Scilab Textbook Companion for Analog Integrated Circuits by P. Sharma [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.

Contents

List of Scilab Codes

Chapter 1

Differential Amplifiers

Scilab code Exa 1.1 `Find various parameters of Differential Amplifier`

```
//Exa 1.1
clc;
clear;
close;
//given data
Icq=100;//in uA
BETAac=100;//unitless
BETAdc=100;//unitless
Ad=100;//unitless
CMRRdB=60;//in dB
//part (a)
IE=2*Icq;//in UA
VT=25;//in mV
re=2*VT/IE;//in ohm
RC=Ad*re;//in Kohm
CMRR=10^(CMRRdB/20);//using formula CMRRdB=20log10(CMRR)
//calculate RE using formula CMRR=1+2*RE/re
RE=((CMRR-1)*re)/2;//in Kohm
disp("Value of RC is "+string(RC)+" Kohm"+" and value of RE is "+string(RE)+" Kohm");
```

```
//part (b)
Ri1=2*BETAac*re;//in kohm
Ri2=2*BETAac*re;//in kohm
disp("Value of Ri1 is "+string(Ri1)+" Kohm"+" and value of Ri2 is "+string(Ri2)+" Kohm");
//part (c)
Ric=BETAac*(re+2*RE);//in kohm
disp("Value of Ric is "+string(Ric)+" Kohm.");
```

Scilab code Exa 1.2 Calculate output voltage and CMRR in dB

```
//Exa 1.2
clc;
clear;
close;
//given data
V1=50;//in uV
V2=-50;//in uV
Ad=2000;//unitless
Ac=0.5;//unitless
Vid=V1-V2;//in uV
Vc=(V1+V2)/2;//in uV
//output voltage
Vo=Ad*Vid+Ac*Vc;//in uV
Vo=Vo*10^(-6);//in Volts
CMRRdB=20*log10(Ad/Ac);
disp(Vo,"Output voltage in volts is : ");
disp(CMRRdB,"CMRR in dB is : ");
```

Scilab code Exa 1.3 Find output voltage of Differential Amplifier

```
//Exa 1.3
clc;
```

```
clear;
close;
//given data
V1=5;//in mV
V2=6;//in mV
Ad=70;//in dB
CMRR=90;//in dB
Vid=V2-V1;//in mV
Vc=(V1+V2)/2;//in mV
Ad=10^(Ad/20);//unitless
Ad=floor(Ad);
CMRR=10^(CMRR/20);//unitless
//output voltage
Vo=Ad*(Vid+Vc/CMRR);//in mV
Vo=round(Vo);
Vo=Vo*10^(-3);//in Volts
Vid=Vid*10^(-3);//in Volts
ErrorVotage=Vo-Ad*Vid;
PercentageError=(ErrorVotage*100)/Vo;
disp(Vo,"Output voltage in volts is : ");
disp(ErrorVotage,"ErrorVotage is : ");
disp(PercentageError,"PercentageError is : ")
```

Scilab code Exa 1.4 Calculate differential mode and common mode output voltages

```
//Exa 1.4
clc;
clear;
close;
//given data
V1=5;//in uV
V2=4;//in uV
Ad=80;//in dB
CMRR=100;//in dB
Ad=10^(Ad/20);//unitless
```

```
CMRR=10^(CMRR/20);//unitless
//differential mode output voltage
Vid=V1-V2;//in uV
Vod=Ad*Vid;//in uV
Vod=Vod*10^(-3);//in mV
//common mode output voltage
Vc=(V1+V2)/2;//in uV
Ac=Ad/CMRR;//unitless
Voc=Ac*Vc;//in uV
disp(Vod,"Differential mode output voltage in mV is
   : ")
disp(Voc,"common mode output voltage in uV is : ")
```

Scilab code Exa 1.5 Find magnitude of differential mode gain and common mode gain

```
//Exa 1.5
clc;
clear;
close;
//given data
Rc=2;//in kohm
VE=-5;//in volts
VT=25;//in mVolts
RE=4.3*1000;//in ohm
IE=(-0.7-VE)/RE;//in mA
re=(2*VT*10^(-3))/IE;//in ohm
Rc=Rc*1000;//in ohms
Ad=(Rc)/(2*re)
Ac=-(Rc/(2*RE+re))
CMRR=Ad/Ac;
//CMRR is always positive
disp(Ad,"Differential mode gain is : ")
disp(Ac,"Common mode gain is : ")
disp(-CMRR,"CMRR is : ")
```

Scilab code Exa 1.6 Design a dual input balanced output differential amplifier

```
//Exa 1.6
clc;
clear;
close;
//given data
Ad=50;//unitless
I=5;//in mA
VEE=15;//in Volts
VD=0.7;//in Volts
VT=25;//in mVolt
//desired value of emitter current is 5 mA
IE3=5;//in mA
RE=VD/(IE3*10^(-3));//in ohm
VB3=VEE-2*VD;//in volts
I2=IE3;//in mA
R2=VB3/I2;//in kohm
IE1=IE3/2;//in mA
IE2=IE1;//in mA
re=(2*VT)/IE3;//in ohm
RC=Ad*re;//in ohm
disp("Design values are :")
disp(RC,"Value of Rc in ohm is : ");
disp(RE,"Value of RE in ohm is : ");
disp(R2,"Value of R2 in kohm is : ");
```

Scilab code Exa 1.7 Design a dual input balanced output differential amplifier

```
//Exa 1.7
clc;
clear;
```

```
close;
//given data
Ri=600;//in kohm
Vopp=5;//in volts
VEE=15;//in volts
VT=25;//in mVolts
VD=0.7;//in Volts
BETAac=100;//unitless
BETAdc=100;//unitless
VBE=0.7;//in volts
BETAact=BETAac*BETAdc;//unitless
//formula : Ri=2*BETAact*(2*re1)
re1=Ri/(4*BETAact);//in ohm
//formula : re1=VT/IE1
IE1=(VT*10^(-3))/re1;//in mA
IE3=2*IE1;//in mA
RE=VD/(IE3*10^(-3));//in ohm
R2=(VEE-2*VD)/IE3;//in kohm
disp("Now terhe voltage drop across Rc determines
    the peak to peak output voltage swing.")
disp("We have given Vopp=5volts, sinve the output is
     balance i.e. differential the voltage drop
    across each collector resistor will become2.5Vpp
    or 1.25Volts.")
disp("In other words RcIc=1.25Volts. We have Ic=IE1
    =1.67mA")
IC=IE1;//in mA
RC=1.25/(IC*10^(-3));//in ohm
disp("Thus the Design components values are :")
disp(RC,"Value of Rc in ohm is : ");
disp(RE,"Value of RE in ohm is : ");
disp(R2,"Value of R2 in kohm is : ");
//Answer in the book is not as much accurate as
    calculated by Scilab
```

Scilab code Exa 1.8 Calculate various parameters of differential amplifier

```
//Exa 1.8
clc;
clear;
close;
//given data
BETAac=100;//unitless
BETAdc=100;//unitless
VBE3=0.715;//in volts
VD1=0.715;//in Volts
VZ=6.2;//in Volts
VT=25;//in mVolts
IZt=41;//in mA
VCC=10;//in Volts
VEE=-10;//in Volts
RC1=2.7;//in kohm
RC=4.7;//in kohm
//Part (a)
VB3=VEE+VZ+VD1;//in volts
VE3=VB3-VBE3
IE3=(VE3-VEE)/RC1;//in mA
disp("As the differential amplifier is symmetrical,
    ICQ1=IE1=ICQ2=IE2");
IE2=IE3/2;//in mA
ICQ1=IE2;//in mA
ICQ2=IE2;//in mA
IE1=IE2;//in mA
VCEQ=VCC+VBE3-RC*ICQ1// formula for VCEQ
disp("Hence operating point for Q1 and Q2 are : ")
disp(VCEQ,"VCEQ in volts is :")
disp(ICQ1,"ICQ in mA is :")
disp("and the operating point for Q3 will be : ")
VCE3=-VBE3-VE3;//in Volts
disp(VCE3,"VCE3 in volts is :")
IC3=IE3;//in mA
disp(IE3,"IE3 in mA is :")
//Part (b)
```

```
re=(2*VT)/IC3;//in ohm
Ad=(RC*1000)/re;//unitless
disp(Ad,"Differential voltage gain is ")
//Part (c)
Ri=2*BETAac*re;//in ohm
disp(Ri/1000,"Input resistance in kohm is : ")
//Answer in the book is not as much accurate as calculated by Scilab
```

Scilab code Exa 1.9 Design a two transistor current source

```
//Exa 1.9
clc;
clear;
close;
//given data
Io=180;//in uA
Vcc=20;//in Volts
VBE=0.7;//in Volts
BETA=120;//unitless
IR=Io*(1+2/BETA);//in uA
R=(Vcc-VBE)/(IR*10^-3);//in kohm
disp(IR,"Value of IR in uA is : ");
disp(R,"Value of R in kohm is : ");
```

Scilab code Exa 1.10 Determine Load current

```
//Exa 1.10
clc;
clear;
close;
//given data
VBE=0.7;//in Volts
```

```
BETA=120;//unitless
disp("as BETA>>1");
VCC=10;//in Volts
//KCL at Node a
disp("Writing KCL at Node (a) gives :");
disp("IR=IC1+I");
disp("IR=IC1+IB1+I1");
disp("IR=IC1+IC1/BETA+I1");
disp("IR=IC1(1+1/BETA)+I1");
disp("as BETA>>1");
disp("IR=IC1+I1");
//KCL at Node b
disp("Writing KCL at Node (b) gives :");
disp("I1=IC2+I2");
disp("I1=IC2+IB2+IB3");
disp("I1=IC2+IC2/BETA+IB3");
disp("IR=IC2(1+1/BETA)+IB3");
disp("as BETA>>1");
disp("I1=IC2+IB3");
//solving both equations
disp("IR=IC1+IC2+IB3");
disp("IR=2IC+IB3")
//As transistors are matched
VBE1=VBE;//in Volts
VBE2=VBE;//in Volts
VBE3=VBE;//in Volts
disp("As transistors are matched. IC1=IC2=IC")
disp("IR=2IC+IC3/BETA=2IC+IC/BETA");
disp("Due to current Mirror formed. IC1=IC2=IC3=IC")
disp("IR=IC(2+1/BETA)");
disp("as BETA>>1");
disp("IR=2*IC");
IR=(VCC-VBE)/(3.6);//in mA
IC=IR/2;//in mA
Iload=IC;//in mA
disp(Iload,"Load current in the circuit in mA is :")
```

Scilab code Exa 1.11 Design a two transistor pnp current source

```
//Exa 1.11
clc;
clear;
close;
//given data
Iload=0.5;//in mA
BETA=150;//unitless
VEB=0.7;//in Volts
VCC=10;//in Volts
IR=Iload*(1+2/BETA);//in mA
R=(VCC-VEB)/IR;//in kohm
disp(IR,"Value of IR in mA is : ");
disp(R,"Value of R in kohm is : ");
```

Scilab code Exa 1.12 Determine various parameters of differential amplifier

```
//Exa 1.12
clc;
clear;
close;
//given data
BETAac=110;//unitless
BETAdc=110;//unitless
VBE=0.7;//in volts
VEE=15;//in volts
VT=25;//in mvolts
R=2.7;//in kohm
Rc=3.3;//in kohm
IR=(VEE-VBE)/R;//in mA
IC3=IR;//in mA
```

```
IC1=IC3/2;//in mA
IC2=IC3/2;//in mA
re1=VT/IC1;//in ohm
re2=re1;//in ohm
//  part (i)
Ad=(Rc*1000)/re1;//unitless
//  part (ii)
Ri1=2*BETAac*re1*10^(-3);//in kohm
Ri2=2*BETAac*re2*10^(-3);//in kohm
disp(Ad,"Differential mode voltage gain is : ")
disp("Input resistances are :")
disp(Ri1,"Ri1 in kohm is : ")
disp(Ri2,"Ri2 in kohm is : ")
```

