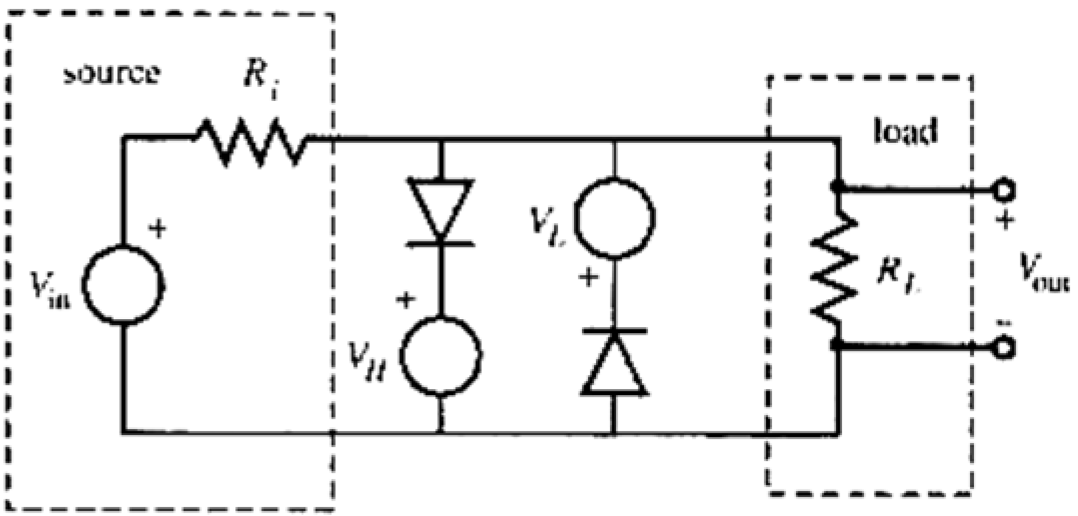
The Voltage Limiter

- Limiter using ideal diodes and batteries

The diode portion of the following circuit is called a **voltage limiter.** Explain why. Sketch some input and output waveforms that illustrate the circuit's behavior. Note: $V_H > V_L$.



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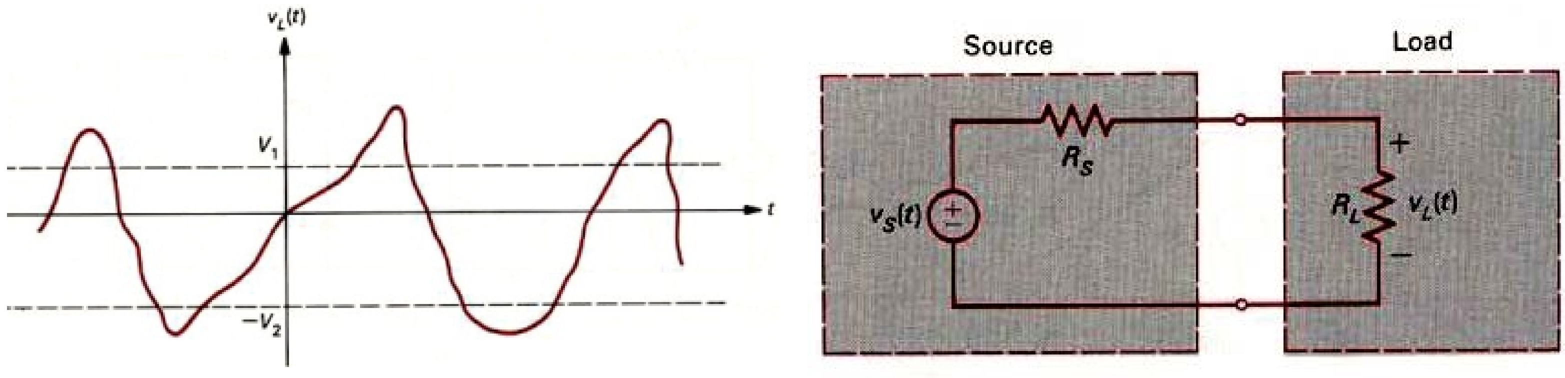
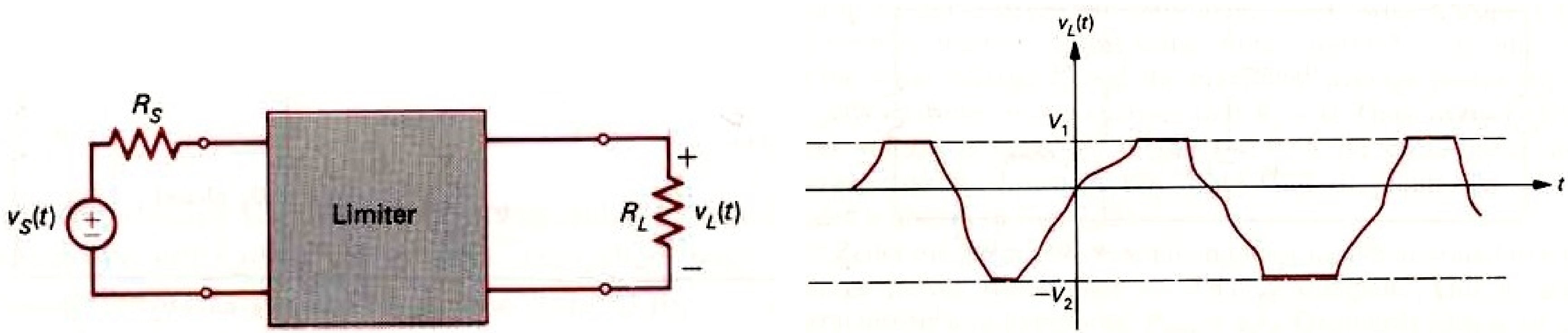


