NOTES & PROBLEM SETS
de
K7QO

INTRODUCTORY ELECTRONIC DEVICES & CIRCUITS
SIXTH EDITION
Conventional Flow Version

by

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CHAPTER 1 NOTES

CHAPTER 1 — Fundamental Solid State Principles

proton	+1 charge	1.673×10^{-24} g
neutron	0 charge	1.675×10^{-24} g
electron	−1 charge	9.11×10^{-28} g

+1 charge = 1.602×10^{-19} C

semiconductor materials Si, Ge and C

conductors $E_g = 0.4\text{eV}$
semiconductors $E_g = 1.1\text{ eV}$
insulators $E_g = 1.8\text{eV}$

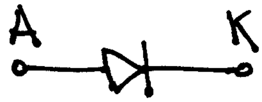
bias – voltage applied to obtain a desired mode of operation

forward biased diode $V_F \cong 0.7V$ (Si)

$V_F \cong 0.3V$ (Ge)

CHAPTER 2 NOTES

CHAPTER 2 — Diodes

schematic symbol   anode  cathode

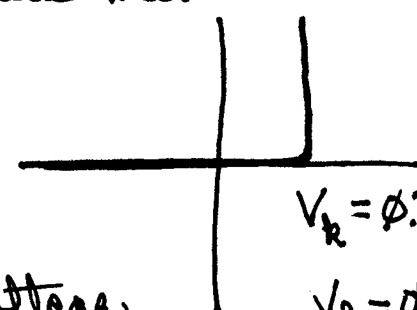
note: diode conducts fully when $V_F = 0.7V$ for Si and $0.3V$ for Ge

it is conducting when voltage is smaller!!
i see lots of hams online screw this one up.

model — representation that demonstrates one or more characteristics of a component or circuit

ideal diode model — simple switch
practical diode model — practical model for analyzing circuit
complet diode model — used for computer simulations

practical diode model



$V_k = 0.7V$ (Si)

$V_k = 0.3V$ (Ge)

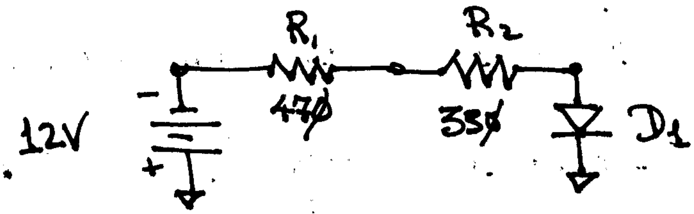
V_k – knee voltage

percentage of error [%] $= \frac{[x - x']}{x'} \times 100$ (2.3)

BOOK IS WRONG!!   google it – 'percentage of error'

do calculations without absolute value operation problem notation

PP 2.1/24. practice problem 2.1 on page 24



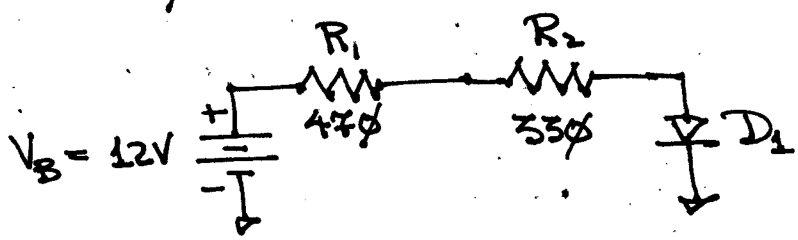
$V_{R1} = 0.0V$

$V_{R2} = 0.0V$

$V_{D1} = -12V$ from anode to cathode

$I = 0.0\,\mu A$ for ideal diode model

PP 2.2/24.



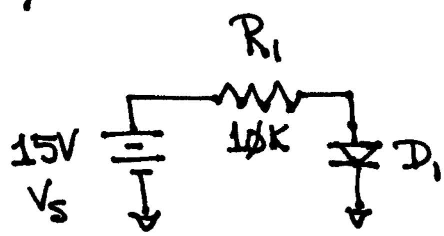
$$I_T = \frac{V_B}{R_1 + R_2}$$

$$I_T = \frac{12V}{470\Omega + 330\Omega}$$

$$I_T = \frac{12V}{800\Omega}$$

$$\boxed{I_T = 150\,mA}$$

PP 2.3/27.



$$I = \frac{V_S - V_F}{R_1}$$

$$I = \frac{15V - 0.7V}{10K}$$

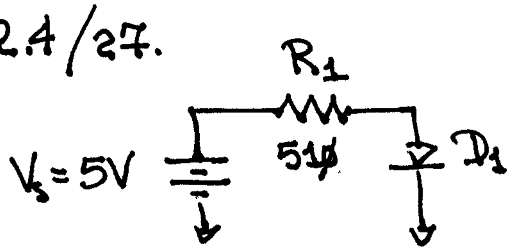
$$I = \frac{14.3V}{10K}$$

$$\boxed{I = 1.43 mA}$$

$$V_{R1} = I \times R_1$$

$$\boxed{V_{R1} = 14.3V}$$

PP 2.4/27.