Scilab code Exa 1.13 Design Differential Amplifier

```
//Exa 1.13
clc;
clear;
close;
//given data
Ad=200;//unitless
Ri=3//in kohm
BETAac=110;//unitless
BETAdc=110;//unitless
VBE=0.7;//in volts
VEE=15;//in volts
VT=25;//in mvolts
re=Ri/(2*BETAac);//in ohm
RC=Ad*re;//in kohm
IC1=VT/re;//in mA
IR=2*IC1;//in mA
IC3=IR;//in mA
R=(VEE-VBE)/(IR*10^(-3));//in kohm
disp(RC,"Value of resistance Rc in kohm is :");
```

```
disp(R,"Value of resistance R in kohm is :");
```

Scilab code Exa 1.14 Design Differential Amplifier

```
//Exa 1.14
clc;
clear;
close;
//given data
Ad=400;//unitless
Ri=3//in kohm
BETAac=110;//unitless
BETAdc=110;//unitless
VBE=0.7;//in volts
VEE=15;//in volts
VT=25;//in mvolts
//circuit bias current IR
IR=3;//in mA
R=(VEE-VBE)/(IR);//in kohm
re=(2*VT)/IR;//in ohm
RC=Ad*re*10^-3;//in kohm
Ri=2*BETAac*re*10^-3;//in kohm
disp(R,"Value of resistance R in kohm is :");
disp(RC,"Value of resistance Rc in kohm is :");
disp(Ri,"Value of resistance Ri in kohm is :");
```

Scilab code Exa 1.15 Find differential input resistance

```
//Exa 1.15
clc;
clear;
close;
//given data
```

```
BETAac=100;//unitless
BETAdc=100;//unitless
VBEon=0.7;//in volts
VCC=5;//in volts
VEE=-5;//in volts
VT=25;//in mVolts
R=18.6;//in kohm
IR=(VCC-VBEon -VEE)/R;//in mA
IC1=IR/2;//in mA
IC2=IC1;//in mA
re1=(2*VT)/IR;//in ohm
re2=re1;//in ohm
Ri1=2*BETAac*re1*10^-3;//in kohm
Ri2=Ri1;//in kohm
disp("Differential input resistances are :")
disp(Ri1,"Ri1 in kohm is :")
disp(Ri2,"Ri2 in kohm is :")
```

Scilab code Exa 1.16 Find out the value of resistor Rc

```
//Exa 1.16
clc;
clear;
close;
//given data
BETAac=100;//unitless
BETAdc=100;//unitless
VBEon=0.7;//in volts
VCC=5;//in volts
VEE=-5;//in volts
VT=25;//in mVolts
R=18.6;//in kohm
Ad=200;//unitless
IR=(VCC-VBEon -VEE)/R;//in mA
IC1=IR/2;//in mA
```

```
IC2=IC1;//in mA
re1=(2*VT)/IR;//in ohm
re2=re1;//in ohm
RC=Ad*re1*10^-3;//in kohm
disp(RC,"Rc in kohm is :")
```

Scilab code Exa 1.17 Calculate various parameters of differential amplifier

```
//Exa 1.17
clc;
clear;
close;
//given data
BETAac=100;//unitless
BETAdc=100;//unitless
VBE=0.7;//in volts
VCC=10;//in volts
VEE=-10;//in volts
VT=25;//in mVolts
R=3.6;//in kohm
RC=2.2;//in kohm
// part (i) //
IR=(VCC-VBE-VEE)/R;//in mA
ICQ=IR/2;//in mA
VE=-2*VBE;//in Volts
VC=VCC-ICQ*RC;//in Volts
VCEQ=VC-VE;//in Volts
disp(VCEQ,"Operating point VCEQ in volt is : ")
// part (ii) //
re=VT/ICQ;//in ohm
re1=re;//in ohm
re2=re;//in ohm
reT=re1+re2;//in ohm
Ad=(RC*1000)/reT;// unitless
disp(Ad,"Differential voltage gain is : ")
```

```
// part (iii) //
BETAT=BETAac*BETAdc;//unitless
Rid=2*BETAT*reT*10^-3;//in kohm
disp(Rid,"Differential input resistance in kohm is :
    ")
```

Scilab code Exa 1.18 Design a three transistor current source

```
//Exa 1.18
clc;
clear;
close;
//given data
Iload=20;//in uA
VBE=0.7;//in volts
VCC=10;//in Volts
IR=Iload;//in mA
R=(VCC-2*VBE)/(IR*10^-3);//in kohm
disp(R,"R in kohm is :")
```

Scilab code Exa 1.19 Design a Widlar current source

```
//Exa 1.19
clc;
clear;
close;
//given data
Io=10;//in uA
IR=1;//in mA
VBE2=0.7;//in volts
VT=25;//in mVolts
VCC=20;//in volts
R=(VCC-VBE2)/IR;//in kohm
```

```
RE=((VT*10^-3)/(Io*10^-6))*log((IR*10^-3)/(Io*10^-6));//in ohm
RE=RE/1000;//in kohm
disp(R,"R in kohm is :")
disp(RE,"RE in kohm is :")
//note : answer in the book of RE is wrong.
```

Scilab code Exa 1.20 `Design a Widlar current source with multiple output transisto`

```
//Exa 1.20
clc;
clear;
close;
//given data
IR=2;//in mA
I2=10;//in uA
I3=20;//in uA
VBE1=0.7;//in volts
VT=25;//in mVolts
VCC=10;//in volts
VEE=-10;//in volts
R=(VCC-VBE1-VEE)/IR;//in kohm
disp("On examining circuit it can be seen that transistor Q1 and Q2 are connected in parallel, to form two widlar current source, one consisting of transistor Q1 and Q2 and the other consisting of Q1 and Q3.");
RE2=(VT/(I2*10^-3))*log(IR/(I2*10^-3));//in kohm
RE3=(VT/(I3*10^-3))*log(IR/(I3*10^-3));//in kohm
VBE2=VBE1-RE2*I2*10^-6;//in volts
VBE3=VBE1-RE3*I3*10^-6;//in volts
RE2=RE2/1000;//in kohm
RE3=RE3/1000;//in kohm
disp(R,"Value of R in kohm is : ")
disp(RE2,"Value of RE2 in kohm is : ")
```

```
disp(RE3,"Value of RE3 in kohm is : ")
disp(VBE2,"Value of VBE2 in Volt is : ")
disp(VBE3,"Value of VBE3 in Volt is : ")
```

Scilab code Exa 1.21 Calculate current through resistor Rc and collector current o

```
//Exa 1.21
clc;
clear;
close;
//given data
BETAac=100;//unitless
BETAdc=100;//unitless
VBE=0.715;//in volts
VEE=10;//in volts
VT=25;//in mvolts
R=5.6;//in kohm
N=3;// as three transistors here
IR=(VEE-VBE)/(R);//in mA
IC1=IR/(1+(1+N)/BETAac);//in mA
IC2=IR/(1+(1+N)/BETAac);//in mA
IC3=IR/(1+(1+N)/BETAac);//in mA
IRC=3*IC1;//in mA
disp(IRC,"Current through resistor Rc in mA is : ")
disp("Collector Current for each transistor : ")
disp(IC1,"IC1 in mA is : ");
disp(IC2,"IC2 in mA is : ");
disp(IC3,"IC3 in mA is : ");
```

Scilab code Exa 1.22 Design current steering circuit

```
//Exa 1.22
clc;
```

```
clear;
close;
//given data
I4=600;//in uA
I2=10;//in uA
I3=20;//in uA
VCC=10;//in volts
VEE=-10;//in volts
VBE=0.7;//in volts
VEB=0.7;//in volts
disp("On examine tthe given circuit , we observe that
    : ")
disp("IR=I1=I3");
disp("I2=2*IR");
disp("I4=3*IR");
IR=I4/3;//in uA
I2=2*IR;//in uA
I1=IR;//in uA
I3=IR;//in uA
R=(VCC-VEB-VBE-VEE)/(IR*10^(-3));//in kohm
disp(IR,"IR in uA is : ");
disp(I1,"I1 in uA is : ");
disp(I2,"I2 in uA is : ");
disp(I3,"I3 in uA is : ");
disp(R,"R in kohm is : ");
```

Scilab code Exa 1.23 `Determine various parameters of differential amplifier`

```
//Exa 1.23
clc;
clear;
close;
//given data
Vo=5;//in volts
BETAac=150;//unitless
```

```
BETAdc=150;//unitless
VT=25;//in mvolts
VCC=10;//in volts
VD=0.7;//in volts
R1=2.7;//in kohm
R2=1.5;//in kohm
// part (i) //
disp("we have IC1/IC2=exp((VBE1-VBE2)/VT)");
disp("Writing KVL for the loop containing both
    emitter base junction yields");
disp("VBE1=VBE2=VBE");
disp("Hence IC1/IC2=1");
disp("IC1=IC2=IC");
IR=(VCC-VD)/R1;//in mA
disp("Writing KCL at the junction of bases of
    transistors Q1 and Q2 gives : ");
disp("IC+2*IB+VBE/R2=IR")
disp("IB=IC/BETAac");
IC=(IR-VD/R2)/(1+2/BETAac);//in mA
IC1=IC;//in mA
IC2=IC;//in mA
RC=(VCC-Vo)/IC;//in kohm
disp(IC1,"IC1 in mA is : ");
disp(IC2,"IC2 in mA is : ");
disp(RC,"RC in kohm is : ");
```