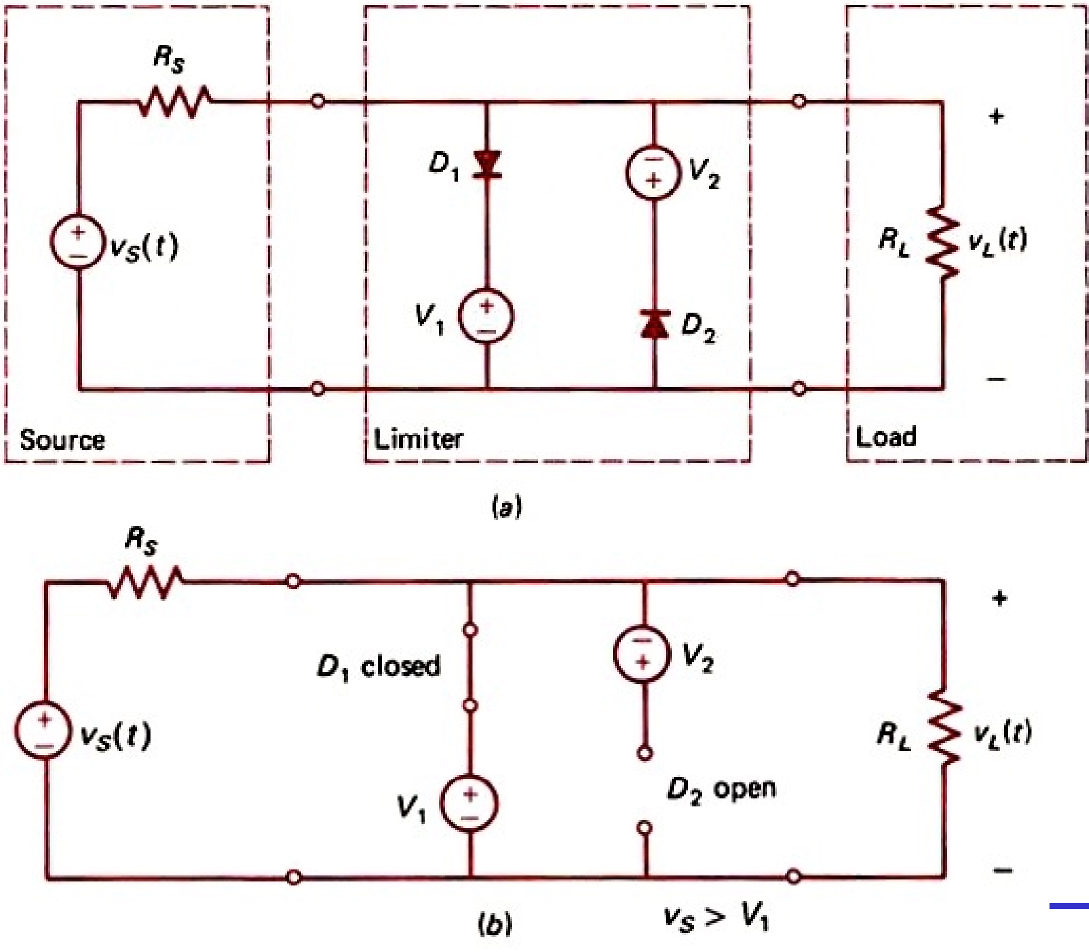
(a)



(b)

