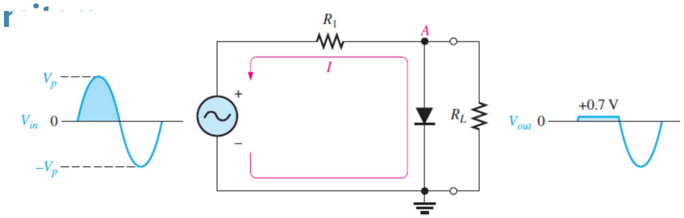
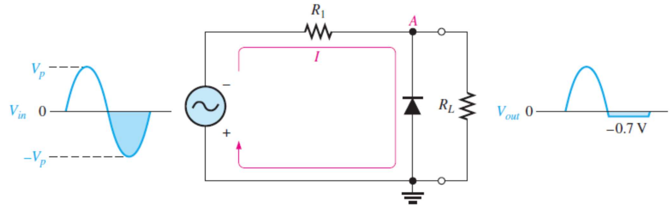
Diode Limiters and Clampers

Diode Lir

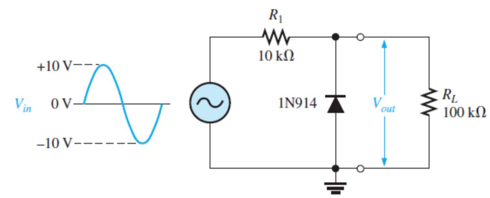




$$V_{out} = \left(\frac{R_L}{R_1 + R_L}\right)V_{in}$$

Diode Limiters and Clampers

Diode Limiters

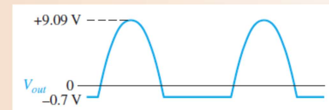


$$V_{out} = \left(\frac{R_L}{R_1 + R_L}\right)V_{in}$$

The diode is forward-biased and conducts when the input voltage goes below −0.7 V. So, for the negative limiter, determine the peak output voltage across R_L by the following equation:

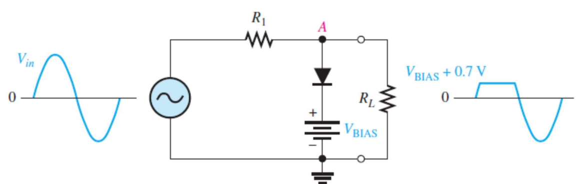
$$V_{p(out)} = \left(\frac{R_L}{R_1 + R_L}\right)V_{p(in)} = \left(\frac{100\ \text{k}\Omega}{110\ \text{k}\Omega}\right)10\ \text{V} = 9.09\ \text{V}$$

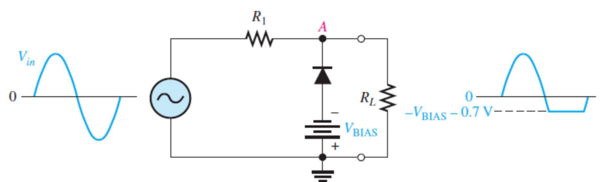
The scope will display an output waveform as shown in Figure 2–54.



Diode Limiters and Clampers

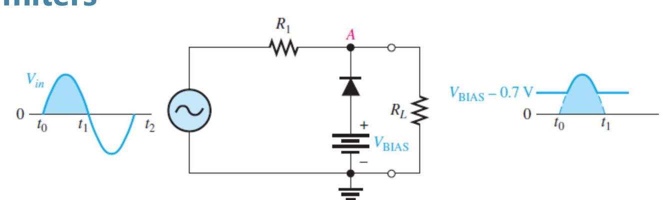
Biased Limiters



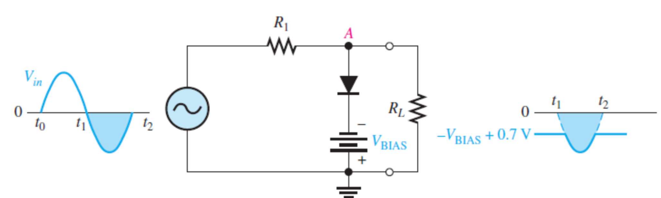


Diode Limiters and Clampers

Biased Limiters



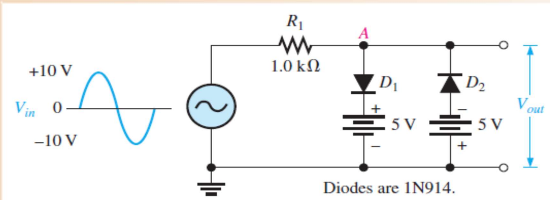
(a)



Diode Limiters and Clampers

Biased Limiters

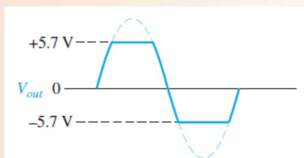
Figure 2–58 shows a circuit combining a positive limiter with a negative limiter. Determine the output voltage waveform.



When the voltage at point A reaches +5.7 V, diode D_1 conducts and limits the waveform to +5.7 V. Diode D_2 does not conduct until the voltage reaches −5.7 V. Therefore, positive voltages above +5.7 V and negative voltages below −5.7 V are clipped off. The resulting output voltage waveform is shown in Figure 2–59.

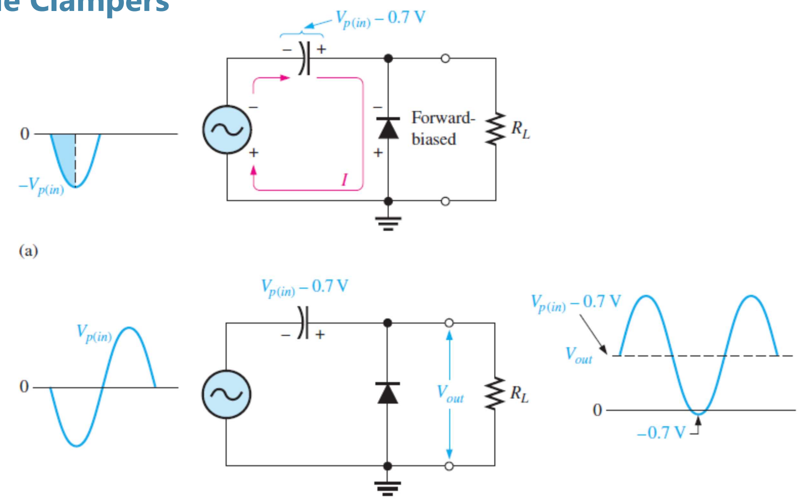
▶ FIGURE 2–59

Output voltage waveform for Figure 2–58.



Diode Limiters and Clampers

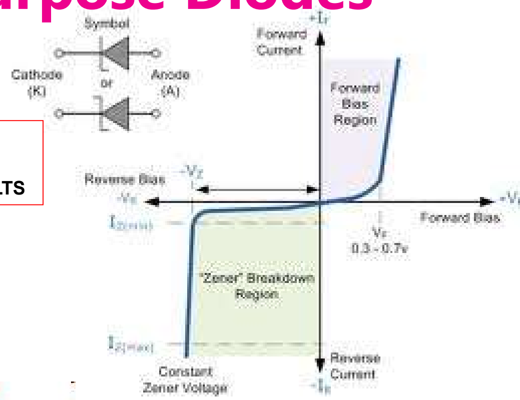
Diode Clampers

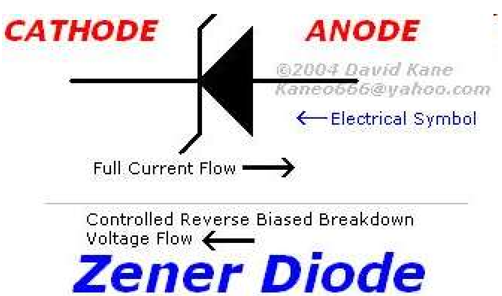


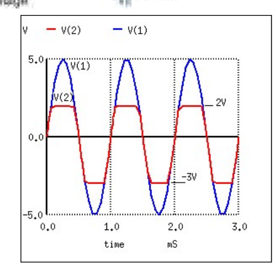
Special-Purpose Diodes

The Zener Diode

WORK AT SPECIFIC BREAKDOWN VOLTAGE.
FUCTION AS A VOLTAGE SENSITIVE SWITCH.
THIS VOLTAGE (Vz) VARY FROM 2 TO 200 VOLTS





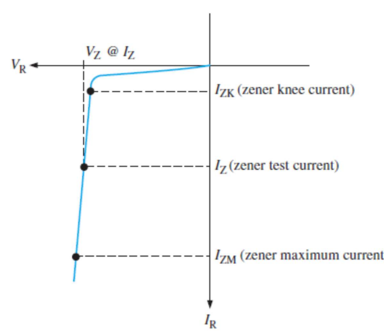


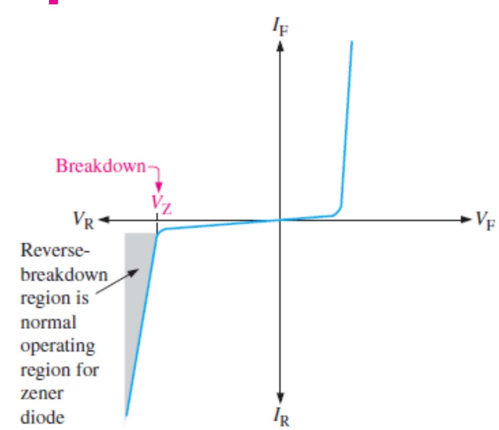
Special-Purpose Diodes

The Zener Diode

▶ FIGURE 3–3

Reverse characteristic of a zener diode. V_Z is usually specified at a value of the zener current known as the test current.