Scilab code Exa 1.24 Determine various parameters of differential amplifier

```
//Exa 1.24
clc;
clear;
close;
//given data
BETAac=100;//unitless
BETAdc=100;//unitless
```

```
VT=25;//in mvolts
VEE=15;//in volts
VCC=15;//in volts
VBE=0.7;//in volts
VEB=-0.7;//in volts
R2=2.2;//in kohm
RC1=2.5;//in kohm
RC6=1.2;//in kohm
RE8=1.2;//in kohm
disp("The given circuit is consist of three stages
    as :");
disp("(i) Dual input balanced output differential
    amplifier comprising of Q1 and Q2.");
disp("(ii) Dual input unbalanced output differential
     amplifier comprising of Q5 and Q6.");
disp("(iii) Level shifter circuitcomprising of Q8
    and RE8.")
disp("Transistor Q3,Q4,Q7 & Q9 serves to form
    current multiple source, to give I3=I7=I9=I2");
I2=(VEE-VBE)/R2;//in mA
IC3=I2;//in mA
IC7=I2;//in mA
IC9=I2;//in mA
IC1=I2/2;//in mA
IC2=IC1;//in mA
IC5=IC1;//in mA
IC6=IC1;//in mA
IC8=I2;//in mA
IC9=I2;//in mA
// calculation of collector to emitter voltages
VC1=VCC-IC1*RC1;//in Volts
VC2=VC1;//in Volts
VCE1=VC1-VEB;//in Volts
VCE2=VCE1;//in Volts
VE5=VC1-VBE;//in Volts
VE6=VE5;//in Volts
VC6=VCC-RC6*IC6
VCE5=VCC-VE5;
```

```
VCE6=VCC-VE6;
VE8=VC6-VBE;
VCE8=VCC-VE8;
// calculation of ac emitter resistances
re1=VT/IC1;//in ohm
re2=re1;//in ohm
re5=re1;//in ohm
re6=re1;//in ohm
re8=VT/IC8;//in ohm
//input resistance of second stage is
Ri2=2*BETAac*re6*10^(-3);//in kohm
// voltage gain of first stage
Ad1=(((RC1*Ri2)/(RC1+Ri2)))/(re1*10^(-3));
//input resistance of third stage is
Ri3=BETAac*(re8+RE8);//in kohm
// voltage gain of second stage
Ad2=(((RC6*Ri3)/(RC6+Ri3)))/(2*re6*10^(-3));
Ad3=1;
//Overall gain of the circuit
Ad=Ad1*Ad2*Ad3;
disp("Maximum peak to peak output voltage swing is
    determined by the voltage drop across the
    collector resistor RC6 of second stage, as the
    third stage is the level shifter circuit with
    unity voltage gain.")
//voltage drop across collector resistor
VRC6=IC1*RC6;//in volts
//Maximum peak to peak output voltage swing
Vopp=3.9;// in volt
//// part (i)
disp("The operating point for each transistor :");
disp("For transistor 1");
disp(IC1,"IC1 in mA is :");disp(VCE1,"VCE1 in Volt
    is :");
disp("For transistor 2");
disp(IC2,"IC2 in mA is :");disp(VCE2,"VCE2 in Volt
    is :");
disp("For transistor 5");
```

```
disp(IC5,"IC5 in mA is :");disp(VCE5,"VCE5 in Volt is :");
disp("For transistor 6");
disp(IC6,"IC6 in mA is :");disp(VCE6,"VCE6 in Volt is :");
disp("For transistor 8");
disp(IC8,"IC8 in mA is :");disp(VCE8,"VCE8 in Volt is :");
//// part (ii)
disp(Ad," Overall voltage gain of the circuit is : ");
//// part (iii)
disp(Vopp,"Maximum peak to peak output voltage swing is ");
//note :answer in the book is not as much accurate as calculated by scilab
```

Scilab code Exa 1.25 Determine smallest possible and largest possible input offset

```
//Exa 1.25
clc;
clear;
close;
//given data
BETAmin=80;//unitless
BETAmax=120;//unitless
IE=400;//in uA
VT=25;//in mvolts
VEE=15;//in volts
VCC=15;//in volts
VBE=0.7;//in volts
VEB=-0.7;//in vol
IE1=IE/2;//in uA
IE2=IE1;//in uA
IBmax=IE1/(1+BETAmin);//in uA
```

```
IBmin=IE1/(1+BETAmax);//in uA
Iiomax=IBmax-IBmin;//in uA
disp(IBmax,"Largest possible input bias current in
   uA is :");
disp(IBmin,"smallest possible input bias current in
   uA is :");
disp(Iiomax,"Largest possible input offset current
   in uA is :");
```

Scilab code Exa 1.26 Determine various parameters of differential amplifier

```
//Exa 1.26
clc;
clear;
close;
//given data
BETAac=100;//unitless
BETAdc=100;//unitless
VT=25;//in mvolts
VEE=10;//in volts
VCC=10;//in volts
VBE=0.7;//in volts
VEB=-0.7;//in volts
RC2=2.7;//in kohm
RC1=2.7;//in kohm
RC3=1.5;//in kohm
RC4=1.5;//in kohm
RE1=5;//in kohm
RE2=10;//in kohm
RE3=10;//in kohm
IE1=(VEE-VBE)/(2*RE1);//in mA
IC1=IE1;
//as Q1 and Q2 are identical
IC2=IC1;
VC1=VCC-RC1*IC1;
```

```
VE1=-0.7;//in Volts
VE2=0.7;//in Volts
VCE1=VC1-VE1;
VCE2=VCE1;
disp("Writing KVL for the base emitter loop of
   tarnsistor Q3 will determine IC3 as :");
disp("VCC-RC2*IC2-VBE3-RE3*2*IE3+VEE=0")
IE3=(VCC-RC2*IC2-VBE+VEE)/(2*RE3);//in mA
IE4=IE3;//in mA
VC3=VCC-RC3*IE3;//in Volts
VC4=VC3;//in Volts
VE3=VC1-VBE;//in Volts
VCE3=VC3-VE3;//in Volts
VCE4=VCE3;//in Volts
disp("Thus operating point for Q1 & Q2 becomes : ")
disp(IC1,"ICQ in mA is : ");disp(VCE1,"VCEQ in volts
    is : ")
disp("And operating point for Q3 & Q4 becomes : ")
disp(IE3,"ICQ in mA is : ");disp(VCE3,"VCEQ in volts
    is : ")

re1=VT/IC1;//in ohm
re2=re1;//in ohm
re3=VT/IE3;//in ohm
re4=re3;//in ohm
Ri2=2*BETAac*re3;//in ohm
Ri2=Ri2*10^-3;//in kohm
Ad1=((RC1*Ri2)/(RC1+Ri2))/(re1*10^-3);
Ad2=RC4/(2*re4*10^-3);
Ad=Ad1*Ad2;
disp(Ad,"Overall voltage gain is : ");
Ri1=2*BETAac*re1;//in ohm
Ri1=Ri1/1000;//in kohm
disp(Ri1,"Input resistance of the cascaded
   differential amplifier in kohm is : ");
Ro2=RC4;//in kohm
disp(Ro2,"Output resistance of the cascaded
   differential amplifier in kohm is : ");
```

Scilab code Exa 1.27 Design a level shifter circuit

```
//Exa 1.27
clc;
clear;
close;
//given data
BETAac=100;//unitless
BETAdc=100;//unitless
VT=25;//in mvolts
VEE=10;//in volts
VCC=10;//in volts
VBE=0.7;//in volts
VD=0.7;//in volts
IE6=2;//in mA
IE1=3.25;//in mA
Ri2=1.538;//in kohm
RC1=2.5;//in kohm
re8=3.85;//in kohm
RE8=1.2;//in kohm
RC6=1.2;//in kohm
RE=VD/(IE6*10^-3);//in ohm
R=(VEE-2*VD)/IE6;//in kohm
VB5=8.74;//in Volts
VE5=VB5-VBE;
R1=VE5/IE6;//in kohm
re1=VT/IE1;//in ohm
re2=re1;re5=re1;re6=re1;//in ohm
re8=VT/6.5;//in ohm
Ri2=2*BETAac*re6*10^-3;//in kohm
Ad1=(1000*(RC1*Ri2)/((RC1+Ri2)))/re1;
Ri3=BETAac*(re8*10^-3+RE8);//in kohm
Ad2=(1000*(RC6*Ri3)/(RC6+Ri3))/(2*re6);
Ad=Ad1*Ad2;
```

```
VRC6=RC6*IE1;//in Volts
Vopp=VRC6;//in Volts
disp(RE,"value of RE in ohm is : ");
disp(R,"value of R in kohm is : ");
disp(VE5,"value of VE5 in Volt is : ");
disp(R1,"value of R1 in kohm is : ");
disp(re1,"AC emitter resistances re1=re2=re5=re6 in
   ohms are :");
disp(re8,"Abd re8 in ohm is : ");
disp(Ri2,"Input resistance of 2nd stage Ri2 in kohm
   is");
disp(Ad1,"Voltage gain of 1st stage is");
disp(Ad2,"Voltage gain of 2nd stage is");
Ad3=1;
disp(Ad3,"Voltage gain of 3rd stage is");
disp(Ad,"Overall Voltage gain of the circuit is");
disp(VRC6,"Voltage drop across collector resistor in
    volt is");
disp(Vopp,"Maximum peak to peak output voltage swing
    in volt is : ")
```

Chapter 2

Opamp Fundamentals

Scilab code Exa 2.2 `Calculate two base bias current`

```
//Exa 2.2
clc;
clear;
close;
//given data
Iio=20;//in nA
IB=100;//in nA
//Iio=IB1-IB2
disp("Eqn(1) : Iio=IB1-IB2=20");
//IB=(IB1+IB2)/2
disp("Eqn(2) : 2*IB=IB1+IB2=200");
disp("Adding two equations gives :");
IB1=(200+20)/2;//in nA
disp(IB1,"IB1 in nA is : ");
IB2=IB1-Iio;//in nA
disp(IB2,"IB2 in nA is : ");
```

Scilab code Exa 2.3 `Calculate output voltage`

```
//Exa 2.3
clc;
clear;
close;
//given data
G=120;//unitless
To=20;//in degree centigrade
T=50;//in degree centigrade
Dvoff=0.13;//in mV/degree centigrade
//input change
dVin=Dvoff*(T-To);//in mVolt
//output change
Vo=G*dVin;//in mVolt
disp(Vo,"Output voltage in mVolt is :")
```

Scilab code Exa 2.4 Find out 741C opamp can be used or not

```
//Exa 2.4
clc;
clear;
close;
//given data
dt=5;//in uSec
Vp=5;//in Volt
dV=(0.9-0.1)*Vp
SR=dV/dt;//in V/uSec
disp(SR,"Calculated SR in V/uSec is : ");
disp("The 741C op-amp with a slew rate of 0.5 V/uSec
    is slow and can not be used.");
```

Scilab code Exa 2.5 Find the rise time

```
//Exa 2.5
```

```
clc;
clear;
close;
//given data
Vo=10;//in Volt
SR=1;//in V/uSec
dV=(0.9-0.1)*Vo
dt=dV/SR;//in uSec
disp(dt,"Rise time in uSec is : ")
```

Scilab code Exa 2.6 Find out the time for output change

```
//Exa 2.6
clc;
clear;
close;
//given data
V1=-5;//in Volt
V2=5;//in Volt
SR=0.5;//in V/uSec
dV=V2-V1;// in Volt
dt=dV/SR;//in uSec
disp(dt,"Rise time in uSec is : ");
```

Scilab code Exa 2.7 Calculate maximum voltage

```
//Exa 2.7
clc;
clear;
close;
//given data
fm=50;//in kHz
SR=0.5;//in V/uSec
```

```
//formula : SR=2*%pie*fm*Vm
Vm=(SR*10^6)/(2*%pi*fm*10^3);//in Volts
disp(Vm,"Maximum vltage in volt is :")
```

Scilab code Exa 2.8 Find the limiting frequency

```
//Exa 2.8
clc;
clear;
close;
//given data
SR=6;//in V/uSec
//formula : SR=2*%pie*fm*Vm
// part (i) Vm=1 volt
Vm=1;//in Volts
fm=((SR*10^6)/(2*%pi*Vm))/1000;//in kHz
disp(fm,"when Vm=1 volt the limiting frequency in KHz is :")
// part (ii) Vm=10 volt
Vm=10;//in Volts
fm=((SR*10^6)/(2*%pi*Vm))/1000;//in kHz
disp(fm,"when Vm=10 volt the limiting frequency in KHz is :")
```

Chapter 3

Opamp with negative feedback

Scilab code Exa 3.1 Determine various parameters of differential amplifier

```
//Exa 3.1
clc;
clear;
close;
// given data
R1=1.5;//in kohm
RF=15;//in kohm
A=2*10^5;//unitless
Ri=1;//in Mohm
Ro=75;//in ohm
fo=5;//in Hz
AF=1+RF/R1;//unitless
B=1/AF;//unitless
RiF=(1+A*B)*Ri*10^6;//in ohm
RoF=Ro/(1+A*B);//in ohm
fF=fo*(1+A*B);//in ohm
disp(AF,"Close loop voltage gain AF is : ");
disp(RiF,"Value of RiF in ohm is : ")
disp(RoF,"Value of RoF in ohm is : ")
disp(fF/1000,"Value of fF in KHz is : ")
```

