

Scilab Textbook Companion for  
Electronics Devices And Circuits  
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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

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

```

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

```

---

### Scilab code Exa 1.2 Finding wavelength

```

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

```

---

### Scilab code Exa 1.3 wavelength of the Balmer series

```

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

```

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

---

# Chapter 3

## Electron Ballistics

Scilab code Exa 3.1 Speed and the kinetic energy

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

---

Scilab code Exa 3.2 Velocity and kinetic energy

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



```

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

```

---

### Scilab code Exa 3.3 velocity and time of travel

```

1 //Example 3.3.
2 clc
3 format(6)
4 d=6*10^-3
5 q=1.6*10^-19
6 m=9.1*10^-31
7 vax=3*10^6
8 E=350/d
9 disp(E,"Therefore , E(V/m) = V / d =")
10 format(10)
11 ax=q*E/m
12 disp(ax," ax(m/s^2) = qE / m =")
13 disp("We know that ,")
14 disp(" x = vox*t + 0.5*a*t^2")
15 disp(" vx = vox + ax*t")
16 disp("(i) Consider x = 3*10^-3 m")
17 disp(" 3*10^-3 = 3*10^6*t + 5.13*10^15*t^2")
18 disp("Solving this equation ,")
19 format(9)
20 t=poly(0, 't')
21 p1=(5.13*10^15)*t^2+(3*10^6)*t-3*10^-3
22 t1=roots(p1)
23 ans1=t1(1)

```

```

24 disp(ans1,"t(seconds)= ")
25 format(8)
26 vx=(3*10^6)+((1.026*10^16)*(5.264*10^-10))
27 disp(vx,"vx(m/s)= ")
28 disp("(ii) Consider x = 6*10^-6 m")
29 disp("t^2+(5.85*10^-10)*t-(1.17*10^-18) = 0")
30 disp("Solving this equation,")
31 format(9)
32 p2=t^2+(5.85*10^-10)*t-1.17*10^-18
33 t2=roots(p2)
34 ans2=t2(1)
35 disp(ans2,"t(seconds)= ")
36 vx1=(3*10^6)+((8.28*10^-10)*(1.026*10^16))
37 disp(vx1,"vx(m/s)= ")

```

---

#### Scilab code Exa 3.4 electron velocity time kinetic energy

```

1 //Example 3.4.
2 clc
3 V=200
4 m=9.1*10^-31
5 format(8)
6 v=sqrt(2*q*V/m)
7 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")
8 disp(v,"v(m/s) = sqrt(2*q*V/m) =")
9 iv=0 //initial velocity
10 fv=8.38*10^6 //final velocity
11 va=(iv+fv)/2 //average velocity of electron in
      transit
12 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,")

```

```

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

```

---

### Scilab code Exa 3.5 time of travel

```

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

```

---

### Scilab code Exa 3.6 position of electron and time

```
1 //Example 3.6.
2 clc
3 format(5)
4 d=(5*10^11*1.76*10^11)*(((1*10^-9)^3)/6)
5 x1=d*10^6
6 disp("The electric field intensity,")
7 disp("E = -5t / d*10^-9 = -5t / 10^-9*1*10^-2 =
      5*10^11*t (for 0 < t < t1)")
8 disp(" = 0 (for t1 < t < infinity)")
9 disp("(i) The position of the electron after 1ns,")
10 disp(x1," d(um) = (5*10^11)*(1.76*10^11)
      *((1*10^-9)^3/6) =")
11 format(6)
12 x2=0.8-(d*10^2)
13 disp(x2,"(ii) The rest of the distance to be covered
      by the electron = 0.8cm - 14.7 um =")
14 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"
      )
15 vx=(5*10^11*1.76*10^11)*(((1*10^-9)^2)/2)
16 disp(vx,"vx(m/s) = (5*10^11)*(q/m)*(t^2/2) =")
17 format(9)
18 x3=(x2/vx)*10^-2
19 disp(x3,"Therefore, the time t2(seconds) = d / vx =")
      )
20 x4=(1*10^-9)+x3
21 disp(x4,"The total time of transit of electron from
      cathode to anode(in seconds) =")
```

---

### Scilab code Exa 3.7 position of the electron

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

---

### Scilab code Exa 3.8 velocity and radius and time

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

```

13 v=sqrt(2*Q*V/M)
14 disp("(i) The velocity of the charged particle
    before entering the field is,")
15 disp(v,"v(m/s) = sqrt(2aV/m) * sqrt(2(3q)V/2m) =
    sqrt(6qV/2m) =")
16 B=0.02
17 format(6)
18 r=(M*v*sin(radians))/(Q*B)
19 r1=r*10^3
20 disp("(ii) The radius of the helical path is")
21 disp(r1,"r(mm) = Mvsine(theta) / QB = 2mvsine(theta)
    / 3qB =")
22 format(9)
23 T=(2*pi*M)/(B*Q)
24 disp("(iii) Time for one revolution,")
25 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

```

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

```

---

**Scilab code Exa 3.10** velocity and acceleration and deflection

```
1 //Example 3.10
2 clc
3 Va=600
4 l=3.5
5 d=0.8
6 L=20
7 Vd=20
8 format(9)
9 q=1.6*10^-19
10 m=9.1*10^-31
11 v=sqrt(2*q*Va/m)
12 disp(v,"(i) The velocity of the electron , v(m/s)= ")
13 format(10)
14 a=(q/m)*(Vd/d)
15 a1=a*10^2
16 disp("(ii) ma = qE")
17 disp(a1,"Thus, acceleration , a(m/s)= qE / m = (q/m)(
    Vd/d) =")
18 format(5)
19 D=(1*L*Vd)/(2*Va*d)
20 disp(D,"(iii) The deflection on the screen , D(cm)=
    ILVd / 2Vad =")
21 format(7)
22 Ds=D/Vd
23 disp(Ds, "(iv) Deflection sensitivity (cm/V)= D / Vd
    =")
```

---

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

```
1 //Example 3.11.
```

```

2  clc
3  q=1.6*10^-19
4  m=9.1*10^-31
5  Va=800
6  l=2
7  d=0.5
8  L=20
9  D=1
10 format(9)
11 v=sqrt(2*q*Va/m)
12 disp(v,"(i) The velocity of the beam, v(m/s)= sqrt(2
      qVa / m) =")
13 Vd=(D*2*d*Va)/(l*L)
14 disp("(ii) The deflection of the beam, D = lLv / 2
      dVa")
15 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

```

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

```



```

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

```

---

**Scilab code Exa 3.13** time required for maximum height

```

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

```

---

**Scilab code Exa 3.14** deflection of the spot

```

1 //Example 3.14.

```

```

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

```

---

### Scilab code Exa 3.15 deflection voltage

```

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

```
1 //Example 4.1.
2 clc
3 un1=3800 //mobility of free electrons in pure
    germanium
4 up1=1800 //mobility of free holes in pure germanium
5 un2=1300 //mobility of free electrons in pure
    silicon
6 up2=500 //mobility of free holes in pure silicon
7 q=1.6*10^-19
8 nig=2.5*10^13
9 nis=1.5*10^10
10 format(7)
11 sigma1=q*nig*(un1+up1)
12 disp("(i) The intrinsic conductivity for germanium,")
    )
13 disp(sigma1,"sigma_i(S/cm) = q*ni*(un+up) = ")
14 format(8)
15 sigma2=q*nis*(un2+up2)
16 disp("(ii) The intrinsic conductivity for silicon,")
17 disp(sigma2,"sigma_i(S/cm)= q*ni*(un+np) =")
```

---

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

```
1 //Example. 4.2.
2 clc
3 disp("The Fermi level in an N-type material is given
      by")
4 disp("Ef = Ec - k*T*ln(Nc/Nd)")
5 disp("(Ec - Ef) = k*T*ln(Nc/Nd)")
6 disp("At T = 300 K,")
7 disp("0.3 = 300*k*ln(Nc/Nd)                      Eq.1")
8 disp("Similarly,")
9 disp("(Ec - Ef1) = 360*k*ln(Nc/Nd)              Eq.2")
10 )
11 disp("Eq.2 divided by Eq.1 gives,")
12 disp("(Ec - Ef1)/0.3 = 360/300")
13 disp("Therefore, (Ec - Ef1) = (360/300) x 0.3")
14 q=(360/300)*0.3
15 disp(q,"Ec - Ef1=")
16 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

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

```

7 disp("(a) At T=350 K, (Ef1 - Ev) = 350*k*ln(Nv/Na)
      Eq.2")
8 disp("Hence, from the above Eq.2 and Eq.1,")
9 disp("(Ef1 - Ev)/0.3 = 350/300")
10 q1=(350/300)*0.3
11 disp("eV",q1,"Therefore, (Ef1 - Ev) = (350/300)*0.3
      = ")
12 disp("(b) At T=400 K, (Ef2 - Ev) = 400*k*ln(Nv/Na)
      Eq.3")
13 disp("Hence, from the above Eq.3 and Eq.1,")
14 disp("(Ef2 - Ev)/0.3 = 400/300")
15 q2=(400/300)*0.3
16 disp(q2,"Therefore, (Ef2 - Ev) = (400/300)*0.3 = ")
      // in eV

```

---

#### Scilab code Exa 4.4 new position of Fermi level

```

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

```

```

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

```

---

#### Scilab code Exa 4.5 new position of Fermi level

```

1 //Example 4.5.
2 clc
3 disp("In an P-type material, the concentration of
      acceptor atoms is given by")
4 disp("NA = NV*e^(-(EF - EV)/k*T)")
5 disp("Let initially NA = NA0, EF = EF0 and EF0 - EV
      = 0.4 eV")
6 disp("Therefore,      NA0 = NV*e^(-0.4/0.025) = NV*e
      ^-16")
7 disp("(a) When NA = 0.5*NA0 and EF = EF1, then")
8 disp("0.5*NA0 = NV*e^(-(EF1-EV)/0.025) = NV*e^-40(
      EF1 - EV)")
9 disp("Therefore,      0.5*NV*e^-16 = NV*e^-40(EF1 - EV
      )")
10 disp("Therefore,      0.5 = e^(-40*(EF1 - EV)+16)")
11 disp("Taking natural logarithm on both sides, we get
      ")
12 disp("ln (0.5) = -40(EF1 - EV) + 16")
13 q1=(16-log(0.5))/40
14 disp(q1,"EF1 - EV(in eV) = ")
15 disp("(b) When NA=4*NA0 and EF = EF2, then")
16 disp("ln 4 = -40*(EF2 - EV) + 16")
17 q2=(16-log(4))/40
18 disp(q2,"EF2 - EV(in eV) = ")

```

---

#### Scilab code Exa 4.6 conductivity of silicon

```
1 //Example 4.6.
2 clc
3 ni=1.5*10^10
4 un=1300
5 up=500
6 q=1.6*10^-19
7 nos=5*10^22
8 disp("(a) In intrinsic condition, n=p=ni")
9 disp("Hence, sigma_i = q*ni*(un+up)")
10 format(8)
11 sigma_i = q*ni*(un+up)
12 disp(sigma_i,"sigma_i(S/cm) = ")
13 disp("(b) Number of silicon atoms/cm^3 = 5*10^22")
14 ND=5*10^22/10^8
15 disp(ND,"Hence, ND(cm^-3) = ")
16 disp("Further, n = ND")
17 disp("Therefore, p = ni^2/n = ni^2/ND")
18 p=ni^2/ND
19 disp(p,"p(cm^-3) = ") // wrong answer in textbook
20 disp("Thus p << n. Hence p may be neglected while
    calculating the conductivity.")
21 disp("Hence, sigma = n*q*un = ND*q*un")
22 sigma=ND*q*un
23 disp(sigma,"sigma(S/cm) = ")
24 NA=(5*10^22)/(5*10^7)
25 disp(NA,"(c) NA(cm^-3) = ")
26 disp("Further, p = NA")
27 disp("Hence, n = ni^2/p = ni^2/NA")
28 n=ni^2/NA
29 disp(n,"n(cm^-3)= ")
30 disp("Thus p >> n. Hence n may be neglected while
    calculating the conductivity.")
```

```

31 disp("Hence ,      sigma = p*q*up = NA*q*up")
32 sigma1=NA*q*up
33 disp(sigma1,"sigma(S/cm) = ")
34 disp("(d) With both types of impurities present
      simultaneously , the net acceptor impurity density
      is ,")
35 Na=NA-ND
36 disp(Na,"Na(cm^-3) = NA - ND = ")
37 disp("Hence ,      sigma = Na*q*up")
38 sigma2=Na*q*up
39 disp(sigma2,"sigma(S/cm) = ")

```

---

#### Scilab code Exa 4.7 resistivity of germanium

```

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

```



```

20 disp(" Also , n = ND")
21 disp(p," Therefore ,  p(holes/cm^3) = ni^2 / n = ni^2
    / ND =")
22 disp(" Here , as n >> p, p can be neglected.")
23 format(6)
24 sigma1=ND*q*un
25 disp(sigma1," Therefore ,  conductivity (S/cm) ,
    sigma = n*q*un = ND*q*un =")
26 rho1=1/sigma1
27 disp(rho1," Hence ,  resistivity (ohm-cm) ,      rho = 1 /
    sigma =")
28 format(8)
29 NA=(4.4*10^22)/10^8
30 disp(NA," (c) NA(cm^-3) = ")
31 disp(" Also , p = NA")
32 format(9)
33 n=ni^2/NA
34 disp(n," Therefore ,  n(electrons/cm^3) = ni^2 / p =
    ni^2 / NA =")
35 format(7)
36 sigma2=NA*q*up
37 disp(" Here , as p >> n, n may be neglected. Then,")
38 disp(sigma2," Conductivity (S/cm) ,      sigma = p*q*up =
    NA*q*up =")
39 format(5)
40 rho2=1/sigma2
41 disp(rho2," Hence ,  resistivity (ohm-cm) ,      rho = 1 /
    sigma = ")
42 format(9)
43 disp("(d) with both p and n type impurities present ,
    ")
44 disp("      ND = 4.4*10^15 cm^-3 and NA = 4.4*10^14
    cm^-3")
45 disp(" Therefore , the net donor density ND'' is")
46 Nd=ND-NA
47 disp(Nd," ND'' (cm^-3) = (ND - NA) =")
48 disp(" Therefore , effective n = ND'' = 3.96*10^15 cm
    ^-3")

```

```

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

```

---

#### Scilab code Exa 4.8 total conduction current density

```

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

```

```

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

```

---

**Scilab code Exa 4.9** concentration of holes and electrons

```

1 //Example 4.9.
2 clc
3 ni=1.5*10^10
4 un=1300
5 up=500
6 q=1.6*10^-19
7 sigma=300
8 disp("(a) Concentration in N-type silicon")
9 format(10)
10 n=sigma/(q*un)
11 disp("The conductivity of an N-type Silicon is sigma
      = q*n*un")
12 disp(n,"Concentration of electrons, n(cm^-3) = sigma
      / q*un =")
13 p=ni^2/n
14 disp(p,"Hence, concentration of holes, p(cm^-3) =
      ni^2 / n =")
15 disp("(b) Concentration in P-type silicon")
16 p=sigma/(q*up)
17 disp("The conductivity of a P-type Silicon is sigma
      = q*p*up")
18 disp(p,"Hence, concentration of holes, p(cm^-3) =
      sigma / q*up =")
19 n=ni^2/p
20 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 germanium

```
1 //Example 4.10.
2 clc
3 format(8)
4 ND=(4.2*10^28)/10^6
5 disp(ND,"Density of added impurity atoms is , ND(
   atoms/m^3) = ")
6 ni=2.5*10^19
7 format(10)
8 p=ni^2/ND
9 disp("Also , n = ND")
10 disp(p,"Therefore ,  $p(m^{-3}) = ni^2 / n = ni^2 / ND =$ 
   ")
11 disp("Here , as  $p \ll n$ ,  $p$  may be neglected.")
12 q=1.6*10^-19
13 un=0.38
14 sigma=q*ND*un
15 disp(sigma,"Therefore ,  $\sigma(S/m) = q*ND*un =$ ")
16 format(9)
17 rho=1/sigma
18 disp(rho,"Therefore , resistivity ,  $\rho(ohm-m) = 1 /$ 
   sigma =")
19 format(5)
20 L=5*10^-3
21 A=5*10^-6
22 R=(rho*L)/A^2
23 R1=R*10^-3
24 disp(R1,"Resistance ,  $R(k.ohm) = \rho*L / A =$ ")
25 I=10^-6
26 V=R*I
27 V1=V*10^3
28 disp(V1,"Voltage drop ,  $V(mV) = RI =$ ")
```

---

**Scilab code Exa 4.11** calculate  $V_a$  and  $E_o$

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

---

**Scilab code Exa 4.12** current flowing in the diode

```
1 //Example 4.12.
2 clc
3 format(7)
4 Ia=0.3*10^-6
5 VF=0.15
6 I=Ia*((%e^(40*VF))-1)
7 I1=I*10^6
8 disp("The current flowing through the PN diode under
```

```

        forward bias is ,")
9  disp(I1," I(uA) = Io*(e^40*VF - 1) =")

```

---

**Scilab code Exa 4.13** calculate the diode current

```

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

```

---

**Scilab code Exa 4.14** determine eta

```

1  //Example 4.14
2  clc
3  format(5)
4  disp("The diode current ,      I=Io*((e^((q*V)/(eta*k*T
   ))) -1)")
5  disp(" Therefore , 0.6*10^-3 = Io*((e^((q*V)/(eta*k*T)
   )) -1) = Io*(e^((q*V)/(eta*k*T)))")
6  disp("
   e^(16/eta)                = Io*e^(400/25*eta) = Io*
   Eq.1")

```

```

7 disp(" Also ,          20*10^-3 = Io*e^(500/25*eta) = Io*
   e^(20/eta)          Eq.2")
8 disp(" Dividing Eq.2 by Eq.1 , we get")
9 disp(" 100/3 = e^(4/eta)")
10 disp(" Taking natural logarithms on both sides , we
   get")
11 disp("    loge (100/3) = 4 / eta")
12 disp("          3.507 = 4 / eta")
13 eta=4/log(100/3)
14 disp(eta," Therefore ,  eta = ")

```

---

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

```

1 //Example 4.15.
2 clc
3 format(5)
4 disp("The current of PN junction diode is ,")
5 disp(" I = Io*(e^(V/VT)-1)")
6 disp(" Therefore ,    -0.09*Io = Io*(e^(V/VT)-1)")
7 disp(" where    VT = T/11600 = 26mV")
8 disp("    -0.9 = e^(V/0.026) - 1")
9 disp("    0.1 = e^(V/0.026)")
10 VT=0.026
11 V=log(0.1)*VT
12 disp(V," Therefore ,  V(V) = ")

```

---

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

```

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

```

```

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

```

---

#### Scilab code Exa 4.17 Calculating the saturation current

```

1 //Example 4.17.
2 clc
3 format(6)
4 Io1=7.5*10^-6
5 T1=27
6 T2=127
7 disp("The saturation current at 400 K is ,")
8 disp("Io2 = Io1 * 2^((T2-T1)/10)")
9 disp("    = 7.5*10^-6 * 2^(127-27/10)")
10 Io2=Io1*(2^((T2-T1)/10))
11 I=Io2*10^3
12 disp(I," Io2(mA) = ")

```

---



# Chapter 5

## Special Diodes

Scilab code Exa 5.1 barrier height and built in potential

