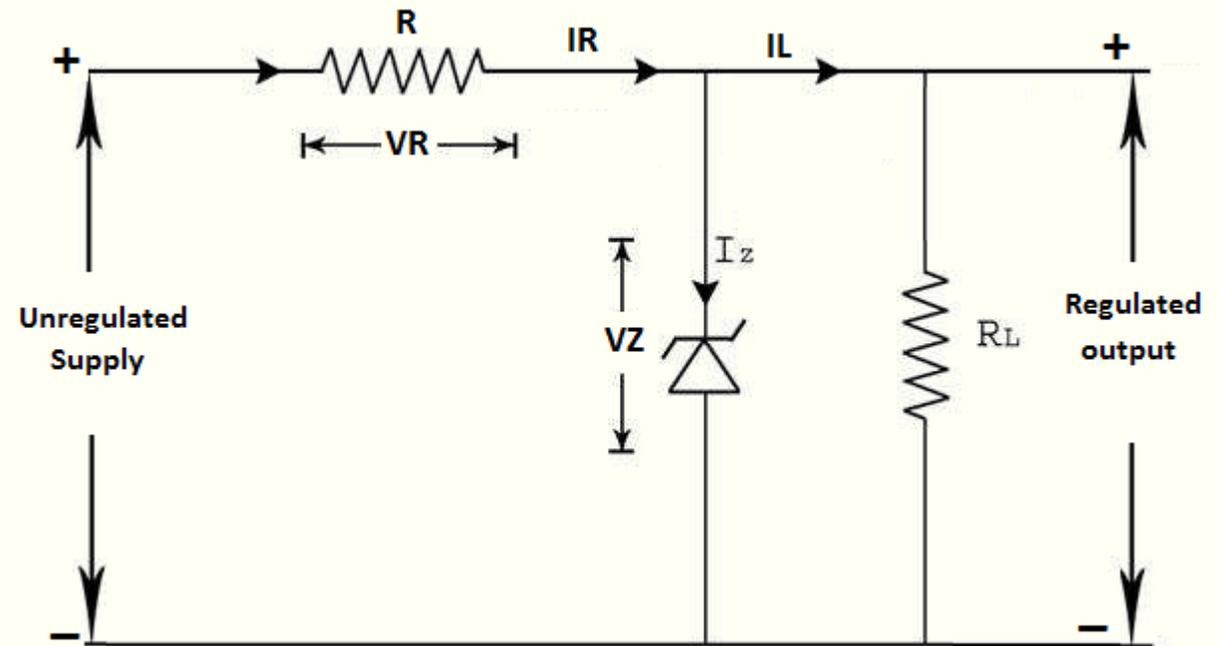
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# Applications

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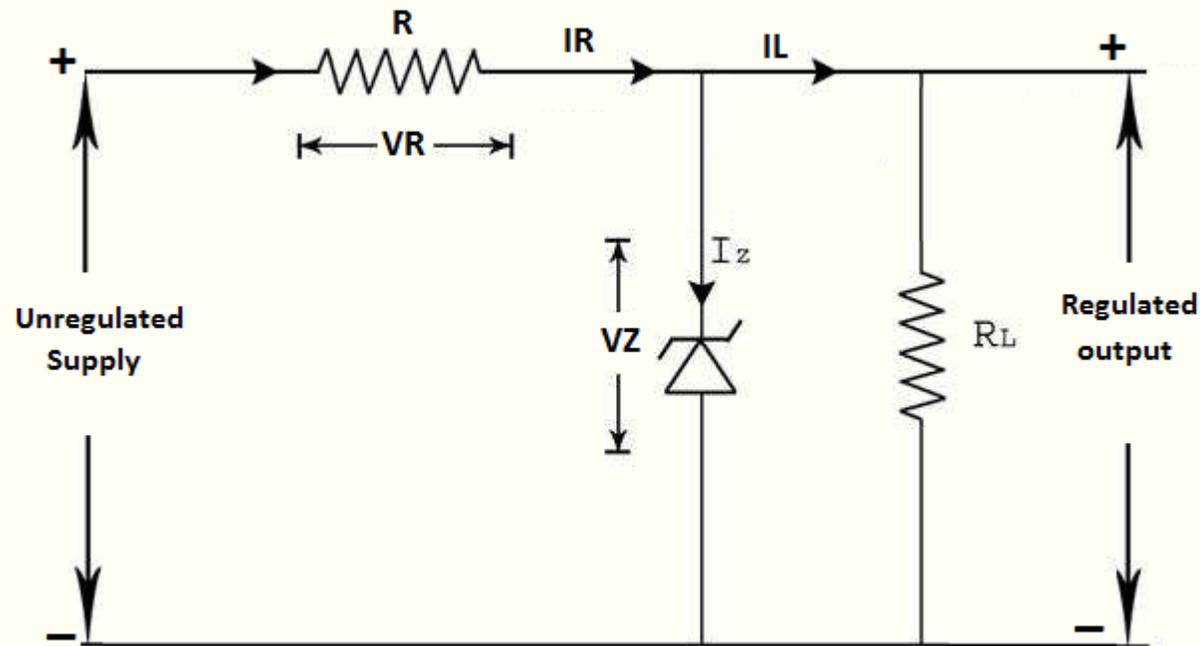
- In a DC circuit, Zener diode can be used as a **voltage regulator** to regulate the voltage across small circuits.
- The function of the regulator is to provide constant output voltage. Zener diode will continue to regulate the voltage until the diodes current falls below the minimum  $I_z$  value in the reverse breakdown region.