Scilab code Exa 3.2 Design closed loop non inverting amplifier

```
//Exa 3.2
clc;
clear;
close;
// given data
AF=100;//unitless
A=2*10^5;//unitless
Ri=1;//in Mohm
Ro=75;//in ohm
//let R1 =1 ohm
R1=1;//in ohm
//formula : AF=1+RF/R1
RF=(AF-1)*R1;//in kohm
B=1/AF;//unitless
RiF=(1+A*B)*Ri*10^6;//in ohm
RoF=Ro/(1+A*B);//in ohm
disp(RF,"Value of RiF in kohm is : ");
disp(RiF,"Value of RiF in ohm is : ")
disp(RoF,"Value of RoF in ohm is : ")
```

Scilab code Exa 3.3 Design closed loop non inverting amplifier

```
//Exa 3.2
clc;
clear;
close;
// given data
AF=1;//unitless
B=1;//unitless
A=2*10^5;//unitless
```

```
fo=5;//in Hz
Ri=1;//in Mohm
Ro=75;//in ohm
//let 1+AB=A; as A>>>1
RiF=A*Ri*10^6;//in ohm
RoF=Ro/A;//in ohm
fF=fo*A;//in ohm
disp(RiF,"Value of RiF in ohm is : ")
disp(RoF,"Value of RoF in ohm is : ")
disp(fF/10^6,"Value of fF in MHz is : ")
```

Scilab code Exa 3.4 Design inverting amplifier

```
//Exa 3.4
clc;
clear;
close;
// given data
R1=50;//in Kohm
AF=-6;//unitless
// here AF=-RF/R1
RF=-AF*R1;//in kohm
disp(RF,"Value of RF in Kohm is : ")
```

Scilab code Exa 3.5 Determine various parameters of opamp

```
//Exa 3.5
clc;
clear;
close;
// given data
A=2*10^5;//unitless
Ri=1;//in Mohm
```

```
Ro=75;//in ohm
fo=5;//in Hz
R1=50;//in kohm
RF=300;//in kohm
K=RF/(R1+RF);//unitless
B=R1/(R1+RF);//unitless
AF=-(A*K/(1+A*B));//unitless
RiF=R1;//in kohm ; ideal
RoF=Ro/(1+A*B);//in ohm
fF=-(A*K*fo/AF);//in Hz
disp(AF,"Close loop voltage gain AF is : ");
disp(RiF,"Value of RiF in ohm is : ")
disp(RoF,"Value of RoF in ohm is : ")
disp(fF/1000,"Value of fF in KHz is : ")
```

Scilab code Exa 3.6 `Design an inverting summing amplifier`

```
//Exa 3.6
clc;
clear;
close;
// given data
disp("We have Vo=(-RF/R)*(V1+V2+V3)");
disp("To produce 3 times the sum of three inputs, i.
   e. Vo=3*(V1+V2+V3)");
disp("hence RF/R=3 or RF=3*R");
// let R1=R2=R3=R=10kohm
R=10;//in kohm
R1=R;//in kohm
R2=R;//in kohm
R3=R;//in kohm
RF=3*R;//in Kohm
disp(RF,"Value of RF in Kohm is : ")
```

Scilab code Exa 3.7 Design inverting opamp circuit

```
//Exa 3.7
clc;
clear;
close;
// given data
RF=1;//in Mohm
AV=-30;//unitless
disp("we have AV=-RF/R1=Vo/V1");
R1=-RF*10^6/AV;//in ohm
//for an inverting amplifier RiF=R1
RiF=R1;//in ohm
disp(R1/1000,"Value of R1 in Kohm is : ")
disp(RiF/1000,"Value of RiF in Kohm is : ")
```

Scilab code Exa 3.8 Design inverting opamp circuit

```
//Exa 3.8
clc;
clear;
close;
// given data
AV=-8;//unitless
Vin=-1;//in Volts
Imax=15;//in uA
Vo=AV*Vin;//in Volts
//Formula : Vo=Imax*R2min
R2min=Vo/(Imax*10^-6);//in kohm
R1min=-Vin/(Imax*10^-6);//in kohm
disp(R2min/1000,"Required value of R2 in kohm is :")
disp(R1min/1000,"Required value of R1 in kohm is :")
```

Scilab code Exa 3.9 `Design preamplifier for a microphone`

```
//Exa 3.9
clc;
clear;
close;
// given data
Vo=1.5;//in Volts
Vin=10;//in mVolts
RiF=500;//in kohm
R1=500;//in kohm
AF=Vo/(Vin*10^-3);//unitless
RF=AF*R1;//in Kohm
disp(RF/1000,"The value of RF in Mohm is :");
disp("This value becomes too large for most of the practical circuit. Thus we make use of op-amp with T-Network.");
disp("We have AF=-R2/R1*(1+R3/R2+R3/R4)");
disp("Choose arbitraly R2/R1=R3/R1=5, then solving this equation.")
//Microphone resistance is Rm=1.2 Kohm
R1eff=100;//in Kohm
Rm=1.2;//in Kohm
R1=R1eff-Rm
R3=5*R1;
R2=R3;//in Kohm
R4=R3/28;//in Kohm
disp(R1,"Value of R1 in Kohm is : ")
disp(R2,"Value of R2 in Kohm is : ")
disp(R3,"Value of R3 in Kohm is : ")
disp(R4,"Value of R4 in Kohm is : ")
```

Chapter 4

Basic application of an opamp

Scilab code Exa 4.2 Determine Vo for adder subtractor

```
//Exa 4.2
clc;
clear;
close;
// given data
disp("As the input impedence of an op-amp circuit is
    very high & no current will enter the op-amp,
   hence node voltages at (a) & (b) will be at same
   potential , let Va=Vb=V");
disp("writing KCL at node (b) we have (6-V)/30+(8-V)
   /40+(0-V)/30=0");
V=48/11;//in volts
disp(V,"Voltage V in Volt is ; ");
disp("writing KCL at node (a) we have (3-V)/10+(4-V)
   /20=(V-Vo)/40");
Vo=-(20-7*V);//in Volts
disp(Vo,"Output Voltage of the circuit Vo in Volt is
    ; ");
```

Scilab code Exa 4.3 Find values for constant A and B

```
//Exa 4.3
clc;
clear;
close;
// given data
disp("The output expression consist of two parts ,
   one when V1 acting alone i.e. due to non
   inverting amplifier , thus constant A becomes the
   gain for non inverting configuration and second
   when V2 acting alone i.e. due to inverting
   amplifier , thus constant B becomes the gain for
   inverting configuration ");
// case (i) when V1 acting alone V2=0;
disp("case (i) when V1 acting alone V2=0 and the
   output is given as");
disp("Vo1=(1+100/10)*Va");
disp("Va=99*V1/(11+99)");
disp("Vo1=(110/10)*(99/110)*V1=9.9V1");
disp("Thus the gain A=Vo1/V1=9.9");
// case (ii) when V2 acting alone V1=0;
disp("case (ii) when V2 acting alone V1=0 and the
   output is given as");
disp("Vo2=(-100/10)*V2");
disp("Thus the gain B=Vo2/V2=-10");
```

Scilab code Exa 4.4 Determine values of unknown resistors

```
//Exa 4.4
clc;
clear;
close;
disp("The output can be obtained using superposition
    theorem , as");
```

```
disp("Vo=Voa+Vob");
// case (i) when Vb=0;
disp("case (i) when Vb=0 the given circuit becomes
    an inverting amplifier to provide an output as");
disp("Voa=-100Kohm*Va/R1=-2*Va ");
disp("It gives R1=50 Kohm");
// case (ii) when Va=0;
disp("case (ii) when Va=0 the given circuit becomes
    an non-inverting amplifier to provide an output
    as");
disp("Vob=(1+100Kohm/R1)*V1 where V1=R3*Vb/(R2+R3)")
    ;
disp("Vob=(1+100Kohm/R1)*V1*(R3*Vb/(R2+R3))=Vb ")
disp("Putting R1=R2=50 Kohm, we get R3=25 Kohm");
```

Scilab code Exa 4.5 Determine output of the circuit

```
//Exa 4.5
clc;
clear;
close;
disp("The given circuit is basically an inverting
    amplifier with node A at virtual ground. Writing
    KCL at node A yields ");
disp("I1+I2=If");
disp("-2/10Kohm+3/20Kohm=-Vo/100Kohm");
Vo=-(-20+15);//in Volts
disp(Vo,"Output voltage in Volt is : ")
```

Scilab code Exa 4.7 Determine output of the circuit

```
//Exa 4.7
clc;
```

```
clear;
close;
disp("The voltage at node X will be equal to the xvoltage across resistor R5, hence ");
disp("Vx=(Vo*R5)/(R5+R6)");
disp("Vx=Vo/8");
Vz=1;//in Volt
disp("writing KCL at node Y yields ");
disp("(Vy-Vx)/R2+(Vy-Vz)/R3=0 or (Vy-Vx)/2+(Vy-1)/4=0");
disp("Vy=(2*Vx+1)/3");
disp("writing KCL at node X yields ");
disp("(1-Vx)/R1+(Vy-Vx)/R2=0 or (1-Vx)/2+(Vy-Vx)/2=0 ");
disp("Vy-2*Vx+1=0");
disp("Now substituting for Vy from above equation, we get")
disp("(2*Vx-1)/3-2*Vx+1=0");
Vx=2/4;//in Volt
disp(Vx,"The value of Vx in volt is :")
Vo=8*Vx;//in Volt
disp(Vo,"The output voltage of the circuit in volt is : ")
```

Scilab code Exa 4.8 `Determine input impedence`

```
//Exa 4.9
clc;
clear;
close;
// given data
R1=10;//in Kohm
R4=8;//in Kohm
R5=3;//in Kohm
RF=45;//in Kohm
```

```
AD=(1+2*R4/R5)*(RF/R1);
disp(AD,"Gain for the instrumention amplifier is : "
    )
```

Scilab code Exa 4.9 Determine the gain for an instrumentation amplifier

```
//Exa 4.9
clc;
clear;
close;
// given data
R1=10;//in Kohm
R4=8;//in Kohm
R5=3;//in Kohm
RF=45;//in Kohm
AD=(1+2*R4/R5)*(RF/R1);
disp(AD,"Gain for the instrumention amplifier is : "
    )
```

Scilab code Exa 4.10 Determine output voltage for an instrumentation amplifier

```
//Exa 4.10
clc;
clear;
close;
// given data
VA=3;//in mVolt
VB=5;//in mVolt
R1=10;//in Kohm
R2=10;//in Kohm
R3=45;//in Kohm
R4=8;//in Kohm
R5=3;//in Kohm
```

```
RF=45;//in Kohm
disp("Considering Voltage Voa is at higher potential than Vob. Concept of virtual short yields");
disp("Vx=VA and Vy=VB");
I=(VA-VB)/R5;//in mA
VoA=VA+I*R4;//in mVolts
VoB=VB-I*R4;//in mVolts
disp(VoA,"Output of op-amp A1 in mVolt is");
disp(VoB,"Output of op-amp A2 in mVolt is");
Vo1=(1+RF/R1)*(R3/(R3+R2))*VoB;
Vo2=-(RF/R1)*VoA;
Vo=Vo1+Vo2;//in mVolt
disp(Vo,"Combined output of the circuit in mVolt is : ");
```