```
1 //Exmample 5.1.
2 clc
3 format(6)
4 thetaM=4.26 //work function
5 chi=4.01 //electron affinity
6 thetaBN=thetaM-chi
7 disp("The barrier height for N-type material is,")
8 disp(thetaBN,"      Theta_BN(V) = Theta_M - Chi = ")
9 thetaIN=thetaBN-(((1.38*10^-23)*300)/(1.6*10^-19))
   *log((2.8*10^25)/(4*10^17))
10 disp("The built-in potential is given by,")
11 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

```
1 //Example 6.1.  
2 clc  
3 format(5)  
4 IE=10  
5 IC=9.8  
6 disp("The emitter current is ,")  
7 disp("IE = IB + IC")  
8 disp("10 = IB + 9.8")  
9 IB=IE-IC  
10 disp(IB," Therefore ,      IB(mA) = ")
```

---

Scilab code Exa 6.2 common base dc current gain

```
1 //Example 6.2.  
2 clc  
3 format(6)  
4 IE=6.28  
5 IC=6.20
```

```
6 disp("The common-base d.c. current gain,")
7 alpha=IC/IE
8 disp(alpha,"alpha = IC/IE =")
```

---

**Scilab code Exa 6.3** find value of base current

```
1 //Example 6.3.
2 clc
3 format(6)
4 alpha=0.967
5 IE=10
6 disp("The common-base d.c. current gain (alpha) is,")
7 )
8 disp("alpha = 0.967 = IC/IE = IC/10")
9 IC=alpha*IE
10 disp(IC,"Therefore , IC(mA) = ")
11 disp("The emitter current , IE = IB + IC")
12 IB=IE-IC
13 disp(IB,"Therefore , IB(mA) = ")
```

---

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

```
1 //Example 6.4.
2 clc
3 format(6)
4 IE=10
5 alpha=0.98
6 disp("The common-base d.c. current gain , alpha = IC/IE")
7 )
8 IC=alpha*IE
9 disp(IC,"Therefore , IC(mA) = ")
10 disp("The emitter current , IE = IB + IC")
11 IB=IE-IC
```

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

---

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

```
1 //Example 6.5.
2 clc
3 format(6)
4 alpha=0.97
5 disp(" If alpha=0.97, beta = alpha/(1 - alpha)")
6 beta=alpha/(1-alpha)
7 disp(beta," beta = ")
8 beta1=200
9 disp(" If beta=200, alpha = beta/(beta + 1)")
10 alpha1 =beta1/(beta1+1)
11 disp(alpha1," alpha = ")
```

---

**Scilab code Exa 6.6** find value of emitter current

```
1 //Example 6.6.
2 clc
3 format(6)
4 beta=100
5 IC=40
6 disp(" beta = 100 = IC / IB")
7 IB=IC/beta
8 disp(IB," Therefore , IB(mA) = ")
9 disp(" IE = IB + IC")
10 IE=IB+IC
11 disp(IE," IE(mA) = ")
```

---

**Scilab code Exa 6.7** collector and base currents

```
1 //Example 6.7.
2 clc
3 format(6)
4 beta=150
5 IE=10
6 alpha=beta/(beta+1)
7 disp(alpha,"The common-base current gain, alpha =
   beta / (beta + 1) = ")
8 disp("Also, alpha = IC / IE")
9 format(5)
10 IC=alpha*IE
11 disp(IC,"Therefore, IC(mA) = ")
12 disp("the emitter current, IE = IB + IC")
13 IB=IE-IC
14 disp(IB,"Therefore, IB(mA) = ")
```

---

**Scilab code Exa 6.8** calculate IB and IE

```
1 //Example 6.8.
2 clc
3 format(5)
4 beta=170
5 IC=80
6 disp("We know that (beta), beta = 170 = IC / IB")
7 IB=IC/beta
8 disp(IB,"Therefore, IB(mA) = ")
9 format(6)
10 IE=IB+IC
11 disp(IE,"and IE(mA) = IB + IC = ")
```

---

**Scilab code Exa 6.9** determine IC and IE

```

1 //Example 6.9.
2 clc
3 format(7)
4 IB=0.125
5 beta=200
6 disp("beta = 200 = IC / IB")
7 IC=beta*IB
8 disp(IC,"Therefore ,      IC(mA) = ")
9 IE=IB+IC
10 disp(IE,"and      IE(mA) = IB + IC = ")

```

---

**Scilab code Exa 6.10** determine IC and IB

```

1 //Example 6.10
2 clc
3 format(7)
4 IE=12
5 beta=100
6 IB=IE/(1+beta)
7 disp(IB,"We know that base current,  IB(mA) = IE /
      (1 + beta) = ")
8 format(8)
9 IC=IE-IB
10 disp(IC,"and collector current,  IC(mA) = IE - IB =
      ")

```

---

**Scilab code Exa 6.11** beta and alpha and IE

```

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

```

```

6 beta=IC/IB
7 disp("(a) To find beta of the transistor ")
8 disp(beta,"beta = IC / IB =")
9 alpha=beta/(beta+1)
10 disp("(b) To find alpha of the transistor")
11 disp(alpha,"alpha = beta / (1+beta) =")
12 IE=IB+IC
13 IE1=IE*10^3
14 disp("(c) To find emitter current , IE")
15 disp(IE1,"IE(mA) = IB + IC =") // answer in the
    textbook is wrong
16 disp("(d) To find the new value of beta when
    delta_IB = 25uA and delta_IC = 0.6mA")
17 delta_IB=25*10^-6
18 delta_IC=0.6*10^-3
19 IB1=IB+delta_IB
20 IB11=IB1*10^6
21 IC1=IC+delta_IC
22 IC11=IC1*10^3
23 disp(IB11,"Therefore , IB(uA) = ")
24 disp(IC11," IC(mA) = ")
25 beta1=IC1/IB1
26 disp("New value of beta of the transistor ,")
27 disp(beta1,"beta = IC / IB = ")

```

---

**Scilab code Exa 6.12** find IC and IE

```

1 //Example 6.12.
2 clc
3 format(6)
4 alpha=0.98
5 IC0=5*10^-6
6 ICB0=IC0
7 IB=100*10^-6
8 IC=((alpha*IB)/(1-alpha))+(IC0/(1-alpha))

```

```

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

```

---

### Scilab code Exa 6.13 IC and new collector current

```

1 //Example 6.13.
2 clc
3 format(6)
4 ICBO=10*10^-6
5 hFE=50
6 beta=hFE
7 IB=0.25*10^-3
8 IC=(beta*IB)+((1+beta)*ICBO)
9 IC1=IC*10^3
10 disp("(a) To find the value of collector current
    when IB = 0.25mA")
11 disp(IC1,"IC(mA) = (beta*IB) + ((1+beta)*ICBO)")
12 T1=27
13 T2=50
14 format(5)
15 I_CB0 = ICBO * (2^((T2-T1)/10))
16 I_CB01=I_CB0*10^6
17 disp("(b) To find the value of new collector current
    if temperature rises to 50 C")
18 disp(I_CB01,"I' 'CBO(beta=50)(in uA) = ICBO*(2^((T2-
    T1)/10)) = ")
19 format(6)
20 IC2=(beta*IB)+((1+beta)*I_CB0)
21 IC3=IC2*10^3
22 disp("Therefore , the collector current at 50 C is")

```



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

---

**Scilab code Exa 6.14** find the current gain

```
1 //Example 6.14.
2 clc
3 format(6)
4 delta_IC=0.99*10^-3
5 delta_IE=1*10^-3
6 alpha=delta_IC/delta_IE
7 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

```
1 //Example 6.15
2 clc
3 format(5)
4 beta_dc=100
5 alpha_dc=beta_dc/(1+beta_dc)
6 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

```
1 //Example 6.16.
2 clc
3 format(6)
```

```

4 delta_IC=0.995*10^-3
5 delta_IE=1*10^-3
6 alpha=delta_IC/delta_IE
7 disp(alpha,"Common base current gain is , alpha =
    delta_IC/delta_IE = ")
8 beta=alpha/(1-alpha)
9 disp(beta,"Common-emitter current gain is beta =
    alpha / (1-alpha) = ")

```

---

**Scilab code Exa 6.17** current gain and base current

```

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

```

---

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

```

1 //Example 6.18.
2 clc
3 format(6)
4 IB=15*10^-6
5 beta=150
6 IC=beta*IB

```

```

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

```

---

#### Scilab code Exa 6.19 IB IC IE and VCE

```

1 //Example 6.19.
2 clc
3 format(6)
4 disp("Referring to fig.6.18 , the base current is,")
5 VBB=4
6 VBE=0.7
7 RB=200*10^3
8 IB=(VBB-VBE)/RB
9 IB1=IB*10^6
10 disp(IB1,"IB(uA) = (VBB - VBE) / RB = ")
11 beta=200
12 IC=beta*IB
13 IC1=IC*10^3
14 disp(IC1,"The collector current is , IC(mA) = beta*IB
  = ")
15 format(7)
16 IE=IC+IB
17 IE1=IE*10^3
18 disp(IE1,"The emitter current is , IE(mA) = IC + IB =
  ")
19 format(6)
20 VCC=10

```

```

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

```

---

**Scilab code Exa 6.20** calculate IC and IE

```

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

```

---

**Scilab code Exa 6.21** alpha dc and beta dc

```

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

```

```

12 disp("We know that ,  $ICEO = ICBO/(1-\alpha) = (1+\beta)$ 
    )*ICBO")
13 beta=(ICEO/ICBO)-1
14 disp(beta,"beta = (ICEO / ICBO)-1 = ")
15 IC=(beta*IB)+((1+beta)*ICBO)
16 disp(IC,"IC(A) = (beta*IB) + ((1+beta)*ICBO) = ")
17 alpha_dc=1-(ICBO/ICEO)
18 disp(alpha_dc,"alpha_dc = 1 - (ICBO / ICEO) = ")
19 format(4)
20 beta_dc=(IC-ICBO)/(IB-ICEO)
21 disp(beta_dc,"beta_dc = (IC-ICBO) / (IB-ICEO) = ")

```

---

**Scilab code Exa 6.22** find emitter current

```

1 //Example 6.22.
2 clc
3 format(6)
4 alpha_dc=0.99
5 ICBO=50*10^-6
6 IB=1*10^-3
7 IC=((alpha_dc*IB)/(1-alpha_dc))+ (ICBO/(1-alpha_dc))
8 IC1=IC*10^3
9 disp("Assume that , IB = 1 mA")
10 disp(IC1,"IC(mA) = ((alpha_dc*IB) / (1-alpha_dc)) +
    (ICBO/(1-alpha_dc)) = ")
11 IE=IC+IB
12 IE1=IE*10^3
13 disp(IE1,"IE(mA) = IC + IB = ")

```

---

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

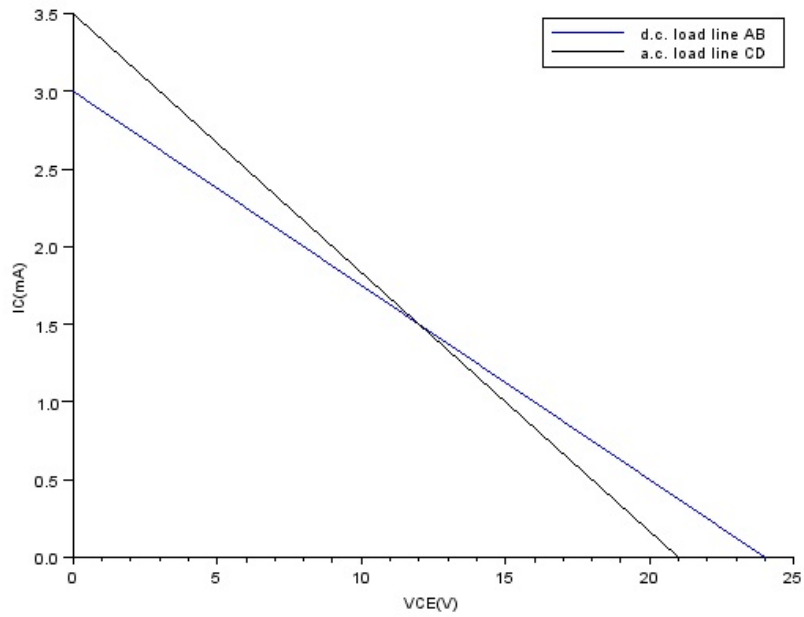


Figure 6.1: dc and ac load line and operating point

```

1 //Example 6.23.refer fig.6.22(a)
2 clc
3 format(6)
4 disp("(i) DC load line:")
5 disp("Refer fig.6.22(a), we have  $V_{CC} = V_{CE} + I_C \cdot R_C$ ")
6 disp("To draw the d.c. load line, we need two end
       points, viz. maximum VCE point(at  $I_C = 0$ ) and
       maximum IC point(at  $V_{CE} = 0$ )")
7 disp("Maximum VCE =  $V_{CC} = 24V$ ")
8  $IC = 24 / (8 \cdot 10^{-3})$  //in Ampere
9  $x1 = IC \cdot 10^3$  //in mA
10 disp(x1, "Maximum IC(mA) =  $V_{CC} / R_C =$ ")
11 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)")
12 disp("")
13 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")
14  $V_{CEQ} = 24 / 2$ 
15 disp(VCEQ, "Here,  $V_{CEQ}(V) = V_{CC} / 2 =$ ") //in volts
16 disp("  $ICQ = 1.5 mA$ ")
17 disp("")
18 disp("(iii) AC load line")
19 disp("To draw the a.c. load line, we need two end
       points, viz. maximum VCE and maximum IC when
       signal is applied")
20  $R_{ac} = (8 \cdot 24) / (8 + 24)$  //in k-ohm
21 disp(Rac, "AC load,  $R_{a.c.}(k-ohm) = R_C || R_L =$ ")
22  $V_{CE} = 12 + ((1.5 \cdot 10^{-3}) \cdot (6 \cdot 10^3))$  //in Volts
23 disp(VCE, "Therefore, maximum VCE(V) =  $V_{CEQ} + I_{CQ} \cdot R_{a.c.} =$ ")
24 disp("This locates the point D( $OD = 21V$ ) on the VCE
       axis")
25  $IC = (1.5 \cdot 10^{-3}) + (12 / (6 \cdot 10^3))$  //in Ampere
26  $x3 = IC \cdot 10^3$  //in mA
27 disp(x3, "Maximum IC(mA) =  $ICQ + V_{CEQ} / R_{a.c.} =$ ")

```

```

28 disp("This locates the point C( $I_C = 3.5\text{mA}$ ) on the IC
      axis. By joining points C and D a.c. load line
      CD is constructed. ")
29 x=[24,0]
30 y=[0,3]
31 plot2d(x,y,style=2)
32 x1=[21,0]
33 y1=[0,3.5]
34 plot2d(x1,y1,style=1)
35 legend("d.c. load line AB", "a.c. load line CD")
36 title("Fig.6.22(b)")
37 xlabel("VCE(V)")
38 ylabel("IC(mA)")

```

---

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

```

1 //Example 6.24. refer fig.6.23(a).
2 clc
3 format(6)
4 disp("(i) DC load line:")
5 disp("Refer fig.6.23(a), we have  $V_{CC} = V_{CE} + I_C \cdot (R_C + R_E)$ ")
6 disp("To draw the d.c. load line, we need two end
      points, viz. maximum VCE point (at  $I_C = 0$ ) and
      maximum IC point (at  $V_{CE} = 0$ )")
7 disp("Maximum VCE =  $V_{CC} = 12\text{V}$ , which locates the
      point B( $O_B = 12\text{V}$ ) of the d.c. load line")
8  $I_C = 12 / (2 \cdot 10^3)$  //in Ampere
9  $x_1 = I_C \cdot 10^3$  //in mA
10 disp( $x_1$ , "Maximum IC(mA) =  $V_{CC} / (R_C + R_E) =$ ")
11 disp("This locates the point A( $O_A = 6\text{mA}$ ) of the d.c.
      load line. Fig.6.23(b) shows the d.c. load line
      AB, with (12V,6mA)")

```



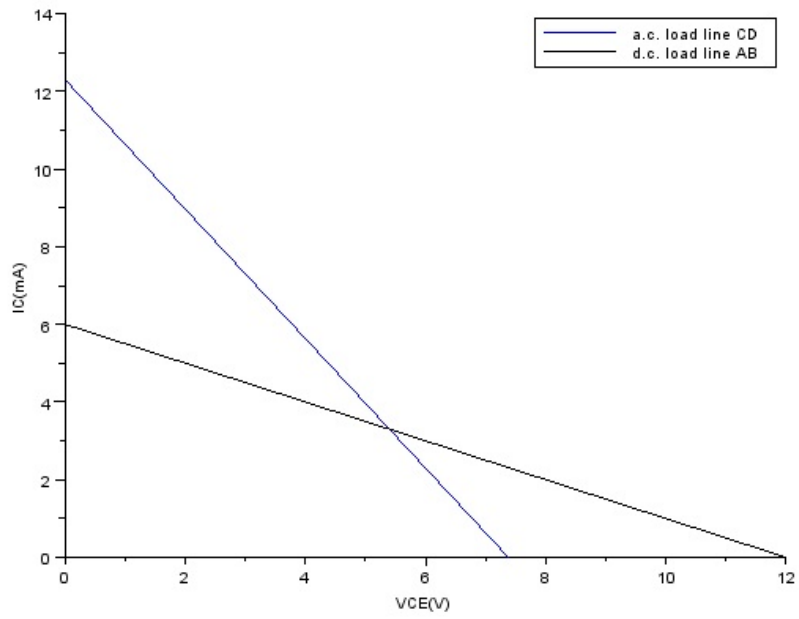


Figure 6.2: ac and dc load line and operating point

```

12 disp("")
13 disp("(ii) Operating point Q")
14 disp("The voltage across R2 is  $V_2 = (R_2/R_1+R_2)*V_{CC}$ "
    )
15 V2=((4*10^3)/(12*10^3))*12 //in V
16 disp(V2,"Therefore,  $V_2(V) =$ ")
17 disp("  $V_2 = V_{BE} + I_E*R_E$ ")
18 IE=(4-0.7)/(1*10^3) //in Ampere
19 x2=IE*10^3 //in mA
20 disp(x2,"Therefore,  $I_E(mA) = (V_2-V_{BE}) / R_E =$ ")
21 IC=x2 //in mA
22 disp(IC,"  $I_C(mA) = I_E(mA) =$ ")
23 VCE=12-((3.3*10^-3)*(2*10^3)) //in volts
24 disp(VCE," $V_{CE}(V) = V_{CC} - I_C(R_C+R_E) =$ ")
25 disp("Therefore, the operating point Q is at 5.4V
    and 3.3mA, which is shown on the d.c. load line")
26 disp("")
27 disp("(iii) AC load line")
28 disp("To draw the a.c. load line, we need two end
    points, viz. maximum VCE and maximum IC when
    signal is applied")
29 Rac=1.5/2.5 //in k-ohm
30 disp(Rac,"AC load,  $R_{a.c.}(k-ohm) = R_C || R_L =$ ")
31 VCE=5.4+((3.3*10^-3)*(0.6*10^3)) //in Volts
32 disp(VCE,"Therefore, maximum  $V_{CE}(V) = V_{CEQ} + I_{CQ}*R_{a.c.} =$ ")
33 disp("This locates the point C( $V_{OC} = 6.24V$ ) on the
    VCE axis")
34 IC=(3.3*10^-3)+(5.4/(0.6*10^3)) //in Ampere
35 x3=IC*10^3 //in mA
36 disp(x3,"Maximum  $I_C(mA) = I_{CQ} + V_{CEQ}/R_{a.c.} =$ ")
37 disp("This locates the point D( $I_{OD} = 12.3mA$ ) on the
    IC axis. By joining points C and D a.c. load line
    CD is constructed. ")
38 x=[7.38,0]
39 y=[0,12.3]
40 plot2d(x,y,style=2)
41 x1=[12,0]

