Scilab Textbook Companion for Electronics Devices And Circuits by S. Salivahanan, N. S. Kumar And A. Vallavaraj[1]

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 1

Physical properties of elements

Scilab code Exa 1.1 `Finding radii`

```
//Example 1.1.
format(6)
epsilon=8.854*10^-12
h=6.62*10^-34 //planck's constant
m=9.1*10^-31 //mass of electron
q=1.6*10^-19 //charge of electron
for n=1
r1=(epsilon*(h^2)*(n^2))/(%pi*m*(q^2)) //radius of 1st orbit for hydrogen
x1=r1*10^10  // in A.U
disp(x1,"r1(A.U)=")
end
for n=2
r2=(epsilon*(h^2)*(n^2))/(%pi*m*(q^2)) //radius of 2st orbit for hydrogen
x2=r2*10^10  // in A.U
disp(x2,"r2(meters)=")
end
for n=3
r3=(epsilon*(h^2)*(n^2))/(%pi*m*(q^2)) //radius of 3st orbit for hydrogen
```

```
x3=r3*10^10  // in A.U
disp(x3,"r3(meters)=")
end
```

Scilab code Exa 1.2 `Finding wavelength`

```
//Example 1.2.
format(7)
E1=-13.6; //energy of 10th state
E10=-13.6/10^2; //enery in the ground state
lamda=12400/(E10-E1); //wavelength of emitted photon
disp("The wavelength in Armstrong units is given by, lamda = 12400 / E2-E1")
disp("Since the hydrogen atoms goes from n=10 state to the ground state, lamda = 12400 / E10-E1")
disp("The energy of the 10th state is E10 = -13.6 / 10^2 = -0.136 eV")
disp("The energy in the ground state is E1 = -13.6 eV")
disp(lamda,"Wavelenth of the emitted photon is(Armstrong) =");
```

Scilab code Exa 1.3 `wavelength of the Balmer series`

```
//Example 1.3.
format(6)
Einfinity=0 //energy of electron at infinite orbit
E2=-13.6/2^2 //energy of electron at second orbit
wavelength=12400/(Einfinity-E2) //wavelength limit
disp("Wavelength of the Balmer series limit = 12400 / Einfinity-E2")
disp("Energy of the electron at the infinity orbit, Einfinity = -13.6 / infinity^2 = 0")
```

```
disp("Energy of the electron at the second orbit, E2 = -13.6 / 2^2 = -3.4")
disp(wavelength,"the wavelength limit(A.U) = 12400 / Einfinity-E2 =")
```

Chapter 3

Electron Ballistics

Scilab code Exa 3.1 `Speed and the kinetic energy`

```
//Example 3.1
format(8)
q=1.6*10^-19 //charge of electron
V=5000 //potential difference
m=9.1*10^-31 //mass of electron
v=sqrt(2*q*V/m) //speed of electron
disp(v,"Speed of the electron, v(m/s) =sqrt(2*q*V/m)
    =")
ke=(q*V)/(1.6*10^-9) //kinetic energyin eV
x1=ke*10^10
disp(x1,"The kinetic energy(eV)= q x V =")
```

Scilab code Exa 3.2 `Velocity and kinetic energy`

```
//Example 3.2.
format(6)
me=1000*9.1*10^-31
disp(me,"Mass of the charged particle(kg) = 1000
   times the mass of an electron =")
```

```
disp("The charge of the partical = 1.6*10^-19 C")
q=1.6*10^-19 //charge of the particle
V=1000 //potential difference
format(8)
v=sqrt(2*q*V/me)
disp(v,"Therefore, The velocity, v(m/s) = sqrt(2*q*V/me) =")
ke=(q*V)/(1.6*10^-19)  // in eV
disp(ke,"Kinetic energy(eV) = q x V =")
```

Scilab code Exa 3.3 `velocity and time of travel`

```
//Example 3.3.
clc
format(6)
d=6*10^-3
q=1.6*10^-19
m=9.1*10^-31
vax=3*10^6
E=350/d
disp(E,"Therefore, E(V/m) = V / d =")
format(10)
ax=q*E/m
disp(ax,"     ax(m/s^2) = qE / m =")
disp("We know that,")
disp("        x = vox*t + 0.5*a*t^2")
disp("       vx = vox + ax*t")
disp("(i) Consider x = 3*10^-3 m")
disp("3*10^-3 = 3*10^6*t + 5.13*10^15*t^2")
disp("Solving this equation,")
format(9)
t=poly(0,'t')
p1=(5.13*10^15)*t^2+(3*10^6)*t-3*10^-3
t1=roots(p1)
ans1=t1(1)
```

```
disp(ans1,"t(seconds)= ")
format(8)
vx=(3*10^6)+((1.026*10^16)*(5.264*10^-10))
disp(vx,"vx(m/s)= ")
disp("(ii) Consider x = 6*10^-6 m")
disp("t^2+(5.85*10^-10)*t-(1.17*10^-18) = 0")
disp("Solving this equation,")
format(9)
p2=t^2+(5.85*10^-10)*t-1.17*10^-18
t2=roots(p2)
ans2=t2(1)
disp(ans2,"t(seconds)= ")
vx1=(3*10^6)+((8.28*10^-10)*(1.026*10^16))
disp(vx1,"vx(m/s)= ")
```

Scilab code Exa 3.4 `electron velocity time kinetic energy`

```
//Example 3.4.
clc
V=200
m=9.1*10^-31;
q = 1.6*10^-19;
format(8)
v=sqrt(2*q*V/m)
disp("(i)The electron starts from rest at plate A, therefore, the initial velocity is zero. The velocity of electron on reaching plate B is")
disp(v,"v(m/s) = sqrt(2*q*V/m) =")
iv=0 //initial velocity
fv=8.38*10^6 //final velocity
va=(iv+fv)/2 //average velocity of electron in transit
disp("(ii)Time taken by the electron to travel from plate A to plate B can be calculated from the average velocity of the electron in transit.The
```

```
   average velocity is,")
disp(va,"vaverage(m/s) = (Initial velocity + Final
   velocity) / 2 =")
sp=3*10^-3 //separation between the plates
time=sp/va
disp("Therefore, time taken for travel is,")
disp(time,"Time(seconds) = Separation between the
   plates / Average velocity =")
ke=q*V
disp("(iii)Kinetic energy of the electron on
   reaching the plate B is")
disp(ke,"Kinetic energy(Joules) = q V =")
```

Scilab code Exa 3.5 `time of travel`

```
//Example 3.5.
clc
format(9)
vinitial=1*10^6
q=1.6*10^-19
V=300
m=9.1*10^-31
vfinal=10.33*10^6
sp=8*10^-3 //separation between plates
v=sqrt(vinitial^2+(2*q*V/m))
disp("The speed acquired by electron due to the
   applied voltage is")
disp(v,"v(m/s) = sqrt(vinitial^2+(2*q*V/m)) =")
format(8)
va=(vinitial+vfinal)/2
disp("The average velocity,")
disp(va,"vaverage(m/s)= (vinitial + vfinal) / 2 =")
time=sp/va
disp(time,"Therefore, time for travel(seconds)=
   seperation between plates / vaverage =")
```

Scilab code Exa 3.6 position of electron and time

```
//Example 3.6.
clc
format(5)
d=(5*10^11*1.76*10^11)*(((1*10^-9)^3)/6)
x1=d*10^6
disp("The electric field intensity,")
disp("E = -5t / d*10*-9 = -5t / 10^-9*1*10^-2 = 5*10^11*t (for 0 < t < t1)")
disp("   = 0      (for t1 < t < infinity)")
disp("(i) The position of the electron after 1ns,")
disp(x1,"      d(um) = (5*10^11)*(1.76*10^11)*((1*10^-9)^3/6) =")
format(6)
x2=0.8-(d*10^2)
disp(x2,"(ii) The rest of the distance to be covered by the electron = 0.8cm - 14.7 um =")
disp("Since, the potential difference drops to zero volt, after 1ns, the electron will travel the distance of 0.799 cm with a constant velocity of")
vx=(5*10^11*1.76*10^11)*(((1*10^-9)^2)/2)
disp(vx,"vx(m/s) = (5*10^11)*(q/m)*(t^2/2) =")
format(9)
x3=(x2/vx)*10^-2
disp(x3,"Therefore, the time t2(seconds) = d / vx =")
x4=(1*10^-9)+x3
disp(x4,"The total time of transit of electron from cathode to anode(in seconds) =")
```

Scilab code Exa 3.7 `position of the electron`

```
//Example 3.7.
clc
format(8)
q=1.6*10^-19
Va=40
m=9.1*10^-31
B=0.91
ve=sqrt(2*q*Va/m)
disp(ve,"The velocity of the electron is(m/s)= sqrt(2qVa/m) =")
format(7)
tt=(2*%pi*m)/(B*q)
disp(tt,"The time taken for one revolution is T(seconds) = 2*pi*m / B*q =")
format(9)
p=tt*ve*(sqrt(3)/2) //cos(30)=sqrt(3)/2
disp(p,"The pitch(meters) = T*v*cos(theta) =")
disp(p,"Thus, the electron has travelled(meters)= ")
```

Scilab code Exa 3.8 `velocity and radius and time`

```
//Example 3.8
clc
function [radians] = degrees2radians(degrees);
radians = degrees*(%pi/180);
endfunction
radians=degrees2radians(25)
q=1.6*10^-19
m=9.1*10^-31
V=50
Q=3*q
M=2*m
format(8)
```

```
v=sqrt(2*Q*V/M)
disp("(i) The velocity of the charged particle before entering the field is,")
disp(v,"v(m/s) = sqrt(2aV/m) * sqrt(2(3q)V/2m) = sqrt(6qV/2m) =")
B=0.02
format(6)
r=(M*v*sin(radians))/(Q*B)
r1=r*10^3
disp("(ii) The radius of the helical path is")
disp(r1,"r(mm) = Mvsine(theta) / QB = 2mvsine(theta) / 3qB =")
format(9)
T=(2*%pi*M)/(B*Q)
disp("(iii) Time for one revolution,")
disp(T,"T(seconds) = 2*pi*M / B*Q = 2*pi*(2m) / B(3q) =")
```

Scilab code Exa 3.9 `radius and time period of rotation`

```
//Example 3.9.
clc
disp("Given,     T = 35.5/B *10^-12 s, B = 0.01 Wb/m^3, Va = 900V")
disp("Therefore, T = 3.55*10^-9 s")
T = 3.55*10^-9
Va=900
format(9)
v=sqrt(2*(1.76*10^11)*900)
disp(v,"Velocity,  v(m/s) = sqrt(2qVa/m) =")
format(6)
r=(17.799*10^6)/(0.01*1.76*10^11)
x1=r*10^3
disp(x1,"Radius,  r(mm) = mv/qB = v/(q/m)B =")
```

Scilab code Exa 3.10 `velocity and acceleration and deflection`

```
//Example 3.10
clc
Va=600
l=3.5
d=0.8
L=20
Vd=20
format(9)
q=1.6*10^-19
m=9.1*10^-31
v=sqrt(2*q*Va/m)
disp(v,"(i) The velocity of the electron, v(m/s)= ")
format(10)
a=(q/m)*(Vd/d)
a1=a*10^2
disp("(ii) ma = qE")
disp(a1,"Thus, acceleration, a(m/s)= qE / m = (q/m)(Vd/d) =")
format(5)
D=(l*L*Vd)/(2*Va*d)
disp(D,"(iii) The deflection on the screen, D(cm)= ILVd / 2Vad =")
format(7)
Ds=D/Vd
disp(Ds, "(iv) Deflection sensitivity(cm/V)= D / Vd =")
```

Scilab code Exa 3.11 `velocity and deflection of the beam`

```
//Example 3.11.
```

```
clc
q=1.6*10^-19
m=9.1*10^-31
Va=800
l=2
d=0.5
L=20
D=1
format(9)
v=sqrt(2*q*Va/m)
disp(v,"(i) The velocity of the beam, v(m/s)= sqrt(2qVa / m) =")
Vd=(D*2*d*Va)/(l*L)
disp("(ii) The deflection of the beam, D = lLVd / 2dVa")
disp(Vd,"Therefore, the voltage that must be applied to the plates, Vd(V) =")
```

Scilab code Exa 3.12 `velocity and deflection sensitivity and theta`

```
//Example 3.12
clc
format(9)
v=sqrt((2*(1.6*10^-19)*1000)/(9.1*10^-31))
disp(v,"(i) Velocity of beam, v(m/s) = sqrt(2qVa/m) =")
format(6)
D=((2*10^-2)*(20*10^-2)*25)/(2*1000*(0.5*10^-2))
disp("(ii) Deflection sensitivity = D/Vd")
disp(D,"where D(cm) = l*L*Vd / 2*Va*d =")
format(7)
ds=D/25
disp(ds,"Therefore, the deflection sensitivity(cm/V) = ")
theta=atand(1/1800)
```

```
disp("(iii) To find the angle of deflection, theta :")
disp("  tan(theta) = D/L-l")
disp(theta,"Therefore,  theta(in degree) = tan^-1(D/L-l) =")
```

Scilab code Exa 3.13 `time required for maximum height`

```
//Example 3.13.
clc
v0=3*10^5
E=910
theta=60
m=9.109*10^-31
q=1.6*10^-19
format(8)
disp("The electron starts moving in the +y direction, but, since acceleration is along the -y direction, its velocity isreduced to zero at time t=t''")
v0y=v0*cosd(theta)
disp(v0y,"v0y(m/s) = v0 * cos(theta) =")
format(10)
ay=(q*E)/m
disp(ay,"ay(m/s^2) = qE / m =")
format(6)
tdash=v0y/ay
x1=tdash*10^9
disp(x1,"t''(ns) = v0y / ay =")
```

Scilab code Exa 3.14 `deflection of the spot`

```
//Example 3.14.
```

```
clc
format(5)
D=(((2*10^-2)*(1*10^-4)*(20*10^-2))/sqrt(800))*sqrt((1.6*10^-19)/(2*9.1*10^-31))
x1=D*10^2
disp("The deflection of the spot,")
disp(x1,"D(cm) = (IBL/sqrt(Va))*sqrt(q/2m) =")
```

Scilab code Exa 3.15 `deflection voltage`

```
//Example 3.15.
clc
disp("The magnetostatic deflection, D = (IBL/sqrt(Va))*sqrt(q/2m)")
disp("The electrostatic deflection, D = lLVd / 2dVa")
disp("For returning the beam back to the centre, the electrostatic deflection and the magnetostatic deflection must be equal, i.e.,")
disp("(IBL/sqrt(Va))*sqrt(q/2m) = lLVd / 2dVa")
disp("Therefore,")
format(6)
Vd=(1*10^-2*2*10^-4)*sqrt((2*800*1.6*10^-19)/(9.1*10^-31))
disp(Vd,"Vd(V) = dB*sqrt(2*Va*q/m) =")
```

Chapter 4

Semiconductor Diodes

Scilab code Exa 4.1 `intrinsic conductivity for both germanium and silicon`

```
//Example 4.1.
clc
un1=3800 //mobility of free electrons in pure
   germanium
up1=1800 //mobility of free holes in pure germanium
un2=1300 //mobility of free electrons in pure
   silicon
up2=500 //mobility of free holes in pure silicon
q=1.6*10^-19
nig=2.5*10^13
nis=1.5*10^10
format(7)
sigma1=q*nig*(un1+up1)
disp("(i) The intrinsic conductivity for germanium,"
   )
disp(sigma1,"sigmai(S/cm) = q*ni*(un+up) = ")
format(8)
sigma2=q*nis*(un2+up2)
disp("(ii) The intrinsic conductivity for silicon,")
disp(sigma2,"sigmai(S/cm)= q*ni*(un+np) =")
```

Scilab code Exa 4.2 `new position of the fermi level`

```
//Example. 4.2.
clc
disp("The Fermi level in an N-type material is given by")
disp("Ef = Ec - k*T*ln(Nc/Nd)")
disp("(Ec - Ef) = k*T*ln(Nc/Nd)")
disp("At T = 300 K,")
disp("0.3 = 300*k*ln(Nc/Nd)                    Eq.1")
disp("Similarly,")
disp("(Ec - Ef1) = 360*k*ln(Nc/Nd)                    Eq.2")
disp("Eq.2 divided by Eq.1 gives,")
disp("(Ec - Ef1)/0.3 = 360/300")
disp("Therefore,      (Ec - Ef1) = (360/300) x 0.3")
q=(360/300)*0.3
disp(q,"Ec - Ef1= ")
disp("Hence, the new position of the Fermi level lies 0.36 eV below the conduction level")
```

Scilab code Exa 4.3 `new position of the Fermi level for different temperatures`

```
//Example 4.3.
clc
disp("The Fermi level in a P-type material is given by")
disp("Ef = Ev + k*T*ln(Nv/Na)")
disp("Therefore,       (Ef - Ev) = k*T*ln(Nv/Na)")
disp("At T=300 K,       0.3 = 300*k*ln(Nv-Na)                    Eq.1")
```

```
disp("(a) At T=350 K, (Ef1 - Ev) = 350*k*ln(Nv/Na)
                Eq.2")
disp("Hence, from the above Eq.2 and Eq.1,")
disp("(Ef1 - Ev)/0.3 = 350/300")
q1=(350/300)*0.3
disp("eV",q1,"Therefore, (Ef1 - Ev) = (350/300)*0.3
   = ")
disp("(b) At T=400 K, (Ef2 - Ev) = 400*k*ln(Nv/Na)
                Eq.3")
disp("Hence, from the above Eq.3 and Eq.1,")
disp("(Ef2 - Ev)/0.3 = 400/300")
q2=(400/300)*0.3
disp(q2,"Therefore, (Ef2 - Ev) = (400/300)*0.3 = ")
    // in eV
```

Scilab code Exa 4.4 `new position of Fermi level`

```
//Example 4.4.
clc
format(6)
disp("In an N-type material, the concentration of
   donor atoms is given by")
disp("ND = NC*e^(-(EC - EF)/k*T)")
disp("Let initially ND = ND0, EF = EF0 and EC - EF0
   = 0.2 eV")
disp("Therefore,     ND0 = NC*e^(-0.2/0.025) = NC*e
   ^-8")
disp("(a) When ND = 4ND0 and EF = EF1, then")
disp("4*ND0 = NC*e^(-(EC-EF1)/0.025) = NC*e^-40(EC -
    EF1)")
disp("Therefore,     4*NC*e^-8 = NC*e^-40(EC - EF1)")
disp("Therefore,     4 = e^(-40*(EC - EF1)+8)")
disp("Taking natural logarithm on both sides, we get
   ")
disp("ln 4 = -40(EC - EF1) + 8")
```

```
q1=(8-log(4))/40
disp(q1,"EC - EF1(in eV) = ")
disp("(b) When ND=8*ND0 and EF = EF2, then")
disp("ln 8 = -40*(EC - EF2) + 8")
q2=(8-log(8))/40
disp(q2,"EC - EF2(in eV) = ")
```

Scilab code Exa 4.5 `new position of Fermi level`

```
//Example 4.5.
clc
disp("In an P-type material, the concentration of acceptor atoms is given by")
disp("NA = NV*e^(-(EF - EV)/k*T)")
disp("Let initially NA = NA0, EF = EF0 and EF0 - EV = 0.4 eV")
disp("Therefore,     NA0 = NV*e^(-0.4/0.025) = NV*e^-16")
disp("(a) When NA = 0.5*NA0 and EF = EF1, then")
disp("0.5*NA0 = NV*e^(-(EF1-EV)/0.025) = NV*e^-40(EF1 - EV)")
disp("Therefore,     0.5*NV*e^-16 = NV*e^-40(EF1 - EV)")
disp("Therefore,     0.5 = e^(-40*(EF1 - EV)+16)")
disp("Taking natural logarithm on both sides, we get")
disp("ln (0.5) = -40(EF1 - EV) + 16")
q1=(16-log(0.5))/40
disp(q1,"EF1 - EV(in eV) = ")
disp("(b) When NA=4*NA0 and EF = EF2, then")
disp("ln 4 = -40*(EF2 - EV) + 16")
q2=(16-log(4))/40
disp(q2,"EF2 - EV(in eV) = ")
```

Scilab code Exa 4.6 `conductivity of silicon`

```
//Example 4.6.
clc
ni=1.5*10^10
un=1300
up=500
q=1.6*10^-19
nos=5*10^22
disp("(a) In intrensic condition, n=p=ni")
disp("Hence, sigma_i = q*ni*(un+up)")
format(8)
sigma_i = q*ni*(un+up)
disp(sigma_i,"sigma_i(S/cm) = ")
disp("(b) Number of silicon atoms/cm^3 = 5*10^22")
ND=5*10^22/10^8
disp(ND,"Hence, ND(cm^-3) = ")
disp("Further, n = ND")
disp("Therefore,    p = ni^2/n = ni^2/ND")
p=ni^2/ND
disp(p,"p(cm^-3) = ")  // wrong answer in textbook
disp("Thus p << n. Hence p may be neglected while
   calculating the conductivity.")
disp("Hence,       sigma = n*q*un = ND*q*un")
sigma=ND*q*un
disp(sigma,"sigma(S/cm) = ")
NA=(5*10^22)/(5*10^7)
disp(NA,"(c) NA(cm^-3) = ")
disp("Further, p = NA")
disp("Hence,      n = ni^2/p = ni^2/NA")
n=ni^2/NA
disp(n,"n(cm^-3)= ")
disp("Thus p >> n. Hence n may be neglected while
   calculating the conductivity.")
```

```
disp("Hence,      sigma = p*q*up = NA*q*up")
sigma1=NA*q*up
disp(sigma1,"sigma(S/cm) = ")
disp("(d) With both types of impurities present simultaneously, the net acceptor impurity density is,")
Na=NA-ND
disp(Na,"Na(cm^-3) = NA - ND = ")
disp("Hence,      sigma = Na*q*up")
sigma2=Na*q*up
disp(sigma2,"sigma(S/cm) = ")
```

Scilab code Exa 4.7 `resistivity of germanium`

```
//Example 4.7.
clc
ni=2.5*10^13
un=3800
up=1800
nog=4.4*10^22
q=1.6*10^-19
format(8)
sigma=q*ni*(un+up)
disp("(a) n = p = ni = 2.5*10^13 cm^-3")
disp(sigma,"Therefore,  conductivity(S/cm),  sigma = q*ni*(un+np) =")
format(6)
rho=1/sigma
disp(rho,"Hence,  resistivity(ohm-cm)   rho = 1 / sigma =")
format(8)
ND=(4.4*10^22)/10^7
disp(ND,"(b) ND(cm^-3) = ")
format(9)
p=ni^2/ND
```

```
disp("Also, n = ND")
disp(p,"Therefore, p(holes/cm^3) = ni^2 / n = ni^2 / ND =")
disp("Here, as n >> p, p can be neglected.")
format(6)
sigma1=ND*q*un
disp(sigma1,"Therefore, conductivity(S/cm), sigma = n*q*un = ND*q*un =")
rho1=1/sigma1
disp(rho1,"Hence, resistivity(ohm-cm), rho = 1 / sigma =")
format(8)
NA=(4.4*10^22)/10^8
disp(NA,"(c) NA(cm^-3) = ")
disp("Also, p = NA")
format(9)
n=ni^2/NA
disp(n,"Therefore, n(electrons/cm^3) = ni^2 / p = ni^2 / NA =")
format(7)
sigma2=NA*q*up
disp("Here, as p >> n, n may be neglected. Then,")
disp(sigma2,"Conductivity(S/cm), sigma = p*q*up = NA*q*up =")
format(5)
rho2=1/sigma2
disp(rho2,"Hence, resistivity(ohm-cm), rho = 1 / sigma = ")
format(9)
disp("(d) with both p and n type impurities present,")
disp("      ND = 4.4*10^15 cm^-3 and NA = 4.4*10^14 cm^-3")
disp("Therefore, the net donor density ND'' is")
Nd=ND-NA
disp(Nd,"ND''(cm^-3) = (ND - NA) =")
disp("Therefore, effective n = ND'' = 3.96*10^15 cm^-3")
```

```
format(10)
p1=ni^2/Nd
disp(p1,"p(cm^-3) = ni^2 / N''D =")
disp("Here again p(= ni^2 / N''D) is very small compared with N''D and may be neglected in calculating the effective conductivity.")
format(6)
sigma3=Nd*q*un
disp(sigma3,"Therefore, conductivity(S/cm), sigma = ND''*q*un =")
rho3=1/sigma3
disp(rho3,"Hence, resistivity(ohm-cm), rho = 1 / sigma =")
```

Scilab code Exa 4.8 `otal conduction current density`

```
//Example 4.8
clc
un=1250
up=475
q=1.6*10^-19
sigma_i=1/(25*10^4)
format(9)
ni=1/((25*10^4)*(1.6*10^-19)*(1250+475))
disp("  sigma_i = qni(un+up) = 1 / 25*10^4")
disp(ni,"Therefore, ni = sigma_i / q(un+up) =")
format(7)
ND=(4*10^10)-10^10
disp(ND,"Net donor density, ND(= n)(in cm^-3) = ")
p=ni^2/ND
disp(p,"Hence, p(cm^-3) = ni^2 / ND =")
format(8)
sigma=(1.6*10^-19)*((1250*3*10^10)+(475*0.7*10^10))
disp(sigma,"Hence, sigma = q*(n*un + p*up) =")
format(11)
```

```
J=6.532*4*10^-6
disp(J,"Therefore, total conduction current density, J(A/cm^2) = sigma*E =")
```

