

Scilab Textbook Companion for
Basic Electronics
by D. De¹

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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

Semiconductor Fundamentals

Scilab code Exa 1.1 Calculate wave vector carried by photon

```
1 // Calculate wave vector carried by photon
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-1 in page 7
7
8 clear; clc; close;
9
10 // Given data
11 c=3*10^8; // Speed of light in m/s
12 h=6.64*10^-34; // Planks constant in Js
13 E_photon=2*1.6*10^-19; // Energy of photon in J
14
15 // Calculations
16 lambda=(c*h)/E_photon;
17 k=(2*%pi/lambda);
18
19 printf("The wavelenght of a 2.0eV photon = %0.3e m\n",lambda);
20 printf("The magnitude of k vector = %0.2e m^-1",k);
```

```

21
22 // Results
23 // The wavelength of a 2.0 eV photon is 6225
    Angstrom
24 // The magnitude of k-vector is  $1.01 * 10^7 \text{ m}^{-1}$ 

```

Scilab code Exa 1.2 Calculate semiconductor band gap

```

1 // Calculate semiconductor band gap
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-2 in page 7
7
8 clear; clc; close;
9
10 // Data given
11 lambda=0.5*10^-6; // Wavelength of emitted light in
    m
12 c=3*10^8; // Speed of light in vacuum in m/s
13 h=1.05*10^-34; // Constant of calculation
14
15 // Calculation
16 E_g= (2*pi*h*c)/lambda;
17 A= E_g*10^19/1.6;
18
19 printf("The material band gap has to be %0.3f eV",A)
    ;
20
21 // Result
22 //The material band gap is 2.474 eV
23 // Semiconductors like C,BN,GaN,SiC meet this

```

Scilab code Exa 1.3 Calculate E k relation of conduction electrons

```
1 // Calculate E-k relation of conduction electrons
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-3 in page 20
7
8 clear; clc; close;
9
10 // Data given
11 m_c=0.1*0.91*10^-30; // Effective mass of conduction
    electron in kg
12 k=0.3*10^10; // Wave vector in /m
13 h=1.05*10^-34; // Constant of calculation in Js
14
15 // Calculation
16 E= (h^2*k^2)/(2*m_c);
17 A= E/(1.6*10^-19);
18
19 printf("Energy of conduction electrons = %0.1f eV",A
    );
20
21 // Result
22 //Energy of the conduction electrons in vertically
    upward direction is 3.4 eV
```

Scilab code Exa 1.4 Energies of electrons in conduction band

```
1 // Energies of electrons in conduction band
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-4 in page 21
7
8 clear; clc; close;
9
10 // Data given
11 k=0.01*10^10; // k-vector value /m
12 h=1.05*10^-34; // Constant of calculation Js
13 m_0=0.91*10^-30; // Mass of conduction electron Kg
14 m_c1=0.067*m_0; // Effective mass of GaAs conduction
    electron Kg
15 m_c2=0.01*m_0; // Effective mass if InAs conduction
    electron Kg
16
17 // Calculation
18 E_1=(h^2*(9*k^2))/(2*m_c1);
19 A_1=(E_1)/(1.6*10^-19);
20
21 printf("(a)Energy of conduction electron in GaAs =
    %0.2e eV\n",A_1);
22
23 E_2=(h^2*(9*k^2))/(2*m_c2);
24 A_2=(E_2)/(1.6*10^-19);
25
26 printf("(b)Energy of conduction electron in InAs =
    %0.3e eV",A_2);
```

```

27
28 // Results
29 // (a) Energy of conduction electron in GaAs is 50.9
    meV
30 // (b) Energy of conduction electron in InAs is
    340.7 meV

```

Scilab code Exa 1.5 Energies of electrons in conduction band

```

1 // Energies of electrons in conduction band
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-5 in page 21
7
8 clear; clc; close;
9
10 // Data given
11 h=1.05*10^-34; // Constant of calculation Js
12 k=0.1,0.1,0,0; // Values of k-vector
13 m_c=0.067*0.091*10^-30; // Effective mass of
    conduction electron
14
15 // Calculation
16 E=(h^2*(((0.1*10^10)^2)+((0.1*10^10)^2)))/(2*m_c);
17 A= E/(1.6*10^-19);
18
19 printf("Energy of conduction electron is %0.3f eV",A
    );
20
21 // Result
22 // Energy of conduction electron in the vertically

```

```

    upward direction = 11.302 eV
23 // The non parabolic E-k dispersion relation is more
    appropriate here

```

Scilab code Exa 1.6 Estimation of smallest k vector along x direction

```

1 // Estimation of smallest k-vector along x-direction
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-6 in page 21
7
8 clear; clc; close;
9
10 // Data given
11 x=1; // x-coordiante
12 y=1; // y-coordinate
13 z=1; // z-coordinate
14 E=0.3*1.6*10^-19; // Energy separation in eV
15 m_c=0.067*0.91*10^-30; // Effective mass of
    conduction electron in kg
16 h=1.05*10^-34; // Constant of calculation in Js
17
18 // Calculation
19 k_x=(2*m_c*E)/(3*h^2);
20 A=sqrt(k_x);
21
22 printf("K vector along (111) direction is %0.1e m^-1
    ",A);
23
24 // Result
25 //Value of k-vector along (111) direction is

```



```

    4.2*108 m-1
26 //Parabolic expression has been used to compute the
    k-vector

```

Scilab code Exa 1.7 Energies of electrons in conduction band

```

1 // Energies of electrons in conduction band
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-7 in page 22
7
8 clear; clc; close;
9
10 // Data given
11 k=0.01*1010; // k-vector value /m
12 h=1.05*10-34; // Constant of calculation Js
13 m_0=0.91*10-30; // Mass of conduction electron Kg
14 m_c1=0.067*m_0; // Effective mass of GaAs conduction
    electron Kg
15 m_c2=0.01*m_0; // Effective mass if InAs conduction
    electron Kg
16
17 // Calculation
18 E_1=(h2*(9*k2))/(2*m_c1);
19 A_1=(E_1)/(1.6*10-19);
20
21 printf("(a)Energy of conduction electron in GaAs =
    %0.2e eV\n",A_1);
22
23 E_2=(h2*(9*k2))/(2*m_c2);
24 A_2=(E_2)/(1.6*10-19);

```

```

25
26 printf("(b)Energy of conduction electron in InAs =
    %0.3e eV",A_2);
27
28 // Results
29 // (a) Energy of conduction electron in GaAs is 50.9
    meV
30 // (b) Energy of conduction electron in InAs is
    340.7 meV

```

Scilab code Exa 1.8 Find position of Fermi level

```

1 // Find position of Fermi level
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-8 in page 33
7
8 clear; clc; close;
9
10 // Data given
11 n_0=6*10^17; // Electron concentration in the
    conduction band /cm^3
12 k_bT=0.026; // Expressed in eV at room temperature
13 N_c=4.45*10^17; // Constant of Calculation /cm^3
14
15 // Calculation
16 E_f=k_bT*log(n_0/N_c);
17 A=E_f*10^3;
18
19 printf("Position of Fermi level is %0.2f meV",A);
20

```

```

21 // Result
22 // Position of Fermi level is 7.77 meV
23 // Intrinsic carrier density is lesser than dopant
    density
24 // Hence semiconductor is non-degenerate

```

Scilab code Exa 1.9 Find Fermi level at room temperature

```

1 // Find Fermi level at room temperature
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-9 in page 34
7
8 clear; clc; close;
9
10 // Data given
11 k=1; // Assumed constant
12 m_e=2*k; // Effective mass of an electron in Kg
13 m_h=k; // Effective mass of only heavy hole in Kg
14 k_bT=0.026; // Expressed in eV at room temperature
15
16 // Calculation
17 E_f=(3/4)*0.026*log(m_e/m_h);
18 printf("E_f = ((-E_g/2) - %0.3f) eV\n",E_f);
19 printf("Thus Fermi level is below center of
    forbidden gap by 0.014 eV");
20
21 // Result
22 // Fermi level in the intrinsic semiconductor is ((-
    E_g/2) - 0.014) eV

```

Scilab code Exa 1.10 Position of Fermi energy at 0K

```
1 //Position of Fermi energy at 0K
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-10 in page 34
7
8 clear; clc; close;
9
10 // Data given
11 h=1.5*10^-34; // Constant of calculation in Js
12 m_c=0.067*0.91*10^-30; // Effective mass of
    conduction electron in Kg
13 n_0=10^24; // Electron concentration at 0K /m^3
14
15 // Calculation
16 E_f= ((h^2*(3*pi^2*n_0)^(2/3))/(2*m_c));
17 A=E_f/(1.6*10^-19);
18
19 printf("Position of Fermi level at 0K is %0.4f eV",A
    );
20
21 // Result
22 // Fermi energy at 0K as measured from edge of
    conduction band is 0.11 eV
23 // Fermi energy is placed 0.11 eV above the edge of
    conduction band
24 // Fermi energy is within the conduction band
```

Scilab code Exa 1.11 Time taken to reach Brillouin zone

```
1 // Time taken to reach Brillouin zone
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-11 in page 46
7
8 clear; clc; close;
9
10 // Data given
11 h=1.05*10^-34; // Constant of calculation in Js
12 Kb=1.112*10^8; // Wave vector at Brillouin zone
    along x-axis /cm
13 E_0=10^4; // External electric field applied in V/cm
14 e=1.6*10^-19; // Charge on an electron in C
15
16 // Calculation
17 tou=(h*Kb)/(e*E_0);
18
19 printf("Time taken by electron is %0.3e s",tou);
20
21 // Result
22 // Time taken by electron to reach Brillouin zone is
    7.297 ps
```

Scilab code Exa 1.12 Calculate drift velocity

```

1 // Calculate drift velocity
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1–12 in page 46
7
8 clear; clc; close;
9
10 // Data given
11 m_c=0.067*0.91*10^-30; // Effective electron mass in
    Kg
12 e=1.6*10^-19; // Charge on an electron in C
13 E_0=10^5; // External electric field in KV/m
14 tou1=10^-13; // First Brillouin zone time in s
15 tou2=10^-12; // Second Brillouin zone time in s
16 tou3=10^-11; // Third Brillouin zone time in s
17
18 // Calculation
19 v_01=(e*tou1*E_0)/m_c;
20 v_02=(e*tou2*E_0)/m_c;
21 v_03=(e*tou3*E_0)/m_c;
22
23 printf("(a) Drift velocity in first case is %0.2e m/s
    \n",v_01);
24 printf("(b) Drift velocity in second case is %0.2e m/
    s\n",v_02);
25 printf("(c) Drift velocity in third case is %0.2e m/s
    ",v_03);
26
27 // Result
28 // (a) Drift velocity in first case is 2.62*10^4 cm/
    s
29 // (b) Drift velocity in second case is 2.62*10^5 cm
    /s
30 // (c) Drift velocity in third case is 2.62*10^6 cm/
    s

```

Scilab code Exa 1.13 Compute conductivity drift velocity current density

```
1 // Compute conductivity ,drift velocity ,current
  density
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-13 in page 47
7
8 clear; clc; close;
9
10 // Data given
11 mu=35.2*10^-4; // Mobility of electrons in m^2/Vs
12 n_0=7.87*10^28; // Number of free electrons per
  cubic meter
13 e=1.6*10^-19; // Charge on an electron in C
14 E_0=30*10^2; // External electric field applied in V
  /m
15
16 // Calculation
17 sigma=n_0*e*mu;
18 printf("(a) Mobility = %0.1e m^2/Vs\n",mu);
19 printf("Conductivity of the specimen is %0.2e s/m\n\
  n",sigma);
20 V_0=mu*E_0;
21 J=sigma*E_0;
22 printf("(b) Electric field Eo = %0.0e V/m\n",E_0);
23 printf("Drift velocity of free electrons is %0.2f m/
  s\n",V_0);
24 printf("Current density is %0.2e A/meter^3",J);
25
```

```
26 // Result
27 // (a) Conductivity of specimen is  $4.43 \times 10^7$  s/m
28 // (b) Drift velocity of free electrons is 10.56 m/s
29 // (c) Current density is  $13.3 \times 10^{10}$  A/meter cube
```

Scilab code Exa 1.14 Calculate drift velocity in copper conductor

```
1 // Calculate drift velocity in copper conductor
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-14 in page 47
7
8 clear; clc; close;
9
10 // Data given
11 A=10^-5; // Cross sectional area in m^2
12 I=100; // Current flowing in A
13 n_0=8.5*10^28; // Free electron concentration of
    copper per cubic meter
14 e=1.6*10^-19; // Charge on an electron in C
15
16 // Calculation
17 V_d=I/(n_0*A*e);
18
19 printf("The drift velocity in copper is %0.3e m/s",
    V_d);
20
21 // Result
22 // Drift velocity in copper is  $7.353 \times 10^{-4}$  m/s
```

Scilab code Exa 1.16 Calculate drift velocity in copper

```
1 // Calculate drift velocity in copper
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-16 in page 47
7
8 clear; clc; close;
9
10 // Data given
11 tau=10^-14; // Relaxation time in s
12 m_c=0.02*9.1*10^-31; // Effective mass of electron
    in Kg
13 E_0=0.1; // Electric field across conductor in V/m
14 e=1.6*10^-19; // Charge on an electron in C
15
16 // Calculation
17 V_0=(e*E_0*tau)/m_c;
18
19 printf("The drift velocity of electrons in copper is
    %0.3f m/s",V_0);
20
21 // Result
22 // Drift velocity of electrons in copper is 0.009 m/
    s
```

Scilab code Exa 1.17 Equilibrium hole concentration in Si

```
1 // Equilibrium hole concentration in Si
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-17 in page 48
7
8 clear; clc; close;
9
10 // Data given
11 n_0=10^17; // Free electron concentration /cm^3
12 n_i=1.5*10^10; // Constant of calculation
13 // Calculation
14 p_0= n_i^2/n_0;
15
16 printf("Equilibrium hole concentration is %0.2e cm
    ^-3",p_0);
17
18 // Result
19 // Equilibrium hole concentration in Si sample is
    2.25*10^3 cm^-3
```

Scilab code Exa 1.18 Time taken to reach Brillouin zone

```
1 // Time taken to reach Brillouin zone
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-18 in page 48
7
```

```

8 clear; clc; close;
9
10 // Data given
11 h=1.05*10^-34; // Constant of calculation in Js
12 kB=1.112*10^8; // Brillouin zone edge along x-axis
13 e=1.6*10^-19; // Charge on an electron in C
14 E_0=10^4; // External electric field in V/m
15
16 // Calculation
17 tou=(h*kB)/(e*E_0);
18 printf("Time taken to reach Brillouin zone is %0.3e
        s", tou);
19
20 // Result
21 // Time taken by GaAs electron to reach Brillouin
    zone is 7.298 ps

```

Scilab code Exa 1.20 Electron hole concentration at minimum conductivity

```

1 // Electron ,hole concentration at minimum
    conductivity
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-20 in page 49
7
8 clear; clc; close;
9
10 // Data given
11 mu_n=1350; // Mobility of electrons in cm^2/Vs
12 mu_p=450; // Movility of holes in cm^2/Vs
13 n_i=1.5*10^10; // Intrinsic carrier concentration /

```

```

    cm ^ 3
14
15 // Calculation\
16 //Minimum conductivity of Si when slightly p-type
    has been proved in text
17 //Thus the electron and hole concentrations are
    derived as below
18 n_0=n_i*sqrt(mu_p/mu_n);
19 p_0=n_i*sqrt(mu_n/mu_p);
20
21 printf("(a)Electron concentration is %0.2e cm^-3\n",
    n_0);
22 printf("(b)Hole concentration is %0.2e cm^-3",p_0);
23
24 // Result
25 // (a) Electron concentration is 8.66*10^9 cm^-3
26 // (b) Hole concentration is 2.6*10^10 cm^-3

```

Scilab code Exa 1.21 Position of Fermi level at room temperature

```

1 // Position of Fermi level at room temperature
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-22 in page 50
7
8 clear; clc; close;
9
10 // Data given
11 C_Ge=4.41*10^22; // Concentration of Ge atom /cm^3
12 N_D=4.41*10^15; // Number of free donor atoms
13 N_C=8.87*10^18; // Number of conduction electrons

```

```

    assuming full ionization
14 K_BT=0.026; // Measured in eV at room temperature
15
16 // Calculation
17 E_F=K_BT*log(N_D/N_C);
18
19 printf("Position of fermi level is %0.4f",E_F);
20
21 // Result
22 // Position of Fermi level from edge of conduction
    band is -0.1977
23 // Thus E_F is below E_C

```

Scilab code Exa 1.22 Mobility of free electrons in Aluminium

```

1 // Mobility of free electrons in Aluminium
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-22 in page 50
7
8 clear; clc; close;
9
10 // Data given
11 n_0=18*10^28; // Derived from the given formula in
    textbook
12 rho=3.44*10^-6; // Resistivity in ohm-cm
13 e=1.6*10^-19; // Charge on an electron in C
14
15 // Calculation
16 mu=10^2/(n_0*e*rho);
17

```

```

18 printf("Mobility of free electrons is %0.0e m^2/V-s"
    ,mu);
19
20 // Result
21 // Mobility of free electrons in Alluminium is 10^-3
    m^2/V-s

```

Scilab code Exa 1.23 Percentage of increase in carrier concentration

```

1 // Percentage of increase in carrier concentration
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-23 in page 51
7
8 clear; clc; close;
9
10 // Data given
11 kT=0.026; // Value at T=300K
12 T=300; // Room temperature in K
13 dT=1/300; // Rate of change of temperature
14 E_g=0.785; // Band gap energy in germanium in eV
15
16 // Calculation
17 dni=((1.5+(E_g/(2*kT)))*dT)*100;
18
19 printf("Rise in intrinsic carrier concentration is
    %0.1f percent/degree",dni);
20
21 // Result
22 // Percentage rise in intrinsic carrier
    concentration is 5.5 %/degree

```

Scilab code Exa 1.24 Previous problem calculated for intrinsic silicon

```
1 // Previous problem calculated for intrinsic silicon
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-24 in page 51
7
8 clear; clc; close;
9
10 // Data given
11 kT=0.026; // Value at T=300K
12 T=300; // Room temperature in K
13 dT=1/300; // Rate of change of temperature
14 E_g=1.21; // Band gap energy in silicon in eV
15
16 // Calculation
17 dni=((1.5+(E_g/(2*kT)))*dT)*100;
18
19 printf("Rise in intrinsic carrier concentration is
    %0.1f percent/degree",dni);
20
21 // Result
22 // Percentage rise in intrinsic carrier
    concentration is 8.3 %/degree
```

Scilab code Exa 1.25 Find drift velocity mobility conductivity

```

1 // Find drift velocity ,mobility ,conductivity
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-25 in page 51
7
8 clear; clc; close;
9
10 // Data given
11 A=0.835*10^-6; // Cross section of wire in m^2
12 J=2.4*10^6; // Current density in A/m^2
13 n_0=8.4*10^27; // Concentration of electrons in
    copper in electrons/m^3
14 e=1.6*10^-19; // Charge on an electron in C
15 ohm=0.0214; // Resistance per meter
16 E_0=2*ohm; // Electric field in V/m
17
18 // Calculations
19 v_0=(J)/(n_0*e);
20 printf("(a)The drift velocity is %0.2e m/s\n",v_0);
21 mu=v_0/E_0;
22 printf("(b)The mobility of electrons is %0.2e m^2/V-
    s\n",mu);
23 sigma=(n_0*10*e*mu);
24 printf("(c)Therefore the conductivity is %0.2e /ohm-
    m",sigma);
25
26 // Result
27 // (a) The drift velocity is 1.78*10^-3 m/s
28 // (b) Mobility in this case is 4.16*10^-2 m^2/V-s
29 // (c) Conductivity is 5.61*10^8 1/ohm-m

```

Scilab code Exa 1.26 Determine concentration of electrons and holes

```
1 // Determine concentration of electrons and holes
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-26 in page 52
7
8 clear; clc; close;
9
10 // Data given
11 N_D=2*10^14; // Number of donor atoms in atoms/cm^2
12 N_A=3*10^14; // Number of acceptor atoms in atoms/cm
    ^2
13 ni=2.5*10^19; // number of intrinsic atoms in atoms/
    cm^2
14
15 // Calculation
16 p_0=(0.5*10^14)+sqrt(0.25*10^28 + 6.25*10^26);
17 n_0=-(0.5*10^14)+sqrt(0.25*10^28 + 6.25*10^26);
18 printf("(a) Concentration of free electrons is %0.3e
    cm^-3\n", n_0);
19 printf("(b) Concentration of holes is %0.3e cm^-3\n",
    p_0);
20 printf("since p_0>n_0 the sample is p-type\n");
21 printf("When N_A=N_D=10^15,\n n_0=p_0 from the
    neutrality equation\n");
22 printf("Thus the germanium sample in this question
    is intrinsic by compensation");
23 printf("When N_D=10^16,\n");
24 p_0=(6.25*10^26)/10^16;
25 printf("(c) p_0=%0.2e cm^-3\n", p_0);
26 printf("Since n_0>p_0, germanium sample in this case
    is n-type");
27
28 // Result
29 // (a) Number of free electrons are 0.058*10^14 cm
```

```

    ^-3
30 // (b) Number of holes are  $1.058 \times 10^{14} \text{ cm}^{-3}$ 
31 // Semiconductor can be made intrinsic without
    doping or by equal doping