```

```

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

```

---

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

```

1 //Example 6.25.
2 clc
3 format(6)
4 ICQ=1*10^-3
5 VCEQ=6
6 VCC=10
7 beta=100
8 VBE=0.7
9 RC=(VCC-VCEQ)/ICQ
10 RC1=RC*10^-3
11 RC2=round(RC1)
12 disp(RC2,"The collector resistance is , RC(k-ohm) = (
    VCC - VCEQ) / ICQ = ")
13 IBQ=ICQ/beta
14 IBQ1=IBQ*10^6
15 disp(IBQ1,"The base current is , IBQ(uA) = ICQ / beta
    = ")
16 RB=(VCC-VBE)/IBQ
17 RB1=RB*10^-6
18 disp(RB1,"The base resistance is , RB(M-ohm) = (VCC -
    VBE(on)) / IBQ = ")

```

---

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

```

1 //Example 6.26.
2 clc
3 format(6)
4 beta=100
5 VBE=0.7
6 VCC=10
7 RB=20*10^3
8 RC=0.4*10^3
9 RE=0.6*10^3
10 VBB=5
11 disp("Referring to fig.6.25, Kirchhoff voltage law
      equation is,")
12 disp("VBB = IB*RB + VBE(on) + IE*RE")
13 disp("Also, IE = IB + IC = IB + beta*IB = (1 + beta
      )*IB")
14 IB=(VBB-VBE)/(RB+((1+beta)*RE))
15 IB1=IB*10^6
16 disp(IB1,"The base current, IB(uA) = (VBB - VBE(on)
      ) / (RB + ((1+beta)*RE)) = ")
17 IC=beta*IB
18 IC1=IC*10^3
19 disp(IC1,"Therefore, IC(mA) = beta*IB = ")
20 IE=IC+IB
21 IE1=IE*10^3
22 disp(IE1,"IE(mA) = IC + IB")
23 VCE=VCC-(IC*RC)-(IE*RE)
24 disp(VCE,"VCE(V) = VCC - (IC*RC) - (IE*RE) = ")
25 disp("The Q point is at")
26 disp(VCE,"VCEQ(V) = ")
27 disp(IC1,"and ICQ(mA) = ")

```

---

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

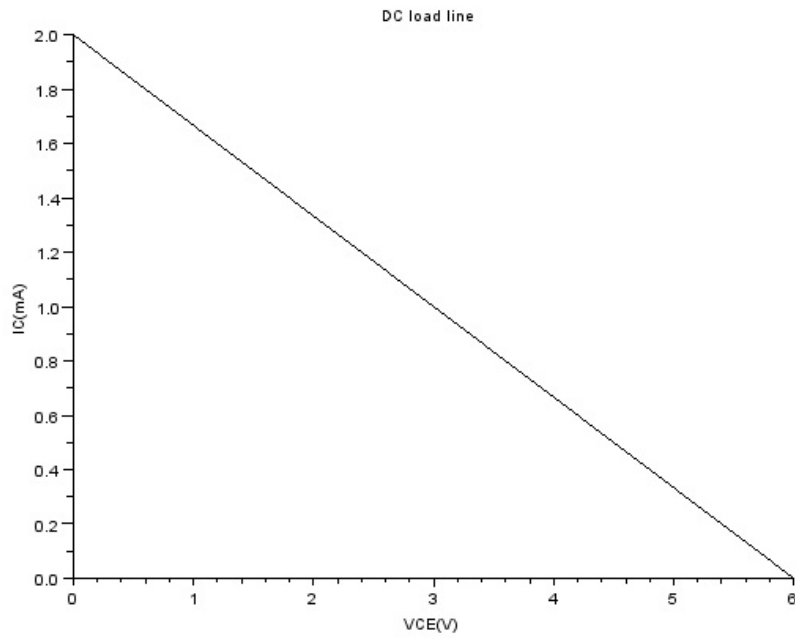


Figure 6.3: dc load line and operating point and S

```

1 //Example 6.27. refer fig.6.26.
2 clc
3 format(6)
4 disp(" (i) DC load line:")
5 disp("          VCE = VCC - IC*RC")
6 disp("When IC = 0, VCE = VCC = 6V")
7 IC=6/(3*10^3) //in Ampere
8 x1=IC*10^3 //in mA
9 disp(x1,"When VCE = 0, IC(mA) = VCC/RC =")
10 disp("")
11 disp(" (ii) Operating point Q:")
12 disp("          For silicon transistor, VBE = 0.7V")
13 disp("          VCC = IB*RB +
          VBE")
14 IB=(6-0.7)/(530*10^3)
15 x2=IB*10^6
16 disp(x2,"Therefore,          IB(uA) = VCC-VBE /
          RB =")
17 IC=100*10*10^-6 // in Ampere
18 x3=IC*10^3 // in mA
19 disp(x3,"Therefore,          IC(mA) = beta*IB =")
20 VCE=6-((1*10^-3)*(3*10^3)) // in volts
21 disp(VCE,"          VCE(V) = VCC -
          IC*RC =")
22 disp("Therefore operating point is VCEQ = 3 V and
          ICQ = 1 mA")
23 disp("")
24 disp(" (iii) Stability factor: S = 1 + beta = 1 +
          100 = 101")
25 x=[6,0]
26 y=[0,2]
27 plot2d(x,y,style=1)
28 xtitle("DC load line","VCE (V) ---->","IC (mA) ---->")

```

---

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

```
1 // Example 6.28.
2 clc
3 format(6)
4 VCC=12
5 beta=100
6 VBE=0.7
7 disp("Refer fig.6.26. We know that for a silicon
      transistor , VBE = 0.7 V")
8 disp("(a) To determine RB :")
9 VCE=7
10 IC=1*10^-3
11 RC=(VCC-VCE)/IC
12 RC1=RC*10^-3
13 disp(RC1,"RC(k-ohm) = (VCC - VCE) / IC = ")
14 IB=IC/beta
15 IB1=IB*10^6
16 disp(IB1,"IB(uA) = IC / beta = ")
17 RB=(VCC-VBE-(IC*RC))/IB
18 RB1=RB*10^-3
19 disp(RB1,"RB(k-ohm) = (VCC - VBE - (IC*RC)) / IB = ")
20 S=(1+beta)/(1+(beta*(RC/(RC+RB))))
21 format(5)
22 disp(S,"(b) Stability factor , S =(1 + beta) / (1 + (
      beta*(RC / (RC+RB)))) = ")
23 beta1=50
24 format(6)
25 disp("(c) VCC = (beta*IB*RC) + (IB*RB) + VBE")
26 disp("      = IB * ((beta*RC) + RB) + VBE")
27 IB=(VCC-VBE)/((beta1*RC)+RB)
28 IB1=IB*10^6
29 disp(IB1,"IB(uA) = (VCC-VBE) / ((beta*RC)+RB) = ")
30 IC=beta1*IB
31 IC1=IC*10^3
32 disp(IC1,"IC(mA) = beta*IB = ")
33 VCE=VCC-(IC*RC)
```

```

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

```

---

**Scilab code Exa 6.29** calculate RB and stability factor

```

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

```

---

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

```

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

```



```

9 alpha=0.985
10 VBE=0.3
11 disp("For a germanium transistor , VBE=0.3V. As alpha
      =0.985")
12 beta=alpha/(1-alpha)
13 beta1=round(beta)
14 disp(beta1,"beta = alpha / ( 1 - alpha) = ")
15 disp("(a) To find the coordinates of the operating
      point")
16 disp("Referring to fig. 6.29,")
17 VT=(R2/(R1+R2))*VCC
18 disp(VT,"Thevenin voltage,          VT(V) = (R2 / (R1+R2)
      ) * VCC = ")
19 format(7)
20 RB=(R1*R2)/(R1+R2)
21 RB1=RB*10^-3
22 disp(RB1,"Thevenin resistance ,  RB(k-ohm) = (R1 * R2
      ) / (R1 + R2) =")
23 disp("The loop equation around the base circuit is,")
24 disp("VT = ( IB * RB) + VBE + ((IB + IC)*RE)")
25 disp("VT = ((IC / beta) * RB) + VBE + (((IC / beta)
      + IC)*RE)")
26 format(5)
27 IC=(VT-VBE)/((RB/beta)+(RE/beta)+RE)
28 IC1=IC*10^3
29 disp(IC1,"Therefore ,    IC(mA) = ")
30 disp("Since IB is very small , IC ~ IE = 1.73 mA")
31 IE=IC
32 VCE=VCC-(IC*RC)-(IE*RE)
33 disp(VCE,"Therefore ,          VCE(V) = VCC - (IC*RC) - (IE
      *RE) = ")
34 disp("Therefore , the coordinates of the operating
      point are :")
35 disp(IC1,"IC(mA) = ")
36 disp(VCE,"VCE(V) = ")
37 disp("(b) To find the stability factor S")
38 disp("S = (1+beta)*((1+(RB/RE))/(1+beta+(RB/RE)))")

```

```

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

```

---

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

```

1 //Example 6.31.
2 clc
3 format(4)
4 VCE=12
5 IC=2*10^-3
6 VCC=24
7 VBE=0.7
8 beta=50
9 RC=4.7*10^3
10 S=5.1
11 disp("(a) To determine RE,")
12 disp("VCE = VCC - (IC*RC) - (IE*RE)")
13 RE = (VCC - (IC*RC) - VCE)/IC //IC=IE
14 RE1=RE*10^-3
15 disp(RE1,"Therefore , RE(k-ohm) = ")
16 disp("")
17 disp("(b) To determine R1 and R2,")
18 disp("Stability factor , S = (1+beta)/(1+beta(RE+(RE
+RB))), where RB = (R1*R2)/(R1+R2)")
19 RB=((RE*beta)/(((1+beta)/S)-1))-RE
20 RB1=(RB*10^-3)
21 disp(RB1,"Therefore , RB(k-ohm) = ((RE*beta) / (((1+
beta)/S)-1)) - RE =")
22 disp("Also , for a good voltage divider , the value of
resistor R2 = 0.1*beta*RE")
23 R2=0.1*beta*RE
24 R2_1=R2*10^-3
25 disp(R2_1,"Therefore , R2(k-ohm) = ")
26 disp("RB = (R1*R2) / (R1+R2)")

```

```

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

```

---

Scilab code Exa 6.32 determine the Q point

```

1 //Example 6.32. refer fig.6.30.
2 clc
3 format(5)
4 R1=56*10^3
5 R2=12.2*10^3
6 RC=2*10^3
7 RE=400
8 VCC=10
9 VBE=0.7
10 beta=150
11 disp("From the Thevenin equivalent circuit shown in
      fig.6.30(b),")
12 RTH=(R1*R2)/(R1+R2)
13 RTH1=round(RTH*10^-3)
14 disp(RTH1,"RTH(k-ohm) = R1 || R2 =")
15 VTH=(R2/(R1+R2))*VCC
16 disp(VTH,"VTH(V) = (R2 / (R1+R2)) * VCC =")
17 disp("By kirchhoff voltage law equation,")
18 IBQ=(VTH-VBE)/(RTH+((1+beta)*RE))
19 IBQ1=IBQ*10^6
20 disp(IBQ1,"IBQ(uA) = (VTH-VBE(on)) / (RTH + ((1+beta
      )*RE)) = ")
21 ICQ=beta*IBQ
22 ICQ1=ICQ*10^3
23 disp(ICQ1,"Therefore , ICQ(mA) = beta * IBQ = ")
24 format(6)
25 IEQ=IBQ+ICQ
26 IEQ1=IEQ*10^3
27 disp(IEQ1,"IEQ(mA) = IBQ + ICQ")

```

```

28 VCEQ=VCC-(ICQ*RC)-(IEQ*RE)
29 disp(VCEQ,"VCEQ(V) = VCC - (ICQ*RC) - (IEQ*RE)")
30 disp("The Q point is at :")
31 disp(VCEQ,"VCEQ(V) = ")
32 format(5)
33 disp(ICQ1,"ICQ(mA) = ")

```

---

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

```

1 //Example 6.33. refer from fig.6.31.
2 clc
3 VCC=22
4 RC=2*10^3
5 beta=60
6 VBE=0.6
7 R1=100*10^3
8 R2=5*10^3
9 RE=100
10 disp("For the given circuit")
11 disp("          VCC = R1*(I1+IB) + I1*R2")
12 disp("          I1 = (VCC - IB*R1) / (R1 + R2)
          Eq.1")
13 disp("Further, VCC = R1*[I1+IB] + VBE + IE*RE")
14 disp("As,      IE = IC + IB")
15 disp("          = beta*IB + IB = (1 + beta)*IB")
16 disp("Hence,    VCC = R1*[I1 + IB] + VBE + (1 + beta
          )*IB*RE")
17 disp("Substituting for I1 from Eq.1,")
18 disp("          VCC = R1*[(VCC - IB*R1)/R1+R2] - IB
          ] + VBE + (1 + beta)*IB*RE")
19 disp("          VCC = R1*[(VCC + IB*R2)/R1+R2] + VBE
          + (1 + beta)*IB*RE")
20 format(6)
21 a=VCC-VBE-((R1*VCC)/(R1+R2))
22 c=(((R1*R2)/(R1+R2))+((1+beta)*RE))

```

```

23 IB=a/c
24 IB1=IB*10^6
25 disp("Substituting for VCC, R1, R2, VBE, beta and RE
      , ")
26 disp(IB1,"          IB(uA) =")
27 format(5)
28 IC=beta*IB
29 IC1=IC*10^3
30 disp(IC1,"          IC(mA) =")
31 disp("Applying KVL to collector circuit,")
32 disp("          VCC = IC*RC + VCE + IE*RE = IC*RC +
      VCE + (1+beta)*IB*RE")
33 disp("Hence,          VCE = VCC - IC*RC - (1+beta)*IB*RE")
34 format(7)
35 VCE = VCC - (IC*RC) - ((1+beta)*IB*RE)
36 disp(VCE,"          VCE(V) = ")
37 disp("To find stability factor, (S):")
38 disp("Stability factor for voltage divider bias is")
39 format(5)
40 RB=(R1*R2)/(R1+R2)
41 S=(1+beta)/(1+(beta*(RE/(RE+RB))))
42 disp(S,"          S =(1+beta)/(1+(beta*(RE/(RE+RB))))
      ) =          where RB = R1 || R2")

```

---

**Scilab code Exa 6.34** Q point and stability factor

```

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

```

```

10 disp("the collector to base transistor circuit")
11 disp("          VCC = (beta*IB*RC) + IB*RB + VBE
      ")
12 disp("Therefore ,      IB = (VCC - VBE) / (RB + (beta*
      RC))")
13 IB=(VCC-VBE)/(RB+(beta*RC))
14 IB1=IB*10^6
15 disp(IB1,"          IB(uA) =")
16 IC=beta*IB
17 IC1=IC*10^3
18 disp(IC1,"Hence , IC(mA) = beta * IB = ")
19 VCE=VCC-(IC*RC)
20 disp(VCE,"          VCE(V) = VCC - IC*RC =")
21 disp("Therefore ,the co-ordinates of the new
      operating point are:")
22 disp(VCE,"VCEQ(V) = ")
23 disp(IC1,"ICQ(mA) = ")
24 disp("To find the stability factor S")
25 S=(1+beta)/(1+(beta*[RC/(RC+RB)]))
26 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

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

---

Scilab code Exa 7.2 value of transconductance

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

```

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

```

---

**Scilab code Exa 7.3** value of Vgs and Vp

```

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

```

---

**Scilab code Exa 7.4** value of Vds and Ids

```

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

```



```

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

```

---

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

```

1 //Example 7.5.
2 clc
3 format(6)
4 IDSS=10*10^-3
5 VGS=-3
6 ID=4*10^-3
7 VDD=20
8 disp("The value of drain current at Q-point,")
9 IDQ=IDSS/2
10 IDQ1=IDQ*10^3
11 disp(IDQ1,"IDQ(mA) = IDSS / 2 =")
12 disp("and the value of drain-to-source at Q-point,")
13 VDSQ=VDD/2
14 disp(VDSQ,"VDSQ(V) = VDD / 2 =")
15 disp("Therefore, the operating point is at:")
16 disp(VDSQ,"VDS(V) = ")
17 disp(IDQ1,"ID(mA) = ")
18 disp("Also, the drain-to-source voltage,")
19 disp("      VDS = VDD - ID*RD")
20 RD=(VDD-VDSQ)/ID
21 RD1=RD*10^-3
22 disp(RD1,"Therefore, RD(k-ohm) =")
23 disp("The source voltage or voltage across the
      source resistor RS is")
24 VS=-VGS
25 disp("      VS = -VGS = -3 V")
26 disp("Also, VS = ID*RS ")
27 RS=VS/ID
28 disp(RS,"Therefore, RS(ohm) = ")

```

---

**Scilab code Exa 7.6** value of  $R_s$

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

---

**Scilab code Exa 7.7** value of  $I_D$  and verify FET

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

```

14 disp(" Also ,          ID = IDSS*(1-(VGS/VP))^2")
15 disp("                = IDSS*(1-((VGG-(ID*RS))/VP))
    ^2,          where VGS = VGG - ID*RS")
16 disp(" Expressing ID and IDSS in mA, we have")
17 disp("                9ID^2 - 73ID +144 = 0 ")
18 x=poly(0, 'x')
19 p1=roots((9*x^2) - (73*x) +144)
20 ans1=p1(1)
21 p1=roots((9*x^2) - (73*x) +144)
22 ans2=p1(2)
23 disp(ans2," or",ans1," Therefore , ID(mA) = ")
24 disp(" As ID = 4.72mA > 4mA = IDSS, this value is
    inappropriate. So, IDQ=3.39 mA is selected.")
25 disp(" Therefore ,")
26 IDQ=3.39*10^-3
27 VGSQ=VGG-(IDQ*RS)
28 disp(VGSQ,"          VGSQ(V) = VGG - (IDQ*RS) =")
29 format(7)
30 VDSQ=VDD-(IDQ*(RD+RS))
31 disp(VDSQ," and          VDSQ(V) = VDD - (IDQ*(RD+RS)) =")
32 VDGQ = VDSQ - VGSQ
33 disp(VDGQ," Then,          VDGQ(V) = VDSQ - VGSQ")
34 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

```

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

```

```

9 RS=0.5*10^3
10 disp("Assume that the JFET is biased in the
    saturation region. Then the dc drain current is
    given by")
11 disp("          ID = IDSS*(1-(VGS/VP))^2")
12 VGS=VP*(1-(sqrt(ID/IDSS)))
13 disp(VGS,"Therefore , VGS(V) =") // textbook answer
    is wrong
14 disp("The voltage at the source terminal is")
15 VS=(ID*RS)-5
16 disp(VS,"          VS(V) = (ID*RS) - 5 =")
17 disp("The gate voltage is")
18 VG=VGS+VS
19 disp(VG,"          VG(V) = VGS + VS =")
20 disp("The gate voltage is")
21 disp("          VG = ((R2 / (R1 + R2))*10) - 5"
    )
22 R2=(Rth*(VG+5))/10
23 R2_1=R2*10^-3
24 disp(R2_1,"Therefore ,          R2(k-ohm) =") //
    textbook answer is wrong
25 R1=Rth-R2
26 R1_1=R1*10^-3
27 disp(R1_1,"and          R1(k-ohm) =") // textbook
    answer is wrong
28 disp("The drain-to-source voltage is")
29 disp("VDS = 5 - ID*RD - ID*RS - (-5)")
30 RD=(10-VDS-(ID*RS))/ID
31 RD1=RD*10^-3
32 disp(RD1,"          RD(k-ohm) = ")
33 format(5)
34 x=VGS-VP
35 disp(x,"VGS - VP = ") // textbook has taken a
    different value hence the wrong answer in
    textbook
36 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