Scilab code Exa 4.9 concentration of holes and electrons

```
//Example 4.9.
clc
ni=1.5*10^10
un=1300
up=500
q=1.6*10^-19
sigma=300
disp("(a) Concentration in N-type silicon")
format(10)
n=sigma/(q*un)
disp("The conductivity of an N-type Silicon is sigma = q*n*un")
disp(n,"Concentratoin of electrons, n(cm^-3) = sigma / q*un =")
p=ni^2/n
disp(p,"Hence, concentration of holes, p(cm^-3) = ni^2 / n =")
disp("(b) Concentration in P-type silicon")
p=sigma/(q*up)
disp("The conductivity of a P-type Silicon is sigma = q*p*up")
disp(p,"Hence, concentratoin of holes, p(cm^-3) = sigma / q*up =")
n=ni^2/p
disp(n,"and concentration of electrons, n(cm^-3) = ni^2 / p =")
```

Scilab code Exa 4.10 `resistivity and resistance and the voltage of the doped germa`

```
//Example 4.10.
clc
format(8)
ND=(4.2*10^28)/10^6
disp(ND,"Density of added impurity atoms is, ND(atoms/m^3) = ")
ni=2.5*10^19
format(10)
p=ni^2/ND
disp("Also, n = ND")
disp(p,"Therefore, p(m^-3) = ni^2 / n = ni^2 / ND = ")
disp("Here, as p << n, p may be neglected.")
q=1.6*10^-19
un=0.38
sigma=q*ND*un
disp(sigma,"Therefore, sigma(S/m) = q*ND*un =")
format(9)
rho=1/sigma
disp(rho,"Therefore, resistivity, rho(ohm-m) = 1 / sigma =")
format(5)
L=5*10^-3
A=5*10^-6
R=(rho*L)/A^2
R1=R*10^-3
disp(R1,"Resistance, R(k.ohm) = rho*L / A =")
I=10^-6
V=R*I
V1=V*10^3
disp(V1,"Voltage drop, V(mV) = RI =")
```

Scilab code Exa 4.11 `calculate Va and Eo`

```
//Example 4.11.
clc
q=1.6*10^-19
ni=2.5*10^13
up=1800
un=3800
VT=0.026
rho=6
format(9)
NA=1/(6*q*up)
disp("(a) Resistivity, rho = 1 / sigma = 1 / NA*q*up = 6 ohm-cm")
disp(NA,"Therefore, NA(1/cm^3) = 1 / 6*q*up =")
ND=1/(4*q*un)
disp(ND,"Similarly, ND(1/cm^3) = 1 / 4*q*un =")
format(7)
Va=VT*log((ND*NA)/ni^2)
disp(Va,"Therefore, Va(V) = VT*ln(ND*NA / ni^2) =")
disp(Va,"Hence, Eo(eV) = ")
Va1=0.026*log((2*ND*2*NA)/ni^2)
disp(Va1,"(b) Vo(V) = 0.026*ln(2*ND*2*NA / ni^2) =")
disp(Va1,"Therefore, Eo(eV) = ")
```

Scilab code Exa 4.12 `current flowing in the diode`

```
//Example 4.12.
clc
format(7)
Ia=0.3*10^-6
VF=0.15
I=Ia*((%e^(40*VF))-1)
I1=I*10^6
disp("The current flowing through the PN diode under forward bias is,")
disp(I1,"I(uA) = Io*(e^40*VF - 1) =")
```

Scilab code Exa 4.13 `calculate the diode current`

```
//Example 4.13.
clc
format(7)
VF=0.6
T=298
Io=10^-5
eta=2
VT=T/11600
disp("The volt−equivalent of the temperature(T) is,")
disp(VT,"VT(V) = T / 11600 = ")
format(6)
I=Io*((%e^((VF/(eta*VT))))-1)
disp(I,"Therefore, the diode current, I(A) = Io∗e^((VF/eta∗VT)−1) =")
```

Scilab code Exa 4.14 `determine eta`

```
//Example 4.14
clc
format(5)
disp("The diode current,      I=Io∗((e^((q∗V)/(eta∗k∗T)))−1)")
disp("Therefore, 0.6∗10^−3 = Io∗((e^((q∗V)/(eta∗k∗T)))−1) = Io∗(e^((q∗V)/(eta∗k∗T)))")
disp("                         = Io∗e^(400/25∗eta) = Io∗e^(16/eta)          Eq.1")
disp("Also,          20∗10^−3 = Io∗e^(500/25∗eta) = Io∗e^(20/eta)          Eq.2")
```

```
disp(”Dividing Eq.2 by Eq.1, we get”)
disp(”100/3 = e^(4/eta)”)
disp(”Taking natural logarithms on both sides, we get”)
disp(”   loge (100/3) = 4 / eta”)
disp(”          3.507 = 4 / eta”)
eta=4/log(100/3)
disp(eta,”Therefore,  eta = ”)
```

Scilab code Exa 4.15 `the voltage in a germanium PN junction diode`

```
//Example 4.15.
clc
format(5)
disp(”The current of PN junction diode is,”)
disp(”I = Io*(e^(V/VT)-1)”)
disp(”Therefore,    -0.09*Io = Io*(e^(V/VT)-1)”)
disp(”where    VT = T/11600 = 26mV”)
disp(”         -0.9 = e^(V/0.026) - 1”)
disp(”          0.1 = e^(V/0.026)”)
VT=0.026
V=log(0.1)*VT
disp(V,”Therefore,  V(V) = ”)
```

Scilab code Exa 4.16 `forward resistance of PN junction diode`

```
//Example 4.16.
clc
format(6)
I=5*10^-3
T=300
```

```
disp("Forward resistance of a PN junction diode, rf = (eta*VT)/I  where VT = T/11600 and eta = 2 for silicon")
disp("Therefore,  rf = 2*(T/11600) / 5*10^-3")
eta=2 //for silicon
rf=600/(11600*5*10^-3)
disp(rf,"     rf(ohm) = ")
```

Scilab code Exa 4.17 `Calculating the saturation current`

```
//Example 4.17.
clc
format(6)
Io1=7.5*10^-6
T1=27
T2=127
disp("The saturation current at 400 K is,")
disp("Io2 = Io1 * 2^((T2-T1)/10)")
disp("     = 7.5*10^-6 * 2^(127-27/10)")
Io2=Io1*(2^((T2-T1)/10))
I=Io2*10^3
disp(I,"Io2(mA) = ")
```

Chapter 5

Special Diodes

Scilab code Exa 5.1 `barrier height and built in potential`

```
//Exmaple 5.1.
clc
format(6)
thetaM=4.26 //work function
chi=4.01 //electron affinity
thetaBN=thetaM-chi
disp("The barrier height for N-type material is,")
disp(thetaBN,"    Theta_BN(V) = Theta_M - Chi = ")
thetaIN=thetaBN-((((1.38*10^-23)*300)/(1.6*10^-19)))*log((2.8*10^25)/(4*10^17))
disp("The built-in potential is given by,")
disp(thetaIN,"    Theta_IN(V) = Theta_BN - (kT/q)*ln(NC/ND) =")  // answer in the textbook is wrong, even if we take log10 we get a answer 0.047.
```

Chapter 6

Bipolar junction transistor

Scilab code Exa 6.1 `find value of the base current IB`

```
//Example 6.1.
clc
format(5)
IE=10
IC=9.8
disp("The emitter current is,")
disp("IE = IB + IC")
disp("10 = IB + 9.8")
IB=IE-IC
disp(IB,"Therefore,     IB(mA) = ")
```

Scilab code Exa 6.2 `common base dc current gain`

```
//Example 6.2.
clc
format(6)
IE=6.28
IC=6.20
```

```
disp("The common−base d.c. current gain,")
alpha=IC/IE
disp(alpha,"alpha = IC/IE =")
```

Scilab code Exa 6.3 `find value of base current`

```
//Example 6.3.
clc
format(6)
alpha=0.967
IE=10
disp("The common−base d.c. current gain (alpha) is,"
  )
disp("alpha = 0.967 = IC/IE = IC/10")
IC=alpha*IE
disp(IC,"Therefore,    IC(mA) = ")
disp("The emitter current,    IE = IB + IC")
IB=IE-IC
disp(IB,"Therefore,    IB(mA) = ")
```

Scilab code Exa 6.4 `find values of IC and IB`

```
//Example 6.4.
clc
format(6)
IE=10
alpha=0.98
disp("The common−base d.c. current gain, alpha = IC/
  IE")
IC=alpha*IE
disp(IC,"Therefore,  IC(mA) = ")
disp("The emitter current, IE = IB + IC")
IB=IE-IC
```

```
disp(IB,"Therefore,   IB(mA) = ")
```

Scilab code Exa 6.5 `find value of beta and alpha`

```
//Example 6.5.
clc
format(6)
alpha=0.97
disp("If alpha=0.97, beta = alpha/(1 - alpha)")
beta=alpha/(1-alpha)
disp(beta,"beta = ")
beta1=200
disp("If beta=200, alpha = beta/(beta + 1)")
alpha1 =beta1/(beta1+1)
disp(alpha1,"alpha = ")
```

Scilab code Exa 6.6 `find value of emitter current`

```
//Example 6.6.
clc
format(6)
beta=100
IC=40
disp("beta = 100 = IC / IB")
IB=IC/beta
disp(IB,"Therefore,     IB(mA) = ")
disp("IE = IB + IC")
IE=IB+IC
disp(IE,"IE(mA) = ")
```

Scilab code Exa 6.7 collector and base currents

```
//Example 6.7.
clc
format(6)
beta=150
IE=10
alpha=beta/(beta+1)
disp(alpha,"The common-base current gain, alpha = beta / (beta + 1) = ")
disp("Also,    alpha = IC / IE")
format(5)
IC=alpha*IE
disp(IC,"Therefore,    IC(mA) = ")
disp("the emitter current,    IE = IB + IC")
IB=IE-IC
disp(IB,"Therefore,    IB(mA) = ")
```

Scilab code Exa 6.8 calculate IB and IE

```
//Example 6.8.
clc
format(5)
beta=170
IC=80
disp("We know that (beta),  beta = 170 = IC / IB")
IB=IC/beta
disp(IB,"Therefore,    IB(mA) = ")
format(6)
IE=IB+IC
disp(IE,"and    IE(mA) = IB + IC = ")
```

Scilab code Exa 6.9 determine IC and IE

```
//Example 6.9.
clc
format(7)
IB=0.125
beta=200
disp("beta = 200 = IC / IB")
IC=beta*IB
disp(IC,"Therefore,    IC(mA) = ")
IE=IB+IC
disp(IE,"and    IE(mA) = IB + IC = ")
```

Scilab code Exa 6.10 `determine IC and IB`

```
//Example 6.10
clc
format(7)
IE=12
beta=100
IB=IE/(1+beta)
disp(IB,"We know that base current,  IB(mA) = IE / (1 + beta) = ")
format(8)
IC=IE-IB
disp(IC,"and collector current,  IC(mA) = IE - IB = ")
```

Scilab code Exa 6.11 `beta and alpha and IE`

```
//Example 6.11
clc
format(6)
IB=100*10^-6
IC=2*10^-3
```

```
beta=IC/IB
disp(”(a) To find beta of the transistor ”)
disp(beta,”beta = IC / IB =”)
alpha=beta/(beta+1)
disp(”(b) To find alpha of the transistor”)
disp(alpha,”alpha = beta / (1+beta) =”)
IE=IB+IC
IE1=IE*10^3
disp(”(c) To find emitter current, IE”)
disp(IE1,”IE(mA) = IB + IC =”)  // answer in the textbook is wrong
disp(”(d) To find the new value of beta when delta_IB = 25uA and delta_IC = 0.6mA”)
delta_IB=25*10^-6
delta_IC=0.6*10^-3
IB1=IB+delta_IB
IB11=IB1*10^6
IC1=IC+delta_IC
IC11=IC1*10^3
disp(IB11,”Therefore,  IB(uA) = ”)
disp(IC11,”             IC(mA) = ”)
beta1=IC1/IB1
disp(”New value of beta of the transistor,”)
disp(beta1,”beta = IC / IB = ”)
```

Scilab code Exa 6.12 `find IC and IE`

```
//Example 6.12.
clc
format(6)
alpha=0.98
ICO=5*10^-6
ICBO=ICO
IB=100*10^-6
IC=((alpha*IB)/(1-alpha))+(ICO/(1-alpha))
```

```
IC1=IC*10^3
disp(IC1,"The collector current is, IC(mA) = ((alpha*IB)/(1-alpha))+(ICO/(1-alpha))")
IE=IB+IC
IE1=IE*10^3
disp(IE1,"The emitter current is, IE(mA) = IB + IC = ")
```

Scilab code Exa 6.13 `IC and new collector current`

```
//Example 6.13.
clc
format(6)
ICBO=10*10^-6
hFE=50
beta=hFE
IB=0.25*10^-3
IC=(beta*IB)+((1+beta)*ICBO)
IC1=IC*10^3
disp("(a) To find the value of collector current when IB = 0.25mA")
disp(IC1,"IC(mA) = (beta*IB) + ((1+beta)*ICBO)")
T1=27
T2=50
format(5)
I_CBO = ICBO * (2^((T2-T1)/10))
I_CBO1=I_CBO*10^6
disp("(b) To find the value of new collector current if temperature rises to 50 C")
disp(I_CBO1,"I''CBO(beta=50)(in uA) = ICBO*(2^((T2-T1)/10)) = ")
format(6)
IC2=(beta*IB)+((1+beta)*I_CBO)
IC3=IC2*10^3
disp("Therefore, the collector current at 50 C is")
```

```
disp(IC3,"IC(mA) = (beta*IB) + ((1+beta)*I''CBO) = ")
```

Scilab code Exa 6.14 `find the current gain`

```
//Example 6.14.
clc
format(6)
delta_IC=0.99*10^-3
delta_IE=1*10^-3
alpha=delta_IC/delta_IE
disp(alpha,"The current gain of the transistor is alpha = delta_IC/delta_IE = ")
```

Scilab code Exa 6.15 `dc current gain in CB mode`

```
//Example 6.15
clc
format(5)
beta_dc=100
alpha_dc=beta_dc/(1+beta_dc)
disp(alpha_dc,"The d.c. current gain of the transistor in CB mode is , alpha_dc = beta_dc/(1+beta_dc) = ")
```

Scilab code Exa 6.16 `current gain alpha and beta`

```
//Example 6.16.
clc
format(6)
```

```
delta_IC=0.995*10^-3
delta_IE=1*10^-3
alpha=delta_IC/delta_IE
disp(alpha,"Common base current gain is, alpha =
    delta_IC/delta_IE = ")
beta=alpha/(1-alpha)
disp(beta,"Common-emitter current gain is beta =
    alpha / (1-alpha) = ")
```

Scilab code Exa 6.17 `current gain and base current`

```
//Example 6.17.
clc
format(6)
beta=49
alpha=beta/(1+beta)
disp("We know that,  alpha = beta/(1+beta)")
disp(alpha,"Therefore, the common base current gain
    is, alpha = ")
disp("We also know that, alpha = IC / IE")
IE=3*10^-3
IC=alpha*IE
IC1=IC*10^3
disp(IC1,"Therefore,  IC(mA) = alpha * IE = ")
```

Scilab code Exa 6.18 `determine IC and IE and alpha`

```
//Example 6.18.
clc
format(6)
IB=15*10^-6
beta=150
IC=beta*IB
```

```
IC1=IC*10^3
disp(IC1,"The collector current, IC(mA) = beta * IB = ")
IE=IC+IB
IE1=IE*10^3
disp(IE1,"The emitter current, IE(mA) = IC + IB = ")
format(7)
alpha=beta/(1+beta)
disp(alpha,"Common-base current gain, alpha = beta/(1+beta) = ")
```

Scilab code Exa 6.19 `IB IC IE and VCE`

```
//Example 6.19.
clc
format(6)
disp("Referring to fig.6.18, the base current is,")
VBB=4
VBE=0.7
RB=200*10^3
IB=(VBB-VBE)/RB
IB1=IB*10^6
disp(IB1,"IB(uA) = (VBB - VBE) / RB = ")
beta=200
IC=beta*IB
IC1=IC*10^3
disp(IC1,"The collector current is, IC(mA) = beta*IB = ")
format(7)
IE=IC+IB
IE1=IE*10^3
disp(IE1,"The emitter current is, IE(mA) = IC + IB = ")
format(6)
VCC=10
```

```
RC=2*10^3
VCE=VCC-(IC*RC)
disp(VCE,"Therefore,  VCE(V) = VCC - IC*RC = ")
```

Scilab code Exa 6.20 `calculate IC and IE`

```
//Example 6.20.
clc
format(6)
alpha_dc=0.99
ICBO=5*10^-6
IB=20*10^-6
IC=((alpha_dc*IB)/(1-alpha_dc))+(ICBO/(1-alpha_dc))
IC1=IC*10^3
disp(IC1,"IC(mA) = ((alpha_dc*IB)/(1-alpha_dc)) + (
    ICBO/(1-alpha_dc)) = ")
IE=IB+IC
IE1=IE*10^3
disp(IE1,"Therefore,  IE(mA)= IB + IC = ")
```

Scilab code Exa 6.21 `alpha dc and beta dc`

```
//Example 6.21.
clc
format(6)
ICBO=0.2*10^-6
ICEO=18*10^-6
IB=30*10^-3
disp("The leakage current  ICBO = 0.2 uA")
disp("                     ICEO = 18 uA")
disp("Assume that          IB = 30 mA")
disp("IE = IB + IC")
disp("IC = IE - IB = (beta*IB)+((1+beta)*ICBO)")
```

```
disp(”We know that,  ICEO = ICBO/(1-alpha) = (1+beta)*ICBO”)
beta=(ICEO/ICBO)-1
disp(beta,”beta = (ICEO / ICBO)-1 = ”)
IC=(beta*IB)+((1+beta)*ICBO)
disp(IC,”IC(A) = (beta*IB) + ((1+beta)*ICBO) = ”)
alpha_dc=1-(ICBO/ICEO)
disp(alpha_dc,”alpha_dc = 1 - (ICBO / ICEO) = ”)
format(4)
beta_dc=(IC-ICBO)/(IB-ICEO)
disp(beta_dc,”beta_dc = (IC-ICBO) / (IB-ICEO) = ”)
```

Scilab code Exa 6.22 `find emitter current`

```
//Example 6.22.
clc
format(6)
alpha_dc=0.99
ICBO=50*10^-6
IB=1*10^-3
IC=((alpha_dc*IB)/(1-alpha_dc))+(ICBO/(1-alpha_dc))
IC1=IC*10^3
disp(”Assume that,  IB = 1 mA”)
disp(IC1,”IC(mA) = ((alpha_dc*IB) / (1-alpha_dc)) + (ICBO/(1-alpha_dc)) = ”)
IE=IC+IB
IE1=IE*10^3
disp(IE1,”IE(mA) = IC + IB = ”)
```

Scilab code Exa 6.23 `dc and ac load line and operating point`

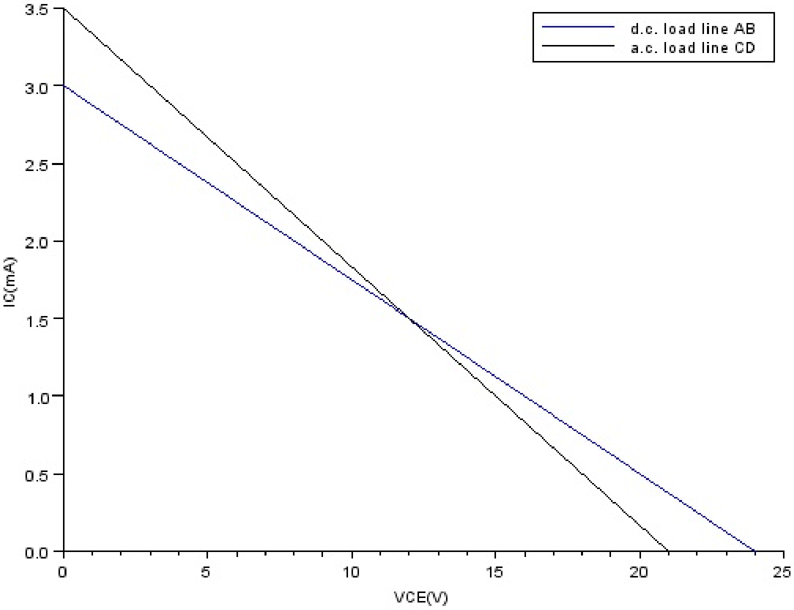

Figure 6.1: dc and ac load line and operating point

```
//Example 6.23.refer fig.6.22(a)
clc
format(6)
disp(”(i) DC load line:”)
disp(”Refer fig.6.22(a), we have VCC = VCE + IC∗RC”)
disp(”To draw the d.c. load line,we need two end points, viz. maximum VCE point(at IC = 0) and maximum IC point(at VCE = 0)”)
disp(”Maximum VCE = VCC = 24V”)
IC=24/(8*10^3)  //in Ampere
x1=IC*10^3  //in mA
disp(x1,”Maximum IC(mA) = VCC / RC =”)
disp(”Therefore, the d.c. load line AB is drawn with the point B(OB = 24V) on the VCE axis and the point A(OA = 3mA) on the IC axis, as shown in fig.6.22(b)”)
disp(””)
disp(”(ii) For fixing the optimum operating point Q, mark the middle of the d.c. load line AB and the corresponding VCE and IC values can be found”)
VCEQ=24/2
disp(VCEQ,”Here,    VCEQ(V) = VCC / 2 =”) //in volts
disp(”          ICQ = 1.5 mA”)
disp(””)
disp(”(iii) AC load line”)
disp(”To draw the a.c. load line, we need two end points, viz. maximum VCE and maximum IC when signal is applied”)
Rac=(8*24)/(8+24) //in k–ohm
disp(Rac,”AC load,   R_a.c.(k–ohm) = RC || RL =”)
VCE=12+((1.5*10^-3)*(6*10^3)) //in Volts
disp(VCE,”Therefore, maximum VCE(V) = VCEQ + ICQ∗R_a.c. =”)
disp(”This locates the point D(OD = 21V) on the VCE axis”)
IC=(1.5*10^-3)+(12/(6*10^3))  //in Ampere
x3=IC*10^3  //in mA
disp(x3,”Maximum IC(mA) = ICQ + VCEQ/R_a.c. =”)
```

```
disp("This locates the point C(OC = 3.5mA) on the IC
     axis. By joining points C and D a.c. load line
   CD is constructed. ")
x=[24,0]
y=[0,3]
plot2d(x,y,style=2)
x1=[21,0]
y1=[0,3.5]
plot2d(x1,y1,style=1)
legend("d.c. load line AB","a.c. load line CD")
title("Fig.6.22(b)")
xlabel("VCE(V)")
ylabel("IC(mA)")
```

Scilab code Exa 6.24 `ac and dc load line and operating point`

```
//Example 6.24. refer fig.6.23(a).
clc
format(6)
disp("(i) DC load line:")
disp("Refer fig.6.23(a), we have VCC = VCE + IC*(RC+
   RE)")
disp("To draw the d.c. load line,we need two end
   points, viz. maximum VCE point(at IC = 0) and
   maximum IC point(at VCE = 0)")
disp("Maximum VCE = VCC = 12V, which locates the
   point B(OB = 12V) of the d.c. load line")
IC=12/(2*10^3)   //in Ampere
x1=IC*10^3   //in mA
disp(x1,"Maximum  IC(mA) = VCC / (RC+RE) =")
disp("This locates the point A(OA = 6mA) of the d.c.
     load line. Fig.6.23(b) shows the d.c. load line
   AB, with (12V,6mA)")
```

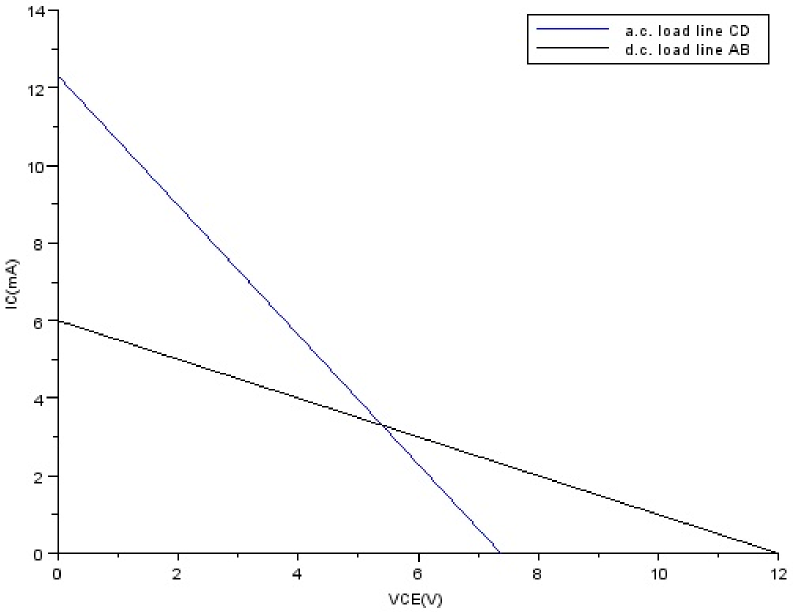

Figure 6.2: ac and dc load line and operating point

```
disp("")
disp("(ii) Operating point Q")
disp("The voltage across  R2 is V2 = (R2/R1+R2)*VCC")
V2=((4*10^3)/(12*10^3))*12  //in V
disp(V2,"Therefore,    V2(V) =")
disp("         V2 = VBE + IE*RE")
IE=(4-0.7)/(1*10^3)  //in Ampere
x2=IE*10^3  //in mA
disp(x2,"Therefore,  IE(mA) = V2-VBE / RE =")
IC=x2 //in mA
disp(IC,"          IC(mA) = IE(mA) = ")
VCE=12-((3.3*10^-3)*(2*10^3)) //in volts
disp(VCE,"VCE(V) = VCC - IC(RC+RE) =")
disp("Therefore, the operating point Q is at 5.4V and 3.3mA, which is shown on the d.c. load line")
disp("")
disp("(iii) AC load line")
disp("To draw the a.c. load line, we need two end points, viz. maximum VCE and maximum IC when signal is applied")
Rac=1.5/2.5 //in k-ohm
disp(Rac,"AC load,   Ra.c.(k-ohm) = RC || RL =")
VCE=5.4+((3.3*10^-3)*(0.6*10^3)) //in Volts
disp(VCE,"Therefore, maximum VCE(V) = VCEQ + ICQ*Ra.c. =")
disp("This locates the point C(OC = 6.24V) on the VCE axis")
IC=(3.3*10^-3)+(5.4/(0.6*10^3))  //in Ampere
x3=IC*10^3  //in mA
disp(x3,"Maximum  IC(mA) = ICQ + VCEQ/Ra.c. =")
disp("This locates the point D(OD = 12.3mA) on the IC axis. By joining points C and D a.c. load line  CD is constructed. ")
x=[7.38,0]
y=[0,12.3]
plot2d(x,y,style=2)
x1=[12,0]
```

```
y1=[0,6]
plot2d(x1,y1,style=1)
legend("a.c. load line CD","d.c. load line AB")
title("Fig.6.23(b)")
xlabel("VCE(V) -->")
ylabel("IC(mA) -->")
```