Scilab code Exa 4.12 Determine an instrumentation amplifier

```
//Exa 4.12
clc;
clear;
close;
// given data
RF=10;//in Kohm
R1=10;//in Kohm
R2=R1;//in Kohm
R3=R1;//in Kohm
R5max=50;//in Kohm
ADmin=5;//unitless
ADmax=200;//unitless
//Formula : ADmin=1+2*R4/R5max
R4=(ADmin-1)*(R5max/2);//in Kohm
//Formula : ADmax=1+2*R4/R5min
R5min=(2*R4)/(ADmax-1);//in Kohm
disp("Thus design values of resistors in Kohm are :");
```

```
disp(R1,"R1");
disp(R2,"R2");
disp(R3,"R3");
disp(R4,"R4");
disp(RF,"RF");
disp(R5min,"R5min");
disp(R5max,"R5max");
```

Scilab code Exa 4.13 Calculate output voltage

```
//Exa 4.13
clc;
clear;
close;
// given data
Vdc=10;//in Volt
R1=10;//in Kohm
R2=10;//in Kohm
R3=100;//in Kohm
RF=100;//in Kohm
// Part(i)  Balance Bridge : RA=RB=RC=RT=150ohm and
   VAB=0
RA=150;//in ohm
RB=150;//in ohm
RC=150;//in ohm
RT=150;//in ohm
VAB=0;//in Volt
Vo=(-RF/R1)*VAB;
// Part(ii)  Unbalance Bridge : RT=200ohm
RT=200;//in ohm
VA=(RA/(RA+RT))*Vdc;
VB=(RB/(RB+RC))*Vdc;
VAB=VA-VB;//in Volt
Vo=(-RF/R1)*VAB;
disp(0,"Balance bridge have output voltage Vo in
```

```
    volt is :");
disp(Vo,"Unbalance bridge have output voltage Vo in
    volt is :");
```

Scilab code Exa 4.15 Design a practical integrator circuit

```
//Exa 4.15
clc;
clear;
close;
// given data
Gain=10;//Unitless
fb=10;//in KHz
//Assuming fa=fb/10
fa=fb/10;//in KHz
// Formula : fa=1/(2*pi*RF*CF)
RFCF=1/(2*%pi*fa);
//Assuming R1=1Kohm
R1=1;//in Kohm
RF=10*R1;//in Kohm
CF=RFCF/RF;//in uF
Rcomp=(R1*RF)/(R1+RF);// in Kohm
disp(RF,"Value of RF in Kohm is : ");
disp(CF,"Value of CF in uF is : ");
disp(Rcomp*1000,"Value of Rcomp in ohm is : ");
```

Scilab code Exa 4.16 Design a circuit

```
//Exa 4.16
clc;
clear;
close;
```

```
disp("Using superposition theorem, we have output for the fiven two inputs integrator adder as");
disp("Vo=-integrate(V1/R1CF+V2/R2CF,0,t)");
disp("Comparing above expression with the specified output given, we have");
disp("1/R1CF=3 & 1/R2CF=2")
CF=10;//in uF
R1=1/(3*CF*10^-6);//in KOhm
R2=1/(2*CF*10^-6);//in KOhm
disp(R1/1000,"Value of R1 in Kohm is : ");
disp(R2/1000,"Value of R2 in Kohm is : ");
```

Scilab code Exa 4.22 `Design a practical differentiator`

```
//Exa 4.22
clc;
clear;
close;
// given data
fa=1.5;//in KHz
fmax=1.5;//in KHz
C1=0.1;//in uF
RF=1/(2*%pi*fa*C1);//in Kohm
fb=10*fa;//in Khz
R1=1/(2*%pi*fb*C1);//in Kohm
CF=(R1*C1)/RF;//in uF
Rcomp=RF;//in Kohm
disp(RF,"Value of resistance RF in Kohm is : ")
disp(R1*1000,"Value of resistance R1 in ohm is : ")
disp(CF,"Value of Capacitance CF in uF is : ")
disp(Rcomp,"Value of resistance Rcomp in Kohm is : "
)
```

Scilab code Exa 4.25 Design a practical differentiator circuit

```
//Exa 4.25
clc;
clear;
close;
// given data
C1=0.1;//in uF
f=100;//in Hz
T=1/f;//in sec
// Given also R1C1=0.2*T;
R1=(0.2*T)/(C1*10^-6);//in ohm
RF=0.05/(C1*10^-6);//in ohm
CF=(R1*C1)/RF;//in uF
disp(R1/1000,"Value of resistance R1 in ohm is : ")
disp(RF/1000,"Value of resistance RF in Kohm is : ")
disp(CF,"Value of Capacitance CF in uF is : ")
```

Chapter 5

Waveform Generators

Scilab code Exa 5.1 Design a square wave generator

```
// Exa 5.1
clc;
clear;
close;
// given data
fo=1;//in KHz
disp("As choosing R2=1.16R1 will give f=1/2RC")
// assume R1=1 Kohm and C=1 uF
R1=1;//in Kohm
C=1;//in uF
R2=1.16*R1;//in Kohm
R=1/(2*fo*10^3*C*10^-6)
disp(R1,"Value of R1 in Kohm is ; ")
disp(R2,"Value of R2 in Kohm is ; ")
disp(R,"Value of R in ohm is ; ")
disp(C,"Value of C in uF is ; ")
```

Scilab code Exa 5.2 Design a square wave generator

```
// Exa 5.2
clc;
clear;
close;
// given data
fo=1;//in KHz
BETA=0.6;//unitless
disp("As choosing R1=1 Kohm")
// assume R1=1 Kohm and C=1 uF
R1=1;//in Kohm
C=1;//in uF
R=1/(2*fo*10^3*C*10^-6*log((1+BETA)/(1-BETA)));
disp(R,"Value of R in ohm is ; ");
//Answer in the book is wrong
```

Scilab code Exa 5.3 Determine output signal frequency

```
// Exa 5.3
clc;
clear;
close;
// given data
BETA=0.41;//unitless
R=2.7;//in Kohm
C=0.1;//in uF
fo=1/(2*R*C*log((1+BETA)/(1-BETA)));//in KHz
disp(fo,"Output signal frequency in Khz is ; ")
```

Scilab code Exa 5.4 Design a circuit to produce an asymmetrical wave

```
// Exa 5.4
clc;
clear;
```

```
close;
// given data
Ton=100;//in mSEC
Toff=200;//in mSEC
BETA=0.2;//unitless
//Let R1=1 Kohm
R1=1;//in Kohm
R2=R1*(1-BETA)/BETA;//in Kohm
// Assuming C=10 uF
C=10;//in uF
R3=Ton*10^-3/(C*10^-6*0.41);//in Kohm
R4=Toff*10^-3/(C*10^-6*0.41);// in Kohm
disp(R1,"Value of R1 in Kohm is ; ")
disp(R2,"Value of R2 in Kohm is ; ")
disp(R3/1000,"Value of R3 in Kohm is ; ")
disp(R4/1000,"Value of R4 in Kohm is ; ")
disp(C,"Value of C in uF is ; ")
```

Scilab code Exa 5.5 Design a circuit to produce an square wave

```
// Exa 5.5
clc;
clear;
close;
// given data
Vo=7.5;//in Volt
fo=1;// in KHz
DutyCycle=60;//in %
disp("Zener diioe has to be used at the output to
    limit the output at +7.5 volt or -7.5 volt.");
disp("Thus choose Vz=Vz1=Vz2=6.8 volt as VD=0.7 volt
    ")
Vz=6.8;// in volt
Vz1=6.8;// in volt
Vz2=6.8;// in volt
```

```
VD=0.7;// in volt
T=1/fo;//in mSec
// duty cycle 60% gives Ton & Toff
Ton=0.6*T;//in mSec
Toff=T-Ton;//in mSec
// choosing R2=1.16*R1
R1=1;//in Kohm
C=0.1;//in uF
R2=1.16*R1;//in Kohm
R3=Ton*10^-3/(C*10^-6);//in ohm
R4=Toff*10^-3/(C*10^-6);//in ohm
disp(R1,"Value of R1 in Kohm is ; ")
disp(R2,"Value of R2 in Kohm is ; ")
disp(R3/1000,"Value of R3 in Kohm is ; ")
disp(R4/1000,"Value of R4 in Kohm is ; ")
disp(C,"Value of C in uF is ; ");
```

Scilab code Exa 5.6 `Determine frequency of oscillation and duty cycle`

```
// Exa 5.6
clc;
clear;
close;
// given data
RA=6.8;//in Kohm
RB=3.3;//in Kohm
C=0.1;//in uF
fo=1.45/((RA+2*RB)*C);// in KHz
d=(RA+RB)/(RA+2*RB);
disp(fo,"Frequency of oscillation in Khz is ; ");
disp(d*100,"Duty cycle in % is :");
```

Scilab code Exa 5.7 `Design an astable multivibrator`

```
// Exa 5.7
clc;
clear;
close;
// given data
fo=50;//in KHz
d=75/100;//unitless
C=1;//in nF
disp("RA+2RB=1/(0.693*fo*10^3*C*10^-9);// in Kohm");
disp("RA+2RB=28.9 Kohm");
disp("d=0.75=(RA+RB)/(RA+2*RB)");
disp("It gives RA=2*RB");
RA=28.9/2;// in Kohm
RB=RA/2;//in Kohm
disp(RA,"Value of RA in Kohm is :")
disp(RB,"Value of RB in Kohm is :");
```

Scilab code Exa 5.8 Design 555 timer as an astable multivibrator

```
// Exa 5.8
clc;
clear;
close;
// given data
fo=800;// in Hz
d=60/100;//unitless
T=1/fo;//in Sec
TC=0.6*T;//in Sec
TD=T-TC;//in Sec
C=0.01;//in uF
C2=10;//in uF
RB=TD/(0.69*C*10^-6);//in ohm
RA=(TC-0.69*RB*C*10^-6)/(0.69*C*10^-6);//in ohm
disp(RA/1000,"Value of RA in Kohm is ; ")
disp(RB/1000,"Value of RB in Kohm is ; ")
```

```
disp(C,"Value of C in uF is ; ");
disp(C2,"Value of C2 in uF is ; ");
```

Scilab code Exa 5.9 Design 555 timer as an astable multivibrator

```
// Exa 5.9
clc;
clear;
close;
// given data
fo=700;// in Hz
d=50/100;//unitless
T=1/fo;//in Sec
TC=0.5*T;//in Sec
TD=T-TC;//in Sec
C=0.1;//in uF
RB=TD/(0.69*C*10^-6);//in ohm
RA=TC/(0.69*C*10^-6);//in ohm
disp(RA/1000,"Value of RA in Kohm is ; ")
disp(RB/1000,"Value of RB in Kohm is ; ")
disp(TC*1000,"We have TC=TD in mSEC is :")
```

Scilab code Exa 5.10 Design an astable multivibrator

```
// Exa 5.10
clc;
clear;
close;
// given data
fo=1;// in KHz
d=40/100;//unitless
T=1/fo;//in Sec
TC=0.4*T;//in mSec
```

```
TD=T-TC;//in mSec
C=0.1;//in uF
RB=TD*10^-3/(0.69*C*10^-6);//in ohm
RA=TC*10^-3/(0.69*C*10^-6);//in ohm
disp(RA/1000,"Value of RA in Kohm is ; ")
disp(RB/1000,"Value of RB in Kohm is ; ")
disp(TC,"We have TC in mSEC is :")
disp(TD,"We have TD in mSEC is :")
```

Scilab code Exa 5.11 Design IC555 as a monostable multivibrator

```
// Exa 5.11
clc;
clear;
close;
// given data
T=100;// in uSec
C=15;//in
R=T*10^-6/(1.1*C*10^-9);//in ohm
disp(R/1000,"To obtain a output pulse at 100uSec
    rsistor required in Kohm is :")
//Note : in the question 15uF is given but in the
    solution 15nF is used in the book
```