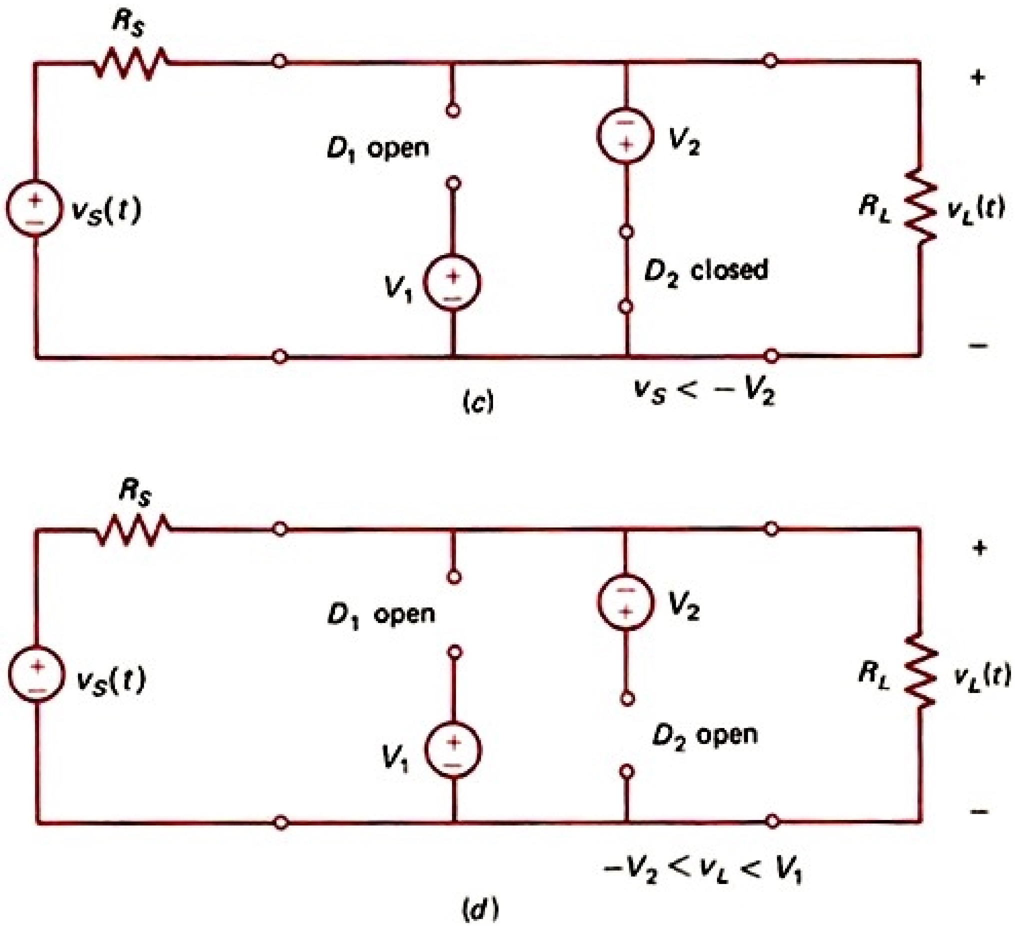
The Voltage Limiter

- Limiter using ideal diode and batteries



The Voltage Limiter

- Limiter using ideal diode and batteries

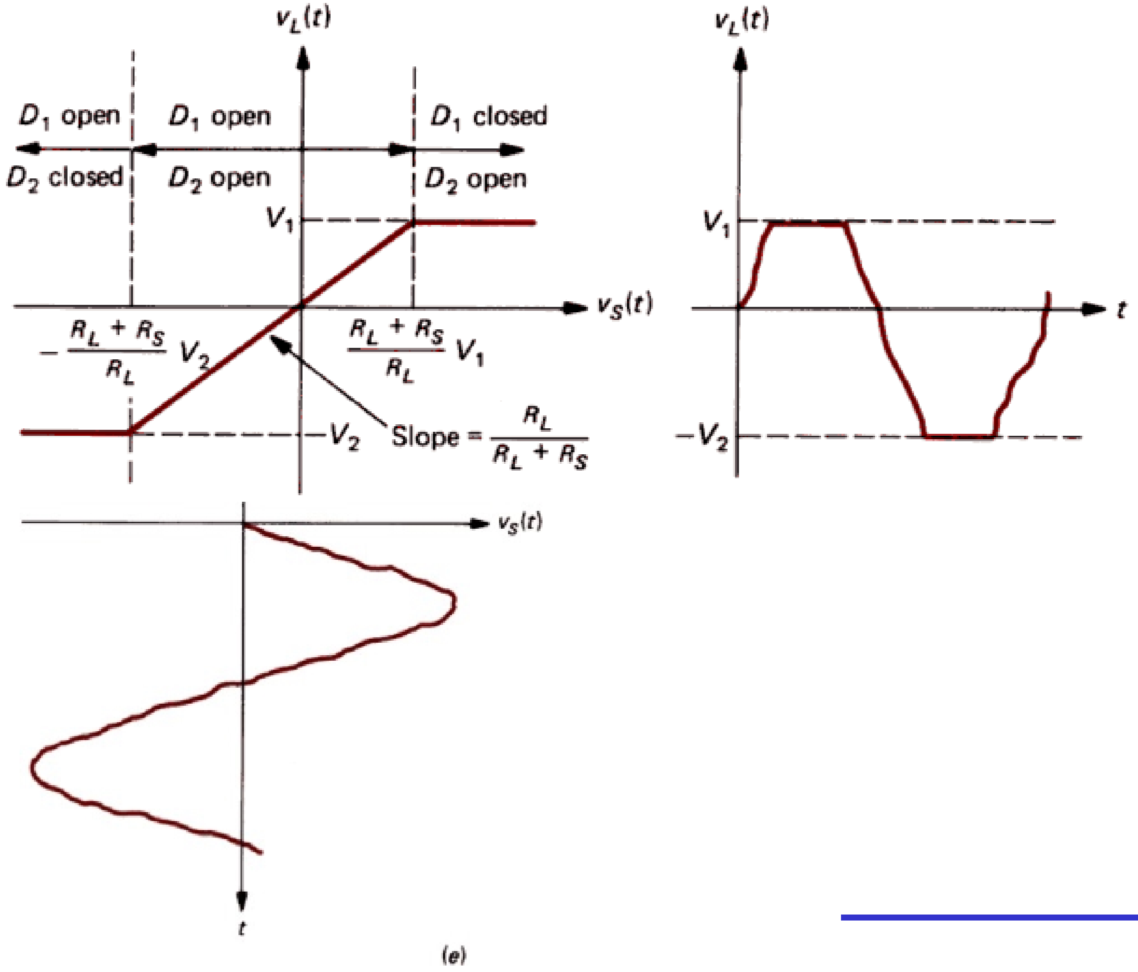


Load voltage is limited for source voltage

$$-\frac{R_L + R_s}{R_L} V_2 < v_s(t) < \frac{R_L + R_s}{R_L} V_1$$

