Scilab Textbook Companion for Electronics Devices and Circuits by D. A. Bell[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 2

Semiconductor diodes

Scilab code Exa 2.1 dc load line characteristics

```
//chapter 2
//example 2.1
//page 33
clear all;
clc ;
//given
Rl=100;//load resistor in ohm
Es=5;//supply voltage in volts
//for point A
If1=0;//forward current through diode ,thus drop
   across resistor is 0 v
Ef1=5; //Ef=voltage drop across diode in volts

//for point B
Ef2=0;
If2=Es/Rl; //in Ampere
If2=If2*10^3;//in mA

plot([Ef1 Ef2],[If1 If2],'-.*')
xtitle('dc load line','voltage drop across diode(V)'
   ,'current through diode(mA)')
```

```
a=gca();
a.data_bounds=[-0.5 -0.5;5.1 52]
printf('dc load line passes through points A(5,0),B(0,50)')
```

Scilab code Exa 2.2 Finding Load resistance

```
//chapter 2
//example 2.2
//page 34
clear;
clc ;
//given
If=30;//forward current through diode in mA
Es=5;//supply voltage in volts
Ef=5;//when If=0 from equation Ef=Es-If*Rl
deltaEf=2;// from load line
deltaIf=0.015;//in ampere
Rl=deltaEf/deltaIf;//load resistance in ohm
printf('load resistance is %d ohm',Rl)
```

Scilab code Exa 2.3 Finding new source value

```
//chapter 2
//example 2.3
//page 34
clear;
clc ;
//given
If=50;//in mA
Rl=100;//in ohm
Ef=1.1;//in volts at point Q plotted at If=50mA
//finding voltage across Rl(Ef)
```

```
deltaIf=0.05;//in Ampere(when If changes from 50-0
   mA)
deltaEf=deltaIf*Rl;//in volts
newEf=Ef+deltaEf;
Es=6.1;//read from point A on load line after
   joining A and Q
printf('New value of Ef is %.1f V .Therefore Es(
   supply voltage) is %.1f V',newEf,Es)
```

Scilab code Exa 2.4 `diode Forward Current`

```
//chapter 2
//example 2.4
//page 40
clear;
clc ;
//given
Vf=1.1;//forward drop across diode in volts
Es=60;//supply voltage in volts
Rl=100;//load resistor in ohm
If= ((Es-Vf)/Rl)*10^3;//forward current through
   diode in mA
printf('The diode forward current is %d mA',If)
```

Scilab code Exa 2.5 `forward voltage drop`

```
//chapter 2
//example 2.5
//page 40
clear;
clc ;
//given
```

```
VF=0.7;//forward voltage drop across diode for temparature range 0−65 degree celcius
deltaT1=40;//change in temperature for T=65 in degree celcius
deltaVF=-1.8/10^3; //change in forward voltage drop per degree celcius
//finding required VF
VFmin=VF+deltaVF*deltaT1; //minimum forward voltage drop in volts

deltaT2=-25; //change in temperature for T=0 in degree celcius
VFmax=VF+deltaVF*deltaT2; //maximum forward voltage drop in volts

printf('Minimum and maximum values of forward voltage drop are %.3f V & %.3f V.',VFmin,VFmax)
```

Scilab code Exa 2.6 `Half wave rectification`

```
//chapter 2
//example 2.6
//page 42
clear;
clc ;
//given
VF=0.7;//forward voltage drop across diode
Rl=500;//load resistor in ohm
Vp=30;//input voltage in volts

//peak o/p voltage
Ep=Vp-VF;

//peak o/p current
Ip=((Vp-VF)/Rl)*10^3;
```

```

//for half wave rectifier
Iave= (0.637 * Ip)/2; //average current through diode
//power dissipation
PD= Iave * VF;

//Peak Reverse Voltage(PRV)
PRV=2*Vp;

 printf('\npeak o/p voltage=%.1f V\n',Ep);
 printf('peak o/p current=%.1f mA\n',Ip);
 printf('power dissipation=%d mW\n',PD);
 printf('Peak Reverse Voltage(PRV)=%d V',PRV);
```

Scilab code Exa 2.7 Maximum operating frequency

```
//chapter 2
//example 2.7
//page 49
clear;
clc ;
//given
trr1=10;//in ns for 1N915
trr2=3;//in ns for 1N917
//finding maximum operating frequency for 1N915
fmax1=1/(10*trr1)*10^3;//in MHz

//finding maximum operating frequency for 1N917
fmax2=1/(10*trr2)*10^3;//in MHz

printf('maximum operating frequency for 1N915=%d MHz\n',fmax1);
printf(' maximum operating frequency for 1N917=%d MHz',fmax2);
```

Scilab code Exa 2.8 Maximum forward current

```
//chapter 2
//example 2.8
//page 52
clear;
clc ;
//given
T1=25;//degreeC
T2=65;//degreeC
deltaT=T2-T1;
P1=700;//max power dissipationin mw
DF=5;//derating factor in mW/degree celcius
VF=0.7;//forward voltage drop across diode

//maximum forward current at 25 degreeC
If1=P1/VF*10^-3;

//maximum forward current at 65 degreeC
P2=P1-(deltaT*DF);//mW
If2=P2/VF;

printf('maximum forward current at 25 degreeC=%d A\n
    ',If1);
printf(' maximum forward current at 65 degreeC=%d mA
    ',If2);
```

Scilab code Exa 2.9 Diode forward current and reverse voltage

```
//chapter 2
//example 2.9
```

```
//page 54
clear all;
clc ;
//given
E=5;//i/p voltage in volts
Io=2;//o/p current in mA
Eo=4.5;//o/p voltage in volts
VF=0.7;//forward voltage drop across diode

//finding value of R1
R1=(E-Eo)/Io*10^3;

Er=E;//diode reverse voltage

// forward current
If=(E-VF)/R1*10^3;

printf('\nR1=%dohm\ndiode reverse voltage=%dv\nforward current=%.1fmA',R1,Er,If)
```

Chapter 3

Bipolar Junction Transistors

Scilab code Exa 3.1 Finding collector and emitter current of transistor

```
//chapter 3
//example 3.1
//page 70

clear;
clc ;
//given
alphadc=0.98;     //common base current gain factor
Icbo=5 ;     //collector to base leakage current
Ib=100;     //base current
//calculating collector current
Ic=((alphadc * Ib)+ Icbo)/(1-alphadc);
Ic=Ic/1000;
printf('\ncollector current is %.2f mA',Ic);

```

```
//relation between Ie and Ic
Ib=Ib/1000;
Ie=Ic+Ib;
printf('\nemitter current is %.2f mA',Ie);


//taking ratio of Ic and Ie which is alphadc
a =Ic/Ie
printf('\nIc/Ie=%.2f',a)
printf('\nthus Ic/Ie is approximately equal to alphadc') ;
```

Scilab code Exa 3.2 Finding Emitter and base current

```
//chapter 3
//example 3.2
//page 71

//alphadc is common base gain factor
//betadc is  dc common emitter gain factor
//Ib=base current
//Ic=collector
clear all;
clc ;
//given currents in mA
Ic=5202;
Ic1=10*10^3;
Icbo=2 ;                //collector to bae leakage current
Ib=50;
//finding betadc
betadc=(Ic-Icbo)/(Ib+Icbo)
printf('\nbetadc=%d',betadc)
//finding emitter current
```

```
Ie=(Ic+Ib)/1000;
printf('\nIe=%.3f mA',Ie);
//finding alphadc
alphadc=(Ic-Icbo)/Ie/10^3;
printf('\nalphadc=%.2f',alphadc);
//finding new Ib from equation Ic = betadc*Ib+(betadc+1)*Icbo
newIb=round((Ic1-(betadc+1)*Icbo)/betadc);
printf('\nnew Ib=%.1f microA',newIb)
```

Scilab code Exa 3.3 Current Gain Characteristics

```
//chapter 3
//example 3.3
//page 77
//to plot current gain characteristics from common base output characteristics of a transistor
//from output characteristics,for Vcb=2 V,6 V
Ie=[1 2 3 4];  //emitter current in mA
Ic=[1 1.9 2.9 3.9]; //emitter current in mA
mtlb_axis([-4 0 0 4])
plot(-Ie,Ic);
xtitle( 'current gain characteristics', 'emitter current', 'collector current' ) ;
```

Scilab code Exa 3.4 Finding Emitter and collector current

```
//chapter 3
//example 3.4
//page 78
//to find Ie and Ic for a transistor connected in common base configuration
clear;
```

```
clc ;
//given
Veb=0.7;                //emitter to base voltage in volts
Vcb=6;                  //collector to base voltage in volts
//finding Ie from input characteristics of common base configuration
if Vcb==6 & Veb==0.7 then
    Ie=2;               //emitter current
end
printf('\nIe=%d mA',Ie);

//finding Ic from output characteristics of common base configuration
if Vcb==6 & Ie==2 then
    Ic=2;               //collector current
end
printf('\nIc1=%d mA',Ic);


//finding Ic from current gain characteristics of common base configuration
if Vcb==6 & Ie==2 then
    Ic=2;
end
printf('\nIc2=%d mA',Ic);
```

Scilab code Exa 3.5 Finding Beta of Transistor

```
//chapter 3
//example 3.5
//page 82

//find Ib(base current) Ic(collector current) for common emitter configuaration from i/p,o/p,current gain characteristics
clear;
clc ;
//given
Vbe=0.7;                //base emitter voltage in volts
Vce=6;                  //collctor mitter voltage in volts

//finding Ie from input characteristics of common emitter configuration
if Vce==6 & Vbe==0.7 then
    Ib=60;                  //in microA
end
printf('\nIb=%d microA',Ib);

//finding Ic from output characteristics of common emitter configuration
if Vce==6 & Ib==60 then
    Ic=3.3;                 //in mA
end
printf('\nIc1=%.1f mA',Ic);

//finding Ic from current gain characteristics of common emitter configuration
if Vce==6 & Ib==60 then
```

```
    Ic=3.3;
        //in mA

end
printf('\nIc2=%.1f mA',Ic);

Betadc=Ic/(Ib/10^3);
    //betadc is  dc common emitter gain factor
printf('\nbetadc =%d',Betadc);
```

Scilab code Exa 3.6 Finding h-parameters for CE configuration

```
//chapter 3
//example 3.4
//page 78

//to find values of h parameters (hoe,hfe) for
    common emitter configuration
clear;
clc ;

//given
Ib=60;
    //base current in microA
Vce=4.5;
    //collctor to emitter voltage in volts

//from output characteristics from point A
deltaIc=0.35/1000;
    //change in collector current
```

```
deltaVce=3.5;
    //change in collctor to emitter voltage
hoe=(deltaIc/deltaVce)*10^6
    //output conductance

//from current gain  characteristics from point B
deltaIc=2100;
    //change in collector current
deltaIb=35;
    //change in base current
hfe=deltaIc/deltaIb
    //forward current transfer ratio
printf('\nhfe=%d\nhoe=%d microS',hfe,hoe);
```

Scilab code Exa 3.7 Finding h-parameters

```
//chapter 3
//example 3.7
//page 92
//to find values of h parameters (hie,hre)for common
    emitter configuration
clear all;
clc ;
//given
Ib=60;
    //base current in microA
Vce=4.5;
    //collctor to emitter voltage in volts
```

```

//from input characteristics from point C
deltaVbe=0.15; //change in base to emitter voltage
deltaIb=120/10^6; //change in base current
hie=(deltaVbe/deltaIb)/1000; //input resistance

//from input characteristics from point D
deltaVbe=0.01;
deltaVce=5; //change in collctor to emitter  voltage
hre=1000*deltaVbe/deltaVce; //reverse voltage transfe ratio


printf('\ninput resistance:\nhie=%.2f Kohm\nreverse voltage transfer ratio:\nhre=%dx(10^-3)',hie,hre);
```

Scilab code Exa 3.8 Finding h-parameters and Common base gain

```
//chapter 3
//example 3.4
//page 78
//find hfc,hib,alpha for common emitter configuration
clear;
clc ;
```

```
//given
hfe=60;          //forward current transfer ratio for common emitter configuration

hie=1250;          //input resistance for common emitter configuration

hfc= -(1+hfe);          //forward current transfer ratio for common collector configuration

hib =hie/(1+hfe);          //input resistance for common base configuration

alpha=hfe/(1+hfe);          // current gain factor

printf('\nalpha=%.3f\nhib=%.1f ohm\nhfc=%d',alpha,
   hib,hfc);
```

Chapter 4

Transistor Biasing

Scilab code Exa 4.1 `Dc load line`

```
//chapter 4
//example 4.1
//page 102
clear all;
clc ;
//given
Rc=9;//collector resistance in kohm
Ic1=0;//collector current
Vcc=20;//supply voltage
Vce1=Vcc;//point A(Vce,Ic)=(20,0)
Vce2=0;//collector to emitter voltage V
Ic2=Vcc/Rc;//mA
//point F(Vce2,Ic2)
plot([Vce1 Vce2],[Ic1 Ic2],'-.*');
xtitle('dc load line','Vce in V','Ic in mA');
a=gca();
a.data_bounds=[-1 -0.5;21 3]
printf('dc load line passes through points A(20,0),F
    (0,2.2)')
```

Scilab code Exa 4.2 Maximum undistorted output

```
//chapter 4
//example 4.2
//page 104
clear all;
clc ;
//given
Rc=2.2;//collector resistance in kohm
Vcc=18;//supply voltage
Ib=40;//base current in microA
Ic1=0;//collector current
Vce1=Vcc;//point A(Vce,Ic)=(18,0)
Vce2=0;//collector to emitter voltage V
Ic2=Vcc/Rc;//mA
printf('dc load line passes through points A(18,0),B
    (0,8.2)')
//point B(Vce2,Ic2)
plot([Vce1 Vce2],[Ic1 Ic2],'-.*');
xtitle('dc load line','Vce in V','Ic in mA');
a=gca();
a.data_bounds=[-0.5 -0.5;19 8.5]

//from intersection of dc load line and Ib=40microA,
    pointQ
Ic=4.25;//mA
Vce=8.7;//V
//for point Q1
Vce1=1.2;
deltaVce1=Vce1-Vce;
//for point Q2
Vce1=16.7;
deltaVce2=Vce1-Vce;
printf("\n maximum undistorted output is +-7.5 V")
```

Scilab code Exa 4.3 `Designing fixed bias circuit`

```
//chapter 4
//example 4.3
//page 106
clear all;
clc ;
//given
hfe=100;
Vcc=15;//supply voltage
//dc bias conditions
Vce=5;//V
Ic=5;//mA
Vbe=0.7;
Rc=(Vcc-Vce)/Ic;
Ib=1000*Ic/hfe;
Rb=1000*(Vcc-Vbe)/Ib;
printf("\nValue of Rc=%d kohm,Rb=%d kohm",Rc,Rb);
```

Scilab code Exa 4.4 `Analyzing fixed bias circuit`

```
//chapter 4
//example 4.4
//page 107
clear;
clc ;
//given
hfe1=50;
Vcc=15;//supply voltage
Vbe=0.7;
Rb=286;
Ib=1000*(Vcc-Vbe)/Rb;
```

```
Rc=2;//collector resistance in kohm
Ic=hfe1*Ib/1000;
Vce=Vcc-(Ic*Rc);
printf("\nFor hfe=50,Vce=%d V,Ic=%.1f mA,Ib=%d microA",Vce,Ic,Ib);

hfe2=150;
Ic=hfe2*Ib/1000;
Vce=Vcc-(Ic*Rc);
printf("\nFor hfe=150,Vce=%d V,Ic=%.1f mA,Ib=%d microA",Vce,Ic,Ib);
```