Scilab code Exa 5.12 Design a timer circuit using IC555

```
// Exa 5.12
clc;
clear;
close;
// given data
VCC=15;//in Volt
T=10;//in mSec
```

```
ILED=20;//in mA
Vf=1.4;//in Volt
VBE=0.7;//in Volt
VCEsat=0.2;//in Volt
C=0.22;//in uF
R=T*10^-3/(1.1*C*10^-6);//in ohm
//output of the device
Vo=VCC-2*VBE-VCEsat;
R5=(Vo-Vf)/(ILED*10^-3);//in ohm
disp(R/1000,"Value of R in Kohm is ; ")
disp(Vo,"Output of the device in volt is : ")
disp(R5,"Value of RB in Kohm is ; ")
disp("Note : To improve the noise immunity of the
    device, a 0.01 uF capacitor is connected between
    pin 5 and ground. ")
```

Scilab code Exa 5.13 Find out the value of R

```
// Exa 5.13
clc;
clear;
close;
// given data
fo=2;// in KHz
C=0.01;//in uF
disp("For a divide-by-2 network, tp, output pulse
    duration, should be slightly larger than Y i.e.
    period of trigger pulse.")
T=1/fo;//in mSec
tp=1.2*T;//in mSec
R=tp*10^-3/(1.1*C*10^-6);//in ohm
disp(tp,"Period of trigger pulse in mSEC is :");
disp(R/1000,"Value of R in Kohm is ; ");
```

Scilab code Exa 5.14 `Design a triangular wave generator`

```
// Exa 5.14
clc;
clear;
close;
// given data
fo=2;// in KHz
Vopp=5;//in volts
Vsat=13;//in Volts
// Let the value of R2 used be 10 Kohm
R2=10;//in Kohm
R3=(2*R2*Vsat)/Vopp;//in Kohm
// Let C1=0.1 uF
C1=0.1;// in uF
R1=R3/(4*fo*10^3*C1*10^-6*R2);// in ohm
disp(R1/1000,"Value of R1 in Kohm is ; ");
disp(C1,"Value of C1 in uF is ; ");
disp(R2,"Value of R2 in Kohm is ; ");
disp(R3,"Value of R3 in Kohm is ; ");
```

Scilab code Exa 5.15 `Find amplitude and frequency`

```
// Exa 5.15
clc;
clear;
close;
// given data
Vcc=12;//in Volt
R1=10;//in Kohm
R2=100;//in Kohm
R3=820;//in Kohm
```

```
// Let Vsat=10 volt
Vsat=10;//in volt
// part (a)
Vopp=2*R2*Vsat/R3;//in Volt
disp(Vopp,"Amplitude of triangular wave in volt is : ")
Vopp=Vsat-(-Vsat);// in Volt
disp(Vopp,"Amplitude of square wave in volt is :  ")
// part (b)
C1=0.1;// in uF
fo=R3*1000/(4*R1*1000*R2*1000*C1*10^-6);// in Hz
disp(fo/1000,"Frequenci in KHz is :");
```

Scilab code Exa 5.16 Design a phase shift oscillator

```
// Exa 5.16
clc;
clear;
close;
// given data
fo=1;// in KHz
// choose C=.01 uF
C=.01;// in uF
R=1/(2*%pi*sqrt(6)*fo*1000*C*10^-6);// in ohm
disp("Choose the value of R1 to get RF, while considering that R1 >= 10*R to avoid loading effect. Thus choosing R1=35.6 Kohm");
R1=35.6;// in  Kohm
RF=29*R1;//in ohm
disp("Hence desired components values are :");
disp(C,"Value of C in uF is ; ");
disp(R/1000,"Value of R in Kohm is ; ");
disp(R1,"Value of R1 in Kohm is ; ");
disp(RF/1000,"Value of RF in Mohm is ; ");
// Note : Answer in the book is wrong
```

Scilab code Exa 5.17 Design a Wein bridge oscillator

```
// Exa 5.17
clc;
clear;
close;
// given data
fo=1;// in KHz
// choose C=.01 uF
C=.01;// in uF
R=1/(2*%pi*fo*1000*C*10^-6);// in ohm
// choosing R1=10 Kohm
R1=10;// in Kohm
RF=2*R1;//in Kohm
disp("Hence desired components values are :");
disp(C,"Value of C in uF is ; ");
disp(R/1000,"Value of R in Kohm is ; ");
disp(R1,"Value of R1 in Kohm is ; ");
disp(RF,"Value of RF in Kohm is ; ");
```

Scilab code Exa 5.19 Determine frequency of oscillation

```
// Exa 5.19
clc;
clear;
close;
// given data
R=1;//in Kohm
C=3.6;//in uF
fo=1/(2*%pi*R*1000*C*10^-6);// in Hz
disp(fo,"The frequency of oscillation in Hz is :");
```

Scilab code Exa 5.20 Determine various parameters of opamp

```
// Exa 5.20
clc;
clear;
close;
// given data
R1=10;//in Kohm
R2=47;//in Kohm
R3=5.6;//in Kohm
RT=4.7;//in Kohm
CT=0.05;//in uF
V1=-10;//in Volt
V2=2;//in Volt
disp("By the concept of virtual ground and using
    superposition theorem the op-amp output voltage
    can be calculated.");
Vop=-(R1*V1/R2+R1*V2/R3);// in volt
VEE=0;//in Volt
I=(VEE+3-Vop)/RT;// in mA
fo=0.32*I*10^-3/(CT*10^-6);//in Hz
disp(Vop,"Op-amp voltage in volt is : ");
disp(fo/1000,"Frequency in KHz is :");
```

Scilab code Exa 5.21 Calculate free running frequency lock range and capture range

```
// Exa 5.21
clc;
clear;
close;
// given data
RT=50;//in Kohm
```

```
CT=0.001;//in uF
V=20;//in Volt
C=10;//in uF
fo=0.25/(RT*10^3*CT*10^-6);//in Hz
dfl=7.8*fo/V;//in Hz
dfc=sqrt(dfl/(2*%pi*3.6*10^3*C*10^-6));//in Hz
disp(fo/1000,"Free running frequency in KHz is :");
disp(dfl/1000,"Lock range in KHz is :");
disp(dfc,"Capture range in Hz is :");
```

Scilab code Exa 5.22 Determine frequency of reference oscillator

```
// Exa 5.22
clc;
clear;
close;
// given data
fomax=100;// in KHz
Resolution=2;//in Hz
flowest=Resolution;//in Hz
fclk=fomax*2.2;//in KHz
// formula: 2^n=fclk/flowest
n=(log10(fclk*1000/flowest))/log10(2);
disp(fclk,"Frequency of reference oscillator in KHz
    is :");
disp(ceil(n),"No. of bits needed is :");
```

Chapter 6

Active Filters

Scilab code Exa 6.2 Determine cut off frequency

```
// Exa 6.2
clc;
clear;
close;
// given data
R=10;//in Kohm
C=0.01;//in uF
R1=4.7;//in Kohm
RF=47;//in Kohm
fc=1/(2*%pi*R*1000*C*10^-6);//in Hz
AF=1+RF/R1;//unitless
disp(fc/1000,"Cut-off frequency in KHz is ; ")
disp(AF,"Pass band gain is ; ")
```

Scilab code Exa 6.3 Design a first order low pass filter

```
// Exa 6.3
clc;
```

```
clear;
close;
// given data
fc=2;//in KHz
AF=2;//unitless
// let C=0.01 uF
C=0.01;//in uF
R=(1/(2*%pi*fc*1000*C*10^-6))/1000;//in Kohm
R=ceil(R);
// Bias compensation Rbc
//Rbc=R1*RF/(R1+RF) ohm
disp("Bias compensation :R=R1*RF/(R1+RF)=Rdash/2 ohm
    ");
//Rdash=R1=RF=2*R;//in ohm
Rdash=2*R;//in ohm
R1=2*R;//in ohm
RF=2*R;//in ohm
R1=RF;//in kohm
disp("Component values are :");
disp(R1,"R1=RF in Kohm is ;");
disp(R,"R in Kohm is ;");
```

Scilab code Exa 6.4 Using frequency scaling change the cut off frequency

```
// Exa 6.4
clc;
clear;
close;
// given data
fc_original=2;//in KHz
fc_new=3;//in KHz
R_original=8;//in Kohm
R_new=fc_original*R_original/fc_new;//in Kohm
disp("Change the resistance value 8 Kohm to a new
    value.");
```

```
disp(R_new,"New value of resistance in ohm is :")
```

Scilab code Exa 6.5 Design a first order high pass filter

```
// Exa 6.5
clc;
clear;
close;
// given data
fc=1;//in KHz
AF=2;//unitless
// let C=0.01 uF
C=0.01;//in uF
R=(1/(2*%pi*fc*1000*C*10^-6))/1000;//in Kohm
disp("AF=1+RF/R1=2 gives RF=R1=Rdash")
//For Bias compensation
//Rbc=R1*RF/(R1+RF) ohm
disp("Bias compensation :R=R1*RF/(R1+RF)=Rdash/2 ohm");
//Rdash=R1=RF=2*R;//in ohm
Rdash=2*R;//in ohm
R1=2*R;//in ohm
RF=2*R;//in ohm
R1=RF;//in kohm
disp("Component values are :");
disp(R1,"R1=RF in Kohm is ;");
disp(R,"R in Kohm is ;");
```

Scilab code Exa 6.6 Design a filter using sallen key unity gain low pass active fi

```
// Exa 6.6
clc;
clear;
```

```
close;
// given data
AF=5;//unitless
fc=1;//in KHz
disp("To have a roll off rate of 40dB/decade a
    second order filter is requied.");
disp("For flattest passband, butterworth type filter
     has to be used, hence alfa=1.414");
alfa=1.414;//unitless
// assume C2=0.1 uF
C2=0.1;//in uF
C3=(C2*alfa^2)/4;// in uF
R=1/(2*%pi*fc*10^3*sqrt(C2*10^-6*C3*10^-6));//in ohm
//Take RF=10 Kohm
RF=10;//in  Kohm
R1=RF/(AF-1);//in Kohm
disp(R/1000,"Value of R in Kohm is :")
disp(RF,"Value of RF in Kohm is :")
disp(R1,"Value of R1 in Kohm is :")
```

Scilab code Exa 6.7 Determine the type and frequency of filter

```
// Exa 6.7
clc;
clear;
close;
// given data
C2=0.1;//in uF
C3=0.0333;//in uF
alfa=2*sqrt(C3/C2);//unitless
disp(alfa,"According to the value of alfa i.e. : ");
disp("This filter is situated between Butterworth
    and the Chebyshev, hence approximating Klp=1.1");
Klp=1.1;//unitless
R=2.25;//in Kohm
```

```
f3dB=Klp/(2*%pi*R*sqrt(C2*C3));//in KHz
disp(f3dB,"f3dB in KHz is : ");
//Note : Answer in the book is wrong
```

Scilab code Exa 6.8 Design a filter using sallen key equal component low pass acti

```
// Exa 6.8
clc;
clear;
close;
// given data
Klp=1;//unitless// it is 1 for butterworth filter
alfa=1.414;//unitless// it is 1.414 for butterworth
    filter
fc=1;//in KHz
R=15.9;//in Kohm
// assume C=0.01 uF
C=0.01;//in uF
R=Klp/(2*%pi*fc*1000*C*10^-6);// in ohm
AF=3-alfa;//unitless
R1=2*R/0.369;//in Kohm
RF=(AF-1)*R1;//in Kohm
A2=5/AF;//unitless
disp(RF/1000,"Value of RF in Kohm is :");
disp("Now to obtain an overall gain of 5, add an
    amplifier A2 after the filter.");
disp(A2,"Gain of this amplifier is :");
```