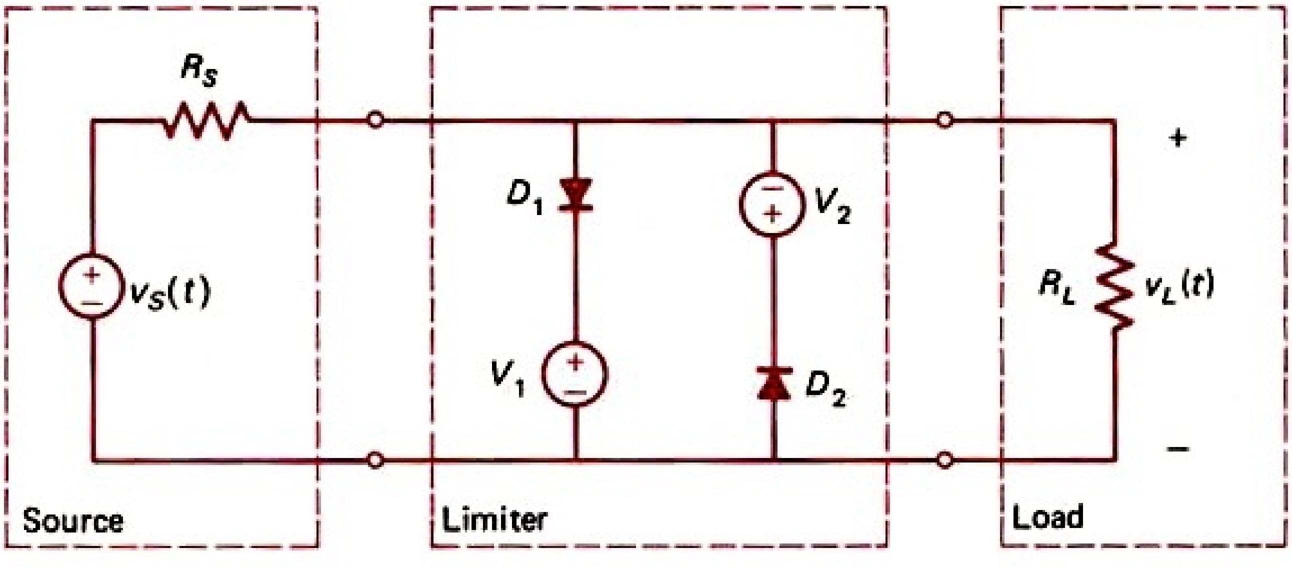
The Voltage Limiter

- Limiter using ideal diode and batteries



Example

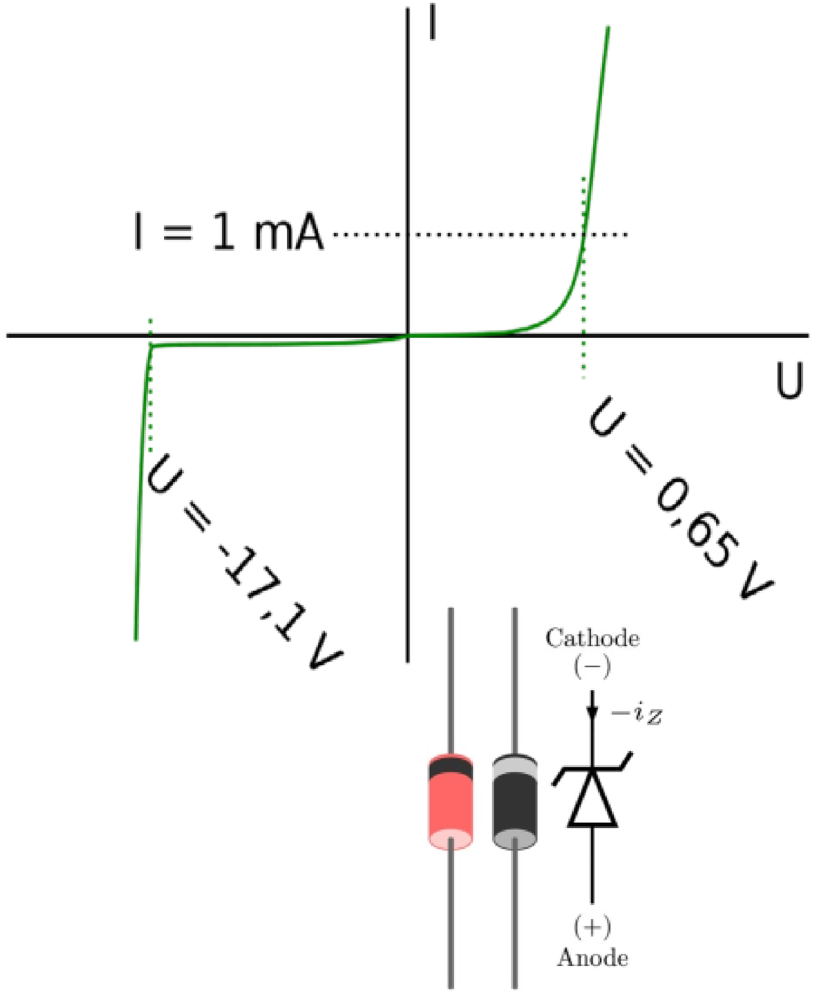
- For a limiter shown below, assume identical piecewise-linear diodes with R_f=100Ω, E_f=0.5V, V_1=V_2=10V, R_L=100Ω, R_s=100Ω, and $v_s(t)$=50sinωt V, sketch $v_L(t)$



(a)