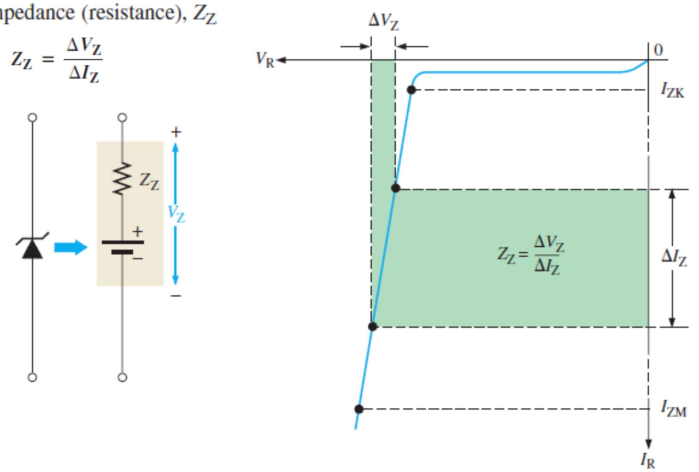


Special-Purpose Diodes

The Zener Diode

zener impedance (resistance), Z_Z

$$Z_Z = \frac{\Delta V_Z}{\Delta I_Z}$$



(a) Practical model (b) Characteristic curve. The slope is exaggerated for illustration.

Special-Purpose Diodes

The Zener Diode

zener impedance (resistance), Z_Z

$$Z_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

$$\Delta V_Z = V_Z \times TC \times \Delta T$$

An 8.2 V zener diode (8.2 V at 25°C) has a positive temperature coefficient of 0.05%/°C. What is the zener voltage at 60°C?

The change in zener voltage is

$$\Delta V_Z = V_Z \times TC \times \Delta T = (8.2\text{ V})(0.05\%/°\text{C})(60°\text{C} - 25°\text{C})$$
$$= (8.2\text{ V})(0.0005/°\text{C})(35°\text{C}) = 144\text{ mV}$$

Notice that 0.05%/°C was converted to 0.0005/°C. The zener voltage at 60°C is

$$V_Z + \Delta V_Z = 8.2\text{ V} + 144\text{ mV} = \mathbf{8.34\text{ V}}$$

Special-Purpose Diodes

The Zener Diode

zener impedance (resistance), Z_Z

$$Z_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

$$\Delta V_Z = V_Z \times TC \times \Delta T$$
$$P_D = V_Z I_Z$$
$$P_{D(derated)} = P_{D(max)} - (\text{mW}/°\text{C})\Delta T$$

A certain zener diode has a maximum power rating of 400 mW at 50°C and a derating factor of 3.2 mW/°C. Determine the maximum power the zener can dissipate at a temperature of 90°C.

$$P_{D(derated)} = P_{D(max)} - (\text{mW}/°\text{C})\Delta T$$
$$= 400\text{ mW} - (3.2\text{ mW}/°\text{C})(90°\text{C} - 50°\text{C})$$
$$= 400\text{ mW} - 128\text{ mW} = \mathbf{272\text{ mW}}$$

A certain 50 W zener diode must be derated with a derating factor of 0.5 W/°C above 75°C. Determine the maximum power it can dissipate at 160°C.

Special-Purpose Diodes

The Zener Diode

FAIRCHILD
SEMICONDUCTOR®

1N4728A - 1N4764A

Zeners

DO-41 Glass case
COLOR BAND DENOTES CATHODE

Absolute Maximum Ratings * T_a = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
P_D	Power Dissipation @ TL ≤ 50°C, Lead Length = 3/8"	1.0	W
	Derate above 50°C	6.67	mW/°C
T_J, T_{STG}	Operating and Storage Temperature Range	-65 to +200	°C

*These ratings are limiting values above which the serviceability of the diode may be impaired.

Special-Purpose Diodes

The Zener Diode

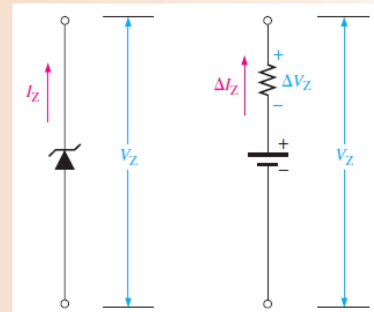
Electrical Characteristics T_a = 25°C unless otherwise noted

Device	V_Z (V) @ I_Z (Note 1)			Test Current I_Z (mA)	Max. Zener Impedance			Leakage Current	
	Min.	Typ.	Max.		Z_Z @ I_Z (Ω)	Z_{ZK} @ I_{ZK} (Ω)	I_{ZK} (mA)	I_R (μA)	V_R (V)
1N4728A	3.315	3.3	3.465	76	10	400	1	100	1
1N4729A	3.42	3.6	3.78	69	10	400	1	100	1
1N4730A	3.705	3.9	4.095	64	9	400	1	50	1
1N4731A	4.085	4.3	4.515	58	9	400	1	10	1
1N4732A	4.465	4.7	4.935	53	8	500	1	10	1
1N4733A	4.845	5.1	5.355	49	7	550	1	10	1
1N4734A	5.32	5.6	5.88	45	5	600	1	10	2
1N4735A	5.89	6.2	6.51	41	2	700	1	10	3
1N4736A	6.46	6.8	7.14	37	3.5	700	1	10	4
1N4737A	7.125	7.5	7.875	34	4	700	0.5	10	5
1N4738A	7.79	8.2	8.61	31	4.5	700	0.5	10	6
1N4739A	8.645	9.1	9.555	28	5	700	0.5	10	7
1N4740A	9.5	10	10.5	25	7	700	0.25	10	7.6
1N4741A	10.45	11	11.55	23	8	700	0.25	5	8.4
1N4742A	11.4	12	12.6	21	9	700	0.25	5	9.1
1N4743A	12.35	13	13.65	19	10	700	0.25	5	9.9
1N4744A	14.25	15	15.75	17	14	700	0.25	5	11.4
1N4745A	15.2	16	16.8	15.5	16	700	0.25	5	12.2
1N4746A	17.1	18	18.9	14	20	750	0.25	5	13.7
1N4747A	19	20	21	12.5	22	750	0.25	5	15.2

Special-Purpose Diodes

The Zener Diode

From the datasheet in Figure 3–7, a 1N4736A zener diode has a Z_Z of 3.5 Ω. The datasheet gives $V_Z = 6.8$ V at a test current, I_Z, of 37 mA. What is the voltage across the zener terminals when the current is 50 mA? When the current is 25 mA? Figure 3–8 represents the zener diode.



Special-Purpose Diodes

The Zener Diode

For $I_Z = 50$ mA: The 50 mA current is a 13 mA increase above the test current, I_Z, of 37 mA.

$$\Delta I_Z = I_Z - 37\text{ mA} = 50\text{ mA} - 37\text{ mA} = +13\text{ mA}$$
$$\Delta V_Z = \Delta I_Z Z_Z = (13\text{ mA})(3.5\ \Omega) = +45.5\text{ mV}$$

The change in voltage due to the increase in current above the I_Z value causes the zener terminal voltage to increase. The zener voltage for $I_Z = 50$ mA is

$$V_Z = 6.8\text{ V} + \Delta V_Z = 6.8\text{ V} + 45.5\text{ mV} = \mathbf{6.85\text{ V}}$$

For $I_Z = 25$ mA: The 25 mA current is a 12 mA decrease below the test current, I_Z, of 37 mA.

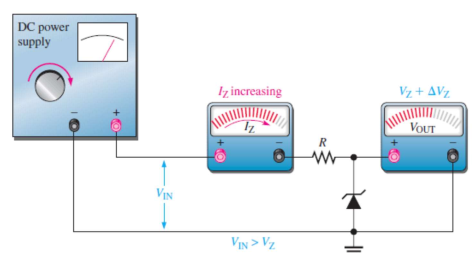
$$\Delta I_Z = -12\text{ mA}$$
$$\Delta V_Z = \Delta I_Z Z_Z = (-12\text{ mA})(3.5\ \Omega) = -42\text{ mV}$$

The change in voltage due to the decrease in current below the test current causes the zener terminal voltage to decrease. The zener voltage for $I_Z = 25$ mA is

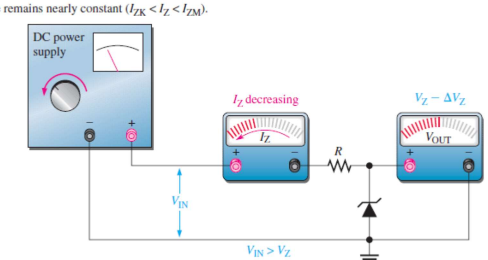
$$V_Z = 6.8\text{ V} - \Delta V_Z = 6.8\text{ V} - 42\text{ mV} = \mathbf{6.76\text{ V}}$$

Special-Purpose Diodes

The Zener Diode Application



(a) As the input voltage increases, the output voltage remains nearly constant ($I_{ZK} < I_Z < I_{ZM}$).