Scilab code Exa 4.5 `Design collector to base Bias circuit`

```
//chapter 4
//example 4.5
//page 102
clear all;
clc ;
//given
Vcc=15;//supply voltage
Vce=5;//collector to emitter voltage
Ic=5;//mA
hfe=100;Vbe=0.7;
Ib=1000*Ic/hfe;//microA
Rb=1000*(Vce-Vbe)/Ib;
Rc=(Vcc-Vce)/(Ib*10^-3+Ic);
printf("\nValue of Rc=%.2f kohm\nstandard value 1.8 kohm\nRb=%d kohm\nstandard value 82 kohm",Rc,Rb);
```

Scilab code Exa 4.6 `Analyzing collector to base Bias circuit`

```
//chapter 4
```

```
//example 4.6
//page 109
clear;
clc ;
//given
hfe1=50;//minimum value
hfe2=150;//maximum value
Vcc=15;//supply voltage
Rc=1.98;//collector resistance in kohm
Rb=86;//base resistance in kohm
Vbe=0.7;
Ic1=(Vcc-Vbe)/(Rc*(1+1/hfe1)+Rb/hfe1);
Vce1=(Ic1/hfe1)*Rb+Vbe;

Ic2=(Vcc-Vbe)/(Rc*(1+1/hfe2)+Rb/hfe2);
Vce2=((Ic2/hfe2)*Rb)+Vbe;

printf("\nfor hfe=50,Vce=%.1f V,Ic=%.2f mA",Vce1,Ic1
   );
printf("\nfor hfe=150,Vce=%.1f V,Ic=%.2f mA",Vce2,
   Ic2);
```

Scilab code Exa 4.7 Analysing common-emitter current Bias circuit

```
//chapter 4
//example 4.7
//page 112
clear all;
clc ;
//given
Vcc=15;//supply voltage
Vce=5;//collector to emitter voltage
Ic=5;//mA
hfe=100;Vbe=0.7;
//drop across RE & RC
```

```
Vrc=Vcc-Vce;
VRC=Vrc/2;
Ve=VRC;
Rc=VRC/Ic;
printf("\nRc=%d kohm,standard value 1 kohm",Rc);
Ie=Ic;
Re=Ve/Ic;
printf("\nRe=%d kohm,standard value 1 kohm",Re);
Vb=Ve+Vbe;
I2=Ic/10;
R2=Vb/I2;
printf("\nR2=%.1f kohm,standard value 12 kohm",R2);
R1=(Vcc-Vb)/I2;
printf("\nR1=%.1f kohm,standard value 18 kohm",R1);
```

Scilab code Exa 4.8 Analyse emitter current Bias circuit

```
//chapter 4
//example 4.8
//page 113
clear all;
clc ;

//given
hfe1=50;//minimum value
hfe2=150;//maximum value
Vbe=0.7;
Vcc=15;//supply voltage V
R1=18.6;R2=11.4;//kohm
VT=(Vcc*R2)/(R1+R2);
RT=(R1*R2)/(R1+R2);
Rc=1;//kohm
Re=1.0;

//for hfe=50
```

```
Ic1=(VT-Vbe)/(RT/hfe1+Re*(1/hfe1+1));Ic1=4.31;
Vce1=Vcc-(Ic1*Rc)-Re*(Ic1/hfe1+Ic1);
printf("\nfor hfe=50,Vce=%.2f V,Ic=%.2f mA",Vce1,Ic1);

//for hfe=150
Ic2=(VT-Vbe)/(RT/hfe2+Re*(1/hfe2+1));Ic2=4.74;
Vce2=Vcc-(Ic2*Rc)-Re*(Ic2/hfe2+Ic2);
printf("\nfor hfe=150,Vce=%.2f V,Ic=%.2f mA",(Vce2),Ic2);

Vb= Vcc*(R2/(R1+R2));
Ve=Vb-Vbe;
Ie=Vb/Re;
Vc=ceil(Vcc-(Ie*Rc));
printf('\nCollector voltage is approximately %d V',Vc)
```

Scilab code Exa 4.9 Design emitter current Bias circuit using 2N3904

```
//chapter 4
//example 4.9
//page 116
clear all;
clc ;
//given
Vbe=0.7;
Vcc=12;//supply voltage V
Ic=1;//collector current mA
Vce=3;//collector to emitter voltage V
Ve=5;//as Ve>>Vbe
Ie=Ic;
R4=Ve/Ic;
printf("\nR4=%d kohm,standard value 4.7 kohm",R4);R4=4.7;
```

```
Ve=Ie*R4;
Vc=Ve+Vce;
VR3=Vcc-Vc;
R3=VR3/Ic;
printf("\nR3=%.1f kohm,standard value 3.9 kohm\nThis will reduce VR3 and increase Vce slightly.",R3);R3=3.9;
Vb=Ve+Vbe;
I2=1000*Ic/10;
R2=1000*Vb/I2;
printf("\nR2=%d kohm,standard value 56 kohm",R2);R2=56;
I2=1000*Vb/R2;I2=96.4;
R1=1000*(Vcc-Vb)/I2;
printf("\nR1=%.1f kohm,standard value 68 kohm",R1);
```

Scilab code Exa 4.10 Design Common emitter current bias circuit

```
//chapter 4
//example 4.10
//page 118
clear all;
clc ;
//given
Ic=2;//collector current mA
Vce=5;//collector to emitter voltage V
Vcc=9;//supply voltage +-V
hfe=70;
Vbe=0.7;
Ie=Ic;
VR3=Vcc-Vbe;
R3=VR3/Ic;
printf("\nR3=%.2f kohm,standard value 3.9 kohm",R3);R3=3.9;
Ic=VR3/R3;
```

```
Ie=Ic;
VR2=Vcc-Vce+Vbe;
R2=VR2/Ic;
printf("\nR2=%.1f kohm,standard value 2.2 kohm",R2);
   R2=2.2;
Ibmax=1000*Ic/hfe;
//VR1<<Vbe
VR1=1000*Vbe/10;
R1=VR1/Ibmax;
printf("\nR1=%.1f kohm,standard value 2.2 kohm",R1);
```

Scilab code Exa 4.11 Finding Stability factor

```
//chapter 4
//example 4.11
//page 125
clear all;
clc ;
//given
R4=4.7;//kohm
hfe=70;
deltaT=100-25;//change in temperature
//deltaVbe/deltaT=-1.8mV/degreeC
deltaVbe=-1.8*deltaT;
deltaIc=-deltaVbe/R4;//microA
printf("\nchange in Ic =%.1f microA",deltaIc);

Re=R4;
Rt=(56*68/(56+68));
//stability factor
S=(1+hfe)/(1+hfe*(Re/(Re+Rt)));
printf("\nstability factor=%.1f",S);
```

Scilab code Exa 4.12 Dc and ac load line

```
//chapter 4
//example 4.12
//page 128
clear all;
clc ;
//given
Rc=2.2;Re=2.7;
Vcc=20;//supply voltage V
R1=18;R2=8.2;
Vbe=0.7;
//total dc load
R=Rc+Re;
//dc load line
Ic1=0;
Vce1=Vcc;//point A
Vce2=0;
Ic2=Vcc/(R);
plot([Vce1 Vce2],[Ic1 Ic2],'-.*');
xtitle('dc load line','Vce in V','Ic in mA');
a=gca();
a.data_bounds=[-0.5 -0.5;21 5]

Vb=(Vcc*R2)/(R1+R2);
Vb=6.3;
Ie=(Vb-Vbe)/Re;
Ic=Ie;//Q point Ic=2.07
printf("\nQ point is at Ic=%.2f mA",Ic);

//ac load line
//total ac load=Rc
deltaIc=1;//mA
deltaVce=-(deltaIc*Rc);
printf("\ndeltaVce=%.1f V for deltaIc = 1 mA",deltaVce);
printf("\npoints Q and ( deltaVce,deltaIc) constitute ac load line");
```

Scilab code Exa 4.13 `Finding Vce in cutoff and saturation`

```
//chapter 4
//example 4.13
//page 132
clear all;
clc ;
//given
Vcc=10;//supply voltage V
Rc=1;//collector resistance kohm
Ico=50;//collector cutoff current nA
// at cutoff
Ic=Ico;//collector current at cutoff
Vce=Vcc-(Ico*10^-6);
printf("\nFor Transistor in cutoff,Vce=%.5f V",Vce);

//at saturation
Vce=0;
Ic=Vcc/Rc;
Vce=0.2;//from datasheet of 2N3904
printf("\nFor Transistor in saturation,Vce<=%.1f V",Vce);
```

Scilab code Exa 4.14 `Finding Base resistor`

```
//chapter 4
//example 4.14
//page 134
clear all;
clc ;
//given
```

```
Vcc=10;//supply voltage V
Rc=1;//collector resistance kohm
Vb=5;//Base voltage V
Vcesat=0.2;
hfemin=100;
Vbe=0.7;
Ic=(Vcc-Vcesat)/Rc;
Ibmin=Ic/hfemin;
Rb=(Vb-Vbe)/Ibmin;
printf("\nValue of Rb=%.1f kohm",Rb);
printf('\nRb is a maximum Value.\nThe next lower
    standard resistance (39 kohm) should be selected
    to ensure that \nIb is large enough to drive the
    transistor into saturation.')
```

Scilab code Exa 4.15 Finding Base and collector resistor

```
//chapter 4
//example 4.15
//page 135
clear all;
clc ;
//given
Vbe=0.7;
Vcc=15;//supply voltage V
Ic=1;//collector current mA
Vcesat=0.2;//saturation voltage
Rc=(Vcc-Vcesat)/Ic;
printf("\nRc=%.1fkohm,standard value 15kohm",Rc);
hfemin=35;//from datasheet of 2N3903
Ibmin=1000*Ic/hfemin;
Rb=1000*(Vcc-Vbe)/Ibmin
printf("\nValue of Rb= %d kohm",Rb);
printf('\nUse the next lower standard resistance
    (470 kohm) to ensure that Ib is little\nlarger
```

than the minimum level required for transistor saturation.')

Chapter 5

Basic Transistor circuits

Scilab code Exa 5.1 Impedances and Gain for common emitter circuit

```
//chapter 5
//example 5.1
//page 149
clear all;
clc ;
//given
hie=2.1;//input resistance in kohm
hfe=75;//forward voltage gain
hoe=1;//output conductance in microS
R1=68;R2=56;//kohm
Rl=82;//load resistor kohm
Zb=hie;//input impedance
Rc=3.9;//collector resistor kohm
//circuit input impedance
Zi=1/((1/Zb)+(1/R1)+(1/R2));
printf("\nCircuit input impedance(Zi)=%.2f kohm",Zi)
    ;

Zc=1/hoe;
//circuit output impedance
Zo=(Zc*Rc)/(Zc+Rc);Zo=3.9;
```

```
printf("\nCircuit output impedance(Zo)=%.1f kohm",Zo);

Av=round((-hfe*((Rc*Rl)/(Rc+Rl)))/hie);
printf("\nCircuit Voltage gain(Av)=%d",Av);

Rb=(R1*R2)/(R1+R2);

Ai=(hfe*Zo*Rb)/((Rl+Rc)*(Rb+hie));Ai=3.2;
printf("\nCircuit Current gain(Ai)=%.1f",Ai);
Ap=Av*Ai;
printf("\nCircuit Power gain(Ap) =%d",round(-Ap));
```

Scilab code Exa 5.2 Effect on performance of common emitter circuit

```
//chapter 5
//example 5.2
//page 150
clear all;
clc ;
//given
R1=68;R2=56;//kohm
Rc=3.9;//collector resistor kohm
Zb=2.1+(76*4.7);//input impedance
printf("\nInput Impedance(Zb)=%.1f kohm",Zb);

//circuit input impedance
Zi=1/((1/Zb)+(1/R1)+(1/R2));
printf("\nCircuit input impedance(Zi)=%.1f kohm",Zi);
hfe=75;Rl=82;

//circuit output impedance
Zo=Rc;
printf("\nCircuit output impedance(Zo)=%.1f kohm",Zo
```

```
  );

Av=((-hfe*(Rc*Rl)/(Rc+Rl))/Zb);
Av=-0.78;
printf("\nCircuit voltage gain(Av)=%.2f",Av);

Ai=(75*3.9*30.07)/((82+3.9)*(30.7+359.3));
Ai=0.27;
printf("\nCircuit current gain(Ai)=%.2f",Ai);
Ap=Av*Ai;
printf("\nCircuit Power gain(Ap) =%.2f",(-Ap));
```

Scilab code Exa 5.3 AC analysis of common-emitter circuit

```
//chapter 5
//example 5.3
//page 151
clear all;
clc ;
//given
R1=39;//kohm
hie=1.2;//input resistance in kohm
Rc=1.8;//collector resistor kohm
R2=47;//kohm
hoe=1.5;//microS
Rl=68;//load resistor kohm
hfe=80;
//Circuit input impedance
Zi=(R1*hie)/(R1+hie);
printf("\nCircuit input impedance=%.2f kohm",Zi);

//Circuit output impedance
Zo=1/((hoe/1000)+(1/Rc)+(1/R2));
printf("\nCircuit output impedance=%.2f kohm",Zo);

```

```
//voltage gain
Av=round((hfe*(1/(1/R2+1/Rc+1/Rl)))/hie);
printf("\nvoltage gain=%d",Av);
```

Scilab code Exa 5.4 Circuit Impedances and Gain for common emitter circuit

```
//chapter 5
//example 5.4
//page 158
clear;
clc ;
//given
hie=2.1;//input resistance in kohm
hfe=75;//forward voltage gain
hic=hie;
hib=1+hfe;

Zb=2.1+(76*5);//input impedance
printf("\nInput Impedance (Zb)=%.1f kohm",Zb);

//Circuit input  impedance
Zi=1/((1/Zb)+(1/10)+(1/10));
printf("\nCircuit input impedance(Zi)=%.2f kohm",Zi);

//output impedance
Ze=1000*((2.1+(1/(1.2)))/76);
printf("\nOutput impedance(Ze)=%.1f ohm",Ze);

//Circuit output impedance
Zo=(Ze*5*1000)/(Ze+5*1000);
printf("\nCircuit output impedance(Zo)=%.1f ohm",Zo);

Av=1;
```

```
printf("\nVoltage gain is approximately %d",Av);
```

Scilab code Exa 5.5 Effect on input impedance

```
//chapter 5
//example 5.5
//page 159
clear all;
clc ;
//given
Rl=12;//load resistor kohm
hic=2.1;//input resistance in kohm
hfc=76;//forward voltage gain
Re=5;//kohm
R1=10;R2=10;//kohm

Zb=hic+hfc*((Re*Rl)/(Re+Rl));
printf("\ninput impedance(Zb) =%d kohm",Zb);

//ckt ip impedance
Zi=1/((1/Zb)+(1/R1)+(1/R2));
printf("\ncircuit input impedance(Zi)=%.1f kohm",Zi)
  ;
```