```

Scilab code Exa 1.27 Concentration of holes and electrons

```

1 // Concentration of holes and electrons
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-27 in page 52
7
8 clear; clc; close;
9
10 // Data given
11 sigma=100; // Conductivity of p-type germanium
12 e=1.6*10^-19; // Charge on an electron in eV
13 mu_p=1800; // Mobility of holes in cm^2/Vs
14 ni=2.5*10^13; // Number of intrinsic atoms in
    germanium
15 mu_n=1300; // Mobility of electrons in cm^2/Vs
16 sigma1=0.1; // Conductivity in n-type silicon in /
    ohm-cm
17 ni1=1.5*10^10; // Number of intrinsic atoms in
    silicon
18 P_p=3.47*10^17; // Constant of calculation
19
20 // Calculation
21 printf("For Germanium:\n");
22 p_0=sigma/(e*mu_p);
23 n_0=(ni^2)/P_p;

```

```

24 printf("(a) Concentration of holes is %0.2e cm-3\n",
    p_0);
25 printf("(b) Concentration of electrons is %0.2e m-3\n",n_0);
26 printf("For Silicon:\n");
27 n_0=sigma1/(e*mu_n);
28 p_0=(ni1^2)/(4.81*10^14);
29 printf("(c) Concentration of electrons is %0.2e cm-3\n",n_0);
30 printf("(d) Concentration of holes is %0.2e m-3",p_0);
31
32 // Result
33 // (a) For Ge,Hole conc. = 3.47*1017 cm-3,
    Electron conc. = 1.8*1015 m-3
34 // (b) For Si,Hole conc. = 4.68*105 cm-3, Electron
    conc. = 4.81*1014 cm-3

```

Scilab code Exa 1.28 To prove resistivity is 45 ohm cm

```

1 // To prove ,resistivity is 45 ohm-cm
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-28 in page 53
7
8 clear; clc; close;
9
10 // Data given
11 ni=2.5*10^13; // Intrinsic concentration /cm3
12 mu=5600; // Sum of mobilities of holes and electrons
13 e=1.6*10^-19; // Charge on an electron in C

```

```

14
15 // Calculation
16 sigma=e*ni*mu;
17 printf("Conductivity of germanium is %0.3f (s/cm)
    ^-1\n",sigma);
18 rho=1/sigma;
19 printf("Therefore resistivity is %0.1f ohm-cm",rho);
20
21 // Result
22 // Conductivity of germanium = 0.0232 (s/cm)^-1
23 // Resistivity = 44.6 ohm-cm

```

Scilab code Exa 1.29 Find conductivity of intrinsic germanium

```

1 // Find conductivity of intrinsic germanium
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 1-29 in page 53
7
8 clear; clc; close;
9
10 // Data given
11 ni=2.5*10^13; // Intrinsic concentration /cm^3
12 e=1.6*10^-19; // Charge on an electron in C
13 mu_n=3800; // Mobility of electrons in cm^2/Vs
14 mu_p=1800; // Mobility of holes in cm^2/Vs
15 N_D=4.41*10^15; // Concentration of donor atoms in
    Ge /cm^3
16
17 // Calculation
18 sigma=(ni*e)*(mu_n+mu_p);

```

```

19 printf("(a) Intrinsic conductivity=%0.4f s/cm\n",
    sigma);
20 p_0=(ni^2)/N_D;
21 printf("p_0=%0.2e /cm^3\n",p_0);
22 sigma1=N_D*e*mu_n;
23 printf("(b) Since n_0>p_0, Conductivity=%0.2f s/cm\n"
    ,sigma1);
24 n_0=(ni^2)/N_D;
25 printf("With given acceptor impurity,\nn_0=%0.2e /cm
    ^3\n",n_0);
26 sigma2=N_D*e*mu_p;
27 printf("(c) Since p_0>n_0, Conductivity=%0.2f s/cm",
    sigma2);
28
29 // Result
30 // (a) Conductivity in first case is 0.0224 s/cm
31 // (b) Conductivity in second case is 2.68 s/cm
32 // (c) Conductivity in third case is 1.27 s/cm

```

Chapter 2

Diode Fundamentals

Scilab code Exa 2.1 Calculate width of depletion layer

```
1 // Calculate height of potential-energy barrier
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-1 in page 77
7
8 clear; clc; close;
9
10 // Given data
11 rho1=1.5; // Resistivity of p-side of Ge diode in
           ohm-cm
12 rho2=1; // Resistivity of n-side of Ge diode in ohm-
           cm
13 e=1.6*10^-19; // Charge on an electron in C
14 mu_p=1800; // Mobility of holes
15 mu_n=3800; // Mobility of electrons
16
17 // Calculation
18 N_A=1/(rho1*e*mu_p);
19 N_D=1/(rho2*e*mu_n);
```

```

20 printf("(a) rho = 2 ohm-cm\n");
21 printf("N_A=%0.2e /cm^3\n",N_A);
22 printf("N_D=%0.2e /cm^3\n",N_D);
23 printf("The height of the potential energy barrier
    is:\n");
24 V_0=0.026*log((N_A*N_D)/(2.5*10^13)^2);
25 printf("V_0=%0.3f eV\n\n",V_0);
26 printf("(b)For silicon:\n");
27 N_A1=1/(rho1*e*500);
28 N_D1=1/(2*e*1300);
29 printf("N_A=%0.2e /cm^3\n",N_A1);
30 printf("N_D=%0.2e /cm^3\n",N_D1);
31 V_01=0.026*log((N_A1*N_D1)/(1.5*10^10)^2);
32 printf("The height of the potential energy barrier
    is:\n");
33 printf("V_0=%0.3f eV",V_01);
34
35 // Result
36 // (a) For Ge, V_0 = 0.226 eV
37 // (b) For Si, V_0 = 0.655 eV

```

Scilab code Exa 2.2 Width of depletion zone at 300K

```

1 // Width of depletion zone at 300K
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-2 in page 83
7
8 clear; clc; close;
9
10 // Given data

```

```

11 N_d=10^16; // Donor concentration /cm^3
12 N_a=5*10^18; // Acceptor concentration /cm^3
13 ni=1.5*10^10; // Intrinsic concentration /cm^3
14 e=1.6*10^-19; // Charge on an electron in C
15 epsln=11.8*8.85*10^-14; // Constant of calculation
16
17 // Calculation
18 V_0=0.0259*log((N_d*N_a)/(ni^2));
19 printf("The height of the barrier energy is %0.2f V\
n",V_0);
20
21 W=sqrt(2*((epsln*V_0)/(e))*((1/N_a)+(1/N_d)));
22 printf("Width of depletion zone is %0.3e cm",W);
23
24 // Result
25 // The height of the barrier energy is 0.86 V
26 // Width of depletion zone in n-type Si is
3.354*10^-5 cm

```

Scilab code Exa 2.3 Find thermal and barrier volatge

```

1 // Find thermal and barrier volatge
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-3 in page 84
7
8 clear; clc; close;
9
10 // Given data
11 T=303; // Temperature in K
12 ni=1.5*10^16; // Intrinsic concentration /cm^3

```



```

13 e=1.6*10^-19; // Charge on an electron in C
14 k_BT=1.38*10^-23; // Measured in eV at 303K
15 N_A=10^22; // Acceptor concentration /cm^3
16 N_D=1.2*10^21; // Donor concentration /cm^3
17
18 // Calculation
19 V_T=(k_BT*T)/e;
20 printf("Thermal voltage = %0.2e V\n",V_T);
21 ni1=ni^2;
22 printf("ni^2 = %0.3e\n",ni1);
23 V_0=V_T*log((N_A*N_D)/(ni1));
24 printf("Barrier voltage = %0.3f V",V_0);
25
26 // Result
27 // Thermal voltage = 26.1 mV
28 // Barrier voltage = 0.635 V

```

Scilab code Exa 2.4 Barrier potential for silicon junction

```

1 // Barrier potential for silicon junction
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-4 in page 84
7
8 clear; clc; close;
9
10 // Given data
11 t=[70 0]; // Declaring the variables
12 t1=25; // Given temperature in K
13
14 // Calculation

```

```

15 alp=[1 2];
16 for i=1:2
17 delta_V=-0.002*(t(i)-t1);
18 Vb=0.7+delta_V;
19 printf("(%.0f) delta_V at %d degrees = %.2f V\n",
        alp(i),t(i),delta_V);
20 printf("Thus the barrier potential at %d degrees =
        %.2f V\n",t(i),Vb);
21 end
22
23 // Result
24 // (a) Barrier potential at 70 degrees is 0.61 V
25 // (b) Barrier potential at 0 degrees is 0.75 V

```

Scilab code Exa 2.5 Find depletion layer capacitance

```

1 // Find depletion layer capacitance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-5 in page 86
7
8 clear; clc; close;
9
10 // Given data
11 epsln=12/(36*%pi*10^11); // Constant for Si in F/cm
12 A=8.11058*10^-1; // Cross sectional area in m^2
13 mu_p=500; // Mobility of holes
14 e=1.6*10^-19; // Charge on an electron in C
15 V_j=4.9; // Junction potential in V
16
17 // Calculation

```

```

18 printf("(a)We have C_t/A = sqrt((e*epsln)/2)*sqrt(Na
    /Vj)\n");
19 K=sqrt((e*epsln)/2);
20 printf("sqrt((e*epsln)/2) = %0.2e\n",K);
21 printf("Hence C_t = %0.2e * sqrt(Na/Vj) F/cm^2\n",K)
    ;
22 K1=K*10^12;
23 printf("Or C_t = %0.2e * sqrt(Na/Vj) pF/cm^2\n",K1);
24 N_A=1/(3*mu_p*e);
25 C_T=(2.9*10^-4)*sqrt(N_A/V_j)*(8.14*10^-3);
26 printf("(b)The depletion layer capacitance = %0.2f
    pF",C_T);
27
28 // Result
29 // (a) The expression for depletion layer
    capacitance is proved
30 // (b) The depletion layer capacitance in silicon is
    68.84 pF

```

Scilab code Exa 2.6 Compute decrease in capacitance

```

1 // Compute decrease in capacitance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-6 in page 87
7
8 clear; clc; close;
9
10 // Given data
11 V=6.5; // Increased bias voltage in V
12 lambda=(20*sqrt(5)); // Constant of calculation

```

```

13
14 // Calculation
15 C_T=lambda/sqrt(V);
16
17 printf("Transition capacitance of abrupt junction at
        6.5 V = %0.2f pF\n",C_T);
18 printf("This corresponds to a decrease of 2.46 pF");
19
20 // Result
21 // Transition capacitance = 17.54 pF
22 // This corresponds to a decrease of 2.46 pF

```

Scilab code Exa 2.7 Calculate barrier capacitance of Ge

```

1 // Calculate barrier capacitance of Ge
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-7 in page 87
7
8 clear; clc; close;
9
10 // Given data
11 epsln=1.41*10^-12; // Dielectric constant
12 A=0.0225; // Junction area in cm^2
13 W=2*10^-4; // Space-charge thickness in cm
14
15 // Calculation
16 C_T=epsln*(A/W);
17
18 printf("Barrier capacitance = %0.2e F",C_T);
19

```

```
20 // Result
21 // Barrier capacitance = 159.3 pF
```

Scilab code Exa 2.8 Calculate width of depletion layer

```
1 // Calculate width of depletion layer
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-8 in page 87
7
8 clear; clc; close;
9
10 // Given data
11 V=[10.2 0.3 0.1]; // Applied voltages in V
12 epsln=16; // Constant of calculation
13 A=1*10^-6; // Cross sectional area in m^2
14
15 // Calculation
16 alp=[1 2 3];
17 for i=1:3
18     W=sqrt((V(i)*10^-10)/14.3);
19     printf("(%.0f)Width of depletion layer for %.2
20           f V = %.2e mu-m\n\n",alp(i),V(i),W);
21 end
22 W=[8.5 1.45];
23 alp1=[1 2];
24 for j=1:2
25     C_T=(epsln*10^-9)/(36*%pi*W(j));
26     printf("(%.0f)Space charge capacitance for %.2
27           f mu-m = %.2e F\n\n",alp(j),W(j),C_T);
28 end
```

```

27
28 // Result
29 // Widths of depletion layer are:
30 // (a) 8.5 mu-m
31 // (b) 1.45 mu-m
32 // (c) 0.84 mu-m respectively
33 // Space charge capacitances are:
34 // (a) 16.65 pF
35 // (b) 97.6 pF respectively

```

Scilab code Exa 2.10 Reverse saturation point of current

```

1 // Reverse saturation point of current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-10 in page 93
7
8 clear; clc; close;
9
10 // Given data
11 b=2.11; // Constant
12 Lsigma=3*10^-4; // Constant
13 Vt=0.026; // Threshold voltage in V
14 A=1.5*10^-6; // Cross sectional area in mm^2
15 sigma_i=2.24; // Intrinsic conductivity /ohm-cm
16
17 // Calculation
18 I_0=((A*Vt*b*sigma_i^2)/(1+b)^2)*((1/0.45)+(1/0.015))
19 ;
20 printf("Reverse saturation point of current is %0.2e

```

```

    A", I_0);
21
22 // Result
23 // Reverse saturation point of current is 2.94  $\mu\text{A}$ 

```

Scilab code Exa 2.12 Find reverse saturation current

```

1 // Find reverse saturation current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-12 in page 94
7
8 clear; clc; close;
9
10 // Given data
11 A=5*10^-2; // Cross sectional area in  $\text{m}^2$ 
12 b=2.6; // Constant of calculation
13 Lsigma=10^-4; // Constant of calculation
14 sigmai=4.32*10^-6; // Intrinsic conductivity in ohm/
    cm
15 Vt=0.026; // Constant in eV
16
17 // Calculation
18 I_0=A*Vt*(b/(1+b)^2)*sigmai^2*(2*10^4);
19
20 printf("The reverse saturation current = %0.2e A",
    I_0);
21
22 // Result
23 // The reverse saturation current = 97.25 pA

```

Scilab code Exa 2.13 Ratio of reverse saturation current

```
1 // Ratio of reverse saturation current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-13 in page 95
7
8 clear; clc; close;
9
10 // Given data
11 b1=2.6; // Constant of calculation
12 b2=2.11; // Constant of calculation
13 sigma1=4.32*10^-6; // Intrinsic conductivity for Si
    /ohm-cm
14 sigma2=2.24*10^-2; // Intrinsic conductivity for Ge
    /ohm-cm
15
16 // Calculation
17 printf("For Si:\n");
18 Y1=((b1*sigma1^2)/(1+b1)^2)*(2*10^4);
19 printf("Y_Si = %0.2e ohm-cm^2\n",Y1);
20 printf("For Ge:\n");
21 Y2=((b2*sigma2^2)/(1+b2)^2)*(2*10^2);
22 printf("Y_Ge = %0.2e ohm-cm^2\n",Y2);
23 Y=Y2/Y1;
24 printf("Therefore the ratio is %0.1e",Y);
25
26
27 // Result
28 // Y_Si = 7.49*10^-8 ohm-cm^2
```



```
29 // Y_Ge = 2.189*10^-2 ohm-cm^2
30 // Ratio = 0.29*10^6
```

Scilab code Exa 2.14 Calculate the current flowing

```
1 // Calculate the current flowing
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-14 in page 96
7
8 clear; clc; close;
9
10 // Given data
11 I_0=9*10^-7; // Current flowing in A
12 V=0.1; // Applied forward bias in V
13
14 // Calculation
15 I=I_0*(exp(40*V)-1);
16 printf("Current flowing through diode = %0.2e A",I);
17
18 // Result
19 // Current flowing through the diode under forward
    bias = 48.15 mu-A
```

Scilab code Exa 2.15 Find voltage to be applied

```
1 // Find voltage to be applied
```

```

2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-15 in page 96
7
8 clear; clc; close;
9
10 // Given data
11 J_0=500*10^-3; // Saturation current density in mA/m
    ^2
12 J=10^5; // Forward current density in A/m^2
13 e=1.6*10^-19; // Charge on an electron in C
14 etaK=1.38*10^-23; // Constant of calculation
15 T=350; // Temperature in K
16
17 // Calculation
18 A=2.303*log10(2*10^5);
19 V=(A*etaK*T)/e;
20
21 printf("Voltage to be applied = %0.4f V",V);
22
23 // Result
24 // The voltage to be applied = 0.3685 V

```

Scilab code Exa 2.16 Find current when forward biased

```

1 // Find current when forward biased
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-16 in page 97

```

```

7
8 clear; clc; close;
9
10 // Given data
11 k_T=1.38*10^-23; // Constant of calculation
12 T=293; // Temperature in K
13 I_s=1.5*10^-13; // Saturation current in A
14 e=1.6*10^-19; // Charge on an electron in C
15 V=0.55; // Forward bias voltage in V
16
17 // Calculation
18 printf("At T = 20 degrees:\n");
19 V_T=(k_T*T)/e;
20 I=I_s*(exp(V/0.02527)-1);
21 printf("V_T = %0.4f V\n",V_T);
22 printf("(a)I = %0.3e A\n",I);
23 printf("At T = 100 degrees:\n");
24 V_T=(k_T*373)/e;
25 printf("V_T = %0.4f V\n",V_T);
26 printf("I_s doubles 8 times ie I_s = 256. Therefore,\n
n");
27 I=1.5*256*10^-13*(exp(0.55/0.032)-1);
28 printf("(b)I = %0.3f A",I);
29
30 // Result
31 // (a) At T=20 degrees , I = 4.251*10^-4 A
32 // (b) At T=100 degrees , I = 0.001 A

```

Scilab code Exa 2.17 Calculate current and voltage

```

1 // Calculate current and voltage
2 // Basic Electronics
3 // By Debashis De

```

```

4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-17 in page 97
7
8 clear; clc; close;
9
10 // Given data
11 I1=2*10^-6; // Saturation current in A
12 I2=4*10^-6; // Saturation current in A
13 Vz=100; // Breakdown voltages are equal
14 eta=2; // Constant of calculation
15
16 // Calculation
17 printf("At V=90V, none of the diodes will break down.
        I is determined by the diode with the smallest
        I_0\n");
18 printf("Thus for D1, I = 1 mu-A and for D2, I = -1 mu-
        A\n");
19 V2=eta*0.026*log(1-(I1/I2));
20 printf("(a) V2 = %0.1e V\n", V2);
21 printf("(b) V1 = -89.964 V");
22
23 // Result
24 // (a) V2 = -36 mV
25 // (b) V1 = -89.964 V

```

Scilab code Exa 2.18 Calculate forward currents for voltages

```

1 // Calculate forward currents for voltages
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India

```

```

6 // Example 2-18 in page 98
7
8 clear; clc; close;
9
10 // Given data
11 Vt=0.026; // Thermal voltage at room temperature in
           eV
12 V=[0.1 0.2 0.3]; // Given voltages in V
13
14 // Calculation
15 V1=0.026*-2.3;
16 printf("(a)V=%0.2 f V\n",V1);
17 R=(exp(1.92)-1)/(exp(-1.92)-1);
18 printf("(b)Ration of forward bias current to reverse
           bias current=%0.2 f\n",R);
19 printf("(c):\n")
20 for i=1:3
21     I=15*(exp(V(i)/0.026)-1);
22     printf("I = %0.3 e A\n",I);
23 end
24
25 // Result
26 // (a) V = -0.060 V
27 // (b) Ratio = -6.83
28 // (c) Forward currents = 0.687 mA, 32.86 mA and
           1.539 A respectively

```

Scilab code Exa 2.19 Factor to be multiplied with reverse saturation current

```

1 // Factor to be multiplied with reverse saturation
  current
2 // Basic Electronics
3 // By Debashis De

```

```

4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-19 in page 98
7
8 clear; clc; close;
9
10 // Given data
11 T1=25; // Initial temperature for Ge in degree
        celcius
12 T2=70; // Final temperature for Ge in degree celcius
13 T_2=150; // Final temperature for Si in degree
        celcius
14
15 // Calculation
16 printf("(a)Let the reverse saturation current for Ge
        at 25 degrees be Io(25)\n");
17 A=2^((T2-T1)/10);
18 printf("The factor to be multiplied when temperature
        is raised to 70 degrees is %0.0f\n",A);
19 printf("Therefore , Io(70) = %0.0f*Io(25)\n\n",A);
20 printf("(b)Let the reverse saturation current for Si
        at 25 degrees be Io(25)\n");
21 A1=2^((T_2-T1)/10);
22 printf("The factor to be multiplied when temperature
        is raised to 150 degrees is %0.0f\n",A1);
23 printf("Therefore , Io(150) = %0.0f*Io(25)",A1);
24
25 // Results
26 // (a) Io(70) = 23*Io(25)
27 // (b) Io(150) = 5793*Io(25)

```

Scilab code Exa 2.20 Leakage resistance shunting the diode

```

1 // Leakage resistance shunting the diode
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-20 in page 99
7
8 clear; clc; close;
9
10 // Given data
11 // Kirchoff's law has been applied and equations
    solved to get final expression
12
13 // Calculation
14 I_R=(0.08*5*10^-6)/0.15;
15 R=10/I_R;
16 printf("Leakage resistance = %0.2e Mohm",R);
17
18 // Result
19 // Leakage resistance shunting the diode = 3.75 Mohm

```

Scilab code Exa 2.21 Maximum reverse bias voltage to be maintained

```

1 // Maximum reverse-bias voltage to be maintained
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-21 in page 99
7
8 clear; clc; close;
9
10 // Given data