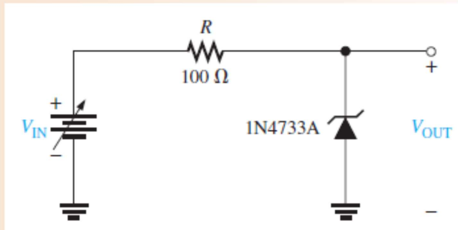
(b) As the input voltage decreases, the output voltage remains nearly constant ($I_{ZK} < I_Z < I_{ZM}$).

Special-Purpose Diodes

The Zener Diode Application

Determine the minimum and the maximum input voltages that can be regulated by the zener diode in Figure 3–11.

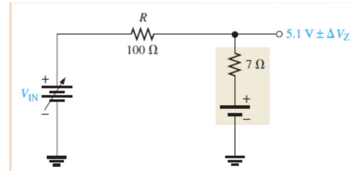
▶ FIGURE 3–11



From the datasheet in Figure 3–7 for the 1N4733A: $V_Z = 5.1$ V at $I_Z = 49$ mA, $I_{ZK} = 1$ mA, and $Z_Z = 7\ \Omega$ at I_Z. For simplicity, assume this value of Z_Z over the range of current values. The equivalent circuit is shown in Figure 3–12.

Special-Purpose Diodes

The Zener Diode Application



At $I_{ZK} = 1$ mA, the output voltage is

$$V_{OUT} \cong 5.1\text{ V} - \Delta V_Z = 5.1\text{ V} - (I_Z - I_{ZK})Z_Z = 5.1\text{ V} - (49\text{ mA} - 1\text{ mA})(7\ \Omega)$$
$$= 5.1\text{ V} - (48\text{ mA})(7\ \Omega) = 5.1\text{ V} - 0.336\text{ V} = 4.76\text{ V}$$

Therefore,

$$V_{IN(min)} = I_{ZK}R + V_{OUT} = (1\text{ mA})(100\ \Omega) + 4.76\text{ V} = \mathbf{4.86\ V}$$

To find the maximum input voltage, first calculate the maximum zener current. Assume the temperature is 50°C or below; so from Figure 3–7, the power dissipation is 1 W.

$$I_{ZM} = \frac{P_{D(max)}}{V_Z} = \frac{1\text{ W}}{5.1\text{ V}} = 196\text{ mA}$$

At I_{ZM}, the output voltage is

$$V_{OUT} \cong 5.1\text{ V} + \Delta V_Z = 5.1\text{ V} + (I_{ZM} - I_Z)Z_Z$$
$$= 5.1\text{ V} + (147\text{ mA})(7\ \Omega) = 5.1\text{ V} + 1.03\text{ V} = 6.13\text{ V}$$

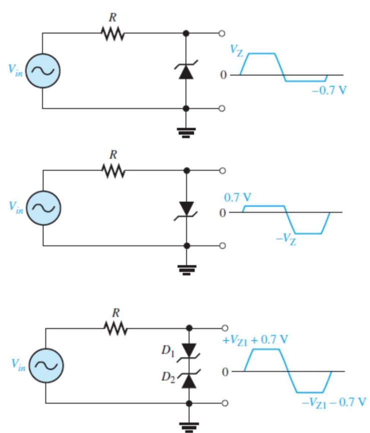
Therefore,

$$V_{IN(max)} = I_{ZM}R + V_{OUT} = (196\text{ mA})(100\ \Omega) + 6.13\text{ V} = \mathbf{25.7\ V}$$

Special-Purpose Diodes

The Zener Diode Application

Zener Limiter

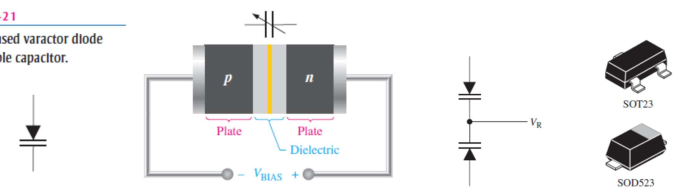


Special-Purpose Diodes

Varactor Diode

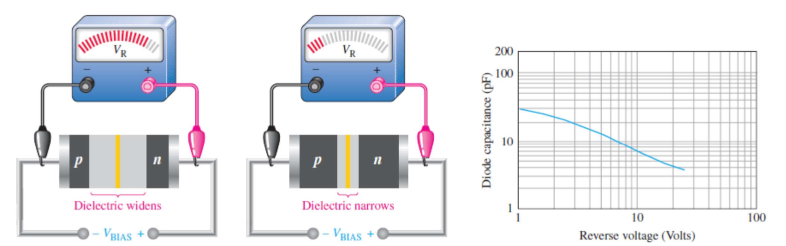
▶ FIGURE 3–21

The reverse-biased varactor diode acts as a variable capacitor.



Basic Operation

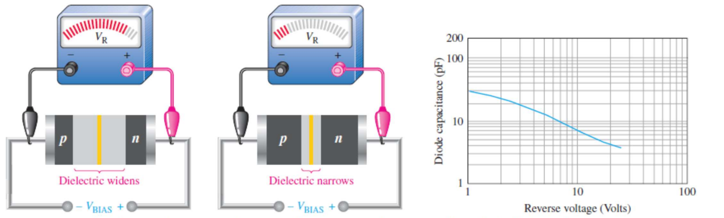
Recall that capacitance is determined by the parameters of plate area (A), dielectric constant (ϵ), and plate separation (d), as expressed in the following formula:



(a) Greater reverse bias, less capacitance (b) Less reverse bias, greater capacitance (c) Example of a diode capacitance versus reverse voltage graph

Special-Purpose Diodes

Varactor Diode



(a) Greater reverse bias, less capacitance (b) Less reverse bias, greater capacitance (c) Example of a diode capacitance versus reverse voltage graph

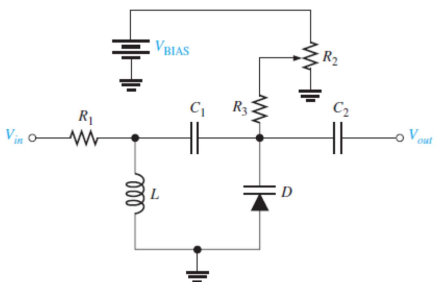
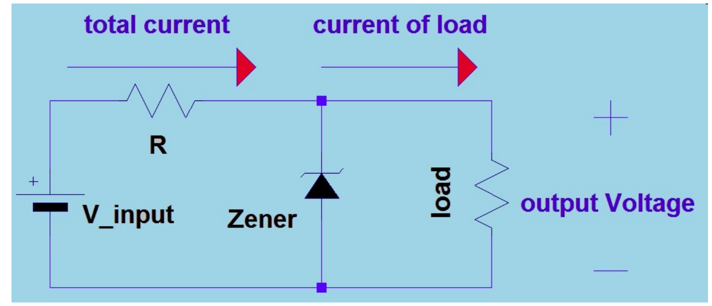
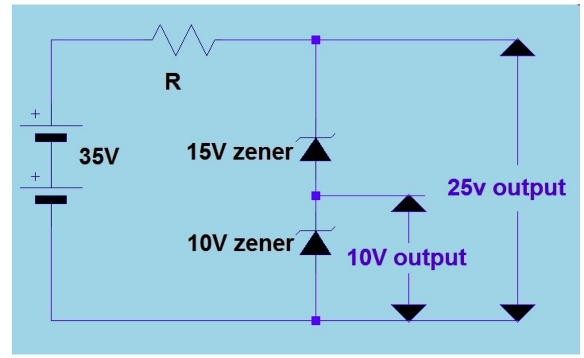


FIGURE 3–26

A resonant band-pass filter using a varactor diode for adjusting the resonant frequency over a specified range.