```
1 //Example 7.9. refer fig.7.17.
2 clc
3 format(6)
4 KN=1*10^-3
5 lamda=0.01
6 Ri=100*10^3
7 IDt=4*10^-3
8 IDQ=1.5*10^-3
9 VTN=1.5
10 VDD=12
11 VDSQ=7
12 disp("To determine VDSi")
13 disp("We have,")
14 disp("          IDt = KN*(VGst - VTN)^2")
15 disp("where the subscript t indicates transition
      point values.")
16 VGSt=sqrt(IDt/KN)+VTN
17 disp(VGSt,"          VGSt(V) =")
18 disp("Therefore,")
19 VDSSt=VGSt-VTN
20 disp(VDSSt,"          VDSSt(V) = VGSt - VTN =")
21 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.")
22 disp("From fig.7.17,")
23 disp("          VDSQ = VDD - IDQ*RD")
24 format(5)
25 RD=(VDD-VDSQ)/IDQ
26 RD1=RD*10^-3
27 disp(RD1,"Therefore, RD(k-ohm) = (VDD - VDSQ) / IDQ
      =")
28 disp("Then,          IDQ = KN*(VGSQ-VTN)^2")
```

```

29 VGSQ=(sqrt(IDQ/KN))+VTN
30 disp(VGSQ," Therefore , VGSQ(V) =")
31 disp(" Then, VGSQ = 2.73 = (R2/(R1+R2))*VDD")
32 disp(" = (1/R1)*(R2/(R1+R2))*VDD")
33 disp(" = (Ri/R1)*VDD")
34 disp(" By Solving , we get ")
35 format(6)
36 R1=1200/2.73
37 disp(R1," R1(k-ohm) =")
38 format(7)
39 R2=R1/((12/2.73)-1)
40 disp(R2," R2(k-ohm) =")

```

---

#### Scilab code Exa 7.10 ID and Vds

```

1 //Example 7.10. refer fig.7.18.
2 clc
3 format(6)
4 VTN=-2
5 KN=0.1*10^-3
6 VDD=5
7 RS=5*10^3
8 VGS=0
9 disp(" Assuming that the MOSFET is biased in the
      saturation region. Then the d.c. drain current is
      ")
10 disp(" ID = KN*(VGS-VTN)^2 = KN*(-VTN)^2")
11 ID=KN*(-VTN)^2
12 ID1=ID*10^3
13 disp(ID1," ID(mA) =")
14 disp(" The d.c. drain-to-source voltage is")
15 VDS=VDD-(ID*RS)
16 disp(VDS," VDS(V) = VDD - ID*RS =")
17 VDSsat=VGS-VTN
18 disp(VDSsat," Then, VDSsat(V) = VGS - VTN =")

```

```
19 disp("Since  $V_{DS} > V_{DSsat}$ , the MOSFET is biased in  
the saturation region")
```

---

# Chapter 8

## Thyristors

Scilab code Exa 8.1 SCR half wave rectifier

```
1 //Example 8.1.
2 clc
3 format(6)
4 Vm=220
5 V1=110
6 RL=100
7 disp("We have ,")
8 disp("                                V1 = Vm*sin(theta)")
9 disp(" Therefore ,")
10 x=asind(V1/Vm)
11 disp(x," Firing angel, theta =")
12 ca=180-x
13 disp(ca,"      Conduction angle = 180 - theta =")
14 disp(" Average voltage , Vav = (Vm/2pi) * (1+cos(theta
    ))")
15 Vav = (Vm/(2*%pi))*(1+cosd(x))
16 disp(Vav,"                                Vav(V) =")
17 format(7)
18 Iav=Vav/RL
19 disp(Iav," Average current , Iav(A) = Vav / RL =")
20 po=Vav*Iav
```



```

21 disp(po,"Power output(W) = Vav*Iav =")
22 disp("As, V1 = Vm*sin(theta) = Vm*sin(omega*t),")
23 disp("      omega*t = theta = 30 = pi/6")
24 disp("      (2*pi)*(50*t) = pi/6")
25 disp("Therefore, the time during which the SCR
      remains OFF is")
26 format(6)
27 t=1/(2*6*50)
28 t1=t*10^3
29 disp(t1,"      t(ms) = ")

```

---

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

```

1 //Example 8.2.
2 clc
3 format(6)
4 Vdc=150
5 Vm=230*sqrt(2)
6 RL=10
7 disp("For an SCR full wave rectifier,")
8 disp("      Vdc = (Vm/pi)*(1+cos(theta))")
9 x=acosd(((Vdc*%pi)/Vm)-1)
10 disp(x,"Therefore,      theta =")
11 disp("For 50Hz, T = 20 ms for 360")
12 format(5)
13 t = (20/360)*x
14 disp(t,"Therefore      t(ms) = (20*10^3/360)*63.34 =
      ")
15 Iav=Vdc/RL
16 disp(Iav,"Load current,      Iav(A) = Vav / RL =")

```

---

#### Scilab code Exa 8.3 power rating of the SCR

```

1 //Example 8.3.
2 clc
3 format(6)
4 Vm=400
5 PIV=sqrt(3)*Vm
6 disp("As the supply voltage is 400 sin 314t, Vm =
      400 V")
7 disp(PIV,"Peak inverse voltage(PIV)(V) = sqrt(3)*Vm
      =")
8 RMS=20
9 ff=1.11
10 Iav=round(RMS/ff)
11 disp("RMS value of current = 20 V")
12 disp(Iav,"Average value of current , Iav(A) = RMS
      value/form factor =")
13 pr=PIV*Iav
14 pr1=pr*10^-3
15 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

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

```

17 x1=Ro*10^-3
18 disp(x1,"      Ro(k-ohm) = 1/Yo =")
19 disp("  Approximate analysis")
20 disp("      AI = -hfe = -50")
21 disp("      Ri = hie = 1 k-ohm")
22 Av=-(50*1000)/1000
23 disp(Av,"      Av = - hfe*RL / hie =")
24 disp("      Ro = infinity")

```

---

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

```

1 //Example 9.2.
2 clc
3 RC=2*10^3
4 hie=1300
5 hre=2*10^-4
6 hfe=55
7 hoe=22*10^-6
8 disp("(i) For RE = 200 ohm,")
9 format(7)
10 RE=200
11 x=hoe*(RE+RC)
12 disp(x,"      hoe*(RE + RC) =")
13 disp("Since hoe*(RE+RC) < 0.1, the approximate model
      is permissible.")
14 format(6)
15 AI=-hfe
16 disp("      AI = -hfe = -55")
17 Ri=hie+((1+hfe)*RE)
18 x1=Ri*10^-3
19 disp(x1,"      Ri(k-ohm) = hie + (1+hfe)*RE =")
20 Av=AI*(RC/Ri)
21 disp(Av,"      Av = AI * (RC/Ri) =")
22 disp("Output resistance , Ro = infinity")
23 disp("Output terminal resistance , RoT = Ro || RC = 2

```

```

    k-ohm")
24 disp("(ii) For RE = 400 ohm")
25 format(7)
26 RE=400
27 x2=hoe*(RE+RC)
28 disp(x2,"      hoe*(RE + RC) =")
29 disp("Since hoe*(RE+RC) < 0.1, the approximate model
      is permissible.")
30 format(6)
31 AI=-hfe
32 disp("      AI = -hfe = -55")
33 Ri=hie+((1+hfe)*RE)
34 x3=Ri*10^-3
35 disp(x3,"      Ri(k-ohm) = hie + (1+hfe)*RE =")
36 format(5)
37 Av=AI*(RC/Ri)
38 disp(Av,"      Av = AI * (RC/Ri) =")
39 disp("Output resistance , Ro = infinity")
40 disp("Output terminal resistance , RoT = Ro || RC = 2
      k-ohm")
41 disp("(iii) For RE = 1000 ohm")
42 disp("Since hoe*(RE+RC) < 0.1, the approximate model
      is permissible.")
43 format(6)
44 AI=-hfe
45 disp("      AI = -hfe = -55")
46 Ri=1300+((1+55)*1000)
47 x3=Ri*10^-3
48 disp(x3,"      Ri(k-ohm) = hie + (1+hfe)*RE =")
49 Av=AI*(RC/Ri)
50 disp(Av,"      Av = AI * (RC/Ri) =")
51 disp("Output resistance , Ro = infinity")
52 disp("Output terminal resistance , RoT = Ro || RC = 2
      k-ohm")

```

---

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

```
1 //Example 9.3.
2 clc
3 RS=900
4 RL=2000
5 hie=1200
6 hre=2*10^-4
7 hfe=60
8 hoe=25*10^-6
9 disp("Conversion formulae :")
10 hic=hie
11 disp("      hic = hie = 1200 ohm,")
12 hfc=-(1+hfe)
13 disp(hfc,"      hfc = -(1+hfe) =")
14 disp("hre = 1, hoc = hoe = 25 uA/V")
15 hoc=hoe
16 hre=1
17 disp("Exact analysis :")
18 format(7)
19 AI=-hfc/(1+(hoc*RL))
20 disp(AI,"Current gain,      AI = -hfe / (1 + (hoc*RL
      )) =")
21 format(8)
22 Ri=hic + (hre*AI*RL)
23 x1=Ri*10^-3
24 disp(x1,"Input impedance,      Ri(k-ohm) = hic + hrc
      *AI*RL =")
25 format(7)
26 Av=(AI*RL)/Ri
27 disp(Av,"Voltage gain,      Av = AI*RL / Ri =")
28 Yo=hoc-((hfc*hre)/(hic+RS))
29 disp("Output resistance, Ro :")
30 disp(Yo,"      Yo(mho) = 1/Ro = hoc - (hfc*hrc/hic+
      Rs) =")
31 Ro=1/Yo
32 disp(Ro,"      Ro(ohm) =")
33 disp("Approximate analysis :")
```

```

34 AI=1+hfe
35 disp(AI," Current gain ,           AI = 1 + hfe ==")
36 Ri=hie+((1+hfe)*RL)
37 x2=Ri*10^-3
38 disp(x2," Input impedance ,           Ri(k-ohm) = hie + (1+
      hfe)RL ==")
39 Av=1-(hie/Ri)
40 disp(Av," Voltage gain ,           Av = 1 - hie/Ri ==")
41 disp(" Output resistance ,           Ro:")
42 format(6)
43 Yo=(1+hfe)/(hie+RS)
44 disp(Yo,"           Yo(mho) = (1+hfe) / (hie+RS) ==")
45 Ro=1/Yo
46 disp(Ro,"           Ro(ohm) ==")

```

---

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

```

1 //Example 9.4.refer fig.9.14.
2 clc
3 hic=1.4*10^3
4 hfc=-100
5 hrc=1
6 hoc=20*10^-6
7 R1=20*10^3
8 RS=1*10^3
9 R2=20*10^3
10 RE=10*10^3
11 RL=40*10^3
12 disp(" Current gain ,           AI = -hfc / 1+hoc*RL' ")
13 RLd=(RE*RL)/(RE+RL)
14 x1=RLd*10^-3
15 disp(x1," where ,           RL' '(k-ohm) = RE || RL ==")
16 format(5)
17 AI = -hfc / (1+(hoc*RLd))
18 disp(AI," Therefore ,   AI ==")

```

```

19 Ri=hic+(hrc*AI*RLd)
20 x2=Ri*10^-3
21 disp(x2,"Input resistance ,           Ri(k-ohm) = hic +
      hrc*AI*RL' ' =")
22 format(6)
23 Av=(AI*RLd)/Ri
24 disp(Av,"Voltage gain ,           Av = AI*RL' ' / Ri =")
25 disp("Output resistance ,           Ro = 1 / Yo")
26 disp("           Yo = hoc - (hfc*hrc)/(hic+RS' ')")
27 format(4)
28 RSd=(RS*R1*R2)/((R1*R2)+(RS*R2)+(RS*R1))
29 x3=RSd*10^-3
30 disp(x3,"where ,           RS' '(k-ohm) = RS || R1 || R2
      =")
31 format(6)
32 Yo = hoc - ((hfc*hrc)/(hic+RSd))
33 disp(Yo,"           Yo =") // answer in textbook is
      wrong
34 Ro=1/0.0435
35 disp(Ro,"           Ro(ohm) =")
36 Rod=(Ro*RLd)/(Ro+RLd)
37 disp(Rod,"           Ro' '(ohm) = Ro || RLdash =")

```

---

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

```

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

```



```

11 AI=-hfb/(1+(hob*RL))
12 disp(AI,"Current gain ,           AI = -hfb / (1 + hob*RL)
    =")
13 Ri=hib+(hrb*AI*RL)
14 disp(Ri,"Input impedance ,       Ri(ohm) = hib + hrb*
    AI*RL =")
15 format(7)
16 Av=(AI*RL)/Ri
17 disp(Av,"Voltage gain ,         Av = AI*RL / Ri =")
18 format(6)
19 Avs=(Av*Ri)/(Ri+Rs)
20 disp(Avs,"Overall current gain ,   Avc = Av*Ri /
    Ri+Rs =")
21 AIS=(AI*Rs)/(Ri+Rs)
22 disp(AIS,"Overall current gain ,   AIS = AI*Rs /
    Ri+Rs =")
23 format(7)
24 Yo=hob-((hfb*hrb)/(hib+Rs))
25 x1=Yo*10^6
26 disp(x1,"Output admittance ,     Yo(u-mho) = hob * (
    hfb*hrb / hib+Rs) =")
27 format(8)
28 Ro=1/Yo
29 x2=Ro*10^-6
30 disp(x2,"           Ro(M-ohm) = 1 / Yo =")
31 format(6)
32 AP=Av*AI
33 disp(AP,"Power gain ,           AP = Av*AI =")
34 disp(" ")
35 disp("Approximate analysis")
36 AI=-hfb
37 disp(AI,"Current gain ,         AI = -hfb =")
38 Ri=hib
39 disp(Ri,"Input impedance ,       Ri(ohm) = hib =")
40 disp("Voltage gain ,           Av = hfe*RL / hie")
41 disp("From Table 9.3 ,         hfb = -hfe / 1+hfe")
42 hfe = -hfb / (1+hfb)
43 disp(hfe,"Reaaranging this equation ,   hfe = -hfb

```

```

/ 1+hfb =")
44 disp("From Table 9.3,      hib = hie / 1+hfe")
45 hie=hib*(1+hfe)
46 disp(hie,"      hie(ohm) = hib(1+hfe) =")
47 Av=hfe*RL / hie
48 disp(Av,"      Av =")
49 disp("Output impedance,      Ro = infinity")
50 Avs=(Av*Ri)/(Ri+Rs)
51 disp(Avs," Overall voltage gain,      Avs = Av*Ri /
      Ri+Rs =")
52 AIS=(AI*Rs)/(Ri+Rs)
53 disp(AIS," Overall current gain,      AIS = AI*Rs /
      Ri+Rs =")
54 AP=Av*AI
55 disp(AP," Power gain,      AP = Av*AI =")

```

---

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

```

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

```

```

18 disp(AI,"          AI =")
19 disp("Input impedance Ri :")
20 Ri=hib+(hrb*AI*RLd)
21 disp(Ri,"          Ri(ohm) = hib + hrb*AI*RL' ' =")
22 disp("Voltage gain Av :")
23 format(7)
24 Av=(AI*RLd)/Ri
25 disp(Av,"          Av = (AI*RL' ' ) / Ri =")
26 disp("Output Resistance Ro :")
27 disp("The output admittance")
28 format(6)
29 RSd=(RS*RE)/(RS+RE)
30 Yo=hob-((hfb*hrb)/(hib+RSd))
31 x4=Yo*10^6
32 disp(x4,"          Yo(u-mho) = 1 / Ro = hob - (hfb*hrb /
          hib+RS' ' ) =          where RS' ' = RS || RE")
33 Ro=1/Yo
34 x2=Ro*10^-6
35 disp(x2,"          Ro(M-ohm) = 1 / Yo =")
36 format(5)
37 RSd=(Ro*RLd)/(Ro+RLd)
38 x3=RSd*10^-3
39 disp(x3,"          RS' '(k-ohm) = Ro || RL' ' =")

```

---

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

```

1 //Example 9.7.refer fig.9.39
2 clc
3 hfe=60
4 hie=500
5 IC=3*10^-3
6 RB=220*10^3
7 RC=5.1*10^3
8 VCC=12
9 VBE=0.6

```

```

10 format(5)
11 disp("      RB = 200 k-ohm >> hie = 500 ohm")
12 disp("From h-parameter model")
13 beta=hfe
14 Zo=RC
15 Av=(-hfe*RC)/hie
16 disp("      Zi = hie = 500 ohm")
17 disp("      Zo = RC = 5.1 k-ohm")
18 disp(Av,"      Av = (-hfe*RC) / hie =")
19 disp("      AI = -hfe = -60")
20 disp("From re model")
21 disp("      Zi = beta*re      where re = 26mV / Ie")
22 Ib=(VCC - VBE)/RB
23 x1=Ib*10^6
24 disp(x1,"From the circuit ,      Ib(uA) = (VCC - VBE)
      / RB =")
25 format(6)
26 Ie=beta*(51.8*10^-6)
27 x2=Ie*10^3
28 disp(x2,"      Ie(mA) = Ic = beta*Ib =")
29 format(5)
30 re = (26) / (3.108)
31 disp(re,"      re(ohm) = 26mV / Ie =")
32 format(6)
33 Zi = beta*8.37
34 disp(Zi,"      Zi(ohm) = beta*re =")
35 disp("      Zo = RC = 5.1 k-ohm")
36 Av=int(-RC/re)
37 disp(Av,"      Av = -RC / re =")
38 disp("      AI = -beta = -60")

```

---

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

```

1 //Example 9.8. refer fig.9.47
2 clc

```

```

3  hie=3.2*10^3
4  hfe=100
5  R1=40*10^3
6  R2=4.7*10^3
7  RC=4*10^3
8  VCC=16
9  VBE=0.6
10 RE=1.2*10^3
11 beta=100
12 disp("h-parameter analysis :")
13 disp("Zi = RB || hie")
14 format(4)
15 RB=(R1*R2)/(R1+R2)
16 x1=RB*10^-3
17 disp(x1,"          RB = R1 || R2 = 40 k-ohm || 4.7 k-ohm
          =")
18 format(5)
19 Zi=(RB*hie)/(RB+hie)
20 x2=Zi*10^-3
21 disp(x2,"          Zi = 4.2 k-ohm || 3.2 k-ohm =")
22 disp("          Zo = RC = 4 k-ohm")
23 Av=(-hfe*RC)/hie
24 disp(Av,"          Av = -hfe*RC / hie =")
25 format(6)
26 AI=(-hfe*RB)/(RB+hie)
27 disp(AI,"          AI = -hfe*RB / RB+hie =")
28 disp("Using r model :")
29 disp("To find IB,")
30 VB=(R2*VCC)/(R1+R2)
31 disp(VB,"          VB = R2*VCC / R1+R2")
32 disp("Using Thevenin equivalent for input part,")
33 IB=1.082/(125.4*10^3)
34 x3=IB*10^6
35 disp(x3,"IB(uA) = (VB-VBE) / (RB+((1+beta)*RE))")
36 format(5)
37 IC=beta*IB
38 x4=IC*10^3
39 disp(x4,"          IC(mA) = beta*IB =")