```

```

11 Rt=0.15*10^-3; // Thermal resistance of mechanical
    contact between diode and surroundings in mW/
    degree celcius
12 T1=25; // Ambient temperature in degree celcius
13 T2=35; // Rise in ambient temperature in degree
    celcius
14 I_25=5*10^-6; // Reverse saturation current at 25
    degrees in mu-A
15
16 // Calculation
17 Po=Rt*(T2-T1);
18 printf("P_out = %0.2e mW\n",Po);
19 printf("We know that reverse saturation current
    doubles for every 10 degree rise in temperature\n
    ");
20 I_35=2*I_25;
21 V=Po/I_35;
22 printf("Thus the maximum reverse bias voltage to be
    maintained is %0.0f V",V);
23
24 // Result
25 // Maximum reverse bias voltage that can be
    maintained across diode is 150V

```

Scilab code Exa 2.22 Factor to be multiplied with current

```

1 // Factor to be multiplied with current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-22 in page 100
7

```



```

8 clear; clc; close;
9
10 // Given data
11 V_T=0.0364; // Thermal voltage in V
12 // Simplified expression for I has been derived
13 I_25=0.01; // Current at 25 degrees in mA
14 I_150=2.42; // Current at 150 degrees in mA
15
16 // Calculation
17 printf("At 150 degrees:\n");
18 I=5792*(exp(0.4/0.0728)-1);
19 printf("I = %0.0f * Io(25)\n",I);
20 printf("At 25 degrees:\n");
21 I=exp(0.4/0.0514)-1;
22 printf("I = %0.0f * Io(25)\n",I);
23 R=I_150/I_25;
24 printf("Factor to be multiplied with current = %0.0f
    ",R);
25
26 // Result
27 // When temp is increased from 25–150 degrees ,
    current has to be multiplied by 242

```

Scilab code Exa 2.24 Find the diffusion length

```

1 // Find the diffusion length
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2–24 in page 101
7
8 clear; clc; close;

```

```

9
10 // Given data
11 C_D=1.5*10^-6; // Diffusion capacitance in F
12 D_p=13; // Constant
13 eta=2; // Constant
14 V_t=0.026; // Voltage at room temperature in V
15 I=1*10^-3; // Current in mA
16
17 // Calculation
18 L_p=sqrt((C_D*D_p*eta*V_t)/I);
19
20 printf(" Diffusion length = %0.3e m",L_p);
21
22 // Result
23 // Diffusion length = 31.84*10^-3 m

```

Scilab code Exa 2.25 Find static resistance

```

1 // Find static resistance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-25 in page 103
7
8 clear; clc; close;
9
10 // Given data
11 I_0=20*10^-6; // Current in micro A
12 V_F=0.2; // Forward voltage in V
13
14 // Calculation
15 I=I_0*(exp(40*V_F)-1);

```

```

16 r_dc=(0.0343/(80*10^-6))*exp(0.2/0.0343);
17
18 printf("Forward current through the diode = %0.3e A\
n",I);
19 printf("Static resistance = %0.3e ohm",r_dc);
20
21 // Result
22 // Forward current = 59.599 mA
23 // Static resistance = 0.146 Mohm

```

Scilab code Exa 2.26 Dynamic resistance in Forward Reverse direction

```

1 // Dynamic resistance in forward ,reverse direction
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-26 in page 103
7
8 clear; clc; close;
9
10 // Given data
11 T=398; // Temperature in K
12 I_0=80*10^-6; // Current in micro A
13 eta=1; // Constant
14 V_F=[-0.2 0.2]; // Forward voltages in Volts
15 V_T=0.0343; // Thermal voltage in volts
16
17 // Calculation
18 alp=[1 2];
19 for i=1:2
20     R_ac=(V_T/I_0)*exp(V_F(i)/V_T);
21     printf("(%0.0f)Dynamic resistance = %0.3e ohm\n"

```

```

        ,alp(i),R_ac);
22 end
23
24 // Result
25 // (a) Dynamic resistance in forward direction =
    1.258 ohm
26 // (b) Dynamic resistance in reverse direction =
    0.146 Mohm

```

Scilab code Exa 2.27 Dynamic resistance at forward bias

```

1 // Dynamic resistance at forward bias
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-27 in page 103
7
8 clear; clc; close;
9
10 // Given data
11 k_BT=25.86*10^-3; // Constant
12 I_0=1.5*10^-6; // Current in microA
13 V=0.15; // Forward bias voltage in volts
14 V_T=0.02586; // Thermal voltage in volts
15
16 // Calculation
17 R_ac=k_BT/(I_0*exp(V/V_T));
18
19 printf("Dynamic resistance = %0.2f W",R_ac);
20
21 // Result
22 // Dynamic resistance at forward bias = 52.17 W

```

Scilab code Exa 2.28 Maximum forward current forward resistance

```
1 // Maximum forward current ,forward resistance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-28 in page 104
7
8 clear; clc; close;
9
10 // Given data
11 P_max=2.5; // Maximum power in watt
12 V_f=0.9; // Forward voltage in V
13 I_max=2.2; // Maximum current in A
14
15 // Calculation
16 I_fmax=P_max/V_f;
17 R_f=P_max/(I_max)^2;
18
19 printf("(a)Maximum forward current = %0.2f A\n",
        I_fmax);
20 printf("(b)Forward diode resistance = %0.3f ohm",R_f
        );
21
22 // Result
23 // Forward current = 2.78 A
24 // Diode forward resistance = 0.517 ohm
```

Scilab code Exa 2.29 Height of potential energy barrier

```
1 // Height of potential energy barrier
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-29 in page 104
7
8 clear; clc; close;
9
10 // Given data
11 rho1=2; // Resistivity of p-side in ohm-cm
12 rho2=1; // Resistivity of n-side in ohm-cm
13 e=1.6*10^-19; // Charge on an electron in C
14
15 // Calculation
16 N_A1=1/(rho1*e*1800);
17 N_D1=1/(rho2*e*3800);
18 N_A2=1/(rho1*e*500);
19 N_D2=1/(rho2*e*1300);
20 V_01=0.026*log((N_A1*N_D1)/(2.5*10^13)^2);
21 V_02=0.026*log((N_A2*N_D2)/(1.5*10^10)^2);
22 printf("(a) For Ge:\n");
23 printf("N_A = %0.2e /cm^3\nN_D = %0.2e /cm^3\n", N_A1
    , N_D1);
24 printf("Therefore barrier potential energy for Ge =
    %0.2f eV\n\n", V_01);
25 printf("(b) For Si:\n");
26 printf("N_A = %0.2e /cm^3\nN_D = %0.2e /cm^3\n", N_A2
    , N_D2);
27 printf("Therefore barrier potential energy for Si =
```

```

    %0.3 f eV",V_02);
28
29 // Result
30 // (a) Height of barrier potential energy for Ge =
    0.22 eV
31 // (b) Height of barrier potential energy for Si =
    0.667 eV

```

Scilab code Exa 2.30 Dynamic resistance in forward reverse direction

```

1 // Dynamic resistance in forward ,reverse direction
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-30 in page 105
7
8 clear; clc; close;
9
10 // Given data
11 V_T=0.0343; // Thermal voltage at 398K in V
12 eta=1; // Constant for Ge
13
14 // Calculation
15 // Final expression for r derived after
    differentiating w.r.t V
16 r1=((35*10^-6)/(34.3*10^-3))*exp(5.83);
17 A1=1/r1;
18 r2=3.185*10^-6
19 A2=1/r2;
20
21 printf("(a)Dynamic resistance in forward direction =
    %0.3 f ohm\n",A1);

```

```

22 printf("(b)Dynamic resistance in reverse direction =
    %0.3e ohm",A2);
23
24 // Result
25 // (a) Resistance in forward direction = 2.879 ohm
26 // (b) Resistance in reverse direction = 0.314 Mohm

```

Scilab code Exa 2.31 Maximum and minimum Zener currents

```

1 // Maximum and minimum Zener currents
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-31 in page 110
7
8 clear; clc; close;
9
10 // Given data
11 V_z=10; // Zener voltage in V
12 R_s=1*10^3; // Shunt resistance in K-ohm
13 R_l=10*10^3; // Load resistance in K-ohm
14 Vi_max=40; // Maximum input voltage in V
15 Vi_min=25; // Minimum input voltage in V
16
17 // Calculation
18 I_zmax=((Vi_max-V_z)/1000)-(5*10^-3);
19 I_zmin=((Vi_min-V_z)/R_s)-(5*10^-3);
20
21 printf("Maximum value of zener current = %0.2e A\n",
    I_zmax);
22 printf("Minimum value of zener current = %0.2e A",
    I_zmin);

```



```
23
24 // Result
25 // Maximum zener current = 25 mA
26 // Minimum zener current = 10 mA
```

Scilab code Exa 2.32 Find the range for R

```
1 // Find the range for R
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-32 in page 110
7
8 clear; clc; close;
9
10 // Given data
11 P=250; // Maximum power dissipation in mW
12 V=15; // Supply voltage in V
13
14 // Caluclation
15 I=(250*10^-3)/5;
16 printf("Maximum permissible current = %0.3e A\n",I);
17 printf("10 percent of 50mA = 5mA\n");
18 I1=I-(5*10^-3);
19 printf("Maximum current through diode to maintain
    constant voltage = %0.1e A",I1);
20
21 // Result
22 // Maximum current to maintain constant voltage = 45
    mA
```

Scilab code Exa 2.33 Find breakdown voltage

```
1 // Find breakdown voltage
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-33 in page 111
7
8 clear; clc; close;
9
10 // Given data
11 E=1.5*10^5; // Electric field in V/cm
12 epsln=11.9*8.854*10^-16; // Constant
13 e=1.6*10^-19; // Charge on an electron in eV
14 N_d=2*10^15; // Doping concentration /cm^3
15
16 // Calculation
17 W=(E*epsln)/(e*N_d);
18 V_b=(W*E)/2;
19
20 printf("Width of depletion region = %0.3e m\n",W);
21 printf("Therefore ,breakdown voltage Vbr = %0.4f V",
    V_b);
22
23 // Result
24 // Breakdown voltage = 0.3704 V
```

Scilab code Exa 2.35 Calculate Vz

```
1 // Calculate Vz
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-35 in page 112
7
8 clear; clc; close;
9
10 // Given data
11 // (a) Proof of  $V_z=51/\sigma_i$  has been given
12  $\sigma_i=1/45$ ; // Intrinsic conductivity in 1/ohm-cm
13  $\sigma_p=1/3.9$ ; // Conductivity of p material in 1/ohm-
    cm
14  $I_0=6*10^{-6}$ ; // Current in microA
15
16 // Calculation
17  $Vz1=51/\sigma_i$ ;
18  $Vz2=51/\sigma_p$ ;
19  $I=I_0*(\exp(100/26)-1)$ ;
20 printf("(a) Proof of  $V_z=51/\sigma_p$  has been given\n")
    ;
21 printf("(b) When material is intrinsic ,  $V_z = \%0.3f$  V\
    n", Vz1);
22 printf("(c) When resistivity drops ,  $V_z = \%0.1f$  V\n",
    Vz2);
23 printf("(d)  $I = \%0.3e$  A", I);
24
25 // Result
26 // (a)  $V_z = 51/\sigma_p$  is proved
27 // (b)  $Vz1 = 2300V$ 
28 // (c)  $Vz2 = 198.9V$ 
29 // (d)  $I = 0.274$  mA
```

Scilab code Exa 2.37 Find the ideality factor

```
1 // Find the ideality factor
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-37 in page 112
7
8 clear; clc; close;
9
10 // Given data
11 I1=0.5*10^-3; // Diode current in mA at 340mV
12 I2=15*10^-3; // Diode current in mA at 465mV
13 kb_T=5*10^-3; // Constant in mV
14
15 // Calculation
16 // After simplifying the current equation we get an
    expression for eta
17 eta=5/(2.303*log10(30));
18
19 printf("Ideality factor = %0.2f",eta);
20
21 // Result
22 // Ideality factor = 1.47
```

Scilab code Exa 2.38 Temperature coefficient of Avalanche diode

```

1 // Temperature coefficient of Avalanche diode
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-38 in page 113
7
8 clear; clc; close;
9
10 // Given data
11 V=12; // Voltage of avalanche diode in V
12 T=1.7*10^-3; // Temperature coeff of Si diode
13
14 // Calculation
15 A=(T/V)*100;
16 printf("Temperature coeff in percentage = %0.4f
    percent/degree-C",A);
17
18 // Result
19 // Temperature coeff in percentage = 0.0142 %/degree
    -C

```

Scilab code Exa 2.39 Limits for varying V

```

1 // Limits for varying V
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 2-39 in page 113
7
8 clear; clc; close;
9

```

```

10 // Given data
11 I_d=5*10^-3; // Diode current in mA
12 R=2.5*10^3; // Resistance in K-ohm
13 I_T=40*10^-3; // Diode current in mA
14
15 // Calculation
16 I_max=I_T-I_d;
17 printf("(a)I_max = %0.2e A\n",I_max);
18 printf("(b)Minimum I_d for good regulation is 5 mA,
    hence I_T=30 mA\n");
19 V_max1=(30*3.5)+60;
20 printf("V_max = %0.0f V\n",V_max1);
21 printf("Maximum I_d for good regulation is 40 mA,
    hence I_T=65 mA\n");
22 V_max2=(65*3.5)+60;
23 printf("V_max = %0.1f V",V_max2);
24
25 // Result
26 // (a) I_max = 35 mA
27 // (b) V_max1 = 165 V
28 // (c) V_max2 = 287.5 V

```

Chapter 3

Diode Circuits

Scilab code Exa 3.1 Calculate the dc load current

```
1 // Find current if diode is forward-biased
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-1 in page 143
7
8 clear; clc; close;
9
10 // Given data
11 I=29.8*10^-3; // Current in mA
12 V=0.208; // Voltage in V
13
14 // Calculation
15 I=(45-V)/(1.5*10^3);
16 printf("I = %0.2e A\n",I);
17 printf("For this current ,V = 0.2 V\n");
18 printf("(a) Therefore I = 29.8 mA\n");
19 printf("(b) If battery is inserted with reverse
    polarity ,voltage drop across the 1.5 K resistors
    is only 15 mV and may be neglected\n");
```

```

20 printf("(c)In forward direction , I=29.8 mA\n");
21 printf("In reverse direction we draw a load line
    from V=-30 V to I=-30 mA\n");
22 y=[-30 -25 -20 -15 -10 -5 0];
23 x=[-30 -25 -20 -15 -10 -5 0];
24 x=-30-y;
25 plot(x,y);
26 xlabel('Voltage');
27 ylabel('Current');
28 title('Current in forward direction');
29 I=-30*(20/30);
30 printf("Then, I = %0.0f mA\n",I);
31 printf("Current=20 mA as there is a 10 V drop");
32
33 // Result
34 // Graph shows current in reverse direction
35 // I' = -20 mA
36 // Set axis positions to 'origin' in axis properties
    to view the graph correctly

```

Scilab code Exa 3.2 Find the diode currents

```

1 // Find the diode currents
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-2 in page 144
7
8 clear; clc; close;
9
10 // Given data
11 R=10*10^3; // Resistance in K-ohms

```



```

12
13 // Calculation
14 printf("(a) R = 10K. Assume both diodes are
    conducting. We have:\n");
15 printf("100 = 10.02*I1 + 10*I2 + 0.2\n 100 = 10.01*
    I2 + 10*I1 + 0.6\n");
16 function y=f(i);
17     y(1)=10.02*i(1)+10*i(2)+0.2-100
18     y(2)=10.015*i(2)+10*i(1)+0.6-100
19 endfunction
20 ans=fsolve([0.1;0.1],f);
21 I1=ans([1]);
22 I2=ans([2]);
23 printf("I1 = %0.3f A, I2 = %0.3f A\n",I1,I2);
24 printf("Solving, we find I2 < 0. Thus D is not ON\n");
25 I1=(100-0.2)/10.02;
26 printf("I1 = %0.2e A and I2 = 0\n\n",I1);
27 printf("(b) R=1K. Assume both diodes are ON, we have:\n
    n");
28 printf("100 = 1.52*I1 + 1.5*I2 + 0.2\n 100 = 1.515*
    I2 + 1.5*I1 + 0.6\n");
29 function y1=g(j);
30     y1(1)=1.52*j(1)+1.5*j(2)+0.2-100
31     y1(2)=1.515*j(2)+1.5*j(1)+0.6-100
32 endfunction
33 ans1=fsolve([0.1;0.1],g);
34 I1=ans1([1]);
35 I2=ans1([2]);
36 printf("Solving, we find\n I1 = %0.3f A and I2 = %0.3f
    A. Hence assumption is valid",I1,I2);
37
38 // Result
39 // Since both currents are positive, assumption is
    valid for I1 = 39.717 mA and I2 = 26.287 mA

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 3.3 Calculate break region

```
1 // Calculate break region
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-3 in page 145
7
8 clear; clc; close;
9
10 // Given data
11 R=10^4; // Factor multiplied with dynamic resistance
        of diode
12 Vt=26; // Thermal voltage in volts
13 eta1=2; // Constant at room temperature for Si
14 eta2=1; // Constant at room temperature for Ge
15
16 // Calculation
17 printf("r1/r2 = 10^4\n");
18 V1=eta1*Vt*4*2.3;
19 V2=eta2*Vt*4*2.3;
20 printf("Break region for silicon = %0.0f mV\n",V1);
21 printf("Break region for Germanium = %0.0f mV",V2);
22
23 // Result
24 // Break region for silicon = 478 mV
25 // Break region for Germanium = 239 mV
```

Scilab code Exa 3.4 Calculate the peak load current

```
1 // Calculate the peak load current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-4 in page 153
7
8 clear; clc; close;
9
10 // Given data
11 Rf=30; // Internal resistance in ohms
12 Rl=990; // Load resistance in ohms
13 Vm=110; // Rms supply voltage in in V
14
15 // Calculation
16 Im=(Vm/2)/(Rf+Rl);
17 I_dc=Im/%pi;
18 I_rms=Im/2;
19 V_dc=(Im*Rl)/%pi;
20 Pi=I_rms^2*(Rf+Rl);
21 R=((Vm/%pi)-(I_dc*Rl))/(I_dc*Rl))*100;
22
23 printf("(a)Im = %0.2e A\n",Im);
24 printf("(b)I_dc = %0.2e A\n",I_dc);
25 printf("(c)I_rms = %0.2e A\n",I_rms);
26 printf("(d)V_dc = %0.3e V\n",V_dc);
27 printf("(e)Input power = %0.2f W\n",Pi);
28 printf("(f)Percentage regulation = %0.3f percent",R)
29 ;
```

```

30 // Result
31 // (a) Im=53.9mA
32 // (b) Idc=17.2mA
33 // (c) Irms=27mA
34 // (d) Vdc=16.99V
35 // (e) Pi=0.74W
36 // (f) Percentage regulation=106%

```

Scilab code Exa 3.8 Calculate the dc load current

```

1 // Calculate the dc load current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-8 in page 157
7
8 clear; clc; close;
9
10 // Given data
11 Vm=280; // Supply voltage in V
12 Rl=2000; // Load resistance in ohms
13 Rf=500; // Internal resistance of the diodes in ohms
14
15 // Calculation
16 Idc=(2*Vm)/(2*pi*2500);
17 Idc_t=Idc/2;
18 printf("(a) I_dc = %0.2e A\n(b) I_dc (tube) = %0.2e A\n",
        Idc, Idc_t);
19 printf("(c) Voltage across conducting diode is
        sinusoidal with a peak value 0.2 Vm\n");
20 V_rms=0.905*(280*sqrt(2));
21 Pdc=Idc^2*Rl;

```

```

22 R=(Rf/Rl)*100;
23 printf("Rms voltage V_rms = %0.0f V\n",V_rms);
24 printf("(d)DC output power = %0.1f W\n",Pdc);
25 printf("(e)Percentage regulation = %0.0f percent",R)
    ;
26
27 // Result
28 // (a) Idc = 71 mA,
29 // (b) Idc_tube = 35.7 mA,
30 // (c) V_rms = 358 V,
31 // (d) P_dc = 10.167W,
32 // (e) Percentage regulation = 25%

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 3.10 Full scale reading of dc meter

```

1 // Full scale reading of dc metere
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-10 in page 158
7
8 clear; clc; close;
9
10 // Given data
11 R=5020; // Total resistance in ohm
12 Vrms=5.58; // Input rms voltage in V
13 // Calculation
14 I_dc=(2*sqrt(2)*Vrms)/(%pi*5020);
15 V_0=R*I_dc;

```

```
16 printf("Full scale reading = %0.2f V",V_0);
17
18 // Result
19 // Full scale reading = 5.58 V
```

Scilab code Exa 3.11 Find dc output Peak inverse voltage

```
1 // Find dc output,Peak inverse voltage
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-11 in page 159
7
8 clear; clc; close;
9
10 // Given data
11 Vi=220; // AC input voltage in V
12 N=10; // Turn ratio of transformer
13
14 // Calculation
15 V2=Vi/N;
16 Vm=sqrt(2)*V2;
17 V_dc=0.318*Vm;
18 PIV=Vm;
19
20 printf("(a)DC output voltage = %0.2f V\n",V_dc);
21 printf("(b)PIV = %0.2f V",Vm);
22
23 // Result
24 // (a) Dc output voltage = 9.89V
25 // (b) PIV = 31.11 V
```

Scilab code Exa 3.12 Determine maximum and average values of power

```
1 // Determine maximum and average values of power
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-12 in page 159
7
8 clear; clc; close;
9
10 // Given data
11 V1=230; // Input voltage in V
12 N=1/3; // Turn ratio
13 R1=200; // Load resistance in ohms
14
15 // Calculation
16 V2=V1*N;
17 Vm=sqrt(2)*V2;
18 Im=Vm/R1;
19 P=Im^2*R1;
20 Vdc=0.318*Vm;
21 Idc=Vdc/R1;
22 Pdc=Idc^2*R1;
23 printf("Maximum load power = %0.2 f W\n",P);
24 printf("Average load power = %0.2 f W",Pdc);
25
26 // Result
27 // Maximum power = 58.78 W
28 // Average power = 5.94 W
```