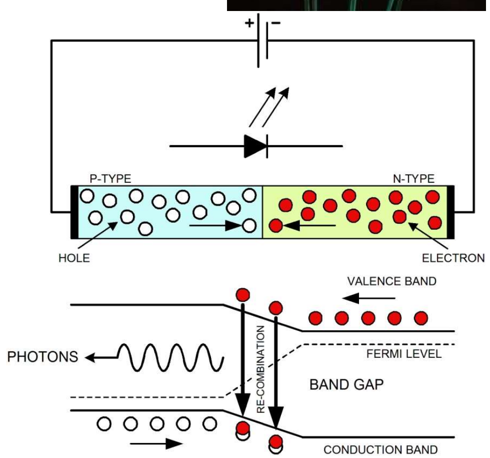
$$f_r \cong \frac{1}{2\pi\sqrt{LC}}$$

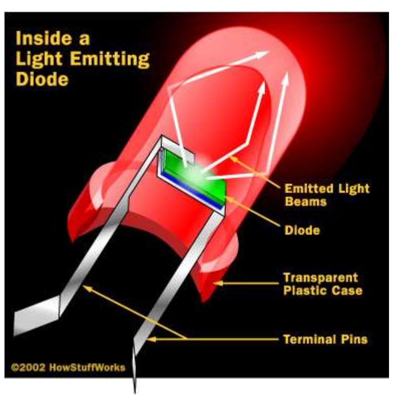


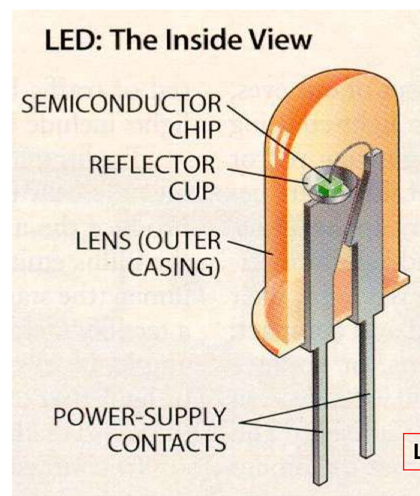


LIGHT EMITTING DIODE (LED)

ALL DIODES EMIT SOME EM RADIATION WHEN FORWARD BIASED. DIODES MADE FROM CERTAIN SEMICONDUCTORS EMIT LOTS OF LIGHT. THESE ARE CALLED LEDS





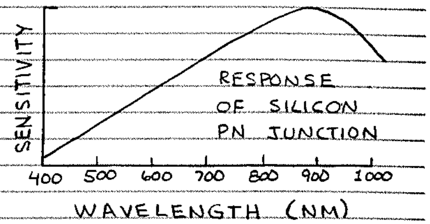


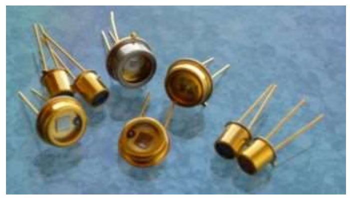
LEDS CAN EMIT AND DETECT LIGHT

YOU TUBE: MAKE presents: The LED http://www.youtube.com/watch?v=P3PDLsJQcGI

PN JUNCTION LIGHT DETECTORS (PHOTODIODES)

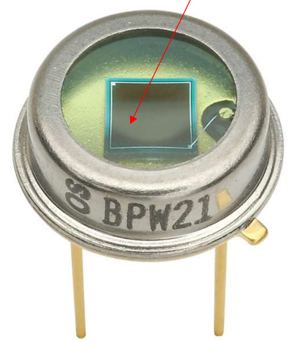
PN JUNCTION LIGHT DETECTORS FORM THE LARGEST FAMILY OF PHOTONIC SEMICONDUCTORS. MOST ARE MADE FROM SILICON AND CAN DETECT BOTH VISIBLE LIGHT AND NEAR-INFRARED.



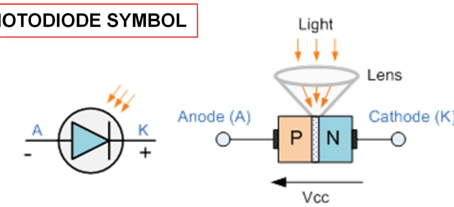


PHOTODIODES

ARE DESIGNED TO DETECT LIGHT. (ALL PN JUNCTIONS ARE LIGHT SENSITIVE) THEY HAVE A WINDOW WHERE LIGHT ENTERS TO A LARGE EXPOSED JUNCTION REGION. SOME COMMON USES INCULDE CAMERAS, ALARMS, LIGHTWAVE DIODES (LASERS).



PHOTODIODE SYMBOL



PHOTODIODES CAN BE USED TO DETECT FAST PULSES OF INFRARED LIGHT, USED IN LIGHTWAVE COMMUNICATIONS

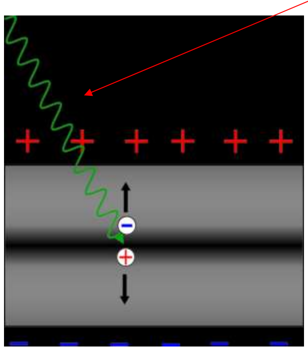
how photodiode works http://www.youtube.com/watch?v=U6Wvmrc3akc

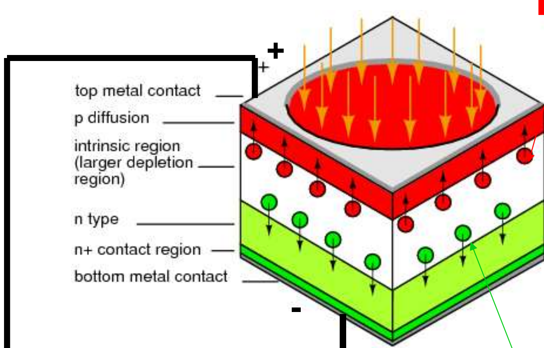
HOW PHOTODIODES WORK

A INCOMING PHOTON WILL CREATE A HOLE ELECTRON PAIR AT THE PN JUNCTION. A CURRENT WILL FLOW IF BOTH SIDES ARE CONNECTED.

INCOMING PHOTONS

HOLES

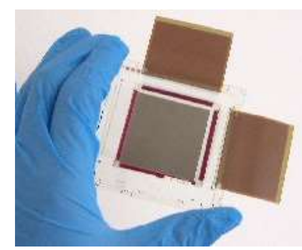




ELECTRONS

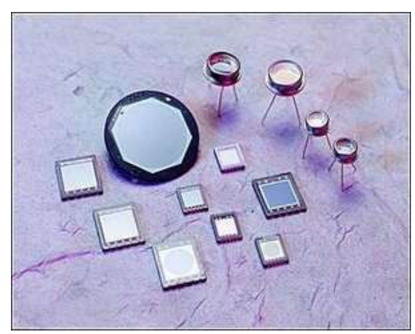
The Photodiode http://www.youtube.com/watch?v=U6Wvmrc3akc

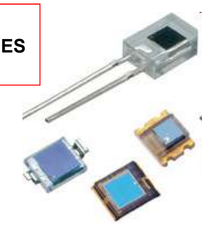
TYPES OF PHOTODIODES

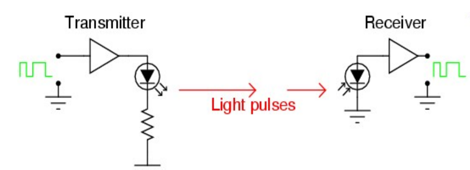


SMALL AREA PHOTODIODES
THESE HAVE VERY FAST RESPONS TIMES

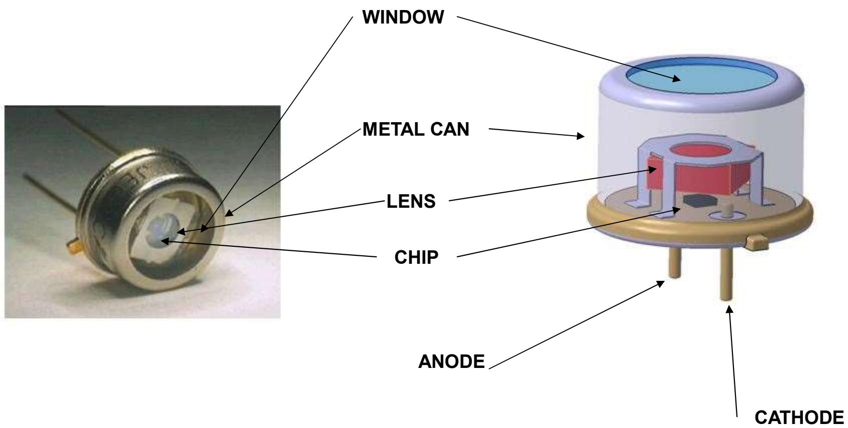
LARGE AREA PHOTODIODES
HAVE SLOWER RESPONSE TIMES THEN SMALL AREA PHOTODIODES THESE LARGE SURFACE AREA GIVES HIGH SENSITIVITY.