```

```

40 disp(x4,"          IE(mA) ~ IC(mA) =")
41 IE = IC
42 format(6)
43 re=(26*10^-3)/(0.86*10^-3)
44 disp(re,"          re(ohm) = 26mV / IE =")
45 format(5)
46 Zi=(RB*beta*re)/(RB+(beta*re))
47 x5=Zi*10^-3
48 disp(x5,"          Zi(k-ohm) = RB || beta*re")
49 disp(" Zo = RC = 4 k-ohm")
50 format(6)
51 Av=-RC/re
52 disp(Av,"          Av = -RC / re =")
53 format(7)
54 AI=(-100*(4.2*10^3))/((4.2*10^3)+(100*30.23))
55 disp(AI,"          AI = (-beta*RB) / (RB+(beta*re)) =")

```

---

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

```

1 //Example 9.9. refer fig 9.52.
2 clc
3 format(6)
4 VBE=0.6
5 VEE=8
6 VCC=10
7 RE=4*10^3
8 RC=3*10^3
9 IE=(VEE-VBE)/RE
10 x1=IE*10^3
11 disp(x1,"          |IE|(mA) = VEE-VBE / RE =")
12 re=(26*10^-3)/IE
13 disp(re,"          re(ohm) = 26mV / IE =")
14 Zi=(RE*re)/(RE+re)
15 disp(Zi,"          Zi(ohm) = RE || re =")
16 Zo=RC*10^-3

```

```

17 disp(Zo,"      Zo(k-ohm) = RC =")
18 format(7)
19 Av=3000/14.05
20 disp(Av,"      Av = RC / re =")
21 disp("      AI = 1")

```

---

#### Scilab code Exa 9.10 Zi and Av

```

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

```

---

#### Scilab code Exa 9.11 Zi and overall voltage gain

```

1 //Example 9.11.refer fig.9.55
2 clc
3 format(6)
4 VCC=10
5 RB=470*10^3
6 RE=3.3*10^3
7 beta=100
8 RS=1*10^3
9 RL=50
10 re=22.4
11 VBE=0.7
12 IB = (VCC-VBE) / (RB + ((1+beta)*RE))
13 x1=IB*10^6
14 disp(x1,"From fig.9.55, IB(uA) = (VCC-VBE) / (RB +
    (1+beta)*RE)")
15 format(5)
16 IE=(1+beta)*IB
17 x2=IE*10^3
18 disp(x2," IE(mA) = (1+beta)*IB =")
19 rL=(RE*RL)/(RE+RL)
20 disp(rL,"The load resistance of the emitter follower
    is rL(ohm) = RE || RL =")
    // answer in textbook
    is wrong
21 x=(1+beta)*(re+rL)
22 Zi=(RB*x)/(RB+x)
23 x3=Zi*10^-3
24 disp(x3," Zi(k-ohm) = RB || (1+beta)(re+rL) =")
25 y=(50/(22.4+50))*((7.13*10^3)/((1*10^3)+(7.3*10^3)))
    // answer in textbook is wrong
26 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 current gain



```

1 //Example 9.12. refer fig 9.56
2 clc
3 RS=50
4 RE=2*10^3
5 Ro=1*10^3
6 RL=4*10^3
7 VEE=6
8 VBE=0.7
9 RC=1000
10 VS=10*10^-3
11 format(5)
12 IE=(VEE-VBE)/RE
13 x1=IE*10^3
14 disp("We know that , IE = VEE-VBE / RE")
15 disp(x1," Therefore , IE(mA) =")
16 re=0.026/IE
17 disp(re," Zb(ohm) = re(ohm) =")
18 Zi=(re*RE)/(re+RE)
19 disp(Zi," Zi(ohm) = re || RE =")
20 format(6)
21 Av=RC/re
22 disp(Av," Av = RC / re =")
23 x=Av*(re/(re+RS))*(RL/(RL+RC))
24 disp(x," VL / VS = Av*(re/re+RS)*(RL/RL+RS) =")
25 VL=x*VS
26 x2=VL*10^3
27 disp(x2," VL(in mV (rms)) = Av*VS =")
28 iL=VL/RL
29 format(5)
30 x3=iL*10^6
31 disp(x3," iL( in uA (rms)) = VL / RL =")
32 alpha=1
33 format(6)
34 y=alpha*(RS/(RS+re))*(RC/(RC+RL))
35 disp(y," iL / iS = alpha*(RS/RS+re)*(RC/RC+RL)
    =")

```

---

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

```
1 //Example 9.13.refer fig.9.57.
2 clc
3 RC=12*10^3
4 RL=15*10^3
5 RS=10
6 RE=22*10^3
7 VEE=24
8 VBE=0.3
9 disp("The emitter current of the common base
      amplifier is")
10 format(8)
11 IE=(VEE-VBE)/RE
12 disp(IE,"      IE(A) = VEE-VBE / RE =")
13 format(6)
14 re=0.026/IE
15 disp(re,"      re(ohm) = 0.026 / IE =")
16 format(5)
17 Av=RC/re
18 disp(Av,"      Av = RC /re =")
19 format(8)
20 x=497*(24.14/(24.14+10))*((15*10^3)/((12*10^3)
      +(15*10^3)))
21 disp(x,"      VL/VS = Av*(re/re+RS)*(RL/RL+RC) =")
22 format(6)
23 Ai=3.413
24 y=Ai*(RS/(RS+re))*(RC/(RC+RL))
25 disp(y,"      iL/iS = Ai*(RS/RS+re)*(RC/RC+RL) =")
```

---

**Scilab code Exa 9.14** Ri and Ro and VL

```

1 //Example 9.14. refer fig.9.58.
2 clc
3 rc=1.5*10^6
4 RE=4.7*10^3
5 Ro=2.2*10^3
6 RS=20
7 RL=10*10^3
8 VS=20*10^-3
9 VEE=9
10 VBE=0.7
11 IE=(VEE-VBE)/RE
12 format(6)
13 x1=IE*10^3
14 disp(x1,"We know that, IE(mA) = VEE-VBE / RE =")
15 format(5)
16 re=0.026/IE
17 disp(re," re(ohm) = 0.026 / IE =")
18 Zi=(RE*re)/(RE+re)
19 disp(Zi," Zi(ohm) = RE || re =")
20 Zo=(Ro*rc)/(Ro+rc)
21 x2=Zo*10^-3
22 disp(x2," Zo(k-ohm) = RC || re =")
23 format(6)
24 Av=Zo/Zi
25 disp(Av," Av = Zo/Zi = RC || rc/RE || re =")
26 format(5)
27 x=Av*(Zi/(RS+Zi))*(RL/(RL+Zo))
28 disp(x," VL/Vs = Av*(Zi/RS+Zi)*(RL/RL+Zo) =")
29 format(6)
30 y=x*VS
31 disp(y," VL(rms) = Av*VS(rms) =")

```

---

### Scilab code Exa 9.15 Zi and overall voltage gain

```

1 //Example 9.15. refer fig.9.59.

```

```

2  clc
3  beta=100
4  VCC=10
5  R2=4.7*10^3
6  R1=27*10^3
7  RE=680
8  RC=3.3*10^3
9  RS=600
10 RL=15*10^3
11 disp("Referring to fig.9.59(a),")
12 format(5)
13 VB=(10*4.7*10^3)/((27*10^3)+(4.7*10^3))
14 disp(VB,"          VB(V) = (R2 / R1+R2)*VCC =") //
    answer in textbook is wrong
15 VE=1.39-0.7
16 disp(VE,"          VE(V) = 1.39 - 0.7 =")
17 format(4)
18 IE=VE/RE
19 x1=IE*10^3
20 disp(x1,"          IE(mA) = VE / RE =")
21 re=0.026/IE
22 disp(re,"          re(ohm) = 0.026/IE =")
23 x=beta*(re+RE)
24 format(5)
25 Zi=(R1*R2*x)/((R2*x)+(R1*x)+(R1+R2)) // answer in
    textbook is wrong
26 x2=Zi*10^-3
27 disp(x2,"          Zi(k-ohm) = R1 || R2 || beta*(re+RE)
    =")
28 format(4)
29 y=(-RC/(RE+re))*(Zi/(RS+Zi))*(RL/(RC+RL))
30 disp(y,"The overall voltage gain is VL/VS = (-RC/RE+
    re)*(Zi/RS+Zi)*(RL/RC+RL) =")
31 disp("Referring to fig.9.59(b),")
32 format(5)
33 u=beta*re
34 Zi=(R1*R2*u)/((R2*u)+(R1*u)+(R1+R2))
35 x3=Zi*10^-3

```

```

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

```

---

### Scilab code Exa 9.16 overall voltage gain

```

1 //Example 9.16. refer fig.9.53(b).
2 clc
3 RB1=7.5*10^3
4 RB2=6.8*10^3
5 RB3=3.3*10^3
6 RE=1.3*10^3
7 RC=2.2*10^3
8 beta1=120
9 beta2=120
10 VCC=18
11 VBE1=0.7
12 format(6)
13 disp("From the circuit given in Fig.9.53(b),")
14 disp("          IE2 = IE1 and hence, IC2 = IC1")
15 disp("Since,          beta1 = beta2")
16 disp("          IB1 = IC1/beta1 = IC2/beta = IB2")
17 disp("By voltage division,")
18 VB1=(RB3*VCC)/(RB3+RB2+RB1)
19 disp(VB1,"          VB1(V) = (RB3*VCC)/(RB3+RB2+RB1) =")
20 format(5)
21 IE1=(VB1-VBE1)/RE
22 x1=IE1*10^3
23 disp(x1,"          IE1 (mA) = VE1/RE = (VB1-VBE1)/RE =")
24 format(6)
25 re1=(26*10^-3)/IE1
26 disp(re1,"          re1 (ohm) = 26mV/IE1 =")
27 re2=re1

```

```

28 disp(re2,"          re2(ohm) =                (since
    IE2 = IE1)")
29 disp("Voltage gain of the first stage,")
30 disp("          Av1 = -re1/re1 = -1")
31 disp("Voltage gain of the second stage,")
32 format(7)
33 Av2=RC/re2
34 disp(Av2,"          Av2 = RC / re2 =")
35 disp("Overall voltage gain,")
36 Av1=-1
37 Av=Av1*Av2
38 disp(Av,"          Av = Av1*Av2 =")

```

---

#### Scilab code Exa 9.17 Av and Zi and Zo

```

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

```

---

#### Scilab code Exa 9.18 Av and Zi and Zo

```

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

```

---

#### Scilab code Exa 9.19 Av and Zi and Zo

```

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

```

```

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

```

---

Scilab code Exa 9.20 the percentage difference

```

1 //Example 9.20.
2 clc
3 disp(" In the first set,")
4 Vid=100-(-100) //in uV
5 disp(Vid," Vid = Vd(uV) = V1 = V2 =")
6 Vc=(1/2)*(100+(-100)) // in uV
7 disp(Vc," Vc(uV) = 1/2(V1+V2) =")
8 disp(" Vo = Ad*Vid * [1 + 1/CMRR * Vc/Vid]")
9 disp(" = Ad*200 * [1 + 1/1000 * 0/200] = 200*Ad
    uV Eq.1")
10 disp(" In the second set,")
11 Vd=1100-900 // in uV
12 disp(Vd," Vd(uV) = V1 - V2 =")
13 Vc=(1/2)*(1100+900)
14 disp(Vc," Vc(uV) = 1/2(V1+V2) =")
15 disp("Hence, Vo = Ad*Vid * [1 + 1/CMRR * Vc/Vid]")
16 disp(" = Ad*200 * [1 + 1/1000 * 1000/200]
    = 201*Ad uV Eq.2")
17 disp("Comparing Eq.1 and 2, the output voltages for
    the two sets of input signals result in a 0.5%
    difference.")
18 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.")
19 disp("When CMRR = 10000, a similar analysis as that
    of case (i) gives")
20 disp(" Vo = Ad*200 * [1 + 1/10000 * 1000/200]

```



```

    = 200.1*Ad uV")
21 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

```

1 //Example 9.21. refer fig.9.87.
2 clc
3 format(6)
4 VEE=15
5 VBE=0.7
6 REE=65*10^3
7 disp("The emitter current can be found by writing a
    loop equation starting at the base of Q1")
8 disp("      VBE + 2*IE*REE - VEE = 0")
9 IE = (VEE - VBE)/(2*REE)
10 IE1=IE*10^6
11 disp(IE1,"      IE(uA) = (VEE - VBE)/2*REE =")
12 alphaF=100/101
13 IC=(alphaF*IE)
14 IC1=IC*10^6
15 disp(IC1,"      IC(uA) = alpha_F*IE =")
16 betaF=100
17 IB=IC/betaF
18 IB1=IB*10^6
19 disp(IB1,"      IB(uA) = IC / beta_F =")
20 VCC=VEE
21 RC=REE
22 VC=VCC-(IC*RC)
23 disp(VC,"      VC(V) = VCC - IC*RC =")
24 VE=-0.7
25 VCE=VC - VE
26 disp(VCE,"      VCE(V) = VC - VE =")
27 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")
28 disp("As VEE >> VBE, IE can be approximated by")
29 format(7)
30 IE=(VEE/(2*REE))*10^6
31 disp(IE,"      IE(uA) = VEE / 2*REE =")

```

---

### Scilab code Exa 9.22 Qpoint and maximum VIC

```

1 //Example 9.22. refer fig.9.88
2 clc
3 format(6)
4 VDD=12
5 VSS=VDD
6 ISS=175*10^-6
7 RD=65*10^3
8 Kn=3*10^-3
9 VTN=1
10 IDS=ISS/2
11 IDS1=IDS*10^6
12 disp(IDS1,"      IDS(uA) = ISS / 2 =")
13 VGS=VTN+sqrt(ISS/Kn)
14 disp(VGS,"      VGS(V) = VTH + sqrt(ISS/Kn) =")
15 format(5)
16 VDS=VDD-(IDS*RD)+VGS
17 disp(VDS,"      VDS(V) = VDD - (IDS*RD) + VGS =")
18 disp("Checking for saturation,")
19 format(6)
20 x=VGS-VTN
21 disp(x,"      VGS - VTN =")
22 disp("and VDS >= 0.2. Thus, both transistors in the
      differential amplifier are biased at Q-point of :
      ")
23 disp(IDS1)
24 format(5)

```

```

25 disp(VDS)
26 disp(" Requiring saturation of M1 for non zero VIC,")
27 disp("      VGD = VIC - (VDD - IDS*RD) <= VTN")
28 disp("      VIC <= VDD - ID*RD + VTN")
29 VIC = VDD - IDS*RD + VTN
30 disp(VIC, "      VIC(V) =")

```

---

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

```

1 //Example 9.23. refer fig.9.89
2 clc
3 VS1=60*10^-3
4 VS2=40*10^-3
5 hie=3.2*10^3
6 hfe=100
7 VEE=12
8 VCC=VEE
9 VBE=0.7
10 beta=hfe
11 RE=5.6*10^3
12 RS=120
13 RC=4.5*10^3
14 Rc=4.5*10^-5
15 format(6)
16 IE=(VEE-VBE)/((2*RE)+(RS/beta))
17 IE1=IE*10^3
18 disp("beta = hfe = 100")
19 disp(IE1, "      IE(mA) = (VEE-VBE) / ((2*RE)+(RS/beta)
20      )")
21 IC=IE
22 disp("IC ~ IE = 1.009 mA")
23 disp(IE1, "      Therefore      ICQ(mA) =")
24 format(5)
25 VCE=VCC+VBE-(IC*Rc)
26 disp(VCE, "      VCE(V) = VCC + VBE - IC*RC =") //

```

```

    answer in textbook is wrong
26 disp(VCE,"and VCEQ(V) =") // answer in
    textbook is wrong
27 disp("The differential gain is")
28 format(7)
29 Ad=(hfe*RC)/(RS+hie)
30 disp(Ad," Ad = hfe*RC / RS+hie =")
31 disp("Common mode gain is,")
32 format(7)
33 AC=(hfe*RC)/(((2*RE)*(1+hfe))+RS+hie)
34 disp(AC," AC = (hfe*Re) / (((2*RE)*(1+hfe)) + RS
    + hie) =")
35 format(8)
36 CMRR = Ad / AC
37 disp(CMRR,"CMRR = Ad / AC =")
38 format(7)
39 CMRR1=20*log10(135.54/0.3966)
40 disp(CMRR1,"CMRR(dB) = 20log|Ad/AC| =")
41 disp("The output voltage is Vo = Ad*Vd + AC*VC. Here
    ,")
42 Vd=VS1-VS2
43 Vd1=Vd*10^3
44 disp(Vd1," Ad [mV(peak-peak)] = VS1 - VS2 =")
45 VC=(VS1+VS2)/2
46 VC1=VC*10^3
47 disp(VC1," Then, VC [mV(peak-peak)] = (VS1+VS2) /
    2 =")
48 format(5)
49 Vo = Ad*Vd + AC*VC
50 disp(Vo," Therefore, Vo [V(peak-peak)] =")

```

---

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

```

1 //Example 9.24. refer fig.9.90(a)
2 clc

```

```

3  hie=400
4  hre=2.1*10^-4
5  hfe=40
6  hoe=25*10^-6
7  RL=5*10^3
8  RC=3*10^3
9  disp("From the circuit 9.90(a),")
10 format(6)
11 Rth=(RL*RC)/(RL+RC)
12 RLd=hoe*(Rth)
13 disp(RLd," RL = hoe*(RL || RC) =")
14 disp("For equivalent circuit refer fig.9.90(b).")
15 Ri=(hie*100*10^3)/(hie+(100*10^3))
16 disp(Ri," Input resistance , Ri = hie || 100k =")
17 R1=50*10^3
18 format(7)
19 Ro=(R1*RC*RL)/((RC*RL)+(R1*RL)+(R1*RC))
20 disp(Ro," Output resistance , Ro = 50k || 3k || 5
    k =")
21 disp(" Vo/Vs = (Vo/Vi) * (Vi/Vs)")
22 disp(" Vo/Vi = (-hfe*RL) / hie")
23 x=(-hfe*Ro)/hie
24 disp(x," Therefore , Vo/Vi = -hfe*Ro / hie =")
25 disp("In the equivalent circuit ,")
26 disp(" Vi = (Vs*Ri) / (Ri+RS)")
27 RS=1*10^3
28 y=Ri/(Ri+RS)
29 disp(y," Vi/Vs = Ri/(Ri+RS) =")
30 format(6)
31 Avs=abs(x*y)
32 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

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

```

19 AI2=-hfc/(1+(hoc*RE2))
20 disp(AI2,"                AI2 = -Ie2 / Ib2 = -hfc /
    (hoc*RE2) =")
21 disp("The input impedance Ri of a particular stage
    is given by")
22 disp("                Ri = hi + hf*AI*ZL")
23 disp("For the second stage,")
24 Ri2 = hic + (hrc*AI2*RE2)
25 Ri22=Ri2*10^-3
26 disp(Ri22,"                Ri2(k-ohm) = hic + (hrc*AI2*RE2
    ) =")
27 disp("Thus, the CC stage has a high input impedance.
    ")
28 disp("The voltage gain of a particular stage is")
29 disp("                AV = (AI*ZL) / Zi")
30 disp("For the second stage,")
31 Re2=4000
32 AV2=(AI2*Re2)/Ri2
33 disp(AV2,"                AV2 = Vo/V2 = (AI2*Re2) /
    Ri2")
34 disp("The First Stage :")
35 RC1=4000
36 format(5)
37 RL1=(RC1*Ri2)/(RC1+Ri2)
38 RL11=RL1*10^-3
39 disp(RL11,"                RL1(k-ohm) = RC1 || Ri2 =")
40 disp("Current gain,")
41 AI1= -hfe/(1+(hoe*RL1))
42 disp(AI1,"                AI1 = -IC1/Ib1 = -hfe
    /(1+(hoe*RL1)) =")
43 disp("The input impedance of the first stage, which
    is also the input impedance of the cascaded
    amplifier is")
44 Ri1=hie +(hre*AI1*RL1) // answer in textbook is
    wrong
45 Ri11=Ri1*10^-3
46 disp(Ri11,"                Ri1(k-ohm) = hie + hre*AI1*RL1 =
    ")

```