Scilab code Exa 3.13 Find maximum value of ac voltage

```
1 // Find maximum value of ac voltage
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-13 in page 160
7
8 clear; clc; close;
9
10 // Given data
11 Vdc=30; // DC voltage in V
12 Rf=25; // Internal resistance in ohms
13 Rl=500; // Load resistance in ohms
14
15 // Calculation
16 Idc=Vdc/Rl;
17 Im=%pi*Idc;
18 Vi=Im^2*(Rf+Rl);
19 printf("Voltage required at the input = %0.2f V",Vi)
20 ;
21 // Result
22 // Voltage required at the input is = 18.65 V
```

Scilab code Exa 3.14 Calculate ac voltage rectification efficiency


```

1 // Calculate ac voltage ,rectification efficiency
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-14 in page 160
7
8 clear; clc; close;
9
10 // Given data
11 Vdc=100; // DC voltage in V
12 Rl=500; // Load resistance in ohms
13 Rf=20; // Internal resistance in ohms
14
15 // Calculation
16 Idc=Vdc/Rl;
17 Im=Idc*%pi;
18 Vm=Im*(Rl+Rf);
19 eta=(0.406/(1+(Rf/Rl)))*100;
20
21 printf("(a)AC voltage required = %0.2f V\n",Vm);
22 printf("(b) Rectification efficiency = %0.0f percent"
    ,eta);
23
24 // Result
25 // (a) Vm = 326.73V
26 // (b) Rectification efficiency = 39 percent

```

Scilab code Exa 3.15 Find current dc voltage voltage across load

```

1 // Find current ,dc voltage ,voltage across load
2 // Basic Electronics
3 // By Debashis De

```

```

4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-15 in page 150
7
8 clear; clc; close;
9
10 // Given data
11 Vm=50; // Maximum voltage in V
12 f=50; // Frequency in Hz
13 Rf=20; // Internal resistance in ohms
14 Rl=5000; // Load resistance in ohms
15
16 // Calculation
17 Im=Vm/(Rl+Rf);
18 printf("Since diode conducts only during positive
        half of the input ,Im = %0.0e A\n",Im);
19 printf("(a)Hence i = 10*sin100*pi*t\n");
20 Vdc=(Im/%pi)*Rl;
21 printf("(b)V_dc = %0.1f V\n",Vdc);
22 printf("Hence V_0v=15.9 sin100*pi*t\n");
23 printf("(c)When diode is reverse biased ,voltage
        across diode = %0.1f*sin100*pi*t for 0<100*pi*t<
        pi and 0 for pi,100*pi*t<2*pi",Vdc);
24
25 // Result
26 // (a) Current in the circuit = 10 sin100*pi*t
27 // (b) DC output voltage across load = 15.9 sin100*pi
    *t
28 // (c) Voltage across diode = 15.9 sin100*pi*t for
    0<100*pi*t and 0 for pi<100*pi*t<2*pi

```

Scilab code Exa 3.16 Estimate value of capacitance needed

```

1 // Estimate value of capacitance needed
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-16 in page 161
7
8 clear; clc; close;
9
10 // Given data
11 Vrms=230; // RMS voltage in V
12 f=50; // Frequency in Hz
13 gamma_hwr=0.003; // Ripple factor assumed
14 I=0.5; // Load current in A
15
16 // Calculation
17 Vm=sqrt(2)*Vrms;
18 Vdc=(Vm/%pi);
19 Rl=Vdc/I;
20 C=1/(2*sqrt(3)*f*gamma_hwr*Rl);
21 printf("Capacitance needed = %0.2e F",C);
22
23 // Result
24 // Capacitance needed = 9.29 mF

```

Scilab code Exa 3.17 Calculate the ripple factor

```

1 // Calculate the ripple factor
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-17 in page 161

```

```

7
8 clear; clc; close;
9
10 // Given data
11 Rl=3.15*10^3; // Load resistance in K-ohms
12 Rf=20; // Internal resistance in ohms
13 Vm=230; // Maximum voltage in volts
14 f=50; // Frequency in Hertz
15
16 // Calculation
17 Irms=0.707*(Vm/(Rl+Rf));
18 Idc=0.637*(Vm/(Rl+Rf));
19 gamma_fwr=sqrt((Irms/Idc)^2-(1));
20
21 printf("Ripple factor = %0.2f",gamma_fwr);
22
23 // Result
24 // Ripple factor = 0.48

```

Scilab code Exa 3.18 Find DC output voltage pulse frequency

```

1 // Find DC output voltage ,pulse frequency
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-18 in page 162
7
8 clear; clc; close;
9
10 // Given data
11 Vp=230; // Peak voltage in V
12 f=50; // Frequency in Hz

```

```

13 Rl=200; // Load resistance in ohms
14 N=1/4; // Turn ratio
15
16 // Calculation
17 Vs=Vp*N;
18 Vm=Vs*sqrt(2);
19 Idc=(2*Vm)/(pi*Rl);
20 Vdc=Idc*Rl;
21 fout=2*f;
22 printf("(a)DC output voltage = %0.2f V\n",Vdc);
23 printf("(b)Pulse frequency of output = %0.0f Hz",
    fout);
24
25 // Result
26 // (a) Vdc = 51.77 V
27 // (b) F_out = 100 HZ

```

Scilab code Exa 3.19 Find maximum dc voltage

```

1 // Find maximum dc voltage
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-19 in page 162
7
8 clear; clc; close;
9
10 // Given data
11 Vp=220; // Peak voltage in V
12 f=50; // Frequency in Hz
13 Rl=1.5*10^3; // Load resistance in ohms
14 N=0.1; // Turn ratio

```

```

15
16 // Calculation
17 Vs=Vp*N;
18 Vrms=Vs*sqrt(2);
19 Vm=Vrms/2;
20 Idc=(2*Vm)/(pi*Rl);
21 Vdc=Idc*Rl;
22 printf("Maximum dc output voltage = %0.2f V",Vdc);
23
24 // Result
25 // Dc output voltage = 9.9 V

```

Scilab code Exa 3.20 Calculate input voltage value of filter

```

1 // Calculate input voltage ,value of filter
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-20 in page 163
7
8 clear; clc; close;
9
10 // Given data
11 Vdc=30; // DC voltage in volts
12 Rl=1000; // Load resistance in ohms
13 gamma_fwr=0.015; // Ripple factor
14
15 // Calculation
16 Idc=Vdc/Rl;
17 C=2900/(gamma_fwr*Rl);
18 Vm=Vdc+((5000*Idc)/C);
19 Vi=(2*Vm)/sqrt(2);

```

```

20 printf("Value of capacitor filter = %0.0f mu-F",C);
21 printf("Input voltage required = %0.2f V\n",Vi);
22
23
24 // Result
25 // V_in = 43.52 V
26 // C = 193 mu-F

```

Scilab code Exa 3.21 Calculate inductance for L section filter

```

1 // Calculate inductance for L-section filter
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-21 in page 163
7
8 clear; clc; close;
9
10 // Given data
11 C=40*10^-6; // Capacitance in micro-F
12 r=0.0001; // Ripple factor
13 Vm=40; // Maximum voltage in V
14 Idc=0.1; // DC current in A
15 R=40; // Circuit resistance in ohms
16
17 // Calculation
18 L=(1.76/C)*sqrt(0.472/r);
19 Vdc=((2*sqrt(2)*Vm)/%pi)-(Idc*R);
20
21 printf("(a) Inductance L = %0.2e H\n",L);
22 printf("(b) Output voltage = %0.0f V",Vdc);
23

```

```
24 // Result
25 // (a)  $L = 3.02 \times 10^6$  H
26 // (b)  $V_{dc} = 32$  V
```

Scilab code Exa 3.22 DC output voltage and ripple voltage

```
1 // DC output voltage and ripple voltage
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-22 in page 164
7
8 clear; clc; close;
9
10 // Given data
11 C=4; // Capacitances in micro-F
12 L=20; // Inductance choke in H
13 I1=50*10^-6; // Load current in micro-A
14 R=200; // Resistance of choke in ohm
15
16 // Calculation
17 Vdc=(300*sqrt(2))-((4170/C)*0.05)-(0.05*R);
18 r=(3300*0.05)/(4*4*20*353);
19 Vrms=r*Vdc;
20
21 printf("(a) Output voltage = %0.2f V\n",Vdc);
22 printf("(b) Ripple voltage = %0.3f V",Vrms);
23
24 // Result
25 // (a) Output voltage = 362.13 V
26 // (b) Ripple voltage = 0.529 V
```

Scilab code Exa 3.23 Sketch steady state output

```
1 // Sketch steady state output
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3–23 in page 168
7
8 clear; clc; close;
9
10 // Given data
11 Rf=0; // Forward resistance of diode
12 Rr=2*10^6; // Reverse resistance of diode
13
14 // Calculation
15 printf("Diode conducts when Vi<2.5 V\n");
16 printf("Diode is open when Vi>2.5 V and Vo = 2.5+((
    Vi-2.5)/3)\n");
17 printf("Diode conducts when Vi>2.5 V");
18
19 // Result
20 // Diagram shows the output of the clipping circuit
    to a sinusoidal input
```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 3.24 Sketch output voltage V_o

```
1 // Sketch output voltage  $V_o$ 
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-24 in page 169
7
8 clear; clc; close;
9
10 // Given data
11 // Data is provided in the diagrams
12
13 // Calculation
14 printf("(a)When  $V_i < 50$  V, Second diode conducts\n");
15  $V_o = 100 - ((2/3) * 27)$ ;
16 printf("Vo = %0.0 f V\n",  $V_o$ );
17 printf("When  $50 < V_i < 100$  both diodes conduct and  $V_o = V_i$ 
    .When  $V_i > 100$ , only the first diode conducts.Hence
     $V_o = 100$  V\n");
18 printf("(b)When  $V_i < 25$  V, neither diodes conduct and
     $V_o = 25$  V.When  $V_i > 25$ , upper diode conducts\n");
19  $V_i = ((100 - 25) * (3/2)) + 25$ ;
20 printf("When  $V_o$  reaches 100 V,  $V_i$  rises to %0.1 f V",
     $V_i$ );
21
22 // Result
23 // The output voltage is shown in the xcos diagrams
```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 3.25 Devise a circuit

```
1 // Devise a circuit
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-25 in page 169
7
8 clear; clc; close;
9
10 // The xcos diagram shows the devised circuit
```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 3.27 Find currents and voltages

```
1 // Find currents and voltages
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-27 in page 179
7
8 clear; clc; close;
9
10 // Given data
11 //Diode acts as short circuited.Both diodes are
    forward biased
12 V1=0; // Voltage at junction 1 in V
13 V2=0; // Voltage at junction 2 in V
14
15 //Calculation
16 I1=(20-V1)/(20*10^3);
```

```

17 I2=(V2-(-10))/(20*10^3);
18
19 printf(" I1 = %0.0 e A\n",I1);
20 printf(" I2 = %0.1 e A",I2);
21
22 // Result
23 // I1 = 1 mA
24 // I2 = 0.5 mA

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 3.28 Find voltage across diode

```

1 // Find voltage across diode
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-28 in page 180
7
8 clear; clc; close;
9
10 // Given data
11 I=0.1075; // Cirremt across diode in A
12 Rd=1; // Internal resistance of diode in ohm
13
14 // Calculation
15 Vd=I*Rd;
16 printf(" Voltage across diode = %0.4 f V",Vd);
17
18 // Result
19 // Voltage across diode = 0.1075 V

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 3.30 Calculate R I_L max

```
1 // Calculate R, IL(max)
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 3-30 in page 181
7
8 clear; clc; close;
9
10 // Given data
11 V0=50; // Zener diode voltage in V
12 IL=0; // Load current in A
13
14 // Calculation
15 R=(150)/(40*10-3);
16 printf("(a)R = %0.2e ohm\n",R);
17 printf("IL = Imax when Id = Id_min = 10mA\n");
18 ILmax=40-10;
19 printf("(b)Maximum load current = %0.0f mA",ILmax);
20
21 // Result
22 // (a) R = 3.75 K-ohms
23 // (b) ILmax = 30 mA
```

This code can be downloaded from the website www.scilab.in

Chapter 4

BJT Fundamentals

Scilab code Exa 4.1 Calculate Base and Collector Currents

```
1 // Calculate Base and Collector Currents
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-1 in page 208
7
8 clear; clc; close;
9
10 // Given Data
11 alpha=0.90; // Current Gain in CB mode
12 Ico=15*10^-6; // Reverse saturation Current in micro
    -A
13 Ie=4*10^-3; // Emitter Current in mA
14
15 // Calculations
16 Ic=Ico+(alpha*Ie);
17 Ib=Ie-Ic;
18
19 printf("(a)The value of the Base Current is %0.2e A
    \n",Ib);
```

```

20 printf("(b)The value of the Collector Current is %0
    .3e A \n",Ic);
21
22 // Results
23 // (a) The value of the Base Current is 385 mu-A
24 // (b) The value of the Collector Current is 3.615
    mA

```

Scilab code Exa 4.2 Calculate alpha using beta

```

1 // Calculate alpha using beta
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-2 in page 209
7
8 clear; clc; close;
9
10 // Given Data
11 beta_bjt=90; // beta gain for the BJT
12 Ic=4*10^-3; // Collector Current in mA
13
14 // Calculations
15 alpha=beta_bjt/(1+beta_bjt);
16 Ib=Ic/beta_bjt;
17 Ie=Ic+Ib;
18
19 printf("(a)The Current gain alpha for BJT is %0.3f \
    n",alpha);
20 printf("(b)The value of the base Current is %0.2e A
    \n",Ib);
21 printf("(c)The value of the Emitter Current is %0.2e

```



```

    A \n",Ie);
22
23 // Results
24 // (a) The Current Gain alpha for BJT is 0.989
25 // (b) The value of the Base Current is 44.44 mu-A
26 // (c) The value of the Emitter Current is 4.04 mA

```

Scilab code Exa 4.3 Collector Current in C E mode

```

1 // Collector Current in C-E mode
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-3 in page 209
7
8 clear; clc; close;
9
10 // Given Data
11 alpha=0.90; // Current Gain of BJT
12 Ico=15*10^-6; // Reverse Saturation Current of BJT
    in micro-A
13 Ib=0.5*10^-3; // Base Current in C-E mode in mA
14
15 // Calculations
16 beta_bjt=alpha/(1-alpha);
17 Ic=(beta_bjt*Ib)+(beta_bjt+1)*Ico;
18
19 printf("(a)The value of Current gain beta for BJT is
    %0.0f \n",beta_bjt);
20 printf("(b)The value of the Collector Current is %0
    .2e A \n",Ic);
21

```

```
22 // Results
23 // (a) The value of Current Gain beta for BJT is 9
24 // (b) The value of the Collector Current is 4.65 mA
```

Scilab code Exa 4.4 Calculate beta for the BJT

```
1 // Calculate beta for the BJT
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-4 in page 209
7
8 clear; clc; close;
9
10 // Given Data
11 Ib=20*10^-6; // Base current in micro-A
12 Ic=5*10^-3; // Collector Current in mA
13
14 // Calculations
15 beta_bjt=Ic/Ib;
16
17 printf("The Current gain beta for the Device is %0.0
18         f \n",beta_bjt);
19
20 // Results
21 // The Current Gain beta for the Device is 250
```

Scilab code Exa 4.5 To Compute Alpha Beta and Emitter Current

```

1 // To Compute alpha , beta and Emitter Current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-5 in page 209
7
8 clear; clc; close;
9
10 // Given Data
11 Ib=50*10^-6; // Base Current in mu-A
12 Ic=5*10^-3; // Collector Current in mA
13
14 // Calculations
15 Ie=Ic+Ib;
16 beta_bjt=Ic/Ib;
17 alpha=Ic/Ie;
18
19 printf("(a)The value of the Emitter Current is %0.2e
        A \n",Ie);
20 printf("(b)The value of beta gain of the BJT is %0.0
        f \n",beta_bjt);
21 printf("(c)The value of alpha gain of the BJT is %0
        .3f \n",alpha);
22
23 // Results
24 // (a) The value of the Emitter Current is 5.05 mA
25 // (b) The value of the beta gain of the BJT is 100
26 // (c) The value of the alpha gain of the BJT is
        0.990

```

Scilab code Exa 4.6 Calculate alpha reverse and beta reverse

```

1 // Calculate alpha reverse and beta reverse
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-6 in page 210
7
8 clear; clc; close;
9
10 // Given Data
11 Ie=10*10^-3; // Emitter Current in mA
12 Ib=5*10^-3; // Base Current in mu-A
13
14 // Calculations
15 Ic=Ie-Ib;
16 beta_reverse=Ib/Ic;
17 alpha_reverse=Ie/Ic;
18
19 printf("The value of inverse beta of the BJT is %0.0
    f \n",beta_reverse);
20 printf("The value of inverse alpha of the BJT is %0
    .0f \n",alpha_reverse);
21
22 // Results
23 // The value of inverse beta of the BJT is 1
24 // The value of inverse alpha of the BJT is 2

```

Scilab code Exa 4.7 Calculate Labeled Currents and Voltages

```

1 // Calculate Labeled Currents and Voltages
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010

```

```

5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-7 in page 210
7
8 clear; clc; close;
9
10 // Given Data
11 beta_bjt=100; // beta gain of BJT
12 Vbe=0.7; // Base-Emitter voltage of BJT in V
13
14 // Calculation
15 Vcc1=10;
16 Vee1=-10;
17 Ve1=-0.7;
18 R1=10*10^3;
19 Ie1=(Vcc1-Vbe)/R1;
20 Ib1=Ie1/(beta_bjt+1);
21 Vc1=Vcc1-R1*(Ie1-Ib1);
22 Vcc2=10;
23 Vee2=-15;
24 Ve2=-0.7;
25 R2=5*10^3;
26 Ie2=(Vcc2-Vbe)/R2;
27 Ic2=(beta_bjt/(beta_bjt+1))*Ie2;
28 Vc2=Vee2+R2*(Ie2);
29 printf(" Circuit 1:\n(a) Emitter Current=%0.2e A\n(b)
      Base Current=%0.2e A\n(c) Collector Voltage=%0.3f
      V\n\n", Ie1, Ib1, Vc1);
30 printf(" Circuit 2:\n(a) Emitter Current=%0.2e A\n(b)
      Collector Current=%0.3e A\n(c) Collector Voltage=
      %0.3f V\n", Ie2, Ic2, Vc2);
31
32 // Results
33 // (a) Circuit 1 : Emitter Current = 0.93 mA
34 // (b) Circuit 1 : Base Current = 9.2 mu-A
35 // (c) Circuit 1 : Collector Voltage = 0.792 V
36
37 // (a) Circuit 2 : Emitter Current = 1.86 mA
38 // (b) Circuit 2 : Collector Current = 1.842 mA

```

39 `//(c) Circuit 2 : Collector Voltage : -5.7 V`

This code can be downloaded from the website www.scilab.in

Scilab code Exa 4.8 Calculate labeled Voltages

```
1 // Calculate labeled Voltages
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-8 in page 211
7
8 clear; clc; close;
9
10 // Given Data
11 Vbe=0.7; // Base-Emitter voltage of BJT in V
12 Vcc2=10; // DC voltage across Collector in V
13 Vee2=-15; // DC voltage across Emitter in V
14 Rc2=5*10^3; // Collector Resistance in K-ohms
15 // Beta Current Gain of BJT is Infinity
16
17 // Calculations
18 Vb1=0;
19 Ve1=-0.7;
20 Ve2=0.7;
21 Vc2=Vee2+Rc2*((Vcc2-Vbe)/Rc2);
22
23 printf("Circuit 1:\n(a)Base Voltage = %0.1f V\n(b)
      Emitter Voltage = %0.1f V\n",Vb1,Ve1);
24 printf("Circuit 2:\n(a)Emitter Voltage = %0.1f V\n(b
      )Collector Voltage = %0.1f V\n",Ve2,Vc2);
```

```

25
26 //Results
27 // Circuit 1 : Base Voltage = 0 V
28 // Circuit 1 : Emitter Voltage = -0.7 V
29 // Circuit 2 : Emitter Voltage = 0.7 V
30 // Circuit 2 : Collector Voltage = -5.7 V

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 4.9 Calculating BJT parameters assuming Vbe

```

1 // Calculating BJT parameters assuming Vbe
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-9 in page 211
7
8 clear; clc; close;
9
10 // Given Data
11 Ve=1; // Emitter Voltage of BJT in V
12 Vbe=0.7; // Base-Emitter Voltage of BJT in V
13 Rb=20*10^3; // Base Resistance of Circuit in K-ohms
14 Rc=5*10^3; // Collector Resistance of Circuit in K-
    ohms
15 Re=5*10^3; // Emitter Resistance of Circuit in K-
    ohms
16 Vcc=5; // DC voltage across Collector in V
17 Vee=-5; // DC voltage across Emitter in V
18
19 // Calculations

```