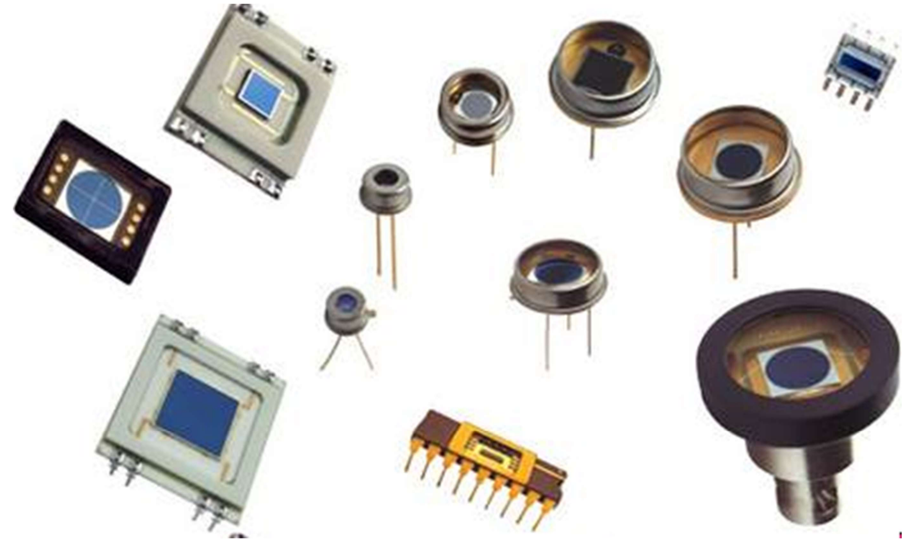




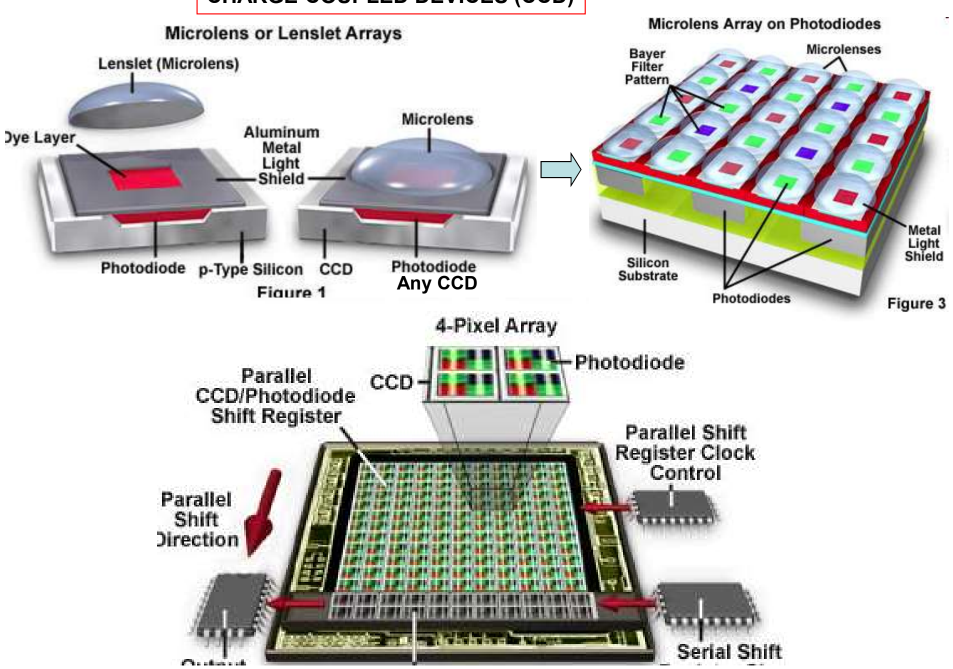
COMPOENTS OF A PHOTODIODE



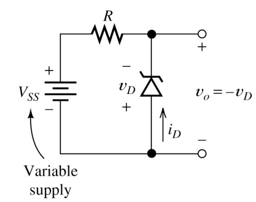
DIFFERENT PACKAGE STYLES FOR PHOTODIODES



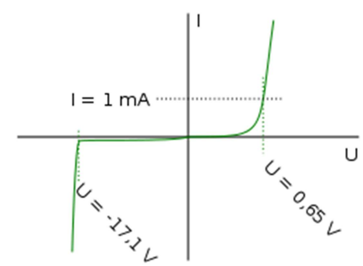
CHARGE COUPLED DEVICES (CCD)



Zener Diode - Voltage Regulator (reverse biased)

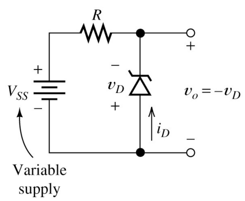


A simple regulator circuit that provides a nearly constant output voltage v_o from a variable supply voltage.



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".

Zener Diode - Voltage Regulator (reverse biased)



A simple regulator circuit that provides a nearly constant output voltage v_o from a variable supply voltage.

Problem

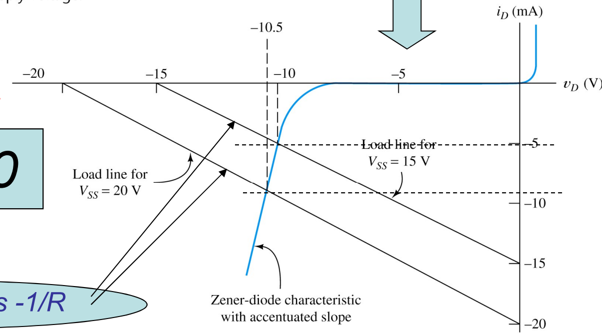
Find the output voltage for Vss=15V and Vss=20V if R=1kΩ and a Zener diode has the ch-tic shown below.

Load Line analysis

Kirchhoff's voltage law

$$V_{ss} + Ri_D + v_D = 0$$

Slope of the load is -1/R



Reverse bias region

Load Line Analysis of Complex Circuits

Thevenin Equivalent

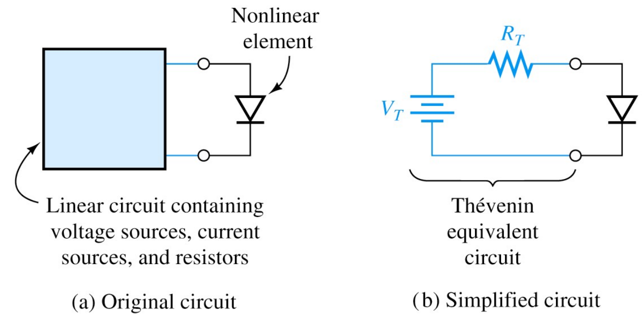


Figure 10.11 Analysis of a circuit containing a single nonlinear element can be accomplished by load-line analysis of a simplified circuit.

EASTERN WASHINGTON UNIVERSITY

Voltage Regulator (1)

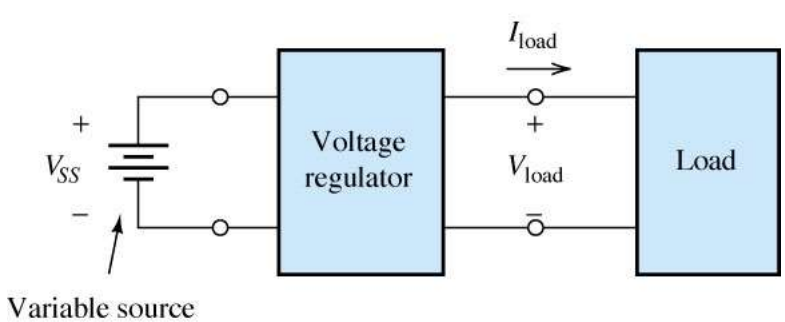


Figure 3.24 A voltage regulator supplies constant voltage to a load.

EASTERN WASHINGTON UNIVERSITY

Voltage Regulator (2)

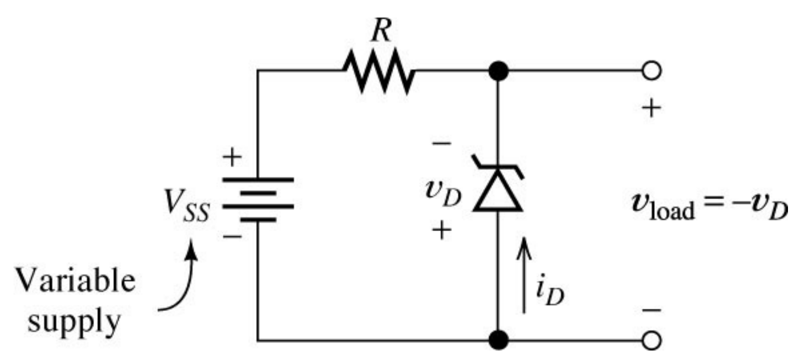
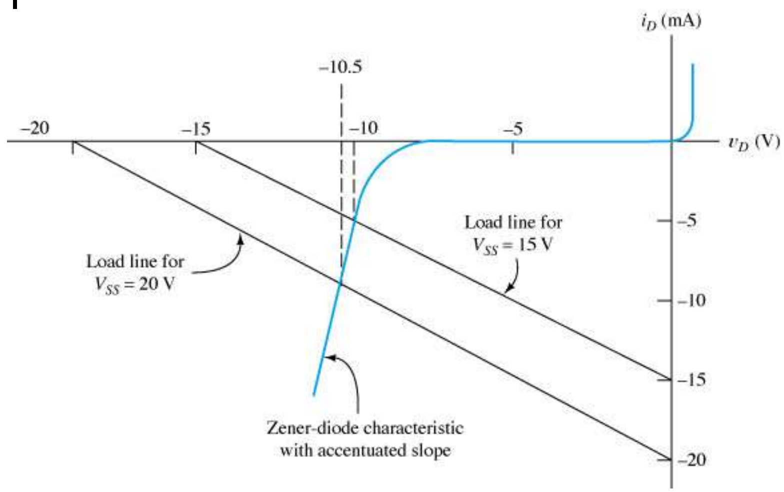


Figure 3.25 A simple regulator circuit that provides a nearly constant output voltage from a variable supply voltage.