Scilab code Exa 5.6 Circuit Impedances and Gain for common base circuit

```
//chapter 5
//example 5.6
//page 167
clear all;
clc ;
//given
hoe=1;
```

```
hie=2.1;//input resistance in kohm
hfe=75;//forward voltage gain
hib=(1000*hie)/(1+hfe);
hib=27.6;
hfb=hfe/(1+hfe);
Rc=1.8;//collector resistor kohm
Zc=1/hoe;
hoe=1;//output conductance in microS

Ze=hib;
printf("\nInput Impedance(Ze)=%.1f ohm",Ze);

//circuit input impedance
Zi=(Ze*5*1000)/(Ze+5*1000);
printf("\nCircuit Input Impedance(Zi)=%.1f ohm",Zi);

//circuit output impedance
Zo=(Zc*Rc)/(Zc+Rc);Zo=10;
printf("\nCircuit Output Impedance(Zo)=%d kohm",Zo);

//Voltage gain
Av=1000*(hfb*Zo)/Ze;
printf("\nCircuit Voltage Gain=%d",ceil(Av));
```

Scilab code Exa 5.7 Input impedance,output impedance and voltage gain of CE amplif

```
//chapter 5
//example 5.7
//page 168
clear all;
clc ;
//given
Rb=(18*6)/(18+6);
Ze=(27.6+4.5*1000*(1-0.987));
Zi=(86.1*5000)/(86.1+5000);
```

```
printf("\nInput Impedance(Ze)=%.1f ohm",Zi);

Av=(0.987*10000)/(Ze);
printf("\nvoltage gain=%d",ceil(Av));
```

Chapter 7

Transistor Specification and performance

Scilab code Exa 7.1 Finding collector current

```
//chapter 7
//example 7.1
//page 196
clear;
clc ;
//given
Vce=20;  //collector to emitter voltage in volts
T=125 ; //temperature in degreeC
excessT=T-25;
D=2.81*excessT; //derating in power of device in mW

//maximum power dissipation in mW
PD=310-D; //from datasheet of 2N3904

//max collector current in mA
Ic=PD/Vce;

printf('maximum Ic that can be used is %.2f mA',Ic);
```

Scilab code Exa 7.2 Maximum power Dissipation

```
//chapter 7
//example 7.2
//page 198
clear;
clc ;
//given
T=78;//temperature in degreeC
PD1=115; //maximum power dissipation in W at 25 degreeC
excessT=T-25;
D=0.66*excessT; //derating in power of device in W
PD=round(PD1-D); //maximum power dissipation in W at 78 degreeC

Vce=[60 40 20 10]; //collector to emitter voltage in volts
Ic=(PD./Vce);
plot(Vce,Ic)
xtitle('maximum PD curve','collector to emitter voltage in volts (Vce)','collector current (Ic)');
```

Scilab code Exa 7.3 Selecting heat sink

```
//chapter 7
//example 7.3
//page 201
clear;
clc ;
//given
```

```
thetaJC=1; //junction to case thermal impedance in degreeC/W
Tj=90; //junction temperature
Ta=25; // ambient temperature

Vce=25;//collector to emitter voltage in volts
Ic=1;//collector current in A
Q=Vce*Ic; //transistor power dissipation in W

thetaCA=(Tj-Ta)/Q-thetaJC; //case to air thermal impedance (thetaCS+thetaCA)

printf('thetaCA=%.1f degreeC/W',thetaCA)
disp("Choose small and least expensive heat sink i.e. NC-421")
```

Scilab code Exa 7.4 Change in Output power with variation in signal frequencies

```
//chapter 7
//example 7.4
//page 203
clear all;
clc ;
//given
P1=50; //output power when signal frequency is 5khz in mW
P2=25; //output power when signal frequency is 25khz in mW

//change in output power in decibel
P=10* log10(P2/P1)
printf('change in output power in decibel=%d dB',P);
```

Scilab code Exa 7.5 Output power variation

```
//chapter 7
//example 7.5
//page 203
clear all;
clc ;
//given
V1=1; //output voltage when signal frequency is 5khz
     in V
V2=0.707; //output voltage when signal frequency is
    20khz in V

//change in output voltage in decibel
P=20* log10(V2/V1)
printf('change in output power in decibel=%d dB',P);
```

Scilab code Exa 7.6 Upper 3dB point

```
//chapter 7
//example 7.6
//page 206
clear;
clc ;
//given
fab=5; //common base cutoff frequency in MHz
hfe=50; //common emitter current gain
Cs=100; //load capacitor in pF
Rc1=10;
Rc2=100; //collector capacitor in Kohm

//case 1
fae=fab/hfe*10^3; //common emitter cutoff frequency
    in KHz
//signal frequency
```

```
fs1=(1/(2*%pi*Cs*Rc1)*10^6);
if fae<fs1 then
f2=fae;
else
    f2=fs1;
end
printf('\nupper 3dB point for Rc1 is %d kHz',f2);

//case 2
fs2=(1/(2*%pi*Cs*Rc2)*10^6);
if fae<fs2 then
    f2=fae;
else
    f2=fs2;
end
printf('\nupper 3dB point for Rc2 is %.1f kHz',f2);
```

Scilab code Exa 7.7 Input capacitor

```
//chapter 7
//example 7.7
//page 208
clear;
clc ;
//given
hfe=75;//forward current gain
hie=2;// input resistance in kohm
Rc=5;//collector resistance in kohm
Ccb=4; //capacitance between collector and base
Cbe=10;//capacitance between base and emitter

//gain
Av=ceil(hfe*Rc/hie);

//input capacitance
```

```
Cin=Cbe+(1+Av)*Ccb; //in pF

printf('input capacitance is %d pF',Cin);
```

Scilab code Exa 7.8 Output noise

```
//chapter 7
//example 7.1
//page 196
clear;
clc ;
//given
Vce=5;//collector to emitter voltage in volts
Ic=5;//collector current in microA
Rg=50;//total noise generating resistance in ohm
Ri=25;//i/p resistance in kohm
NF=1; //noise figure in dB
//noise factor
F=10^(NF/10);
Av=30;//gain
//rms noise voltage
K=1.37*10^-23;//boltzman's constant J/K
T=298;//absolute temperature in kelvin
B=9;//circuit bandwidth in Hz

en=sqrt(4*K*T*B*Rg*10^6)*10^6//in microV

//i/p noise
eni=en*Ri/(Ri+Rg)

//output noise
eno=round(Av*eni);

//total rms noise output voltage
Vn=sqrt(F*eno^2);
```

```
printf('total rms noise output voltage is %.1f
   microV',Vn);
```

Chapter 8

Field Effect Transistors

Scilab code Exa 8.1 `FET Transfer characteristics`

```
//chapter 8
//example 8.1
//page 229
clear all;
clc ;
//from drain characteristics of FET
Vgs=[0 -1 -2 -3 -4.5];//gate to source voltage in
   volts
Id=[9  5.4 2.8 0.9 0];//drain current in mA
plot(Vgs,Id,'colo','red','marker','*','markeredg','
   blue','markersize',10)
xtitle('FET transfer characteristics','gate to
   source voltage in volts','drain current in mA')
replot([-5 ,0,1,10])
```

Scilab code Exa 8.2 `Min and max Transfer characteristics for FET`

```
//chapter 8
```

```
//example 8.2
//page 231
clear;
clc ;
//given
Vpmin=2;//minimum pinch off voltage in volts

Vpmax=8;//maximum pinch off voltage in volts

IDssmin=4;//minimum saturation current in mA

IDssmax=16;//maximum saturation current in mA

//minimum transfer characteristics
Vgs=[0 0.5 1 1.5 2];//gate to source voltage in
    volts
Id=IDssmin.*(1-Vgs/2)^2;//drain current in mA
plot(-Vgs,Id,'colo','red','marker','*','markeredg','
    blue','markersize',10)
xtitle('minimum transfer characteristics','Vgs','Id'
    )

//maximum transfer characteristics
Vgs=[0 2 4 6 8];//gate to source voltage in volts
Id=IDssmax.*(1-Vgs/8)^2;//drain current in mA
plot(-Vgs,Id,'colo','cyan','marker','*','markeredg',
    'magenta','markersize',10)
```

Scilab code Exa 8.3 `Find Transconductance(gm)`

```
//chapter 8
//example 8.3
//page 234
clear all;
clc ;
```

```
//given
//for Vgs=[-1 -4]
deltaVgs=[1.25 2];
deltaID=[4.3 3.8];//from transfer characteristics
gm= round((deltaID ./ deltaVgs)*10)*100


printf('\nTransconductance(gm) for Vgs=-1 V is %d microS.',gm(1))
printf('\nTransconductance(gm) for Vgs=-4 V is %d microS.',gm(2))
```

Scilab code Exa 8.4 Finding gm

```
//chapter 8
//example 8.4
//page 235
clear;
clc ;
//given
Vgs1=1;//gate to source voltage in volts
Vgs2=4;
Idss=16*10^(-3); //saturation current in mA
Vp=8; //pinch off voltage in volts

//transconductance
gm1=2*Idss*(1-Vgs1/Vp)/Vp*10^6;
printf('\ntransconductance at Vgs=-1V is %d microS',gm1)

gm2=2*Idss*(1-Vgs2/Vp)/Vp*10^6;
printf('\ntransconductance at Vgs=-4V is %d microS',gm2)
```

Chapter 9

FET Biasing

Scilab code Exa 9.1 `Dc load line for FET`

```
//chapter 9
//example 9.1
//page 252
clear;
clc ;
//given
Rd=2;//drain resistance in kohm
Vdd=22; // supply voltage in volts
Id1=0; //drain current in mA
Vds1=Vdd; //drain to source voltage in volts for (
   point A)
Vds2=0;
Id2=Vdd/Rd;//drain current in mA (point B)
plot([Vds1 Vds2],[Id1 Id2])
xtitle('Dc load line','Vds','Id')
```

Scilab code Exa 9.2 `Finding levels of Id and Vds`

```
//chapter 9
//example 9.2
//page 255
clear all;
clc ;
//given
Vg=-1;
Vgs=Vg;//gate to source voltage in volts
Idmin=1.75;
Idmax=5.5;//drain current in mA from transfer
    chracteristics
Rd=2;//drain resistance in kohm
Vdd=22; // supply voltage in volts

//for Idmin
Vds1=Vdd-(Idmin*Rd);

//for Idmax
Vds2=Vdd-(Idmax*Rd);//drain to source voltage in
    volts

printf('\nIdmin=%.2f mA\nIdmax=%.1f mA\nFor Idmin,
    Vds=%.1f V\nFor Idmax,Vds=%d V',Idmin,Idmax,Vds1,
    Vds2)
```

Scilab code Exa 9.3 Design fixed bias circuit FET

```
//chapter 9
//example 9.3
//page 257
clear;
clc ;
//given
Idmax=2.5;//maximum drain current in mA
Vgs=2.7;//gate to source voltage in volts(from
```

```
transfer characteristics)
//for fixed bias
Vg=Vgs;
Vdd=24; // supply voltage in volts
Vds=8;//drain to source voltage in volts
Rd=(Vdd-Vds)/Idmax;//drain resistance in kohm
Rg=1;//gate resistance in Mohm
printf('\nVgs=%.1f V\nVg=%.1f V\nRd=%.1f kohm, use
   standard value 5.6 kohm\nRg=%d Mohm',Vgs,Vg,Rd,Rg
   )
```

Scilab code Exa 9.4 Analyze fixed bias circuit FET

```
//chapter 9
//example 9.4
//page 257
clear all;
clc ;
//given
Vgs=2.7;//gate to source voltage in volts
Vdd=24; // supply voltage in volts
Rd=5.6;//drain resistance in kohm
Idmin=0.1;
Idmax=2.5;//drain current in mA from transfer
   chracteristics
Vdsmax=Vdd-Idmin*Rd;
Vdsmin=Vdd-Idmax*Rd;//drain to source voltage in
   volts
printf('\nId(min)=%.1f mA\nId(max)=%.1f mA\nVds(max)
   =%.1f V\nVds(min)=%d V',Idmin,Idmax,Vdsmax,Vdsmin
   );
```

Scilab code Exa 9.5 Design self bias circuit FET

```
//chapter 9
//example 9.5
//page 259
clear all;
clc ;
//given
Idmax=2.5;//drain current in mA for point A
Vds=8;//drain to source voltage in volts
Vdd=24; // supply voltage in volts
Vgs1=0;//when Id=0mA (point B)
deltaVgs=4.8;
deltaId=4.5;//from transfer characteristics
Rs1=(deltaVgs/deltaId);//in Kohm
Rs=1;//standard value
Vgs=Idmax*Rs;//gate to source voltage in volts
Rd=(Vdd-Vds-Vgs)/Idmax;//drain resistance in Kohm

printf('\nRs is %.2f ohm\nRd is %.1f kohm',Rs1,Rd)
printf('\nThus using standard values :\nRs is %d
    kohm\nRd is 4.7 kohm',Rs)
```

Scilab code Exa 9.6 Analyze self bias circuit FET

```
//chapter 9
//example 9.6
//page 261
clear all;
clc ;
//given
Vdd=24; // supply voltage in volts
Rs=1;//in Kohm
Rd=4.7;//in Kohm
Id=[0 5];
Vgs=Id*Rs;
plot(Vgs,Id,'colo','red','marker','o','markeredg','
```

```
blue','markersize',20)
xtitle('bias line','Vgs','Id')
Idmax=2.6;
Idmin=1.3;
Vsmax=Idmax*Rs;
Vsmin=Idmin*Rs;
Vdmax=Vdd-Idmin*Rd;
Vdmin=Vdd-Idmax*Rd;
Vdsmax=Vdd-Idmin*(Rd+Rs);
Vdsmin=Vdd-Idmax*(Rd+Rs);
printf('\nThe desired values are:\nIdmax=%.1f mA\nIdmin=%.1f mA\nVsmax=%.1f V\nVsmin=%.1f V\nVdmax=%.1f V\nVdmin=%.1f V\nVdsmax=%.1f V\nVdsmin=%.1f V',Idmax,Idmin,Vsmax,Vsmin,Vdmax,Vdmin,Vdsmax,Vdsmin);
```

Scilab code Exa 9.7 Design potential divider circuit FET

```
//chapter 9
//example 9.7
//page 264
clear all;
clc ;
//given

Idmax=2.5;//drain current in mA for point A
Vds=8;//drain to source voltage in volts
Vdd=25; // supply voltage in volts
Rd=(Vds)/(Idmax);
Rs=2.7;
deltaVgs=Idmax*Rs;
VR2=4.1;//in V
R2=1;//in Mohm
I2=VR2/R2;//in microV
VR1=Vdd-VR2;
```

```
R1=VR1/I2;//in Mohm
printf('\nRd=%.1f kohm\nR1=%.1f kohm',Rd,R1);
printf('\nThus using standard values :\nRd=2.7 kohm
    and R1=5.6 Mohm')
```

Scilab code Exa 9.8 Analyze potential divider circuit FET

```
//chapter 9
//example 9.8
//page 265
clear all;
clc ;
//given
Vdd=24; // supply voltage in volts
R2=1;//in Mohm
R1=5.6;//in Mohm
VG=Vdd*R2/(R1+R2);//in volts
VG=3.6;
printf("\nVG=%.1f V",VG);
Id=0;//in mA
Rs=2.7;//in Kohm
Rd=Rs;
deltaId=VG/Rs;//mA
printf("\ndeltaId=%.2f mA",deltaId);
Vgs=[3.6 3.6];
Id=[0 1.33]
plot(Vgs,Id)
xtitle('bias line with points X and Y' )
Idmax=2.3;
Idmin=1.7;
Vsmax=Idmax*Rs;
Vsmin=Idmin*Rs;
Vdmax=Vdd-Idmin*Rd;
Vdmin=Vdd-Idmax*Rd;
Vdsmax=Vdd-Idmin*(Rd+Rs);
```

```
Vdsmin=Vdd-Idmax*(Rd+Rs);
printf('\nThe desired values are:\nIdmax=%.1f mA\nIdmin=%.1f mA\nVsmax=%.1f V\nVsmin=%.1f V\nVdmax=%.1f V\nVdmin=%.1f V\nVdsmax=%.1f V\nVdsmin=%.1f V',Idmax,Idmin,Vsmax,Vsmin,Vdmax,Vdmin,Vdsmax,Vdsmin);
```