```

20 Vb=Ve-Vbe;
21 Ib=Vb/Rb;
22 Ie=(Vcc-1)/Re;
23 Ic=Ie-Ib;
24 Vc=(Rc*Ic)-Vcc;
25 beta_bjt=Ic/Ib;
26 alpha=Ic/Ie;
27
28 printf("Circuit Parameters:\n(a)Base Voltage = %0.3f
      V\n(b)Base Current = %0.3e A\n(c)Emitter Current
      = %0.3e A\n(d)Collector Current = %0.3e A\n(e)
      Collector Voltage = %0.3f V\n(f)beta gain = %0.3f
      \n(g)alpha gain = %0.3f\n",Vb,Ib,Ie,Ic,Vc,
      beta_bjt,alpha);
29
30 // Results
31 // For the BJT Circuit ,
32 // (a) Base Voltage = 0.3 V
33 // (b) Base Current = 0.015 mA
34 // (c) Emitter Current = 0.8 mA
35 // (d) Collector Current = 0.785 mA
36 // (e) Collector Voltage = -1.075 volt
37 // (f) Beta gain = 52.3
38 // (g) Alpha gain = 0.98

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 4.10 Measurement of Circuit Voltage changes

```

1 // Measurement of Circuit Voltage changes
2 // Basic Electronics
3 // By Debashis De

```



```

4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-10 in page 211
7
8 clear; clc; close;
9
10 // Given Data
11 Vb=-5; // Base Voltage of BJT in V
12 Rc=1*10^3; // Collector Resistance in K-ohms
13 Ie=2*10^-3; // Emitter Current of BJT in mA
14 delB=+0.4; // Change in Base Voltage
15
16 // Calculations
17 delE=+0.4;
18 delC=0;
19
20 printf("(a)Change in Emitter voltage is +%0.2f V\n",
        delE);
21 printf("(b)Change in Collector Voltage is %0.2f V\n"
        ,delC);
22
23 // Results
24 // (a) Change in Emitter Voltage in the Circuit =
        +0.4 V
25 // (b) Change in Collector Voltage in the Circuit =
        0.0 V

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 4.11 To Determine mode of operation of BJT

```

1 // Determine mode of operation of BJT

```

```

2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 4-11 in page 212
7
8 clear; clc; close;
9
10 // Given Data
11 Vbe=0.7; // Base-Emitter Voltage in V
12 beta_bjt=100; // beta gain of BJ
13
14 // Calculation
15 printf("Assume active mode for circuit 1\n");
16 Vb1=2;
17 Ve_1=Vb1-Vbe;
18 Ie1=1*10^-3;
19 Ic1=Ie1*(beta_bjt/(1+beta_bjt));
20 Ve1=6-(3*0.99);
21 printf("(a)Ve = %0.2f V\n(b)Ic = %0.2e A\n(c)Ve = %0
    .2f V\n",Ve_1,Ic1,Ve1);
22 printf("Thus the circuit operates in an active mode\
    n\n");
23
24 printf("For circuit 2,assume active mode\n");
25 Vcc=1;
26 Ve2=Vcc+Vbe;
27 Ie2=(6-Ve2)/(10*10^3);
28 Vc=0+(10*0.43);
29 printf("(a)Ve = %0.1f V\n(b)Ie = %0.2e A\n(c)Vc = %0
    .2f V\n",Ve2,Ie2,Vc);
30 printf("This circuit operates in a saturated mode\n\
    n");
31
32 printf("For circuit 3,assume active mode\n");
33 Ve3=-5+Vbe;
34 Ie3=(9.5-Ve3)/(200*10^3);
35 Ic=Ie3*(beta_bjt/(1+beta_bjt));

```

```

36 Vc3=-50+(0.492*20);
37 printf("(a)Ve = %0.1f V\n(b)Ie = %0.4e A\n(c)Ic = %0
    .3e A\n(d)Vc = %0.1f V\n",Ve3,Ie3,Ic,Vc3);
38 printf("The circuit operates in an active mode\n\n")
    ;
39
40 printf("For circuit 4,assume active mode\n");
41 Ve4=-20.7;
42 Ie4=(30+Ve4)/(5*10^3);
43 Vc4=(-Ie4*(beta_bjt/(1+beta_bjt))*(2*10^3))-10;
44 printf("(a)Ie = %0.2e A\n(b)Vc = %0.2f V\n",Ie4,Vc4)
    ;
45 printf("The circuit operates in an active mode");
46
47 // Result
48 // (a) Circuit 1 operates in active mode
49 // (b) Circuit 2 operates in saturation mode
50 // (c) Circuit 3 operates in active mode
51 // (d) Circuit 4 operates in active mode

```

This code can be downloaded from the website www.scilab.in

Chapter 5

BJT Circuits

Scilab code Exa 5.1 Calculate BJT parameters using beta gain

```
1 // Calculate BJT parameters using beta gain
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 5-1 in page 235
7
8 clear; clc; close;
9
10 // Part 1
11 // Given Data
12 beta_bjt=100; // Beta Gain of BJT
13 Vcc=10; // DC voltage across Collector in V
14 Rb=100000; // Base Resistance of BJT in ohm
15 Rc=2000; // Collector Resistance of BJT in ohm
16 Vbe=0.7; // Base-Emitter voltage of BJT
17
18 // Calculations
19 Ib=(Vcc-Vbe)/((beta_bjt*Rc)+Rc+Rb);
20 Ic=beta_bjt*Ib;
21
```

```

22 Vce=Vcc-(Ib+Ic)*Rc;
23
24 printf("Part 1 \n");
25 printf("(a)The value of Base Current in the BJT
    circuit is %0.3e A \n",Ib);
26 printf("(b)The value of Collector Current in the BJT
    circuit is %0.3e A \n",Ic);
27 printf("(c)The value of Collector-Emmitter voltage in
    the circuit is %0.3f V \n",Vce);
28
29 // Part 2
30 // Given Data
31 Vce2=7; // Collector-Emmitter voltage of BJT
32 Vcc=10; // DC voltage across Collector in V
33 Rc=2000; // Collector Resistance of BJT in ohm
34 Vbe=0.7; // Base-Emmitter voltage of BJT
35 Rc2=2000; // Collector Resistance of BJT in ohm
36
37 // Calculations
38 constant=(Vcc-Vce2)/Rc;
39 Ib2=constant/101;
40 Ic2=100*Ib2;
41 Rb2=(Vcc-Vbe-(Rc2*constant))/Ib2;
42
43 printf("\nPart 2 \n");
44 printf("(a)The value of the Base Resistance of the
    Circuit is %0.3e ohm \n ",Rb2);
45
46 // Results
47 // Circuit 1: Value of Base Current of circuit =
    0.031 mA
48 // Circuit 1: Value of Collector Current of circuit
    = 3.1 mA
49 // Circuit 1: Value of Collector-Emmitter voltage of
    BJT circuit = 3.779 V
50 // Circuit 2: Value of BAse Resistance required =
    424.24 K-ohm

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 5.4 To establish Operating Point and Stability Factor

```
1 // To establish Operating Point & Stability Factor
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 5-4 in page 238
7
8 clear; clc; close;
9
10 // Given Data
11 beta_bjt=50; // Beta Gain of the BJT circuit
12 Vbe=0.7; // Base-Emitter voltage of BJT in V
13 Vcc=22.5; // DC voltage across Collector in V
14 Rc=5600; // Resistance across Collector in ohm
15 Vce=12; // Operating Collector-Emitter voltage of
    circuit in V
16 Ic=1.5*10^-3; // Operating Collector current of
    circuit in mA
17 sfactor=3; // Stability factor of the circuit
18
19 // Calculations
20 Re=((Vcc-Vce)/Ic)-Rc;
21 constant=((beta_bjt+1)*(sfactor-1))/((beta_bjt+1)-
    sfactor);
22 Rb=constant*Re;
23 Ib=Ic/beta_bjt;
24 voltage=(Ib*Rb)+Vbe+((Ib+Ic)*Re);
```

```

25 R1=Rb*(Vcc/voltage);
26 R2=(R1*voltage)/(Vcc-voltage);
27
28 printf("(a)The value of Emitter Resistance of the
    BJT circuit is %0.2e ohm \n",Re);
29 printf("(b)The value of Resistance-1 of the BJT
    circuit is %0.2e ohm \n",R1);
30 printf("(c)The value of Resistance-2 of the BJT
    circuit is %0.2e ohm \n",R2);
31
32 // Results
33 // The value of Emitter Resistance of the BJT
    circuit is 1.4 K-ohm
34 // The value of Resistance-1 of the BJT circuit is
    22.8 K-ohm
35 // The value of Resistance-2 of the BJT circuit is
    3.4 K-ohm

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 5.5 Design Bias Circuit for given Stability Factor

```

1 // Design Bias Circuit for given Stability Factor
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 5-5 in page 239
7
8 clear; clc; close;
9
10 // Given data

```

```

11 Vcc=20; // Supply DC Voltage in V
12 Rc=1.5*10^3; // Collector Resistance in ohm
13 Vce=8; // Collector-Emmitter Resistance in V
14 Ic=4*10^-3; // Collector Current in A
15 S=12; // Stability Factor of circuit
16 beta_bjt=50; // Beta Gain of BJT
17
18 // Calculations
19 Ib=Ic/beta_bjt;
20 Re=(Vcc-Vce-Ic*Rc)/(Ib+Ic);
21 Rb=Re*((S*beta_bjt)/((beta_bjt+1)-S));
22 Ie=Ic+Ib;
23 Vbn=0.2+Ie*Re;
24 Vth=Vbn+Ib*Rb;
25 R1=(Vcc*Rb)/Vth;
26 Ir1=(Vcc-Vbn)/R1;
27 Ir2=Ir1-Ib;
28 R2=Vbn/Ir2;
29
30 // For S=3
31 S_2=3;
32 Rc_2=1.47*10^3;
33 Re_2=Re;
34 Rb_2=Re*((S_2*beta_bjt)/((beta_bjt+1)-S_2));
35 Vth_2=Vbn+(Ib*Rb_2)+6.16;
36 R1_2=(Vcc*Rb_2)/Vth_2;
37 Ir1_2=(Vcc-Vbn)/R1_2;
38 Ir2_2=Ir1_2-Ib;
39 R2_2=Vbn/Ir2_2;
40
41 printf("For S=12 \n");
42 printf("(a) Ib = %0.2e A \n(b) Ir1 = %0.2e A \n(c) Ir2
    = %0.2e A \n", Ib, Ir1, Ir2);
43 printf("(d) Re = %0.2e ohm \n(e) Rb = %0.2e ohm \n(f)
    R1 = %0.2e ohm \n(g) R2 = %0.2e ohm \n", Re, Rb, R1,
    R2);
44 printf("(h) Base-Ground Voltage Vbn = %0.2f V \n(i)
    Thevenin Voltage Vth = %0.2f V \n", Vbn, Vth);

```



```

45 printf("\n For S=3 \n");
46 printf("(a)Re = %0.2e ohm \n(b)Rb = %0.2e ohm \n(c)
    R1 = %0.2e ohm \n(d)R2 = %0.2e ohm \n",Re_2,Rb_2,
    R1_2,R2_2);
47 printf("(e)Thevenin Voltage Vth = %0.2f V \n(f)Ir1 =
    %0.2e A \n(g)Ir2 = %0.2e A \n",Vth_2,Ir1_2,Ir2_2
    );
48
49 // Results
50 // S=12
51 // (a) Ib=80 mu-A
52 // (b) Re=1.47 K-ohm
53 // (c) Rb=21.17 K-ohm
54 // (d) Vbn=5.91 V
55 // (e) Vth=7.60 V
56 // (f) R1=55.71 K-ohm
57 // (g) R2=37.16 K-ohm
58 // (h) IR1=0.253 mA
59 // (i) IR2=0.173 mA
60 // S=3
61 // (a) Rb=3.13 K-ohm
62 // (b) R1=10.16 K-ohm
63 // (c) IR1=1.387 mA
64 // (d) R2=4.52 K-ohm
65 // (e) IR2=1.307 mA

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 5.8 Calculate circuit parameters of a Emitter Follower

```

1 // Calculate circuit parameters of a Emitter
  Follower

```

```

2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 5-8 in page 251
7
8 clear; clc; close;
9
10 // Given data
11 Rs=0.5*10^3; // Source resistance in ohm
12 Rl=5*10^3; // Load resistance in ohm
13 hfe=50; // h-parameter value of the BJT
14 hie=1*10^3; // h-parameter value of the BJT in ohm
15 hoe=25*10^-6; // h-parameter value of the BJT in A/V
16
17 // Calculations
18 Ai=(1+hfe)/(1+hoe*Rl);
19 Ri=hie+Ai*Rl;
20 Av=1-(hie/Ri);
21 Avs=Av*(Ri/(Ri+Rs));
22
23 printf("(a)The current gain of circuit Ai = %0.1f \n
",Ai);
24 printf("(b)The input resistance of circuit Ri = %0.2
e ohm \n",Ri);
25 printf("(c)The voltage gain of circuit Av = %0.4f \n
",Av);
26 printf("(d)The voltage gain of circuit Avs = %0.4f \
n",Avs);
27
28 // Results
29 // (a) The current gain of circuit Ai=45.3
30 // (b) The input resistance of circuit Ri=227 ohm
31 // (c) The voltage gain of circuit Av=0.9956
32 // (d) The voltage gain of circuit Avs=0.9934

```

Scilab code Exa 5.9 Design of an Emitter Follower

```
1 // Design of an Emitter Follower
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 5-9 in page 252
7
8 clear; clc; close;
9
10 // Given data
11 Ri=500*10^3; // Input Resistance in ohm
12 Ro=20; // Output Resistance in ohm
13 hfe=50; // h-parameter of BJT
14 hie=1*10^3; // h-parameter of BJT in ohm
15 hoe=25*10^-6; // h-parameter of BJT in A/V
16 const=499*10^3; // Product of Ai and Rl in ohm
17 Av=0.999; // Voltage gain of circuit
18 const_2=10^6; // Product of Ai and Rl in ohm for Av
    =0.999
19
20 // Calculations
21 Ai=1+hfe-(const*hoe);
22 Rl=const/Ai;
23 Rs=((hfe+1)*hoe*Ro)-hie;
24 Ri_2=hie/(1-Av);
25 Rl_2=((1+hfe)/const_2)-1)/hoe;
26
27 printf("The current gain of circuit=%0.1f \n",Ai);
28 printf("When Av=0.999, \n(a)Ri=%0.2e ohm \n(b)Rl=%0
    .2e ohm \n",Ri_2,Rl_2);
```

```
29
30 // Results
31 // The current gain of circuit = 38.5
32 // For Av = 0.999,
33 // (a) Ri = 1 M-ohm,
34 // (b) Rl = -40.0 K-ohm
```

This code can be downloaded from the website www.scilab.in

Chapter 6

Field Effect Transistor

Scilab code Exa 6.1 Determine approximate drain source resistance

```
1 // Determine approximate drain-source resistance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-1 in page 274
7
8 clear; clc; close;
9
10 // Given data
11 I_ds=10*10^-3; // Drain current in mA
12 Vp=-2; // Peak voltage in V
13 Vgs=[0 -0.5]; // Values of Vgs in V
14
15 // Calculation
16 alp=[1 2];
17 for i=1:2
18     r=Vp^2/(2*I_ds*(Vgs(i)-Vp));
19     printf("( %0.0 f) r_ds when Vgs = %d V is %0.2 f ohm
20         \n",alp(i),Vgs(i),r);
20 end
```

```

21
22 // Result
23 // (a) When  $V_{gs} = 0$  V,  $r_{ds} = 100$  ohms
24 // (b) When  $V_{gs} = 0.5$  V,  $r_{ds} = 133.33$  ohms

```

Scilab code Exa 6.2 Find I_d and V_{ds}

```

1 // Find  $I_d$  and  $V_{ds}$ 
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-2 in page 274
7
8 clear; clc; close;
9
10 // Given data
11  $I_{ds}=12 \times 10^{-3}$ ; // Drain current in mA
12  $V_p=-4$ ; // Peak voltage in V
13  $V_{gs}=-2$ ; // Gate to source voltage in V
14  $R_d=3 \times 10^3$ ; // Drain resistance in K-ohms
15  $V_{cc}=15$ ; // Supply voltage in V
16
17 // Calculation
18  $i_d=I_{ds} \times (1 - (V_{gs}/V_p))^2$ ;
19  $V_{ds}=-i_d \times R_d + V_{cc}$ ;
20
21 printf("(a)  $I_d = \%0.0e$  A\n",  $i_d$ );
22 printf("(b)  $V_{ds} = \%0.0f$  V",  $V_{ds}$ );
23
24 // Result
25 // (a)  $I_d = 3mA$ 
26 // (b)  $V_{ds} = 6V$ 

```

Scilab code Exa 6.3 Find the value of Rd

```
1 // Find the value of Rd
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-3 in page 275
7
8 clear; clc; close;
9
10 // Given data
11 Ids=12*10^-3; // Drain current in mA
12 Vp=-4; // Peak voltage in V
13 Rs=0; // Source resistance in ohms
14 Vds=0.1; // Drain-source voltage in V
15 Vgg=0; // Gate voltage in V
16
17 // Calculation
18 id=Ids*(50*10^-3-625*10^-6);
19 Rd=(15-Vds)/id;
20
21 printf("(a) i_d = %0.3e A\n",id);
22 printf("(b) Rd = %0.3e ohm",Rd);
23
24 // Result
25 // (a) i_d = 592.6 mu-A
26 // (b) Rd = 25.15 k-ohm
```

Scilab code Exa 6.4 Find i_d V_{ds} slope of operation of JFET

```
1 // Find  $i_d$ ,  $V_{ds}$ , slope of operation of JFET
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-4 in page 275
7
8 clear; clc; close;
9
10 // Given data
11 Ids=12*10^-3; // Drain current in mA
12 Vp=-4; // Peak voltage in V
13 Rd=1*10^3; // Drain resistance in k-ohm
14 Vdd=15; // Drain voltage in V
15
16 // Calculation
17 Id=Ids;
18 Vds=(-Rd*Id)+Vdd;
19 printf("Id = %0.2e A\n", Id);
20 printf("Vds = %0.0f V\n", Vds);
21 printf("Consider it to be operating in the ohmic
    region\n");
22 Vds1=(7+sqrt(49-45))/(3/2);
23 Vds2=(7-sqrt(49-45))/(3/2);
24 printf("Then Vds = %0.2f V, %0.2f V\n", Vds1, Vds2);
25 printf("6V is neglected since it is lesser than -Vp\
    n");
26 id=(15-Vds2)/(1*10^3);
27 Vds=Vds2;
28 printf("(a) Id = %0.3e A\n", id);
```



```

29 printf("(b)Vds = %0.2f V",Vds);
30 printf("Since Vds<Vgs-Vp,operation region is
    confirmed in the ohmic region");
31
32 // Result
33 // (a) Id = 11.67 mA
34 // (b) Vds = 3.33 V
35 // (c) Operation region is in the ohmic region

```

Scilab code Exa 6.5 Find id Vgs Rd Vds

```

1 // Find id ,Vgs ,Rd ,Vds
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-5 in page 276
7
8 clear; clc; close;
9
10 // Given data
11 Ids=10*10^-3; // Drain current in mA
12 Vp=-4; // Peak voltage in V
13 Vdd=12; // Drain voltage in V
14 Vgg=0; // Gate voltage in V
15
16 // Calculation
17 id=10*10^-3*(1-(2/4))^2;
18 Vgs=(sqrt(9/10)-1)*4;
19 Rd=(12-7.5)/(0.625*10^-3);
20 Vds=12-2-(3*0.625);
21 printf("(a)Id = %0.2e A\n",id);
22 printf("(b)Vgs = %0.3f V\n",Vgs);

```

```

23 printf("(c)Rd = %0.2e ohm\n",Rd);
24 printf("(d)Vds = %0.3f V",Vds);
25
26 // Result
27 // (a) Id = 2.5 mA
28 // Vgs = -0.205 V
29 // (c) Rd = 7.2 k-ohm
30 // (d) Vds = 8.125 V

```

Scilab code Exa 6.6 Determine Vgs Id Vds operating region

```

1 // Determine Vgs,Id,Vds,operating region
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-6 in page 276
7
8 clear; clc; close;
9
10 // Given data
11 Ids=16*10^-3; // Drain current in mA
12 Vp=-4; // Peak voltage in V
13 Vdd=18; // Drain voltage in V
14 Rd=500; // Drain resistance in ohms
15
16 // Calculation
17 vgs1=(-10+sqrt(100-64))/2;
18 vgs2=(-10-sqrt(100-64))/2;
19 printf("(a)Vgs = %d V,%d V\n",vgs1,vgs2);
20 id=-vgs1/500;
21 Vds=18-((1*10^3)*(4*10^-3));
22 printf("(b)id = %0.0e A\n",id);

```

```

23 printf("(c)Vds = %0.0f V\n",Vds);
24 printf("Saturation region operation is confirmed
    from above results");
25
26 // Result
27 // (a) Vgs = -2V
28 // (b) Id = 4 mA,
29 // (c) Vds = 14 V,

```

Scilab code Exa 6.7 Determine Vgs Id Vds

```

1 // Determine Vgs,Id,Vds
2 // Determine Vgs,Id,Vds,operating region
3 // Basic Electronics
4 // By Debashis De
5 // First Edition , 2010
6 // Dorling Kindersley Pvt. Ltd. India
7 // Example 6-7 in page 277
8
9 clear; clc; close;
10
11 // Given data
12 Ids=8*10^-3; // Drain current in mA
13 Vp=-4; // Peak voltage in V
14 Vdd=18; // Drain voltage in V
15 Rd=8*10^3; // Drain resistance in K-ohms
16
17 // Calculation
18 vgs1=(-214+sqrt(214^2-(4*63*180)))/(2*63);
19 vgs2=(-214-sqrt(214^2-(4*63*180)))/(2*63);
20 printf("(a)Vgs = %0.2f V,%0.2f V\n",vgs1,vgs2);
21 id1=-vgs1/(1*10^3);
22 id2=-vgs2/(1*10^3);