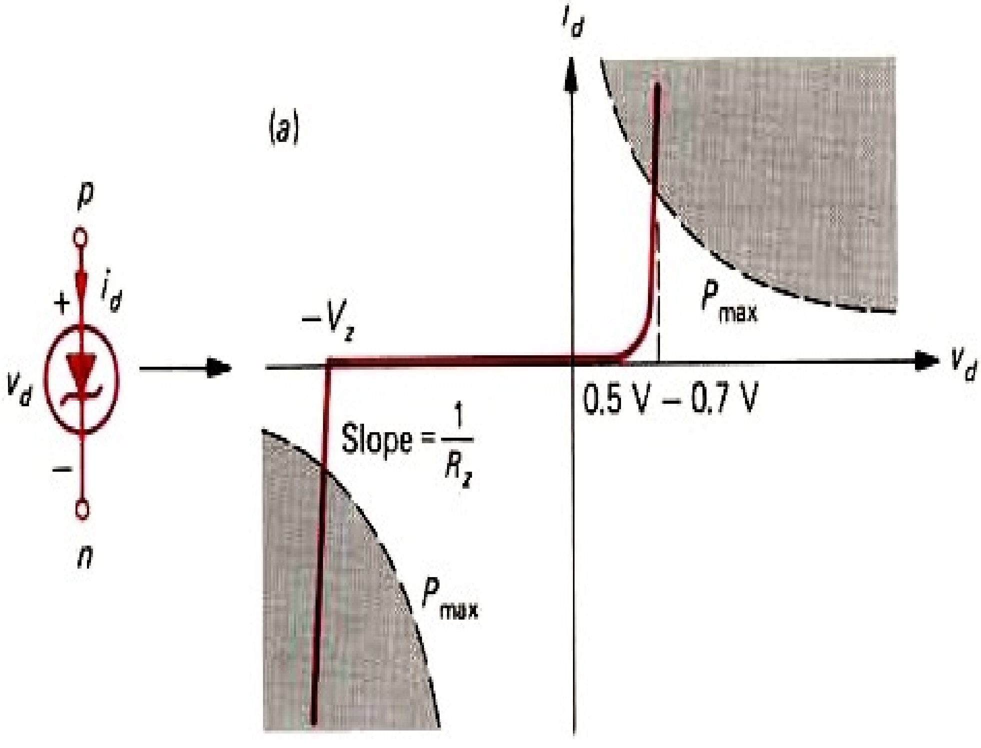
Zener Diodes

- A Zener diode is a type of diode that permits current not only in the forward direction like a normal diode, but also in the reverse direction if the voltage is larger than the breakdown voltage known as "Zener knee voltage" or "Zener voltage". The device was named after Clarence Zener, who discovered this electrical property.