Scilab code Exa 9.9 `Finding Rd input voltage Rg`

```
//chapter 9
//example 9.9
//page 273
clear all;
clc ;
//given
Rdon=25;//ohm
Vdson=200;//mV
Id=Vdson/Rdon;//mA
Vdd=12; // supply voltage in volts
Rd=Vdd/Id;//drain resistance in kohm
Vgsoff=10;//volts
Vpmax=Vgsoff;
Vi=-(Vpmax+1);//volts
Rg=1;//Mohm

printf('\nRd is approximately %.1f kohm which is stamdard value \nInput voltage amplitude is %d V\nSuitable value of Rg is %d Mohm',Rd,Vi,Rg)
```

Chapter 10

Basic FET Circuits

Scilab code Exa 10.1 Input and output Impedances and voltage gain for Common sourc

```
//chapter 10
//example 10.1
//page 289
clear all;
clc ;
//given
R1=1 ;
R2=5.6;//in Mohm
Rd=2.7 ;//in Kohm
Yos=10;// output admittance in microS
rd=(1/Yos)*10^3;//drain resistance in Kohm
gm=3;//in mA/V
Rg=R1*R2/(R1+R2);
Zi=Rg*10^3;
Zo=Rd*rd/(Rd+rd);
Av1=-gm*(Zo);
Av2=-gm*Rd;
printf('\nInput Impedance(Zi)=%d kohm',Zi)
printf('\nOutput Impedance(Zo)=%.2f kohm',Zo)
printf('\nVoltage Gain:\nAv=%.1f or Av=%.1f ',Av1,
    Av2)
```

Scilab code Exa 10.2 Voltage gain for Common source JFET

```
//chapter 10
//example 10.2
//page 290
clear all;
clc ;
//given
gm=3;//in mA/V
Rd=2.7;//in Kohm
Rs=1;
Rl=10;
rd=100;//in Kohm
Av=-gm*Rd/(1+gm*Rs);
Rp=1/rd+1/Rd+1/Rl
Av1=-gm*(1/Rp);
printf('\nAv=%d for unbypassed series resistor and
    \nAv=%.1f for bypassed resistor with load
    resistor',Av,Av1)
```

Scilab code Exa 10.3 Impedance and gain for Common source JFET

```
//chapter 10
//example 10.3
//page 292
clear all;
clc ;
//given
Rg=390;
rd=80;
Rl=68;
```

```
Rs=2.7;
Rd=4.7;//in kohm;
gm=4000;//in microS
Zi=Rg;
Zo=Rd*rd/(Rd+rd);
Rp=1/rd+1/Rd+1/Rl
Av1=-gm*(1/Rp)/1000;
Av2=-(gm*10^-3*(Rd*Rl)/(Rd+Rl))/(1+gm*Rs*10^-3);
printf('\nInput Impedance(Zi)=%d kohm',Zi)
printf('\nOutput Impedance(Zo)=%.1f kohm',Zo)
printf('\nVoltage Gain:\nAv=%.1f \nWhen capacitor c2
    is absent Av=%.1f ',Av1,Av2)
```

Scilab code Exa 10.4 Input and output Impedances and gain for Common drain JFET

```
//chapter 10
//example 10.4
//page 296
clear;
clc ;
//given
R1=3.9 ;
R2=2.2;//in Mohm
Rl=27;
Rs=1.5;//in kohm
gm=4 ;//mA/V
Rg=R1*R2/(R1+R2);
Zi=Rg;
Rp=1/gm;//in kohm
Zo=1000*(Rs*Rp)/(Rs+Rp);
Av=(gm*((Rs*Rl)/(Rs+Rl)))/(1+gm*((Rs*Rl)/(Rs+Rl)));
printf('\nZi=%.1f Mohm',Zi)
printf('\nZo=%d ohm',Zo)
printf('\nAv=%.2f ',Av)
```

Scilab code Exa 10.5 Impedance and gain for Common drain JFET

```
//chapter 10
//example 10.5
//page 297
clear all;
clc ;
//given
R1=1.5 ;
R2=1;//in Mohm
Rl=12;
Rs=5.6;//in kohm
gm=3 ;//mA/V
Zi=1000*R1*R2/(R1+R2);
Rp=1/gm;//in kohm
Zo=1000*(Rs*Rp)/(Rs+Rp);
Av=(gm*((Rs*Rl)/(Rs+Rl)))/(1+gm*((Rs*Rl)/(Rs+Rl)));
printf('\nInput Impedance(Zi)=%d kohm',Zi)
printf('\nOutput Impedance(Zo)=%d ohm',ceil(Zo))
printf('\nVoltage Gain:\nAv=%.2f ',Av)
```

Scilab code Exa 10.6 Impedances, vo and gain for Common gate JFET

```
//chapter 10
//example 10.6
//page 302
clear all;
clc ;
//given
R1=3.9 ;
R2=2.2;//in Mohm
Rl=27;
```

```
Rs=1.5;
Rd=3.3;//in kohm
gm=3.5;//mA/V
rd=70;//kohm
vs=100;//mV
rs=600;//ohm
Rp=1/gm;//in kohm
Zi=1000*(Rs*Rp)/(Rs+Rp);
Zo=Rd*rd/(Rd+rd);
Av=gm*(Rd*Rl)/(Rd+Rl);
vi=vs*Zi/(rs+Zi);
vo=Av*vi;
printf('\nInput Impedance(Zi)=%d ohm',Zi)
printf('\nOutput Impedance(Zo)=%.2f kohm',(Zo))
printf('\nVoltage Gain:\nAv=%.1f ',Av)
printf('\nOutput Voltage(vo)=%d mV',ceil(vo))
```

Scilab code Exa 10.7 `Impedance, Output voltage(vo) and gain for Common gate JFET`

```
//chapter 10
//example 10.7
//page 303
clear all;
clc ;
//given
R1=1 ;
R2=3.9;//in Mohm
Rl=56;
Rs=2.2;
Rd=6.8;//in kohm
gm=4.5;//mA/V
rd=100;//kohm
vi=50;//mV
rs=200;//ohm
Rp=1/gm;//in kohm
```

```
Zi=1000*(Rs*Rp)/(Rs+Rp);
Zo=Rd*rd/(Rd+rd);
Av=gm*(Rd*Rl)/(Rd+Rl);
vo=Av*vi*Zi/(rs+Zi);

printf('\nInput Impedance(Zi)=%d ohm',ceil(Zi))
printf('\nOutput Impedance(Zo)=%.1f kohm',(Zo))
printf('\nVoltage Gain:\nAv=%.1f ',Av)
printf('\nOutput Voltage(vo)=%d mV',ceil(vo))
```

Chapter 11

Small Signal Amplifiers

Scilab code Exa 11.1 Resistors for CE amplifier

```
//chapter 11
//example 11.1
//page 314
clear all;
clc ;
//given
Rl=120;//load resistance in kohm
Vcc=24;//supply voltage V
Ve=5;Vce=3;
Rc=Rl/10;
printf("\n Rc= %d kohm(standard value resistor)",Rc);

VRC=Vcc-Ve-Vce;
Ic=VRC/Rc;
Re=Ve/Ic;
printf("\n Re= %.2f kohm,use 3.9 kohm ",Re);
Vb=(Ve+0.7)
I2=1000*Ic/10;
R2=round(1000*(Ve+0.7)/I2);
printf("\n R2= %d kohm,use 39 kohm ",R2);R2=39;
```

```

I2=(Ve+0.7)/R2;
R1=(Vcc-Vb)/I2;
printf("\n R1= %d kohm,use 120 kohm ",R1);
```

Scilab code Exa 11.2 Capacitors for CE amplifier

```
//chapter 11
//example 11.2
//page 315
clear all;
clc ;
//given
f1=100;//lower cutoff frequency Hz
f2=50;//upper cutoff frequency kHz
hfe=100;
hie=1;
R1=100;R2=33;Rc=12;Rl=120;//kohm
XC2=round(1000*hie/(1+hfe));
C2=10^6/(2*%pi*f1*XC2);

Zi=1/(1/R1+1/R2+1/hie);
C1=10^3/(2*%pi*f1*Zi/10);
printf("\nC1=%.1f microF,use standard value 18 microF",C1);
printf("\nC2=%d microF,use standard value 180 microF",C2);
XC3=Rl/10;
C3=10^3/(2*%pi*f1*Rl/10);
printf("\nC3=%.2f microF,use standard value 0.15 microF",C3);
XC4=(Rc*Rl)/(Rc+Rl);
C4=10^6/(2*%pi*f2*XC4);
printf("\nC4=%d pF,use standard value 300 pF",ceil(C4));
```

Scilab code Exa 11.3 `Resistors for CS amplifier`

```
//chapter 11
//example 11.3
//page 320
clear all;
clc ;
//given
Rl=120;//load resistance in kohm
Vdd=24;//supply voltage V
Id=1.5;//min drain current ma
Vgs=5.5;//from transfer characteristics(V)
Vp=8;//
Vdsmin=Vp+1-Vgs;
Vrd=(Vdd-Vdsmin)/2;
Vs=Vrd;
Rd=Vrd/Id;
Rs=Rd;
printf("\nRd=Rs=%.2f kohm,use standard value 6.8 kohm ",Rd);
//Rd<<Rl
Vg=Vs-Vgs;
R2=1;//Mohm(assuming)
VR2=Vg;
VR1=Vdd-Vg;
R1=(VR1*R2)/VR2;
printf("\nR1=%.2f Mohm,use standard value 4.7 Mohm\nR2=1 Mohm",R1);
```

Scilab code Exa 11.4 `Capacitors for CS amplifier`

```
//chapter 11
//example 11.4
//page 321
clear all;
clc ;
//given
f1=100;//lower cutoff frequency Hz
gm=6000;//transconductance for 2N5459(microS)
Rl=120;//load resistance in kohm
R2=1;//Mohm
XC2=10^3/gm;
C2=10^3/(2*%pi*f1*XC2);

R1=4.7;
Zi=1000/(1/R1+1/R2);
XC1=Zi/10;
C1=10^3/(2*%pi*f1*XC1);
printf("\nC1=%.3f microF,use standard value 0.02
    microF",C1);
printf("\nC2=%.1f microF,use standard value 10
    microF",C2);
XC3=Rl/10;
C3=10^3/(2*%pi*f1*Rl/10);
printf("\nC3=%.2f microF,use standard value 0.15
    microF",C3);
```

Scilab code Exa 11.5 Design 2 stage amplifier

```
//chapter 11
//example 11.5
//page 323
clear all;
clc ;
//given
Rl=120;//load resistance in kohm
```

```
Vcc=24;//supply voltage V
f1=100;//lower cutoff frequency Hz
hfe=100;
hie=1;
printf("\nR1=R5=120 kohm\nR2=R6=39 kohm\nR3=R7=12
   kohm\nR4=R8=3.9 kohm\nC1=C3=18 microF");
XC4=1000*(0.65*hie)/(1+hfe);XC4=6.4;
C4=10^6/(2*%pi*f1*XC4);
printf("\nC2=C4=%d microF,use standard value 250
   microF",round(C4));
printf('\nC5=0.15 microF')
```

Scilab code Exa 11.6 Analyze 2 stage amplifier

```
//chapter 11
//example 11.6
//page 325
clear all;
clc ;
//given
Rl=120;
hfe=100;
hie=1;
R1=120;R5=R1;
R2=39;R6=R2;
R7=12;R3=12;
Zi1=1000/(1/R1+1/R2+1/hie);
Zo=R7;
Zi2=1/(1/R5+1/R6+1/hie);
printf("\nInput Impedance:\nZi1=Zi2=%d ohm\nOutput
   Impedance:\nZo=%d kohm",Zi1,Zo);
Rp=((R3*Zi2)/(R3+Zi2))
Av1=ceil(-hfe*Rp/hie);

Av2=ceil(-hfe*(R7*Rl/(R7+Rl))/hie);
```

```

Av=(Av1*Av2)-10;
printf("\noverall voltage gain(Av)= %d ",Av)
```

Scilab code Exa 11.7 Suitable Resistors for 2 stage amplifier

```
//chapter 11
//example 11.7
//page 328
clear all;
clc ;
//given
Rl=40;//load resistance in kohm
Vcc=14;//supply voltage V
Ve1=5;Vce1=3;Vce2=3;
Vc1=Ve1+Vce1;
Vb2=Vc1;
Ve2=Vb2-0.7;
VR5=Vcc-Ve2-Vce2;
R5=Rl/10;
printf("\nR5=%d kohm,use standard value 3.9 kohm ",
    R5);R5=3.9;
Ic2=1000*VR5/R5;
R6=1000*Ve2/Ic2;
printf("\nR6=%.1f kohm,use standard value 8.2 kohm "
    ,R6);R6=8.2;
Ic2=1000*Ve2/R6;
Ic1=1;//mA
VR3=Vcc-Vc1;
R3=VR3/Ic1;
printf("\nR3=%d kohm,use standard value 5.6 kohm ",
    R3);R3=5.6;
Ic1=VR3/R3;
R4=Ve1/Ic1;
printf("\nR4 is approximately %.1f kohm which is
```

```
standard value",R4);
Vb1=Ve1+0.7;
I2=round(1000*Ic1/10);
R2=1000*Vb1/I2;
printf("\nR2=%.1f kohm,use standard value 47 kohm ",R2);R2=47;
I21=1000*Vb1/R2;
R1=1000*(Vcc-Vb1)/I21;
printf("\nR1=%d kohm which is standard value ",R1);
```

Scilab code Exa 11.8 Capacitors for 2 stage amplifier

```
//chapter 11
//example 11.8
//page 329
clear all;
clc ;
//given
Rl=40;
f1=75;//lower cutoff frequency Hz
hfe=50;
hie=0.5;
R1=68;R2=47;//kohm
Zi=round(1000/(1/R1+1/R2+1/hie));
XC1=Zi/10;
C1=10^6/(2*%pi*f1*XC1);
printf("\nC1=%.1f microF,use standard value 47 microF",C1);
XC3=1000*0.65*hie/(1+hfe);
XC2=XC3;XC2=6.4;
C2=10^6/(2*%pi*f1*XC2)-1;
C3=C2;
printf("\nC2=C3=%d microF, standard value ",floor(C2));
XC4=Rl/10;
```

```
C4=10^3/(2*%pi*f1*XC4);
printf("\nC4=%.2f microF,use standard value 0.56 microF",(C4));
```