Scilab code Exa 6.9 Calculate critical frequency

```
// Exa 6.9
clc;
clear;
```

```
close;
// given data
R2=20;//in Kohm
R3=20;//in Kohm
R=R2;//in Kohm
C2=0.47;//in uF
C3=0.47;//in uF
C=C2;//in uF
RF=56;//in Kohm
R1=56;//in Kohm
AF=1+RF/R1;//unitless
alfa=3-AF;//unitless
Klp=1.238;//unitless
disp(alfa,"Value of alfa is :");
disp("alfa=1 corresponds to chebyshev filter
    response.");
f3dB=Klp/(2*%pi*R*1000*C*10^-6);//in Hz
disp(f3dB,"Critical frequency in Hz is :")
```

Scilab code Exa 6.10 Design a second order low pass filter

```
// Exa 6.10
clc;
clear;
close;
// given data
fc=2;//in KHz
disp("As the type of the filter is not given, here
    we design a sallen key equal component filter
    with Butterworth response.");
alfa=1.414;//unitless
Klp=1;//unitless
//assume C=0.01 uF
C=0.01;//in uF
R=Klp/(2*%pi*fc*1000*C*10^-6);//in ohm
```

```
AF=3-alfa;//unitless
R1=2*R/0.369;//in ohm
RF=0.586*R1;//in ohm
disp("Design components values are :");
disp(R1/1000,"Value of R1 in Kohm is :")
disp(RF/1000,"Value of RF in Kohm is :")
disp(R/1000,"Value of R2=R3=R in Kohm is :")
disp(C,"Value of C2=C3=C in uF is :")
```

Scilab code Exa 6.11 calculate 3dB frequency filter type and pass band gain

```
// Exa 6.11
clc;
clear;
close;
// given data
C=0.1;//in uF
R=11;//in Kohm
RF=5.6;//in Kohm
R1=10;//in Kohm
AF=1+RF/R1;//unitless
alfa=3-AF;//unitless
Klp=1;//unitless// for Butterworth filter
Khp=1/Klp;//unitless
f3dB=Khp/(2*%pi*R*1000*C*10^-6);//in Hz
disp(f3dB,"3 dB frequency in Hz is :")
disp(alfa,"Value of alfa is :");
disp("Value of alfa shows that it is a Butterworth
    flter.");
disp(Khp,"Passband gain for a high pass filter is :
    ")
```

Scilab code Exa 6.12 Design a second order high pass filter

```
// Exa 6.12
clc;
clear;
close;
// given data
fc=2;//in KHz
disp("As the type of the filter is not given, here
    we design a sallen key equal component filter
    with Butterworth response.");
alfa=1.414;//unitless
Klp=1;//unitless
//assume C=0.01 uF
C=0.01;//in uF
R=Klp/(2*%pi*fc*1000*C*10^-6);//in ohm
AF=3-alfa;//unitless
R1=2*R/0.369;//in ohm
RF=0.586*R1;//in ohm
disp("Design components values are :");
disp(R1/1000,"Value of R1 in Kohm is :")
disp(RF/1000,"Value of RF in Kohm is :")
disp(R/1000,"Value of R2=R3=R in Kohm is :")
disp(C,"Value of C2=C3=C in uF is :")
```

Scilab code Exa 6.13 Design a band pass filter

```
// Exa 6.13
clc;
clear;
close;
// given data
fL=200;//in Hz
fH=1;//in KHz
AFBP=4;//unitless
//for LP section design
//assume C=0.01 uF
```

```
C=0.01;//in uF
R=1/(2*%pi*fH*1000*C*10^-6);//in ohm
disp("For low pass section design component values
    are :");
disp(R/1000,"Value of R in Kohm is :")
disp(C,"Value of C in uF is :")
//for HP section design
//assume C=0.05 uF
C=0.05;//in uF
R=1/(2*%pi*fL*1000*C*10^-6);//in ohm
disp("For high pass section design component values
    are :");
disp(R,"Value of R in Kohm is :");
disp(C,"Value of C in uF is :");
disp("We have AFBP=AFHP*AFLP=4");
disp("The gain of HP section as well as LP section
    could be set equal to 2 to obtain overall gain of
     4. This gives equal value for input and feedback
     resistors for both sections, i.e. ");
disp("R=10 Kohm");
fc=sqrt(fH*fL*1000);//in Hz
BW=fH*1000-fL;//in Hz
Q=fc/BW;//unitless
disp(fc,"Center frequency in Hz is : ");
disp(BW,"BW in Hz is :");
disp(Q,"Selectivity is :")
disp("As Q<10, hence the given filter is wide band
    pass filter.")
```

Scilab code Exa 6.14 Design a band pass filter with single opamp

```
// Exa 6.14
clc;
clear;
close;
```

```
// given data
fL=2;//in KHz
fH=2.5;//in KHz
AF=-5;//unitless
fc=sqrt(fH*1000*fL*1000);//in Hz
BW=fH*1000-fL*1000;//in Hz
Q=fc/BW;//unitless
disp(fc,"Center frequency in Hz is : ");
disp(BW,"BW in Hz is :");
disp(Q,"Selectivity is :");
disp("HenceQ is within limit 1<Q<10 for a single op-amp band pass filter.");
//assume C=0.01 uF
C=0.01;//in uF
R2=2/(2*%pi*C*10^-6*BW);//in Kohm
R1=-R2/(2*AF);//in KOhm
R3=R1/((4*%pi*%pi*R1*R2*fc*1000*fc*1000*C*C*10^-12)-1);//in Kohm
disp(R1/1000,"Value of R1 in Kohm is :")
disp(R2/1000,"Value of R2 in Kohm is :")
disp(R3*1000,"Value of R3 in ohm is :")
disp(C,"Value of C in uF is :")
```

Scilab code Exa 6.15 Design a filter to meet the specifications

```
// Exa 6.15
clc;
clear;
close;
// given data
AF=-10;//unitless
Q=20;//unitless
fc=50;//in Hz
disp("To get a roll-off rate of 60 dB/decade, three single op-amp band pass filters have to be
```

```
   cascaded. ");
fc1=fc;//in Hz
fc2=fc;//in Hz
fc3=fc;//in Hz
Q1=0.51*Q;//unitless
Q2=0.51*Q;//unitless
Q3=0.51*Q;//unitless
AF1=-(-AF)^(1/3);//unitless
disp("A single op-amp band passed filter can be
   design with specifications :");
disp(fc,"Center frequency in Hz is : ");
disp(AF1,"AF1 is :");
disp(Q1,"Q1 is : ");
```

Scilab code Exa 6.16 Determine type of filter to produce given phase shift

```
// Exa 6.16
clc;
clear;
close;
// given data
f=2;//in KHz
fi_degree=-135;//in degree
fi_radian=fi_degree*(%pi/180);
disp("A phase shift of -135 degree is achieved by an
    all pass phase lag filter.");
//assume C=0.1 uF and R1=RF=10 Kohm
C=0.1;//in uF
R1=10;//in Kohm
RF=10;//in Kohm
R=tan(-fi_radian/2)/(2*%pi*f*1000*C*10^-6);
disp("Component values are :");
disp(R1,"Value of R1 in Kohm is :")
disp(RF,"Value of RF in Kohm is :")
disp(R/1000,"Value of R in Kohm is :")
```

```
disp(C,"Value of C in uF is :")
```

Scilab code Exa 6.17.a Find type of response

```
// Exa 6.17a
clc;
clear;
close;
// given data
R=10;//in Kohm
R1=R;//in Kohm
R2=R;//in Kohm
R3=R;//in Kohm
Rf=5.6;//in Kohm
R4=Rf;//in Kohm
R5=Rf;//in Kohm
RA=2.7;//in Kohm
RB=1.5;//in Kohm
C=0.01;//in uF
C1=C;//in uF
C2=C;//in uF
alfa=3*RB/(RA+RB);
disp("The type of response will be determined by the
    value of damping coefficient.");
disp(alfa,"Value of alfa is :");
disp("This value correspondes to the chebyshev
    response.");
```

Scilab code Exa 6.17.b Determine low and high cut off frequency

```
// Exa 6.17b
clc;
clear;
```

```
close;
// given data
R=10;//in Kohm
R1=R;//in Kohm
R2=R;//in Kohm
R3=R;//in Kohm
Rf=5.6;//in Kohm
R4=Rf;//in Kohm
R5=Rf;//in Kohm
RA=2.7;//in Kohm
RB=1.5;//in Kohm
C=0.01;//in uF
C1=C;//in uF
C2=C;//in uF
fc=1/(2*%pi*Rf*1000*C*10^-6);//in Hz
Klp=1.238;//unitless
fH=fc*Klp;//in Hz
Khp=1/Klp;//unitless
fL=fc*Khp//in Hz
disp(fc/1000,"Critical frequency in KHz is : ");
disp(fH/1000,"High cut-off frequency in KHz is : ");
disp(fL/1000,"Low cut-off frequency in KHz is : ");
    //
```

Scilab code Exa 6.17.c Determine band pass center frequency

```
// Exa 6.17c
clc;
clear;
close;
// given data
R=10;//in Kohm
R1=R;//in Kohm
R2=R;//in Kohm
R3=R;//in Kohm
```

```
Rf=5.6;//in Kohm
R4=Rf;//in Kohm
R5=Rf;//in Kohm
RA=2.7;//in Kohm
RB=1.5;//in Kohm
C=0.01;//in uF
C1=C;//in uF
C2=C;//in uF
fc=1/(2*%pi*Rf*1000*C*10^-6);//in Hz
disp(fc/1000,"Band pass center frequency in KHz is :
    ");
```

Scilab code Exa 6.17.d Determine band pass bandwidth

```
// Exa 6.17d
clc;
clear;
close;
// given data
R=10;//in Kohm
R1=R;//in Kohm
R2=R;//in Kohm
R3=R;//in Kohm
Rf=5.6;//in Kohm
R4=Rf;//in Kohm
R5=Rf;//in Kohm
RA=2.7;//in Kohm
RB=1.5;//in Kohm
C=0.01;//in uF
C1=C;//in uF
C2=C;//in uF
alfa=3*RB/(RA+RB);//unitless
Q=1/alfa;//unitless
fc=1/(2*%pi*Rf*1000*C*10^-6);//in Hz
BW=fc/Q;//in Hz
```

```
disp(BW/1000,"Band pass bandwidth in KHz is :")
```

Scilab code Exa 6.17.e Determine band pass gain at center frequency

```
// Exa 6.17e
clc;
clear;
close;
// given data
R=10;//in Kohm
R1=R;//in Kohm
R2=R;//in Kohm
R3=R;//in Kohm
Rf=5.6;//in Kohm
R4=Rf;//in Kohm
R5=Rf;//in Kohm
RA=2.7;//in Kohm
RB=1.5;//in Kohm
C=0.01;//in uF
C1=C;//in uF
C2=C;//in uF
alfa=3*RB/(RA+RB);//in unitless
Q=1/alfa;//in unitless
disp(Q,"The band pass gain at center frequency is :");
```

Chapter 7

Non Linear Circuits

Scilab code Exa 7.3 Design a schmitt trigger

```
// Exa 7.3
clc;
clear;
close;
// given data
VH=4;//in Volt
VSat=13;//in Volt
// Assume R2=10 Kohm
R2=10;//in Kohm
disp("The hysteresis voltage for an schmitt trigger
   is given as : ");
disp("VH=R1*2*VSat/(R1+R2)");
R1=R2/((2*VSat/VH)-1);//in Kohm
disp("Component values are :");
disp(R1,"Value of R1 in Kohm is :");
disp(R2,"Value of R2 in Kohm is :");
```