Scilab code Exa 6.25 `Design circuit in fig 6 24`

```
//Example 6.25.
clc
format(6)
ICQ=1*10^-3
VCEQ=6
VCC=10
beta=100
VBE=0.7
RC=(VCC-VCEQ)/ICQ
RC1=RC*10^-3
RC2=round(RC1)
disp(RC2,"The collector resistance is, RC(k-ohm) = (VCC - VCEQ) / ICQ = ")
IBQ=ICQ/beta
IBQ1=IBQ*10^6
disp(IBQ1,"The base current is, IBQ(uA) = ICQ / beta = ")
RB=(VCC-VBE)/IBQ
RB1=RB*10^-6
disp(RB1,"The base resistance is, RB(M-ohm) = (VCC - VBE(on)) / IBQ = ")
```

Scilab code Exa 6.26 `characteristics circuit in fig 6 25`

```
//Example 6.26.
clc
format(6)
beta=100
VBE=0.7
VCC=10
RB=20*10^3
RC=0.4*10^3
RE=0.6*10^3
VBB=5
disp("Referring to fig.6.25, Kirchhoff voltage law equation is,")
disp("VBB = IB*RB + VBE(on) + IE*RE")
disp("Also,  IE = IB + IC = IB + beta*IB = (1 + beta)*IB")
IB=(VBB-VBE)/(RB+((1+beta)*RE))
IB1=IB*10^6
disp(IB1,"The base current,  IB(uA) = (VBB - VBE(on)) / (RB + ((1+beta)*RE)) = ")
IC=beta*IB
IC1=IC*10^3
disp(IC1,"Therefore,  IC(mA) = beta*IB = ")
IE=IC+IB
IE1=IE*10^3
disp(IE1,"IE(mA) = IC + IB")
VCE=VCC-(IC*RC)-(IE*RE)
disp(VCE,"VCE(V) = VCC - (IC*RC) - (IE*RE) = ")
disp("The Q point is at")
disp(VCE,"VCEQ(V) = ")
disp(IC1,"and ICQ(mA) = ")
```

Scilab code Exa 6.27 `dc load line and operating point and S`

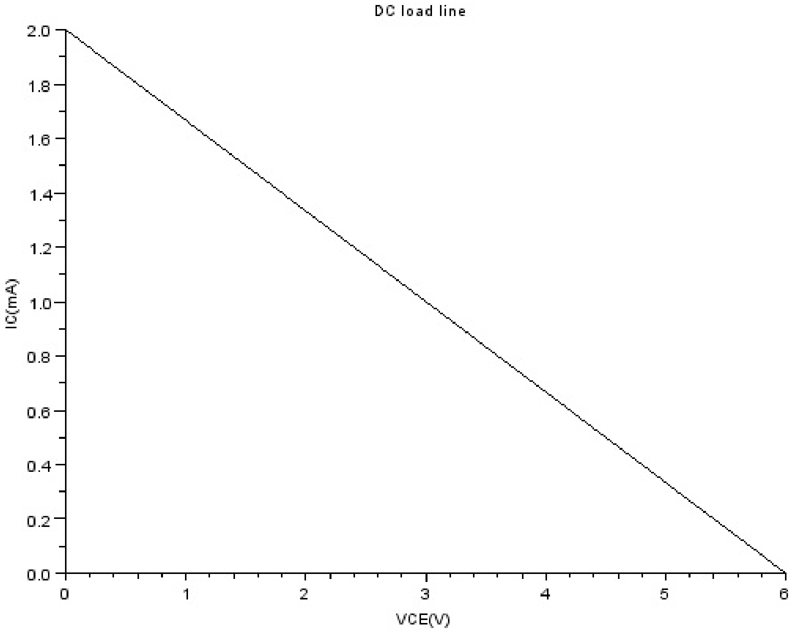

Figure 6.3: dc load line and operating point and S

```
//Example 6.27. refer fig.6.26.
clc
format(6)
disp("(i) DC load line:")
disp("      VCE = VCC - IC*RC")
disp("When  IC = 0, VCE = VCC = 6V")
IC=6/(3*10^3) //in Ampere
x1=IC*10^3  //in mA
disp(x1,"When  VCE = 0, IC(mA) = VCC/RC =")
disp("")
disp("(ii) Operating point Q:")
disp("     For silicon transistor,  VBE = 0.7V")
disp("                              VCC = IB*RB + VBE")
IB=(6-0.7)/(530*10^3)
x2=IB*10^6
disp(x2,"Therefore,                 IB(uA) = VCC-VBE / RB =")
IC=100*10*10^-6 // in Ampere
x3=IC*10^3 // in mA
disp(x3,"Therefore,                 IC(mA) = beta*IB =")
VCE=6-((1*10^-3)*(3*10^3)) // in volts
disp(VCE,"                            VCE(V) = VCC - IC*RC =")
disp("Therefore operating point is VCEQ = 3 V and ICQ = 1 mA")
disp("")
disp("(iii) Stability factor:    S = 1 + beta = 1 + 100 = 101")
x=[6,0]
y=[0,2]
plot2d(x,y,style=1)
xtitle("DC load line","VCE (V) --->","IC (mA) --->")
```

Scilab code Exa 6.28 `RB and S and operating point`

```
// Example 6.28.
clc
format(6)
VCC=12
beta=100
VBE=0.7
disp("Refer fig.6.26. We know that for a silicon transistor, VBE = 0.7 V")
disp("(a) To determine RB :")
VCE=7
IC=1*10^-3
RC=(VCC-VCE)/IC
RC1=RC*10^-3
disp(RC1,"RC(k-ohm) = (VCC - VCE) / IC = ")
IB=IC/beta
IB1=IB*10^6
disp(IB1,"IB(uA) = IC / beta = ")
RB=(VCC-VBE-(IC*RC))/IB
RB1=RB*10^-3
disp(RB1,"RB(k-ohm) = (VCC - VBE - (IC*RC)) / IB = ")
S=(1+beta)/(1+(beta*(RC/(RC+RB))))
format(5)
disp(S,"(b) Stability factor, S =(1 + beta) / (1 + (beta*(RC / (RC+RB)))) = ")
beta1=50
format(6)
disp("(c) VCC = (beta*IB*RC) + (IB*RB) + VBE")
disp("          = IB * ((beta*RC) + RB) + VBE")
IB=(VCC-VBE)/((beta1*RC)+RB)
IB1=IB*10^6
disp(IB1,"IB(uA) = (VCC-VBE) / ((beta*RC)+RB) = ")
IC=beta1*IB
IC1=IC*10^3
disp(IC1,"IC(mA) = beta*IB = ")
VCE=VCC-(IC*RC)
```

```
disp(VCE,"VCE = VCC - (IC*RC) = ")
disp("Therefore the coordinates of new operating
   point are :")
disp(VCE,"VCEQ(V) = ")
disp(IC1,"ICQ(mA) = ")
```

Scilab code Exa 6.29 `calculate RB and stability factor`

```
//Example 6.29.
clc
format(6)
VCC=12
RC=250
IB=0.25*10^-3
beta=100
VCEQ=8
RB=VCEQ/IB
RB1=RB*10^-3
disp(RB1,"RB(k-ohm) = VCEQ / IB = ")
S=(1+beta)/(1+(beta*(RC/(RC+RB))))
disp(S,"Stability factor, S = (1+beta) / 1 + (beta*(
   RC/RC+RB)) = ")
```

Scilab code Exa 6.30 `operating point coordinates and stability factor`

```
//Example 6.30. Refer fig. 6.27.
clc
format(5)
VCC=16
RC=3*10^3
RE=2*10^3
R1=56*10^3
R2=20*10^3
```

```
alpha=0.985
VBE=0.3
disp("For a germanium transistor, VBE=0.3V. As alpha=0.985")
beta=alpha/(1-alpha)
beta1=round(beta)
disp(beta1,"beta = alpha / ( 1 - alpha) = ")
disp("(a) To find the coordinates of the operating point")
disp("Referring to fig. 6.29,")
VT=(R2/(R1+R2))*VCC
disp(VT,"Thevenin voltage,      VT(V) = (R2 / (R1+R2)) * VCC = ")
format(7)
RB=(R1*R2)/(R1+R2)
RB1=RB*10^-3
disp(RB1,"Thevenin resistance,  RB(k-ohm) = (R1 * R2) / (R1 + R2) =")
disp("The loop equation around the base circuit is,")
disp("VT = ( IB * RB) + VBE + ((IB + IC)*RE)")
disp("VT = ((IC / beta) * RB) + VBE + (((IC / beta) + IC)*RE)")
format(5)
IC=(VT-VBE)/((RB/beta)+(RE/beta)+RE)
IC1=IC*10^3
disp(IC1,"Therefore,    IC(mA) = ")
disp("Since IB is very small, IC ~ IE = 1.73 mA")
IE=IC
VCE=VCC-(IC*RC)-(IE*RE)
disp(VCE,"Therefore,     VCE(V) = VCC - (IC*RC) - (IE*RE) = ")
disp("Therefore, the coordinates of the operating point are :")
disp(IC1,"IC(mA) = ")
disp(VCE,"VCE(V) = ")
disp("(b) To find the stability factor S")
disp("S = (1+beta)*((1+(RB/RE))/(1+beta+(RB/RE)))")
```

```
format(6)
S = (1+beta)*((1+(RB/RE))/(1+beta+(RB/RE)))
disp(S,"S = ")
```

Scilab code Exa 6.31 `resistors RE and R1 and R2`

```
//Example 6.31.
clc
format(4)
VCE=12
IC=2*10^-3
VCC=24
VBE=0.7
beta=50
RC=4.7*10^3
S=5.1
disp("(a) To determine RE,")
disp("VCE = VCC - (IC*RC) - (IE*RE)")
RE = (VCC - (IC*RC) - VCE)/IC   //IC=IE
RE1=RE*10^-3
disp(RE1,"Therefore,  RE(k-ohm) = ")
disp("")
disp("(b) To determine R1 and R2,")
disp("Stability factor,  S = (1+beta)/(1+beta(RE+(RE+RB))),     where RB = (R1*R2)/(R1+R2)")
RB=((RE*beta)/(((1+beta)/S)-1))-RE
RB1=(RB*10^-3)
disp(RB1,"Therefore,  RB(k-ohm) = ((RE*beta) / (((1+beta)/S)-1)) - RE =")
disp("Also, for a good voltage divider, the value of resistor R2 = 0.1*beta*RE")
R2=0.1*beta*RE
R2_1=R2*10^-3
disp(R2_1,"Therefore,    R2(k-ohm) = ")
disp("RB = (R1*R2) / (R1+R2)")
```

```
R1=(5.9*10^3*R2)/(R2-(5.9*10^3)) //RB=5.9
R1_1=round(R1*10^-3)
disp(R1_1,"Therefore, R1(k-ohm) = R2 / ((R2/RB)-1)")
```

Scilab code Exa 6.32 determine the Q point

```
//Example 6.32. refer fig.6.30.
clc
format(5)
R1=56*10^3
R2=12.2*10^3
RC=2*10^3
RE=400
VCC=10
VBE=0.7
beta=150
disp("From the Thevenin equivalent circuit shown in fig.6.30(b),")
RTH=(R1*R2)/(R1+R2)
RTH1=round(RTH*10^-3)
disp(RTH1,"RTH(k-ohm) = R1 || R2 =")
VTH=(R2/(R1+R2))*VCC
disp(VTH,"VTH(V) = (R2 / (R1+R2)) * VCC =")
disp("By kirchhoff voltage law equation,")
IBQ=(VTH-VBE)/(RTH+((1+beta)*RE))
IBQ1=IBQ*10^6
disp(IBQ1,"IBQ(uA) = (VTH-VBE(on)) / (RTH + ((1+beta)*RE)) = ")
ICQ=beta*IBQ
ICQ1=ICQ*10^3
disp(ICQ1,"Therefore,     ICQ(mA) = beta * IBQ = ")
format(6)
IEQ=IBQ+ICQ
IEQ1=IEQ*10^3
disp(IEQ1,"IEQ(mA) = IBQ + ICQ")
```

```
VCEQ=VCC-(ICQ*RC)-(IEQ*RE)
disp(VCEQ,"VCEQ(V) = VCC - (ICQ*RC) - (IEQ*RE)")
disp("The Q point is at :")
disp(VCEQ,"VCEQ(V) = ")
format(5)
disp(ICQ1,"ICQ(mA) = ")
```

Scilab code Exa 6.33 `IB IC and VCE and S`

```
//Example 6.33. refer from fig.6.31.
clc
VCC=22
RC=2*10^3
beta=60
VBE=0.6
R1=100*10^3
R2=5*10^3
RE=100
disp("For the given circuit")
disp("            VCC = R1*(I1+IB) + I1*R2")
disp("             I1 = (VCC - IB*R1) / (R1 + R2)        Eq.1")
disp("Further,    VCC = R1*[I1+IB] + VBE + IE*RE")
disp("As,          IE = IC + IB")
disp("              = beta*IB + IB = (1 + beta)*IB")
disp("Hence,      VCC = R1*[I1 + IB] + VBE + (1 + beta)*IB*RE")
disp("Substituting for I1 from Eq.1,")
disp("            VCC = R1*[[(VCC - IB*R1)/R1+R2] - IB] + VBE + (1 + beta)*IB*RE")
disp("            VCC = R1*[(VCC + IB*R2)/R1+R2] + VBE + (1 + beta)*IB*RE")
format(6)
a=VCC-VBE-((R1*VCC)/(R1+R2))
c=(((R1*R2)/(R1+R2))+((1+beta)*RE))
```

```
IB=a/c
IB1=IB*10^6
disp("Substituting for VCC, R1, R2, VBE, beta and RE, ")
disp(IB1,"        IB(uA) =")
format(5)
IC=beta*IB
IC1=IC*10^3
disp(IC1,"        IC(mA) =")
disp("Applying KVL to collector circuit,")
disp("          VCC = IC*RC + VCE + IE*RE = IC*RC + VCE + (1+beta)*IB*RE")
disp("Hence,    VCE = VCC - IC*RC - (1+beta)*IB*RE")
format(7)
VCE = VCC - (IC*RC) - ((1+beta)*IB*RE)
disp(VCE,"      VCE(V) = ")
disp("To find stability factor, (S):")
disp("Stability factor for voltage divider bias is")
format(5)
RB=(R1*R2)/(R1+R2)
S=(1+beta)/(1+(beta*(RE/(RE+RB))))
disp(S,"           S =(1+beta)/(1+(beta*(RE/(RE+RB)))) =          where RB = R1 || R2")
```

Scilab code Exa 6.34 `Q point and stability factor`

```
//Example 6.34.
clc
format(6)
VCC=10
RC=2*10^3
beta=50
RB=100*10^3
VBE=0.7  //collector to base resistor
disp("To determine quiescent point")
```

```
disp("the collector to base transistor circuit")
disp("                  VCC = (beta*IB*RC) + IB*RB + VBE ")
disp("Therefore,      IB   = (VCC - VBE) / (RB + (beta*RC))")
IB=(VCC-VBE)/(RB+(beta*RC))
IB1=IB*10^6
disp(IB1,"          IB(uA) =")
IC=beta*IB
IC1=IC*10^3
disp(IC1,"Hence, IC(mA) = beta * IB = ")
VCE=VCC-(IC*RC)
disp(VCE,"         VCE(V) = VCC - IC*RC =")
disp("Therefore,the co-ordinates of the new operating point are:")
disp(VCE,"VCEQ(V) = ")
disp(IC1,"ICQ(mA) = ")
disp("To find the stability factor S")
S=(1+beta)/(1+(beta*[RC/(RC+RB)]))
disp(S,"S = (1+beta) / (1 + (beta*[RC/(RC+RB)])) = ")
```

Chapter 7

Field effect transistor

Scilab code Exa 7.1 `resistance between gate and source`

```
//Example 7.1.
clc
format(6)
VGS=12
IG=10^-9
GSR=VGS/IG
GSR1=GSR*10^-6
disp("VGS = 12 V, IG = 10^-9 A")
disp(GSR1,"Therefore, gate-to-source resistance(M-
   ohm) = VGS / IG = ")
```

Scilab code Exa 7.2 `value of transconductance`

```
//Example 7.2.
clc
format(6)
delta_VGS=0.1
delta_ID=0.3*10^-3
```

```
disp("delta_VGS = 4 - 3.9 = 0.1 V")
disp("delta_ID = 1.6 - 1.3 = 0.3 mA")
gm=delta_ID/delta_VGS
gm1=gm*10^3
disp(gm1,"Therefore, transconductance, gm(m-mho) =
    delta_ID / delta_VGS = ")
```

Scilab code Exa 7.3 `value of Vgs and Vp`

```
//Example 7.3
clc
format(5)
VGSoff=-6
IDSS=8
ID=4
disp("ID = IDSS*[1 - (VGS/VGS_off)]^2")
VGS=(1-sqrt(ID/IDSS))*VGSoff
disp(VGS,"Therefore,    VGS(V) = ")
VP=abs(VGSoff)
disp(VP,"VP(V) = |VGS_off| = ")
```

Scilab code Exa 7.4 `value of Vds and Ids`

```
//Example 7.4.
clc
format(6)
VGS=-2
VP=-5
IDSS=8*10^-3
disp("The minimum value of VDS for pinch-off to
    occur for VGS = -2 V is")
VDSmin=VGS-VP
disp(VDSmin,"VDSmin(V) = VGS - VP = ")
```

```
IDS=IDSS*[1-(VGS/VP)]^2
IDS1=IDS*10^3
disp(IDS1,"IDS(mA) = IDSS * [1-(VGS/VP)]^2 = ")
```

Scilab code Exa 7.5 `operating point and RD and RS`

```
//Example 7.5.
clc
format(6)
IDSS=10*10^-3
VGS=-3
ID=4*10^-3
VDD=20
disp("The value of drain current at Q-point,")
IDQ=IDSS/2
IDQ1=IDQ*10^3
disp(IDQ1,"IDQ(mA) = IDSS / 2 =")
disp("and the value of drain-to-source at Q-point,")
VDSQ=VDD/2
disp(VDSQ,"VDSQ(V) = VDD / 2 =")
disp("Therefore, the operating point is at:")
disp(VDSQ,"VDS(V) = ")
disp(IDQ1,"ID(mA) = ")
disp("Also, the drain-to-source voltage,")
disp("     VDS = VDD - ID*RD")
RD=(VDD-VDSQ)/ID
RD1=RD*10^-3
disp(RD1,"Therefore,  RD(k-ohm) =")
disp("The source voltage or voltage across the
   source resistor RS is")
VS=-VGS
disp("      VS = -VGS = -3 V")
disp("Also,VS = ID*RS ")
RS=VS/ID
disp(RS,"Therefore, RS(ohm) = ")
```

Scilab code Exa 7.6 `value of Rs`

```
//Example 7.6.
clc
format(6)
IDSS=40*10^-3
VP=-10
VGSQ=-5
disp("We know that,  ID = IDSS * [1 - (VGS/VP)]^2")
disp("Substituting the given values, we get")
ID = IDSS*[1-(VGSQ/VP)]^2
ID1=ID*10^3
disp(ID1,"  ID(mA) =")
RS=abs(VGSQ/ID)
disp(RS,"Therefore,  RS(ohm) = |VGSQ / ID| =")
```

Scilab code Exa 7.7 `value of ID and verify FET`

```
//Example 7.7. Refer fig.7.13.
clc
format(5)
VDD=24
R2=8.57*10^6
R1=12*10^6
VP=-2
IDSS=4*10^-3
RD=910
RS=3*10^3
disp("From fig.7.13.,")
VGG=round(VDD*(R2/(R1+R2)))
disp(VGG,"    VGG(V) = VDD*(R2 / (R1+R2)) =")
```

```
disp("Also,          ID = IDSS*(1-(VGS/VP))^2")
disp("                   = IDSS*(1-((VGG-(ID*RS))/VP))^2,        where VGS = VGG - ID*RS")
disp("Expressing ID and IDSS in mA, we have")
disp("              9ID^2 - 73ID +144 = 0 ")
x=poly(0,'x')
p1=roots((9*x^2) - (73*x) +144)
ans1=p1(1)
p1=roots((9*x^2) - (73*x) +144)
ans2=p1(2)
disp(ans2,"or",ans1,"Therefore,  ID(mA) = ")
disp("As ID = 4.72mA > 4mA = IDSS, this value is inappropriate. So, IDQ=3.39 mA is selected.")
disp("Therefore,")
IDQ=3.39*10^-3
VGSQ=VGG-(IDQ*RS)
disp(VGSQ,"          VGSQ(V) = VGG - (IDQ*RS) =")
format(7)
VDSQ=VDD-(IDQ*(RD+RS))
disp(VDSQ,"and     VDSQ(V) = VDD - (IDQ*(RD+RS)) =")
VDGQ = VDSQ - VGSQ
disp(VDGQ,"Then,  VDGQ(V) = VDSQ - VGSQ")
disp("which is grater than |VP| = 2 V. Hence, the FET is in the pinch-off region.")
```

Scilab code Exa 7.8 `values of R1 and R2 and RD`

```
//Example 7.8. refer fig.7.16.
clc
format(6)
IDSS=10*10^-3
VP=-3.5
Rth=120*10^3 //R1+R2=120 k-ohm
ID=5*10^-3
VDS=5
```

```
RS=0.5*10^3
disp("Assume that the JFET is biased in the saturation region. Then the dc drain current is given by")
disp("                ID = IDSS*(1-(VGS/VP))^2")
VGS=VP*(1-(sqrt(ID/IDSS)))
disp(VGS,"Therefore,  VGS(V) =") // textbook answer is wrong
disp("The voltage at the source terminal is")
VS=(ID*RS)-5
disp(VS,"                VS(V) = (ID*RS) - 5 =")
disp("The gate voltage is")
VG=VGS+VS
disp(VG,"                VG(V) = VGS + VS =")
disp("The gate voltage is")
disp("                    VG = ((R2 / (R1 + R2))*10) - 5")
R2=(Rth*(VG+5))/10
R2_1=R2*10^-3
disp(R2_1,"Therefore,          R2(k-ohm) =") // textbook answer is wrong
R1=Rth-R2
R1_1=R1*10^-3
disp(R1_1,"and                 R1(k-ohm) =")  // textbook answer is wrong
disp("The drain-to-source voltage is")
disp("VDS = 5 - ID*RD - ID*RS - (-5)")
RD=(10-VDS-(ID*RS))/ID
RD1=RD*10^-3
disp(RD1,"     RD(k-ohm) = ")
format(5)
x=VGS-VP
disp(x,"VGS - VP = ")  // textbook has taken a different value hence the wrong answer in textbook
disp("Here, since VDS > (VGS-VP), the JFET is biased in the saturation region, which satisfies the initial assumption")
```

Scilab code Exa 7.9 `design the MOSFET circuit`

```
//Example 7.9. refer fig.7.17.
clc
format(6)
KN=1*10^-3
lamda=0.01
Ri=100*10^3
IDt=4*10^-3
IDQ=1.5*10^-3
VTN=1.5
VDD=12
VDSQ=7
disp("To determine VDSi")
disp("We have,")
disp("              IDt = KN*(VGst - VTN)^2")
disp("where the subscript t indicates transition point values.")
VGSt=sqrt(IDt/KN)+VTN
disp(VGSt,"       VGSt(V) =")
disp("Therefore,")
VDSt=VGSt-VTN
disp(VDSt,"        VDSt(V) = VGSt - VTN =")
disp("If the Q-point is in the middle of the saturation region, then VDSQ = 7 V, which gives 10 V peak-to-peak symmetrical output voltage.")
disp("From fig.7.17,")
disp("             VDSQ = VDD - IDQ*RD")
format(5)
RD=(VDD-VDSQ)/IDQ
RD1=RD*10^-3
disp(RD1,"Therefore,   RD(k-ohm) = (VDD - VDSQ) / IDQ =")
disp("Then,       IDQ = KN*(VGSQ-VTN)^2")
```

```
VGSQ=(sqrt(IDQ/KN))+VTN
disp(VGSQ,"Therefore,  VGSQ(V) =")
disp("Then,          VGSQ = 2.73 = (R2/(R1+R2))*VDD")
disp("                    = (1/R1)*(R2/(R1+R2))*VDD")
disp("                    = (Ri/R1)*VDD")
disp("By Solving, we get ")
format(6)
R1=1200/2.73
disp(R1,"    R1(k-ohm) =")
format(7)
R2=R1/((12/2.73)-1)
disp(R2,"    R2(k-ohm) =")
```