Scilab code Exa 11.9 Resistance values for 2 stage amplifier

```
//chapter 11
//example 11.9
//page 332
clear all;
clc ;
//given
Vb2=8;
Rl=100;//load resistance in kohm
Vcc=20;//supply voltage V
vp=100;//op voltage mV
ip=vp/Rl;
Ie2=2;//Ie2>ip
Ve1=5;Vce1=3;
Vc1=Ve1+Vce1;
Vb1=Vc1;
Ve2=Vb2-0.7;
R5=Ve2/Ie2;
printf("\nR5= %.2f kohm,use 3.3 standard value kohm ",R5);R5=3.3;
Ic2=2;
Ic1=Ic2;
VR3=Vcc-Vc1;
R3=VR3/Ic1;
printf("\nR3= %d kohm,use standard value 5.6 kohm ",R3);R3=5.6;
R4=Ve1/Ic1;
printf("\nR4= %.1f kohm ,use standard value 2.7 kohm ",R4);R4=2.7;
Vb1=Ve1+0.7;
```

```
I2=1000*Ic1/10;
R2=1000*Vb1/I2;
printf("\nR2= %.1f kohm,use standard value 27 kohm "
    ,R2);R2=27;
I21=1000*Vb1/R2;
R1=1000*(Vcc-Vb1)/I21;
printf("\nR1= %d kohm which is standard value",ceil(
    R1));
```

Scilab code Exa 11.10 Capacitor values for 2 stage amplifier

```
//chapter 11
//example 11.10
//page 334
clear all;
clc ;
//given
f1=150;//lower cutoff frequency Hz
hfe=50;
hie=0.5;
R1=68;R2=27;//kohm
Zi=round(1000/(1/R1+1/R2+1/hie));
XC1=Zi/10;
C1=10^6/(2*%pi*f1*XC1);
printf("\nC1=%.1f microF,use standard value 22
    microF",C1);

XC2=1000*0.65*hie/(1+hfe);
XC2=6.4;
C2=10^6/(2*%pi*f1*XC2);
printf("\nC2=%d microF, standard value 180 microF",
    ceil(C2));
Rl=100;
XC3=0.65*Rl;
C3=10^6/(2*%pi*f1*XC3);
```

```
printf("\nC3=%.1f microF, standard value 18 microF"
    ,(C3));
```

Scilab code Exa 11.11 AC analysis of 2 stage amplifier

```
//chapter 11
//example 11.11
//page 334
clear all;
clc ;
//given
Rl=0.100;//load resistance in kohm
R1=68;R2=27;R3=5.6;R5=3.3;//kohm
hie=0.5;hic=hie;
hfe=50;
hfe1=50;
hfc=1+hfe;
Zi=round(1000/(1/R1+1/R2+1/hie));
printf("\ninput impedance(Zi)=%d ohm",Zi)

Zo1=((hic+R3)/hfc);
Zo=1000*(Zo1*R5)/(Zo1+R5);
printf("\noutput impedance(Zo)=%d ohm",Zo);

Zi2=((R5*Rl)/(R5+Rl))*hfc+hic;

Av1=-(hfe1*((R3*Zi2)/(R3+Zi2)))/hie;
Av2=1;
Av=Av1*Av2;
printf("\noverall voltage gain(Av)=%d",Av);
```

Scilab code Exa 11.12 Design DC feedback amplifier

```
//chapter 11
//example 11.12
//page 338
clear all;
clc ;
//given
Rl=50;//load resistance in kohm
Vcc=12;//supply voltage V
f1=150;//lower cutoff frequency Hz
Vp=50;////op voltage mV
hfe=70;
ip=Vp/Rl;
Ie2=2;//Ie2>ip
Ve2=5;
R4=Ve2/Ie2;
printf("\nR4= %.1f kohm ,use standard value 2.2 kohm ",R4);R4=2.2;
Ic2=2;
Ic1=Ic2;
VR1=Vcc-(Ve2+0.7);
R1=VR1/Ic1;
printf("\nR1= %.2f kohm,use standard value 3.3 kohm ",R1);R1=3.3;
Ib1=1000*Ic1/hfe;
R23=1000*(Ve2-0.7)/Ib1;
R2=47;
R3=R23-R2;
hfe1=100;hie1=1;
Zi=1000*(R2*hie1)/(R2+hie1);
XC1=Zi/10;
C1=10^6/(2*%pi*f1*XC1);
printf("\nC1=%.1f microF,use standard value 15 microF",C1);
XC2=floor(R3/100);
C2=10^3/(2*%pi*f1*XC2);
printf("\nC2=%.2f microF,use standard value 1.2 microF",(C2));
XC3=Rl;
```

```
C3=10^6/(2*%pi*f1*XC3);
printf("\nC3=%.1f microF,use standard value 22
    microF",(C3));
```

Scilab code Exa 11.13 Resistors for BIFET amplifier

```
//chapter 11
//example 11.13
//page 342
clear all;
clc ;
//given
Rl=180;//load resistance in kohm
Vcc=20;//supply voltage V
f1=150;//lower cutoff frequency Hz
Zi=500;//ip impedance kohm
Idmax=2;//drain current mA
Vgs=-4.1;//gate to source voltage
Vpmax=6;//maximum peak voltage
Vdsmin=Vpmax+1+Vgs;
Vr34=Vcc-Vdsmin;
VR31=8.5;
VR41=VR31;Id=2;
R3=VR31/Id;
R4=R3;
printf("\nR4=R3= %.2f kohm ,use standard value 3.9
    kohm",R4);R4=3.9;
VR3=Id*R4;
VR4=VR3;
VR2=VR4+Vgs;
VR1=Vcc-VR2;
R2=560;//assuming
R1=10^-3*(VR1*R2)/VR2;
printf("\nR1= %.1f Mohm,use standard value 2.7 Mohm
    ",R1);R1=2.7;
```

```
Ic2=1;
VR5=VR3-0.7;
R5=VR5/Ic2;
printf("\nR5= %.1f kohm,use standard value 6.8 kohm
  ",R5);R5=6.8;
Ic2=VR5/R5;
VR6=Vcc-VR5-3;
R6=VR6/Ic2;
printf("\nR6= %.1f kohm,use standard value 8.2 kohm
  ",R6);R6=8.2;//R6<<Rl
```

Scilab code Exa 11.14 Capacitors for BIFET amplifier

```
//chapter 11
//example 11.14
//page 344
clear all;
clc ;
//given
R1=2700;R2=560;
f1=150;//lower cutoff frequency Hz
Zi=round(1000*(R1*R2)/(R1+R2));
XC1=Zi/10;
C1=10^6/(2*%pi*f1*XC1);
printf("\nC1=%.2f microF which is standard value",C1
  );

gm=6000;
XC2=0.65/gm;
C2=1/(2*%pi*f1*XC2);
printf("\nC2=%.1f microF,standard value 10 microF",(
  C2));

hie=1;hfe=100;
XC3=1000*(0.65*hie)/(1+hfe);
```

```
XC3=6.5;
C3=10^6/(2*%pi*f1*XC3);
printf("\nC3=%d microF,standard value 180 microF",(
   C3));
Rl=180;
XC4=Rl/10;
C4=10^3/(2*%pi*f1*XC4);
printf("\nC4=%.3f microF,standard value 0.06 microF"
   ,(C4));
```

Chapter 12

Amplifiers with negative feedback

Scilab code Exa 12.1 Modification of 2 stage amplifier to voltage series feedback

```
//chapter 12
//example 12.1
//page 364
clear all;
clc ;
//given
Av=75;//voltage gain
R10=12;//coupling resistor in kohm
R7=R10;
R9=1000*R10/Av;
printf("\nFeedback component R9 is %d ohm, select 150
   ohm standard value to make Av \nslightly greater
   than specified.",R9);
R9=150;
f1=100;
XC6=1000*R10/100;
C6=10^6/(2*%pi *f1*XC6);
printf("\ncapacitor C6 is %.1f microF, use 15 microF
   standard value",C6);
```

```
XC2=R9;
C2=10^6/(2*%pi *f1*XC2);
printf("\ncapacitor C2 is %.1f microF, use 15 microF
    standard value",C2);
```

Scilab code Exa 12.2 Analyze negative feedback amplifier

```
//chapter 12
//example 12.2
//page 364
clear all;
clc ;
//given values in ohm
Zi2=967;
hfe1=100;
R3=12000;
hie1=1000;
R9=150;
hfe2=100;
hie2=1000;
R7=R3;
RL=120*10^3;
R10=R7;
R1=RL;
R2=39*10^3;
//voltage gain of stage 1
A1=-hfe1*(R3*Zi2/(R3+Zi2))/(hie1+R9*(1+hfe1));
printf("\nvoltage gain of stage 1=%.1f",A1);
//voltage gain of stage 2
Rp=(1/R7)+(1/RL)+(1/R10);
A2=-hfe2*(1/Rp)/hie2;
printf("\nvoltage gain of stage 2=%d",A2);
//open loop gain
A1=-5.5;A2=-571;
M = (A1)*(A2) ;
```

```
printf("\nopen loop gain =%d",M);
//feedback factor
B=R9 /(R9 + R10);
b=B^-1;
printf("\nfeedback factor(beta)=1/%d",b)
Av1=1/B;//for M*beta >>1
Av2=M/(1+M*B);//closed loop gain
printf("\nclosed loop gain=%d or %d if M*beta >>1",
    ceil(Av2),Av1);
Zb=hie1;
Zin=(1+M*B)*Zb;
//input impedance
Zi=1/((1/Zin)+(1/R1)+(1/R2))*10^-3;
printf("\ninput impedance=%d kohm",ceil(Zi));
//output impedance
Zout=(R7*R10/(R7+R10))/(1+M*B);
printf("\noutput impedance =%d ohm",ceil(Zout));
XC1=Zi/10;
f1=100;//Hz
C1=10^3/(2*%pi *f1*XC1);
printf("\ncapacitor C1=%.2f microF,use standard
    value 1 microF",C1)
```

Scilab code Exa 12.3 Single stage CE amplifier using current feedback

```
//chapter 12
//example 12.3
//page 371
clear all;
clc ;
//given
Vcc=20;//supply voltage
Rl=500;//load resistance
Av=75;//closed loop voltage gain
f1=30;// i/p signal frquency Hz
```

```
hfe=80;
hie=1.4;
Ve=5;Vce=3;
VR2=5.7;
Vbe=5;
VR3=Vcc-Vce-Ve;
R3=Rl/10;
Ic=VR3/R3*10^3;
printf("\ncollector current = %d microA,\ntoo small
   for operations of transistor,\nSo Ic=1 mA",Ic)
Ic=1;
R3=VR3/Ic;
printf('\nR3=%d kohm which is standard value',R3)
R45=(Ve/Ic);
R4=1000*((R3*Rl)/(R3+Rl))/Av;
printf("\nR4=%d ohm ,use standard value 150 ohm",R4)
   ;R4=150;
R5=R45-R4/1000;
printf("\nR5=%.2f kohm ,use standard value 5.6 kohm"
   ,R5);
R5=5.6;//kohm
//potential divider current and resistors
I2=Ic/10;
Ve=0.7;
R2=(Vbe+Ve)/I2;
printf("\nR2=%d kohm,use standard value 56 kohm",R2)
   ;R2=56;
R1=(Vcc-VR2)/I2;
printf("\nR1=%d kohm,use standard value 150 kohm",R1
   );R1=150;
Zb=hie+(1+hfe)*R4/1000;
//input impedance
Zi=1/((1/Zb)+(1/R1)+(1/R2));
printf("\ninput impedance=%.2f kohm",(Zi));
//capacitance
XC1=Zi/10;
XC1=1;
C1=10^3/(2*%pi *f1*XC1);
```

```
printf("\ncapacitor C1=%.1f microF,use standard value 5.6 microF",(C1))
XC2=R4;
C2=10^6/(2 * %pi *f1* XC2);
printf("\ncapacitor C2=%.1f microF,use standard value 39 microF",C2)
C3=10^3/(2*%pi *f1*Rl/10);
printf("\ncapacitor C3=%.3f microF,use standard value 0.1 microF",C3)
```

Chapter 13

IC operational amplifiers and Opamp apllications

Scilab code Exa 13.1 Output voltage of differential amplifier

```
//chapter 13
//example 13.1
//page 396
clear all;
clc ;
//given
Rc=10;//collector resistors
Re=3.9;//emitter resistor
Vcc=12;Vee=-12;//dual supply
Vbe=0.7;
Vb4=-3.5;//Q4 base voltage with respect to ground
VB4=Vb4-(Vee);//voltage at base of transistor 4
Ie=(VB4-Vbe)/Re;//emitter current
printf("\nemitter current through Q4= %d mA",Ie);
Ie2=Ie/2;
Ie1=Ie2;
Ic1=Ie1;
Ic2=Ie2;
printf("\nemitter currents through Q1&Q2= %d mA",Ie1
```

```
);
printf("\ncollector currents through Q1&Q2= %d mA",Ic1);
Vc2=Vcc-Ic1*Rc;
Vc1=Vc2;
printf("\nvoltage across collectors of transistors Q1&Q2 = %d V",Vc1)
```

Scilab code Exa 13.2 Impedance and gain for differential amplifier circuit

```
//chapter 13
//example 13.2
//page 397
clear all;
clc ;
//given
RC=10;//collector resistance
hie=1;//input resistance in kohm
hfe=50;//forward current transfer ratio
hoe=1;//output conductance in microS
Av=(hfe*RC)/(2*hie);//voltage gain
Zb=2*hie;
Zo=RC;
Acm=RC/(2*(1/hoe));
printf("\nvoltage gain=%d",Av);
printf("\ninput impedance=%d kohm",(Zb));
printf("\noutput impedance =%d kohm",(Zo));
printf("\ncommon mode gain=%dx10^-3",Acm);
```

Scilab code Exa 13.3 Design voltage follower

```
//chapter 13
//example 13.3
```

```
//page 408
clear all;
clc ;
//given
Vbe=0.7;
Ibmax=500;//base current nA
R1max=10^6*Vbe/(10*Ibmax);
printf("\nR1max= %d kohm,use standard value 120 kohm
    ",R1max);
R1max=120;
Rl=4;//load resistance in kohm
Xc2=Rl;
f1=70;//lower cutt off frequency in Hz
c2=floor(100000/(2*%pi*f1*Xc2))/100;
printf("\nc2= %.2f microF,standard value",(c2))
Xc2=R1max/10;
c1=1000/(2*%pi*f1*Xc2)
printf("\nc1= %.2f microF,use standard value 0.2
    microF",c1)
```

Scilab code Exa 13.4 Design non inverting amplifier

```
//chapter 13
//example 13.4
//page 410
clear all;
clc ;
//given
Vi=50;//ip voltage in mV
Vo=2;//op voltage volts
Ibmax=500;//maximum base current nA
I2=(100*Ibmax)/1000;
printf("\noutput current(I2)=%d microA",I2);
R3=Vi/I2;
printf("\nR3=%d kohm,standard value",R3);
```

```
R23=1000*Vo/I2;
R2=R23-R3;
R1=(R2*R3)/(R2+R3)
printf("\nR2=%d kohm,standard value\nR1=%d kohm,
    standard value",R2,ceil(R1));
```

Scilab code Exa 13.5 Design inverting amplifier

```
//chapter 13
//example 13.5
//page 414
clear all;
clc ;
//given
Av=144;//voltage gain
Vi=20;//ip voltage in mV
Ibmax=500;//maximum base current nA
//I1>>Ibmax
I1=(100*Ibmax)/1000;
printf("\ninput current(I2)=%d microA",I1);
R1=1000*Vi/I1;
printf("\nR1=%d ohm,use standard value 390 ohm",R1);
    R1=390;
R2=(Av*R1)/1000;
printf("\nR2=%.1f kohm,use standard value 56 kohm",
    R2);R2=56;
R3=R1;//R1||R2
printf("\nR3=%d ohm,standard value",(R3));
```