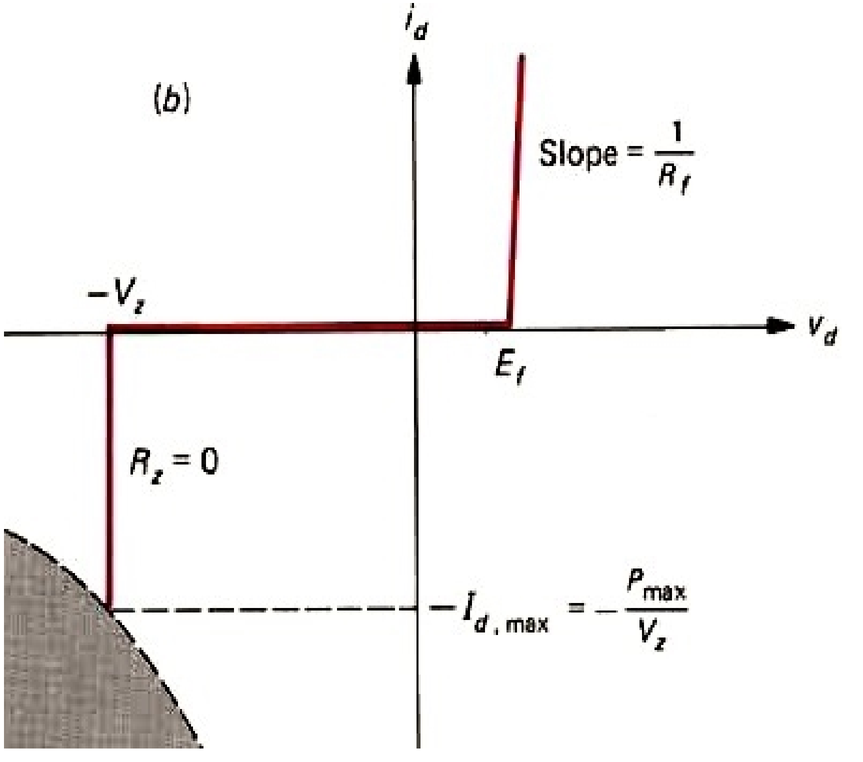


Zener Diodes

- Device characteristic of Zener diode

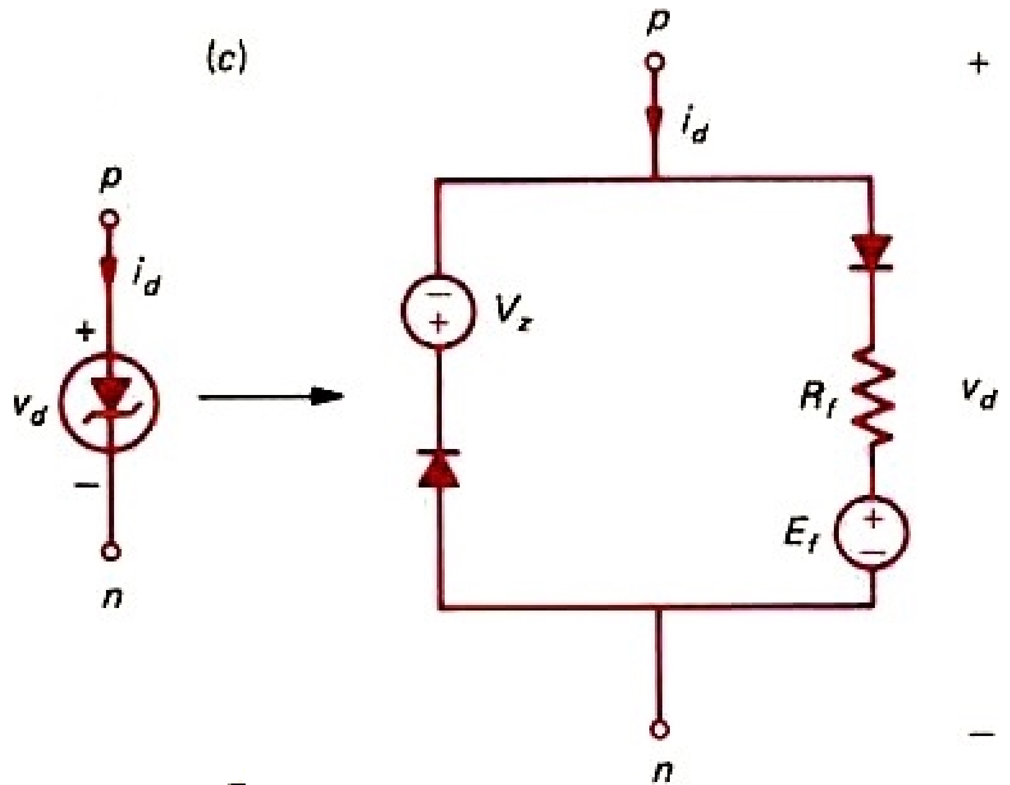


- Piecewise-linear characteristic



Zener Diodes

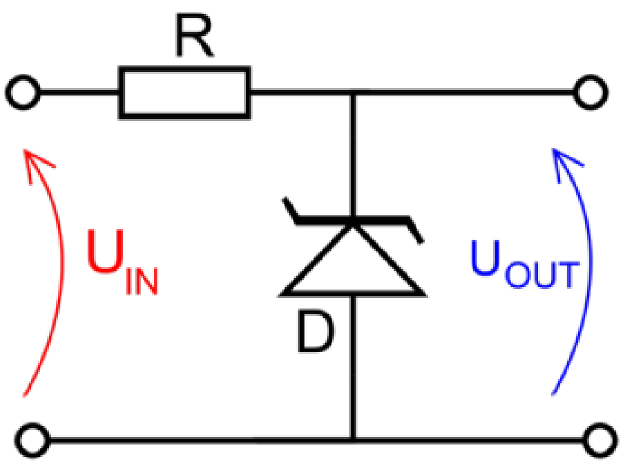
- Piecewise-linear model



$$I_{d,\max} = -\frac{P_{\max}}{V_z}$$

Zener Diode Regulator

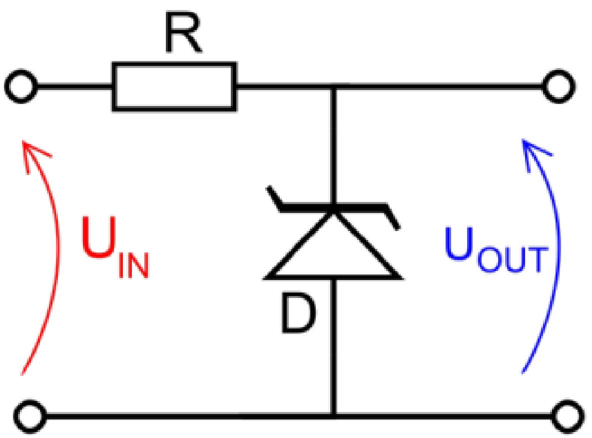
- *R* must be small enough that the current through D keeps D in reverse breakdown. The value of this current is given in the data sheet for D. For example, the common BZX79C5V6 device, a 5.6 V 0.5 W Zener diode, has a recommended reverse current of 5 mA. If insufficient current exists through D, then U_{OUT} will be unregulated, and less than the nominal breakdown voltage. When calculating *R*, allowance must be made for any current through the external load, not shown in this diagram, connected across U_{OUT}.



- *R* must be large enough that the current through D does not destroy the device. If the current through D is I_D, its breakdown voltage V_B and its maximum power dissipation P_{MAX}, then $I_D V_B < P_{MAX}$.

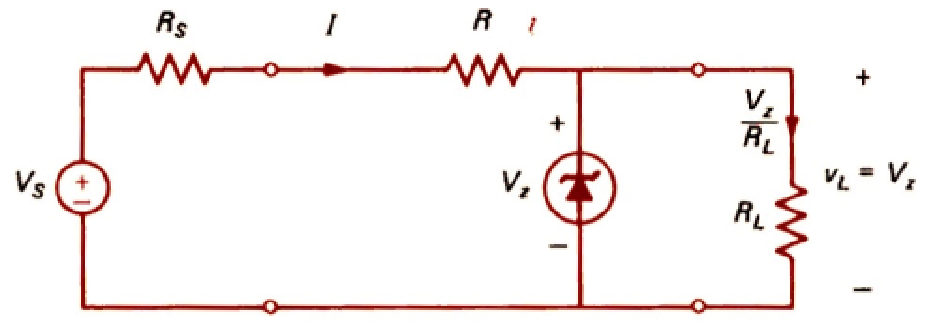
Zener Diode Regulator

- In this circuit, a typical voltage reference or regulator, an input voltage, U_{IN}, is regulated down to a stable output voltage U_{OUT}. The intrinsic voltage drop of diode D is stable over a wide current range and holds U_{OUT} relatively constant even though the input voltage may fluctuate over a fairly wide range. Because of the low impedance of the diode when operated like this, Resistor R is used to limit current through the circuit.

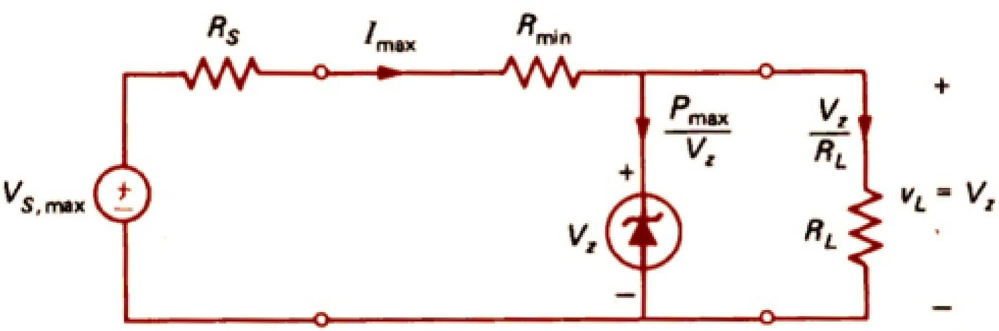


$$I_{Diode} = (U_{IN} - U_{OUT}) / R$$

Zener Diode regulator



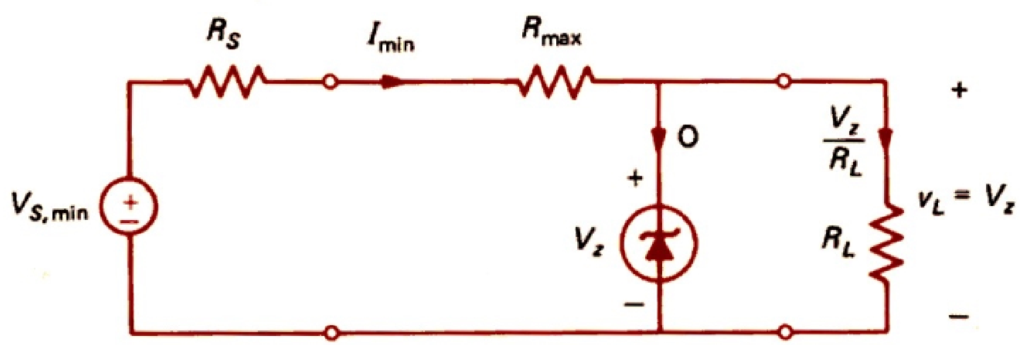
(a)