# Applications: Zener diode can as a Voltage Regulator

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- The principle of this regulator is that when the zener diode is operated in breakdown region (zener region), the voltage across it is constant for a large change in current through it. So as far as the input voltage is greater than  $V_z$ , the zener operates in breakdown region & maintains constant voltage across  $R_L$  even there is change in input voltage  $V_{in}$  or load current  $I_L$ .

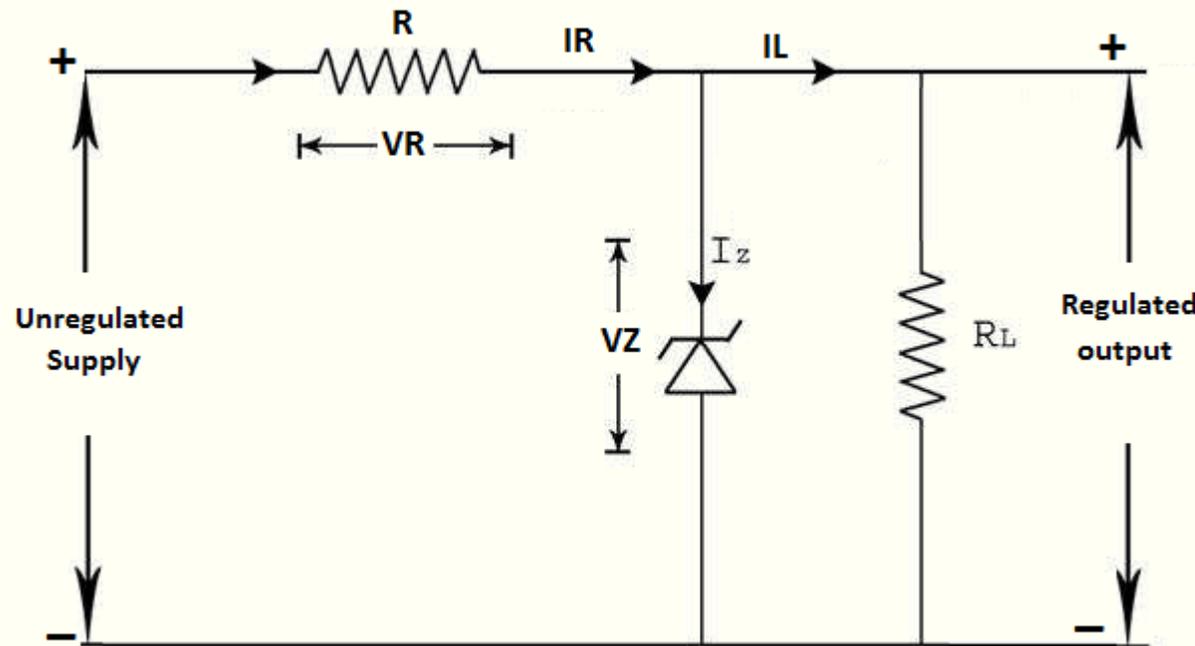


# Applications: Zener diode can as a Voltage Regulator

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## Variation in input:

- If input is increased, current  $I_R$  will also increase
- In this case, the excessive current flows through zener diode ( $I_Z$ ) while  $I_L$  remains the same.
- Due to increase in  $I_R$ , the voltage drop across  $R$  ( $V_R$ ) increases in such a way that load voltage remains same.



$$V_R = V_i - V_o$$
$$I_R = I_Z + I_L$$

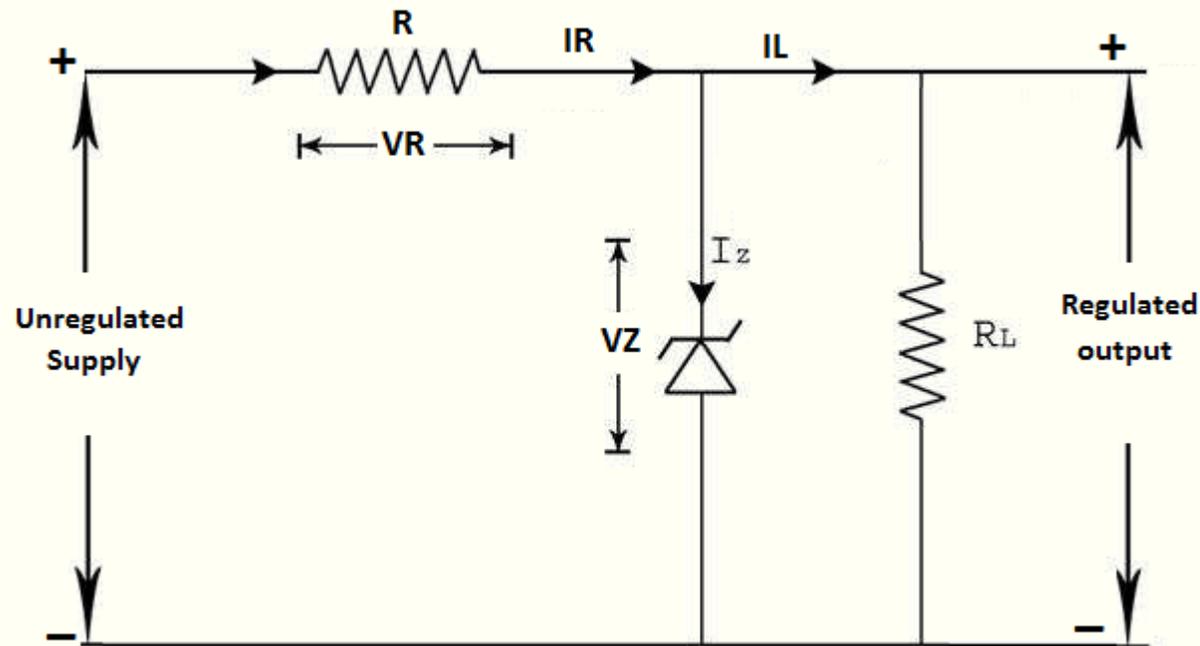
$$R = \frac{V_R}{I_R}$$
$$= \frac{(V_i - V_o)}{(I_Z + I_L)}$$

# Applications: Zener diode can as a Voltage Regulator

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## Variation in input:

- If input is decreased, current  $I_R$  will also decrease, the extra current which was flowing through zener diode decreases maintaining load current  $I_L$  constant and hence voltage across load is also constant.