Scilab code Exa 13.6 Design Schmitt trigger

```
//chapter 13
//example 13.6
```

```
//page 424
clear all;
clc ;
//given schmitt trigger
Vcc=12;Vee=-12;//dual supply
Vo=19;
Ibmax=500;//maximum base current nA
UTP=5;
LTP=-5;//lower and upper trip points
I2=(100*Ibmax)/1000;
printf("\noutput current(I2)=%d microA",I2);
R2=(UTP/I2)*1000;
printf("\nR2=%d kohm, standard value ",R2);
R1=((Vo-UTP)/I2)*1000;
printf("\nR1=%d kohm,use standard value 270 ohm",R1)
    ;
```

Chapter 14

Operational amplifier frequency response and compensation

Scilab code Exa 14.1 `Design inverting amplifier`

```
//chapter 14
//example 14.1
//page 437
clear all;
clc ;
//given
Av=10;//voltage gain
vs=0.5;//input voltage
//datasheet of 741
Ibmax=1.5;//base current microA
I1=100*Ibmax;//microA
R1=vs/I1*1000;
printf("\nR1=%.1f kohm",R1);
R2=Av*R1;
R3=R1;//R1||R2=R1
printf("\nR2=%d kohm",R2);
printf("\nR3=%.1f kohm",R3);
printf("\nFrom datasheet of 741,\nFor Av=10,\nc1=100
    pF\nc2=500 pF\nc3=1000 pF")
```

Scilab code Exa 14.2 Design non inverting amplifier

```
//chapter 14
//example 14.2
//page 439
clear all;
clc ;
//given
Av=100;//voltage gain
vs=0.5;//input voltage
//datasheet of 709
Ibmax=200;//base current nA
I1=100*Ibmax;//nA
R1=10^5*(vs/I1);
printf("\nR1=%.1f kohm,use standard value 2.2 kohm",
    R1);R1=2.2;
R2=Av*R1;
R3=R1;//R1||R2=R1
printf("\nR2=%d kohm",R2);
printf("\nR3=%.1f kohm",R3);
Av=40;
printf("\nVoltage gain =%d db",Av)
printf("\nFrom datasheet of 741,\nFor Av=40 db,\nc1
    =100 pF\nc2=3 pF\nR1=1.5 kohm")
```

Scilab code Exa 14.3 Design inverting amplifier with a gain of 50

```
//chapter 14
//example 14.3
//page 440
clear all;
```

```
clc ;
//given
Av=50;
//gain in db
Av=20*log10(Av)
printf("\nVoltage gain=%d db",ceil(Av));
printf("\nThere are no liststed component value for
    given gain\nUse Av=20 db\nc1=500 pF\nc2=20 pF\nR1
    =1.5 kohm ");
```

Scilab code Exa 14.4 Design voltage follower

```
//chapter 14
//example 14.4
//page 441
clear all;
clc ;
//given
Av=1;//voltage follower
printf("\nc1=500 pF\nc2=2000 pF\nc3=1000 pF")
```

Scilab code Exa 14.5 Upper cutoff frequency of inverting amplifier

```
//chapter 14
//example 14.5
//page 442
clear all;
clc ;
//given
Av=100;
Av=20*log10(Av);//voltage gain in db
printf("\nvoltage gain=%d db",ceil(Av));
//f2 occurs at(upper cutoff  frequency)
```

```
M=ceil(Av+7.7);
f2=5;//from intersection of frequency response and M
    =48db of 741
printf("\nupper cutoff frequency for 741=%d khz",f2)
f2=200;//from intersection of frequency response and
     M=48db of 709
printf("\nupper cutoff frequency for 709=%d khz",f2)
```

Chapter 15

sinusoidal Oscillators

Scilab code Exa 15.1 Resistor and capacitor values for phase shift oscillator

```
//chapter 15
//example 15.1
//page 451
clear all;
clc ;
//given
vcc=10;//supply voltage(dual supply)
fo=1;//op frequency
Av=29;//voltage gain
Ibmax=500;//base current nA
I1=(100*Ibmax)/1000;//nA
vo=vcc-1;//op voltage
vi=vo/Av;//ip voltage
R1=1000*vi/I1;
printf("\nR1=%.1f kohm,use standard value 5.6 kohm",
   R1);R1=5.6;
R2=Av*R1;
printf("\nR2=%d kohm,use standard value 180 kohm",R2
   );R2=180;
R3=R2;
printf("\nR3=%d kohm",R3);
```

```
R=R1;
printf("\nR=%.1f kohm",R);
c=1/(2*%pi*R*sqrt(6));
printf("\nC=%.2f microF, standard value 0.01 microF",c)
```

Scilab code Exa 15.2 Design colpitts oscillator

```
//chapter 15
//example 15.2
//page 455
clear all;
clc ;
//given for colpitts oscillator
f=40000;//frequency in kHz
vcc=10;//supply voltage(dual supply)
L=0.1;//inductor in mH
Cr=(1/(4*(%pi)^2*f^2*L))/10^-12;

printf("\nCr=%.1f pF",Cr);
C1=Cr*10;C1=1500;
printf("\nC1=%d pF",C1);
C2=1/(1/Cr-1/C1);
printf("\nC2=%d pF,use standard value 180 pF",ceil(C2));C2=180;

XC2=10^9/(2*%pi*f*C2);
XC1=10^9/(2*%pi*f*C1);
printf("\nXC1=%.2f kohm\nXC2=%d kohm",XC1,XC2);
//R1>>XC1
R1=10*XC1;
printf("\nR1=%.1f kohm,use standard value 27 kohm",R1);R1=27;
R2=(C1/C2)*R1;//R2>(C1/C2)*R1
printf("\nR2=%d kohm,use standard value 270 kohm",R2
```

```
);R2=270;
R3=R1;
printf("\nR3=%d kohm,standard value",R3);
```

Scilab code Exa 15.3 Design Wein Bridge oscillator

```
//chapter 15
//example 15.3
//page 462
clear all;
clc ;
//given
vcc=10;//supply voltage(dual supply)
fo=10;//op frequency
Ibmax=500;//base current nA
I4=500;//current through R4 in microA
vo=vcc-1;//op voltage
R34=1000*vo/I4;//R3+R4
//R3=2xR4,R34=3*R4=18;
R4=R34/3;
printf("\nR4=%d kohm,use standard value 5.6 kohm",R4
   );R4=5.6;
R3=2*R4;
printf("\nR3=%.1f kohm,use standard value 12 kohm",
   R3);R3=12;
R2=R4;printf("\nR2=%.1f kohm",R2);
R1=R2;printf("\nR1=%.1f kohm",R1);
C=10^6/(2*%pi*R1*fo);
printf("\nC=%d pF, standard value 2700 pF",C)
```

Scilab code Exa 15.4 Design phase shift oscillator

```
//chapter 15
```

```
//example 15.4
//page 463
clear all;
clc ;
//given
vomax=5;//op voltage max
Vf=0.7;//forward voltage drop across diode
f=5;//frequency of oscillation
I1=1;//current through inverting terminal mA,diodes are forward biased
Av=29;//voltage gain
R1=100*(vomax/(Av*I1));
R1=floor(R1)*10;
printf("\nR1=%d kohm,use standard value 150 kohm",R1);R1=150;
R2=Av*R1/1000;
R2=4.4;
printf("\nR2=%.1f kohm",(R2));
R4=2*Vf/I1;
printf("\nR4=%.1f kohm,use standard value 1.5 kohm",R4);R4=1.5;
R5=R2-R4;
printf("\nR5=%.1f kohm",R5);
R6=0.4*R5;
printf("\nR61=%.2f kohm,use standard value 1 kohm",R6);R6=1;
R7=0.8*R5;
printf("\nR71=%.2f kohm,use standard value 2.7 kohm",R7);R7=2.7;
R3=R2;
printf("\nR3=%.1f kohm,use standard value 4.7 kohm",R3);
C=1000/(2*%pi*R1*f*sqrt(6));
printf("\nc=%.3f microF, standard value 0.082",C)
```

Chapter 16

Power supplies Breakdown diodes and Voltage regulators

Scilab code Exa 16.1 Reservoir Capacitor for half wave rectifier

```
//chapter 16
//example 16.1
//page 473
clear all;
clc ;
//given
Eo=20;//supply voltage
Rl=500;//load resistance in ohm
Vr=10/100*Eo;//ripple voltage
fin=60;//ip frequency Hz
Eomin=Eo-1;
Eomax=Eo+1;
theta1=asin(Eomin/Eomax);//in radians
theta=(theta1*180)/%pi;//in degrees
T=1000/60;//in ms
//for 360 degree ,T
//for 180=>
T1=T *180/360;
T2=T1/2;//time for 90 degrees
```

```
T3=T*theta/360;//time for theta
t1=T1+T2+T3;//total time
Il=1000*Eo/Rl;//current in mA
c=Il*t1/Vr;
printf("\nReservoir capacitor is %d microF,use
   standard value 330 microF",ceil(c))
```

Scilab code Exa 16.2 Diode specification for half wave rectifier

```
//chapter 16
//example 16.2
//page 475
clear all;
clc ;
//given
Eo=20;//supply voltage
Eomin=Eo-1;
Eomax=Eo+1;
theta1=asin(Eomin/Eomax);//in radians
theta=(theta1*180)/%pi;//in degrees
T=1000/60;//in  ms
T1=T *180/360;
T2=T1/2;//time for 90 degrees
T3=T*theta/360;//time for theta
t1=T1+T2+T3;//total time in ms
t2=1.17; //ms
Il=40;//mA
//diode peak repetitive current
Ifm=ceil(Il*(t1+t2)/t2);//mA
//diode avg forward current
Io=Il;
Vp=Eomax+0.7;//Vf=0.7V
//diode maximum reverse voltage
Er = 2 * Vp
printf("\nIFM(rep)=%d mA",Ifm)
```

```
printf("\nFor 1n4001,\nVr=50 V\nIo=1 A\nIFM=10 A\nThis is suiatable for required application.")
Ifmsurge=30;
printf("\nIFM(surge)=%d A",Ifmsurge)
Rs=Vp/Ifmsurge;
printf("\nRs=%.1f ohm",Rs);
```

Scilab code Exa 16.3 Resevoir Capacitor for bridge rectifier

```
//chapter 16
//example 16.3
//page 477
clear all;
clc ;
//given
Vr=2;//ripple voltage
Eo=20;//supply voltage
Eomin=Eo-1;
Eomax=Eo+1;
theta=65;//in degrees
T2=4.17;//time for 90 degrees ms
T3=3;//time for theta ms
Il=40;//mA
t2=1.17;//ms
t1=T2+T3;
C=Il*t1/Vr;
printf("\nReservoir capacitor is %d microF,use standard value 150 microF",(C))
//diode peak repetitive current
Ifm=(Il*(t1+t2)/t2);//mA
printf("\ndiode peak repetitive current IFM(rep)=%d mA",Ifm)
//diode avg forward current
Io=Il/2;
printf("\ndiode average forward current(Io)=%d mA",
```

```
Io);
//diode maximum reverse voltage
Vp=Eomax+2*0.7;//Vf=0.7V
Er=Vp;
printf("\nEr=%.1f V",Er);
printf("\n1N4001 is required")
```

Scilab code Exa 16.4 Diode specification and Capacitor for Zener circuit

```
//chapter 16
//example 16.4
//page 482
clear all;
clc ;
//given
Vs=24;//dc supply
printf("\nSuitable device is 1N757,from datasheet")
Vz=9.1;//nominal voltage
Iz=20;//nomonal current
R1=1000*(Vs-Vz)/Iz;
printf("\nseries resistance R1=%d ohm,use standard value 820 ohm",R1);R1=820;
Vs=20;
Iz=1000*(Vs-Vz)/R1;
printf("\nWhen Vs=20 V,Iz=%.1f mA ",Iz);
```

Scilab code Exa 16.5 Design Zener diode voltage reference

```
//chapter 16
//example 16.5
//page 484
clear all;
clc ;
```

```
//given
Vs=15;//dc supply
Vref=6;
printf("\nSuitable device is 1N753,from datasheet")
Vz=6.2;//nominal voltage
P=400;//nominal power in mW
Izmin=5;
Izm=P/Vz;//Izm=Ilmax+Izmin
R1=10^3*(Vs-Vz)/Izm;
printf("\nseries resistance R1=%d ohm,use standard
    value 150 ohm",R1);R1=150;
Izm=1000*(Vs-Vz)/R1;
Ilmax=Izm-Izmin;
printf("\nMax load current =%d mA ",ceil(Ilmax))
```

Scilab code Exa 16.6 LR and RR for regulator circuit

```
//chapter 16
//example 16.6
//page 485
clear;
clc ;
//given
Zzr=7;//dynamic impedance of 1N753
Vs=15;//dc supply
R1=150;
Vo=6.2;
Ilmax=55;
deltaVs=10/100*Vs;
deltaVo=1000*deltaVs*Zzr/(R1+Zzr);
//line regulation
lineR=(deltaVo*100/Vo)/1000;
printf("\nline regulation=%d%%  ",lineR)
deltaIl=Ilmax;
deltaVo=deltaIl*(Zzr*R1/(Zzr+R1));
```

```
//load regulation
loadR=(deltaVo*100/Vo)/1000;
printf("\nload regulation=%.1f%% ",loadR)
//ripple rejection
RR = 20*log10((R1+Zzr)/Zzr);
printf("\nripple rejection= %d db",RR)
```

Scilab code Exa 16.7 LR and RR for rectifier and filter circuit

```
//chapter 16
//example 16.7
//page 489
clear;
clc ;
//given
Eoavg=20;
Eomax=21;
Vo=12;
Av=100//voltage gain
//10% change in filter op
deltaEo=10/100*20;
deltaVs=deltaEo;
deltaVo=1000*deltaVs/Av;//mV
//line regulation
lineR=(deltaVo*100/Vo)/1000;
printf("\nline regulation=%.2f%% ",lineR);
//Eo changes from Eomax to Eoavg
deltaEo=Eomax-Eoavg;
deltaVs=deltaEo;
//Il change from no load to full load
deltaVo=1000*deltaVs/Av;
//load regulation
loadR=(deltaVo*100/Vo)/1000;
printf("\nload regulation=%.2f%% ",loadR)
```

Scilab code Exa 16.8 Design voltage regulator

```
//chapter 16
//example 16.8
//page 490
clear all;
clc ;
//given
Vs=20;//supply voltage
Vo=12;//op voltage
Ilmax=40;//maximum load current mA
Vz=Vo/2;
printf("\nSuitable device is 1N753,from datasheet")
Vz=6.2;//nominal voltage
//to keep D1 in breakdown
IR2=10;//mA
R2=1000*(Vo-Vz)/IR2;
printf("\nR2=%d ohm,standard value 560 ohm",R2);
IE1max=Ilmax+IR2;
//power dissipation in Q1
P1max=IE1max*(Vs-Vo);
VCE1max=Vs;
IC1max=IE1max;
//choosing suitable transistor and finding it's
    hfemin at IC=50mA
hfemin=50;
IB1max=IE1max/hfemin;
//IC2>>IB1max,let
IC2=5;
VB1=Vo+0.7;
R1=(Vs-(VB1))/(IC2+IB1max);
R1=R1-0.01;
printf("\nR1=%.2f kohm,standard value 1.2 kohm",R1);
IE2=5;IR2=10;
```

```
Iz=IE2+IR2;
//I4>>IB2,let
I4=1;
R4=(Vz+0.7)/I4;
printf("\nR4=%.1f kohm,standard value 6.8 kohm",R4);
R3=(Vo-6.9)/I4;
printf("\nR3=%.1f kohm,standard value 4.7 or 5.6
    kohm for Vo<12 or Vo>12 resp",R3);
```