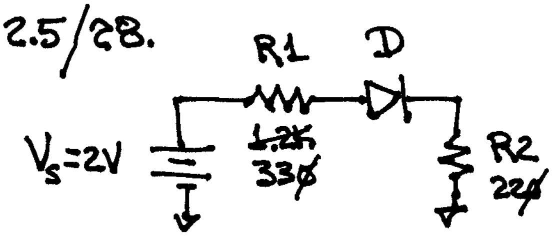
$$I = \frac{V_S - V_F}{R_1}$$

$$I = \frac{5V - 0.7V}{510\Omega}$$

$$I = \frac{4.3V}{510\Omega}$$

$$\boxed{I = 8.43 mA}$$

PP2.5/28.



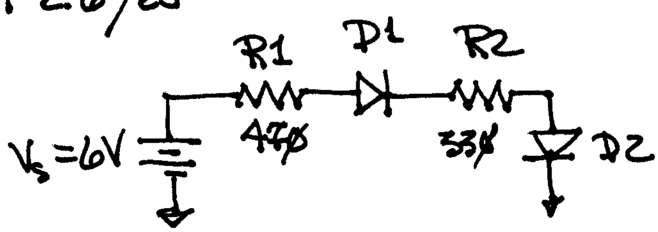
$$I = \frac{V_s - V_F}{R1+R2}$$

$$I = \frac{2.0V - 0.7V}{330\Omega + 220\Omega}$$

$$I = \frac{1.3V}{550\Omega}$$

$$\boxed{I = 2.36mA}$$

PP2.6/28



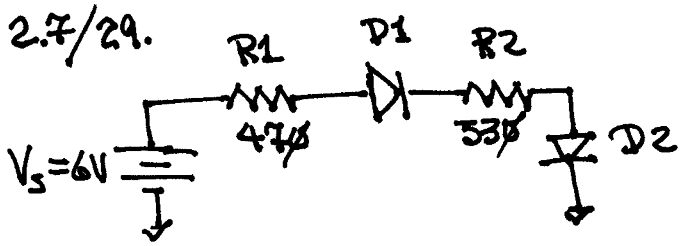
$$I = \frac{V_s - V_{D1} - V_{D2}}{R1+R2}$$

$$I = \frac{6.0V - 0.7V - 0.7V}{470\Omega + 330\Omega}$$

$$I = \frac{4.6V}{800\Omega}$$

$$\boxed{I = 5.75mA}$$

PP 2.7/29.



using ideal diode model

$$I = \frac{V_s - V_{D1} - V_{D2}}{R1 + R2}$$

$$I = \frac{6.0V - 0.0V - 0.0V}{470\,\Omega + 330\,\Omega}$$

$$I = \frac{6.0V}{800\,\Omega}$$

$$\boxed{I = 7.50\,mA}$$

using correct percentage error formula

$$PE = \frac{I - I'}{I'} \times 100\ \%$$

$$PE = \frac{7.50mA - 5.75mA}{5.75mA}\ \% \times 100$$

$$\boxed{PE = 30.4\ \%}$$

ideal model value too large

using wrong percentage error formula in book

$$PE = \frac{|I - I'|}{I} \times 100\ \%$$

$$PE = \frac{7.50 - 5.75}{7.50} \times 100\ \%$$

$$PE = 23.3\%$$

value too low

PP2.8/31.