Scilab code Exa 7.10 `ID and Vds`

```
//Example 7.10. refer fig.7.18.
clc
format(6)
VTN=-2
KN=0.1*10^-3
VDD=5
RS=5*10^3
VGS=0
disp("Assuming that the MOSFET is baised in the saturation region. Then the d.c. drain current is")
disp("     ID = KN*(VGS-VTN)^2 = KN*(-VTN)^2")
ID=KN*(-VTN)^2
ID1=ID*10^3
disp(ID1," ID(mA) =")
disp("The d.c. drain-to-source voltage is")
VDS=VDD-(ID*RS)
disp(VDS,"     VDS(V) = VDD - ID*RS =")
VDSsat=VGS-VTN
disp(VDSsat,"Then,  VDSsat(V) = VGS - VTN =")
```

```
disp("Since VDS > VDSsat, the MOSFET is biased in the saturation region")
```

Chapter 8

Thyristors

Scilab code Exa 8.1 `SCR half wave rectifier`

```
//Example 8.1.
clc
format(6)
Vm=220
V1=110
RL=100
disp("We have,")
disp("                    V1 = Vm*sin(theta)")
disp("Therefore,")
x=asind(V1/Vm)
disp(x," Firing angel, theta =")
ca=180-x
disp(ca,"    Conduction angle = 180 - theta =")
disp("Average voltage, Vav = (Vm/2pi) * (1+cos(theta))")
Vav = (Vm/(2*%pi))*(1+cosd(x))
disp(Vav,"                Vav(V) =")
format(7)
Iav=Vav/RL
disp(Iav,"Average current,  Iav(A) = Vav / RL =")
po=Vav*Iav
```

```
disp(po,”Power output(W) = Vav∗Iav =”)
disp(”As, V1 = Vm∗sin(theta) = Vm∗sin(omega∗t),”)
disp(”      omega∗t = theta = 30 =  pi/6”)
disp(”      (2∗pi)∗(50∗t) = pi/6”)
disp(”Therefore, the time during which the SCR remains OFF is”)
format(6)
t=1/(2*6*50)
t1=t*10^3
disp(t1,”          t(ms) = ”)
```

Scilab code Exa 8.2 `firing angle and time and load current`

```
//Example 8.2.
clc
format(6)
Vdc=150
Vm=230*sqrt(2)
RL=10
disp(”For an SCR full wave rectifier,”)
disp(”                Vdc = (Vm/pi)∗(1+cos(theta))”)
x=acosd(((Vdc*%pi)/Vm)-1)
disp(x,”Therefore,     theta =”)
disp(”For 50Hz, T = 20 ms for 360”)
format(5)
t = (20/360)*x
disp(t,”Therefore        t(ms) = (20∗10^3/360)∗63.34 = ”)
Iav=Vdc/RL
disp(Iav,”Load current,     Iav(A) = Vav / RL =”)
```

Scilab code Exa 8.3 `power rating of the SCR`

```
//Example 8.3.
clc
format(6)
Vm=400
PIV=sqrt(3)*Vm
disp("As the supply voltage is 400 sin 314t, Vm =
   400 V")
disp(PIV,"Peak inverse voltage(PIV)(V) = sqrt(3)*Vm
   =")
RMS=20
ff=1.11
Iav=round(RMS/ff)
disp("RMS value of current = 20 V")
disp(Iav,"Average value of current, Iav(A) = RMS
   value/form factor =")
pr=PIV*Iav
pr1=pr*10^-3
disp(pr1,"Power rating of the SCR(kW) = PIV * Iav ="
   )
```

Chapter 9

Midband Analysis of Small Signal Amplifiers

Scilab code Exa 9.1 `Ai and Ri and Av and Ro`

```
//Example 9.1.
clc
format(7)
disp("  Exact analysis :")
AI=(-50)/(1+((25*10^-6)*(10^3)))
disp(AI,"Current gain ,  AI = -hfe / 1+hoe*RL =")
Ri=1000-((50*2*10^-4)/((25*10^-6)+(1/1000)))  //in ohm
disp(Ri,"Input resistance ,  Ri(ohm) = hie - (hfe*hre / hoe+(1/RL)) =")
Av=(-48.78)*(1000/990.24)
disp(Av,"Voltage gain ,    Av = AI*(RL/Ri) =")
disp("Output resistance ,  Ro")
format(10)
Yo=(25*10^-6)-((100*10^-4)/(1000+800))  //in mho
disp(Yo,"       Yo(mho) = hoe - (hfe*hre / hie+Rs) =")
format(6)
Ro=1/Yo //in ohm
```

```
x1=Ro*10^-3
disp(x1,"        Ro(k-ohm) = 1/Yo =")
disp("  Approximate analysis")
disp("          AI = -hfe = -50")
disp("          Ri = hie = 1 k-ohm")
Av=-(50*1000)/1000
disp(Av,"         Av = - hfe*RL / hie =")
disp("          Ro = infinity")
```

Scilab code Exa 9.2 `AI and Ri and Av and Ro and RoT`

```
//Example 9.2.
clc
RC=2*10^3
hie=1300
hre=2*10^-4
hfe=55
hoe=22*10^-6
disp("(i) For RE = 200 ohm,")
format(7)
RE=200
x=hoe*(RE+RC)
disp(x,"       hoe*(RE + RC) =")
disp("Since hoe*(RE+RC) < 0.1, the approximate model
    is permissible.")
format(6)
AI=-hfe
disp("        AI = -hfe = -55")
Ri=hie+((1+hfe)*RE)
x1=Ri*10^-3
disp(x1,"       Ri(k-ohm) = hie + (1+hfe)*RE =")
Av=AI*(RC/Ri)
disp(Av,"       Av = AI * (RC/Ri) =")
disp("Output resistance, Ro = infinity")
disp("Output terminal resistance, RoT = Ro || RC = 2
```

```
k−ohm”)
disp(”(ii) For RE = 400 ohm”)
format(7)
RE=400
x2=hoe*(RE+RC)
disp(x2,”       hoe∗(RE + RC) =”)
disp(”Since hoe∗(RE+RC) < 0.1, the approximate model is permissible.”)
format(6)
AI=-hfe
disp(”       AI = −hfe = −55”)
Ri=hie+((1+hfe)*RE)
x3=Ri*10^-3
disp(x3,”       Ri(k−ohm) = hie + (1+hfe)∗RE =”)
format(5)
Av=AI*(RC/Ri)
disp(Av,”       Av = AI ∗ (RC/Ri) =”)
disp(”Output resistance, Ro = infinity”)
disp(”Output terminal resistance, RoT = Ro || RC = 2 k−ohm”)
disp(”(iii) For RE = 1000 ohm”)
disp(”Since hoe∗(RE+RC) < 0.1, the approximate model is permissible.”)
format(6)
AI=-hfe
disp(”       AI = −hfe = −55”)
Ri=1300+((1+55)*1000)
x3=Ri*10^-3
disp(x3,”       Ri(k−ohm) = hie + (1+hfe)∗RE =”)
Av=AI*(RC/Ri)
disp(Av,”       Av = AI ∗ (RC/Ri) =”)
disp(”Output resistance, Ro = infinity”)
disp(”Output terminal resistance, RoT = Ro || RC = 2 k−ohm”)
```

Scilab code Exa 9.3 `AI and RI and Av and Ro`

```
//Example 9.3.
clc
RS=900
RL=2000
hie=1200
hre=2*10^-4
hfe=60
hoe=25*10^-6
disp("Conversion formulae :")
hic=hie
disp("        hic = hie = 1200 ohm,")
hfc=-(1+hfe)
disp(hfc,"        hfc = -(1+hfe) =")
disp("hre = 1, hoc = hoe = 25 uA/V")
hoc=hoe
hre=1
disp("Exact analysis :")
format(7)
AI=-hfc/(1+(hoc*RL))
disp(AI,"Current gain,        AI = -hfe / (1 + (hoc*RL
   )) =")
format(8)
Ri=hic + (hre*AI*RL)
x1=Ri*10^-3
disp(x1,"Input impedance,        Ri(k-ohm) = hic + hrc
   *AI*RL =")
format(7)
Av=(AI*RL)/Ri
disp(Av,"Voltage gain,        Av = AI*RL / Ri =")
Yo=hoc-((hfc*hre)/(hic+RS))
disp("Output resistance, Ro :")
disp(Yo,"        Yo(mho) = 1/Ro = hoc - (hfc*hrc/hic+
   Rs) =")
Ro=1/Yo
disp(Ro,"        Ro(ohm) =")
disp("Approximate analysis :")
```

```
AI=1+hfe
disp(AI,"Current gain,          AI = 1 + hfe =")
Ri=hie+((1+hfe)*RL)
x2=Ri*10^-3
disp(x2,"Input impedance,          Ri(k-ohm) = hie + (1+hfe)RL =")
Av=1-(hie/Ri)
disp(Av,"Voltage gain,          Av = 1 - hie/Ri =")
disp("Output resistance,          Ro:")
format(6)
Yo=(1+hfe)/(hie+RS)
disp(Yo,"          Yo(mho) = (1+hfe) / (hie+RS) =")
Ro=1/Yo
disp(Ro,"          Ro(ohm) =")
```

Scilab code Exa 9.4 `AI and Av and Ri and Ro`

```
//Example 9.4.refer fig.9.14.
clc
hic=1.4*10^3
hfc=-100
hrc=1
hoc=20*10^-6
R1=20*10^3
RS=1*10^3
R2=20*10^3
RE=10*10^3
RL=40*10^3
disp("Current gain,             AI = -hfc / 1+hoc*RL''")
RLd=(RE*RL)/(RE+RL)
x1=RLd*10^-3
disp(x1,"where,             RL''(k-ohm) = RE || RL =")
format(5)
AI = -hfc / (1+(hoc*RLd))
disp(AI,"Therefore,   AI =")
```

```
Ri=hic+(hrc*AI*RLd)
x2=Ri*10^-3
disp(x2,"Input resistance,          Ri(k-ohm) = hic + hrc*AI*RL'' =")
format(6)
Av=(AI*RLd)/Ri
disp(Av,"Voltage gain,          Av = AI*RL'' / Ri =")
disp("Output resistance,          Ro = 1 / Yo")
disp("          Yo = hoc - (hfc*hrc)/(hic+RS'')")
format(4)
RSd=(RS*R1*R2)/((R1*R2)+(RS*R2)+(RS*R1))
x3=RSd*10^-3
disp(x3,"where,          RS''(k-ohm) = RS || R1 || R2 =")
format(6)
Yo = hoc - ((hfc*hrc)/(hic+RSd))
disp(Yo,"          Yo =")  // answer in textbook is wrong
Ro=1/0.0435
disp(Ro,"          Ro(ohm) =")
Rod=(Ro*RLd)/(Ro+RLd)
disp(Rod,"          Ro''(ohm) = Ro || RLdash =")
```

Scilab code Exa 9.5 `AI and Ri and Av and Avs and Ais and Zo and Ap`

```
//Example 9.5.
clc
Rs=1200
RL=1000
hib=22
hrb=3*10^-4
hfb=-0.98
hob=0.5*10^-6
format(5)
disp("        Exact analysis")
```

```
AI=-hfb/(1+(hob*RL))
disp(AI,"Current gain,        AI = -hfb / (1 + hob*RL) =")
Ri=hib+(hrb*AI*RL)
disp(Ri,"Input impedance,        Ri(ohm) = hib + hrb*AI*RL =")
format(7)
Av=(AI*RL)/Ri
disp(Av,"Voltage gain,        Av = AI*RL / Ri =")
format(6)
Avs=(Av*Ri)/(Ri+Rs)
disp(Avs,"Overall current gain,        Avc = Av*Ri / Ri+Rs =")
AIS=(AI*Rs)/(Ri+Rs)
disp(AIS,"Overall current gain,        AIS = AI*Rs / Ri+Rs =")
format(7)
Yo=hob-((hfb*hrb)/(hib+Rs))
x1=Yo*10^6
disp(x1,"Output admittance,        Yo(u-mho) = hob * ( hfb*hrb / hib+Rs) =")
format(8)
Ro=1/Yo
x2=Ro*10^-6
disp(x2,"        Ro(M-ohm) = 1 / Yo =")
format(6)
AP=Av*AI
disp(AP,"Power gain,        AP = Av*AI =")
disp("")
disp("Approximate analysis")
AI=-hfb
disp(AI,"Current gain,        AI = -hfb =")
Ri=hib
disp(Ri,"Input impedance,        Ri(ohm) = hib =")
disp("Voltage gain,        Av = hfe*RL / hie")
disp("From Table 9.3,        hfb = -hfe / 1+hfe")
hfe = -hfb / (1+hfb)
disp(hfe,"Reaaranging this equation,        hfe = -hfb
```

```
   / 1+hfb =")
disp("From Table 9.3,        hib = hie / 1+hfe")
hie=hib*(1+hfe)
disp(hie,"        hie(ohm) = hib(1+hfe) =")
Av=hfe*RL / hie
disp(Av,"        Av =")
disp("Output impedance,        Ro = infinity")
Avs=(Av*Ri)/(Ri+Rs)
disp(Avs,"Overall voltage gain,        Avs = Av*Ri /
   Ri+Rs =")
AIS=(AI*Rs)/(Ri+Rs)
disp(AIS,"Overall current gain,        AIS = AI*Rs /
   Ri+Rs =")
AP=Av*AI
disp(AP,"Power gain,        AP = Av*AI =")
```

Scilab code Exa 9.6 `Ai and Ri and Av and Ro`

```
//Example 9.6.refer fig.9.16.
clc
hib=24
hfb=-0.98
hob=0.49*10^-6
hrb=2.9*10^-4
RS=600
RE=6*10^3
RC=12*10^3
RL=14*10^3
disp("Current gain,        AI = -hfb / 1+hob*RL''")
format(5)
RLd=(RC*RL)/(RC+RL)
x1=RLd*10^-3
disp(x1,"where,        RL''(k-ohm) = RC || RL =")
format(6)
AI=-hfb / (1+hob*RLd)
```

```
disp(AI,"        AI =")
disp("Input impedance Ri :")
Ri=hib+(hrb*AI*RLd)
disp(Ri,"        Ri(ohm) = hib + hrb*AI*RL'' =")
disp("Voltage gain Av :")
format(7)
Av=(AI*RLd)/Ri
disp(Av,"        Av = (AI*RL'') / Ri =")
disp("Output Resistance Ro :")
disp("The output admittance")
format(6)
RSd=(RS*RE)/(RS+RE)
Yo=hob-((hfb*hrb)/(hib+RSd))
x4=Yo*10^6
disp(x4,"        Yo(u-mho) = 1 / Ro = hob - (hfb*hrb / hib+RS'') =         where RS'' = RS || RE")
Ro=1/Yo
x2=Ro*10^-6
disp(x2,"        Ro(M-ohm) = 1 / Yo =")
format(5)
RSd=(Ro*RLd)/(Ro+RLd)
x3=RSd*10^-3
disp(x3,"        RS''(k-ohm) = Ro || RL'' =")
```

Scilab code Exa 9.7 `Av and AI and Zi and Zo`

```
//Example 9.7.refer fig.9.39
clc
hfe=60
hie=500
IC=3*10^-3
RB=220*10^3
RC=5.1*10^3
VCC=12
VBE=0.6
```

```
format(5)
disp("        RB = 200 k-ohm >> hie = 500 ohm")
disp("From h-parameter model")
beta=hfe
Zo=RC
Av=(-hfe*RC)/hie
disp("        Zi = hie = 500 ohm")
disp("        Zo = RC = 5.1 k-ohm")
disp(Av,"        Av = (-hfe*RC) / hie =")
disp("        AI = -hfe = -60")
disp("From re model")
disp("        Zi = beta*re        where re = 26mV / Ie")
Ib=(VCC - VBE)/RB
x1=Ib*10^6
disp(x1,"From the circuit ,        Ib(uA) = (VCC - VBE) / RB =")
format(6)
Ie=beta*(51.8*10^-6)
x2=Ie*10^3
disp(x2,"        Ie(mA) = Ic = beta*Ib =")
format(5)
re = (26) / (3.108)
disp(re,"        re(ohm) = 26mV / Ie =")
format(6)
Zi = beta*8.37
disp(Zi,"        Zi(ohm) = beta*re =")
disp("        Zo = RC = 5.1 k-ohm")
Av=int(-RC/re)
disp(Av,"        Av = -RC / re =")
disp("        AI = -beta = -60")
```

Scilab code Exa 9.8 `Zi and Zo and Av and Ai`

```
//Example 9.8. refer fig.9.47
clc
```

```
hie=3.2*10^3
hfe=100
R1=40*10^3
R2=4.7*10^3
RC=4*10^3
VCC=16
VBE=0.6
RE=1.2*10^3
beta=100
disp("h-parameter analysis :")
disp("Zi = RB || hie")
format(4)
RB=(R1*R2)/(R1+R2)
x1=RB*10^-3
disp(x1,"        RB = R1 || R2 = 40 k-ohm || 4.7 k-ohm =")
format(5)
Zi=(RB*hie)/(RB+hie)
x2=Zi*10^-3
disp(x2,"        Zi = 4.2 k-ohm || 3.2 k-ohm =")
disp("        Zo = RC = 4 k-ohm")
Av=(-hfe*RC)/hie
disp(Av,"        Av = -hfe*RC / hie =")
format(6)
AI=(-hfe*RB)/(RB+hie)
disp(AI,"        AI = -hfe*RB / RB+hie =")
disp("Using r model :")
disp("To find IB,")
VB=(R2*VCC)/(R1+R2)
disp(VB,"        VB = R2*VCC / R1+R2")
disp("Using Thevenin equivalent for input part,")
IB=1.082/(125.4*10^3)
x3=IB*10^6
disp(x3,"IB(uA) = (VB-VBE) / (RB+((1+beta)*RE))")
format(5)
IC=beta*IB
x4=IC*10^3
disp(x4,"        IC(mA) = beta*IB =")
```

```
disp(x4,"          IE(mA) ~ IC(mA) =")
IE = IC
format(6)
re=(26*10^-3)/(0.86*10^-3)
disp(re,"          re(ohm) = 26mV / IE =")
format(5)
Zi=(RB*beta*re)/(RB+(beta*re))
x5=Zi*10^-3
disp(x5,"       Zi(k-ohm) = RB || beta*re")
disp(" Zo = RC = 4 k-ohm")
format(6)
Av=-RC/re
disp(Av,"          Av = -RC / re =")
format(7)
AI=(-100*(4.2*10^3))/((4.2*10^3)+(100*30.23))
disp(AI,"          AI = (-beta*RB) / (RB+(beta*re)) =")
```

Scilab code Exa 9.9 `Zi and Zo and Av and Ai`

```
//Example 9.9. refer fig 9.52.
clc
format(6)
VBE=0.6
VEE=8
VCC=10
RE=4*10^3
RC=3*10^3
IE=(VEE-VBE)/RE
x1=IE*10^3
disp(x1,"          |IE|(mA) = VEE-VBE / RE =")
re=(26*10^-3)/IE
disp(re,"          re(ohm) = 26mV / IE =")
Zi=(RE*re)/(RE+re)
disp(Zi,"          Zi(ohm) = RE || re =")
Zo=RC*10^-3
```

```
disp(Zo,"        Zo(k-ohm) = RC =")
format(7)
Av=3000/14.05
disp(Av,"        Av = RC / re =")
disp("        AI = 1")
```

Scilab code Exa 9.10 `Zi and Av`

```
//Example 9.10. refer fig.9.54
clc
disp("We know that IB = VCC-VBE / RB+(1+beta)*RE")
format(5)
IB=((15-0.7)/((75*10^3)+(101*910)))*10^6
disp(IB,"Therefore,  IB(uA) =")  // in uA
disp("IE = (1+beta)*IB = 8.57 mA")
disp("The dynamic resistance is")
re=0.026/(8.57*10^-3)
disp(re,"     re(ohm) =")  // in ohm
disp("The input impedance of the amplifier is")
zb=(101*(3.03+910))*10^-3  // in k-ohm
disp(zb,"     Zb(k-ohm) = (1+beta)(re+RE) =")
disp("The input impedance of the amplifier stage is")
format(6)
Zi=((75*92.2*10^6)/((75*10^3)+(92.2*10^3)))*10^-3  // in k-ohm
disp(Zi,"     Zi(k-ohm) = RB || Zb =")
disp("The voltage gain of the amplifier is")
av=910/(3.03+910)
disp(av,"Av = RE / re+RE =")
```

Scilab code Exa 9.11 `Zi and overall voltage gain`

```
//Example 9.11.refer fig.9.55
clc
format(6)
VCC=10
RB=470*10^3
RE=3.3*10^3
beta=100
RS=1*10^3
RL=50
re=22.4
VBE=0.7
IB = (VCC-VBE) / (RB + ((1+beta)*RE))
x1=IB*10^6
disp(x1,"From fig.9.55, IB(uA) = (VCC-VBE) / (RB + (1+beta)*RE)")
format(5)
IE=(1+beta)*IB
x2=IE*10^3
disp(x2,"  IE(mA) = (1+beta)*IB =")
rL=(RE*RL)/(RE+RL)
disp(rL,"The load resistance of the emitter follower is rL(ohm) = RE || RL =")                          // answer in textbook is wrong
x=(1+beta)*(re+rL)
Zi=(RB*x)/(RB+x)
x3=Zi*10^-3
disp(x3,"  Zi(k-ohm) = RB || (1+beta)(re+rL) =")
y=(50/(22.4+50))*((7.13*10^3)/((1*10^3)+(7.3*10^3)))     // answer in textbook is wrong
disp(y,"  VL / VS = (rL/re+rL)(Zi/Rs+Zi) =")
```

Scilab code Exa 9.12 Zb and Zi and Av and VL and iL and overall voltage and curren

```
//Example 9.12. refer fig 9.56
```

```
clc
RS=50
RE=2*10^3
Ro=1*10^3
RL=4*10^3
VEE=6
VBE=0.7
RC=1000
VS=10*10^-3
format(5)
IE=(VEE-VBE)/RE
x1=IE*10^3
disp("We know that, IE = VEE-VBE / RE")
disp(x1,"Therefore, IE(mA) =")
re=0.026/IE
disp(re,"       Zb(ohm) = re(ohm) =")
Zi=(re*RE)/(re+RE)
disp(Zi,"       Zi(ohm) = re || RE =")
format(6)
Av=RC/re
disp(Av,"       Av = RC / re =")
x=Av*(re/(re+RS))*(RL/(RL+RC))
disp(x,"       VL / VS = Av*(re/re+RS)*(RL/RL+RS) =")
VL=x*VS
x2=VL*10^3
disp(x2,"       VL(in mV (rms)) = Av*VS =")
iL=VL/RL
format(5)
x3=iL*10^6
disp(x3,"       iL( in uA (rms)) = VL / RL =")
alpha=1
format(6)
y=alpha*(RS/(RS+re))*(RC/(RC+RL))
disp(y,"       iL / iS = alpha*(RS/RS+re)*(RC/RC+RL) =")
```

Scilab code Exa 9.13 `Av and overall voltage and current gain`

```
//Example 9.13.refer fig.9.57.
clc
RC=12*10^3
RL=15*10^3
RS=10
RE=22*10^3
VEE=24
VBE=0.3
disp("The emitter current of the common base amplifier is")
format(8)
IE=(VEE-VBE)/RE
disp(IE,"       IE(A) = VEE-VBE / RE =")
format(6)
re=0.026/IE
disp(re,"       re(ohm) = 0.026 / IE =")
format(5)
Av=RC/re
disp(Av,"       Av = RC /re =")
format(8)
x=497*(24.14/(24.14+10))*((15*10^3)/((12*10^3)+(15*10^3)))
disp(x,"       VL/VS = Av*(re/re+RS)*(RL/RL+RC) =")
format(6)
Ai=3.413
y=Ai*(RS/(RS+re))*(RC/(RC+RL))
disp(y,"       iL/iS = Ai*(RS/RS+re)*(RC/RC+RL) =")
```

Scilab code Exa 9.14 `Ri and Ro and VL`

```
//Example 9.14. refer fig.9.58.
clc
rc=1.5*10^6
RE=4.7*10^3
Ro=2.2*10^3
RS=20
RL=10*10^3
VS=20*10^-3
VEE=9
VBE=0.7
IE=(VEE-VBE)/RE
format(6)
x1=IE*10^3
disp(x1,"We know that,  IE(mA) = VEE-VBE / RE =")
format(5)
re=0.026/IE
disp(re,"        re(ohm) = 0.026 / IE =")
Zi=(RE*re)/(RE+re)
disp(Zi,"        Zi(ohm) = RE || re =")
Zo=(Ro*rc)/(Ro+rc)
x2=Zo*10^-3
disp(x2,"        Zo(k-ohm) = RC || re =")
format(6)
Av=Zo/Zi
disp(Av,"        Av = Zo/Zi = RC||rc/RE||re =")
format(5)
x=Av*(Zi/(RS+Zi))*(RL/(RL+Zo))
disp(x,"        VL/VS = Av*(Zi/RS+Zi)*(RL/RL+Zo) =")
format(6)
y=x*VS
disp(y,"        VL(rms) = Av*VS(rms) =")
```