(b)

$$I_{\max} = \frac{V_{s,\max} - V_z}{R_s + R_{\min}} = \frac{P_{\max}}{V_z} + \frac{V_z}{R_L}$$

$$I_{\min} = \frac{V_{s,\min} - V_z}{R_s + R_{\max}} = \frac{V_z}{R_L}$$



(c)

Example

- A source voltage varies between 120V and 75V. The source resistance is zero, and the load resistance is 1kΩ. It is desired to maintain the load voltage at 60V. Determine the value of a regulator resistor R that will accomplish this and the required power rating of the zener.

1. A zener having a zener voltage of 60V is selected
2. The maximum value of regulator resistance

$$I_{\min} = \frac{V_z}{R_L} = \frac{60}{1000} = 60mA$$

$$\longrightarrow \quad R_{\max} = \frac{V_{s,\min} - V_z}{I_{\min}} = 250\Omega$$

3. The power rating is determined when $V_s = V_{s,max}$.

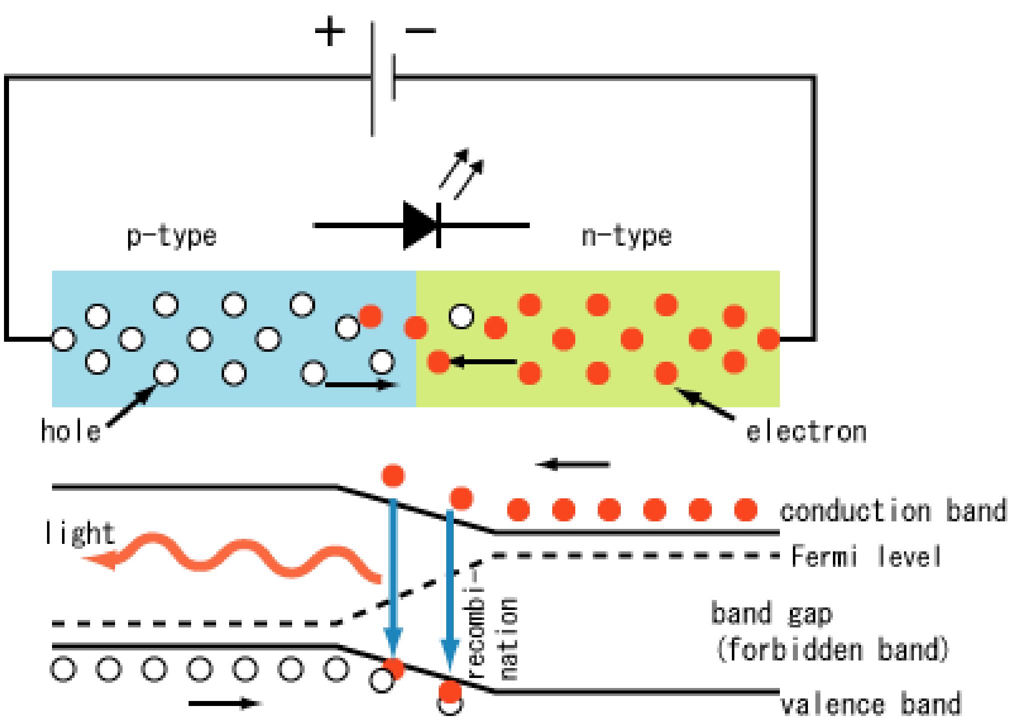
And zener draw the maximum current

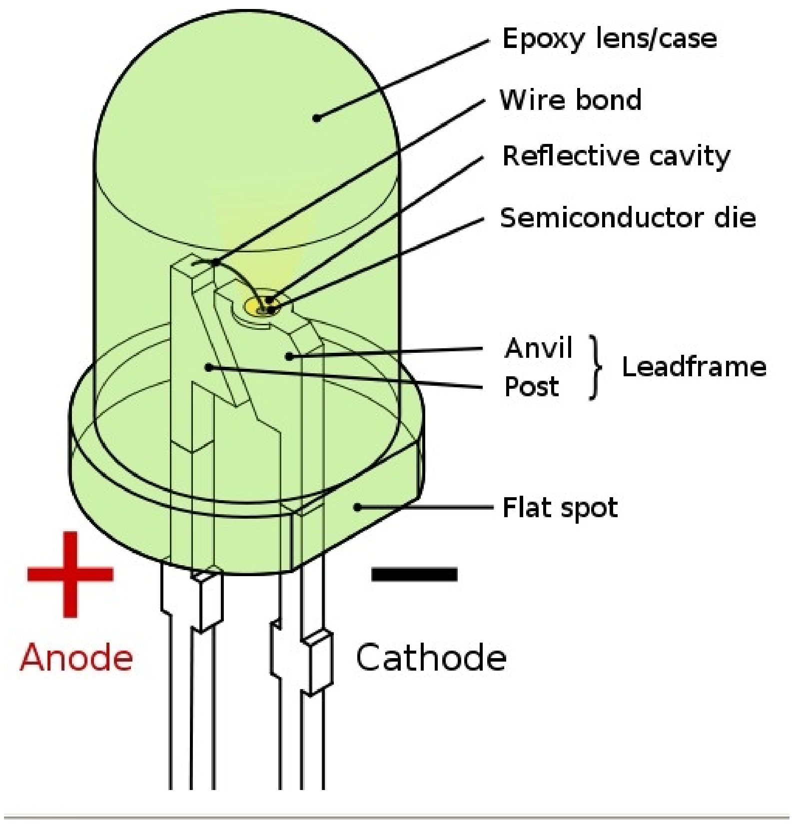
$$I_{\max} = \frac{P_{\max}}{V_z} = \frac{V_{s,\max} - V_z}{R} - \frac{V_z}{R_L} = 0.18A$$