$$V_{pk} = 175V$$

$$V_{RRM} = 1.2 \times V_{pk}$$

$$V_{RRM} = 1.2 \times 175V$$

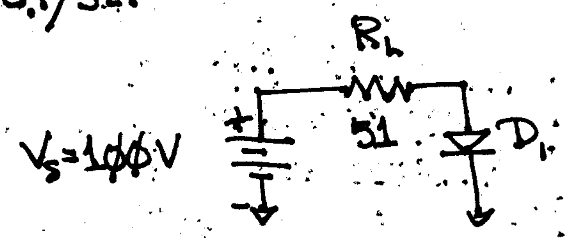
$$\boxed{V_{RRM} = 210V}$$

	peak reverse voltage
1N4001	50V
1N4002	100V
1N4003	200V
1N4004	400V
1N4005	600V
1N4006	800V
1N4007	1000V

diodes that can be used are

1N4004
1N4005
1N4006
1N4007

PP 29/32.



$$I_F = \frac{V_S - V_F}{R_L}$$

$$I_F = \frac{100.0V - 0.7V}{51\Omega}$$

$$\boxed{I_F = 1.95A}$$

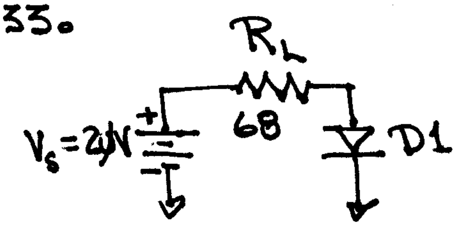
$$I_D = 1.2 \times I_F$$

$$I_D = 1.2 \times 1.95A$$

$$\boxed{I_D = 2.34A}$$

minimum average current rating for diode

PP 2.10/33.



$$I_F = \frac{V_S - V_F}{R_L}$$

$$I_F = \frac{20V - 0.7V}{68\Omega}$$

$$I_F = \frac{19.3V}{68\Omega}$$

$$\boxed{I_F = 273.5\,mA}$$

$$P_F = (0.2735A)(0.7V)$$

$$\boxed{P_F = 191.5\,mW}$$

$$P_D = 1.2 \times 191.5\,mW$$

$$\boxed{P_D = 230\,mW}$$ minimum rating for diode

PP 2.11/34.

diode rating $P_D = 500$ mW

$I_D = 750$ mA

$V_F = 0.7$ V

$P_D = I_D \times V_F$

$P_D = 750\text{ mA} \times 0.7\text{ V}$

$\boxed{P_D = 525\text{ mW}}$ > 500 mW, thus P_D exceeded

PP 2.12/36.

$R_B = 8\,\Omega \qquad I_D = 12mA$

$V_F = V_B + I_D R_B$

$V_F = 0.7V + 12mA \cdot 8\,\Omega$

$V_F = 0.7V + 0096V$

$\boxed{V_F = 0.796V}$

PP 2.13/49.

zener diode $P_D = 1W$

$V_Z = 27V$

$I_{ZM} = P_D / V_Z$

$I_{ZM} = 1W / 27W$

$\boxed{I_{ZM} = 37.1\ mA}$

PP 2.14/50.

$T = 125°C$ operating temperature for zener

derating value $= (4mV/°c)(125°c - 75°c)$

derating value $= 200mW$

$P_D = 500\ mW - 200mW$

$\boxed{P_D = 300mW}$

PP 2.15/52.

$V_Z = 75V$ for zener diode

$P_D = 4W$

using figure 2.34:

1N5374A

zener to use in application

PP 2.16/53.

$V_Z = 6.8V$

$I_Z = 175\ mA$

$P_D = V_Z \cdot I_Z$

$P_D = 6.8V \cdot 175mA$

$P_D =$ $\boxed{P_D = 1.19W}$

1N5921A @ 1.5W 1N5342A @ 5W

← 6.8V zeners could be used

PP 2.17/56.

$1.4V \leq V_F \leq 1.8V$ LED voltage range

$I_F = 12mA$ $V_{pk} = 14V$

$$R_S = \frac{V_{pk} - V_F}{I_F}$$

$$R_S = \frac{14V - 1.4V}{12mA}$$ use minimum V_F

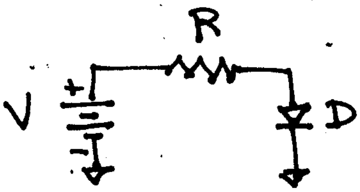
$R_S = 1050\ \Omega$ calculated value

1.5K for 10% tolerance

1.3K for 2% and 5% tolerance

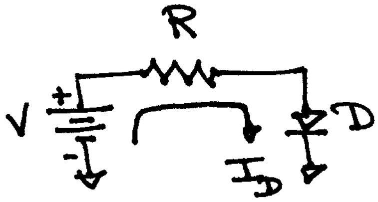
from appendix A, page 928.