Voltage Regulator (3)



Designing a power supply

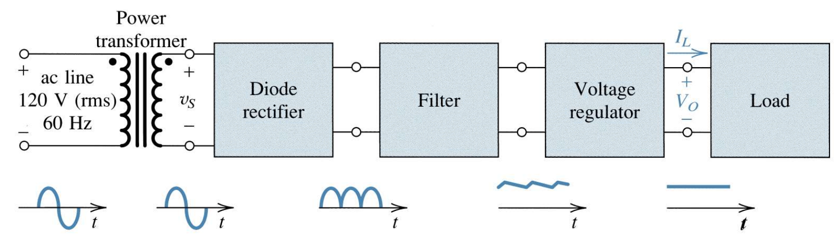
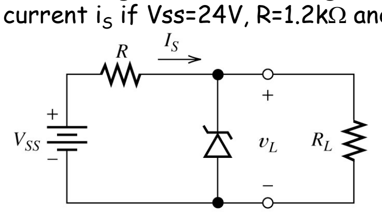


Fig. 3.36 Block diagram of a dc power supply.

Problem

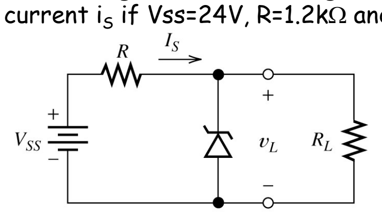
Consider the Zener diode regulator shown in figure (a). Find the load voltage v_L and the source current i_S if Vss=24V, R=1.2kΩ and RL=6kΩ.



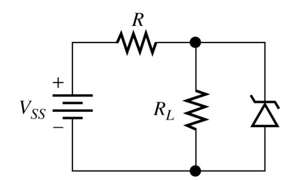
(a) Regulator circuit with load

Problem

Consider the Zener diode regulator shown in figure (a). Find the load voltage v_L and the source current i_S if Vss=24V, R=1.2kΩ and RL=6kΩ.



(a) Regulator circuit with load

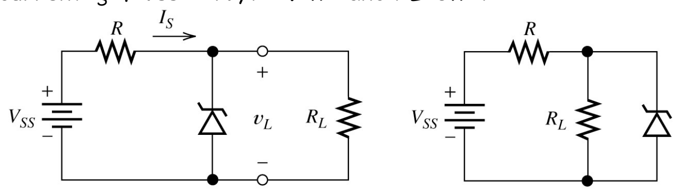


(b) Circuit of (a) redrawn

Exercise – find Thevenin equivalent

Problem

Consider the Zener diode regulator shown in figure (a). Find the load voltage v_L and the source current i_S if Vss=24V, R=1.2kΩ and RL=6kΩ.

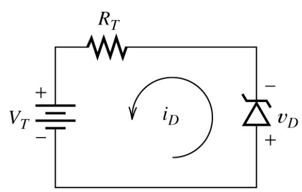


(a) Regulator circuit with load (b) Circuit of (a) redrawn

Thevenin equivalent

$V_T=V_{ss}*(R_L/(R+R_L))=20V$

$R_T=(RR_L)/(R+R_L)=1k\Omega$



(c) Circuit with linear portion

Load line equation

$V_T + R_T i_D + V_D = 0$

$V_L=-V_D=10V$

$i_D=-10mA$

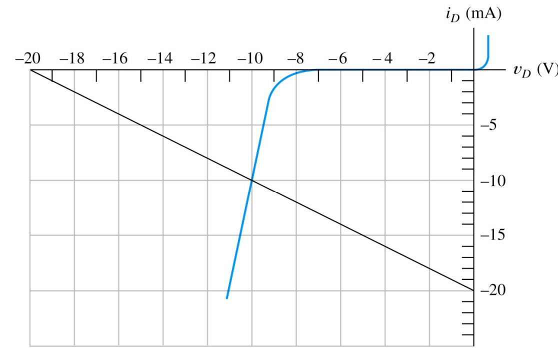


Figure 10.13 Zener-diode characteristic for Example 10.4 and Exercise 10.4.

Finally $i_S=(V_{SS}-V_L)/R=11.67$ mA (from circuit "a")

Exercise 10.4 & 10.5

Ideal diode Model

Useful for circuits with more than one diode

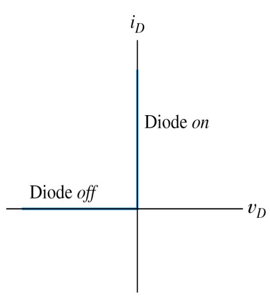


Figure 10.15 Ideal-diode volt–ampere characteristic.

(1) Assume a state for each diode, either "on" or "off" -2^n combinations

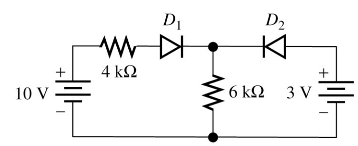
(2) Assume a short circuit for diode "on" and an open circuit for diode "off"

(3) Check to see if the result is consistent with the assumed state for each diode (current must flow in the forward direction for diode "on" and the voltage across the diodes assumed to be "off" must be positive at the cathode – reverse bias)

(4) If the results are consistent with the assumed states, the analysis is finished. Otherwise return to step (1) and choose a different combination of diode states.

Problem

Analyze the circuit shown below using the ideal diode model. Start by assuming the **D1 is off and D2** is on.

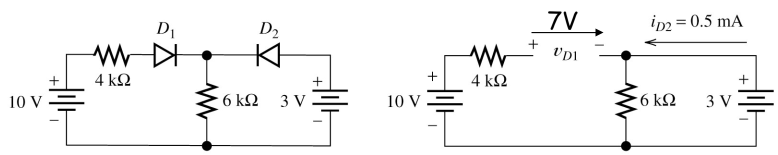


(a) Circuit diagram

Exercise 10.6 & 10.7 & 10.8

Problem

Analyze the circuit shown below using the ideal diode model. Start by assuming the **D1 is off and D2** is on.



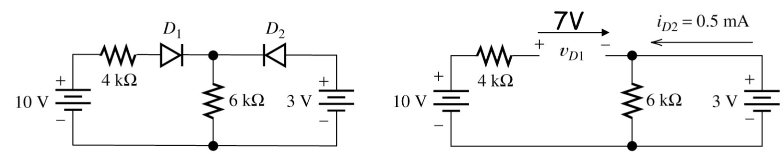
(a) Circuit diagram

(b) Equivalent circuit assuming D_1 off and D_2 on (since v_{D1} = +7 V, this assumption is not correct)

Not consistent with the assumption that D1 is off

Problem

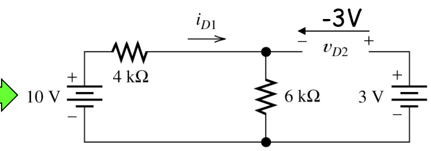
Analyze the circuit shown below using the ideal diode model. Start by assuming the D1 is off and D2 is on.



(a) Circuit diagram

(b) Equivalent circuit assuming D_1 off and D_2 on (since v_{D1} = +7 V, this assumption is not correct)

This is OK



(c) Equivalent circuit assuming D_1 on and D_2 off (this is the correct assumption since i_{D1} turns out to be a positive value and v_{D2} turns out negative)

Piecewise Linear Diode Models

More accurate that the ideal diode model and do not relies on nonlinear equation or graphical techniques.

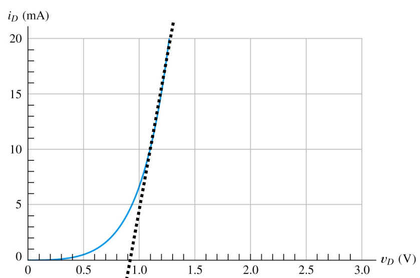


Figure 10.8 Diode characteristic for Exercise 10.3.

$$v = R_a i + V_a$$

(1) Diode V-I ch-tic approximated by straight line segments

(2) We model each section of the diode I-V ch-tic with R in series with a fixed voltage source

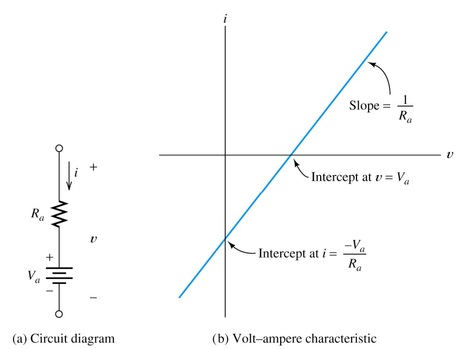


Figure 10.18 Circuit and volt–ampere characteristic for piecewise-linear models.

Problem

Find circuit models for the Zener-diode volt-ampere ch-tic shown in figure below using the piecewise-linear diode model.