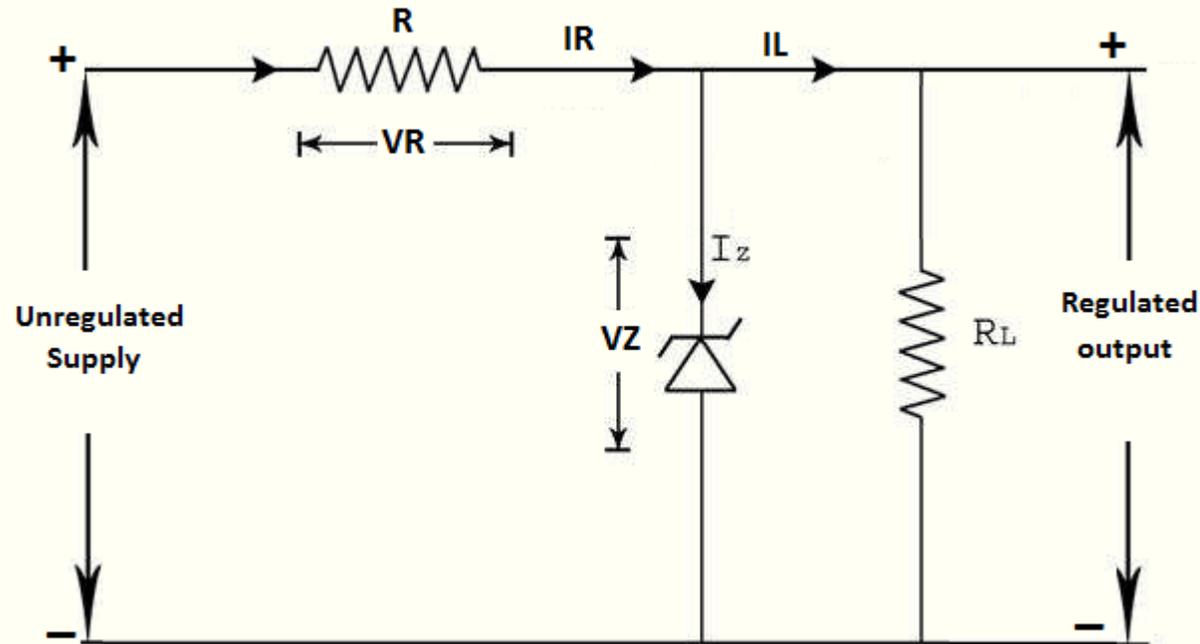


# Applications: Zener diode can as a Voltage Regulator

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## Variation in load:

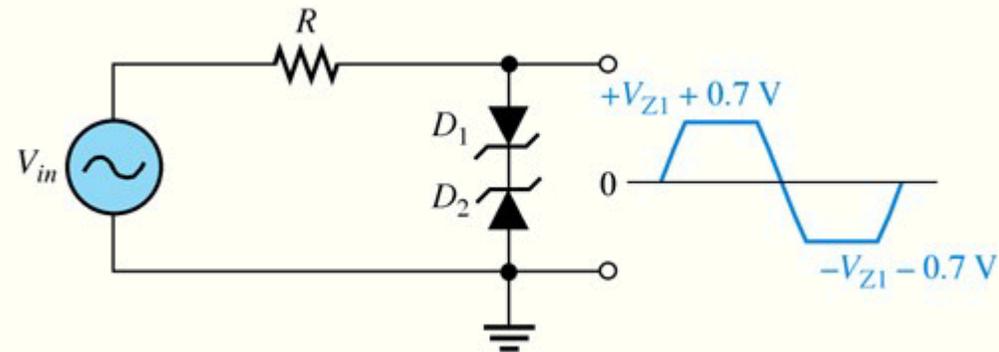
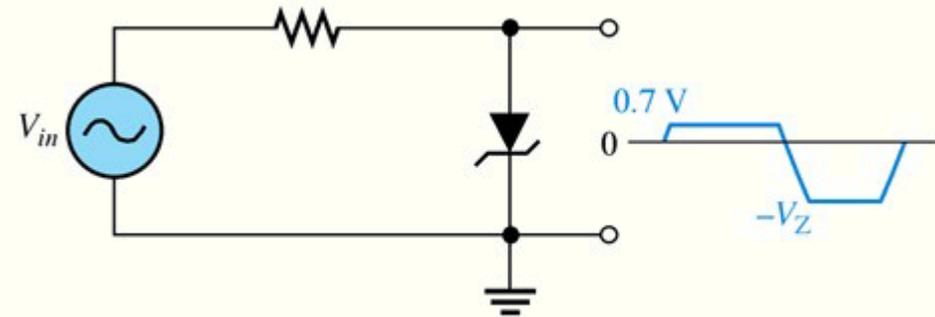
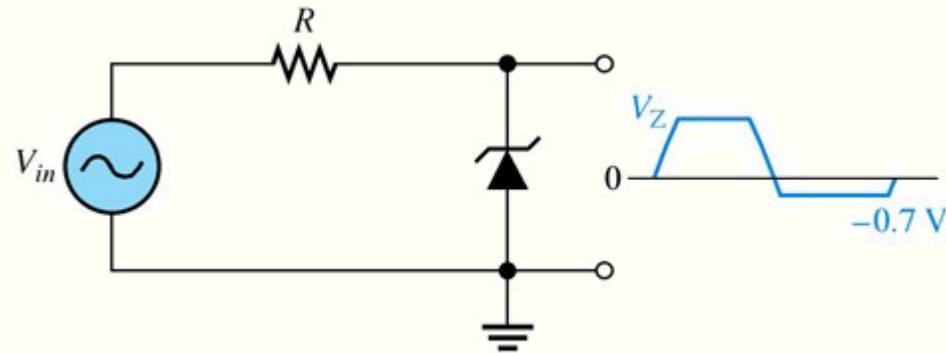
- If load  $R_L$  is decreased, this will cause increase in load current. The extra load current will be from decrease in zener current. Consequently, the output voltage remains constant.