Scilab code Exa 9.15 `Zi and overall voltage gain`

```
//Example 9.15.refer fig.9.59.
```

```
clc
beta=100
VCC=10
R2=4.7*10^3
R1=27*10^3
RE=680
RC=3.3*10^3
RS=600
RL=15*10^3
disp("Referring to fig.9.59(a),")
format(5)
VB=(10*4.7*10^3)/((27*10^3)+(4.7*10^3))
disp(VB,"       VB(V) = (R2 / R1+R2)*VCC =")  // answer in textbook is wrong
VE=1.39-0.7
disp(VE,"       VE(V) = 1.39 - 0.7 =")
format(4)
IE=VE/RE
x1=IE*10^3
disp(x1,"       IE(mA) = VE / RE =")
re=0.026/IE
disp(re,"       re(ohm) = 0.026/IE =")
x=beta*(re+RE)
format(5)
Zi=(R1*R2*x)/((R2*x)+(R1*x)+(R1+R2))  // answer in textbook is wrong
x2=Zi*10^-3
disp(x2,"       Zi(k-ohm) = R1 || R2 || beta*(re+RE) =")
format(4)
y=(-RC/(RE+re))*(Zi/(RS+Zi))*(RL/(RC+RL))
disp(y,"The overall voltage gain is VL/VS = (-RC/RE+re)*(Zi/RS+Zi)*(RL/RC+RL) =")
disp("Referring to fig.9.59(b),")
format(5)
u=beta*re
Zi=(R1*R2*u)/((R2*u)+(R1*u)+(R1*R2))
x3=Zi*10^-3
```

```
disp(x3,"       Zi(k-ohm) = R1 || R2 || betare =")
z=(-RC/re)*(Zi/(RS+Zi))*(RL/(RC+RL))  // answer in textbook is wrong
disp(z,"       VL/VS = (-RC/re)*(Zi/RS+Zi)*(RL/RC+RL) =")
```

Scilab code Exa 9.16 `overall voltage gain`

```
//Example 9.16. refer fig.9.53(b).
clc
RB1=7.5*10^3
RB2=6.8*10^3
RB3=3.3*10^3
RE=1.3*10^3
RC=2.2*10^3
beta1=120
beta2=120
VCC=18
VBE1=0.7
format(6)
disp("From the circuit given in Fig.9.53(b),")
disp("       IE2 = IE1 and hence, IC2 = IC1")
disp("Since,    beta1 = beta2")
disp("       IB1 = IC1/beta1 = IC2/beta = IB2")
disp("By voltage division,")
VB1=(RB3*VCC)/(RB3+RB2+RB1)
disp(VB1,"       VB1(V) = (RB3*VCC)/(RB3+RB2+RB1) =")
format(5)
IE1=(VB1-VBE1)/RE
x1=IE1*10^3
disp(x1,"       IE1(mA) = VE1/RE = (VB1-VBE1)/RE =")
format(6)
re1=(26*10^-3)/IE1
disp(re1,"       re1(ohm) = 26mV/IE1 =")
re2=re1
```

```
disp(re2,"       re2(ohm) =                (since IE2 = IE1)")
disp("Voltage gain of the first stage,")
disp("       Av1 = -re1/re1 = -1")
disp("Voltage gain of the second stage,")
format(7)
Av2=RC/re2
disp(Av2,"       Av2 = RC / re2 =")
disp("Overall voltage gain,")
Av1=-1
Av=Av1*Av2
disp(Av,"       Av = Av1*Av2 =")
```

Scilab code Exa 9.17 `Av and Zi and Zo`

```
//Example 9.17. refer fig.10.66(b).
clc
format(6)
RD=5*10^3
RG=10*10^6
u=50
rd=35*10^3
disp("The voltage gain,")
Av=(-u*RD)/(RD+rd)
disp(Av,"       Av = Vo/Vi = -u*RD / RD+rd =")
disp("The minus sign indicates a 180 degree phase shift between Vi and Vo")
Zi=RG*10^-6
disp(Zi,"Input impedance  Zi(M-ohm) = RG =")
Zo=RD*10^-3
disp(Zo,"Output impedance  Zo(k-ohm) = RD =")
```

Scilab code Exa 9.18 `Av and Zi and Zo`

```
//Example 9.18. refer fig.9.67(b)
clc
format(6)
RS=4*10^3
RG=10*10^6
u=50
rd=35*10^3
disp("The voltage gain,")
Av=(u*RS)/(((1+u)*RS)+rd)
disp(Av,"        Av = Vo/Vi = u*RS / (u+1)*RS+rd =")
disp("The positive value indicates that Vo and Vi
   are in-phase and further note that Av < 1 for CD
   amplifier.")
disp("Input impedance,  Zi = RG = 10 M-ohm")
x=rd/u
Zo=(x*RS)/(RS+x)
disp(Zo,"Output impedance,  Zo(ohm) = 1/gm || RS = (
   rd/u) || RS =")
```

Scilab code Exa 9.19 `Av and Zi and Zo`

```
//Example 9.19. refer fig.9.68(b)
clc
format(5)
RD=2*10^3
RS=1*10^3
gm=1.43*10^-3
rd=35*10^3
disp("The voltage gain,")
Av=(((gm*rd)+1)*RD)/(RD+rd)
disp(Av,"    Av = Vo/Vi = (gm*rd + 1)*RD / (RD+rd) ="
   )
x=1/gm
Zi=(RS*x)/(RS+x)
x1=Zi*10^-3
```

```
disp(x1,"Input impedance,  Zi(k-ohm) = RS || 1/gm =")
disp("Output impedance,  Zo ~ RD = 2 k-ohm")
```

Scilab code Exa 9.20 `the percentage difference`

```
//Example 9.20.
clc
disp("  In the first set,")
Vid=100-(-100) //in uV
disp(Vid,"     Vid = Vd(uV) = V1 = V2 =")
Vc=(1/2)*(100+(-100)) // in uV
disp(Vc,"       Vc(uV) = 1/2(V1+V2) =")
disp("  Vo = Ad*Vid * [1 + 1/CMRR * Vc/Vid]")
disp("      = Ad*200 * [1 + 1/1000 * 0/200] = 200*Ad uV                    Eq.1")
disp("  In the second set,")
Vd=1100-900 // in uV
disp(Vd,"       Vd(uV) = V1 - V2 =")
Vc=(1/2)*(1100+900)
disp(Vc,"       Vc(uV) = 1/2(V1+V2) =")
disp("Hence,  Vo = Ad*Vid * [1 + 1/CMRR * Vc/Vid]")
disp("             = Ad*200 * [1 + 1/1000 * 1000/200] = 201*Ad uV                Eq.2")
disp("Comparing Eq.1 and 2, the output voltages for the two sets of input signals result in a 0.5% difference.")
disp("Thought the difference voltage Vd = 200 uV in both the cases, the output is not the same and hence the effect of common mode voltage Vc has same influence in the output voltage and it decreases with increase in CMRR.")
disp("When CMRR = 10000, a similar analysis as that of case (i) gives")
disp("          Vo = Ad*200 * [1 + 1/10000 * 1000/200]
```

```
 = 200.1*Ad uV")
disp("Here the output voltages differ by 0.05%. Hence as the CMRR increases , the difference between the output voltages decreases .")
```

Scilab code Exa 9.21 `Qpoint and Vc and IB`

```
//Example 9.21. refer fig.9.87.
clc
format(6)
VEE=15
VBE=0.7
REE=65*10^3
disp("The emitter current can be found by writing a loop equation starting at the base of Q1")
disp("     VBE + 2*IE*REE - VEE = 0")
IE = (VEE - VBE)/(2*REE)
IE1=IE*10^6
disp(IE1,"      IE(uA) = (VEE - VBE)/2*REE =")
alphaF=100/101
IC=(alphaF*IE)
IC1=IC*10^6
disp(IC1,"     IC(uA) = alpha_F*IE =")
betaF=100
IB=IC/betaF
IB1=IB*10^6
disp(IB1,"     IB(uA) = IC / beta_F =")
VCC=VEE
RC=REE
VC=VCC-(IC*RC)
disp(VC,"     VC(V) = VCC - IC*RC =")
VE=-0.7
VCE=VC - VE
disp(VCE,"     VCE(V) = VC - VE =")
disp("Both transistor of the differential amplifier
```

```
are based at a Q-point(108.9 uA, 8.621 V) with IB = 1.089 uA and VC = 7.921 V")
disp("As VEE >> VBE, IE can be approximated by")
format(7)
IE=(VEE/(2*REE))*10^6
disp(IE,"     IE(uA) = VEE / 2*REE =")
```

Scilab code Exa 9.22 `Qpoint and maximum VIC`

```
//Example 9.22. refer fig.9.88
clc
format(6)
VDD=12
VSS=VDD
ISS=175*10^-6
RD=65*10^3
Kn=3*10^-3
VTN=1
IDS=ISS/2
IDS1=IDS*10^6
disp(IDS1,"     IDS(uA) = ISS / 2 =")
VGS=VTN+sqrt(ISS/Kn)
disp(VGS,"     VGS(V) = VTH + sqrt(ISS/Kn) =")
format(5)
VDS=VDD-(IDS*RD)+VGS
disp(VDS,"     VDS(V) = VDD - (IDS*RD) + VGS =")
disp("Checking for saturation,")
format(6)
x=VGS-VTN
disp(x,"      VGS - VTN =")
disp("and VDS >= 0.2. Thus, both transistors in the differential amplifier are baised at Q-point of :")
disp(IDS1)
format(5)
```

```
disp(VDS)
disp("Requiring saturation of M1 for non zero VIC,")
disp("     VGD = VIC - (VDD - IDS*RD) <= VTN")
disp("     VIC <= VDD - ID*RD + VTN")
VIC = VDD - IDS*RD + VTN
disp(VIC,"     VIC(V) =")
```

Scilab code Exa 9.23 `ICQ and VCEQ and Ad and Ac`

```
//Example 9.23. refer fig.9.89
clc
VS1=60*10^-3
VS2=40*10^-3
hie=3.2*10^3
hfe=100
VEE=12
VCC=VEE
VBE=0.7
beta=hfe
RE=5.6*10^3
RS=120
RC=4.5*10^3
Rc=4.5*10^-5
format(6)
IE=(VEE-VBE)/((2*RE)+(RS/beta))
IE1=IE*10^3
disp("beta = hfe = 100")
disp(IE1,"     IE(mA) = (VEE-VBE) / ((2*RE)+(RS/beta))")
IC=IE
disp("IC ~ IE = 1.009 mA")
disp(IE1,"     Therefore          ICQ(mA) =")
format(5)
VCE=VCC+VBE-(IC*Rc)
disp(VCE,"     VCE(V) = VCC + VBE - IC*RC =")   //
```

```
answer in textbook is wrong
disp(VCE,"and       VCEQ(V) =")  // answer in textbook is wrong
disp("The differential gain is")
format(7)
Ad=(hfe*RC)/(RS+hie)
disp(Ad,"       Ad = hfe*RC / RS+hie =")
disp("Common mode gain is,")
format(7)
AC=(hfe*RC)/(((2*RE)*(1+hfe))+RS+hie)
disp(AC,"     AC = (hfe*Re) / (((2*RE)*(1+hfe)) + RS + hie) =")
format(8)
CMRR = Ad / AC
disp(CMRR,"CMRR = Ad / AC =")
format(7)
CMRR1=20*log10(135.54/0.3966)
disp(CMRR1,"CMRR(dB) = 20log|Ad/AC| =")
disp("The output voltage is Vo = Ad*Vd + AC*VC. Here,")
Vd=VS1-VS2
Vd1=Vd*10^3
disp(Vd1,"       Ad [mV(peak-peak)] = VS1 - VS2 =")
VC=(VS1+VS2)/2
VC1=VC*10^3
disp(VC1,"Then,       VC [mV(peak-peak)]= (VS1+VS2) / 2 =")
format(5)
Vo = Ad*Vd + AC*VC
disp(Vo,"Therefore,       Vo [V(peak-peak)] =")
```

Scilab code Exa 9.24 `Ri and RLdash and Av and AVS and Ro`

```
//Example 9.24. refer fig.9.90(a)
clc
```

```
hie=400
hre=2.1*10^-4
hfe=40
hoe=25*10^-6
RL=5*10^3
RC=3*10^3
disp("From the circuit 9.90(a),")
format(6)
Rth=(RL*RC)/(RL+RC)
RLd=hoe*(Rth)
disp(RLd," RL = hoe*(RL || RC) =")
disp("For equivalent circuit refer fig.9.90(b).")
Ri=(hie*100*10^3)/(hie+(100*10^3))
disp(Ri," Input resistance,   Ri = hie || 100k =")
R1=50*10^3
format(7)
Ro=(R1*RC*RL)/((RC*RL)+(R1*RL)+(R1*RC))
disp(Ro," Output resistance,   Ro = 50k || 3k || 5k =")
disp("   Vo/VS = (Vo/Vi) * (Vi/VS)")
disp("   Vo/Vi = (-hfe*RL) / hie")
x=(-hfe*Ro)/hie
disp(x,"Therefore,   Vo/Vi = -hfe*Ro / hie =")
disp("In the equivalent circuit,")
disp("   Vi = (VS*Ri) / (Ri+RS)")
RS=1*10^3
y=Ri/(Ri+RS)
disp(y,"   Vi/VS = Ri/(Ri+RS) =")
format(6)
Avs=abs(x*y)
disp(Avs,"Hence,   Avs = Vo/VS = (Vo/Vi)*(Vi/VS) =")
```

Chapter 10

Multistage Amplifiers

Scilab code Exa 10.1 `Zi and Zo and overall current and voltage gains`

```
//Example 10.1. refer fig.10.8.
clc
format(6)
hie=1600
hfe=60
hre=5*10^-4
hoe=25*10^-6
hic=1600
hfc=-61
hrc=1
hoc=25*10^-6
disp("The AC equivalent circuit of the CE-CC amplifier is shown in fig.10.9(a)")
disp("The Second Stage :")
disp("Current gain :")
disp("The current gain of a particular stage is given by")
disp("                    AI = -hf / (1 + ho*ZL)")
disp("For the second stage ZL = RE2 and the current gain of the second stage is")
RE2=4000
```

```
AI2=-hfc/(1+(hoc*RE2))
disp(AI2,"                    AI2 = -Ie2 / Ib2 = -hfc / (hoc*RE2) =")
disp("The input impedance Ri of a particular stage is given by")
disp("                    Ri = hi + hf*AI*ZL")
disp("For the second stage,")
Ri2 = hic + (hrc*AI2*RE2)
Ri22=Ri2*10^-3
disp(Ri22,"              Ri2(k-ohm) = hic + (hrc*AI2*RE2) =")
disp("Thus, the CC stage has a high input impedance.")
disp("The voltage gain of a particular stage is")
disp("                    AV = (AI*ZL) / Zi")
disp("For the second stage,")
Re2=4000
AV2=(AI2*Re2)/Ri2
disp(AV2,"                    AV2 = Vo/V2 = (AI2*Re2) / Ri2")
disp("The First Stage :")
RC1=4000
format(5)
RL1=(RC1*Ri2)/(RC1+Ri2)
RL11=RL1*10^-3
disp(RL11,"                   RL1(k-ohm) = RC1 || Ri2 =")
disp("Current gain,")
AI1= -hfe/(1+(hoe*RL1))
disp(AI1,"                    AI1 = -IC1/Ib1 = -hfe /(1+(hoe*RL1)) =")
disp("The input impedance of the first stage, which is also the input impedance of the cascaded amplifier is")
Ri1=hie +(hre*AI1*RL1)   // answer in textbook is wrong
Ri11=Ri1*10^-3
disp(Ri11,"             Ri1(k-ohm) = hie + hre*AI1*RL1 =")
```

```
disp("The voltage gain of the first stage is")
format(7)
AV1=(AI1*RL1)/Ri1  // answer in textbook is wrong
disp(AV1,"                    AV1 = V2/V1 = (AI1*RL1) / Ri1 =")
disp("The output admittance of the first transistor Q1")
RS=600
format(5)
Yo1=hoe-((hfe*hre)/(hie+RS))
Yo0=Yo1*10^6
disp(Yo0,"              Yo1(uA/V) = hoe - ((hfe*hre) / (hie+RS)) =")
disp("The output impedance of the first stage")
format(6)
Ro1=1/Yo1
Ro0=Ro1*10^-3
disp(Ro0,"            Ro1(k-ohm) = 1 / Yo1 =")
disp("The output impedance taking RC1 into account is")
format(5)
Rot1=(Ro1*RC1)/(Ro1+RC1)
Rott=Rot1*10^-3
disp(Rott,"         Rot1(k-ohm) = Ro1 || RC1 =")
disp("This is the effective source resistance RS2 of the second stage")
disp("The output admittance of the second stage")
format(7)
Yo2=hoc-((hfc*hrc)/(hic+Rot1))
disp(Yo2,"               Yo2(A/V) = hoc-((hfc*hrc) / (hic+Rot1)) =")
disp("Output impedance,")
format(4)
RO2=1/(11.525*10^-3)
disp(RO2,"                RO2(ohm) = 1 / Yo2 =")
disp("The amplifier output impedance taking RE2 into account is RO2 || RE2")
format(6)
```

```
Ro2=(87*4000)/(87+4000)
disp(Ro2,"Hence,        Ro2(ohm) = (RO2*RE2) / (RO2+RE2) =")
disp("Overall current gain :")
disp("The output or total current gain of both the stages is")
disp("                 AI = -Ie2 / Ib1 = (-Ie2/Ib2)(Ib2/IC1)(IC1/Ib1)")
disp("                    = -AI2*(Ib2/Ic1)*AI1")
disp("From fig.10.9(b),")
disp("                Ib2 = (-IC1)(Rc1 / Rc1+Ri2)")
Rc1=4000
format(7)
x=(-Rc1)/ (Rc1+Ri2)
disp(x,"          Ib2/Ic1 = -Rc1/ Rc1+Ri2 =")
format(6)
AI=-AI2*x*AI1
disp(AI,"                AI = -AI2*AI1*(Rc1 / Ri2+Rc1) =")
disp("The overall voltage gain of the amplifier,")
disp("                AV = Vo / V1 = (Vo/V2)(V2/V1)")
AV=AV2*AV1
disp(AV,"               AV = AV2*AV1 =")  // answer in textbook is wrong
disp("The overall voltage gain taking the source impedance into account,")
format(4)
AVs=AV*(Ri1/(Ri1+RS))
disp(AVs,"           AVs = Vo/Vs = Av(Ri1 / Ri1+Rs) =") // answer in textbook is wrong
```

Scilab code Exa 10.2 `AIm and AVm and fL and fH and gain bandwidth product`

```
//Example 10.2.
clc
```

```
format(6)
hfe=50
hie=1200
hoe=30*10^-6
hre=2.5*10^-4
RC=5*10^3
C=160*10^-12
CC=6*10^-6
R1=100*10^3
R2=10*10^3
gm=50*10^-3
Ro=1/hoe
x1=(Ro*10^-3)
disp(x1,"Ro(k-ohm) = 1/hoe =")
format(4)
RB=(R1*R2)/(R1+R2)
x2=RB*10^-3
disp(x2,"RB(k-ohm) = R1 || R2 =")
Ri=hie
x3=Ri*10^-3
disp(x3,"Ri(k-ohm) = hie =")
format(5)
R_C=(RC*Ro)/(RC+Ro)
x4=R_C*10^-3
disp(x4,"RC''(k-ohm) = RC || Ro =")
format(4)
R_i=(RB*Ri)/(RB+Ri)
x6=R_i*10^-3
disp(x6,"Ri''(k-ohm) = RB || Ri =")
format(5)
R_ci=(R_C*R_i)/(R_C+R_i)
x7=R_ci*10^-3
disp(x7,"Rci'' = Rc'' || Ri'' =")
rbe=hfe/gm
disp(rbe,"rbe(ohm) = hfe / gm =")
disp("(a) Mid-band current gain,")
AIm=(-50*4.35*10^3)/((4.35*10^3)+(1.1*10^3))
disp(AIm,"AIm = (-hfe*R''C) / (RC''+Ri'') =")
```

```
disp("(b) Mid-band voltage gain,")
format(6)
AVm=(-50)*((0.87*10^3)/(1.2*10^3))
disp(AVm,"AVm = (-hfe) * (Rcid/hie) =")
disp("(c) Lower 3dB frequency,")
format(5)
fL=1/(2*%pi*6*10^-6*(5.45*10^3))
disp(fL,"fL(Hz) = 1 / (2*%pi*CC*(R_C+R_i)) =")
disp("Higher 3dB frequency,")
format(6)
fH=1/(2*%pi*C*rbe)
x8=fH*10^-3
disp(x8,"fH(kHz) = 1 / (2*%pi*C*rbe) =")  // answer in textbook is wrong
disp("(d) Voltage gain x bandwidth")
y=abs(AVm*fH)
x9=(y*10^-6)
disp(x9,"|AVmfH| =")
```

Chapter 11

Frequency Response of Amplifiers

Scilab code Exa 11.2 `approximate bandwidth`

```
//Example 11.2.
clc
format(6)
tr=10*10^-9
BW=0.35/tr
x1=BW*10^-6
disp(x1,"BW(MHz) = 0.35 / tr =")
```

Scilab code Exa 11.3 `AvMF and lower 3 dB gain`

```
//Example 11.3.
clc
hfe=400
hie=10*10^3
Rs=600
RL=5*10^3
```

```
RE=1*10^3
VCC=12
R1=15*10^3
R2=2.2*10^3
CE=50*10^-6
format(8)
RB=(R1*R2)/(R1+R2)
Av=(-hfe*RL)/(Rs+hie+((hie*Rs)/RB))
disp(Av,"AV(MF) = (-hfe*RL) / (RS + hie + ((hie*RS)/RB)) =")
disp("Lower 3-dB point,")
format(4)
f1=(1+hfe)/((Rs+hie)*2*%pi*CE)
disp(f1,"f1 = (1+hfe) / ((RS+hie)*2*%pi*CE) =")
```

Scilab code Exa 11.4 `coupling capacitor`

```
//Example 11.4
clc
RS=600
hie=1*10^3
hfe=60
R1=5*10^3
R2=1.25*10^3
RCE=25
f1=125
disp("The lower 3 dB frequency, f1 = 1 / (2*pi*(RS+R1dash)*CC)")
format(5)
R1dash=(R1*R2*hie)/((R2*hie)+(R1*hie)+(R1*R2))
CC=1 / (2*%pi*f1*(RS+R1dash))
x1=CC*10^6
disp(R1dash,"(a)     R1''(ohm) = R1 || R2 || hie =")
disp(x1,"         CC(uF) = 1 / (2*pi*f1*(RS+R1'')) =")
x2=hie+((1+hfe)*RCE)
```

```
R1dash=(R1*R2*x2)/((R2*x2)+(R1*x2)+(R1*R2))
CC=1 / (2*%pi*f1*(RS+R1dash))
x3=CC*10^6
format(7)
disp(R1dash,"(b)    R1''(ohm) = R1 || R2 || [hie+((1+hfe)*RCE)] =")
format(5)
disp(x3,"       CC(uF) = 1 / (2*pi*f1*(RS+R1'')) =")
```

Scilab code Exa 11.5 `gm and rbdashe and rbbdash and Cbdashe`

```
//Example 11.5
clc
format(6)
gm=1/26 //mho
x1=gm*10^3  //m-mho
disp(x1,"  gm(m-mho) = IC(mA)/26mV = 1/26 =")
rbe=224/(38.46*10^-3)
x2=rbe*10^-3 //k-ohm
disp(x2,"  rb''e(k-ohm) = hfe / gm =")
rbb=6000-5824 //ohm
disp(rbb,"  rbb''(ohm) = hie - rb''e = 6000-5824 =")
cbe=((38.46*10^-3)/(2*%pi*(80*10^6)))-(12*10^-12) //farad
x3=cbe*10^12 //pF
format(5)
disp(x3,"  cb''e(pF) = gm/2*pi*fT - Cb''c =")
```

Scilab code Exa 11.6 `alpha and beta and fT`

```
//Example 11.6.
clc
format(5)
```

```
alpha=224/(2*%pi*(5.9*10^3)*(63*10^-12)) //Hz
x1=alpha*10^-6 //MHz
disp(x1,"  f_alpha(MHz) = hfe / 2*pi*rb''e*Cb''e =")
beta=1/(2*%pi*(5.9*10^3)*((63*10^-12)+(12*10^-12)))
x2=beta*10^-6
format(6)
disp(x2,"   f_beta(MHz) = 1 / 2*pi*rb''e*(Cb''e+Cb''c) =")
fT=(38*10^-3)/(2*%pi*((63*10^-12)+(12*10^-12)))
x3=fT*10^-6
disp(x3,"      fT(MHz) = gm / 2*pi*(Cb''e+Cb''c) =")
```

Chapter 12

Large Signal Amplifiers

Scilab code Exa 12.1 `effective resistance`

```
//Example 12.1.
clc
format(6)
RL=16*10^2 //in ohm
x1=RL*10^-3 // in k-ohm
disp("RL'' = RL / n^2")
disp("where,  n = N2 / N1")
disp(x1,"RL''(k-ohm) = (N1/N2)^2 * RL =")
```

Scilab code Exa 12.2 `transformer turns ratio`

```
//Example 12.2.
clc
format(6)
x1=7200/8
disp(x1,"(N1/N2)^2 = RL''/RL = ")
x2=x1^0.5
disp(x2,"N1/N2 = ")
disp("Hence, N1 : N2 = 30 : 1")
```