```

47 disp("The voltage gain of the first stage is")
48 format(7)
49 AV1=(AI1*RL1)/Ri1 // answer in textbook is wrong
50 disp(AV1," AV1 = V2/V1 = (AI1*RL1) /
    Ri1 =")
51 disp("The output admittance of the first transistor
    Q1")
52 RS=600
53 format(5)
54 Yo1=hoe-((hfe*hre)/(hie+RS))
55 Yo0=Yo1*10^6
56 disp(Yo0," Yo1(uA/V) = hoe - ((hfe*hre) /
    (hie+RS)) =")
57 disp("The output impedance of the first stage")
58 format(6)
59 Ro1=1/Yo1
60 Ro0=Ro1*10^-3
61 disp(Ro0," Ro1(k-ohm) = 1 / Yo1 =")
62 disp("The output impedance taking RC1 into account
    is")
63 format(5)
64 Rot1=(Ro1*RC1)/(Ro1+RC1)
65 Rott=Rot1*10^-3
66 disp(Rott," Rot1(k-ohm) = Ro1 || RC1 =")
67 disp("This is the effective source resistance RS2 of
    the second stage")
68 disp("The output admittance of the second stage")
69 format(7)
70 Yo2=hoc-((hfc*hrc)/(hic+Rot1))
71 disp(Yo2," Yo2(A/V) = hoc - ((hfc*hrc) / (
    hic+Rot1)) =")
72 disp("Output impedance,")
73 format(4)
74 R02=1/(11.525*10^-3)
75 disp(R02," R02(ohm) = 1 / Yo2 =")
76 disp("The amplifier output impedance taking RE2 into
    account is R02 || RE2")
77 format(6)

```



```

78 Ro2=(87*4000)/(87+4000)
79 disp(Ro2,"Hence ,      Ro2(ohm) = (RO2*RE2) / (RO2+
      RE2) =")
80 disp("Overall current gain :")
81 disp("The output or total current gain of both the
      stages is")
82 disp("      AI = -Ie2 / Ib1 = (-Ie2/Ib2)(Ib2
      /IC1)(IC1/Ib1)")
83 disp("      = -AI2*(Ib2/Ic1)*AI1")
84 disp("From fig.10.9(b),")
85 disp("      Ib2 = (-IC1)(Rc1 / Rc1+Ri2)")
86 Rc1=4000
87 format(7)
88 x=(-Rc1)/(Rc1+Ri2)
89 disp(x,"      Ib2/Ic1 = -Rc1/ Rc1+Ri2 =")
90 format(6)
91 AI=-AI2*x*AI1
92 disp(AI,"      AI = -AI2*AI1*(Rc1 / Ri2+Rc1)
      =")
93 disp("The overall voltage gain of the amplifier,")
94 disp("      AV = Vo / V1 = (Vo/V2)(V2/V1)")
95 AV=AV2*AV1
96 disp(AV,"      AV = AV2*AV1 =") // answer in
      textbook is wrong
97 disp("The overall voltage gain taking the source
      impedance into account,")
98 format(4)
99 AVs=AV*(Ri1/(Ri1+RS))
100 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

1 //Example 10.2.

```

2  clc
3  format(6)
4  hfe=50
5  hie=1200
6  hoe=30*10^-6
7  hre=2.5*10^-4
8  RC=5*10^3
9  C=160*10^-12
10 CC=6*10^-6
11 R1=100*10^3
12 R2=10*10^3
13 gm=50*10^-3
14 Ro=1/hoe
15 x1=(Ro*10^-3)
16 disp(x1,"Ro(k-ohm) = 1/hoe =")
17 format(4)
18 RB=(R1*R2)/(R1+R2)
19 x2=RB*10^-3
20 disp(x2,"RB(k-ohm) = R1 || R2 =")
21 Ri=hie
22 x3=Ri*10^-3
23 disp(x3,"Ri(k-ohm) = hie =")
24 format(5)
25 R_C=(RC*Ro)/(RC+Ro)
26 x4=R_C*10^-3
27 disp(x4,"RC''(k-ohm) = RC || Ro =")
28 format(4)
29 R_i=(RB*Ri)/(RB+Ri)
30 x6=R_i*10^-3
31 disp(x6,"Ri''(k-ohm) = RB || Ri =")
32 format(5)
33 R_ci=(R_C*R_i)/(R_C+R_i)
34 x7=R_ci*10^-3
35 disp(x7,"Rci'' = Rc'' || Ri'' =")
36 rbe=hfe/gm
37 disp(rbe,"rbe(ohm) = hfe / gm =")
38 disp("(a) Mid-band current gain,")
39 AIm=(-50*4.35*10^3)/((4.35*10^3)+(1.1*10^3))

```

```

40 disp(AIm,"AIm = (-hfe*R''C) / (RC''+Ri'') =")
41 disp("(b) Mid-band voltage gain,")
42 format(6)
43 AVm=(-50)*((0.87*10^3)/(1.2*10^3))
44 disp(AVm,"AVm = (-hfe) * (Rcid/hie) =")
45 disp("(c) Lower 3dB frequency,")
46 format(5)
47 fL=1/(2*%pi*6*10^-6*(5.45*10^3))
48 disp(fL,"fL(Hz) = 1 / (2*%pi*CC*(R_C+R_i)) =")
49 disp("Higher 3dB frequency,")
50 format(6)
51 fH=1/(2*%pi*C*rbe)
52 x8=fH*10^-3
53 disp(x8,"fH(kHz) = 1 / (2*%pi*C*rbe) =") // answer
    in textbook is wrong
54 disp("(d) Voltage gain x bandwidth")
55 y=abs(AVm*fH)
56 x9=(y*10^-6)
57 disp(x9,"|AVmfH| =")

```

---

# Chapter 11

## Frequency Response of Amplifiers

Scilab code Exa 11.2 approximate bandwidth

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

---

Scilab code Exa 11.3 AvMF and lower 3 dB gain

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

```

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

```

---

#### Scilab code Exa 11.4 coupling capacitor

```

1 //Example 11.4
2 clc
3 RS=600
4 hie=1*10^3
5 hfe=60
6 R1=5*10^3
7 R2=1.25*10^3
8 RCE=25
9 f1=125
10 disp("The lower 3 dB frequency , f1 = 1 / (2*pi*(RS+
    R1dash)*CC)")
11 format(5)
12 R1dash=(R1*R2*hie)/((R2*hie)+(R1*hie)+(R1*R2))
13 CC=1 / (2*%pi*f1*(RS+R1dash))
14 x1=CC*10^6
15 disp(R1dash,"(a) R1''(ohm) = R1 || R2 || hie =")
16 disp(x1," CC(uF) = 1 / (2*pi*f1*(RS+R1'')) =")
17 x2=hie+((1+hfe)*RCE)

```

```

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

```

---

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

```

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

```

---

### Scilab code Exa 11.6 alpha and beta and fT

```

1 //Example 11.6.
2 clc
3 format(5)

```

```

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

```

---

# Chapter 12

## Large Signal Amplifiers

Scilab code Exa 12.1 effective resistance

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

---

Scilab code Exa 12.2 transformer turns ratio

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



---

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

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

---

**Scilab code Exa 12.4** collector circuit efficiency

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

---

**Scilab code Exa 12.5** junction temperature TJ

```

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

```

---

**Scilab code Exa 12.6** desipate power of transistor

```

1 //Example 12.6.
2 clc
3 format(6)
4 TJ=160
5 TA=40
6 theta=80
7 PD=(TJ-TA)/theta
8 disp(PD,"PD(W) = (TJ-TA)/thetaJ-A = (160-40)/80 =")

```

---

**Scilab code Exa 12.7** power dissipation capability

```

1 //Example 12.7.
2 clc
3 format(6)
4 thetaH=8
5 TA=40
6 TJ=160
7 thetaJ=5
8 thetaC=85
9 x1=(thetaC*thetaH)/(thetaC+thetaH)

```

```
10 theta=thetaJ+x1
11 disp(theta,"      theta_J-A(degree C/W) = theta_J-C +
      theta_C-A || theta_HS-A =")
12 PD=(TJ-TA)/theta
13 format(5)
14 disp(PD,"      PD(W) = TJ-TA / theta_J-A =")
```

---

# Chapter 14

## Feedback Amplifiers

Scilab code Exa 14.1 percentage change in gain

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

---

Scilab code Exa 14.2 openloop gain A and feedback ratio

```
1 //Example 14.2.
2 clc
3 format(6)
4 Af=100
5 dAf=0.02
```

```

6 dA=0.2
7 disp("We have ,          dAf/Af = dA/A * 1/(1+A*beta)")
8 disp("    dAf/Af = dA/A * 1/(1+A*beta)")
9 Ab=dA/dAf
10 disp(Ab," Therefore ,          (1 + A*beta) =")
11 disp(" Also , the gain with feedback is")
12 disp("          Af = A / (1+A*beta)")
13 A=Af*Ab
14 disp(A," Therefore ,          A =")
15 disp("          1 + A*beta = 10; i.e. A*beta = 9")
16 beta=9/A
17 disp(beta," Therefore ,          beta =")

```

---

### Scilab code Exa 14.3 bandwidth and feedback ratio

```

1 //Example 14.3.
2 clc
3 format(6)
4 A=125
5 BW=250*10^3
6 beta=0.04
7 disp("(a) We have BWf = (1 + A*beta) * BW")
8 BWf = (1 + (A*beta))*BW
9 x1=BWf*10^-6
10 disp(x1,"          BWf(MHz) =")
11 Af=A/(1+(A*beta))
12 disp(Af," Gain with feedback , Af = A / (1+ A*beta) =")
13 disp("(b) BWf = (1 + A*beta ' ') * BW")
14 disp("1*10^6 = (1 + 125*beta ' ') * 250*10^3")
15 Bd=3/125
16 disp(Bd," Therefore ,          beta =")
17 Bd1=Bd*100
18 disp(Bd1," i.e.          beta (in %) =")

```

---

#### Scilab code Exa 14.4 amplifier voltage gain and Df

```
1 //Example 14.4.
2 clc
3 format(6)
4 A=400
5 f1=50
6 f2=200*10^3
7 D=10
8 beta=0.01
9 disp("The voltage gain with feedback")
10 Af=A/(1+(A*beta))
11 disp(Af," Af = A / (1 + A*beta) =")
12 disp("New lower 3dB frequency ,")
13 f1f=f1/(1+(A*beta))
14 disp(f1f," f_1f(Hz) = f1 / 1+A*beta =")
15 disp("New upper 3dB frequency ,")
16 f2f=(1+(A*beta))*f2
17 x2=f2f*10^-6
18 disp(x2," f2f(MHz) = (1+A*beta)*f2 =")
19 disp("Distortion with feedback ,")
20 Df=D/(1+(A*beta))
21 disp(Df," Df (in %) = D / 1+A*beta =")
```

---

#### Scilab code Exa 14.5 Af and Rif and Rof

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

```

7 beta=0.01
8 format(6)
9 Af=A/(1+(A*beta))
10 disp(Af," Voltage gain ,      Af = A / (1+A*beta) =")
11 Rif=(1+(A*beta))*Ri
12 x1=Rif*10^-3
13 disp(x1," Input resistance ,  Rif(k-ohm) = (1+(A*beta)
        )*Ri =")
14 Rof=Ro/(1+(A*beta))
15 x2=Rof*10^-3
16 format(5)
17 disp(x2," Output resistance , Rof(k-ohm) = Ro / (1+A*
        beta) =")

```

---

#### Scilab code Exa 14.6 $A_i$ and $R_i$ and $A_v$ and $R_o$ and $R_{of}$

```

1 //Example 14.6.
2 clc
3 format(6)
4 Ai=1+80
5 disp(Ai,"  Ai = 1 + hfe =")
6 Ri=(5*10^3)+((1+80)*(2*10^3)) //in ohm
7 x1=Ri*10^-3 //in k-ohm
8 disp(x1,"  Ri(k-ohm) = hie + (1+hfe)*RL =")
9 Av=(81*2*10^3)/(167*10^3)
10 disp(Av,"  Av = Ai*RL / Ri =")
11 Ro=(5000+600)/(1+80) // in ohm
12 disp(Ro,"  Ro(ohm) = hie+Rs / 1+hfe =")
13 Rof=(69.13*2000)/(2069.13) //in ohm
14 disp(Rof,"  Rof(ohm) = Ro || RL =")

```

---

#### Scilab code Exa 14.7 $A_v$ and $R_{if}$ and $A_{vf}$ and $R_{of}$ and $R_{ofdash}$

```

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

```

---

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

```

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

```



```

13 beta=Re/RL
14 disp(beta,"(b) beta = Re / RL =")
15 Rif=hie+((1+hfe)*Re)
16 x1=Rif*10^-3
17 disp(x1,"(c) Rif(k-ohm) = hie + (1+hfe)*Re =")
18 Af=(-hfe*RL)/Rif
19 format(5)
20 disp(Af,"(d) Af = -hfe*RL / Rif =")
21 lg=20*log10(4)
22 format(6)
23 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

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

---

Scilab code Exa 15.2 range over caacitor is varied

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

```

5 disp("Frequency of oscillation of Hartley oscillator
      is")
6 disp("      fo = 1 / 2*pi*sqrt((L1-L2)*C)")
7 disp("Therefore, C = 1 / 4*pi^2*(L1+L2)*fo^2")
8 disp("When fo = 950 kHz")
9 C=1/(4*(%pi^2)*((2*10^-3)+(20*10^-6))*((950*10^3)^2)
    ) //farady
10 x1=C*10^12 //pF
11 disp(x1,"      C(pF) =")
12 disp("When fo = 2050 kHz")
13 C=1/(4*(%pi^2)*((2*10^-3)+(20*10^-6))*((2050*10^3)
    ^2)) //farady
14 x1=C*10^12 //pF
15 format(5)
16 disp(x1,"      C(pF) =")
17 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

```

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

```

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

---

#### Scilab code Exa 15.4 inductor and gain for oscillation

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

---

#### Scilab code Exa 15.5 colpitts osillator

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

```

8 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")
9 fo=1/ (2*%pi*sqrt((L*C1*C2)/(C1+C2)))
10 x1=fo*10^-3
11 disp(x1,"    fo(kHz) = 1 / 2pi*sqrt(LCeq) = 1 / 2pi*
   sqrt(L*C1*C2/C1+C2) =")
12 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,")
13 disp("Vo/Vf = XC1/XC2 = (1/omega*C1)/(1/omegaC2) =
   C2/C1")
14 Vf=(Vo*C1)/C2
15 disp(Vf,"Hence, Vf(V) = Vo*C1 / C2 =")
16 disp("(iii) Since the gain depends upon C1 and C2
   only and is independent of L,")
17 gain=C2/C1
18 disp(gain," Gain = 500*10^-12 / 100*10^-12 =")
19 disp("(iv) When the gain is equal to 10, C2/C1 = 10"
   )
20 x2=C2/10
21 x3=x2*10^12
22 disp(x3,"Therefore , C1(pF) = C2 / 10 =")
23 disp("(v) The frequency of oscillation is")
24 fo=1/ (2*%pi*sqrt((40*50*500*10^-27)/((50*10^-12)
   +(500*10^-12))))
25 x4=fo*10^-3
26 format(7)
27 disp(x4," fo(kHz) =")

```

---

### Scilab code Exa 15.6 range of variable capacitor

```

1 //Example 15.6.
2 clc

```

```

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

```

---

### Scilab code Exa 15.7 range of tuning capacitor

```

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

```

```

16 x2=Cmin*10^12
17 format(4)
18 disp(x2,"When fo = 1650 kHz, Cmin(pF) =")
19 disp("Hence, the capacitor range required is
      9.3–86.87 pF")

```

---

#### Scilab code Exa 15.8 frequency of oscillation

```

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

```

---

#### Scilab code Exa 15.9 minimum current gain

```

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

```

```

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

```

---

#### Scilab code Exa 15.10 C and hfe

```

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

```

---

#### Scilab code Exa 15.11 value of capacitor

```

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

```



```

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

```

---

**Scilab code Exa 15.12** series and parallel resonant frequency and Qfactor

```

1 //Example 15.12.
2 clc
3 format(6)
4 disp("(a) The series resonant frequencies of the
      crystal is")
5 fs=1/(2*%pi*sqrt(0.5*0.06*10^-12)) //in Hz
6 x1=fs*10^-3 //in kHz
7 disp(x1," fs (kHz) = 1 / 2*pi*sqrt(L*Cs) =")
8 format(5)
9 fs=(2*%pi*(918.9*10^3)*0.5)/(5*10^3)
10 disp(fs,"Q factor of the crystal at fs = omegaS*L /
      R = 2*pi*fs*L / R =")
11 disp("(b) The parallel resonant frequency of the
      crystal is")
12 fp=(1/(2*%pi))*sqrt((1.06*10^-12)/(0.5*(0.06*10^-12)
      *(1*10^-12))) // in Hz
13 x1=fp*10^-3
14 disp(x1," fp (kHz) = 1/2pi * sqrt((Cs+Cp)/(L*Cs*Cp))
      =")
15 fp=(2*%pi*(946*10^3)*0.5)/(5*10^3)
16 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

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

---

Scilab code Exa 16.2 size of speedup capacitor and input frequency

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

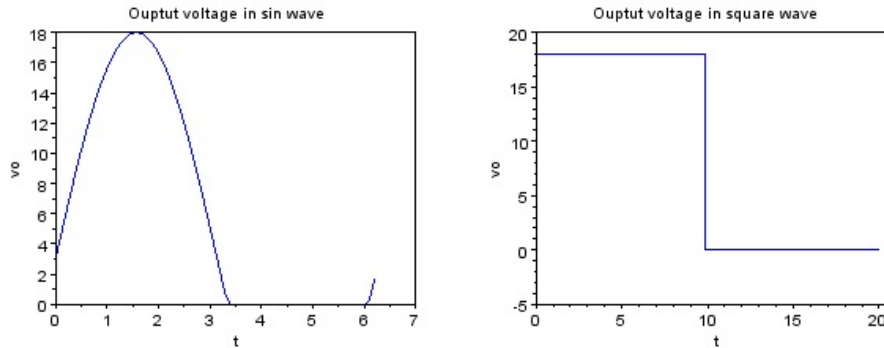


Figure 16.1: negative clipper

```

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

```

---

### Scilab code Exa 16.3 negative clipper

```

1 //Example 16.3.
2 clc
3 format(6)
4 amp = 15;
5 vi_t=3; // transition voltage

```

```

6 t=0:0.1:2*%pi;
7 vi=amp*sin(t);
8 vo=vi+3; // output voltage
9 disp (vi_t, 'transition voltage:');
10 for i=1:length(t)
11 if(vo(i)<=0)
12 vo(i)=0;
13 end
14 end
15 subplot(2,2,1)
16 plot2d1(t,vo,2, '011', '', [0,0,7,18]);
17 xtitle('Ouptut voltage in sin wave', 't', 'vo');
18
19
20 t=0:0.1:20;
21 for i=1:int(length(t)/2)
22 vo(i)=15+3;
23 end
24 for i=int(length(t)/2):length(t)
25 vo(i)=0;
26 end
27 subplot(2,2,2)
28 plot2d2(t,vo,2, '011', '', [0,-5,21,20]);
29 a = gca ();
30 xtitle('Ouptut voltage in square wave', 't', 'vo');

```

---

#### Scilab code Exa 16.4 negative clipper