# Applications: Zener Limiting

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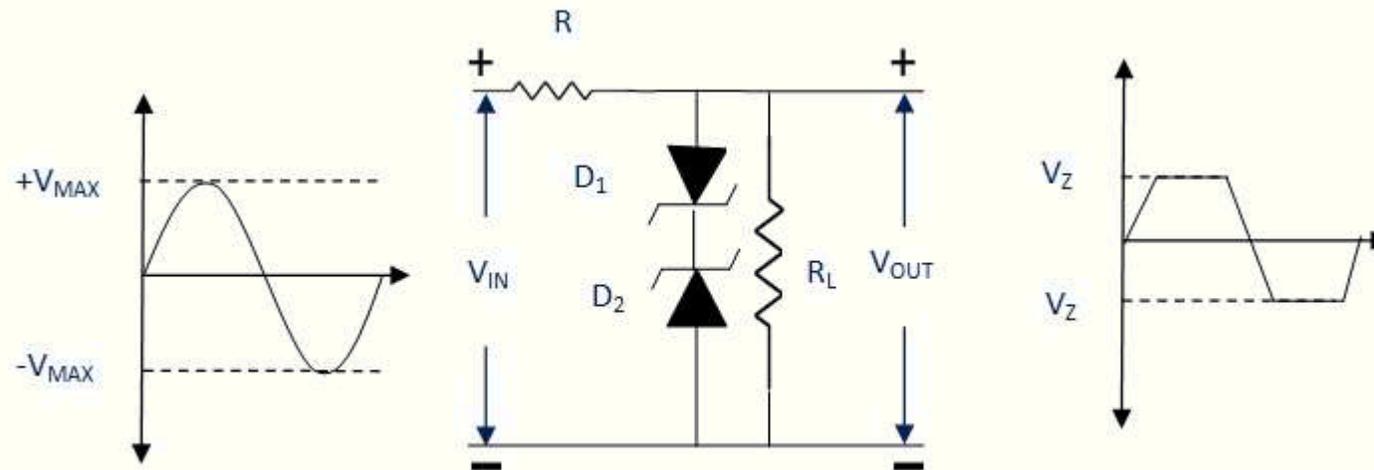
- Zener diodes can be used in ac applications to limit voltage swings to desired levels.



# Applications: Waveform Clipper

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- Zener diode can be used to make a Waveform Clipper. Two Zener diodes facing each other in series will act to clip both halves of an input signal.