```

```

23 printf("(b) Id = %0.2e A,%0.2e A\n",id1,id2);
24 Vds1=((-9*10^3)*id1)+18;
25 Vds2=((-9*10^3)*id2)+18;
26 printf("(c) Vds = %0.2f V,%0.2f V",Vds1,Vds2);
27
28 // Result
29 // (a) Vgs = -1.53 V,-1.86 V
30 // (b) Id = 1.53 mA,1.86 mA
31 // (c) Vds = 4.23 V,1.26 V

```

Scilab code Exa 6.8 Determine R Ids Vgs

```

1 // Determine R,Ids ,Vgs
2 // Determine Vgs,Id ,Vds,operating region
3 // Basic Electronics
4 // By Debashis De
5 // First Edition , 2010
6 // Dorling Kindersley Pvt. Ltd. India
7 // Example 6-8 in page 277
8
9 clear; clc; close;
10
11 // Given data
12 Vp=-3; // Peak voltage in V
13 Vgg=5; // Gate voltage in V
14 Ids=10*10^-3; // Drain current in mA
15
16 // Calculation
17 R=5/(10*10^-3);
18 printf("(a)R = %0.0f ohm\n",R);
19 Ids=5/400;
20 Vds=(2*Ids*R)+15;
21 printf("(b) Idss = %0.2e A\n",Ids);

```

```

22 printf("(c)Vds = %0.0f V\n",Vds);
23 printf("This confirms active region\n");
24 Rid=14/2;
25 Vgs=Vgg-Rid;
26 printf("(d)Vgs = %0.0f V\n",Vgs);
27 printf("Vds=2>Vgs-Vp=-1.5+3=1.5 -> Active region");
28
29 // Result
30 // (a) R = 500ohm,
31 // (b) Ids = 12.5mA,
32 // (c) Vgs = -2V

```

Scilab code Exa 6.9 Find Id Vgs Vds region of operation

```

1 // Find Id,Vgs,Vds,region of operation
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-9 in page 277
7
8 clear; clc; close;
9
10 // Given data
11 Idss=4*10^-3; // Drain current in mA
12 Vp=-2; // Peak voltage in V
13 Vdd=10; // Supply voltage in V
14 Vgs=0; // Gate source voltage in V
15
16 // Calculation
17 Id=Idss*(1-(Vgs/Vp));
18 printf("(a)Id = %0.0e A\n",Id);
19 printf("(b)Since Id=Idss , Vgs=0 V\n");

```

```

20 Vds=10-Vgs;
21 printf("(c)Vds = %0.0f V\n",Vds);
22 printf("Since Vds=10V>Vgs-Vp=2V, Active region
    operation of upper JFET is confirmed");
23
24 // Result
25 // (a) Id = 4 mA,
26 // (b) Vgs = 0 V,
27 // (c) Vds = 10 V

```

Scilab code Exa 6.10 Find pinch off saturation voltage

```

1 // Find pinch off ,saturation voltage
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-10 in page 279
7
8 clear; clc; close;
9
10 // Given data
11 Nd=3*10^21; // Donor concentration in /m^3
12 epsln=12; // Dielectric constant of silicon
13 epsln_0=12*8.85*10^-12; // Constant of calculation
14 e=1.6*10^-19; // Charge on an electron in C
15 a=2*10^-6; // Constant of calculation
16
17 // Calculation
18 Vp=(e*Nd*(a)^2)/(2*epsln_0);
19 printf("(a)Pinch off voltage = %0.3f V\n",Vp);
20 Vds=Vp-2;
21 printf("(b) Saturation voltage = %0.3f V",Vds);

```

```
22
23 // Result
24 // (a) Pinch off voltage = 9.040 V
25 // (b) Saturation voltage = 7.040 V
```

Scilab code Exa 6.11 Determine drain source resistance

```
1 // Determine drain-source resistance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-11 in page 287
7
8 clear; clc; close;
9
10 // Given data
11 Ids=10*10^-3; // Drain current in mA
12 Vp=-2; // Peak voltage in V
13 Vgs=[1 2]; // Gate-source voltage in V
14
15 // Calculation
16 for i=1:2
17     rds=Vp^2/(2*Ids*(Vgs(i)-Vp));
18     printf("Rds = %0.1f ohm\n",rds);
19 end
20
21 // Result
22 // Rds = 66.7 ohm, 50 ohm
```

Scilab code Exa 6.12 Determine approximate Rds

```
1 // Determine approximate Rds
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-12 in page 287
7
8 clear; clc; close;
9
10 // Given data
11 K=0.25*10^-3; // Constant in mA/V^2
12 Vt=2; // Voltage in V
13 Vgs=[4 6 10]; // Drain-source voltage in V
14
15 // Calculation
16 for i=1:3
17     rds=1/(2*K*(Vgs(i)-Vt));
18     printf("Rds = %0.0f ohm\n",rds);
19 end
20
21 // Result
22 // Rds = 1 K-ohm, 500 ohm, 250 ohm
```

Scilab code Exa 6.13 Find Vgs operating region Id Rd

```
1 // Find Vgs, operating region ,Id ,Rd
```



```

2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-13 in page 288
7
8 clear; clc; close;
9
10 // Given data
11 Vdd=10; // Drain voltage in in V
12 Vds=6; // Drain-source voltage in V
13 K=0.2*10^-3; // Constant in mA/V^2
14 Vt=1; // Voltage given
15
16 // Calculation
17 Vgs=Vds;
18 printf("(a)Vgs = %0.0 f V\n",Vgs);
19 printf("Vds=6V>Vgs-Vt=5V\n");
20 Id=K*(Vgs-Vt)^2;
21 Rd=(Vdd-Vds)/Id;
22 printf("(b)Id = %0.0 e A\n",Id);
23 printf("(c)Rd = %0.0 f ohms",Rd);
24
25 // Result
26 // (a) Vgs = 6 V
27 // (b) Id = 5 mA
28 // (c) Rd = 800 ohms

```

Scilab code Exa 6.14 Find operating region Vgs Vds Rd

```

1 // Find operating region ,Vgs,Vds,Rd
2 // Basic Electronics
3 // By Debashis De

```

```

4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-14 in page 288
7
8 clear; clc; close;
9
10 // Given data
11 K=0.2*10^-3; // Constant in mA/V^2
12 Vt=1; // Given voltage in V
13 Vdd=10; // Drain voltage in V
14 Id=3.2*10^-3; // Drain current in mA
15
16 // Calculation
17 printf("Vds=Vgs>Vgs-Vt=Active region operation\n");
18 Vgs=Vt+sqrt(Id/K);
19 Vds=Vgs;
20 Rd=(Vdd-Vds)/Id;
21 printf("(a) Vgs = %0.0 f V,\n(b) Vds = %0.0 f V,\n(c) Rd
    = %0.2 e ohm" ,Vgs ,Vds ,Rd);
22
23 // Result
24 // (a) Vgs = 5 V
25 // (b) Vds = 5 V
26 // (c) Rd = 1.56 K-ohms

```

Scilab code Exa 6.15 Find Id when Vgs equals 4V

```

1 // Find Id when Vgs=4V
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-15 in page 288

```

```

7
8 clear; clc; close;
9
10 // Given data
11 K=0.15*10^-3; // Constant in mA/V^2
12 Vt=2; // Given voltage in V
13 Vdd=12; // Drain voltage in V
14 Vgs=4; // Gate-source voltage in V
15
16 // Calculation
17 Vgg=sqrt(5.4/0.15)+2;
18 Id=K*(Vgs-Vt)^2;
19 printf("(a)Vgg = %0.0f V,\n(b)Id = %0.1e A",Vgg,Id);
20
21 // Result
22 // (a) Vgg = 8 V
23 // (b) Id = 0.6 mA

```

Scilab code Exa 6.16 Determine R_d

```

1 // Determine  $R_d$ 
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-16 in page 289
7
8 clear; clc; close;
9
10 // Given data
11 K=0.25*10^-3; // Constant in mA/V^2
12 Vt=2; // Voltage given in V
13 Vdd=16; // Drain voltage in V

```

```

14 Vgg=[4 10]; // Gate voltage values in V
15
16 // Calculation
17 for i=1:2
18     id=K*(Vgg(i)-2)^2;
19     rd=(16-(Vgg(i)-2))/id;
20     printf("Rd when Vgg is %d V = %0.1e ohm\n",Vgg(i)
21         ),rd);
22
23 // Result
24 // (a) Rd = 14 K-ohm
25 // (b) 500 ohm

```

Scilab code Exa 6.17 Determine Rd

```

1 // Determine Rd
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-17 in page 289
7
8 clear; clc; close;
9
10 // Given data
11 K=0.25*10^-3; // Constant in mA/V^2;
12 Vt=2; // Given voltage in V
13 Rd=1*10^3; // Drain resistance in ohms
14 Vdd=16; // Drain voltage in V
15 Vgg=4; // Gate voltage in V
16
17 // Calculation

```

```

18 id=K*(4-Vt)^2;
19 Vd=(-1*10^3*id)+16;
20 printf("(a)Id = %0.0e A,\n(b)Vd = %0.0f V\n",id,Vd);
21 printf("Since Vds=15>Vgs-Vt=2,active region
        operation is confirmed");
22
23 // Result
24 // (a) Id = 1 mA
25 // (b) Vds = 15 V

```

Scilab code Exa 6.18 Find Id Vds1 Vds2

```

1 // Find Id,Vds1,Vds2
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-18 in page 289
7
8 clear; clc; close;
9
10 // Given data
11 Ids1=8*10^-3; // Drain-source current of M1 in mA
12 Vp=-4; // Peak voltage in V
13 Ids2=16*10^-3; // Drain-source current of M2 in mA
14 Vdd=11; // Drain voltage in V
15 Vgg=10; // Gate voltage in V
16
17 // Calculation
18 Id=Ids2;
19 printf("(a)Id = %0.2e A\n",Id);
20 Vds=(28+sqrt(28^2-128))/2;
21 Vds1=(28-sqrt(28^2-128))/2;

```

```

22 printf("(b)Vds1 = %0.2f V, %0.2f V\n",Vds,Vds1);
23 printf("For ohmic operation Vds1 = 1.19 V\n");
24 Vds2=Vdd-1.19;
25 printf("(c)Vds2 = %0.2f V",Vds2);
26
27 // Result
28 // (a) Id = 16 mA
29 // (b) Vds1 = 1.19 V
30 // (c) Vds2 = 9.81 V

```

Scilab code Exa 6.19 Find operating region Vgs Vds Id

```

1 // Find operating region ,Vgs,Vds,Id
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-19 in page 290
7
8 clear; clc; close;
9
10 // Given data
11 Ids = 4*10^-3; // Drain-source current in mA
12 Vp=-4; // Peak voltage in V
13 Vdd=10; // Drain voltage in V
14 Rd=1*10^3; // Drain resistance in K-ohms
15
16 // Calculation
17 printf("(a)Vd=Vgs<Vgs-Vp.Hence ohmic region
    operation is confirmed\n");
18 Vgs1=(-12+sqrt(12^2+160))/2;
19 Vgs2=(-12-sqrt(12^2+160))/2;
20 printf("(b)Vgs = %0.2f V,%0.2f V\n",Vgs1,Vgs2);

```

```

21 Vds=Vgs1;
22 id=(10-Vds)/(1*10^3);
23 printf("(c)Vds = %0.2 f V,\n(d)Id = %0.2 e A",Vds,id);
24
25 // Result
26 // (a) Ohmic region operation is confirmed
27 // (b) Vgs = 2.72V
28 // (c) Vds = 2.72V
29 // (d) Id = 7.28mA

```

Scilab code Exa 6.20 Find Vgs Id operating region

```

1 // Find Vgs,Id,operating region
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-20 in page 290
7
8 clear; clc; close;
9
10 // Given data
11 Ids=4*10^-3; // Drain-source current in mA
12 Vp=-4; // Peak voltage in V
13 Vdd=10; // Drain voltage in V
14 Vds=6; // Drain-source voltage in V
15
16 // Calculation
17 Vgs=Vds;
18 printf("(a)Vgs = %0.0 f V\n",Vgs);
19 printf("(b)Vds=Vgs<Vgs-Vp.Hence ohmic region
    operation\n");
20 Id=4*10^-3*((2*(5/2)*(3/2))-(9/4));

```

```

21 printf("(c) Id = %0.1e A", Id);
22
23 // Result
24 // (a) Vgs = 6 V
25 // Ohmic region operation is confirmed
26 // (c) Id = 21 mA

```

Scilab code Exa 6.21 Find operating region Vgs Vds Id

```

1 // Find operating region ,Vgs,Vds,Id
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 6-21 in page 290
7
8 clear; clc; close;
9
10 // Given data
11 K=0.2*10^-3; // Constant in mA/V^2
12 Vt=1; // Voltage in V
13 Vdd=10; // Drain voltage in V
14 Rd=1*10^3; // Drain resistance in ohms
15
16 // Calculation
17 printf("(a) Vds=Vgs>Vgs-Vt.Hence active region
    operation\n");
18 printf("0.2*Vgs^2+0.6*Vgs-9.8=0\n");
19 Vgs1=(-0.6+sqrt(0.6^2-4*0.2*-9.8))/(2*0.2);
20 Vgs2=(-0.6-sqrt(0.6^2-4*0.2*-9.8))/(2*0.2);
21 printf("(b) Vgs = %0.2f V or %0.2f V\n", Vgs1, Vgs2);
22 printf("Since 0<Vgs<10, Vgs = %0.2f V\n", Vgs1);
23 Id=(Vdd-5.66)/Rd;

```



```
24 printf("(c)Vds = Vgs = 5.66 V\n(d)Id = %0.2e A",Id);
25
26 //Result
27 // (a) The region of operation is active
28 // (b) Vgs = 5.66 V
29 // (c) Vds = 5.66 V
30 // (c) Id = 4.34 mA
```

Chapter 7

FET Circuits

Scilab code Exa 7.2 Find amplification

```
1 // Find amplification
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-2 in page 312
7
8 clear; clc; close;
9
10 // Given data
11 mu=30; // FET parameter
12 rd=5; // FET parameter
13 Rd=10; // FET parameter value in ohms
14 R=50; // Resistor value in ohms
15
16 // Calculation
17 Av=(-299/50)/((1/rd)+(1/Rd)+(1/R));
18 printf("Amplification Av = %0.1f",Av);
19
20 // Result
21 // Av = -18.7
```

Scilab code Exa 7.3 Find amplification with 40k resistor instead

```
1 // Find amplification with 40k resistor instead
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-3 in page 313
7
8 clear; clc; close;
9
10 // Given data
11 Av=-18.7; // Amplification from prev problem
12 R1=2.54; // Resistance value in ohms
13 R=40; // Load resistor in K-ohms
14
15 // Calculation
16 Avs=(Av)*(R1/(R1+R));
17 printf(" Amplification Avs = %0.2 f",Avs);
18
19 // Result
20 // Avs = -1.11
```

Scilab code Exa 7.6 Find gain if v2 v1 are zero

```
1 // Find gain if v2,v1 are zero
2 // Basic Electronics
```

```

3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-6 in page 315
7
8 clear; clc; close;
9
10 // Given data
11 mu=30; // FET parameter
12 rd=15; // Resistance value in k-ohms
13 Rd=1; // Drain resistance value in k-ohms
14 Rs=0.5; // Source resistance in k-ohms
15
16 // Calculation
17 Av1=(-mu*(rd+Rd))/(Rd+((mu+1)^2*Rs)+((mu+2)*rd));
18 Av2=((mu/(mu+1))*(((mu+1)*Rs)+rd))/(((Rd+rd)/(mu+1))
    +((mu+1)*Rs)+rd);
19 printf("(a)Av when v2 is zero = %0.3f\n",Av1);
20 printf("(b)Av when v1 is zero = %0.3f",Av2);
21
22 // Result
23 // (a) Av1 = -0.499
24 // (b) Av2 = 0.952

```

Scilab code Exa 7.11 Find voltage gain output impedance

```

1 // Find voltage gain ,output impedance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-11 in page 320
7

```

```

8 clear; clc; close;
9
10 // Given data
11 // The Thevenin equivalent of fig. is derived
12
13 // Calculation
14 A=(9.5*10)/(10+20);
15 R_0=(1/(10*10^3))+1/(20*10^3);
16 R=1/R_0;
17 printf("(a) Voltage gain = %0.2f\n",A);
18 printf("(b) Output impedance = %0.2e",R);
19
20 // Result
21 // (a) A = 3.17
22 // (b) R_0 = 6.67 K

```

Scilab code Exa 7.12 Find voltage gain A1 and A2

```

1 // Find voltage gain A1 and A2
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-12 in page 321
7
8 clear; clc; close;
9
10 // Given data
11 Rd=30*10^3; // Drain resistance in K-ohm
12 Rs=2*10^3; // Source resistance in K-ohm
13 mu=19; // Constant for FET
14 rd=10*10^3; // Dynamic resistance in K-ohm
15

```

```

16 // Calculation
17 A1=(-mu*(Rd+rd+((mu+1)*Rs))*Rd)/((rd+Rd)*(Rd+rd+(2*(
    mu+1)*Rs)));
18 A2=(mu*(mu+1)*Rs*Rd)/((rd+Rd)*(Rd+rd+(2*(mu+1)*Rs)))
    ;
19 printf("(a)For the given values of Rd,Rs,rd and mu
    we have:\n");
20 printf("A1 = %0.2 f\nA2 = %0.2 f\n\n",A1,A2);
21 printf("(b) If Rs—>infinity ,\n");
22 A_1=(-mu*Rd)/(2*(rd+Rd));
23 printf("A1 = %0.2 f = -A2\nOr A1 = -A2 = %0.2 f",A_1,
    A_1);
24
25 // Result
26 // (a) A1 = -9.5; A2 = 4.75
27 // (b) A1 = -A2 = -7.13

```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 7.13 Determine Vgs Id Vds Av

```

1 // Determine Vgs,Id,Vds,Av
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-13 in page 322
7
8 clear; clc; close;
9
10 // Given data
11 Rd=12; // Drain resistance in K-ohms

```

```

12 Rg=1; // Gate resistance in M-ohms
13 Rs=0.47; // Source resistance in ohms
14 Vdd=30; // Drain voltage in volts
15 Ids=3*10^-3; // Drain-source current in mA
16
17 // Calculation
18 printf("Vgs=-1.41* (1+ 2Vgs/2.4 + Vgs^2/2.4)\n");
19 Vgs1=(-1.175+sqrt(1.175^2-4*0.245*1.41))/(2*0.245);
20 Vgs2=(-1.175-sqrt(1.175^2-4*0.245*1.41))/(2*0.245);
21 printf("(a)Upon solving we get Vgs = %0.3f V or %0.3
    f V\n",Vgs1,Vgs2);
22 Id=3*(1-(2.398/2.4))^2;
23 Vds=Vdd-Id*(Rd+Rs);
24 gm=((2*Ids)/2.4)*(1-(2.398/2.4));
25 Av=gm*12;
26 printf("(b)Drain current Ids = %0.1e A\n",Id);
27 printf("(c)Vds = %0.2f V\n",Vds);
28 printf("(d)Small signal voltage gain Av = %0.2e",Av)
    ;
29
30 // Result
31 // (a) Vgs = -2.398 V
32 // (b) Ids = 2.1*10^-6 A
33 // (c) Vds = 30 V
34 // (d) Av = 2.5*10^-5

```

Scilab code Exa 7.14 Find the value of R1

```

1 // Find the value of R1
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India

```

```

6 // Example 7-14 in page 322
7
8 clear; clc; close;
9
10 // Given data
11 Idss=2*10^-3; // Drain-source current in mA
12 Vp=-1; // Voltage in volts
13 Rd=56*10^3; // Drain resistance in K-ohms
14 Vdn=10; // Drain to ground voltage in volts
15 Vdd=24; // Drain voltage in volts
16
17 // Calculation
18 Id=(Vdd-Vdn)/Rd;
19 Vgs=-0.65;
20 R1=-Vgs/Id;
21 printf("R1 = %0.1e ohms",R1);
22
23 // Result
24 // R1 = 2.6 K-ohms

```

Scilab code Exa 7.15 Find Vo for given Vi

```

1 // Find Vo for given Vi
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-15 in page 323
7
8 clear; clc; close;
9
10 // Given data
11 Idss=5.6*10^-3; // Drain-source current in mA

```



```

12 Vp=-4; // Peak voltage in V
13 Vi=[0 10]; // Input voltage values in V
14
15 // Calculation
16 alp=[1 2];
17 for i=1:2
18     Vg=(-2.8+sqrt(2.8^2-(4*0.35*5.6)))/(2*0.35);
19     Id=(Vi(i)+12-Vg)/10;
20     Vo=(10*Id)-12;
21     printf("(%.0f) For Vi = %d V, Vo = %.1f V\n",
22           alp(i),Vi(i),Vo);
23 end
24 printf(" If Vo = 0,\n");
25 Vgs=4*(sqrt(0.214)-1);
26 printf("(3) Then Vi = Vgs = %.2f V",Vgs);
27 // Result
28 // When Vi=0,V0=4V
29 // When Vi=10,V0=14V
30 // When Vo=0,Vi=-2.15V