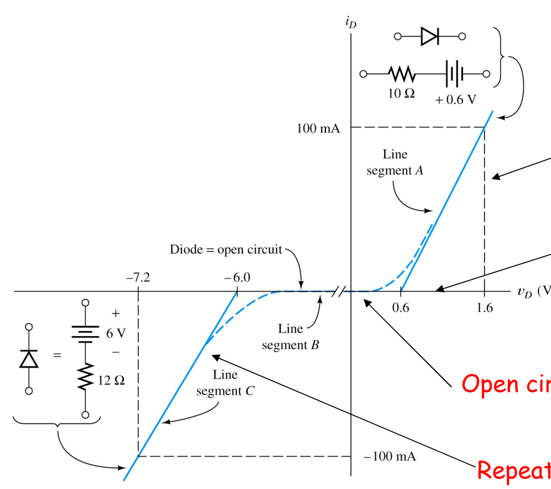


Figure 10.19 Piecewise-linear models for the diode of Example 10.6.

Draw a line

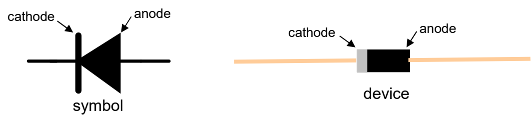
Look for intercept (0.6V) & the reciprocal of the slope (1/R) (1.6V-0.6V)/100mA=10Ω

Open circuit approximation

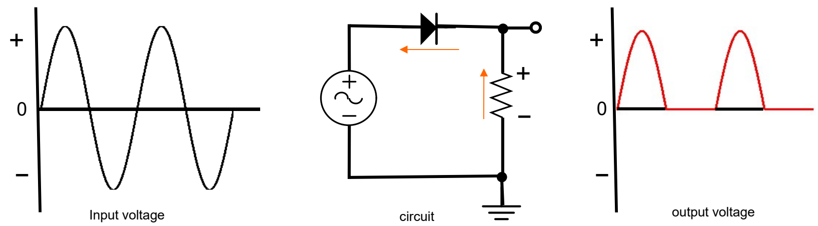
Repeat for the reverse bias

Exercise 10.7

HOW DIODES ARE USED



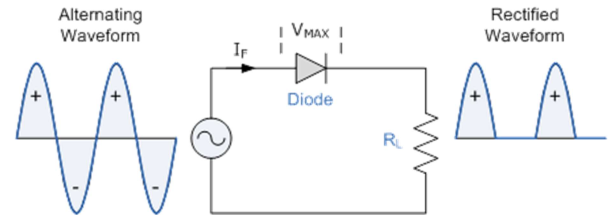
Silicon rectifier diode



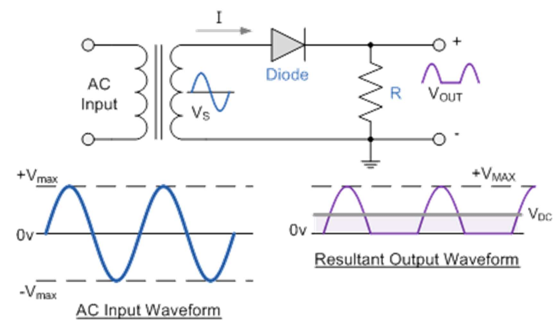
Input and output of a simple rectifier circuit

Fig. 8-23 p.219 A single-phase half-wave rectifier circuit produces one output pulse of dc for each cycle of ac input.

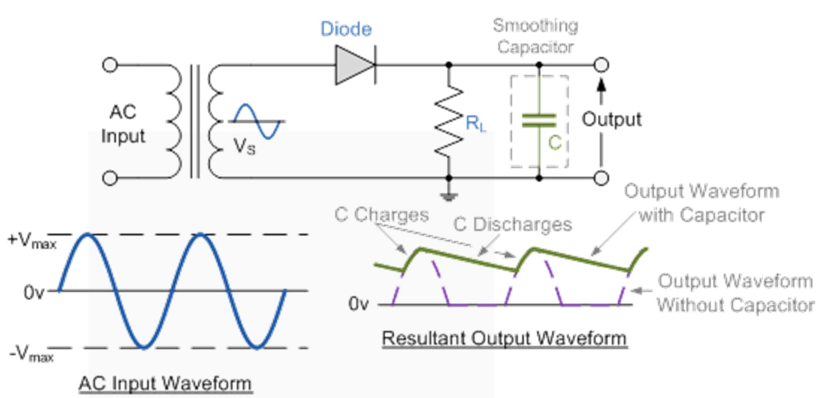
Power Diode Rectifier



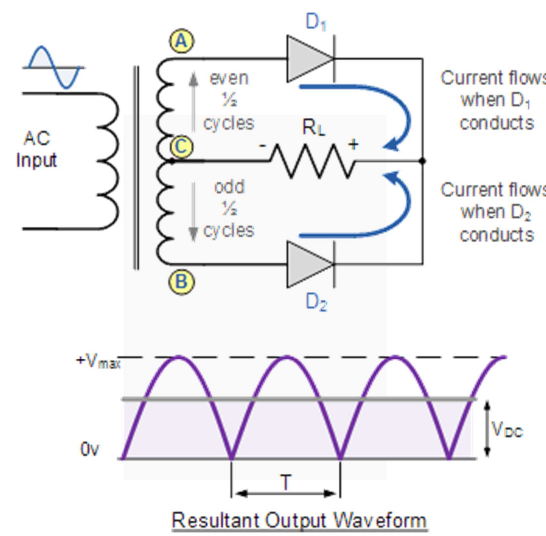
Half Wave Rectifier Circuit



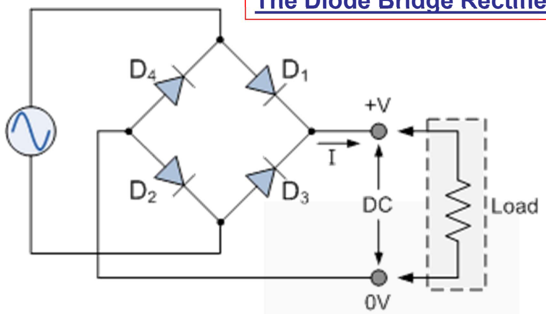
Half-wave Rectifier with Smoothing Capacitor



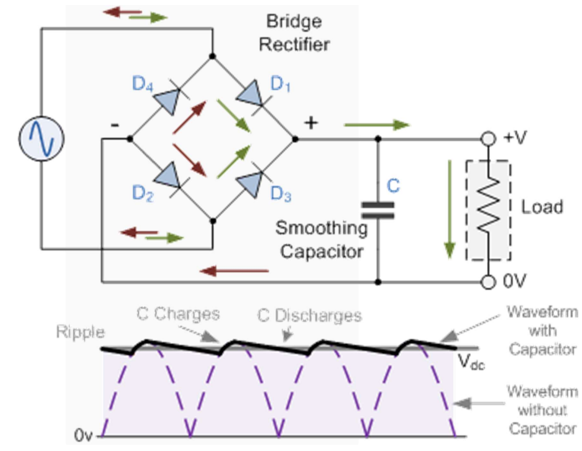
Full Wave Rectifier Circuit



The Diode Bridge Rectifier



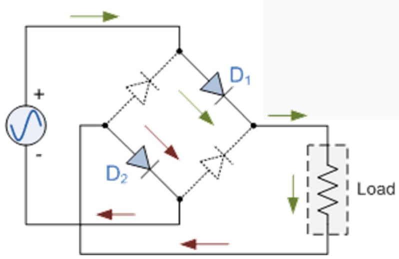
Full-wave Rectifier with Smoothing Capacitor



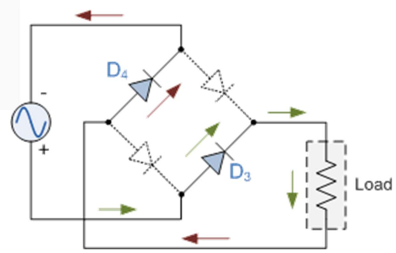
Resultant Output Waveform

Full Wave Bridge Rectifier http://www.youtube.com/watch?v=aCfAdIRRw7M

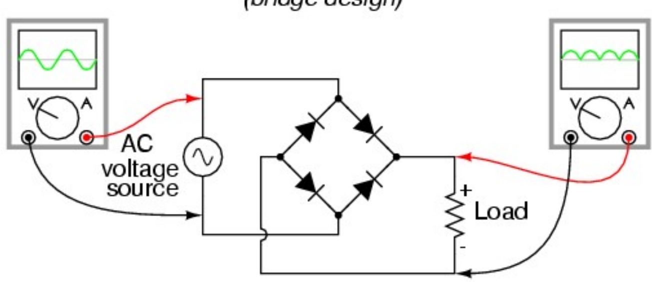
The Positive Half-cycle

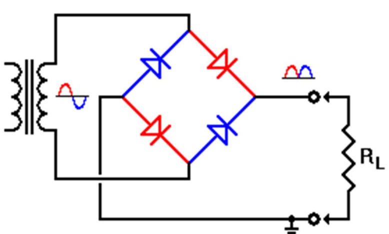


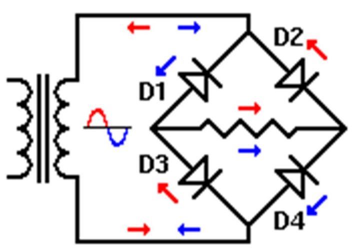
The Negative Half-cycle



Full-wave rectifier circuit (bridge design)