```

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

```

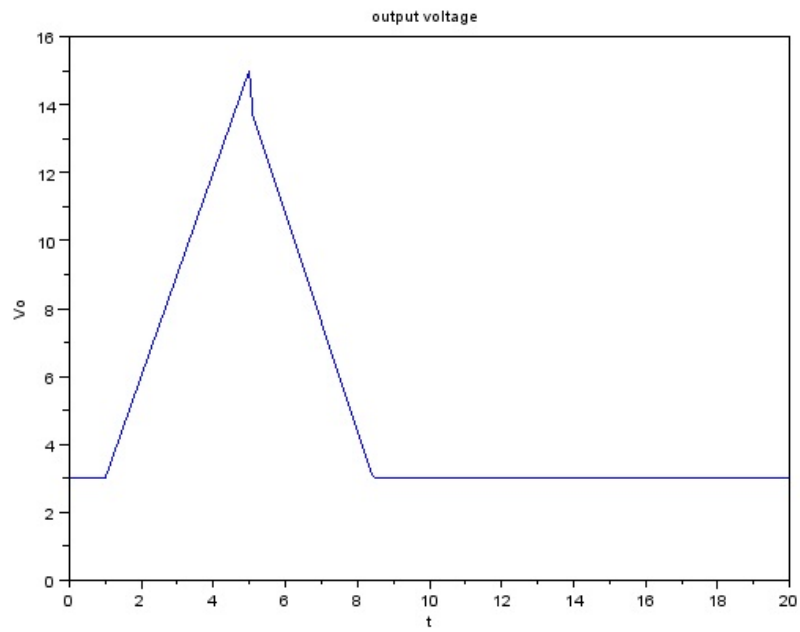


Figure 16.2: negative clipper

```

6 x(i)=(15/5)*t(i);
7 elseif(t(i)>=5&t(i)<=15)
8 x(i)=-3.2*t(i)+30;
9 elseif(t(i)>=15&t(i)<=20)
10 x(i)=(15/5)*t(i)-60;
11 end
12 end
13 for i=1:length(t)
14 if(x(i)>3)
15 y(i)=x(i);
16 elseif(x(i)<=3)
17 y(i)=3;
18 end
19 end
20 plot2d(t,y,2,'011','','[0,0,20,16]);
21 a=gca();
22 xtitle('output voltage','t','Vo')

```

---

### Scilab code Exa 16.5 positive and negative clipper

```

1 //Example 16.5.
2 //let input wave be  $V_{in}=V_{p\_in}\sin(2\%pi*f*t)$ 
3 f=1; //Frequency is 1Hz
4 T=1/f;
5 V_p_in=10; //Peak input voltage
6 V_th=0.7; //knee voltage of diode
7 clf();
8 //let n be double the number of cycles of output
  shown in graph
9 for n=0:1:1
10     t=T.*n/2:0.0005:T.*(n+1)/2 //time for each
      half cycle
11     V_in=V_p_in*sin(2*%pi*f.*t);

```

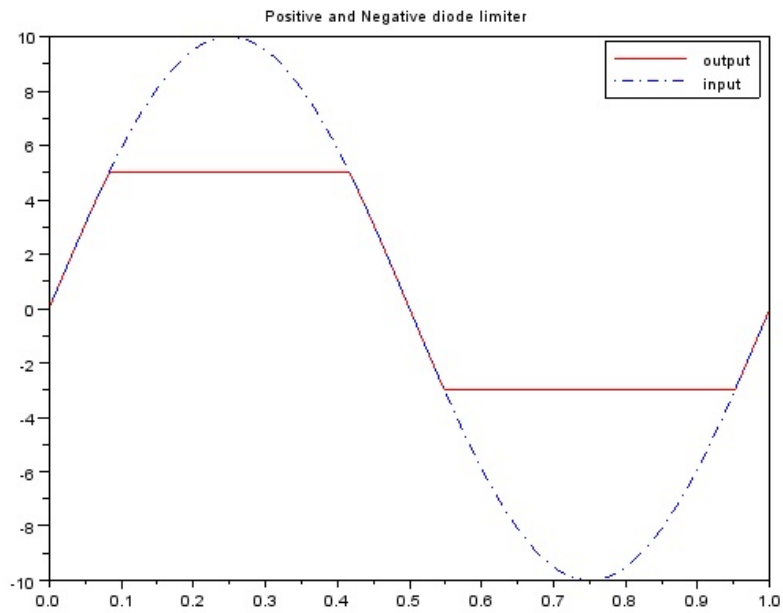


Figure 16.3: positive and negative clipper

```

12     Vout=V_in;
13     if modulo(n,2)==0 then //positive half ,D1
14         conducts till V_in=5V
15         a=bool2s(Vout<5);
16         b=bool2s(Vout>5);
17         y=a.*Vout+5*b; //output follows input
18         till 5V then is constant at 5V
19     else //negative half , D2
20         conducts till V_in=-3V
21         a=bool2s(Vout<-3);
22         b=bool2s(Vout>-3);
23         y=-3*a+b.*Vout; //output follows input
24         till -3V then stays constant at -3V
25     end
26     plot(t,y,'r')
27     plot(t,V_in,'-.')
28     end
29     hl=legend(['output','input']);
30     xtitle('Positive and Negative diode limiter','t',
31           'Vo')
32     disp('max output voltage is 5V')
33     disp('min output voltage is -3V')

```

---

### Scilab code Exa 16.8 positive clamper

```

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

```



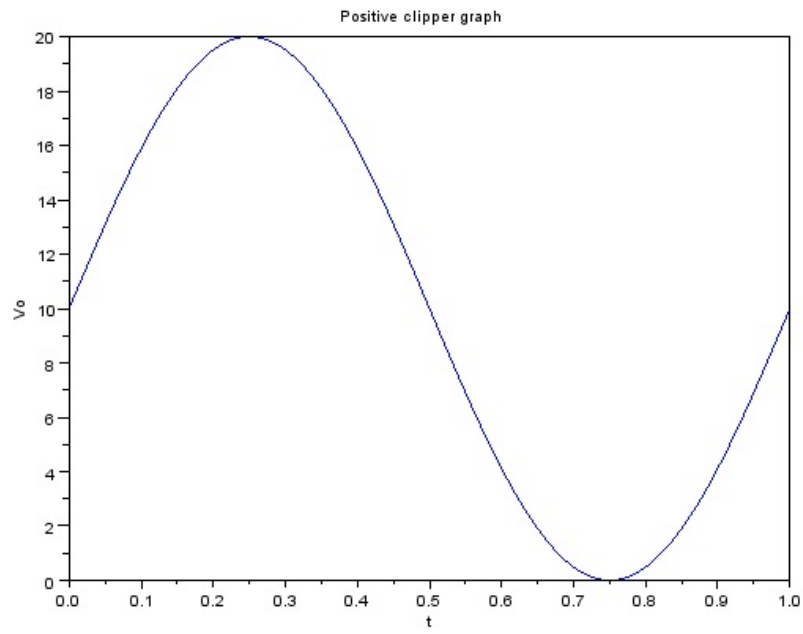


Figure 16.4: positive clamper

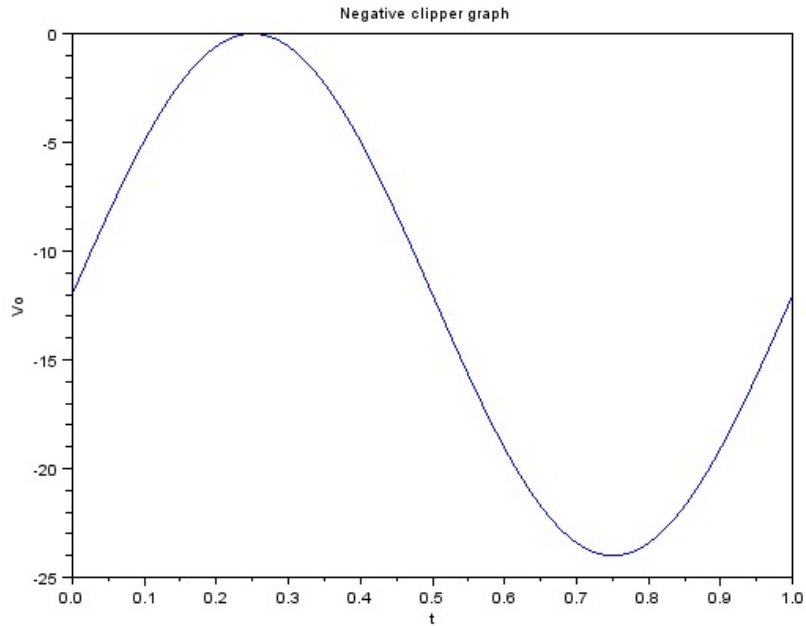


Figure 16.5: negative clamper

```

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

```

---

#### Scilab code Exa 16.9 negative clamper

```

1 //Example 16.9.
2 //Negative Clamping circuit

```

```

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

```

---

**Scilab code Exa 16.10** frequency of oscillation

```

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

```

---

**Scilab code Exa 16.11** period and frequency of oscillation

```

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

```

```

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

```

---

**Scilab code Exa 16.12** astable multivibrator value of capacitor

```

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

```

---

**Scilab code Exa 16.13** design a saturated collector coupled multivibrator

```

1 //Example 16.13.

```

```

2  clc
3  format(6)
4  disp("To design a saturated collector coupled
      astable multivibrator")
5  disp("Let us assume that VCE(sat) = 0.2 V")
6  disp("Refer fig.16.31.")
7  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.
      ")
8  disp("Now, R <= hfe*Rc. Therefore, it is better to
      keep R constant.")
9  disp("RC = VCC-VC2(sat) / IC(ON)")
10 disp("Assuming VC2(sat) = 0.2 V")
11 rc=(12-0.2)/(1*10^-3) // in ohm
12 x1=rc*10^-3 // in k-ohm
13 disp(x1," RC(k-ohm) = 12-0.2/1*10^-3 =")
14 r=100*11.8*10^3 // in ohm
15 x1=r*10^-6 // in M-ohm
16 disp(" R <= hfe*RC")
17 disp(x1," R(M-ohm) <=")
18 disp("Hence, let us assume that R = R1 = R2 = 1 M-
      ohm")
19 disp(" Toff = 0.693*R*C1")
20 format(4)
21 c1=(20*10^-6)/(0.693*10^6) // in faraday
22 x1=c1*10^12 // in pF
23 disp(x1," Therefore, C1(pF) = ")
24 disp(" Ton = 0.693*R*C2")
25 format(5)
26 c1=(10*10^-6)/(0.693*10^6) // in faraday
27 x1=c1*10^12 // in pF
28 disp(x1," Therefore, C2(pF) = ")

```

---

Scilab code Exa 16.14 component values of monostable multivibrator

```

1 //Example 16.14.
2 clc
3 format(5)
4 disp("At stable state, Q2 is ON and Q2 is OFF:")
5 rc2=(6-0.3)/(6*10^-3) // in ohm
6 disp(rc2,"      RC2(ohm) = RC1(ohm) = VCC-VCE(sat) /
      IC(sat) =")
7 ib2=(6*10^-3)/20 // in ampere
8 x1=ib2*10^3 // in mA
9 disp(x1," IB2(sat)(mA) = IC(sat) / hfe(min) =")
10 disp("Also,      IB1(sat) = 0.3 mA")
11 format(6)
12 r=(6-0.7)/(0.3*10^-3) // in ohm
13 x1=r*10^-3 // in k-ohm
14 disp(x1," R(k-ohm) = VCC-VBE(sat) / IB2(sat) =")
15 disp("
      because, VBE(sat) = 0.7 V for Si transistor]")
16 disp("At quasi-stable state, Q1 is ON and Q2 is OFF")
17 disp("      T = 0.693*R*C")
18 format(7)
19 c=(140*10^-6)/(0.693*17.67*10^3) // in F
20 x1=c*10^6 // in uF
21 disp(x1," Therefore,      C(uF) = T / 0.693*R =")
22 format(6)
23 disp(" Assume,      IB1(sat) = IR2")
24 ir2=0.3+0.3 // in mA
25 disp(ir2," Therefore,  IR1(mA) = IB1(sat)+IR2 =")
26 r1=((6-0.7)/(0.6*10^-3))-950 // in ohm
27 x1=r1*10^-3 // in k-ohm
28 disp("      VCC = VBE(sat) + IR1(RC2+R1)")
29 disp(x1," Therefore,  R1(k-ohm) = (VCC-VBE(sat) / IR1
      ) - RC2 =")
30 format(5)
31 r2=(0.7+1.5)/(0.3*10^-3) // in ohm
32 x1=r2*10^-3 // in k-ohm
33 disp(x1,"      R2(k-ohm) = VBE(sat)-(-VBB) / IR2 =")
34 disp("The speed up capacitor C1 is chosen such that

```

```

    RIC1 = 1 us and hence ,")
35 format(6)
36 c1=(10^-6)/(7.833*10^3) // in F
37 x1=c1*10^12 // in pF
38 disp(x1,"      C1(pF) =") // answer in textbook is
    wrong

```

---

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

```

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

```

```

21 disp("          VB2 = VBE2(on) = 0.7 V")
22 format(6)
23 i6=(0.7+12)/(100) // in mA
24 disp(i6,"Therefore , I6(mA) =")
25 i3=0.5+0.127 // in mA
26 disp(i3,"          I3(mA) =")
27 vc1=12-((0.627*10^-3)*(2.2*10^3))
28 disp(vc1,"          VC1(V) =")

```

---

Scilab code Exa 16.16 design a schmitt trigger circuit

```

1 //Example 16.16.
2 clc
3 format(6)
4 disp("Referring to fig. 16.40.")
5 disp("          UTP = VB2 = 5 V")
6 ve=5-0.7 // in volts
7 disp(ve,"Voltage across RE is VE(V) = VB2 - VBE =")
8 disp("          IE = IC = 2 mA")
9 re=4.3/2 // in k-ohm
10 disp(re,"          RE(k-ohm) = VE / IE =")
11 disp("Taking Q2 saturated , VCE(sat) = 0.2 V
        typically ,")
12 x=12-4.3-0.2 // in volts
13 disp(x,"          IC*RC2 = VCC - VE - VCE(sat) =")
14 rc2=7.5/(2) // in k-ohm
15 disp(rc2,"          RC2(k-ohm) =")
16 i2=0.1*2 // in mA
17 disp(i2,"          I2(mA) = 0.1*IC2 =")
18 r2=5/0.2 // in k-ohm
19 disp(r2,"          R2(k-ohm) = VB2 / I2 =")
20 ib2=(2*10^-3)/100 // in A
21 x1=ib2*10^6 // in uA
22 disp(x1,"          IB2(uA) = IC2 / hfe(min) =")
23 disp("          I1 = I2 + IB2")

```



```

24 disp("VCC-VB2 / RC1+R1 = I1 = 0.2*10^-3 + 20*10^-6")
25 disp("12-5 / RC1+R1 = 0.22*10^-3")
26 x=7/(0.22) // in k-ohm
27 format(5)
28 disp(x,"RC1 + R1 =")
29 disp("When Q1 is ON, Vi = LTP = VB2 = 3 V")
30 i1=3/25 // in mA
31 format(6)
32 disp(i1," I1(mA) = VB2 / R2 =")
33 ic1=(3-0.7)/2.15 // in mA
34 disp(ic1," IC1(mA) = IE = VB1-VBE / RE =")
35 disp(" VCC = RC1*(IC1+I1) + I1*(R1+R2)")
36 rc1=(12-((0.12*10^-3)*(56.8*10^3)))/(1.07*10^-3) //
    in ohm
37 x1=rc1*10^-3 // in k-ohm
38 format(5)
39 disp(x1," Therefore , RC1(k-ohm) =")
40 r1=31.8-4.84
41 format(6)
42 disp(r1," R1(k-ohm) =")
43 rb=(100*2.15)/10
44 disp(" RB < hfe*RE")
45 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

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

```
17 disp("So, CE is selected as 0.22 uF")
18 disp("Let the required pluse voltage at B1 = 5V")
19 disp("Let the peak pulse current , IE = 250 mA")
20 R1=5/(250*10^-3) //in ohm
21 disp(R1,"Therefore , R1(ohm) = VR1/IE =")
22 disp("So, R1 is selected to be 22 ohm")
23 disp("We select the voltage characteristics for
      VB1B2 = 4 V")
24 disp("Therefore , VR2 = 20-(4+5) = 11 V")
25 R2=11000/250
26 disp(R2," R2(ohm) = 11*10^3/250 =")
27 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

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

```

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

```

---

### Scilab code Exa 18.2 maximum value of ac voltage

```

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

```

---

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

```

1 //Example 18.3.
2 clc
3 format(6)
4 x1=230/5 // in V
5 vm=sqrt(2) * 46 // in V
6 vdc=65/%pi // in V
7 im=65/300 // in A
8 pm=0.217^2 * 300 // in W
9 idc=20.7/300 // in A
10 format(5)
11 pdc=(0.069^2)*300 // in W

```

```

12 disp(x1,"(a) The transformer secondary voltage(in V)
    =")
13 format(4)
14 disp(vm,"      Maximum value of secondary voltage, Vm
    (V) =")
15 format(5)
16 disp(vdc,"      Therefore, d.c. output voltage, Vd.c
    .(V) = Vm / pi =")
17 disp("(b) PIV of a diode = Vm = 65 V")
18 format(6)
19 disp(im,"(c) Maximum value of load current, Im(A) =
    Vm / RL =")
20 disp("      Therefore, maximum value of power
    delivered to the load,")
21 format(5)
22 disp(pm,"      Pm(W) = Im^2 * RL =")
23 format(6)
24 disp(idc,"(d) The average value of load current, Id
    .c.(A) = Vdc / RL")
25 disp("      Therefore, average value of power
    delivered to the load,")
26 format(5)
27 disp(pdc,"      Pd.c.(W) = (Idc)^2 * RL =")

```

---

#### Scilab code Exa 18.4 centre tap fullwave rectifier

```

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

```

```

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

```

---

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

```

1 //Example 18.5.
2 clc
3 format(6)
4 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.")
5 imax=0.8*400 // in mA
6 disp(imax," Therefore, Imax(mA) =")
7 disp("The maximum value of the secondary voltage,")
8 vm=sqrt(2)*100 // in V
9 disp(vm," Vm(V) =")
10 disp("Therefore, the value of load resistor that

```

```

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

```

---

#### Scilab code Exa 18.6 ac ripple voltage

```

1 //Example 18.6.
2 clc
3 format(6)
4 disp("D.C. power delivered to the load,")
5 disp("          Pdc = Vdc^2 / RL")
6 vdc=sqrt(50*200)
7 disp(vdc,"Therefore , Vdc(V) = sqrt(Pdc*RL) =")
8 disp("The ripple factor , gamma = Vac / Vdc")
9 disp("i.e.          0.01 = Vac / 100")
10 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

```

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

```



```

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

```

---

#### Scilab code Exa 18.8 value of inductance

```

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

```

---

#### Scilab code Exa 18.9 value of capacitance

```

1 //Example 18.9.
2 clc
3 format(6)

```

```

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

```

---

**Scilab code Exa 18.10** design a full wave circuit

```

1 //Example 18.10
2 clc
3 format(6)
4 r1=10/(200*10^-3) // in ohm
5 lc=1.194/0.02
6 disp(r1,"The effective load resistance RL(ohm) =")
7 disp("We know that the ripple factor , gamma = 1.194
      / LC")
8 disp(lc,"i.e.      LC =")
9 disp("Critical value of L(mH) = RL / 3*omega = 50 /
      3*2*pi*f = 53mH")
10 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