Scilab code Exa 12.3 `series fed load and transformer coupled load`

```
//Example 12.3.
clc
format(6)
disp("(i) Series-fed load")
eta=(25*14)/15 //in percentage
disp(eta,"Overall efficiency ,  eta(in percentage) = 25(Vmax-Vmin / Vmax) =")
disp("(ii) Transformer-coupled load")
eta=50*(14/16) //in percentage
disp(eta,"Overall efficiency ,  eta(in percentage) = 50*(Vmax-Vmin / Vmax+Vmin) =")
```

Scilab code Exa 12.4 `collector circuit efficiency`

```
//Example 12.4.
clc
format(6)
VCE=2
VCC=15
format(6)
eta=(%pi/4)*(1-(VCE/VCC))*100
disp("Collector circuity efficiency ,")
disp(eta,"    eta(in percentage) = (%pi/4)*(1-(VCE/VCC))*100% =")
```

Scilab code Exa 12.5 `junction temperature TJ`

```
//Example 12.5.
clc
format(6)
theta=8
TA=27
PD=3
TJ=TA+(theta*PD)
disp("We know that ,  TJ = TA + theta*PD")
disp(TJ,"Therefore ,  TJ(degree C) = 27 degree C + (8 degree C/W)*3W =")
```

Scilab code Exa 12.6 desipate power of transistor

```
//Example 12.6.
clc
format(6)
TJ=160
TA=40
theta=80
PD=(TJ-TA)/theta
disp(PD,"PD(W) = (TJ-TA)/thetaJ-A = (160-40)/80 =")
```

Scilab code Exa 12.7 power dissipation capability

```
//Example 12.7.
clc
format(6)
thetaH=8
TA=40
TJ=160
thetaJ=5
thetaC=85
x1=(thetaC*thetaH)/(thetaC+thetaH)
```

```
theta=thetaJ+x1
disp(theta,”     theta_J-A(degree C/W) = theta_J-C + theta_C-A || theta_HS-A =”)
PD=(TJ-TA)/theta
format(5)
disp(PD,”     PD(W) = TJ-TA / theta_J-A =”)
```

Chapter 14

Feedback Amplifiers

Scilab code Exa 14.1 `percentage change in gain`

```
//Example 14.1.
clc
format(5)
A=1000
beta=0.04
dA=10
disp("The percentage change in gain of the amplifier
   with feedback is")
dAf=dA*(1/(1+(A*beta)))
disp(dAf,"    dAf/Af (in %) = dA/A * 1/(1+A*beta)")
```

Scilab code Exa 14.2 `openloop gain A and feedback ratio`

```
//Example 14.2.
clc
format(6)
Af=100
dAf=0.02
```

```
dA=0.2
disp("We have,        dAf/Af = dA/A * 1/(1+A*beta)")
disp("   dAf/Af = dA/A * 1/(1+A*beta)")
Ab=dA/dAf
disp(Ab,"Therefore,       (1 + A*beta) =")
disp("Also, the gain with feedback is")
disp("        Af = A / (1+A*beta)")
A=Af*Ab
disp(A,"Therefore,        A =")
disp("         1 + A*beta = 10; i.e. A*beta = 9")
beta=9/A
disp(beta,"Therefore,         beta =")
```

Scilab code Exa 14.3 `bandwidth and feedback ratio`

```
//Example 14.3.
clc
format(6)
A=125
BW=250*10^3
beta=0.04
disp("(a) We have BWf = (1 + A*beta) * BW")
BWf = (1 + (A*beta))*BW
x1=BWf*10^-6
disp(x1,"     BWf(MHz) =")
Af=A/(1+(A*beta))
disp(Af,"Gain with feedback,   Af = A / (1+ A*beta) =")
disp("(b) BWf = (1 + A*beta'') * BW")
disp("1*10^6 = (1 + 125*beta'')*250*10^3")
Bd=3/125
disp(Bd,"Therefore,       beta =")
Bd1=Bd*100
disp(Bd1,"i.e.    beta (in %) =")
```

Scilab code Exa 14.4 `amplifier voltage gain and Df`

```
//Example 14.4.
clc
format(6)
A=400
f1=50
f2=200*10^3
D=10
beta=0.01
disp("The voltage gain with feedback")
Af=A/(1+(A*beta))
disp(Af,"  Af = A / (1 + A*beta) =")
disp("New lower 3dB frequency,")
f1f=f1/(1+(A*beta))
disp(f1f,"  f_1f(Hz) = f1 / 1+A*beta =")
disp("New upper 3dB frequency,")
f2f=(1+(A*beta))*f2
x2=f2f*10^-6
disp(x2,"  f2f(MHz) = (1+A*beta)*f2 =")
disp("Distortion with feedback,")
Df=D/(1+(A*beta))
disp(Df,"  Df (in %) = D / 1+A*beta =")
```

Scilab code Exa 14.5 `Af and Rif and Rof`

```
//Example 14.5
clc
format(6)
A=500
Ri=3*10^3
Ro=20*10^3
```

```
beta=0.01
format(6)
Af=A/(1+(A*beta))
disp(Af,”Voltage gain,        Af = A / (1+A*beta) =”)
Rif=(1+(A*beta))*Ri
x1=Rif*10^-3
disp(x1,”Input resistance,   Rif(k–ohm) = (1+(A*beta))*Ri =”)
Rof=Ro/(1+(A*beta))
x2=Rof*10^-3
format(5)
disp(x2,”Output resistance, Rof(k–ohm) = Ro / (1+A*beta) =”)
```

Scilab code Exa 14.6 `Ai and Ri and Av and Ro and Rof`

```
//Example 14.6.
clc
format(6)
Ai=1+80
disp(Ai,”   Ai = 1 + hfe =”)
Ri=(5*10^3)+((1+80)*(2*10^3))   //in ohm
x1=Ri*10^-3 //in k–ohm
disp(x1,”   Ri(k–ohm) = hie + (1+hfe)*RL =”)
Av=(81*2*10^3)/(167*10^3)
disp(Av,”   Av = Ai*RL / Ri =”)
Ro=(5000+600)/(1+80) // in ohm
disp(Ro,”   Ro(ohm) = hie+Rs / 1+hfe =”)
Rof=(69.13*2000)/(2069.13)   //in ohm
disp(Rof,”   Rof(ohm) = Ro || RL =”)
```

Scilab code Exa 14.7 `Av and Rif and Avf and Rof and Rofdash`

```
//Example 14.7. refer fig.14.6
clc
format(6)
RL=((40*2)/42)*10^3 //in ohm
disp(RL,"  R''L(ohm) = RB || RL =")
Av=(-80*1905)/5000
disp(Av,"  Av = -hfe*R''L / hie =")
format(9)
x1=(40000)/(1+30.48)
Rif=(x1*5000)/(x1+5000) //in ohm
disp(Rif,"  Rif(ohm) = hie || (RB / 1-Av) =")
format(6)
Avf=(-30.48*1013.172)/(600+1013.172)
disp(Avf,"  Avf = Vo/Vs = Av*Rif / RS+Rif =")
Rof=(40000/600)*(5600/80) //in ohm
x2=Rof*10^-3 //in k-ohm
disp(x2,"  Rof(k-ohm) = (RB / RS) * (RS+hie / hfe) = ")
Roff=(4.666*2)/(6.666) //in k-ohm
disp(Roff,"  R''of(k-ohm) = Rof || RL =")
```

Scilab code Exa 14.8 `A and beta and Rif and Af and loop gain`

```
//Example 14.8. Refer fig.14.8
clc
format(6)
R1=20*10^3
R2=20*10^3
hie=2*10^3
RL=1*10^3
Re=100
hfe=80
A=(-hfe*RL)/hie
disp(A,"(a)  A = -hfe*RL / hie =")
disp("       Ri = hie = 2 k-ohm")
```

```
beta=Re/RL
disp(beta,"(b) beta = Re / RL =")
Rif=hie+((1+hfe)*Re)
x1=Rif*10^-3
disp(x1,"(c) Rif(k-ohm) = hie + (1+hfe)*Re =")
Af=(-hfe*RL)/Rif
format(5)
disp(Af,"(d) Af = -hfe*RL / Rif =")
lg=20*log10(4)
format(6)
disp(lg,"(e) Loop gain, Abeta(in dB) = -40*0.1 = -4 i.e. 20log4 =")
```

Chapter 15

Oscillators

Scilab code Exa 15.1 `value of L1`

```
//Example 15.1.
clc
format(5)
L1=(1/(4*(%pi^2)*((120*10^3)^2)*0.004*10^-6))-(0.4*10^-3)  //in henry
x1=L1*10^3 //in mH
disp("The frequency of Hartley oscillator is given by")
disp("    fo = 1 / 2*pi*sqrt((L1+L2)*C)")
disp(x1,"Therefore,  L1(mH) = (1 / 4*pi^2*fo^2*C) - L1 =")
```

Scilab code Exa 15.2 `range over caacitor is varied`

```
//Example 15.2.
clc
format(6)
disp("To find the range over which capacitance is to be varied")
```

```
disp("Frequency of oscillation of Hartley oscillator is")
disp("         fo = 1 / 2*pi*sqrt((L1-L2)*C)")
disp("Therfore,  C = 1 / 4*pi^2*(L1+L2)*fo^2")
disp("When fo = 950 kHz")
C=1/(4*(%pi^2)*((2*10^-3)+(20*10^-6))*((950*10^3)^2)) //farady
x1=C*10^12 //pF
disp(x1,"             C(pF) =")
disp("When fo = 2050 kHz")
C=1/(4*(%pi^2)*((2*10^-3)+(20*10^-6))*((2050*10^3)^2)) //farady
x1=C*10^12 //pF
format(5)
disp(x1,"             C(pF) =")
disp("Hence, the range of capacitance is from 2.98 pF to 13.89 pF")
```

Scilab code Exa 15.3 `frequency of oscillation and feedback ratio`

```
//Example 15.3
clc
format(4)
L1=38*10^-6
L2=12*10^-6
C=500*10^-12
disp("    fo = 1 / 2*pi*sqrt(L*C)")
L=L1+L2
fo = 1 / (2*%pi*sqrt(L*C))
x1=fo*10^-6
disp("where  L = L1 + L2 = 38*10^-6 + 12*10^-6 = 50*10^-6 and C = 500 pF")
disp(x1,"Therefore,  fo(MHz) = 1 / 2*pi*sqrt(50*10^-6*500*10^-12) =")
beta=L1/L2
```

```
format(6)
disp(beta,"Feedback factor,  beta = L1 / L2 =")
```

Scilab code Exa 15.4 inductor and gain for oscillation

```
//Example 15.4.
clc
format(7)
C1=0.2*10^-6
C2=0.02*10^-6
fo=10*10^3
disp("The frequency of the Colpitts oscillator is given by")
disp("     fo = 1/2pi * sqrt(C1+C2/L*C1*C2)")
L=(C1+C2)/(4*%pi^2*fo^2*C1*C2)
x1=L*10^3
disp(x1,"Therefore,  L(mH) = (C1+C2) / (4*%pi^2*fo^2*C1*C2) =")
disp("The voltage gain required to produce oscillation is")
x2=C1/C2
disp(x2,"     Av > C1/C2 =")
```

Scilab code Exa 15.5 colpitts osillator

```
//Example 15.5.
clc
format(5)
L=40*10^-3
C1=100*10^-12
C2=500*10^-12
Vo=10
```

```
disp("(i) In a Colpitts oscillator, a series combination of C1 and C2 which is in parallel with inductance L and frequency of oscillations is")
fo=1/ (2*%pi*sqrt((L*C1*C2)/(C1+C2)))
x1=fo*10^-3
disp(x1,"    fo(kHz) = 1 / 2pi*sqrt(LCeq) = 1 / 2pi*sqrt(L*C1*C2/C1+C2) =")
disp("(ii) The output potential is across C1 and is proportional to XC1, and the feedback voltage is across C2 and proportional to XC2. Therefore,")
disp("Vo/Vf = XC1/XC2 = (1/omega*C1)/(1/omegaC2) = C2/C1")
Vf=(Vo*C1)/C2
disp(Vf,"Hence,  Vf(V) = Vo*C1 / C2 =")
disp("(iii) Since the gain depends upon C1 and C2 only and is independent of L,")
gain=C2/C1
disp(gain,"  Gain = 500*10^-12 / 100*10^-12 =")
disp("(iv) When the gain is equal to 10, C2/C1 = 10")
x2=C2/10
x3=x2*10^12
disp(x3,"Therefore,  C1(pF) = C2 / 10 =")
disp("(v) The frequncy of oscillation is")
fo=1/ (2*%pi*sqrt((40*50*500*10^-27)/((50*10^-12)+(500*10^-12))))
x4=fo*10^-3
format(7)
disp(x4,"fo(kHz) =")
```

Scilab code Exa 15.6 range of variable capacitor

```
//Example 15.6.
clc
```

```
format(6)
fo1=400*10^3
fo2=1200*10^3
Lp=60*10^-6
disp("The resonant frequency is given by")
disp("               fo = 1 / 2pi*sqrt(Lp*C)")
disp("Therefore,  C = 1 / 4*pi^2*fo^2*Lp")
C = 1 / (4*%pi^2*fo1^2*Lp)
x1=C*10^12
disp(x1,"When  fo = 400 kHz,  Cmax(pF) =")  // answer in textbook is wrong
C = 1 / (4*%pi^2*fo2^2*Lp)
x2=C*10^12
format(5)
disp(x2,"When  fo = 1200 kHz,  Cmin(pF) =")
disp("Hence, the capacitor range required is Cmin-Cmax pF")
```

Scilab code Exa 15.7 `range of tuning capacitor`

```
//Example 15.7.
clc
format(6)
fo1=540*10^3
fo2=1650*10^3
L=1*10^-3
disp("Given L = 1 mH")
disp("fo ranges from 540-1650 kHz")
disp("The resonant frequency is given by")
disp("               fo = 1 / 2pi*sqrt(L*C)")
disp("Therefore,  C = 1 / 4*pi^2*fo^2*L")
Cmax = 1 / (4*%pi^2*fo1^2*L)
x1=Cmax*10^12
disp(x1,"When  fo = 540 kHz,  Cmax(pF) =")
Cmin = 1 / (4*%pi^2*fo2^2*L)
```

```
x2=Cmin*10^12
format(4)
disp(x2,"When  fo = 1650 kHz,  Cmin(pF) =")
disp("Hence, the capacitor range required is 9.3-86.87 pF")
```

Scilab code Exa 15.8 `frequency of oscillation`

```
//Example 15.8.
clc
format(6)
fo=1/(2*%pi*(200*10^3)*(100*10^-12)*sqrt(6)) //in Hz
x1=fo*10^-3 //in kHz
disp("The frequency of RC phase shift oscillator is given by")
disp("      fo = 1 / 2*pi*R*C*sqrt(6)")
disp(x1," fo(KHz) =")
```

Scilab code Exa 15.9 `minimum current gain`

```
//Example 15.9.
clc
format(5)
fo=1/(2*3.142*10000*(0.01*10^-6)*sqrt(6+((4*2.2*10^3)/(10000)))) //in Hz
disp("The frequency of oscillations of a RC phase shift oscillator is")
disp("  fo = 1 / 2*pi*R*C*sqrt(6+(4*Rc/R))")
disp("Substituting the given values, we get")
disp(fo,"fo(Hz) =")
disp("For sustained oscillations, the minimum value of current gain or forward current gain hfe is")
```

```
disp("            beta = hfe = 23 + 29(R/Rc) + 4(Rc/R)")
format(6)
beta=23+(29*(10/2.2))+(4*(2.2/10))
disp(beta,"Therefore, beta =")
```

Scilab code Exa 15.10 `C and hfe`

```
//Example 15.10.
clc
format(6)
disp("(i) To find capacitance, C:")
disp("    Frequency of oscillation is")
disp("   fo = 1 / 2*pi*fo*R*C*sqrt(6+4K)")
disp("  C = 1 / 2*pi*fo*R*C*sqrt(6+4(Rc/R))")
fo=1/(2*%pi*(10*10^3)*(7.1*10^3)*sqrt(6+((4*40*10^3)/(7.1*10^3)))) // in Farady
x1=fo*10^9 // in nF
disp(x1,"  C(nF) =")
disp("(ii) To find hfe:")
disp("  We know that     hfe >= 23 + 29(R/Rc) + 4(Rc/R)")
h=23+(29*(7.1/40))+(4*(40/7.1))
disp(h,"                       hfe >=")
```

Scilab code Exa 15.11 `value of capacitor`

```
//Example 15.11.
clc
format(5)
C=1/(2*%pi*100000*10000) // in farady
x1=C*10^12 //in pF
```

```
disp("The operating frequency of a Wien-bridge oscillator is given by")
disp("    fo = 1 / 2*pi*R*C")
disp(x1,"Therefore, C(pF) = 1 / 2*pi*R*fo =")
```

Scilab code Exa 15.12 series and parallel resonant freqency and Qfactor

```
//Example 15.12.
clc
format(6)
disp("(a) The series resonant frequencies of the crystal is")
fs=1/(2*%pi*sqrt(0.5*0.06*10^-12))  //in Hz
x1=fs*10^-3 //in kHz
disp(x1,"  fs(kHz) = 1 / 2*pi*sqrt(L*Cs) =")
format(5)
fs=(2*%pi*(918.9*10^3)*0.5)/(5*10^3)
disp(fs,"Q factor of the crystal at fs = omegaS*L / R = 2*pi*fs*L / R =")
disp("(b) The parallel resonant frequency of the crystal is")
fp=(1/(2*%pi))*sqrt((1.06*10^-12)/(0.5*(0.06*10^-12)*(1*10^-12))) // in Hz
x1=fp*10^-3
disp(x1,"  fp(kHz) = 1/2pi * sqrt((Cs+Cp)/(L*Cs*Cp)) =")
fp=(2*%pi*(946*10^3)*0.5)/(5*10^3)
disp(fp,"Q factor of the crystal at fp = omegaS*L / R = 2*pi*fs*L / R =")
```

Chapter 16

Wave Shaping and Multivibrator Circuits

Scilab code Exa 16.1 `value of bandwidth`

```
//Example 16.1.
clc
format(6)
disp("Given      tr = 35 ns")
bw=0.35/(35*10^-9) // in Hz
x1=bw*10^-6  //in MHz
disp("We know that,  tr = 0.35 / BW")
disp(x1,"Therefore,    BW(MHz) = 0.35 / tr =")
```

Scilab code Exa 16.2 `size of speedup capacitor and input frequency`

```
//Example 16.2.
clc
format(6)
disp("Given      ton = 70 ns")
C=(70*10^-9)/(0.1*600)  // in faraday
```

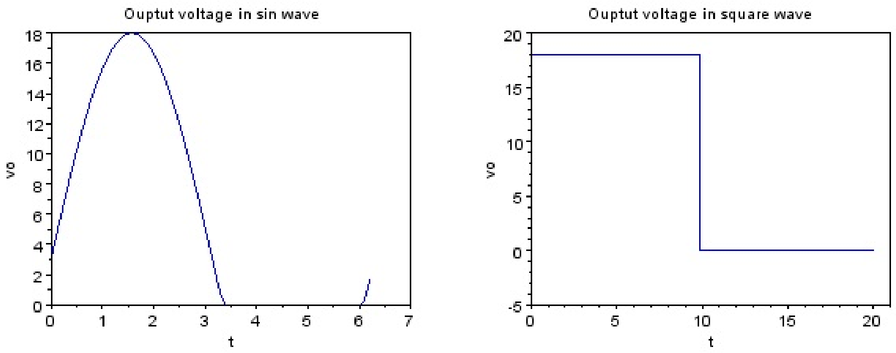

Figure 16.1: negative clipper

```
x1=C*10^12   // in pF
disp(x1,"              C(pF) = ton / 0.1*Rs =")   // approximately 1200 pF
format(4)
tre=2.3*(5.6*10^3)*(1200*10^-12) // in seconds
x2=tre*10^6   //in us
disp(x2,"          tre(useconds) = 2.3*RB*C =")
format(6)
f=1/(2*(15*10^-6))   //in Hz
x3=f*10^-3   //in kHz
disp(x3,"          f(kHz) = 1/2T = 1/2tre =")
```

Scilab code Exa 16.3 negative clipper

```
//Example 16.3.
clc
format(6)
amp = 15;
vi_t=3; // transition voltage
```

```
t=0:0.1:2*%pi;
vi=amp*sin(t);
vo=vi+3; // output voltage
disp (vi_t,'transition voltage:');
for i=1:length(t)
if(vo(i)<=0)
vo(i)=0;
end
end
subplot(2,2,1)
plot2d1(t,vo,2,'011','',[0,0,7,18]);
xtitle('Ouptut voltage in sin wave','t','vo');


t=0:0.1:20;
for i=1:int(length(t)/2)
vo(i)=15+3;
end
for i=int(length(t)/2):length(t)
vo(i)=0;
end
subplot(2,2,2)
plot2d2(t,vo,2,'011','',[0,-5,21,20]);
a = gca ();
xtitle('Ouptut voltage in square wave','t','vo');
```

Scilab code Exa 16.4 `negative clipper`

```
//Example 16.4.
clear ; clc; close ;
t= 0:0.1:20;
for i=1:length(t);
if(t(i)<=5)
```

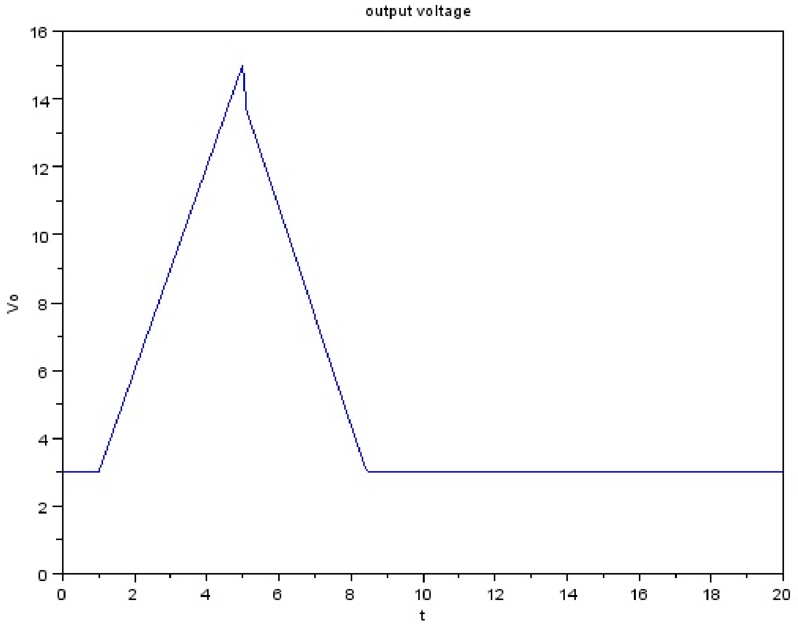

Figure 16.2: negative clipper

```
x(i)=(15/5)*t(i);
elseif(t(i)>=5&t(i)<=15)
x(i)=-3.2*t(i)+30;
elseif(t(i)>=15&t(i)<=20)
x(i)=(15/5)*t(i)-60;
end
end
for i=1:length(t)
if(x(i)>3)
y(i)=x(i);
elseif(x(i)<=3)
y(i)=3;
end
end
plot2d(t,y,2,'011','',[0,0,20,16]);
a=gca();
xtitle('output voltage','t','Vo')
```

Scilab code Exa 16.5 `positive and negative clipper`

```
//Example 16.5.
//let input wave be V_in=V_p_in*sin(2*%pi*f*t)
f=1;      //Frequency is 1Hz
T=1/f;
V_p_in=10;      //Peak input voltage
V_th=0.7;      //knee voltage of diode
clf();
//let n be double the number of cycles of output shown in graph
for n=0:1:1
    t=T.*n/2:0.0005:T.*(n+1)/2      //time for each half cycle
    V_in=V_p_in*sin(2*%pi*f.*t);
```

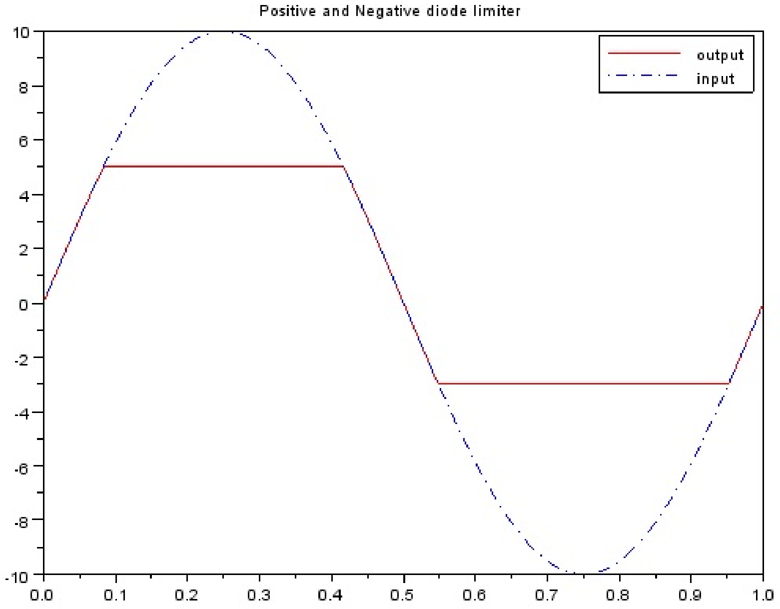

Figure 16.3: positive and negative clipper

```
    Vout=V_in;
    if modulo(n,2)==0 then    //positive half,D1 conducts till V_in=5V
        a=bool2s(Vout<5);
        b=bool2s(Vout>5);
        y=a.*Vout+5*b;    //output follows input till 5V then is constant at 5V
    else                     //negative half, D2 conducts till V_in=-3V
        a=bool2s(Vout<-3);
        b=bool2s(Vout>-3);
        y=-3*a+b.*Vout;    //output follows input till -3V then stays constant at -3V
    end
        plot(t,y,'r')

        plot(t,V_in,'-.')
       end
       hl=legend(['output','input']);
    xtitle('Positive and Negative diode limiter','t','Vo')
    disp('max output voltage is 5V')
    disp('min output voltage is -3V')
```