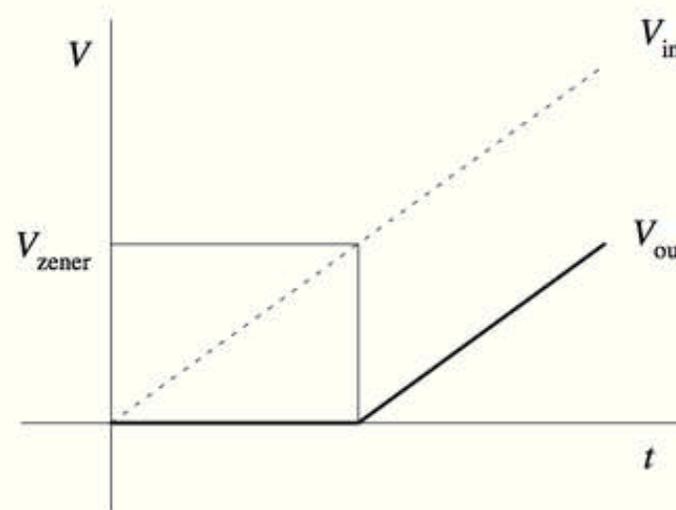
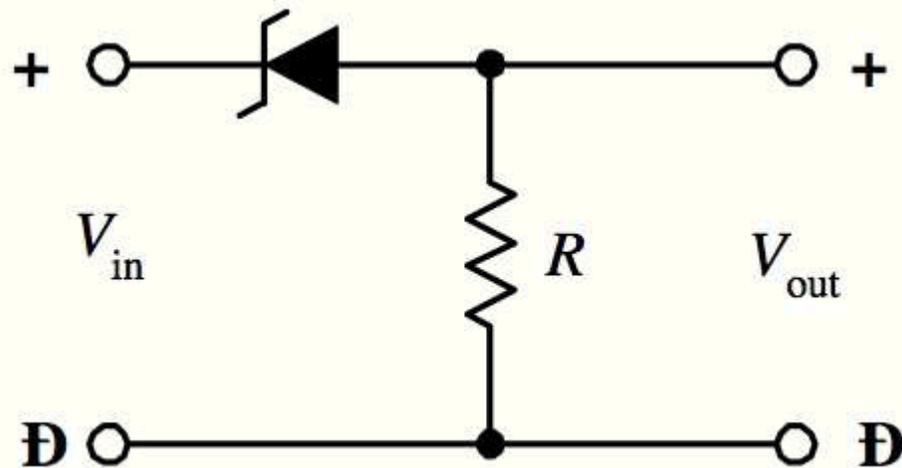


- Waveform clippers can be used to not only reshape a signal, but also to prevent voltage spikes from affecting circuits that are connected to the power supply.

## Applications: voltage shifter

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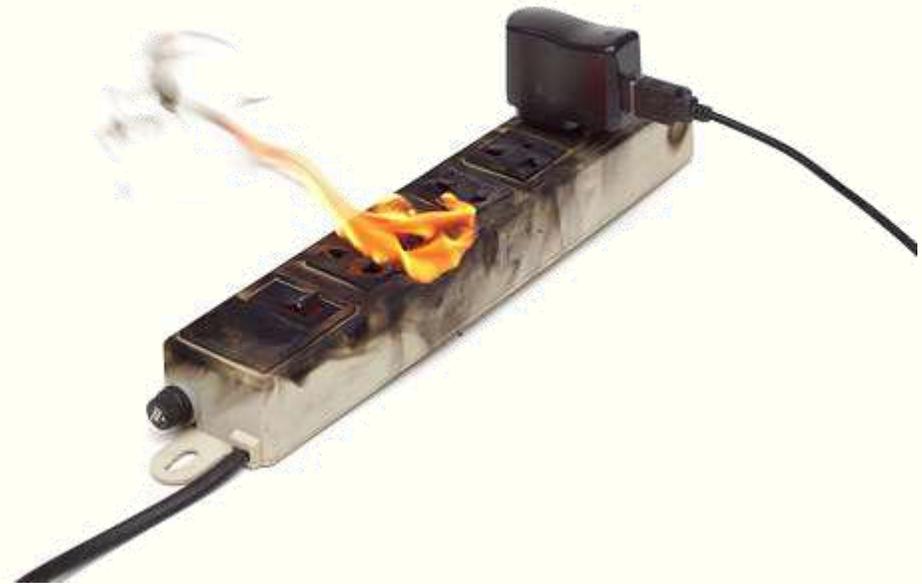
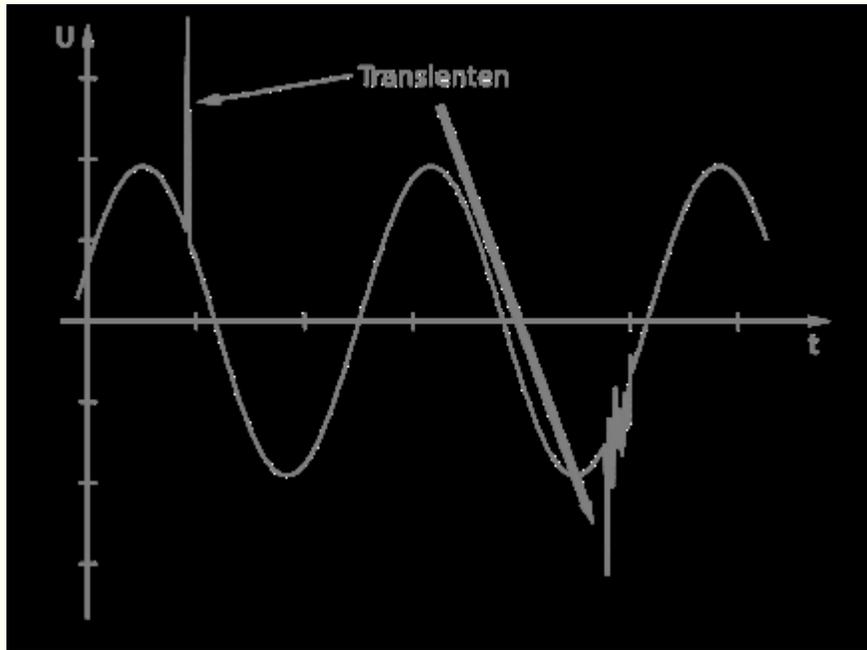
- A Zener diode can be applied to a circuit with a resistor to act as a voltage shifter. This circuit lowers the output voltage by a quantity that is equal to the Zener diode's breakdown voltage.