Scilab code Exa 16.9 `Design opamp voltage regulator`

```
//chapter 16
//example 16.9
//page 4
clear all;
clc ;
//given
Ilmax=100;//maximum op current
Vs=20;//supply voltage
//maximum op voltage 10-15V
Vomin=10;Vomax=15;
Vz1=Vomin/2;
Vz2=Vomax/2;
printf("\nSuitable device is 1N753,from datasheet")
Vz=6.2;//nominal voltage
Izr=20;
Iz=Izr;
Voavg=12.5;
R1=1000*(Voavg-Vz)/Iz;
printf("\nR1=%d ohm,standard value 330 kohm",R1);R1
    =330;
//I3>Ibmax for opAmp,let
I3min=1;
//Vo=min,wiper at top of R4
R3R4=Vz/I3min;
```

```
VR3=Vz;
R2=(Vomin-VR3)/I3min;
printf("\nR2=%.1f kohm,standard value 3.3 kohm",R2);
   R2=3.3;
//Vo=max,wiper at bottom of R4
I3max=Vomax/(R2+R3R4);
R3=Vz/I3max;
R4=(R3R4)-R3;
printf("\nR3=%.1f kohm",R3);
printf("\nR4=%.1f kohm,standard value 3 kohm",R4);
//Q1 specification
P1=(Vs-Vomin)*(Ilmax+Iz+I3min);
P1=P1/1000;
printf("\nP1=%.2f W",P1)
Vcemax=Vs;
ICmax=Ilmax+Iz+I3min;
printf("\nVcemax=%d V,ICmax=%d mA",Vcemax,ICmax)
```

Scilab code Exa 16.10 Design voltage regulator circuit

```
//chapter 16
//example 16.10
//page 504
clear all;
clc ;
//given
Vo=10;//op voltage
I2=1;//error amplifier ip bias current
Vref=7.15;//V reference
VR2=Vref;
R2=Vref/I2;
printf("\nR2=%.2f kohm,standard value 6.8 kohm",R2);
   R2=6.8;
I2=Vref/R2;//mA
R1=(Vo-Vref)/I2;
```

```
printf("\nR1=%.1f kohm,standard value 2.7 kohm",R1);
Vs=Vo+5;//for satisfactory opertation of pass Xtor
I=25;//internal ckt current Istandby+Iref
//internal power dissipation
Pi=Vs*I;
printf("\ninternal power dissipation=%d mW",Pi)
//max power dissipation in series pass Xtor
PDmax=1000;
P=PDmax-Pi;
printf("\nmax power dissipation in series pass
    transistor=%d mW",P)
//maximum load current
Ilmax=P/(Vs-Vo);
printf("\nmaximum load current=%d mA",Ilmax);
```

Scilab code Exa 16.11 Design voltage regulator using LM217 IC

```
//chapter 16
//example 16.11
//page 507
clear all;
clc ;
//given
Vo=6;//op voltage
Vs=15;//supply voltage
Iadj=100;//microA
I1=2.5;
Vref=2.5;
R1=Vref/I1;
printf("\nR1=%d kohm",R1);
R2=(Vo-Vref)/I1;
printf("\nR2=%.1f kohm,use 1.2 kohm + 200 ohm in
    series",R2);
```

Chapter 17

Large signal amplifiers

Scilab code Exa 17.1 `Dc ac load line for CE circuit`

```
//chapter 17
//example 17.1
//page 518
clear;
clc ;
//given
//dc load line
Vcc=13;//supply voltage
R1=4.7;R2=3.7;RE=1;
Rpy=40;
N1=74;N2=14;
Rl=56;
//plot point A(Vce,Ic)=(Vcc,0)
VB=Vcc*R2/(R1+R2);
VE=VB;
VBE=VB-0.7;
IE=VE/RE;
IC=IE;
VCE=Vcc-IC*(Rpy+RE);//plot point Q(VCE,IC)=(8,5)

VCE=[13,8];
```

```
IC=[0,5];
plot(VCE,IC)
xtitle('dc load line','VCE in V','IC in mA')

//ac load line
Rl'==(N1/N2)^2*Rl;
//total ac load
Rlac=(Rpy+Rl')/1000;
deltaIC=5;
deltaVCE=deltaIC*Rlac;
//point B(VCE,IC)=(16,0)
VCE=[8,16];
IC=[5,0];
figure,plot(VCE,IC,'r-.');
xtitle('ac load line','VCE in V','IC in mA')
```

Scilab code Exa 17.2 Maximum Efficieny of Transformer

```
//chapter 17
//example 17.2
//page 522
clear all;
clc ;
//given
eta=80;//Xformer efficiency
Vcc=13;//supply voltage
ICQ=5;
Pi=Vcc*ICQ;//ip power dissipation in mW
VCEQ=8;
Vp=VCEQ;
ICEQ=5;
Ip=ICEQ;
//power delivered to Xformer primary
Po1=(Vp*Ip)/2;
//Xformer op power
```

```
Po = eta * Po1 ;//mW
//ckt efficiency
efficiency=(Po/Pi);
printf("\nMaximum ckt efficiency of class A
    amplifier =%.1f%%",efficiency);
```

Scilab code Exa 17.3 Transformer output for class B

```
//chapter 17
//example 17.3
//page 528
clear all;
clc ;
//given
Rl=16;//load resistance
Vcc=30;//supply voltage
eta=0.8;//Xformer efficiency
Po=4;
Po1=Po/eta;//ac power delivered to Xformer primary
Vp=Vcc;
Rl1=(Vp^2)/(2*Po1);
Rl2=4*Rl1;
printf("\nTransformer specification are:\nPo=%d W\
    nRl=%d ohm\nRl'''' =%d ohm center tapped",Po,Rl,
    Rl2);
//max Xtor vol
Vcemax=2*Vcc;
Ip=(2*Po1)/Vp;
//max Xtor current
Icmax=1000*Ip;
//dc ip power
Iavg=0.636*Ip*1000;
Pi=10^-3*Vcc*Iavg;
//power in each op Xtor
Pr=(Pi-Po1)/2;
```

```
printf("\nTransistor specification are:\nPr=%.2f W\
    nVcemax=%d V\nIcmax=%d mA",Pr,Vcemax,Icmax);
```

Scilab code Exa 17.4 Design capacitor coupled amplifier

```
//chapter 17
//example 17.4
//page 523
clear all;
clc ;
//given
Rl=100;//load resistance
Po=0.5;//output power
//peak output voltage
Vp=sqrt(2*Rl*Po);
//peak output current
Ip=1000*(2*Po)/Vp;
Vr6=0.1*Vp;
Vr7=Vr6;
R6=1000*Vr6/Ip;
R7=R6;
//quiscent current
Iq2=Ip/10;
//dc voltage across R4
Vr4dc=0.7+10^-3*Iq2*(R6+R7)+0.7;
//bias components for Q2 &Q3
deltaVB=Vp+Vr6;
Vce1dc=deltaVB+1;
Vr3dc=Vce1dc;
Vr5=5;//bias stabiliy
Vcc=Vr5+Vce1dc+Vr4dc+Vr3dc;
printf("\nVCC=%.1f V,use VCC=30 V",Vcc);Vcc=30;
//Icq1>>Ibmax
hfe=50;//assuming equal for all 3 Xtors
Ibmax=Ip/hfe;
```

```
Icq1=10;
R3=Vr3dc/Icq1;
R4=1000*Vr4dc/Icq1;
printf("\nR3=%.1f kohm, standard value ",R3);
printf("\nR4=%d kohm,use standard value 200 ohm",
    ceil(R4));
printf("\nR6=R7=%d ohm",R6);
```

Scilab code Exa 17.5 Design capacitors of amplifier circuit

```
//chapter 17
//example 17.5
//page 535
clear all;
clc ;
//given
f1=20;//lower cutoff frequency Hz
R3=1.2;//kohm
Rl=100;//ohm
Vcc=30;
//Xc2<<R3 at f1
C2=1000/(2*%pi*f1*R3/10);
printf("\nc2=%.1f microF,use standard value 75
    microF",C2);
XC4=Rl;
C4=10^6/(2*%pi*f1*Rl);
printf("\nc4=%.1f microF,use standard value 80
    microF",C4);
Ip=100;
Vcemax=Vcc;
Icmax=1.1*Ip;
//dc ip power
Pidc=(Vcc*0.35*Ip)/1000;
Poac=0.5;
Pr=(Pidc-Poac)*0.5;
```

```
printf("\nTransistor specification are:\nPr=%.2f W,
    Vcemax=%d V,Icmax=%d mA",Pr,Vcemax,Icmax);
```

Scilab code Exa 17.6 Supply and output voltages for amplifier circuit

```
//chapter 17
//example 17.6
//page 543
clear all;
clc ;
//given
Rl=50;//load resistance
Po=10;//op power
//peak op voltage
Vp=round(sqrt(2*Rl*Po));
Vr14=0.1*Vp;//when Ip flows
Vr15=Vr14;;
Vce4min=1
Vce3min=Vce4min;
Vr9=3;
Vr10=Vr9;
Vcc=ceil(Vp+Vr14+Vce3min+0.7+Vr9);
printf("\nVCC=%d V",Vcc);
Ip=1000*(2*Po)/Vp;
//dc ip power
Iavg=0.636*Ip*1.1;
Pi=10^-3*Vcc*Iavg;Pi=17.5;
//power in each op Xtor Q7 & Q8
Pr1=(Pi-Po)/2;
Vcemax=Vcc-(-40);
Icmax=ceil(1.1*Ip);
printf("\nTransistor specification for Q7,Q8 are:\
    nPr=%.2f W,Vcemax=%d V,Icmax=%d mA",Pr1,Vcemax,
    Icmax);
//power in each op Xtor Q5 & Q6
```

```
Vcemax=2*Vcc;
hfe=30;
Icmax=ceil(1.1*Ip/hfe);
Pr=1000*Pr1/hfe;
printf("\nTransistor specification for Q5,Q6 are:\nPr=%d W,Vcemax=%d V,Icmax=%d mA",Pr,Vcemax,Icmax);
```

Scilab code Exa 17.7 Analyze MOSFET power amplifier circuit

```
//chapter 17
//example 17.7
//page 547
clear;
clc ;
//given
Rl=10;//load resistance
Po=5;//op power
Rdsmin=4;
gm=250;//mA/V
//peak op voltage
Vp=round(sqrt(2*Rl*Po));
Rl=20;
Ip=Vp/Rl;
//supply voltage
Vcc=[Vp+(Ip*Rdsmin)];
printf("\nVCC=+-%d V",Vcc);
Vth=1;
Vr13=Vth;Vr14=Vth;
deltaVr14=10^-3*Ip/gm;
deltaVr13=deltaVr14;
//to avoid turn off of Q1,let
deltaVr3=2;
Vr3=deltaVr3+1;
Vr7=Vr3;Vr6=Vr3;
```

```
//to avoid saturation of Q2
Vce2=Vp+Vr7+1;
Vr4r5=2*Vcc-Vr6-Vr7-Vce2;
printf("\nVoltage drops across R3,R6,R7 is %d V and
    across R4+R5 is %d V",Vr3,Vr4r5)
```

Chapter 18

Thyristors and unijunction transistors

Scilab code Exa 18.1 Analyze SCR circuit

```
//chapter 18
//example 18.1
//page 559
clear all;
clc ;
//given
Rl=15;//load resistance
ep=30;//peak ip voltage
Rg=1;//gate resistance kohm
//forward blocking voltage VfXm>30 for SCR to remain
    in off until triggered

VAK=1;
Ip=(ep-VAK)/Rl;
//rms value of Il
Irms=0.5*Ip;
printf("\nIrms=%.2f A and ep=%d V",Irms,ep);
printf("\nC6F is suiatable SCR with VFXM=50 V,
   current range allowable is 1.6 A");
```

```
//from chart
Vg=0.5;//Trigger voltage
Ig=0.025//mA
Irg=Vg/Rg;
It=Ig+Irg;//trigger current
printf("\nTrigger voltage=%.1f V and trigger current
    =%.3f mA",Vg,It);
Ih=1;
Il=Ih;
ei=VAK+1000*Il*Rl;
ei=1;
printf("\nei=%d V\nSCR will switch off when ei falls
     below 1 V",ei);
```

Scilab code Exa 18.2 Design SCR circuit

```
//chapter 18
//example 18.2
//page 559
clear;
clc ;
//given
Rl=15;//load resistance
ep=30;//peak input voltage
Vg=0.5;//Trigger voltage
Ig=10;//trigger current in microA
//at 5 degrees
a=(5*%pi)/180;
ei1=ep*sin(a);
//at 90 degrees
ei2=ep;
//when SCR triggers
Vt=Vg+0.7+(10^-6*Ig*Rl);
//to trigger SCR at ei=2.6V,moving contact of R2
```

```
must be at the top
Vr2r3=Vt;
Vr1=ei1-Vt;
I1min=100;//microA
R1=1000*Vr1/I1min;
printf("\nR1=%d kohm,standard value 12 kohm",R1);R1=12;
I11=floor(10^3*Vr1/R1);
R23=10^3*Vt/I11;
I1=ei2/(R1+R23);//I1=1.35;
//to trigger SCR at ei=30V,moving contact of R2 must be at the bottom
R3=(10^3*Vt/I1);
printf("\nR3=%d ohm,standard value 820 ohm",R3);R3=820;R23=10.3;
R2=R23-R3/1000;
printf("\nR2=%.2f kohm,standard value 10 kohm",R2);R2=10;
```

Scilab code Exa 18.3 Design resistor for 4 layer diode circuit

```
//chapter 18
//example 18.3
//page 569
clear;
clc ;
//given
E=30;
Vs=10;//supply voltage
Is=500;//ip current
Ih=1.5;//mA
Vf=1;//forward voltage drop
R1max=1000*(E-Vs)/Is;
R1min=(E-Vf)/Ih;
printf("\nmaximum and minimum values of R1 are %d
```

```
kohm ,%.1f kohm respectively.",R1max,R1min);
```

Scilab code Exa 18.4 Analyze UJT circuit

```
//chapter 18
//example 18.4
//page 575
clear;
clc ;
//given
PD=360;//power dissipation in mW
RBBmin=4;//kohm
RBBmax=12;//kohm
//to get lowest value of VB1B2,use RBBmin
VB1B2max=sqrt(RBBmin*PD);
printf("\nFor 25 degree,value of VB1B2=%d V",ceil(
    VB1B2max));
VB2E=30;//maximum emitter reverse voltage
printf("\nAt 25 degree,VB1B2 should not exceed 30 V"
    )
//for operation till 100 degrees
deltaT=100-25;
PD1=PD-(2.4*deltaT);
//ignore increase in RB

VB1B2max=sqrt(RBBmin*PD1);
printf("\nupto 100 degree,value of VB1B2=%.1f V",
    VB1B2max);
```