Scilab code Exa 16.8 `positive clamper`

```
//Example 16.8.
//Positive Clamping circuit
//let input voltage be V_in=V_p_in*sin(2*%pi*f*t)
V_p_in=10;
V_DC=(V_p_in);    //DC level added to output
disp(V_DC,'V_DC in volts= ')
for n=0:1:1
```

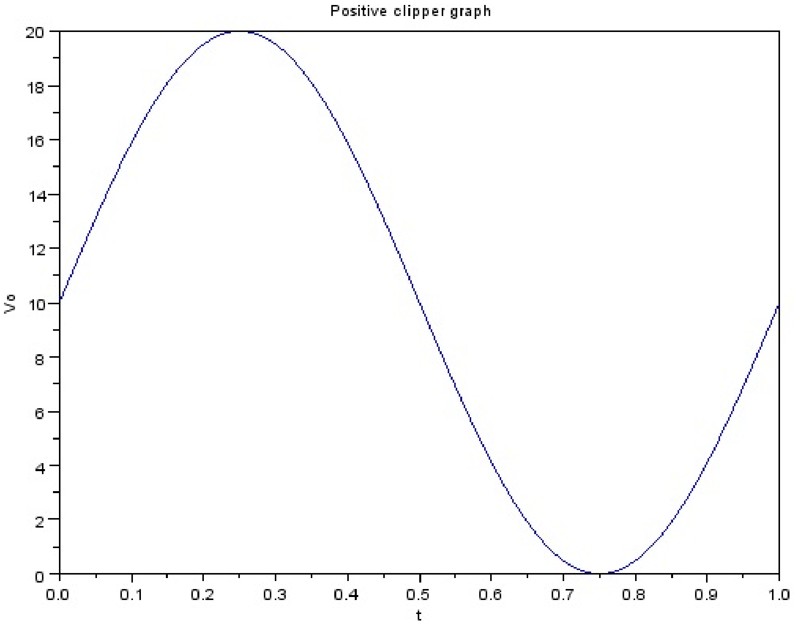

Figure 16.4: positive clamper

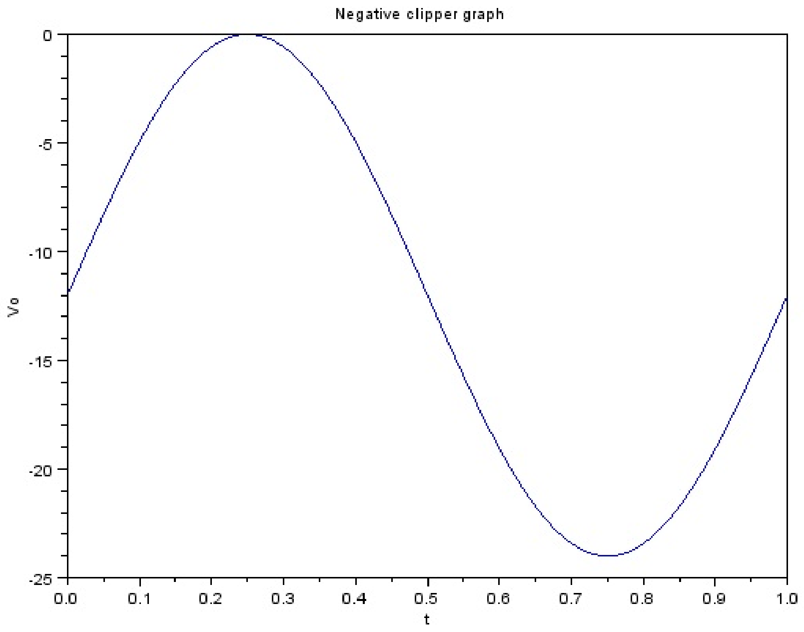

Figure 16.5: negative clamper

```
    t=n/2:0.0005:(n+1)/2;
    V_in=V_p_in*sin(2*%pi*t);
    Vout=V_DC+V_in;
    plot(t,Vout)
end
xtitle('Positive clipper graph','t','Vo')
```

Scilab code Exa 16.9 `negative clamper`

```
//Example 16.9.
//Negative Clamping circuit
```

```
//let input voltage be V_in=V_p_in*sin(2*%pi*f*t)
V_p_in=12;
V_DC=-(V_p_in);     //DC level added to output
disp(V_DC,'V_DC in volts= ')
for n=0:1:1
    t=n/2:0.0005:(n+1)/2;
    V_in=V_p_in*sin(2*%pi*t);
    Vout=V_DC+V_in;
    plot(t,Vout)
end
xtitle('Negative clipper graph','t','Vo')
```

Scilab code Exa 16.10 `frequency of oscillation`

```
//Example 16.10.
clc
format(6)
f=1/(1.386*(20*10^3)*(1000*10^-12))   //in Hz
x1=f*10^-3   // in kHz
disp("The frequency of a symmetrical astable multivibrator is")
disp(x1,"       f(kHz) = 1/1.386RC =")   // answer in textbook is wrong
```

Scilab code Exa 16.11 `period and frequency of oscillation`

```
//Example 16.11.
clc
format(7)
disp("The period of oscillation for an asymmetrical astable multivibrator is,")
t=0.693*(((2*10^3)*0.01*10^-6)+((10*10^3)*(0.05*10^-6))) // seconds
```

```
x1=t*10^6 // in us
disp(x1,"     T(us) = 0.693(R1C1+R2C2) =")
f=1/(360.36*10^-6)  // in Hz
x2=f*10^-3 // in kHz
disp(x2,"Therefore, the frequency of oscillation, f(kHz) = 1/T =")
```

Scilab code Exa 16.12 astable multivibrator value of capacitor

```
//Example 16.12.
clc
format(5)
t=1/(100*10^3)  // in seconds
x1=t*10^6  // in us
disp(x1,"The period of oscillation is,  T(us) = 1/f =")
disp("          T1 = 2us  (given)")
t2=10-2 // in us
disp(t2,"Hence,  T2(us) = T - T1 =")
disp("          T1 = 0.693*R1C1")
c1=(2*10^-6)/(0.693*(20*10^3))  // in faraday
x1=c1*10^12  // in pF
disp(x1,"Therefore,  C1(pF) = T1 / 0.693R1 =")  // answer in textbook is wrong
c2=(8*10^-6)/(0.693*(20*10^3))  // in faraday
x1=c2*10^12  // in pF
disp("          T2 = 0.693*R2*C2")  //answer in textbook is wrong
disp(x1,"Therefore,  C2(pF) = T2 / 0.693R2 =")
```

Scilab code Exa 16.13 design a saturated collector coupled multivibrator

```
//Example 16.13.
```

```
clc
format(6)
disp("To design a saturated collector coupled astable multivibrator")
disp("Let us assume that VCE(sat) = 0.2 V")
disp("Refer fig.16.31.")
disp("Here, C can be kept constant and timing resistor R can be varied to get appropriate Ton, Toff (or) R can be kept constant C can be varied.")
disp("Now, R <= hfe*Rc. Therefore, it is better to keep R constant.")
disp("RC = VCC-VC2(sat) / IC(ON)")
disp("Assuming VC2(sat) = 0.2 V")
rc=(12-0.2)/(1*10^-3)  // in ohm
x1=rc*10^-3  // in k-ohm
disp(x1,"  RC(k-ohm) = 12-0.2/1*10^-3 =")
r=100*11.8*10^3  // in ohm
x1=r*10^-6  // in M-ohm
disp("            R <= hfe*RC")
disp(x1,"  R(M-ohm) <=")
disp("Hence, let us assume that R = R1 = R2 = 1 M-ohm")
disp("      Toff = 0.693*R*C1")
format(4)
c1=(20*10^-6)/(0.693*10^6)  // in faraday
x1=c1*10^12  // in pF
disp(x1,"Therefore,  C1(pF) = ")
disp("      Ton = 0.693*R*C2")
format(5)
c1=(10*10^-6)/(0.693*10^6)  // in faraday
x1=c1*10^12  // in pF
disp(x1,"Therefore,  C2(pF) = ")
```

Scilab code Exa 16.14 `component values of monostable multivibrator`

```
//Example 16.14.
clc
format(5)
disp("At stable state, Q2 is ON and Q2 is OFF:")
rc2=(6-0.3)/(6*10^-3) // in ohm
disp(rc2,"    RC2(ohm) = RC1(ohm) = VCC-VCE(sat) / IC(sat) =")
ib2=(6*10^-3)/20 // in ampere
x1=ib2*10^3  // in mA
disp(x1,"IB2(sat)(mA) = IC(sat) / hfe(min) =")
disp("Also,     IB1(sat) = 0.3 mA")
format(6)
r=(6-0.7)/(0.3*10^-3)  // in ohm
x1=r*10^-3  // in k-ohm
disp(x1,"  R(k-ohm) = VCC-VBE(sat) / IB2(sat) =")
disp("                                              [because, VBE(sat) = 0.7 V for Si transistor]")
disp("At quasi-stable state, Q1 is ON and Q2 is OFF")
disp("    T = 0.693*R*C")
format(7)
c=(140*10^-6)/(0.693*17.67*10^3)  // in F
x1=c*10^6  // in uF
disp(x1,"Therefore,      C(uF) = T / 0.693*R =")
format(6)
disp("Assume,     IB1(sat) = IR2")
ir2=0.3+0.3  // in mA
disp(ir2,"Therefore,  IR1(mA) = IB1(sat)+IR2 =")
r1=((6-0.7)/(0.6*10^-3))-950  // in ohm
x1=r1*10^-3  // in k-ohm
disp("    VCC = VBE(sat) + IR1(RC2+R1)")
disp(x1,"Therefore,  R1(k-ohm) = (VCC-VBE(sat) / IR1) - RC2 =")
format(5)
r2=(0.7+1.5)/(0.3*10^-3)  // in ohm
x1=r2*10^-3  // in k-ohm
disp(x1,"    R2(k-ohm) = VBE(sat)-(-VBB) / IR2 =")
disp("The speed up capacitor C1 is chosen such that
```

```
    R1C1 = 1 us and hence,")
format(6)
c1=(10^-6)/(7.833*10^3)  // in F
x1=c1*10^12  // in pF
disp(x1,"       C1(pF) =")  // answer in textbook is
    wrong
```

Scilab code Exa 16.15 `current and voltage for bistable multivibrator`

```
//Example 16.15.
clc
format(5)
disp("Referring to fig.16.37.")
vb1=(-12*15*10^3)/(115*10^3)  // in volts
disp(vb1,"       VB1(V) = -VBB*R2 / R2+R3 =")
disp("Since VB1 is less than VBE(cut-off), i.e. 0.7
    V for silicon transistor, Q1 is OFF.")
disp("Therefore,     IB1 = 0 and IC1 = 0")
disp("                II2 = I4 + IC2")
disp("               IC2 = I2 - I4")
ic2=((12-0.3)/(2.2*10^3))-((0.3+12)/(115*10^3)) //
    in A
x1=ic2*10^3  // in mA  (Since Q2 is ON VC2(sat) =
    0.3 V)
disp(x1,"           IC2(mA) = [VCC-VC2(sat) / RC2] -
    [VC2(sat)-(-VBB) / R2+R3] =")                    //
    answer in textbook is wrong
ib2=(5.35*10^-3)/20  // in A
x1=ib2*10^3  // in mA
disp(x1,"       IB2 > IC2 / hfe(min) >")  //
    approximately 0.5 mA
disp("         I1 = I3 + IC1")
disp("            = I3, as IC1 = 0")
disp("         I3 = IB2 + I6")
disp("         I6 = VB2-(-VBB) / R4")
```

```
disp("        VB2 = VBE2(on) = 0.7 V")
format(6)
i6=(0.7+12)/(100)  // in mA
disp(i6,"Therefore,  I6(mA) =")
i3=0.5+0.127  // in mA
disp(i3,"              I3(mA) =")
vc1=12-((0.627*10^-3)*(2.2*10^3))
disp(vc1,"              VC1(V) =")
```

Scilab code Exa 16.16 `design a schmitt trigger circuit`

```
//Example 16.16.
clc
format(6)
disp("Referring to fig. 16.40.")
disp("     UTP = VB2 = 5 V")
ve=5-0.7  // in volts
disp(ve,"Voltage across RE is VE(V) = VB2 − VBE =")
disp("     IE = IC = 2 mA")
re=4.3/2 // in k−ohm
disp(re,"     RE(k−ohm) = VE / IE =")
disp("Taking Q2 saturated, VCE(sat) = 0.2 V
   typically,")
x=12-4.3-0.2  // in volts
disp(x,"     IC*RC2 = VCC − VE − VCE(sat) =")
rc2=7.5/(2)  // in k−ohm
disp(rc2,"     RC2(k−ohm) =")
i2=0.1*2  // in mA
disp(i2,"     I2(mA) = 0.1*IC2 =")
r2=5/0.2  // in k−ohm
disp(r2,"     R2(k−ohm) = VB2 / I2 =")
ib2=(2*10^-3)/100  // in A
x1=ib2*10^6  // in uA
disp(x1,"     IB2(uA) = IC2 / hfe(min) =")
disp("     I1 = I2 + IB2")
```

```
disp("VCC-VB2 / RC1+R1 = I1 = 0.2*10^-3 + 20*10^-6")
disp("12-5 / RC1+R1 = 0.22*10^-3")
x=7/(0.22)  // in k-ohm
format(5)
disp(x,"RC1 + R1 =")
disp("When    Q1 is ON, Vi = LTP = VB2 = 3 V")
i1=3/25 // in mA
format(6)
disp(i1,"  I1(mA) = VB2 / R2 =")
ic1=(3-0.7)/2.15  // in mA
disp(ic1,"  IC1(mA) = IE = VB1-VBE / RE =")
disp("  VCC = RC1*(IC1+I1) + I1*(R1+R2)")
rc1=(12-((0.12*10^-3)*(56.8*10^3)))/(1.07*10^-3)  // in  ohm
x1=rc1*10^-3  // in k-ohm
format(5)
disp(x1,"Therefore,  RC1(k-ohm) =")
r1=31.8-4.84
format(6)
disp(r1,"  R1(k-ohm) =")
rb=(100*2.15)/10
disp("  RB < hfe*RE")
disp(rb,"  RB(k-ohm) = hfe*RE / 10 =")
```

Chapter 17

Blocking Oscillators and Time Based Generators

Scilab code Exa 17.1 design a UJT relaxation oscillator

```
//Example 17.1.
clc
format(5)
disp("We know that")
disp("  fo = 1 / (2.303*RE*CE*log10(1/1-eta))")
disp("We know that etamin = 0.56")
disp("For determining RE, we have")
RE=(20-2.9)/(1.6) // in k-ohm
disp(RE,"RE < VBB-VP/IP, i.e.  RE(k-ohm) < 20-2.9/1.6*10^-3 =")
RE=(20-1.118)/(3.5) // in k-ohm
disp(RE,"RE > VBB-VV/IV, i.e.  RE(k-ohm) < 20-1.118/3.5*10^-3 =")  // answer in textbook is wrong
disp("Therefore, RE is selected as 10 k-ohm")
disp("    1/500 = 2.303*10*10^3*CE*log10(1/1-0.56)")
CE=1/(500*(2.303*10^4)*0.36) // in farady
x1=CE*10^6 // in uF
disp(x1,"Therefore,  CE(uF) =")
```

```
disp("So, CE is selected as 0.22 uF")
disp("Let the required pluse voltage at B1 = 5V")
disp("Let the peak pulse current, IE = 250 mA")
R1=5/(250*10^-3) //in ohm
disp(R1,"Therefore,  R1(ohm) = VR1/IE =")
disp("So, R1 is selected to be 22 ohm")
disp("We select the voltage characteristics for
   VB1B2 = 4 V")
disp("Therefore,  VR2 = 20-(4+5) = 11 V")
R2=11000/250
disp(R2,"  R2(ohm) = 11*10^3/250 =")
disp("So, R2 is selected as 100 ohm")
```

Chapter 18

Rectifiers and Power Supplies

Scilab code Exa 18.1 `Im and Idc and Irms and Pdc and Pac and eta`

```
//Example 18.1.
clc
format(7)
im=325/(100+1000)   // in A
x1=im*10^3   // in mA
disp(x1,"(a) Peak value of current,  Im(mA) = Vm /
    rf+RL =")
idc=295.45/%pi // in mA
disp(idc,"    Average current,  Id.c.(mA) = Im / pi
    =")
format(8)
irms=295.45/2  // in mA
disp(irms,"    RMS value of current,  Irms(mA) = Im
    / 2 =")
format(6)
pdc=((94.046*10^-3)^2)*1000  // in W
disp(pdc,"(b) D.C. power output,  Pd.c.(W) = (Id.c.)
    ^2 * RL =")
pac=((147.725*10^-3)^2)*1100 // in W
disp(pac,"(c) AC input power,  Pac = (Irms)^2 * (rf+
    RL)")
```

```
eta=(8.845/24)*100  // in percentage
disp(eta,"(d) Efficiency of rectification,  eta(in percentage) = Pdc / Pac =")
```

Scilab code Exa 18.2 `maximum value of ac voltage`

```
//Example 18.2.
clc
format(6)
icd=(24/500)*10^3  // in mA
disp(icd,"Average value of load current,  Id.c.(mA) = Vdc / RL =")
im=%pi*48 // in mA
disp(im,"Maximum value of load current,  Im(mA) = pi * Idc =")
disp("Therefore, maximum ac voltage required at the input,")
vm=550*150.8*10^-3 // in V
disp(vm,"        Vm(V) = Im * (rf+RL) =")
```

Scilab code Exa 18.3 `Vdc and PIV and Im and Pm and Idc and Pdc`

```
//Example 18.3.
clc
format(6)
x1=230/5 // in V
vm=sqrt(2) * 46  // in V
vdc=65/%pi  // in V
im=65/300  // in A
pm=0.217^2 * 300  // in W
idc=20.7/300 // in A
format(5)
pdc=(0.069^2)*300 // in W
```

```
disp(x1,"(a) The transformer secondary voltage(in V)
    =")
format(4)
disp(vm,"    Maximum value of secondary voltage,  Vm
   (V) =")
format(5)
disp(vdc,"    Therefore, d.c. output voltage,  Vd.c
   .(V) = Vm / pi =")
disp("(b) PIV of a diode  = Vm = 65 V")
format(6)
disp(im,"(c) Maximum value of load current,  Im(A) =
    Vm / RL =")
disp("    Therefore, maximum value of power
   delivered to the load,")
format(5)
disp(pm,"             Pm(W) = Im^2 * RL =")
format(6)
disp(idc,"(d) The average value of load current,  Id
   .c.(A) = Vdc / RL")
disp("    Therefore, average value of power
   delivered to the load,")
format(5)
disp(pdc,"         Pd.c.(W) = (Idc)^2 * RL =")
```

Scilab code Exa 18.4 centre tap fullwave rectifier

```
//Example 18.4.
clc
x1=230/5  // in V
vrms=46/2 // in V
vdc=(2*23*sqrt(2))/%pi // in V
idc=(20.7/1000)*10^3 // in mA
pdc=((20.7*10^-3)^2)*900  // in W
piv=2*23*sqrt(2)  // in V
vrrms=sqrt(23^2 - 20.7^2)  // in V
```

```
f=2*60  // in Hz
format(6)
disp(x1,"The voltage across the two ends of secondary(in V) = 230 / 5 =")
disp(vrms,"Voltage from center tapping to one end, Vrms(V) =")
format(5)
disp(vdc,"(a) d.c. voltage across the load,  Vdc(V) = 2Vm / pi =")
disp("(b) d.c. current flowing through the load,")
disp(idc,"       Idc(mA) = Vdc / (rs+rf+RL) =")
format(6)
disp("(c) d.c. power delivered to the load,")
disp(pdc,"       Pdc(W) = (Idc)^2 * RL =")
format(4)
disp(piv,"(d) PIV across each diode(in W) = 2Vm =")
format(6)
disp(vrrms,"(e) Ripple voltage,  Vr,rms(V) = sqrt(Vrms^2 - Vdc^2) =")
disp(f,"    Frequency of ripple voltage(in Hz) =")
```

Scilab code Exa 18.5 `RL and Vdc and Idc and PIV`

```
//Example 18.5.
clc
format(6)
disp("(a) We know that the maximum value of current flowing through the diode for normal operation should not exceed 80% of its rated current.")
imax=0.8*400  // in mA
disp(imax,"Therefore,  Imax(mA) =")
disp("The maximum value of the secondary voltage,")
vm=sqrt(2)*100  // in V
disp(vm,"       Vm(V) =")
disp("Therefore, the value of load resistor that
```

```
   gives the largest d.c. power output")
format(5)
RL=141.4/(320*10^-3)
disp(RL,"        RL(ohm) = Vm / Imax =")
vdc=(2*141.4)/%pi
disp(vdc,"(b) D.C.(load) voltage,  Vdc(V) =
   (2*141.4)/pi =")
format(6)
idc=90/442
disp(idc,"     D.C. load current,   Idc(A) = Vdc / RL
   =")
disp("(c) PIV of each diode   = 2Vm = 282.8 V")
```

Scilab code Exa 18.6 `ac ripple voltage`

```
//Example 18.6.
clc
format(6)
disp("D.C. power delivered to the load,")
disp("                 Pdc = Vdc^2 / RL")
vdc=sqrt(50*200)
disp(vdc,"Therefore,   Vdc(V) = sqrt(Pdc*RL) =")
disp("The ripple factor,   gamma = Vac / Vdc")
disp("i.e.                       0.01 = Vac / 100")
disp("Therefore, the ac ripple voltage across the
   load, Vac = 1 V")
```

Scilab code Exa 18.7 `Vdc and Pdc and PIV and output frequency`

```
//Example 18.7.
clc
Vrms=230/4   // in V
vm=sqrt(2)*57.5   // in V
```

```
vdc=(2*81.3)/%pi  // in V
pdc=52^2/1000  // in W
format(5)
disp("(a) The rms value of the transformer secondary voltage,")
disp(Vrms,"      Vrms(V) =")
disp("     The maximum value of the secondary voltage")
disp(vm,"      Vm(V) =")
format(4)
disp(vdc,"Therefore, d.c. output voltage,  Vdc(V) = 2Vm / pi =")
format(6)
disp("(b) D.C. power delivered to the load,")
disp(pdc,"      Pd.c.(W) = (Vdc)^2 / RL =")
disp("(c) PIV across each diode = Vm = 81.3 V")
disp("(d) Output frequency = 2 x 50 = 100 Hz")
```

Scilab code Exa 18.8 `value of inductance`

```
//Example 18.8.
clc
format(7)
L=0.0625/0.04 // in H
disp("We know that the ripple factor for inductor filter is gamma = RL / 3*sqrt(2)*omega*L")
disp(L,"Therefore,    L(in Henry) = ")
```

Scilab code Exa 18.9 `value of capacitance`

```
//Example 18.9.
clc
format(6)
```

```
disp("We know that the ripple factor for capacitor filter is")
disp("     gamma = 1 / 4*sqrt(3)*f*C*RL")
c=(0.722)/0.01  // in pF
disp(c,"Therefore,    C(pF) =")
```

Scilab code Exa 18.10 `design a full wave circuit`

```
//Example 18.10
clc
format(6)
rl=10/(200*10^-3)  // in ohm
lc=1.194/0.02
disp(rl,"The effective load resistance  RL(ohm) =")
disp("We know that the ripple factor,  gamma = 1.194 / LC")
disp(lc,"i.e.        LC =")
disp("Critical value of L(mH) = RL / 3*omega = 50 / 3*2*pi*f = 53mH")
disp("Taking L = 60 mH (about 20% higher), C will be about 1000 uF")
```

Scilab code Exa 18.11 `design a CLC or pi section filter`

```
//Example 18.11
clc
rl=(10/(200*10^-3))  // in ohm
c2=11.4/0.02
format(4)
c=sqrt(570)  // in uF
disp(rl,"     RL(ohm) =")
disp("     0.02 = 5700 / L*C1*C2*50 = 114 / L*C1*C2")
```

```
disp("If we assume L = 10 mH and  C1 = C2 = C, we have")
disp("    0.02 = 114 / L*C^2 = 11.4 / C^2")
disp(c2,"    C^2 =")
disp(c,"therefore,C(uF) =")
```

Scilab code Exa 18.12 `design zener shunt voltage regulator`

```
//Example 18.12.
clc
format(5)
disp("Refer fig. 18.18.")
disp("Selection of zener diode")
disp("    Vz = Vo = 10 V")
disp("    Iz_max = 40 mA")
pz=10*40*10^-3  // in W
disp(pz,"    Pz(W) = Vz * Iz_max =")
disp("Hence a 0.5Z 10 zener can be selected")
disp("Value of load resistance, RL")
rlmin=10/(50*10^-3)  // in ohm
disp(rlmin,"  RL_min(ohm) = Vo / IL_max =")
rlmax=10/(30*10^-3)  // in ohm
disp(rlmax,"  RL_max(ohm) = Vo / IL_min =")
disp("Value of input resistance, R")
rmax=(30-10)/((30+40)*10^-3)  // in ohm
disp(rmax,"  Rmax(ohm) = Vin(max)-Vo / ILmin+IZmax =")
rmin=(20-10)/((50+20)*10^-3)  // in ohm
disp(rmin,"  Rmax(ohm) = Vin(min)-Vo / ILmax+IZmin =")
r=(286+143)/2
disp(r,"  R(ohm) = Rmax+Rmin / 2 =")  // answer in textbook is wrong
```