# Applications: surge protectors

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- Zener diodes are also used in surge protectors to limit transient voltage spikes.



# Applications : random number generator

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- Another application of the Zener diode is the use of noise caused by its avalanche breakdown in a random number generator.

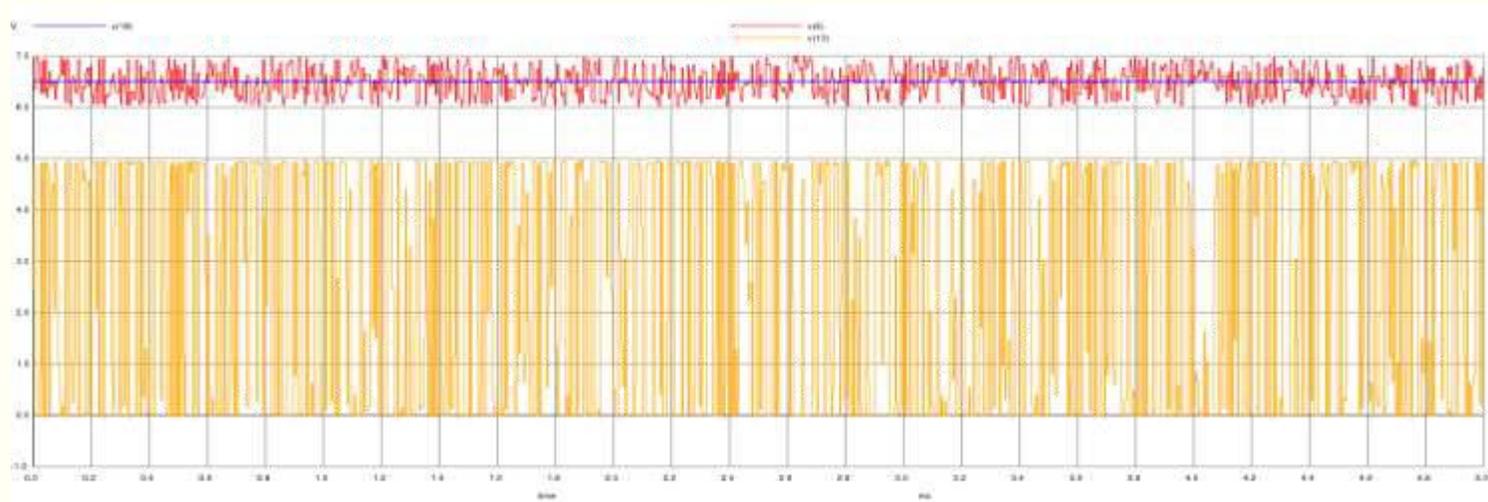


Figure: Avalanche noise curve

# Important Features

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- Zener diodes have a highly doped p-n junction.
- Normal diodes will also break down with a reverse voltage but the voltage and sharpness of the knee are not as well defined as for a Zener diode.
- Zener diode can be operated in breakdown region.
- In the forward bias direction, the zener diode behaves like an ordinary silicon diode.

# Summary

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- Zener diodes are designed to operate at voltages greater than the breakdown voltage (peak reverse voltage).
- Zener diodes are manufactured with a specific breakdown (Zener) voltage.
- Zener diodes are packaged the same as P–N junction diodes.
- Zener diodes are used to stabilize or regulate voltage.

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THANK YOU