```

1 //Example 18.11
2 clc
3 r1=(10/(200*10^-3)) // in ohm
4 c2=11.4/0.02
5 format(4)
6 c=sqrt(570) // in uF
7 disp(r1,"      RL(ohm) =")
8 disp("      0.02 = 5700 / L*C1*C2*50 = 114 / L*C1*C2")

```

```

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

```

---

**Scilab code Exa 18.12** design zener shunt voltage regulator

```

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

```

---

**Scilab code Exa 18.13** design the zener regulator

```
1 //Example 18.13.
2 clc
3 format(6)
4 disp("The minimum Zener current is  $I_Z(\min) = 5$  mA
      when the input voltage is minimum")
5 disp("Here the input voltage varies between 10 V +
      20% i.e. 8 V and 12 V")
6 disp("Therefore, the input voltage  $V_i(\min) = 8$  V")
7 disp("Therefore,")
8 r1=5/(20*10^-3) // in ohm
9 disp(r1,"      RL(ohm) =  $V_o / I_L =$ ")
10 r=(8-5)/((5+20)*10^-3) // in ohm
11 disp(r,"Hence, the series resistance  $R(\text{ohm}) = V_i(\min) - V_o / I_Z(\min) + I_L =$ ")
12 disp("The various values are given in the Zener
      regulator shown in Fig. 18.19")
```

---

**Scilab code Exa 18.14** design the regulator

```
1 //Example 18.14.
2 clc
3 format(6)
4 disp("Load current varies from 0 to 20 mA")
5 disp("       $I_Z(\min) = 10$  mA,  $I_Z(\max) = 100$  mA")
6 disp("Here,       $V_z = V_o = 10$  V (constant)")
7 disp("Applying KVL to a closed loop circuit,")
8 disp("       $20 = IR + 10$ ")
9 disp("or       $IR = 10$ ")
10 disp("Therefore,  $R = 10/I$  ohm, where I is the loop
      current in amperes")
```

```

11 disp("(i) Let  $I_Z = I_Z(\text{min})$  and  $I_L = 0$ ")
12 disp("    The total current  $I = I_L + I_Z = 10 \text{ mA}$ ")
13 r=10/(10*10^-3) // in ohm
14 disp(r,"    Therefore,  $R(\text{ohm}) =$ ")
15 disp("(ii) For  $I_Z = I_Z(\text{max}) = 100 \text{ mA}$  and  $I_L = 20 \text{ mA}$ "
    )
16 i=20+100 // in mA
17 disp(i,"     $I(\text{mA}) = I_L + I_Z =$ ")
18 r=10/(120*10^-3)
19 disp(r,"    Therefore,  $R(\text{ohm}) =$ ")
20 disp("(iii) The range of R varies from 83.33 ohm to
    1000 ohm")

```

---

#### Scilab code Exa 18.15 design zener voltage regulator

```

1 //Example 18.15.
2 clc
3 format(6)
4 r1=5/(10*10^-3) // in ohm
5 disp(r1,"Here, load resistance is  $R_L(\text{ohm}) = V_o / I_L$ 
    =")
6 iz=400/5 // in mA
7 disp(iz,"Maximum Zener Current  $I_{z\_max}(\text{mA}) =$ ")
8 disp("The minimum input voltage required will be
    when  $I_z = 0$ . Under this condition,")
9 disp("     $I = I_L = 10 \text{ mA}$ ")
10 disp("Minimum input voltage  $V_{i\_min} = V_o + I R$ ")
11 vi=10-2 // in V
12 disp(vi,"Hence,  $V_{i\_min}(\text{V}) =$ ")
13 disp("or  $8 = 5 + (10*10^{-3})R$ ")
14 rmax=3/(10*10^-3) // in ohm
15 disp(rmax,"Therefore,  $R_{max}(\text{ohm}) =$ ")
16 disp("Now, maximum input voltage,  $V_{i\_max} = 5 +$ 
     $[(80+10)10^{-3}]R$ ")
17 rmin=7/(90*10^-3) // in ohm

```

```

18 disp(rmin,"      Rmin(ohm) =")
19 disp("The value of R is chosen between 77.77 ohm and
      300 ohm")

```

---

**Scilab code Exa 18.16** series resistance and diode current

```

1 //Example 18.16.
2 clc
3 format(7)
4 il=(24/1200)*10^3 // in mA
5 disp(il,"The load current , IL(mA) = Vo / RL =")
6 iz=600/24 // in mA
7 disp(iz,"Max. Zener current , Iz_max(mA) =")
8 rmax=(32-24)/((20+25)*10^-3) // in ohm
9 disp(rmax," Rmax(ohm) = Vi-Vo / IL_min+IZ_max =")

```

---

**Scilab code Exa 18.17** design a linear voltage regulator

```

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

```

```

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

```

---

**Scilab code Exa 18.18** design a series voltage regulator

```

1 //Example 18.18. refer fig.18.27
2 clc
3 format(6)
4 rlmin=20/(50*10^-3) // in ohm
5 disp(" Selection of Zener diode")
6 disp(rlmin," RLmin(ohm) = Vo / ILmax =")
7 vz=20/2 // in V
8 disp(vz," Vz(V) = Vo / 2 =")
9 disp(" Hence, the zener diode 0.5Z10 is chosen.")
10 disp(" Since, IR1 > IB2, IR1 > IC2/beta, IR2 >
11 10*10^-3 / 150")
11 disp(" IR1 > 66.7 uA")
12 disp(" Let IR1 = IR2 = IR3 = 10 mA (neglecting IB2)")
13 disp(" Let IC2 = IE2 = 10 mA")
14 disp(" So, the current flowing through the Zener,")
15 iz=10+10 // in mA

```

```

16 disp(iz," Iz (mA) = IE2 + IR1 =")
17 pz=10*20*10^-3 // in W
18 disp(pz," Pz(W) = Vz*Iz =") // > 0.5 W
19 disp("Hence selection of 0.5Z10 Zener diode is
    confirmed")
20 disp("")
21 disp("Selection of transistor Q1")
22 ie1=10+10+50 // in mA
23 disp(ie1," IE1(mA) = IR1 + IR2 + IL =")
24 disp(" Vi(max) - Vo = 30 -20 = 10 V")
25 disp("For transistor SL100, the rating are")
26 disp(" IC(max) = 500 mA")
27 disp(" VCE(max) = 50 V")
28 disp(" hre = 50 - 280")
29 disp("Hence, SL100 can be chosen for Q1")
30 disp("")
31 disp("Selection of transistor Q2")
32 disp(" From the fig., VCE2(max) + Vz = (Vo + VBE1)
    ")
33 vce2=20.6-10 // in V
34 disp(vce2," Therefore, VCE2_max(V) = (Vo + VBE1) -
    Vz =")
35 disp("For transistor BC107, the rating are")
36 disp(" VCEO(max) = 45 V")
37 disp(" IC(max) = 200 mA")
38 disp(" hFE = 125 - 300")
39 disp("Hence, transistor BC107 is selected for Q2")
40 disp("")
41 disp("Selection of resistor R1, R2 and R3")
42 vr1=20-10 // in V
43 disp(vr1," VR1(V) = Vo - Vz =")
44 r1=10/(10) // in k-ohm
45 disp(r1," R1(k-ohm) = VR1 / IR1 =")
46 vr2=20-10.6 // in V
47 disp(vr2," VR2(V) = Vo - VR3 =")
48 r2=9.4/(10*10^-3) // in ohm
49 disp(r2," R2(ohm) = VR2 / IR2 =")
50 vr3=10+0.6 // in V

```



```

51 disp(vr3," VR3(V) = Vz + VBE2(sat) =")
52 r3=10.6/(10*10^-3) // in ohm
53 disp(r3," R3(ohm) = VR3 / IR3 =")
54 disp("")
55 disp("Selection of resistor R4")
56 vb1=20+0.6 // in V
57 disp(vb1," VB1(V) = VC2(V) = Vo + VBE1 =")
58 ib1=70/50 // in mA
59 disp(ib1," IB1(mA) = IC1 / beta =")
60 ir4=11.4 // in mA
61 disp(ir4," IR4(mA) = IB1 + IC2 =")
62 format(5)
63 r4max=(30-20.6)/(11.4*10^-3) // in ohm
64 disp(r4max," R4_max(ohm) = VR4(max) / IR4 = Vi(max)
-VB1 / IR4 =")
65 r4min=(22-20.6)/(11.4*10^-3) // in ohm
66 disp(r4min," R4_min(ohm) = VR4(min) / IR4 = Vi(min)
-VB1 / IR4 =")
67 format(6)
68 r4=(825+123)/2 // in ohm
69 disp(r4," R4(ohm) = R4(max)+R4(min) / 2 =")

```

---

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

```

1 //Example 18.19.
2 clc
3 format(6)
4 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")
5 disp("Given data: D.C. output voltage = 9 V and Load
current = 100 mA")
6 disp("The current rating is 1.5 times the maximum
loas current i.e. 150 mA")

```

```

7 disp("A bridge rectifier or full wave rectifier is
      used to get the pulsating d.c. output.")
8 r1=9/(100*10^-3) // in ohm
9 disp(r1," RL(ohm) = Vdc / TL =")
10 disp("A capacitor filter is used to remove the
      ripple and get a smooth output.")
11 disp("      Ripple factor gamma = 1 / 4*sqrt(3)*f*C*RL
      ")
12 disp("Assume the ripple factor to be 0.03")
13 c=(1/(4*sqrt(3)*50*0.03*90))*10^6 // in uF
14 disp(c," C(uf) =") // = 1000 uF
15 disp("The short circuit resistance Rsc connected
      with the series pass transistor is")
16 format(4)
17 rsc=0.7/(150*10^-3) // in ohm
18 disp(rsc," Rsc(ohm) = VBE / Ilim_it =")
19 disp("Assume 7.6 V Zener diode in series with 1.5 k-
      ohm")
20 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

```
1 //Example 19.1.
2 clc
3 format(6)
4 disp("Given the sheet resistance Rs = 200 ohm/square
      ")
5 disp("Then the resistance R = 5 k-ohm = Rs*(l/w) =
      200*(l/w)")
6 x=5000/200
7 disp(x,"Therefore , l/w = R/Rs =")
8 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

```
1 //Example 19.2.
2 clc
3 format(6)
```

```
4 disp("Given the sheet resistance  $R_s = 30$  ohm/square"  
    )  
5 disp("Then the resistance  $R = 1$  k-ohm =  $R_s * (l/w) =$   
     $30 * (l/w)$ ")  
6 disp("Therefore ,  $l/w = R/R_s = 1000/30 = 100/3$ ")  
7 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

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

---

Scilab code Exa 20.2 slew rate of op amp

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

---

### Scilab code Exa 20.3 maximum frequency

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

---

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

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

---

**Scilab code Exa 20.5** closed loop voltage gain

```
1 //Example 20.5. refer fig.20.10.
2 clc
3 format(6)
4 af=-10/1
5 disp(af," The closed-loop voltage gain  $A_f = -R_F /$ 
      R1 =")
```

---

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

```
1 //Example 20.6. refer fig.20.11.
2 clc
3 format(6)
4 af=1+(10/1)
5 disp(af," The closed-loop voltage gain ,  $A_F = 1 + R_F$ 
      /R1 =")
6 beta=1/(1+10)
7 disp(beta," The feedback factor ,  $\beta = R_1 / R_1+R_F$ 
      =")
```

---

**Scilab code Exa 20.7** design the output voltage

```
1 //Example 20.7. refer fig. 20.16.
2 clc
3 format(6)
4 v=-(2+3+4) // in volts
5 disp("The output voltage is given by,")
6 disp(v,"  $V_o(V) = -R_f/R * (V_1+V_2+...+V_n) =$ ")
```

---

**Scilab code Exa 20.8** design a high pass filter

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

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



```

11 r=(0.5)/0.01 // in k-ohm
12 disp(r,"(b) With C = 0.01 uF, R(k-ohm) =
    0.5*10^-3/0.01*10^-6 =")
13 disp("(c) Maximum value of differential input
    voltage is")
14 x=2*14*(100/(100+116))
15 disp(x,"2*Vsat*(R2 / R1+R2) = ")
16 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

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

---

Scilab code Exa 21.2 value of electron concentration

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

---

**Scilab code Exa 21.3** value of electron density

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

---

# Chapter 24

## Digital Circuits

Scilab code Exa 24.1 decimal to octal

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

---

Scilab code Exa 24.2 octal to decimal

```
1 //Example 24.2. convert octal number to decimal.
2 clc
3 d=oct2dec(["444"])
4 disp(d,"(i) octal 444 = decimal")
5 d1=oct2dec(["237"])
```

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

---

#### Scilab code Exa 24.3 decimal to hexadecimal

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

---

#### Scilab code Exa 24.4 hexadecimal to decimal

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

---

**Scilab code Exa 24.5** multiplication of binary numbers

```
1 //Example 24.5. multiply binary numbers
2 clc
3 h=bin2dec('1101')
4 o=bin2dec('1100')
5 p=h*o
6 z=dec2bin(p)
7 disp(z,"(i) 1101 x 1100 = ")
8 h=bin2dec('1000')
9 o=bin2dec('101')
10 p=h*o
11 z=dec2bin(p)
12 disp(z,"(ii) 1000 x 101 = ")
13 h=bin2dec('1111')
14 o=bin2dec('1001')
15 p=h*o
16 z=dec2bin(p)
17 disp(z,"(iii) 1111 x 1001 = ")
```

---

**Scilab code Exa 24.6** division of binary numbers

```
1 //Example 24.6. perform the binary divisions
2 clc
3 x=bin2dec('110')
4 x1=bin2dec('10')
5 x2=x/x1
6 x3=dec2bin(x2)
7 disp("(i) 110 / 10")
8 disp(x3," = binary")
9 disp(x2," = decimal")
10 x=bin2dec('1111')
```

```

11 x1=bin2dec('110')
12 x2=x/x1
13 x3=dec2bin(x2)
14 disp("(ii) 1111 / 110")
15 disp(x3," = binary")
16 disp(x2," = decimal")

```

---

#### Scilab code Exa 24.7 1s complement subtraction

```

1 //Example 24.7
2 clc
3 disp("1's complement method")
4 disp("    1 1 1 1")
5 disp("    0 1 0 1  <-- 1's complement")
6 disp("    -----")
7 disp(" (1) 1 1 0 1  <-- carry")
8 disp("        1  <-- add carry")
9 disp("    -----")
10 disp("    0 1 0 1")

```

---

#### Scilab code Exa 24.8 1s complement subtraction

```

1 //Example 24.8
2 clc
3 disp("1's complement method")
4 disp("    1 0 0 0")
5 disp("    0 1 0 1  <-- 1's complement")
6 disp("    -----")
7 disp("    1 1 0 1")
8 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

```
1 //Example 24.9
2 clc
3 disp("2''s compliment method")
4 disp("      1 1 1 1")
5 disp("      0 1 1 0  ← 2''s complement")
6 disp("      _____")
7 disp(" (1) 0 1 0 1")
8 disp("The carry is discarded. Thus, the answer is
      0101.")
```

---

**Scilab code Exa 24.10** 2s complement subtraction

```
1 //Example 24.10
2 clc
3 disp("2''s compliment method")
4 disp("  1 0 0 0")
5 disp("  0 1 1 0  ← 2''s complement")
6 disp("  _____")
7 disp("  1 1 1 0  ← no carry")
8 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

```
1 //Example 24.11
2 clc
```



```

3 disp(" (i)           1 0 0 1")
4 disp("           + 0 1 0 0")
5 disp("           _____")
6 disp("           1 1 0 1      Invalid BCD number")
7 disp("           + 0 1 1 0      Add 6")
8 disp("           _____")
9 disp(" 0 0 0 1 0 0 1 1      Valid BCD number")
10 disp(" ")
11 disp(" (ii)  0 0 0 1 1 0 0 1")
12 disp("  + 0 0 0 1 0 1 0 0")
13 disp("  _____")
14 disp("  0 0 1 0 1 1 0 1      Right group is invalid
    ")
15 disp("           + 0 1 1 0      Add 6")
16 disp("           _____")
17 disp("  0 0 1 1 0 0 1 1      Valid BCD number")

```

---

#### Scilab code Exa 24.12 Boolean algebra

```

1 //Example 24.12.
2 clc
3 disp(" (i) A + AB           = A(1+B)   distributive
    law")
4 disp("           = A.1       law 2")
5 disp("           = A         law 4")
6 disp(' ')
7 disp(" (ii) A + A' 'B       = (A+A' ')(A+B)
    distributive law")
8 disp("           = 1.(A+B)   law 6")
9 disp("           = A + B     law 4")
10 disp(' ')
11 disp(" (iii) AB + A' 'C + BC = AB + A' 'C + BC1")
12 disp("           = AB + A' 'C + BC(A+A' ')")
13 disp("           = AB + A' 'C + ABC + A' 'BC
    ")

```

```

14 disp("                = AB(1+C) + A' 'C(1+B)")
15 disp("                = AB + A' 'C")
16 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

```

1 //Example 24.13
2 clc
3 disp(" (a)          A + AB + AB' 'C")
4 disp("Step 1: Apply rule 10 of table 24.2, i.e A + AB
      = A. The expression simplifies to")
5 disp("          A + AB' 'C")
6 disp("Step 2: Apply distributive property")
7 disp("          (A+A)(A+B' 'C)")
8 disp("          = A(A+B' 'C)")
9 disp("Step 3: Taking A as the common term,")
10 disp("          A[1.(1+B' 'C)]")
11 disp("Step 4: Apply rule 2 of Table 24.2, i.e. 1 + B
      ' 'C = 1")
12 disp("          A.1 = A")
13 disp("Thus, the simplified expression is A")
14 disp(' ')
15 disp(" (b)          (A' '+B)C + ABC")
16 disp("Step 1: Apply distributive property")
17 disp("          A' 'C + BC + ABC")
18 disp("Step 2: Taking BC as common term,")
19 disp("          A' 'C + BC(1+A)")
20 disp("Step 3: Apply rule 2")
21 disp("          A' 'C + BC.1")
22 disp("Step 4: Taking C as the common term,")
23 disp("          C(A' '+B)")
24 disp("Thus, the simplified expression is C(A' '+B)")
25 disp(' ')
26 disp(" (c)          AB' 'C(BD+CDE) + AC' '")

```

```

27 disp("Step 1: Apply distributive property")
28 disp("      AB'BCD + AB'CCDE + AC'")
29 disp("Step 2: Apply rules 8 and 7 to the first and
      second terms, respectively,")
30 disp("      0 + AB'CDE + AC'")
31 disp("Step 3: Taking A as the common term,")
32 disp("      A(B'CDE+C')")
33 disp("Step 4: Apply rule 11 i.e., B'CDE + C' = B'
      DE + C'")
34 disp("      A(B'DE+C'")
35 disp("Thus, the simplified expression is A(B'DE+C'
      '")

```

---

#### Scilab code Exa 24.14 Simplify Karnaugh map

```

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

```

---

#### Scilab code Exa 24.15 Simplify Karnaugh map

```

1 //example 24.15

```

```

2 clc;
3 disp('The kanaurgh map for given truth table will be
      :');
4 disp('      A''B''  A''B  AB  AB'''); //displaying
      the given kmap
5 disp('C''D''  1    0    0    1');
6 disp('C''D    0    1    1    0');
7 disp('CD      0    0    0    0');
8 disp('CD''    0    0    0    0');
9 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");

```

---