```

Scilab code Exa 7.16 Calculate quiescent values of Id Vgs Vds

```

1 // Calculate quiescent values of Id ,Vgs ,Vds
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-16 in page 324
7
8 clear; clc; close;
9
10 // Given data

```

```

11 // We find Thevenins equivalent to the left of the
    gate
12
13 // Calculation
14 Rth=(1/(200*10^3))+(1/(1.3*10^6));
15 A=1/Rth;
16 Vth=(200/1500)*60;
17 printf("(a)Rth = %0.3e ohms and Vth = %0.0f V\n",A,
    Vth);
18 Vgs=(8+sqrt(8^2-(4*16)))/2;
19 Id=-2-(Vgs/4);
20 printf("(b)Vgs = %0.0f V and Id = %0.2f mA\n",Vgs,Id
    );
21 Vds=-60+((18+4)*2.25);
22 printf("(c)Vds = %0.1f V",Vds);
23
24 // Result
25 // (a) Id = -3 mA
26 // (b) Vgs = 4 V
27 // (c) Vds = -10.5 V

```

Scilab code Exa 7.20 Calculate transconductance amplification factor

```

1 // Calculate transconductance , amplification factor
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-20 in page 328
7
8 clear; clc; close;
9
10 // Given data

```

```

11 Id=2*10^-3; // Drain current in mA
12 Vgs=2; // Gate-source voltage in V
13 Rd=200*10^3; // Drain resistance in K-ohms
14
15 // Calculation
16 gm=Id/Vgs;
17 mu=gm*Rd;
18 printf("(a) Transconductance gm = %0.0e A/V\n",gm);
19 printf("(b) Amplification factor mu = %0.0f",mu);
20
21 // Result
22 // (a) gm = 1 mA/V
23 // (b) mu = 200

```

Scilab code Exa 7.21 Calculate dynamic resistance

```

1 // Calculate dynamic resistance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-21 in page 328
7
8 clear; clc; close;
9
10 // Given data
11 mu=80; // Amplification factor
12 gm=400*10^-6; // Transconductance in micro-mho
13
14 // Calculation
15 rd=mu/gm;
16 printf("Dynamic resistance Rd = %0.1e ohm",rd);
17

```

```
18 // Result
19 // Rd = 0.2*10^6 ohm
```

Scilab code Exa 7.22 Calculate Rd gm mu

```
1 // Calculate Rd, gm, mu
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-22 in page 329
7
8 clear; clc; close;
9
10 // Given data
11 Vds1=6; // Drain-source voltage when Vgs is zero
12 Vds2=16; // Drain-source voltage when Vgs is 0.3
13 Id1=12*10^-3; // Drain current in mA when Vgs is
    zero
14 Id2=12.3*10^-3; // Drain current in mA when Vgs is
    zero
15
16 // Calculation
17 rd=(Vds2-Vds1)/(Id2-Id1);
18 gm=(Id2-Id1)/(0-0.3*10^-3);
19 mu=-gm*rd*10^-4;
20 printf("(a) Drain resistance Rd = %0.2e ohms\n", rd);
21 printf("(b) Transconductance gm = %0.0f (neglecting
    the sign)\n", -gm);
22 printf("(c) Amplification factor mu = %0.2f", mu);
23
24 // Result
25 // (a) Rd = 33.33k-ohms
```

```
26 // (b) gm = 1
27 // (c) mu = 3.33
```

Scilab code Exa 7.23 Find the value of Rs

```
1 // Find the value of Rs
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-23 in page 329
7
8 clear; clc; close;
9
10 // Given data
11 Vgs=1.5; // Gate-source voltage in V
12 Id=2*10^-3; // Drain saturation current in mA
13
14 // Calculation
15 Rs=Vgs/Id;
16 printf("Rs = %0.0 f ohm" ,Rs);
17
18 // Result
19 // Rs = 750 ohm
```

Scilab code Exa 7.24 Find voltage gain of amplifier

```
1 // Find voltage gain of amplifier
2 // Basic Electronics
```

```

3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-24 in page 329
7
8 clear; clc; close;
9
10 // Given data
11 Rl=250; // Load resistance in k-ohms
12 gm=0.5; // Transconductance in mA/V
13 rd=200; // Dynamic resistance in k-ohms
14
15 // Calculation
16 mu=rd*gm;
17 Av=(-mu*Rl)/(rd+Rl);
18 printf("Voltage gain Av = %0.2f",Av);
19
20 // Result
21 // Voltage gain Av = -55.55

```

Scilab code Exa 7.25 Find pinch off voltage

```

1 // Find pinch off voltage
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-25 in page 330
7
8 clear; clc; close;
9
10 // Given data
11 Idss=10; // Drain-source current in mA

```

```

12 Vp=-4; // Original pinch off voltage in V
13 Vgs=-2; // Gate-source voltage in V
14 gm=4; // Transconductance in m-mho
15
16 // Calculation
17 Ids=Idss*(1-(Vgs/Vp))^2;
18 A=(-2*Ids)/gm;
19 printf("Pinch off voltage Vp = %0.0 f V",A);
20
21 // Result
22 // Vp at gm = 4 m-mho is -1V

```

Scilab code Exa 7.26 Calculate quiescent values of Id Vds Vgs

```

1 // Calculate quiescent values of Id ,Vds ,Vgs
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-26 in page 330
7
8 clear; clc; close;
9
10 // Given data
11 Ids=20*10^-3; // Drain-souce current in mA
12 Vp=-4; // Pinch off voltage in volts
13
14 // Calculation
15 printf("We get the equation:\n0.3125*Id^2-6*Id+20=0\n");
16 Id1=(6+sqrt(6^2-4*0.3125*20))/(2*0.3125);
17 Id2=(6-sqrt(6^2-4*0.3125*20))/(2*0.3125);
18 printf("Id = %0.1 f mA and %0.1 f mA\n",Id1,Id2);

```

```

19 printf("We consider only %0.1f mA\n", Id2);
20 Vgs=-Id2*0.5;
21 Vds=30-(Id2*(5+0.5));
22 printf("Vgs = %0.2f V\n(c)Vds = %0.2f V", Vgs, Vds);
23
24 // Result
25 // Id = 4.3 mA
26 // Vgs = -2.15 V
27 // Vds = 6.35 V

```

Scilab code Exa 7.27 Find Id Vds Vgs Av

```

1 // Find Id, Vds, Vgs, Av
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-27 in page 331
7
8 clear; clc; close;
9
10 // Given data
11 Idss=3; // Drain-source current in mA
12 Vp=-2.4; // Pinch off voltage in volts
13
14 // Calculation
15 printf("Id^2-6.73*Id+5.76=0\n");
16 Id1=(6.73+sqrt(6.73^2-4*1*5.76))/2;
17 Id2=(6.73-sqrt(6.73^2-4*1*5.76))/2;
18 printf("Id = %0.2f mA or %0.2f mA\n", Id1, Id2);
19 printf("(a)The possible value is 1.01 mA\n");
20 Vgs=-Id2*1;
21 Vds=20-(1.09*(1+10));

```



```

22 printf("Vgs = %0.2 f V\nVds = %0.2 f V\n",Vgs ,Vds);
23 gm=(-2/Vp)*sqrt(Id2*Idss);
24 Av=gm*10;
25 printf("(b) Voltage gain Av = %0.1 f",Av);
26
27 // Result
28 // Id = 1.01 mA
29 // Vgs = -1.01 V
30 // (a) Vds = 8.01 V
31 // (b) Av = 14.5

```

Scilab code Exa 7.28 Calculate Av Zo Zi

```

1 // Calculate Av,Zo,Zi
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-28 in page 332
7
8 clear; clc; close;
9
10 // Given data
11 Rd=15; // Drain resistance in k-ohms
12 Rg=1; // Gate resistance in M-ohms
13 rd=5; // Dynamic resistance in k-ohms
14 gm=5; // Transconductance in m-mho
15 Vdd=20; // Drain voltage in volts
16
17 // Calculation
18 mu=rd*gm;
19 Av=(mu*Rd)/(rd+Rd);
20 Zo=rd;

```

```

21 Zi=Rg;
22 printf("(a)Av = %0.2 f\n(b)Zo = %0.0 f k-ohms\n(c) Zi =
    %0.0 f M-ohms",Av,Zo,Zi);
23
24 // Result
25 // (a) Av = 18.75
26 // (b) Zo = 5 K-ohms
27 // (c) Zi = 1 M-ohms

```

Scilab code Exa 7.29 Calculate Vo Vi

```

1 // Calculate Vo,Vi
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-29 in page 333
7
8 clear; clc; close;
9
10 // Given data
11 Idss=5*10^-3; // Drain-source current in mA
12 Vp=-4.5; // Pinch off voltage in V
13
14 // Calculation
15 printf("When Vi is zero:\n");
16 Vgs1=(-25.67+sqrt(25.67^2-(4*2.963*55)))/(2*2.963);
17 Vgs2=(-25.67-sqrt(25.67^2-(4*2.963*55)))/(2*2.963);
18 printf("(a)Vgs = %0.2 f V or %0.2 f V\n",Vgs1,Vgs2);
19 printf("Since the gate is connected to ground,Vo = -
    Vgs.Hence Vo = %0.2 f V or %0.2 f V\n",-Vgs1,-Vgs2)
    ;
20 printf("When Vo is zero:\n");

```

```

21 Id=5/(12*10^3);
22 Vgs=4.5*(0.288-1);
23 Vi=Vgs;
24 printf("(b)Vi = %0.1 f V",Vi);
25
26 // Result
27 // (a) When Vi is zero , Vo = 4.78V or 3.88V
28 // (b) When Vo is zero , Vi = -3.2V

```

Scilab code Exa 7.30 Calculate Av Zo

```

1 // Calculate Av,Zo
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-30 in page 334
7
8 clear; clc; close;
9
10 // Given data
11 gm=5; // Transconductance in mA/V
12 rd=10*10^3; // Dynamic resistance in K-ohms
13 mu=50; // Amplification factor
14 Rd=5*10^3; // Drain resistance in K-ohms
15
16 // Calculation
17 Av=(-mu*Rd)/(rd+Rd+((mu+1)*0.1*10^3));
18 Avs=Av*(100/110);
19 Zo=rd+((mu+1)*0.1*10^3);
20 Zo1=(1/15.1)+(1/5);
21 A=1/Zo1;
22 printf("Av = %0.2 f\n",Av);

```

```

23 printf("Over all voltage gain Avs = %0.1f\n",Avs);
24 printf("Output impedance = %0.2e K\n",Zo);
25 printf("Effective output impedance Zo = %0.2f k-ohms
      ",A);
26
27 // Result
28 // (a) Avs = -11.3
29 // (b) Zo = 3.75 K-ohms

```

Scilab code Exa 7.31 Calculate Vgsq gm Rs Vdsq Rl

```

1 // Calculate Vgsq, gm, Rs, Vdsq, Rl
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-31 in page 335
7
8 clear; clc; close;
9
10 // Given data
11 Vp=-4; // Pinch off voltage in V
12 Idss=1.65*10^-3; // Drain-source current in mA
13 Idq=0.8*10^-3; // Desired operating point of current
      in mA
14 Av=10; // Voltage gain in dB
15
16 // Calculation
17 printf("We know that Id = Idss*(1-(Vgs/Vp))^2\n");
18 Vgs=4*(sqrt(0.485)-1);
19 gmo=(-2*Idss)/Vp;
20 gm=gmo*(1-(Vgs/Vp));
21 Rs=Vgs/-Idq;

```

```

22 Rl=Av/gm;
23 Vds=24-(Idq*Rl)-(Idq*Rs);
24 printf("(a)Vgsq = %0.3 f V\n(b)gm = %0.3 e A/V\n(c)Rs
    = %0.3 e ohms\n(d)Rl = %0.2 e ohms\n(e)Vds = %0.3 f
    V\n",Vgs, gm, Rs, Rl, Vds);
25 printf("Therefore, \n(e)Vdsq = 16.48 V");
26
27 // Result
28 // (a) Vgsq = -1.214 V
29 // (b) gm = 0.575 mA/V
30 // (c) Rs = 1.518 K-ohm
31 // (d) Rl = 17.4 K-ohm
32 // (e) Vdsq = 16.48 V

```

Scilab code Exa 7.32 Calculate Z_o for r_d equals 50 k ohms

```

1 // Calculate  $Z_o$  for  $r_d=50k$ -ohms
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-32 in page 337
7
8 clear; clc; close;
9
10 // Given data
11 rd=50*10^3; // Dynamic resistance in K-ohms
12 Rd=20*10^3; // Drain resistance in K-ohms
13
14 // Calculation
15 Zo=(rd*Rd)/(rd+Rd);
16 printf("Output impedance  $Z_o = %0.3 e$  ohms",Zo);
17

```

```
18 // Result
19 // Zo = 14.28 K-ohms
```

Scilab code Exa 7.33 Find voltage gain Current gain ratio

```
1 // Find voltage gain ,Current gain ratio
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-33 in page 337
7
8 clear; clc; close;
9
10 // Given data
11 Rd=5*10^3; // Drain resistance in K-ohms
12 Rg=500*10^3; // Gate resistance in K-ohms
13 mu=60; // Amplification factor
14 rds=30*10^3; // Dynamic resistance in K-ohms
15
16 // Calculation
17 Av=(mu*Rd)/(Rd+rds);
18 Ai=(mu*Rg)/(rds+Rd);
19 printf("(a) Voltage gain Av = %0.2 f\n(b) Current gain
    Ai = %0.2 f", Av, Ai);
20
21 // Reuslt
22 // (a) Av = 8.57
23 // (b) Ai = 857.14
```

Scilab code Exa 7.34 Determine Z_o draw small signal model

```
1 // Determine  $Z_o$ , draw small signal model
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-34 in page 338
7
8 clear; clc; close;
9
10 // Given data
11 gm=1; // Transconductance in m-mho
12 rd=50*10^3; // Dynamic resistance in K-ohms
13 Rd=5*10^3; // Drain resistance in K-ohms
14
15 // Calculation
16 printf("The equivalent circuit at low-frequency
    small signal model is as shown in the figure\n");
17 Zo=(rd*Rd)/(Rd+rd);
18 printf("Zo = %0.2e ohms", Zo);
19
20 // Result
21 // Zo = 4.54 K-ohms
```

This code can be downloaded from the website www.scilab.in

Scilab code Exa 7.35 Find values of R2 Vdd Vds

```
1 // Find values of R2,Vdd,Vds
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-35 in page 338
7
8 clear; clc; close;
9
10 // Given data
11 Vp=-5; // Pinch off voltage in V
12 Idss=12*10^-3; // Drain-source current in mA
13 Vdd=18; // Drain voltage in V
14 Rs=2*10^3; // Source resistance in K-ohms
15 Rd=2*10^3; // Drain resistance in K-ohms
16 R2=90*10^3; // Original value of R2 in K-ohms
17
18 // Calculation
19 Vgs1=(-5.3+sqrt(5.3^2-(4*0.48*10.35)))/(2*0.48);
20 Vgs2=(-5.3-sqrt(5.3^2-(4*0.48*10.35)))/(2*0.48);
21 printf("Vgs = %0.2f V or %0.2f V\nTherefore Vgs =
    -2.53 V\n",Vgs1,Vgs2);
22 Id=(3.306-Vgs2)/2;
23 Vds=18-(Id*Rd)-(Id*Rs);
24 r2=(13.47*400)/4.53;
25 vdd=((16-2.53)*(400+90))/90;
26 vds=vdd-16-16;
27 printf("(a)The new value of R2 is %0.1f K-ohm\n",r2)
    ;
28 printf("(b)The new value of Vdd = %0.2f V\n",vdd);
29 printf("(c)The new value of Vds = %0.2f V",vds);
30
31 // Result
32 // (a) R2 = 1189.4 K-ohm
33 // (b) Vdd = 73.34 V
34 // (c) Vds = 41.34 V
```

Scilab code Exa 7.36 Equation for drain current

```
1 // Equation for drain current
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-36 in page 340
7
8 clear; clc; close;
9
10 // Given
11 Idss=12; // Drain source current in mA
12 Vgs=-5; // Gate source voltage in V when off
13
14 // Calculation
15 printf("Equation for drain current: Id = %0.0f*(1-(
    Vgs/%0.0f))^2", Idss, Vgs);
16 x=[-5 -4 -3 -2 -1 0];
17 y=[12 11 10 9 8 7 6 5 4 3 2 1 0];
18 y=12*(1+(x/5))^2;
19 plot(x,y);
20 xlabel('Vgs');
21 ylabel('Id');
22 title('Transfer characteristics of FET');
23
24 // Result
25 // Graph shows the transfer characteristics of FET
    for the given values
26 // Set axis properties to 'origin' to view graph
    correctly
```

Scilab code Exa 7.37 Find Vgs Vp

```
1 // Find Vgs,Vp
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-37 in page 340
7
8 clear; clc; close;
9
10 // Given data
11 Idss=12; // Drain-source current in mA
12 Vgs_off=-6; // Gate-source voltage when FET is off
13
14 // Calculation
15 Vgs=6*(sqrt(5/12)-1);
16 Vp=Vgs_off;
17 printf("(a) Vgs = %0.2f V\n(b) Vp = -Vgs(off) = 6V",
        Vgs);
18
19 // Result
20 // (a) Vgs = -2.13 V
21 // (b) Vp = 6 V
```

Scilab code Exa 7.38 Find the values of Rs and Rd

```
1 // Find the values of Rs and Rd
```

```

2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-38 in page 341
7
8 clear; clc; close;
9
10 // Given data
11 Id=1.5*10^-3; // Drain current in mA
12 Vds=10; // Drain-source voltage in V
13 Idss=5*10^-3; // Drain-source current in mA
14 Vp=-2; // Pinch off voltage in V
15 Vdd=20; // Drain voltage in V
16
17 // Calculation
18 Vgs=2*(sqrt(1.5/5)-1);
19 Vs=-Vgs;
20 Rs=Vs/Id;
21 Rd=(20-10.9)/Id;
22 printf("Rs = %0.1e ohms\nRd = %0.2e ohms",Rs,Rd);
23
24 // Result
25 // Rs = 0.6 K-ohms
26 // Rd = 6.06 K-ohms

```

Scilab code Exa 7.39 Find the value of Rs

```

1 // Find the value of Rs
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India

```

```

6 // Example 7-39 in page 341
7
8 clear; clc; close;
9
10 // Given data
11 Id=2.5*10^-3; // Drain current in mA
12 Vds=8; // Drain-source voltage in V
13 Vdd=30; // Drain voltage in V
14 R1=1*10^6; // R1 value in M-ohms
15 R2=500*10^3; // R2 value in K-ohms
16 Idss=15*10^-3; // Drain-source current in mA
17 Vp=-5; // Pinch off voltage in volts
18
19 // Calculation
20 Vgs=5*(sqrt(5/30)-1);
21 V2=(Vdd*R2)/(R1+R2);
22 Rs=(V2-Vgs)/Id;
23 printf("Rs = %0.2e ohms\n",Rs);
24 Rd=(Vdd-Vds-(Id*Rs))/Id;
25 printf("Rd = %0.2e ohms",Rd);
26
27 // Result
28 // Rs = 5.18 K-ohms
29 // Rd = 3.62 K-ohms

```

Scilab code Exa 7.40 Calculate voltage gain Av

```

1 // Calculate voltage gain Av
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-40 in page 342

```

```

7
8 clear; clc; close;
9
10 // Given data
11 gm=2*10^-3; // Transconductance in mA/V
12 rd=10*10^3; // Dynamic resistance in K-ohms
13 Zc=31.83*10^3; // Capacitive impedance in K-ohms
14 Vth=16.67; // Thevenin voltage in V at 1 KHz
15
16 // Calculation
17 R=(rd*25*10^3)/(rd+(25*10^3));
18 Av=-gm*R;
19 printf("(a)Av after neglecting capacitance = %0.2f\n",Av);
20 Rth=(rd*50*10^3)/(rd+50*10^3);
21 Av1=(-50*10^3*Vth)/((50*10^3+Rth)-%i*Zc);
22 printf("(b)Av after considering capacitance = %0.2f",Av1);
23
24 // Result
25 // Av after neglecting capacitance = -14.28
26 // Av after considering capacitance = -11.01

```

Scilab code Exa 7.41 Calculate voltage amplification in circuit

```

1 // Calculate voltage amplification in circuit
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-41 in page 343
7
8 clear; clc; close;

```

```

9
10 // Given data
11 gfs=2*10^-3; // Transconductance in mS
12 Rl=10*10^3; // Load resistance
13
14 // Calculation
15 Av=gfs*Rl;
16 printf("Av = %0.0 f",Av);
17
18 // Result
19 // Av = 20

```

Scilab code Exa 7.43 Find the value of Rs

```

1 // Find the value of Rs
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-43 in page 344
7
8 clear; clc; close;
9
10 // Given data
11 Idss=10*10^-3; // Drain-source current in mA
12 Vp=-5; // Pinch off voltage in V
13
14 // Calculation
15 Vgs = 5*(sqrt(6.4/10)-1);
16 Rs=-Vgs/(6.4*10^-3);
17 printf("Rs = %0.0 f ohms",Rs);
18
19 // Result