1/64.



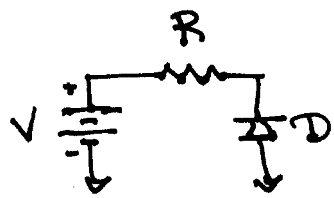
forward biased diode

2/64.



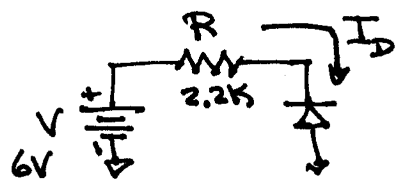
current direction, conventional flow

3/64.



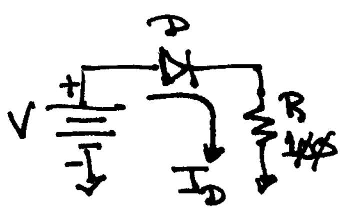
reverse biased diode

4/64. (a)



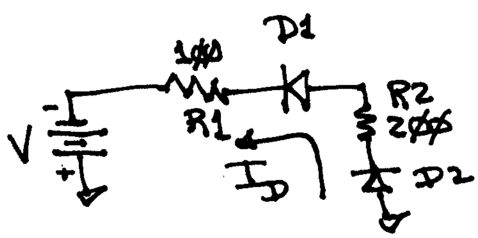
I_D is very small
reverse bias applied to diode
for ideal model, $I_D = 0.0$ mA

(b)



forward biased

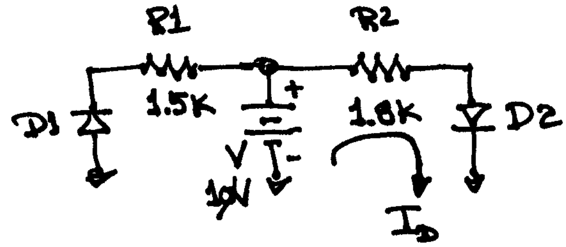
(c)



both diodes forward biased

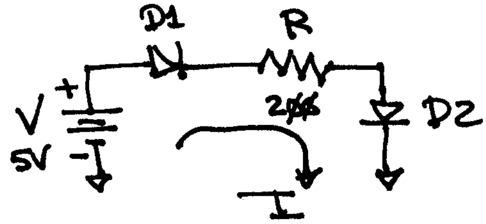
5/64.

(a)



D1 is reverse biased

(b)



both diodes forward biased

(c)

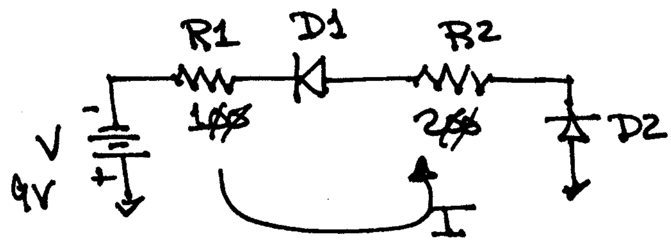
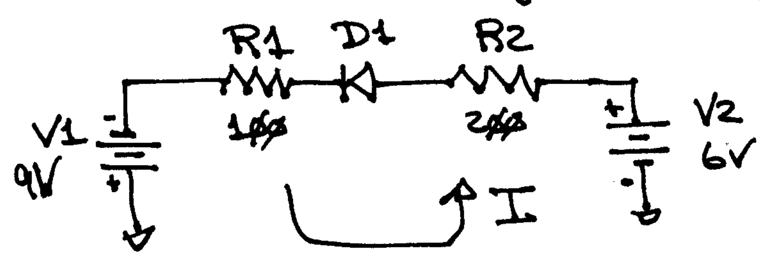