Scilab code Exa 7.4 Determine threshold voltages and hysteresis voltage

```
// Exa 7.4
clc;
clear;
close;
// given data
VSat=13;//in Volt
R1=270;//in ohm
R2=39;//in Kohm
Vut=R1*VSat/(R1+R2*1000);//in Volt
Vlt=R1*(-VSat)/(R1+R2*1000);//in Volt
VH=Vut-Vlt;//in Volt
disp(Vut*1000,"The upper threshold voltage in mVolt
    is :");
disp(Vlt*1000,"The lower threshold voltage in mVolt
    is :");
disp(VH*1000,"Hysteresis voltage in mVolt is :");
```

Scilab code Exa 7.5 Design a schmitt trigger circuit

```
// Exa 7.5
clc;
clear;
close;
// given data
VSat=13;//in Volt
Vut=2;//in Volt
Vlt=-1;//in Volt
// Assume R1=10 Kohm
R1=10;//in Kohm
R2=((VSat/Vut)-1)*R1;//in Kohm
R3=((-VSat/Vlt)-1)*R1;//in Kohm
disp(R1,"Value of R1 in Kohm is :");
disp(R2,"Value of R2 in Kohm is :");
disp(R3,"Value of R1 in Kohm is :");
```

Chapter 8

Analog Multiplier and Operational Transconductance Amplifier

Scilab code Exa 8.1 `Find Transfer Function`

```
// Exa 8.1
clc;
clear;
close;
// given data
disp("We have : ");
disp("Io1=gm1*V1");
disp("Io2=-gm2*Vo");
disp("I=Io1+Io2=gm1*V1-gm2*Vo");
disp("We also have : I=(Vo-V1)*s*C");
disp("From above two eqn :");
disp("gm1*V1-gm2*Vo=(Vo-V1)*s*C");
disp("Arranging terms to get Vo/V1 we have : ");
disp("Transfer Function : V0/V1=(gm1+s*C)/(gm2+s*C)"
  );
```

Scilab code Exa 8.2 Find Transfer Function

```
// Exa 8.2
clc;
clear;
close;
// given data
disp("We have : ");
disp("Io1=gm1*(V1-Vo)");
disp("Io2=gm2*(V1-Vo)");
disp("But Vc=Io1/s*C1");
disp("So Io2=gm2(Io1/s*C1-Vo)")
disp("We also have : Io2=(Vo-V1)*s*C2");
disp("Substituting for Io1 gives :");
disp("gm2*((gm1*(V1-Vo)-s*C1*Vo)/s*C1=(Vo-V1)/s*C2)"
    );
disp("gm1*gm2*V1-gm1*gm2*Vo-gm2*s*C1*Vo=s^2*C1*C2*Vo
    -s^2*C1*C2*V1");
disp("Arranging terms to get Vo/V1 we have : ");
disp("Transfer Function : V0/V1=(s^2*C1*C2+gm1*gm2)
    /(s^2*C1*C2+sgm1*C1+gm1*gm2)");
```

Scilab code Exa 8.3 Find Transfer Function

```
// Exa 8.3
clc;
clear;
close;
// given data
disp("We have : ");
disp("Io1=gm1*(V1-V2)");
disp("Io2=gm2*Vo");
```

```
disp("We also have :")
disp("Io1=-Io2");
disp("Hence gm1*(V1-V2)=-gm2*Vo");
disp("or Vo/(V1-V2)=-gm1/gm2");
```

Scilab code Exa 8.4 `Find Transfer Function`

```
// Exa 8.4
clc;
clear;
close;
// given data
disp("We have : ");
disp("Io1=gm1*(V1-Vdash)");
disp("We also have Io1=s*CVo");
disp("Io2=gm2*Vo and Io3=-gm3*Vdash");
disp("Now we have : s*CVo=gm1*(V1-Vdash)");
disp("or V1-Vdash=s*CV0/gm1 or Vdash=V1-s*CV0/gm1");
disp("So we have :  Io3=-gm3*(V1-s*CV0/gm1)");
disp("Also Io2=-Io3 or Io3=-gm2*Vo");
disp("So we have -gm2*Vo=-gm3*((gm1*V1-s*C*Vo)/gm1)"
  );
disp("or gm1*gm2*Vo+gm3*s*C*Vo=gm1*gm3*V1");
disp("Arranging terms to get Vo/V1 we have : ");
disp("Transfer Function : V0/V1=(gm1*gm3)/(gm1*gm2+s
  *C*gm3)");
```

Chapter 9

Voltage Regulators

Scilab code Exa 9.1 `Obtain 18 v from 15 volt regulator`

```
//Exa 9.1
clc;
clear;
close;
//given data
Iq=5;//in mA
Vo=18;//in volts
Vreg=15;//in volts
disp("we have to find the values of R1 & R2 which
   can be used with IC7815 to produce this voltage")
   ;
R1=Vreg/(10*Iq*10^-3);//in Ohms; Iq must be in
   Amperes here
R2=(Vo-Vreg)/(11*Iq*10^-3);//in Ohms; Iq must be in
   Amperes here
disp(R2,R1,"the values of R1 and R2 are : ");
```

Scilab code Exa 9.2 `Design a current source using 7808 regulator`

```
//Exa 9.2
clc;
clear;
close;
//given data
Vreg=8;//in volts as IC 7808 is given
IL=100;//in mA
IR=100;//in mA
Iq=0;//in mA
RL=50;//in ohms
// let find the value of resistor to deliver
   required current
R=Vreg/(IR*10^-3);// in ohms; so current must be in
   amperes
disp(R,"Required Resistance in ohms : ");
disp("output is given by: Vo = IR*R+IL*RL");
Vo = (IR*10^-3)*R+(IL*10^-3)*RL;
disp(Vo);
//considering 2 volt dropout
Vdropout=2;//in volts
VI=Vo+Vdropout;
disp(VI,"Input voltage must be(in volts): ");
```

Scilab code Exa 9.3 Calculate output current

```
//Exa 9.3
clc;
clear;
close;
//given data
RL1=100;//in ohms
RL2=8;//in ohms
RL3=1;//in ohms
VEBon=0.7;//in volts
Beta=25;
```

```
R=5;//in ohms
//device used 7808 so V=8 volts
V=8;
// part(i) for a laod of 100 ohms
IL1=V/RL1;//in amperes
VacR1=IL1*R;
disp(VacR1,"VacR(in volts) : ")
disp("  Which is less than the given VEBon.Hence
    Transistor remains OFF.")
//so Io=IL and Ic=0
Io1=IL1;//in amperes;
Ic1=0;
disp(Ic1,Io1,"Ic and Io for the 100 ohms load(in
    amperes): ")
// part(ii) for a laod of 8 ohms
IL2=V/RL2;//in amperes
VacR2=IL2*R;
disp(VacR2,"The voltage across R will be(in volts) :
    ")
disp("  Which is greater than the given VEBon.Hence
    Transistor will be ON.")
//expression for Io
Io2=((IL2+(Beta*VEBon)/R))/(Beta+1);//in amperes;
Ic2=IL2-Io2;
disp(Ic2,Io2,"Ic and Io for the 8 ohms load(in
    amperes): ")

// part(iii) for a laod of 1 ohms
IL3=V/RL3;//in amperes
VacR3=IL3*R;
disp(VacR3,"VacR(in volts) : ")
disp("  Which is greater than the given VEBon.Hence
    Transistor will be ON.")
//expression for Io
Io3=((IL3+(Beta*VEBon)/R))/(Beta+1);//in amperes;
Ic3=IL3-Io3;
disp(Ic3,Io3,"Ic and Io for the 1 ohms load(in
    amperes): ")
```

Scilab code Exa 9.4 `Design adjustable voltage regulator using LM317`

```
//Exa 9.4
clc;
clear;
close;
//given data
//for the given IC LM317:
Iadj=100;//in micro amperes
Vref=1.25;//in volts
R1=240;//in ohms
//(i) For Vo=2 volts
//on solving equation Vo=Vref(1+R2/R1)+R2*Iadj
Vo=2;//in volts
R2=(Vo-Vref)/((Vref/R1)+Iadj*10^-6);
disp(R2,"for Output 2 volts the requires value of
    resistance R2(in ohms) : ")
//(i) For Vo=12 volts
Vo1=12;//in volts
//on solving equation Vo=Vref(1+R2/R1)+R2*Iadj
R21=(Vo1-Vref)/(Vref/R1+Iadj*10^-6);
disp(R21,"for Output 12 volts the requires value of
    resistance R2(in ohms) : ")
//use potentiometer for adjustable value
disp("Hence use 3kohm potentiometer to set R2.")
```

Scilab code Exa 9.5 `Calculate minimum and maximum output voltage`

```
//Exa 9.5
clc;
clear;
```

```
close;
//given data
//for the given IC LM317:
Iadj=100;//in micro amperes
Vref=1.25;//in volts
R1=240;//in ohms
//we have output equation Vo=Vref(1+R2/R1)+R2*Iadj
R2min=0;//in ohms
R2max=3000;//in ohms
Vomin=Vref*(1+R2min/R1)+R2min*Iadj*10^-6;//in volts
Vomax=Vref*(1+R2max/R1)+R2max*Iadj*10^-6;//in volts
disp(Vomin,"Minimum output voltage(in volts) is : ")
disp(Vomax,"Maximum output voltage(in volts) is : ")
```

Scilab code Exa 9.6 Design a voltage regulator using IC723

```
//Exa 9.6
clc;
clear;
close;
//given data
//IC 723
Vsense=0.7//in volts
Vo=5;//in volts
Im=50;//in mA
Id=1;//in mA
Vr=7;//in volts
R1=(Vr-Vo)/(Id*10^-3);
R2=Vo/(Id*10^-3);
R3=(R1*R2)/(R1+R2);
Rcl=Vsense/(Im*10^-3);
disp("various resistance values for the circuit is
    as follows : ")
disp(R1,"R1 :")
disp(R2,"R2 :")
```

```
disp(R3,"R3 :")
disp(Rcl,"Rcl :")
```

Scilab code Exa 9.7 Design a voltage regulator using IC723

```
//Exa 9.7
clc;
clear;
close;
//given data
// IC 723
Id=1;//in mA
Vsense=0.7;//in volts
Vo=15;//in volts
Im=50;//in mA
Vr=7;//in volts
R1=(Vo-Vr)/(Id*10^-3);
R2=Vr/(Id*10^-3);
R3=(R1*R2)/(R1+R2);
Rcl=Vsense/(Im*10^-3);
disp("various resistance values for the circuit is
   as follows : ")
disp(R1,"R1 :")
disp(R2,"R2 :")
disp(R3,"R3 :")
disp(Rcl,"Rcl :")
```

Scilab code Exa 9.8 Design a regulated power supply

```
//Exa 9.8
clc;
clear;
close;
```

```
//given data
Im=100;//in mA
Vr=7;//in volts
R2=10;//in kohm
Vsense=0.7;//in volts
//using equation Vo=((R1+R2)/R2)*Vr
//for Vo=10 volts assuming R2=10kohm
disp("Eqn is given by Vo=((R1+R2)/R2)*Vr")
Vo=10;//in volts
R1=((Vo*R2)/Vr)-R2//it gives 3R2=7R1;
disp(R1,"Value of resistance R1(in kohms):  ")
//now let output voltage is 15 volts
Vo=15;//in volts
R1=((Vo*R2)/Vr)-R2//it gives 3R2=7R1;
disp(R1,"Value of resistance R1(in kohms):  ")
R3=(R1*R2)/(R1+R2);
disp(R3,"value of resistance R3 in kohms : ")
Rcl=Vsense/(Im*10^-3);//in ohms
disp(Rcl,"Value of Rcl is ohms is : ");
```