```

20 // Rs = 156 ohms

Scilab code Exa 7.44 Calculate value of Id Vgs Vds

```
1 // Calculate value of Id,Vgs,Vds
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-44 in page 345
7
8 clear; clc; close;
9
10 // Given data
11 Idss=4*10^-3; // Drain-source current in mA
12 Vp=4; // Pinch off voltage in V
13
14 // Calculation
15 Rth=(200*10^3*1.3*10^6)/((200*10^3)+(1.3*10^6));
16 Vth=(200/1500)*(1-60);
17 Vgs=1;
18 Id=(-8-Vgs)/4;
19 Vds=-60-((18+4)*Id);
20 printf("Id = %0.2 f mA\nVgs = %0.0 f V\nVds = %0.1 f V"
        ,Id,Vgs,Vds);
21
22 // Result
23 // Vgs = 1 V
24 // Vds = -10.5 V
25 // Id = -2.25 mA
```

Scilab code Exa 7.45 Calculate input admittance

```
1 // Calculate input admittance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-45 in page 348
7
8 clear; clc; close;
9
10 // Given data
11 mu=20; // Amplification factor
12 rd=10*10^3; // Dynamic resistance in K-ohms
13 gm=2*10^-3; // Transconductance in mA/V
14 Cgs=3*10^-12; // Gate-source capacitance in pF
15 Cds=1*10^-12; // Drain-source capacitance in pF
16 Cgd=2*10^-12; // Gate-drain capacitance in pF
17
18 // Calculation
19 printf("(a)Rd = 50 K\n");
20 printf("At f=1000Hz\n");
21 Ygs=%i*2*%pi*10^3*Cgs;
22 Yds=%i*2*%pi*10^3*Cds;
23 Ygd=%i*2*%pi*10^3*Cgd;
24 Yd=2*10^-6;
25 gd=10^-4;
26 Av=(-gm+Ygd)/(gd+Yd+Yds+Ygs);
27 C1=Cgs+(17.7*Cgd);
28 printf("Av = %0.1 f\nC1 = %0.1 e F\n\n",Av,C1);
29 printf("At f=10^6Hz\n");
30 Ygs1=%i*1.88*10^-6;
```



```

31 Yds1=%i*0.628*10^-6;
32 Ygd1=%i*1.26*10^-6;
33 Av1=(-gm+Ygd1)/(gd+Yd+Yds+Ygs);
34 R1=10^6/2.48;
35 C2=37.6*10^-12;
36 printf("Av = %0.1f\nR1 = %0.2e ohm\nC1=%0.1e F\n\n",
    Av1,R1,C2);
37 Z1=%i*5*10^4;
38 Y1=%i*2*10^-6;
39 printf("(b) Z1 = j5*10^4;Y1 = j2*10^-6\n");
40 printf("For f=1000Hz\n");
41 Av2=-gm/(gd+Y1);
42 C3=Cgs+(20.2*Cgd);
43 R2=20.8*10^6;
44 printf("Av = %0.2f\nR1 = %0.2e ohm\nC1 = %0.1e F\n\n",
    Av2,R2,C3);
45 printf("For f=10^6Hz\n");
46 Av3=(-200+(%i*1.26))/(10+(%i*3.88));
47 C4=Cgs+(18.4*Cgd);
48 R3=10^6/8.64;
49 printf("Av = %0.2f\nR1 = %0.2e ohm\nC1 = %0.2e F",
    Av3,R3,C4);
50
51 // Result
52 // (a)Rd = 50 K
53 // At f=1000Hz
54 // Av = -19.6
55 // C1 = 3.8e-011 F
56
57 // At f=10^6Hz
58 // Av = -19.6
59 // R1 = 4.03e+005 ohm
60 // C1=3.8e-011 F
61
62 // (b) Z1 = j5*10^4;Y1 = j2*10^-6
63 // For f=1000Hz
64 // Av = -19.99
65 // R1 = 2.08e+007 ohm

```

```

66 // C1 = 4.3e-011 F
67
68 // For f=10^6Hz
69 // Av = -17.34
70 // R1 = 1.16e+005 ohm
71 // C1 = 3.98e-011 F

```

Scilab code Exa 7.47 Calculate gain and frequency

```

1 // Calculate gain and frequency
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-47 in page 351
7
8 clear; clc; close;
9
10 // Given data
11 gm=2*10^-3; // Transconductance in mA/V
12 Rs=100*10^3; // Source resistance in K-ohms
13 rd=50*10^3; // Dynamic resistance in K-ohms
14 Ct=9*10^-12; // Total capacitance in pF
15 gd=2*10^-5; // Constant
16
17 // Calculation
18 omega=(gm+gd)/Ct;
19 f=omega/(2*pi);
20 printf(" (a) f = %0.1e Hz\n",f);
21 Av=gm*Rs/(1+(gm+gd)*Rs);
22 printf(" For f=35.6MHz,\n");
23 Av1=(10^2*(sqrt(4.45)))/(202*sqrt(2));
24 printf(" (b) Av = %0.3 f", Av1);

```

```

25
26 // Result
27 // (a) f = 35.6 MHz
28 // (b) Av = 0.738

```

Scilab code Exa 7.48 Calculate the values of Id Vgs Vds

```

1 // Calculate the values of Id,Vgs,Vds
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-48 in page 351
7
8 clear; clc; close;
9
10 // Given data
11 Vp=3; // Pinch off voltage in V
12 // Id = 0.2(Vgs-3)^2
13
14 // Calculation
15 Id1=(25+7)/10;
16 Id2=(25-7)/10;
17 printf("Id = %0.1f mA or %0.1f mA\n",Id1,Id2);
18 printf("FET will be cut off at Id=3.2mA.Hence Id=1.8
    mA\n");
19 Vgs=0.5*(30-18);
20 Vds=30-(1.8*10);
21 printf("Vgs = %0.0f V\nVds = %0.0f V",Vgs,Vds);
22
23 // Result
24 // Id = 1.8 mA
25 // Vgs = 6 V

```

26 // Vds = 12 V

Scilab code Exa 7.52 Calculate complex voltage gain Input admittance

```
1 // Calculate complex voltage gain, Input admittance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-52 in page 355
7
8 clear; clc; close;
9
10 // Given data
11 mu=100; // Amplification factor
12 rd=40*10^3; // Dynamic resistance in K-ohms
13 gm=2.5*10^-3; // Transconductance in mA/V
14 Cgs=4*10^-12; // Gate-source capacitance in pF
15 Cds=0.6*10^-12; // Drain-source capacitance in pF
16 Cgd=2.4*10^-12; // Gate-drain capacitance in pF
17
18 // Calculation
19 Ygs=%i*2*%pi*10^2*4*10^-12;
20 Yds=%i*2*%pi*10^2*0.6*10^-12;
21 Ygd=%i*2*%pi*10^2*2.4*10^-12;
22 gd=2.5*10^-5;
23 Yd=10^-5;
24 Av=(-2.5/3.5)*10^2;
25 Ci=Cgs+(1-Av)*Cgd;
26 printf("Av = %0.2 f\nCi = %0.3 e F\n", Av, Ci);
27 printf("For f=10^6 Hz,\n");
28 Ygs1=%i*2.51*10^-6;
29 Yds1=%i*0.377*10^-6;
```

```

30 Ygd=%i*1.51*10^-6;
31 Av=(((-2.5*3.5*10^2)/12.30)+%i*((2.5*0.188*10^2)
    /12.30));
32 C1=Cgs+(72*Cgd);
33 G1=2*%pi*2.4*10^-12*3.82;
34 R1=1/G1;
35 printf("Av =");
36 disp(Av);
37 printf("C1 = %0.3e F\nR1 = %0.3e ohms",C1,R1);
38
39 // Result
40 // Av = -71.4
41 // Ci = 177.8 pF
42 // At f=10^6 Hz,
43 // Av = -71.2+j3.82
44 // C1 = 177 pF
45 // R1 = 173.5 K-ohms

```

Scilab code Exa 7.54 Find the maximum transconductance

```

1 // Find the maximum transconductance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-54 in page 358
7
8 clear; clc; close;
9
10 // Given data
11 Idss=1*10^-3; // Drain-source current in mA
12 Vp=-5; // Pinch off voltage in V
13

```

```

14 // Calculation
15 gm=(2*Idss)/-Vp;
16 printf("gm = %0.1e mho",gm);
17
18 // Result
19 // gm = 0.4 m-mho

```

Scilab code Exa 7.55 Evaluate Vds and Rd

```

1 // Evaluate Vds and Rd
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-55 in page 358
7
8 clear; clc; close;
9
10 // Given data
11 b=10^-4; // Constant in A/V^2
12 Vdd=10; // Drain voltage in V
13 Vt=1; // Voltage expressed in volts
14 Ids=0.5*10^-3; // Drain-source current in mA
15
16 // Calculation
17 Vds=1+sqrt(5);
18 Rd=(Vdd-Vds)/Ids;
19 printf("Vds = Vgs = %0.2f V\nRd = %0.2e ohm",Vds,Rd)
20 ;
21 // Result
22 // Vds = 3.24 V
23 // Rd = 13.5 K-ohm

```

Scilab code Exa 7.56 Verify FET operation in pinch off region

```
1 // Verify FET operation in pinch-off region
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-56 in page 358
7
8 clear; clc; close;
9
10 // Given data
11 Vp=-2; // Pinch off voltage in V
12 Idss=4*10^-3; // Drain-source current in mA
13 Rd=910; // Drain resistance in ohms
14 Rs=3*10^3; // Source resistance in K-ohms
15 R1=12*10^6; // R1 value in M-ohms
16 R2=8.57*10^6; // R2 value in M-ohms
17 Vdd=24; // Drain voltage in V
18
19 // Calculation
20 Vgg = Vdd*R2/(R1+R2);
21 Id1=(73+sqrt(73^2-(4*9*144)))/(2*9);
22 Id2=(73-sqrt(73^2-(4*9*144)))/(2*9);
23 printf("Id = %0.2e A or %0.2e A\n",Id1,Id2);
24 printf("A value of 3.39 mA is selected\n");
25 Vgsq=10-(3.39*10^-3*3*10^3);
26 Vdsq=Vdd-(3.39*10^-3*3.91*10^3);
27 Vdgq=Vdsq-Vgsq;
28 printf("Vgsq = %0.2fV\nVdsq = %0.2fV\nVdgq = %0.3f V
   \n",Vgsq,Vdsq,Vdgq);
29 printf("Vdgq>Vd.Hence the FET is in the pinch off
```

```

    region");
30
31 // Result
32 // FET operates in the pinch off region

```

Scilab code Exa 7.57 Calculate voltage gain Av

```

1 // Calculate voltage gain Av
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-57 in page 359
7
8 clear; clc; close;
9
10 // Given data
11 gm=2*10^-3; // Transconductance in mA/V
12 rd=10*10^3; // Dynamic resistance in K-ohms
13 C=0.025*10^-6; // Capacitance in microF
14
15 // Calculation
16 Rl=(30*30)/(30+30);
17 Av=(-gm*rd*Rl*10^3)/(Rl+rd);
18 f1=1/(2*pi*37.5*10^3*C);
19 Avl=Av/sqrt(1+(f1/(5*10^3))^2);
20 printf("(a)Av = %0.0 f\n(b)Avl = %0.2 f",Av,Avl);
21
22 // Result
23 // (a) Av = -30
24 // (b) Avl = -29.94

```

Scilab code Exa 7.59 Design a source follower

```
1 // Design a source follower
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 7-59 in page 361
7
8 clear; clc; close;
9
10 // Given data
11 Vds=14; // Drain-source voltage in V
12 Idq=3*10^-3; // Drain-source current in mA
13 Vdd=20; // Drain voltage in V
14 gm=2*10^-3; // Transconductance in mS
15 rd=50*10^3; // Dynamic resistance in K-ohms
16 Vgs=-1.5; // Gate-source voltage in V
17
18 // Calculation
19 R=(20-14)/Idq;
20 R1=Vgs/-Idq;
21 R2=R-R1;
22 Ro=1/gm;
23 Av=R/(R+Ro);
24 R_1=1/(1-(Av*(R2/R)));
25 printf("R1 = %0.1e ohms\nR2 = %0.1e ohms\nRo = %0.1e
        ohms\n",R1,R2,Ro);
26 printf("Av = %0.1f*Av1\n",Av);
27 printf("Effective input resistance R1 = %0.1f*R3",
        R_1);
28
```

```
29 // Result
30 // R1 = 0.5 K
31 // R2 = 1.5 K
32 // Ro = 0.5 K
33 // Av = 0.8*Av'
34 // R1(effective) = 2.5*R3
```

Chapter 8

Special Semiconductor Devices

Scilab code Exa 8.1 Calculate the Gate Source Resistance

```
1 // Calculate the Gate Source Resistance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-1 in page 376
7
8 clear; clc; close;
9
10 // Given Data
11 P=0.5; // Value of Allowable Gate Power Dissipation
    in watt
12 Es=14; // Trigger Source Voltage in V
13 slope=130; // Slope of Gate-Cathode Characteristic
    line
14
15 // Calculations
16 Ig=sqrt(P/slope);
17 Vg=slope*Ig;
18 Rs=(Es-Vg)/Ig;
19
```

```

20 printf("(a)The value of Gate Resistance for the
    Circuit is %0.2e ohm \n",Rs);
21 printf("(b)The value of the Gate Voltage is %0.2e V
    \n",Vg);
22 printf("(c)The value of the Gate Current is %0.2e A
    \n",Ig);
23
24 // Results
25 // (a) The value of Gate Resistance for the Circuit
    is 95.3 ohm
26 // (b) The value of the Gate Voltage is 8.06 V
27 // (c) The value of the Gate Current is 62 mA

```

Scilab code Exa 8.2 Firing angle of Thyristor

```

1 // Firing angle of Thyristor
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-2 in page 377
7
8 clear; clc; close;
9
10 // Given Data
11 Il=50^10*-3; // Latching current of the Thyristor in
    mA
12 t=50^10*-6; // Duration of firing pulse in second
13 Es=50; // DC voltage of the circuit in V
14 R=10; // Resistance of the circuit in ohm
15 L=0.25; // Inductance of the circuit in H
16 e=2.718282; // Constant of calculation
17

```

```

18 // Calculations
19 tou=0.025;
20 i=(Es/R)*(1-exp(-(50*10^-6)/tou));
21 printf("(a) i = %0.3e A\n",i);
22
23 if(i<I1)
24     printf("Since the Gate current is less than
           Latching Current, SCR will not get fired \n");
25 else
26     printf("Since the Gate current is more than
           Latching Current, SCR will get fired \n");
27 end
28
29 // Results
30 // SCR will not get fired in the Circuit

```

Scilab code Exa 8.3 Calculate width of Gating pulse

```

1 // Calculate width of Gating pulse
2 // Basic Electronics
3 // By Debashis De
4 // First Edition, 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-3 in page 377
7
8 clear; clc; close;
9
10 // Given Data
11 I1=4*10^-3; // Latching current of SCR in A
12 V=100; // DC voltage of the circuit in V
13 L=0.1; // Inductance of the circuit in H
14
15 // Calculations

```

```

16 t=(L/V)*I1;
17
18 printf("Required width of the gating pulse is %0.2e
      s",t);
19
20 // Results
21 // Required width of the gating pulse is 4 mu-s

```

Scilab code Exa 8.4 To calculate required Gate source Resistance

```

1 // To calculate required Gate source Resistance
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-4 in page 378
7
8 clear; clc; close;
9
10 // Given Data
11 P=0.012; // Value of Allowable Gate Power
      Dissipation in watt
12 Es=10; // Trigger Source Voltage in V
13 slope=3*10^3; // Slope of Gate-Cathode
      Characteristic line
14
15 // Calculations
16 Ig=sqrt(P/slope);
17 Vg=slope*Ig;
18 Rs=(Es-Vg)/Ig;
19
20 printf("(a)The value of Gate Resistance for the
      Circuit is %0.0f ohm \n",Rs);

```

```

21 printf("(b)The value of the Gate Voltage is %0.2e V
    \n",Vg);
22 printf("(c)The value of the Gate Current is %0.2e A
    \n",Ig);
23
24
25 // Results
26 // (a) The value of Gate Resistance for the Circuit
    is 2 K-ohm
27 // (b) The value of the Gate Voltage is 6 V
28 // (c) The value of the Gate Current is 2 mA

```

Scilab code Exa 8.5 To calculate series Resistance across SCR

```

1 // To calculate series Resistance across SCR
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-5 in page 378
7
8 clear; clc; close;
9
10 // Given Data
11 Ig_min=0.5; // Minimum gate current for quick ON, in
    A
12 Vs=15; // Gate source voltage in V
13 slope=16; // Slope of Gate-Cathode Characteristic
    line
14
15 // Calculations
16 Vg=slope*Ig_min;
17 Rg=(Vs-Vg)/Ig_min;

```

```

18
19 printf("The value of Gate Resistance is %0.2f ohm \n
    ",Rg);
20
21 // Results
22 // The value of Gate Resistance is 14 ohm

```

Scilab code Exa 8.6 To determine critical value of dv/dt

```

1 // To determine critical value of dv/dt
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8–6 in page 379
7
8 clear; clc; close;
9
10 // Given Data
11 ij2=32*10^-3; // Limiting value of the charging
    current in A
12 Cj2=40*10^-12; // Capacitance of reverse biased
    junction J2 in F
13
14 // Calculations
15 dv_dt=ij2/Cj2;
16
17 printf("The value of dv/dt of the given SCR is %0.2e
    volt/second \n",dv_dt);
18
19 // Results
20 // The value of dv/dt of the given SCR is 800 V/mu-s

```

Scilab code Exa 8.7 Calculate surge current and I2t ratings

```
1 // Calculate surge current & I2t ratings
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-7 in page 379
7
8 clear; clc; close;
9
10 // Given Data
11 ish=3000; // half cycle surge current rating of SCR
    in A
12 f=50; // Frequency of operation of supply in Hz
13
14 // Calculations
15 I=ish*sqrt(2*f)/sqrt(4*f);
16 I2t_rate=(I*I)/(2*f);
17
18 printf("(a)The surge current rating of one cycle for
    the SCR is %0.2f A \n",I);
19 printf("(b)The I2t rating of one cycle for the SCR
    is %0.2f A^2-second \n",I2t_rate);
20
21 // Results
22 // (a) The surge current rating of one cycle for the
    SCR is 2121.32 A
23 // (b) The I2t rating of one cycle for the SCR is
    45000 A^2-second
```

Scilab code Exa 8.8 Max and Min firing delays

```
1 // Max and Min firing delays
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-8 in page 386
7
8 clear; clc; close;
9
10 // Given Data
11 Vc=40; // Breakdown voltage of DIAC in V
12 C=470*10^-9; // Capacitance in nF
13 E=240; // Rms voltage at 50 Hz in V
14 omga=2*pi*50; // Angular frequency
15
16 // Calculation
17 printf("When DIAC is not conducting:\n")
18 A=asind(40/335.8)+8.4;
19 Z=1/(omga*C);
20 R1=atand(1/(omga*1000*C));
21 Zd=sqrt(R1^(2+(1/omga^2*C^2)));
22 printf("Minimum delay = %0.2f degrees\n\n",A);
23 printf("When DIAC conducts:\n");
24 A1=asind(40/88.6)+74.84;
25 printf("Maximum delay = %0.2f degrees",A1);
26
27 // Result
28 // Minimum delay = 15.24 degrees
29 // Maximum delay = 101.6 degrees
```

Scilab code Exa 8.10 Design of Triggering Circuit for a UJT

```
1 // Design of Triggering Circuit for a UJT
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-10 in page 390
7
8 clear; clc; close;
9
10 // Given Data
11 Vs=30; // DC source voltage in V
12 eta=0.51; // Intrinsic stand off ratio
13 Ip=10*10^-6; // Peak Emitter current of UJT in mu-A
14 Vv=3.5; // Valley voltage in V
15 Iv=10*10^-3; // Valley current in A
16 f=60; // Source frequency in Hz
17 tg=50*10^-6; // width of triggering pulse in seconds
18 C=0.5*10^-6; // Assumption for circuit Capacitance
    in mu-F
19 Vd=0.5; // Fixed value of Vb in V
20
21 // Calculations
22 Vp=(eta*Vs)+Vd;
23 Rlow=(Vs-Vp)/Ip;
24 Rup=(Vs-Vv)/Iv;
25 tou=1/f;
26 R=(tou/C)*(1/log(1/(1-eta)));
27 Rb1=tg/C;
28 Rb2=10^4/(eta*Vs);
29
```

```

30 printf("(a)The value of Base-1 Resistance of UJT is
    %0.2f ohm \n",Rb1);
31 printf("(b)The value of Base-2 Resistance of UJT is
    %0.2f ohm \n",Rb2);
32 printf("(c)Circuit resistance of the arrangement is
    %0.2e ohm \n",R);
33
34 // Results
35 // (a) The value of Base-1 Resistance of UJT is 100
    ohm
36 // (b) The value of Base-2 Resistance of UJT is 654
    ohm
37 // (c) Circuit resistance of the arrangement is 46.7
    K-ohm

```

Scilab code Exa 8.11 To determine Emitter source voltage of UJT

```

1 // To determine Emitter source voltage of UJT
2 // Basic Electronics
3 // By Debashis De
4 // First Edition , 2010
5 // Dorling Kindersley Pvt. Ltd. India
6 // Example 8-11 in page 391
7
8 clear; clc; close;
9
10 // Given Data
11 Re=1*10^3; // Emitter Resistance of UJT in ohm
12 Iv=5*10^-3; // Valley current of UJT in A
13 Vv=2; // Valley voltage of UJT in V
14
15 // Calculations
16 Ve=Vv;

```

```
17 Ie=Iv;
18 Vee=(Ie*Re)+Ve;
19
20 printf("The value of Emitter source voltage of UJT
    for turn-off is %0.2f V",Vee);
21
22 // Results
23 // The value of Emitter source voltage of UJT for
    turn-off is 7 V
```