VARIOUS TYPES OF POWER RECTIFIERS

https://www.youtube.com/watch?v=ylk6VMBLrvM

Various printed circuit board mounted rectifiers and voltage regulators

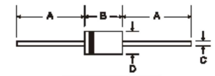
DIODES

1N4001 - 1N4007

1.0A RECTIFIER

Features

- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- Low Reverse Leakage Current
- **Lead Free Finish, RoHS Compliant (Note 3)**



Dim	DO-41 Plastic	
	Min	Max
A	25.40	—
B	4.06	5.21
C	0.71	0.864
D	2.00	2.72
All Dimensions in mm		

Mechanical Data

- Case: DO-41
- Case Material: Molded Plastic. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020D
- Terminals: Finish - Bright Tin. Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Mounting Position: Any
- Ordering Information: See Page 2
- Marking: Type Number
- Weight: 0.30 grams (approximate)

Maximum Ratings and Electrical Characteristics @T_A = 25°C unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 1) @ T_A = 75°C	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load	I_{FSM}	30							A
Forward Voltage @ I_F = 1.0A	V_{FM}	1.0							V
Peak Reverse Current @T_A = 25°C at Rated DC Blocking Voltage @ T_A = 100°C	I_{RM}	5.0 50							µA
Typical Junction Capacitance (Note 2)	C_j	15				8			pF
Typical Thermal Resistance Junction to Ambient	$R_{θJA}$	100							K/W
Maximum DC Blocking Voltage Temperature	T_A	+150							°C
Operating and Storage Temperature Range	T_J, T_{STG}	-65 to +150							°C

Notes:
1. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V DC.
3. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied, see EU Directive 2002/95/EC Annex Notes.

XNYYY

XN YYY

COMPONENT IDENTIFICATION NUMBER

X - NUMBER OF SEMICONDUCTOR JUNCTIONS
N - A SEMICONDUCTOR
YYY - IDENTIFICATION NUMBER (ORDER OR REGISTRATION NUMBER) ALSO INCLUDES SUFFIX LETTER (IF APPLICABLE) TO INDICATE

1. MATCHING DEVICES
2. REVERSE POLARITY
3. MODIFICATION

EXAMPLE - 1N345A (AN IMPROVED VERSION OF THE SEMICONDUCTOR DIODE TYPE 345)

1N4001, 1N4002, 1N4003, 1N4004, 1N4005, 1N4006, 1N4007

1N4004 and 1N4007 are Preferred Devices

Axial Lead Standard Recovery Rectifiers

This data sheet provides information on subminiature size, axial lead mounted rectifiers for general−purpose low−power applications.

Features

- Shipped in plastic bags, 1000 per bag
- Available Tape and Reeled, 5000 per reel, by adding a "RL" suffix to the part number
- Available in Fan−Fold Packaging, 3000 per box, by adding a "FF" suffix to the part number
- Pb−Free Packages are Available

Mechanical Characteristics

- Case: Epoxy, Molded
- Weight: 0.4 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead and Mounting Surface Temperature for Soldering Purposes: 260°C Max. for 10 Seconds, 1/16 in. from case
- Polarity: Cathode Indicated by Polarity Band

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

ON Semiconductor®

http://onsemi.com

LEAD MOUNTED RECTIFIERS
50−1000 VOLTS
DIFFUSED JUNCTION

CASE 59−10
AXIAL LEAD
PLASTIC

MARKING DIAGRAM

A = Assembly Location
1N400x = Device Number
x = 1, 2, 3, 4, 5, 6 or 7
YY = Year
WW = Work Week
▪ = Pb−Free Package
(Note: Microdot may be in either location)

ORDERING INFORMATION

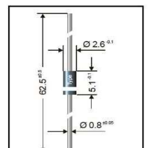
See detailed ordering and shipping information on page 4 of this data sheet.

Preferred devices are recommended choices for future use and best overall value.

Diotec Semiconductor

1N 4001 ... 1N 4007, 1N 4007-1300
EM 513, EM 516, EM 518

Silicon Rectifiers — **Silizium Gleichrichter**



Dimensions / Maße in mm

Nominal current – Nennstrom	1 A
Repetitive peak reverse voltage Periodische Spitzensperrspannung	50…2000 V
Plastic case Kunststoffgehäuse	DO-41 DO-204AL
Weight approx. – Gewicht ca.	0.4 g
Plastic material has UL classification 94V-0 Gehäusematerial UL94V-0 klassifiziert	
Standard packaging taped in ammo pack Standard Lieferform gegurtet in Ammo-Pack	see page 16 siehe Seite 16

Maximum ratings — **Grenzwerte**

Type Typ	Repetitive peak reverse voltage Periodische Spitzensperrspannung V_{RRM} [V]	Surge peak reverse voltage Stoßspitzensperrspannung V_{RSM} [V]
1N 4001	50	50
1N 4002	100	100
1N 4003	200	200
1N 4004	400	400
1N 4005	600	600
1N 4006	800	800
1N 4007	1000	1000
1N 4007-1300	1300	1300
EM 513	1600	1600
EM 516	1800	1800
EM 518	2000	2000

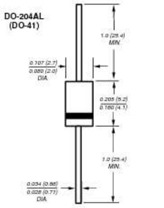
Max. average forward rectified current, R-load Dauergrenzstrom in Einwegschaltung mit R-Last	T_A = 75˚C T_A = 100˚C	I_{FAV} I_{FAV}	1 A [1]) 0.75 A [1])
Repetitive peak forward current Periodischer Spitzenstrom	f > 15 Hz	I_{FRM}	10 A [1])
Peak forward surge current, 50 Hz half sine-wave Stoßstrom für eine 50 Hz Sinus-Halbwelle	T_A = 25˚C	I_{FSM}	50 A

[1]) Valid, if leads are kept at ambient temperature at a distance of 10 mm from case
Gültig, wenn die Anschlußdrähte in 10 mm Abstand von Gehäuse auf Umgebungstemperatur gehalten werden

General Purpose Plastic Rectifier

Reverse Voltage 50 to 1000V
Forward Current 1.0A

DO-204AL
(DO-41)



NOTE: *Lead diameter is* $\frac{0.026\ (0.66)}{0.023\ (0.58)}$ *for suffix "E" part numbers*

Dimensions in inches and (millimeters)

Features

- Plastic package has Underwriters Laboratories Flammability Classification 94V-0
- Construction utilizes void-free molded plastic technique
- Low reverse leakage
- High forward surge capability
- High temperature soldering guaranteed: 350°C/10 seconds, 0.375" (9.5mm) lead length, 5 lbs. (2.3kg) tension

Mechanical Data

Case: JEDEC DO-204AL, molded plastic body
Terminals: Plated axial leads, solderable per MIL-STD-750, Method 2026
Polarity: Color band denotes cathode end
Mounting Position: Any
Weight: 0.012 oz., 0.3 g

Maximum Ratings & Thermal Characteristics

Ratings at 25°C ambient temperature unless otherwise specified.

Parameter	Symb.	1N 4001	1N 4002	1N 4003	1N 4004	1N 4005	1N 4006	1N 4007	Unit
Maximum repetitive peak reverse voltage	V_{RRM}	50	100	200	400	600	800	1000	V
* Maximum RMS voltage	V_{RMS}	35	70	140	280	420	560	700	V
* Maximum DC blocking voltage	V_{DC}	50	100	200	400	600	800	1000	V
* Maximum average forward rectified current 0.375" (9.5mm) lead length at T_A = 75°C	$I_{F(AV)}$	1.0							A
* Peak forward surge current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method) T_A = 75°C	I_{FSM}	30							A
* Maximum full load reverse current, full cycle average 0.375" (9.5mm) lead length T_L = 75°C	$I_{R(AV)}$	30							µA
Typical thermal resistance(1)	$R_{\theta JA}$ $R_{\theta JL}$	50 25							°C/W
* Maximum DC blocking voltage temperature	T_A	+150							V
* Operating junction and storage temperature range	T_J, T_{STG}	−50 to +175							°C

Electrical Characteristics

Ratings at 25°C ambient temperature unless otherwise specified.

Parameter	Symb.	Value	Unit
Maximum instantaneous forward voltage at 1.0A	V_F	1.1	V
* Maximum DC reverse current at rated DC blocking voltage, T_A = 25°C / T_A = 125°C	I_R	5.0 50	µA
Typical junction capacitance at 4.0V, 1MHz	C_J	15	pF

Note: (1) Thermal resistance from junction to ambient at 0.375" (9.5mm) lead length, P.C.B. mounted   * JEDEC registered values