Scilab code Exa 18.13 `design the zener regulator`

```
//Example 18.13.
clc
format(6)
disp("The minimum Zener current is IZ(min) = 5 mA
   when the input voltage is minimum")
disp("Here the input voltage varies between 10 V +-
   20% i.e. 8 V and 12 V")
disp("Therefore, the input voltage Vi(min) = 8 V")
disp("Therefore,")
rl=5/(20*10^-3)   // in ohm
disp(rl,"     RL(ohm) = Vo / IL =")
r=(8-5)/((5+20)*10^-3)   // in ohm
disp(r,"Hence, the series resistance  R(ohm) = Vi(
   min)-Vo / IZ(min)+IL =")
disp("The various values are given in the Zener
   regulator shown in Fig. 18.19")
```

Scilab code Exa 18.14 `design the regulator`

```
//Example 18.14.
clc
format(6)
disp("Load current varies from 0 to 20 mA")
disp("     IZ(min) = 10 mA, IZ(max) = 100 mA")
disp("Here,     Vz = Vo = 10 V (constant)")
disp("Applying KVL to a closed loop circuit,")
disp("     20 = IR + 10")
disp("or     IR = 10")
disp("Therefore, R = 10/I ohm, where I is the loop
   current in amperes")
```

```
disp("(i) Let IZ = IZ(min) and IL = 0")
disp("    The total current   I = IL + IZ = 10 mA")
r=10/(10*10^-3)  // in ohm
disp(r,"    Therefore,  R(ohm) =")
disp("(ii) For IZ = IZ(max) = 100 mA and IL = 20 mA")
i=20+100  // in mA
disp(i,"     I(mA) = IL + IZ =")
r=10/(120*10^-3)
disp(r,"     Therefore,  R(ohm) =")
disp("(iii) The range of R varies from 83.33 ohm to 1000 ohm")
```

Scilab code Exa 18.15 `design zener voltage regulator`

```
//Example 18.15.
clc
format(6)
rl=5/(10*10^-3)  // in ohm
disp(rl,"Here, load resistance is RL(ohm) = Vo / IL =")
iz=400/5  // in mA
disp(iz,"Maximum Zener Current Iz_max(mA) =")
disp("The minimum input voltage required will be when Iz = 0. Under this condition,")
disp("    I = IL = 10 mA")
disp("Minimum input voltage  Vi_min = Vo + IR")
vi=10-2  // in V
disp(vi,"Hence,    Vi_min(V) =")
disp("or    8 = 5 + (10*10^-3)R")
rmax=3/(10*10^-3)  // in ohm
disp(rmax,"Therefore,  Rmax(ohm) =")
disp("Now, maximum input voltage, Vi_max = 5 + [(80+10)10^-3]R")
rmin=7/(90*10^-3)  // in ohm
```

```
disp(rmin,”    Rmin(ohm) =”)
disp(”The value of R is chosen between 77.77 ohm and 300 ohm”)
```

Scilab code Exa 18.16 `series resistance and diode current`

```
//Example 18.16.
clc
format(7)
il=(24/1200)*10^3  // in mA
disp(il,”The load current,  IL(mA) = Vo / RL =”)
iz=600/24  // in mA
disp(iz,”Max. Zener current,  Iz_max(mA) =”)
rmax=(32-24)/((20+25)*10^-3)  // in ohm
disp(rmax,”  Rmax(ohm) = Vi−Vo / IL_min+IZ_max =”)
```

Scilab code Exa 18.17 `design a linear voltage regulator`

```
////Example 18.17.
clc
format(6)
vi=15+3   // in V
disp(”Refer to fig.18.24. We know that”)
disp(vi,”     Vi_min(V) = Vo + 3V =”)
vi=18+1  // in V
disp(”Assuming the ripple voltage Vr = 2V(max), the input voltage is”)
disp(vi,”  Vi(V) = Vi(min) + Vr/2 =”)
vz=19/2  // in V
disp(vz,”Then    Vz(V) = Vi /2 =              (use the zener diode 1N758 for 10V)”)
disp(”Therefore,  Vz = 10 V”)
disp(”              Iz = 20 mA”)
```

```
r1=(19-10)/(20*10^-3)   // in ohm
disp(r1,"     R1(ohm) = Vi-Vz / Iz =")
disp("Let     I2 = IB(max) = 50 uA")
r2=((15-10)/(50*10^-6))*10^-3   // in k-ohm
disp(r2,"     R2(k-ohm) = Vo-Vz / I2 =")
r3=(10/(50*10^-6))*10^-3   // in k-ohm
disp(r3,"     R3(k-ohm) = Vz / I2 =")
disp("Select     C1 = 50 uF")
disp("Specification of transistor Q1")
vce=19+1   // in V
disp(vce,"     VCE_max(V) = Vi_max(V) = Vi + Vr/2 =")
disp("     IE = IL = 50 mA")
p=((19-15)*50)   // in mW
disp(p,"     P(mW) = VCE*IL = (Vi-Vo) * IL =")
disp("Use the transistor 2N718 for Q1")
```

Scilab code Exa 18.18 `design a series voltage regulator`

```
//Example 18.18. refer fig.18.27
clc
format(6)
rlmin=20/(50*10^-3)   // in ohm
disp("Selection of Zener diode")
disp(rlmin,"  RLmin(ohm) = Vo / ILmax =")
vz=20/2   // in V
disp(vz,"  Vz(V) = Vo / 2 =")
disp("Hence, the zener diode 0.5Z10 is chosen.")
disp("Since,  IR1 > IB2, IR1 > IC2/beta, IR2 > 10*10^-3 / 150")
disp("          IR1 > 66.7 uA")
disp("Let  IR1 = IR2 = IR3 = 10 mA (neglecting IB2)")
disp("Let  IC2 = IE2 = 10 mA")
disp("So, the current flowing through the Zener,")
iz=10+10   // in mA
```

```
disp(iz,"   Iz(mA) = IE2 + IR1 =")
pz=10*20*10^-3   // in W
disp(pz,"   Pz(W) = Vz*Iz =")   // > 0.5 W
disp("Hence selection of 0.5Z10 Zener diode is confirmed")
disp("")
disp("Selection of transistor Q1")
ie1=10+10+50   // in mA
disp(ie1,"   IE1(mA) = IR1 + IR2 + IL =")
disp("   Vi(max) - Vo = 30 -20 = 10 V")
disp("For transistor SL100, the rating are")
disp("     IC(max) = 500 mA")
disp("    VCE(max) = 50 V")
disp("          hre = 50 - 280")
disp("Hence, SL100 can be chosen for Q1")
disp("")
disp("Selection of transistor Q2")
disp("   From the fig.,  VCE2(max) + Vz = (V0 + VBE1)")
vce2=20.6-10   // in V
disp(vce2,"   Therefore,  VCE2_max(V) = (Vo + VBE1) - Vz =")
disp("For transistor BC107, the rating are")
disp("     VCEO(max) = 45 V")
disp("       IC(max) = 200 mA")
disp("           hFE = 125 - 300")
disp("Hence, transistor BC107 is selected for Q2")
disp("")
disp("Selection of resistor R1, R2 and R3")
vr1=20-10   // in V
disp(vr1,"   VR1(V) = Vo - Vz =")
r1=10/(10)   // in k-ohm
disp(r1,"   R1(k-ohm) = VR1 / IR1 =")
vr2=20-10.6   // in V
disp(vr2,"   VR2(V) = Vo - VR3 =")
r2=9.4/(10*10^-3)   // in ohm
disp(r2,"   R2(ohm) = VR2 / IR2 =")
vr3=10+0.6   // in V
```

```
disp(vr3," VR3(V) = Vz + VBE2(sat) =")
r3=10.6/(10*10^-3) // in ohm
disp(r3," R3(ohm) = VR3 / IR3 =")
disp("")
disp("Selection of resistor R4")
vb1=20+0.6 // in V
disp(vb1," VB1(V) = VC2(V) = Vo + VBE1 =")
ib1=70/50 // in mA
disp(ib1," IB1(mA) = IC1 / beta =")
ir4=11.4 // in mA
disp(ir4," IR4(mA) = IB1 + IC2 =")
format(5)
r4max=(30-20.6)/(11.4*10^-3) // in ohm
disp(r4max," R4_max(ohm) = VR4(max) / IR4 = Vi(max)-VB1 / IR4 =")
r4min=(22-20.6)/(11.4*10^-3) // in ohm
disp(r4min," R4_min(ohm) = VR4(min) / IR4 = Vi(min)-VB1 / IR4 =")
format(6)
r4=(825+123)/2 // in ohm
disp(r4," R4(ohm) = R4(max)+R4(min) / 2 =")
```

Scilab code Exa 18.19 `design a circuit to supply domestic power`

```
//Example 18.19.
clc
format(6)
disp("The secondary output of step-down transformer is sqrt(2) times the output d.c. voltage required. Therefore, the step-down transformer is wound to have 230 V : 23 V")
disp("Given data: D.C. output voltage = 9 V and Load current = 100 mA")
disp("The current rating is 1.5 times the maximum loas current i.e. 150 mA")
```

```
disp("A bridge rectifier or full wave rectifier is used to get the pulsating d.c. output.")
rl=9/(100*10^-3)  // in ohm
disp(rl," RL(ohm) = Vdc / TL =")
disp("A capacitor filter is used to remove the ripple and get a smooth output.")
disp("    Ripple factor gamma = 1 / 4*sqrt(3)*f*C*RL ")
disp("Assume the ripple factor to be 0.03")
c=(1/(4*sqrt(3)*50*0.03*90))*10^6  // in uF
disp(c," C(uf) =")  // = 1000 uF
disp("The short circuit resistance Rsc connected with the series pass transistor is")
format(4)
rsc=0.7/(150*10^-3)  // in ohm
disp(rsc," Rsc(ohm) = VBE / Ilim_it =")
disp("Assume 7.6 V Zener diode in series with 1.5 k-ohm")
disp("The designed circuit is shown in fig.18.32.")
```

Chapter 19

Integrated Circuit Fabrication

Scilab code Exa 19.1 `design 5 k ohm diffused resistor`

```
//Example 19.1.
clc
format(6)
disp("Given the sheet resistance Rs = 200 ohm/square
   ")
disp("Then the resistance R = 5 k-ohm = Rs*(l/w) =
   200*(l/w)")
x=5000/200
disp(x,"Therefore, l/w = R/Rs =")
disp("So, a 5 k-ohm resistor can be fabricated by
   using a pattern of 25mil x 1mil as shown in fig
   .19.24.")
```

Scilab code Exa 19.2 `design 1 k ohm resistor`

```
//Example 19.2.
clc
format(6)
```

```
disp("Given the sheet resistance Rs = 30 ohm/square")
disp("Then the resistance R = 1 k-ohm = Rs*(l/w) = 30*(l/w)")
disp("Therefore, l/w = R/Rs = 1000/30 = 100/3")
disp("So, a 5 k-ohm resistor can be fabricated by using a pattern of 100mil x 3mil as shown in fig.19.24.")
```

Chapter 20

Operational Amplifiers

Scilab code Exa 20.1 `common mode gain or op amp`

```
//Example 20.1.
clc
format(6)
disp("     CMRR = Ad / Acm = 10^5")
acm=(10^5)/(10^5)
disp(acm,"     Therefore, the common-mode gain, Acm = Ad / CMRR =")
```

Scilab code Exa 20.2 `slew rate of op amp`

```
//Example 20.2.
clc
format(6)
sr=20/(4) // in V/us
disp("     The slew rate,         SR = dVo / dt")
disp(sr,"     SR(in V/us) =")
```

Scilab code Exa 20.3 `maximum frequency`

```
//Example 20.3.
clc
format(5)
disp(”The 741C has typical slew rate of 0.5 V/us. Using Eq.(20.8), the slew rate is,”)
disp(”       SR = 2*pi*f*Vm / 10^6 = 0.5 V/us”)
vm=50*(20*10^-3) // in volts
disp(vm,”The maximum output voltage,  Vm(V) = A*Vid =”)
disp(”The maximum frequency of the input for which undistorted output is obtained is given by,”)
f=(0.5*10^6)/(2*%pi*1) // in kHz
x1=f*10^-3
disp(x1,”      fmax = SR*10^6 / 2*pi*Vm =”)
```

Scilab code Exa 20.4 `maximum peak to peak input signal`

```
//Example 20.4.
clc
format(5)
disp(”The 741C has typical slew rate of 0.5 V/us. Using Eq.(20.8), the slew rate is,”)
disp(”       SR = 2*pi*f*Vm / 10^6 = 0.5 V/us”)
vm=(0.5*10^6)/(2*%pi*(40*10^3)) // in volts
disp(”    = 3.98 V peak-to-peak”,vm,”The maximum output voltage,  Vm(V peak-to-peak) = SR*10^6 / 2*pi*f =”)
disp(”The maximum peak-to-peak input voltage for undistorted output is,”)
vid=3.98/10 // in volts
format(6)
disp(vid,”       Vid(V peak-to-peak) = Vm/A =”)
```

Scilab code Exa 20.5 `closed loop voltage gain`

```
//Example 20.5. refer fig.20.10.
clc
format(6)
af=-10/1
disp(af,"  The closed-loop voltage gain Af = -RF / R1 =")
```

Scilab code Exa 20.6 `closed loop voltage gain and beta`

```
//Example 20.6. refer fig.20.11.
clc
format(6)
af=1+(10/1)
disp(af,"  The closed-loop voltage gain, AF = 1 + RF/R1 =")
beta=1/(1+10)
disp(beta,"  The feedback factor,  beta = R1 / R1+RF =")
```

Scilab code Exa 20.7 `design the output voltage`

```
//Example 20.7. refer fig. 20.16.
clc
format(6)
v=-(2+3+4) // in volts
disp("The output voltage is given by,")
disp(v,"    Vo(V) = -Rf/R * (V1+V2+...+Vn) =")
```

Scilab code Exa 20.8 `design a high pass filter`

```
//Example 20.8.
clc
format(5)
disp("1.   Given: fL = 1 kHz")
disp("2.   Since R and C values are not given, let
   assume C = 0.01 uF")
r=1/(2*%pi*(10^3)*(0.01*10^-6))
x1=r*10^-3   // in k-ohm
disp(x1,"3.   Therefore, R(k-ohm) = 1 / 2*pi*fL*C =")
disp("4.   Given pass band gain A = 1 + Rf/Ri = 2 i.e
   . the value of Rf = Ri")
disp("Let Rf = Ri = 10 k-ohm. The high pass circuit
   values are shown in Fig.20.31")
```

Scilab code Exa 20.9 `T and R and peak differential input voltage`

```
//Example 20.9. refer fig.20.35(a).
clc
format(6)
disp("(a) From Eq.(20.32), the time period, T = 2RC
   ln(R1+2R2 / R1)")
disp("           T = 2RC ln(116*10^3 +
   2*100*10^3/116*10^3)")
disp("           T = 2RC ln(316*10^3/116*10^3)")
disp("           T = 2RC          (since ln
   (316*10^3/116*10^3) = 1)")
disp("Given      f = 1 kHz,   T = 1/f = 1 ms")
disp("That is,    2RC = 1*10^-3 sec")
disp("Therefore, the time constant RC = 0.5*10^-3
   sec")
```

```
r=(0.5)/0.01 // in k-ohm
disp(r,"(b) With        C = 0.01 uF,  R(k-ohm) = 0.5*10^-3/0.01*10^-6 =")
disp("(c) Maximum value of differential input voltage is")
x=2*14*(100/(100+116))
disp(x,"            2*Vsat*(R2 / R1+R2) = ")
disp("Therefore, the peak values for the differential input voltage just exceed +-2 x 6.48 V")
```

Chapter 21

Transducers

Scilab code Exa 21.1 `value of electron mobility`

```
//Example 21.1.
clc
format(6)
u=10*200 // in cm^2/V-s
disp(u,"The electron mobility, un(cm^2/V-s) = sigma*
   RH =")
```

Scilab code Exa 21.2 `value of electron concentration`

```
//Example 21.2.
clc
format(9)
n=10/((50*10^-4)*(1.6*10^-19))  // m^-3
disp("We know that the electron mobilty, un = sigma/
   nq")
disp("Therefore, the electron concentration,")
disp(n,"              n(m^-3) = sigma / uq =")
```

Scilab code Exa 21.3 `value of electron density`

```
//Example 21.3.
clc
format(7)
n=(1.2*20)/(60*(1.6*10^-19)*(0.5*10^-3)) //  in m^3
disp(”We know that the number of conduction electrons, i.e. electron density,”)
disp(n,”        n(m^3) = B*I/VH*q*w =”)
```

Chapter 24

Digital Circuits

Scilab code Exa 24.1 `decimal to octal`

```
//Example 24.1. convert decimal 12 to an octal number
clc
o=dec2oct(12)
disp(”The procedure is as follows.”)
disp(”12 divided by 8 = quotient 1 with a remainder of 4”)
disp(” 1 divided by 8 = quotient 0 with a remainder of 1”)
disp(o,”Therefore, decimal 12 = octal”)
```

Scilab code Exa 24.2 `octal to decimal`

```
//Example 24.2. convert octal number to decimal.
clc
d=oct2dec([”444”])
disp(d,”(i) octal 444 = decimal”)
d1=oct2dec([”237”])
```

```
disp(d1,"(ii) octal 237 = decimal")
d2=oct2dec(["120"])
disp(d2,"(iii) octal 120 = decimal")
```

Scilab code Exa 24.3 `decimal to hexadecimal`

```
//Example 24.3. convert decimal to hexadecimal
   number
clc
h=dec2hex([112])
disp("The procedure is as follows,")
disp("(i) 112 divided by 16 = quotient 7 with a
   remainder of 0")
disp("      7 divided by 16 = quotient 0 with a
   remainder of 7")
disp(h,"decimal 112 = hex")
disp("(ii) 253 divided by 16 = quotient 7 with a
   remainder of 13 i.e. D")
disp("      15 divided by 16 = quotient 0 with a
   remainder of 15 i.e. F")
h=dec2hex([253])
disp(h,"decimal 253 = hex")
```

Scilab code Exa 24.4 `hexadecimal to decimal`

```
//Example 24.4. convert hexadecimal number to
   decimal
clc
h=hex2dec(['4AB'])
disp(h,"(i) hex 4AB = decimal")
h=hex2dec(['23F'])
disp(h,"(ii) hex 23F = decimal")
```

Scilab code Exa 24.5 `multiplication of binary numbers`

```
//Example 24.5. multiply binary numbers
clc
h=bin2dec('1101')
o=bin2dec('1100')
p=h*o
z=dec2bin(p)
disp(z,"(i) 1101 x 1100 = ")
h=bin2dec('1000')
o=bin2dec('101')
p=h*o
z=dec2bin(p)
disp(z,"(ii) 1000 x 101 = ")
h=bin2dec('1111')
o=bin2dec('1001')
p=h*o
z=dec2bin(p)
disp(z,"(iii) 1111 x 1001 = ")
```

Scilab code Exa 24.6 `division of binary numbers`

```
//Example 24.6. perform the binary divisions
clc
x=bin2dec('110')
x1=bin2dec('10')
x2=x/x1
x3=dec2bin(x2)
disp("(i) 110 / 10")
disp(x3,"  = binary")
disp(x2,"  = decimal")
x=bin2dec('1111')
```

```
x1=bin2dec('110')
x2=x/x1
x3=dec2bin(int(x2));
disp("(ii) 1111 / 110")
disp(x3,"  = binary")
disp(x2,"  = decimal")
```

Scilab code Exa 24.7 `1s complement subtraction`

```
//Example 24.7
clc
disp("1''s compliment method")
disp("      1 1 1 1")
disp("      0 1 0 1    <-- 1''s complement")
disp("    ----------")
disp("  (1) 1 1 0 1   <-- carry")
disp("          1   <-- add carry")
disp("    ----------")
disp("      0 1 0 1")
```

Scilab code Exa 24.8 `1s complement subtraction`

```
//Example 24.8
clc
disp("1''s compliment method")
disp("    1 0 0 0")
disp("    0 1 0 1   <-- 1''s complement")
disp("    --------")
disp("    1 1 0 1")
disp("No carry results and the answer is the 1''s complement of 1101 and opposite in sign, i.e. -0010.")
```

Scilab code Exa 24.9 `2s complement subtraction`

```
//Example 24.9
clc
disp("2''s compliment method")
disp("      1 1 1 1")
disp("      0 1 1 0   <-- 2''s complement")
disp("    ----------")
disp("  (1) 0 1 0 1")
disp("The carry is discarded. Thus, the answer is 0101.")
```

Scilab code Exa 24.10 `2s complement subtraction`

```
//Example 24.10
clc
disp("2''s compliment method")
disp("  1 0 0 0")
disp("  0 1 1 0   <-- 2''s complement")
disp("  --------")
disp("  1 1 1 0   <-- no carry")
disp("No carry results. Thus, the difference is negative and the answer is the 2''s compliment of 1110, i.e. 0010")
```

Scilab code Exa 24.11 `BCD addition`

```
//Example 24.11
clc
```

```
disp("(i)          1 0 0 1")
disp("           + 0 1 0 0")
disp("           ----------")
disp("             1 1 0 1      Invalid BCD number")
disp("           + 0 1 1 0      Add 6")
disp("           ----------")
disp("     0 0 0 1 0 0 1 1      Valid BCD number")
disp("")
disp("(ii)    0 0 0 1 1 0 0 1")
disp("      + 0 0 0 1 0 1 0 0")
disp("        ----------------")
disp("        0 0 1 0 1 1 0 1   Right group is invalid")
disp("              + 0 1 1 0   Add 6")
disp("        ----------------")
disp("        0 0 1 1 0 0 1 1   Valid BCD number")
```

Scilab code Exa 24.12 `Boolean algebra`

```
//Example 24.12.
clc
disp("(i) A + AB                = A(1+B)   distributive law")
disp("                          = A.1       law 2")
disp("                          = A         law 4")
disp('')
disp("(ii) A + A''B              = (A+A'')(A+B)   distributive law")
disp("                          = 1.(A+B)       law 6")
disp("                          = A + B         law 4")
disp('')
disp("(iii) AB + A''C + BC       = AB + A''C + BC1")
disp("                          = AB + A''C + BC(A+A'')")
disp("                          = AB + A''C + ABC + A''BC")
```

```
disp(”                         = AB(1+C) + A’’C(1+B)”)
disp(”                         = AB + A’’C”)
disp(”The above property, i.e AB + A’’C + BC = AB +
   A’’C, is called consensus theorem.”)
```

Scilab code Exa 24.13 `Simplify boolean algebra`

```
//Example 24.13
clc
disp(”(a)         A + AB + AB’’C”)
disp(”Step 1: Apply rule 10 of table 24.2,i.e A + AB
    = A. The expression simplifies to”)
disp(”            A + AB’’C”)
disp(”Step 2: Apply distributive property”)
disp(”            (A+A)(A+B’’C)”)
disp(”            = A(A+B’’C)”)
disp(”Step 3: Taking A as the common term,”)
disp(”            A[1.(1+B’’C)]”)
disp(”Step 4: Apply rule 2 of Table 24.2, i.e. 1 + B
   ’’C = 1”)
disp(”            A.1 = A”)
disp(”Thus, the simplified expression is A”)
disp(’’)
disp(”(b)         (A’’+B)C + ABC”)
disp(”Step 1: Apply distributive property”)
disp(”            A’’C + BC + ABC”)
disp(”Step 2: Taking BC as common term,”)
disp(”            A’’C + BC(1+A)”)
disp(”Step 3: Apply rule 2”)
disp(”            A’’C + BC.1”)
disp(”Step 4: Taking C as the common term,”)
disp(”            C(A’’+B)”)
disp(”Thus, the simplified expression is C(A’’+B)”)
disp(’’)
disp(”(c)         AB’’C(BD+CDE) + AC’’”)
```

```
disp("Step 1: Apply distribtive property")
disp("            AB''BCD + AB''CCDE + AC''")
disp("Step 2: Apply rules 8 and 7 to the first and second terms, respectivly,")
disp("             0 + AB''CDE + AC''")
disp("Step 3: Taking A as the common term,")
disp("            A(B''CDE+C'')]")
disp("Step 4: Apply rule 11 i.e., B''CDE + C'' = B''DE + C''")
disp("            A(B''DE+C'')")
disp("Thus, the simplified expression is A(B''DE+C'')")
```

Scilab code Exa 24.14 `Simplify Karnaugh map`

```
//example 24.14
clc;
disp('The kanaurgh map for given truth table will be :');
disp('       A''B''   A''B   AB   AB'''); //displaying the given kmap
disp('C''      1     0     0    1');
disp('C       0     1     1    0');
disp("The adjacent cells that can be combined together are cells 000 and 100 and the cells 011 and 111");
disp("By combining the adjacent cells, we get")
disp("       Y = (A''+A)B''C'' + (A''+A)BC")
disp("         = B''C'' + BC")
```

Scilab code Exa 24.15 `Simplify Karnaugh map`

```
//example 24.15
```

```
clc;
disp('The kanaurgh map for given truth table will be :');
disp('       A''B''  A''B  AB  AB'''); //displaying the given kmap
disp('C''D''     1     0     0    1');
disp('C''D       0     1     1    0');
disp('CD        0     0     0    0');
disp('CD''       0     0     0    0');
disp("In the above K-map, the following adjacent cells can be combined to form two pairs of adjacent 1s. Thus, the cell pairs are B''C''D'' and BC''D. The simplified function is Y = B''C''D'' + BC''D");
```