$$P_{\max} = 10.8W$$

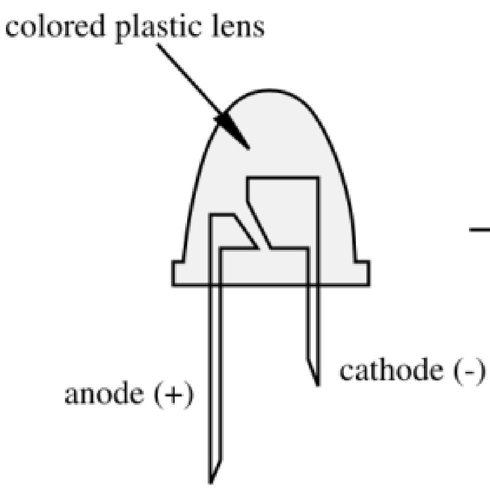
Light Emitting Diode

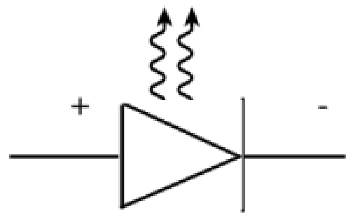
An LED will begin to emit light when the on-voltage is exceeded. Typical on voltages are 2–3 volts



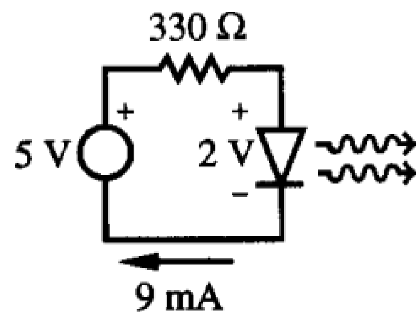


Light Emitting Diode

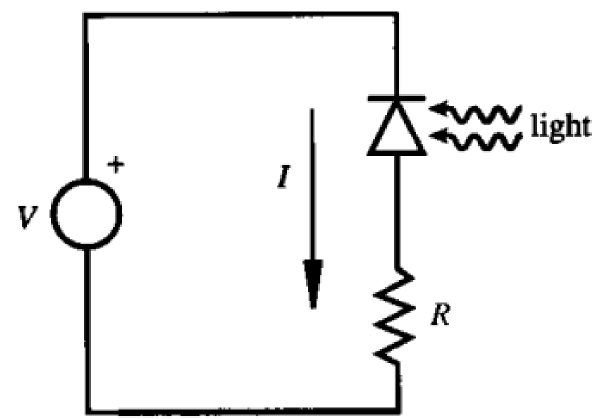




schematic symbol



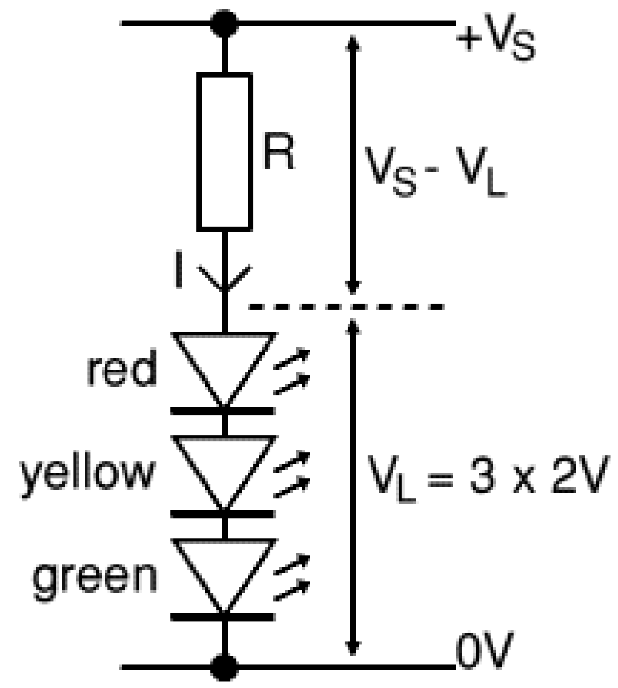
Typical LED circuit in digital systems.



Photodiode light detector circuit.

Connect Light Emitting Diode in Series

Connecting LEDs in series
If you wish to have several LEDs on at the same time it may be possible to connect them in series. This prolongs battery life by lighting several LEDs with the same current as just one LED.
All the LEDs connected in series pass the same current so it is best if they are all the same type. The power supply must have sufficient voltage to provide about 2V for each LED (4V for blue and white) plus at least another 2V for the resistor. To work out a value for the resistor you must add up all the LED voltages and use this for VL.



E**xample calculations:**
A red, a yellow and a green LED in series need a supply voltage of at least 3 × 2V + 2V = 8V,so a 9V battery would be ideal.
VL = 2V + 2V + 2V = 6V (the three LED voltages added up).
If the supply voltage VS is 9V and the current I must be 15mA = 0.015A,
Resistor R = (VS - VL) / I = (9 - 6) / 0.015 = 3 / 0.015 = 200,
so choose R = 220 (the nearest standard value which is greater).