Diagram shows that maybe, just maybe, D2 should be voltage source of 6V



$V1 > V2$, thus D1 is forward biased

14/65. $V' = 12.8V$ calculated voltage

$V = 13.2V$ measured voltage

$$E = \frac{V - V'}{V'} \times 100\%$$

$$E = \frac{13.2V - 12.8V}{12.8V} \times 100\%$$

$$E = \frac{0.4}{12.8} \times 100\%$$

$$E = 0.031 \times 100\%$$

$$\boxed{E = 3.1\%}$$ percentage error

since positive, measured value is higher than calculated value

15/65. $I' = 750\ \mu A$

$I = 880\ \mu A$

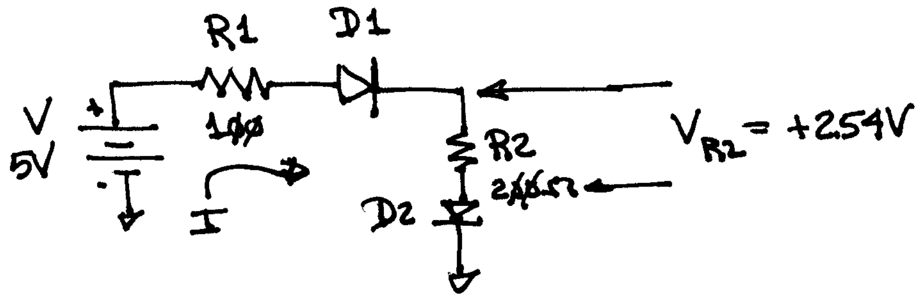
$$E = \frac{I - I'}{I'} \times 100\%$$

$$E = \frac{880\mu A - 750\mu A}{750\mu A} \times 100\%$$

$$E = \frac{130\ \mu A}{750\mu A} \times 100\%$$

$$\boxed{E = 17.3\%}$$

17/65.



$$I = \frac{V - V_{D1} - V_{D2}}{R1 + R2}$$

$$I = \frac{5.0V - 0.7V - 0.7V}{100\Omega + 200\Omega}$$

$$I = 3.6V / 300\Omega$$

$$\boxed{I = 12mA}$$

$$V'_{R2} = I \cdot R2$$

$$V'_{R2} = 12mA \cdot 200\Omega$$

$$\boxed{V'_{R2} = 2.4V}$$

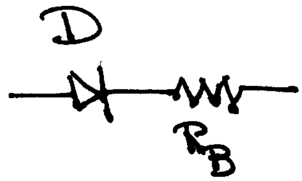
$$E = \frac{V - V'}{V'} \times 100\%$$

$$E = \frac{2.54V - 2.4V}{2.54V} \times 100\%$$

$$E \ \frac{0.14V}{2.54V} \times 100\%$$

$$\boxed{E = 5.5\%}$$

26/66. Si diode



$I = 10\,mA$

$R_B = 5\,\Omega$

what is V_F

$V_B = I \cdot R_B$

$V_B = 10\,mA \cdot 5\,\Omega$

$V_B = 0.05\,V$

$V_F = 0.7\,V + V_B$

$\boxed{V_F = 0.75\,V}$

40/68.

D1

$V_z = 24V$

$P_{D(max)} = 10W$

$I_{zm} = ?$

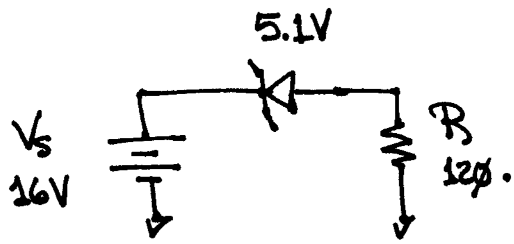
assume operation at $\frac{1}{2} P_{D(max)}$

$$I_{zm} = \frac{P}{V_z}$$

$$I_{zm} = 5W/24V$$

$$\boxed{I_{zm} = 208\text{ mA}}$$

52/69.



$$V_R = V_S - V_Z$$

$$V_R = 16V - 5.1V$$

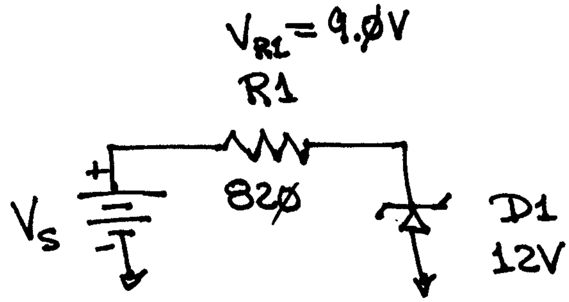
$$V_R = 10.9V$$

$$I = V_R / R$$

$$I = 10.9V / 120\,\Omega$$

$$\boxed{I = 90.8\ mA}$$

53/69.



$$P_{D1} = ?$$

$$I = V_{R1} / R1$$

$$I = 9.0V / 820\,\Omega$$

$$\boxed{I = 10.98\ mA}$$

$$P = I \cdot V_{D1}$$

$$P = 10.98mA \cdot 12V$$

$$\boxed{P = 132\ mW}$$