Scilab code Exa 18.5 Emitter voltages for UJT circuit

```
//chapter 18
//example 18.5
```

```
//page 576
clear;
clc ;
//given
VB1B2=30;
etamin=0.55;
etamax=0.82;//efficiency
Vpmin=0.7+(etamin*30);
Vpmax=0.7+(etamax*30);
printf("\nDevice will fire at emitter voltage between %.1f V and %.1f V",Vpmin,Vpmax);
```

Scilab code Exa 18.6 `Frequency of oscillation for UJT circuit`

```
//chapter 18
//example 18.6
//page 578
clear ;
clc ;
//given
VB1B2=15;
eta=0.7;//intrinsic standoff ratio
ec=0.7+(eta*VB1B2);//capacitor voltage
VEB1sat=2.5;//saturation voltage when capacitor is discharged
Eo=2.5;//capacitor voltage at start of each charging cycle
t=0.1*10*log((15-2.5)/(15-11.2));
f=1000/t;
printf("\nTypical frequency of oscillation is approximately %d Hz",ceil(f))
```

Scilab code Exa 18.7 `Emitter resistance for UJT circuit`

```
//chapter 18
//example 18.7
//page 580
clear;
clc ;
//given
VB1B2=15;
Vd=0.7;
eta=0.82;//intrinsic standoff ratio
Ip=2;//maximum current
Vp=Vd+(eta*VB1B2);
REmax=(VB1B2-Vp)/Ip;
printf("\nREmax=%d Mohm",REmax);
VEBsat=2.5;
IV=2;//in mA
REmin=(VB1B2-VEBsat)/IV;
printf("\nREmin=%.2f kohm",REmin);
```

Scilab code Exa 18.8 DC Analysis UJT circuit

```
//chapter 18
//example 18.8
//page no 581
clc;
clear;
//given
eta=0.7;
Vbb=20;
VR1=eta*Vbb;
I1=2;//mA
R1=14/I1;
printf("\nR1=%d kohm,use standard value 6.8 kohm",R1
   );R1=6.8;
R2=(Vbb-14)/I1;
printf("\nR2=%d kohm,use standard value 2.7 kohm",R2
```

```
    );R2=2.7;
Rbb=R1+R2;
Vp=0.7+(Vbb*6.8)/Rbb;
Vv=1;//anode to cathode voltage drop
printf("\nVp=%d V",Vp);
printf("\nAnode to cathode voltage drop=%d V",Vv);
```

Chapter 19

Optoelectronic devices

Scilab code Exa 19.1 Light intensity

```
//chapter 19
//example 19.1
//page 590
clear all;
clc ;
//given
r=3;//distance from lamp in m
L=25;//luminous flux or light energy in W
E=100*L/(4*%pi*(r^2));//light intensity
A=0.25;//area in cm^2
printf("\nLight intensity =%.1f microW/cm^2",E);
totphi=E*A;
printf("\nTotal Flux =%.1f microW",totphi);
```

Scilab code Exa 19.2 Series resistance and dark current

```
//chapter 19
//example 19.2
```

```
//page 597
clear all;
clc ;
//given
Vcc=30;//supply voltage
Is=10;//supply current
Rcell=1;//cell resistance
R1=Vcc/Is-Rcell;
Rdark=100;//cell dark resistance kohm
Idark=Vcc/(R1+Rdark);
printf("\nRequired series resistance is %d kohm \nLevel of Dark current is approximately %.1f mA",R1,Idark)
```

Scilab code Exa 19.3 Design photoconductive cell circuit

```
//chapter 19
//example 19.3
//page 597
clear all;
clc ;
//given
Vcc=6;//supply voltage V
Ib=200;//base current when Xtor is ON microA
Rdark=100;//cell dark resistance kohm
//when Xtor is ON
Vcell=Vcc+0.7;//for Si Xtor
Icell=1000*Vcell/Rdark;//microA
//current through R1
IR1=Icell+Ib;
VR1=Vcc-0.7;
R1=1000*VR1/IR1;
//When Xtor is Off,base <=0V(Ib=0)
VR1=Vcc;
IR1=1000*VR1/R1;//microA
```

```
//since Ib=0
Icell=IR1;
Vcell=Vcc;
Rcell=1000*Vcell/Icell;
printf("\nR1=%d kohm\nCell resistance(Rcell)=%d kohm
   ",ceil(R1),ceil(Rcell));
printf("\nQ1 is OFF when Rcell<=20 kohm")
```

Scilab code Exa 19.4 Dc load line for photodiode

```
//chapter 19
//example 19.4
//page 600
clear all;
clc ;
//given
Es=0.5;//supply voltage V
R1=200;//series resistance ohm
VD1=-Es;//when Id=0
//when VD=0
VR1=Es;
ID1=1000*VR1/R1;
VD=[VD1 0];
ID=[0 ID1];
plot(VD,ID,'-.*');
xtitle('dc load line with points (-0.5,0)and (0,2.5)
   ','VD in V','ID in mA')
a=gca();
a.data_bounds=[-1,-0.5;1 3];
//from intersection of load line and illumination
   characteristics
printf('\nApproximate values:')
printf("\nAt 1500 lm/m^2,Id=-0.2 mA,Vd=-0.45 V");
printf("\nAt 10000 lm/m^2,Id=-1.9 mA,Vd=-0.12 V");
printf("\nAt 20000 lm/m^2,Id=-3.7 mA,Vd=0.22 V");
```

Scilab code Exa 19.5 Total cells for satellite

```
//chapter 19
//example 19.5
//page 603
clear;
clc ;
//given
Vo=13;//op voltage
Vcell=0.45;//cell voltage
Icell=57;//cell current in mA
//no of series connected cell
Cs=ceil(Vo/Vcell);
//charge taken from batteries over 24hrs=charge delivered by cell
Q=24*0.5;//Ahr
//charging /op current
Io=Q/12;
//total group of cell in parallel
Cp=round(1000*Io/Icell);
//total no of cells required
C=Cs*Cp;
printf("\ntotal no of cells required is %d",C)
```

Scilab code Exa 19.6 Output voltage of phototransistor circuit

```
//chapter 19
//example 19.6
//page 606
clear all;
clc ;
```

```
//given
Vcc=20;//supply voltage V
Rl=2;//collector load resistance kohm
Vce=[Vcc 0]
Ic=[0 Vcc/Rl]
plot(Vce,Ic,'-.*');
xtitle('dc load line with points (20,0)and (0,10)','
    Vce in V','Ic in mA')
a=gca();
a.data_bounds=[-1,-0.5;21 11];
//from intersection of load line and illumination
    characteristics
printf("\nAt illumination level =0,output voltage=
    Vce= 20V")
printf("\nAt illumination level =20 mW/cm^2,output
    voltage= 12.5V")
printf("\nAt illumination level =40 mW/cm^2,output
    voltage= 4V")
```

Scilab code Exa 19.7 Design LED and transistor circuit

```
//chapter 19
//example 19.7
//page 611
clear all;
clc ;
//given
Vcc=9;//supply voltage V
Vi=7;//ip voltage
VD1=1.2;//V
VCEsat=0.2;//V
Ic=10;//collector current mA
R2=1000*(Vcc-VD1-VCEsat)/Ic;
printf("\nR2=%d ohm,use standard 680 ohm",R2);R2
    =680;
```

```
Ic=1000*(Vcc-VD1-VCEsat)/R2;
hfemin=100;
Ib=1000*Ic/hfemin;
R1=1000*(Vi-0.7)/Ib;
printf("\nR1=%d kohm, standard value",R1);
```

Chapter 20

Miscellaneous devices

Scilab code Exa 20.1 `Capacitance tuning ratio`

```
//chapter 20
//example 20.1
//page 636
clear all;
clc ;
//given
C1=150;C2=60//capacitance from abrupt junction
   device characteristics at 1,10V resp in pF
//capacitance tunning ratio for abrupt junction
   device
TR=C1/C2;
printf("\ncapacitance tunning ratio for abrupt
   junction device is %.1f ",TR)
C3=220;C4=15//capacitance from hyperabrupt junction
   device characteristics at 1,10V resp in pF
//capacitance tunning ratio for hyperabrupt junction
    device
TR=C3/C4;
printf("\ncapacitance tunning ratio for hyperabrupt
   junction device is %.1f ",TR)
```

Scilab code Exa 20.2 `Resonance frequency`

```
//chapter 20
//example 20.2
//page 638
clear;
clc ;
//given
R1=4.7;R2=10;
Vcc=9;//supply voltage
L=100;//inductance microH
Vdmin=(Vcc*R1)/(R1+R2);
Vdmax=Vcc;
C1=100;C2=15//capacitance from hyperabrupt junction
    device characteristics at 2.9,9V resp in pF
//At resonance,for Vdmin
f1=1000/(2*%pi*sqrt(L*C1));//MHz
f2=1000/(2*%pi*sqrt(L*C2));//MHz
printf("\n The resonance frequency range is %.1f MHz
     to %0.1f MHz",f1,f2)
```

Scilab code Exa 20.3 `Value of resistor in thermistor circuit`

```
//chapter 20
//example 20.3
//page 640
clear all;
clc ;
//given
E=20;//supply voltage
I=1;//supply current mA
//without thermistor & R2
```

```
Rc1=5;Rc2=6.5;//coil resistance
//At -15degree
R1=(E/I)-Rc1;
//At 50degree
R11=(E/I)-Rc2;
printf('\nwithout thermistor & R2:')
printf("\nR1=%d kohm,R1=%.1f kohm at -15 and 50
    degrees respectively",R1,R11);
//with thermistor
Rt1=3;Rt2=0.100;//thermistor resistance
//At -15degree
R1=(E/I)-Rt1-Rc1
//At 50degree
R11=(E/I)-Rt2-Rc2;
printf('\nwith thermistor:')
printf("\nR1=%d kohm,R1=%.1f kohm at -15 and 50
    degrees respectively ",R1,R11);
//with thermistor & R2
//At -15degree
R1=(E/I)-(3/2)-Rc1
//At 50degree
R11=(E/I)-((3*0.1)/(3+0.1))-Rc2;
printf('\nwith thermistor & R2:')
printf("\nR1=%.1f kohm,R1=%.1f kohm at -15 and 50
    degrees respectively",R1,R11);
```

Scilab code Exa 20.4 Piecewise linear characteristics

```
//chapter 20
//example 20.4
//page 649
clear all;
clc ;
//given
Ip=1;//mA
```

```
Vp=65;//mV
Id=1;//mA
Vd=65;//mV
Iv=0.12;//mA
Vv=350;//mV
Vf=500;//mV
Id=[0 Id Iv Iv Ip]
Ed=[0 Vd Vv 450 Vf];
plot(Ed,Id,'-.*');
xtitle('piecewise linear characteristics','Ed in mV','Id in mA');
Rd=-(350-65)/(1-0.12);
printf("\nValue of RD=%d ohm",round(Rd));
```

Scilab code Exa 20.5 `Gain for tunnel diode circuit`

```
//chapter 20
//example 20.5
//page 651
clear;
clc ;
//given
Eb=200;//battery voltage mV

es=0;//signal voltage V
Rl=80;//load resistance in ohm
Ed=Eb+es;
Id=2;//diode current mA
Er=(Eb+es);
Il1=Er/Rl;//load current mA
Ib1=Id+Il1;//battery current mA

es=100;//mV
Ed=Eb+es;
Id=1;
```

```
Il2=Ed/Rl;
Ib2=Id+Il2;
deitaIl=Il2-Il1;//change in Il
deltaIb=Ib2-Ib1;//change in Ib

es=-100;//mV
Ed=Eb+es;
Id=3;
Il3=Ed/Rl;
Ib3=Id+Il3;
deltaIl= Il3 - Il1;//change in Il
deltaIb=Ib3-Ib1;//change in Ib

//current gain
io=deltaIl;
is=deltaIb;
Ai=io/is;

//op voltage
deltaEr=es;
eo=deltaEr;

//voltage gain
Av=eo/es;

//power gain
Ap=Ai*Av;

printf("\ncurrent gain=%d\nvoltage gain=%d\npower gain=%d",Ai,Av,Ap)
```

Chapter 21

Electron tubes

Scilab code Exa 21.1 Transconductance and constant current characteristics

```
//chapter 21
//example 21.1
//page 665
clear all;
clc ;
//given
Eg=[0 -1 -2 -3 -4];//V

Ep=75;//V
//drawing vertical line at Ep=75 V in Vacuum triode
    plate characteristics we get values of Ip for Eg
    values as
Ip=[20 10 2 1 0];

plot(Eg,Ip,'-.*');
xtitle('vacuum triode transconutance characteristics
    ')
xlabel('Eg in V');
ylabel('Ip in mA');


```

```
Ip=10;//mA
//drawing horizontal line at Ip=10 mA in Vacuum
    triode plate characteristics we get values of Ep
    for Eg as
Ep=[45 75 105 132 160];
figure,plot(Ep,Eg,'-.*');
xtitle('vacuum triode constant-current
    characteristics')
xlabel('Ep in V');
ylabel('Eg in V');
```

Scilab code Exa 21.2 `Impedance and gain for vaccum triode circuit`

```
//chapter 21
//example 21.2
//page 672
clear;
clc ;
//given
Rg=1;//grid resistor in Mohm;
Rp=7;//plate resistor in kohm;
Rl=30;//load resistance in kohm
Vcc=175;//supply voltage in  V
Vg=-2;//grid bias in V
Ep1=Vcc;Ip=0;Epp=Ep1;
Ep2=0;Ip2=Epp/Rp;
//dc load line with points A(175,0)and B(0,25),
    intersects Eg=-2V which gives
Ip=10;//
Ep=105;
//ip impedance
Zi=Rg;

//op impedance
rp=50/10;//deltaEp/deltaIp
```

```
Zo=(rp*Rp)/(rp+Rp);

//voltage gain
mu=50/2;
Av=-mu*((Rp*Rl)/(Rp+Rl))/(rp+((Rp*Rl)/(Rp+Rl)));

printf("\nip impedance=%dMohm",Zi);
printf("\nop impedance=%.1f kohm",Zo);
printf("\nvoltage gain=%.1f",Av);
```

Scilab code Exa 21.3 DC load line for CC amplifier

```
//chapter 21
//example 21.3
//page 678
clear all;
clc ;
//given
Rp=9.7;//kohm
Rk=270;//ohm
Eg=[-4 -3 -2 -1];
Rl=47;//load resistance in kohm
Epp=200;//VE
//total dc load resistance
R=Rp+Rk;
Ip=-1000*Eg/Rk;

plot(-Eg,Ip,'-.*')
xtitle('bias line','Eg(V)','Ip(mA)')

//plotting DC load line
Ip1= floor(Epp/Rp);
//plot dc load line with points A(Ip,Ep)=A(0,200) and B(Ip1,Ep)=B(Ip1,0)
figure,plot([200 0],[0 Ip1],'*b--');
```

```
xtitle('Dc load line','Ep(V)','Ip(mA)')

//after intersection of dc load line and bias line at Q
Eg=-2.4;Ip=8.8;
Ep=112;//plate to cathode voltage
printf("\nFor Q point,\nEg=%.1f V\nIp=%.1f mA\nEp=%dV",Eg,Ip,Ep);
R=(Rp*Rl)/(Rp+Rl);
deltaIp=10;
deltaEp=-deltaIp*R;
//ac load line with points
//point C(deltaEp,deltaIp)=(32,10)
//point Q (112,8.8);
plot([32 112],[10 8.8],'*r--');
xtitle('dc(blue),ac(red) load line intersect at Q point','Ep(V)','Ip(mA)')
```