

Scilab Textbook Companion for
Analog Integrated Circuits
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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Differential Amplifiers

Scilab code Exa 1.1 Find various parameters of Differential Amplifier

```
1 //Exa 1.1
2 clc;
3 clear;
4 close;
5 //given data
6 Icq=100; //in uA
7 BETAac=100; //unitless
8 BETAadc=100; //unitless
9 Ad=100; //unitless
10 CMRRdB=60; //in dB
11 //part (a)
12 IE=2*Icq; //in UA
13 VT=25; //in mV
14 re=2*VT/IE; //in ohm
15 RC=Ad*re; //in Kohm
16 CMRR=10^(CMRRdB/20); //using formula CMRRdB=20log10(
    CMRR)
17 //calculate RE using formula CMRR=1+2*RE/re
18 RE=((CMRR-1)*re)/2; //in Kohm
19 disp("Value of RC is "+string(RC)+" Kohm"+" and
    value of RE is "+string(RE)+" Kohm");
```

```

20 //part (b)
21 Ri1=2*BETAac*re;//in kohm
22 Ri2=2*BETAac*re;//in kohm
23 disp("Value of Ri1 is "+string(Ri1)+" Kohm"+" and
      value of Ri2 is "+string(Ri2)+" Kohm");
24 //part (c)
25 Ric=BETAac*(re+2*RE);//in kohm
26 disp("Value of Ric is "+string(Ric)+" Kohm.");

```

Scilab code Exa 1.2 Calculate output voltage and CMRR in dB

```

1 //Exa 1.2
2 clc;
3 clear;
4 close;
5 //given data
6 V1=50;//in uV
7 V2=-50;//in uV
8 Ad=2000;//unitless
9 Ac=0.5;//unitless
10 Vid=V1-V2;//in uV
11 Vc=(V1+V2)/2;//in uV
12 //output voltage
13 Vo=Ad*Vid+Ac*Vc;//in uV
14 Vo=Vo*10^(-6);//in Volts
15 CMRRdB=20*log10(Ad/Ac);
16 disp(Vo,"Output voltage in volts is : ");
17 disp(CMRRdB,"CMRR in dB is : ");

```

Scilab code Exa 1.3 Find output voltage of Differential Amplifier

```

1 //Exa 1.3
2 clc;

```

```

3  clear;
4  close;
5  //given data
6  V1=5; //in mV
7  V2=6; //in mV
8  Ad=70; //in dB
9  CMRR=90; //in dB
10 Vid=V2-V1; //in mV
11 Vc=(V1+V2)/2; //in mV
12 Ad=10^(Ad/20); //unitless
13 Ad=floor(Ad);
14 CMRR=10^(CMRR/20); //unitless
15 //output voltage
16 Vo=Ad*(Vid+Vc/CMRR); //in mV
17 Vo=round(Vo);
18 Vo=Vo*10^(-3); //in Volts
19 Vid=Vid*10^(-3); //in Volts
20 ErrorVotage=Vo-Ad*Vid;
21 PercentageError=(ErrorVotage*100)/Vo;
22 disp(Vo,"Output voltage in volts is : ");
23 disp(ErrorVotage,"ErrorVotage is : ");
24 disp(PercentageError,"PercentageError is : ")

```

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

```

1  //Exa 1.4
2  clc;
3  clear;
4  close;
5  //given data
6  V1=5; //in uV
7  V2=4; //in uV
8  Ad=80; //in dB
9  CMRR=100; //in dB
10 Ad=10^(Ad/20); //unitless

```

```

11 CMRR=10^(CMRR/20); // unitless
12 // differential mode output voltage
13 Vid=V1-V2; // in uV
14 Vod=Ad*Vid; // in uV
15 Vod=Vod*10^(-3); // in mV
16 // common mode output voltage
17 Vc=(V1+V2)/2; // in uV
18 Ac=Ad/CMRR; // unitless
19 Voc=Ac*Vc; // in uV
20 disp(Vod," Differential mode output voltage in mV is
      : ")
21 disp(Voc," common mode output voltage in uV is : ")

```

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

```

1 //Exa 1.5
2 clc;
3 clear;
4 close;
5 //given data
6 Rc=2; // in kohm
7 VE=-5; // in volts
8 VT=25; // in mVolts
9 RE=4.3*1000; // in ohm
10 IE=(-0.7-VE)/RE; // in mA
11 re=(2*VT*10^(-3))/IE; // in ohm
12 Rc=Rc*1000; // in ohms
13 Ad=(Rc)/(2*re)
14 Ac=-(Rc)/(2*RE+re)
15 CMRR=Ad/Ac;
16 //CMRR is always positive
17 disp(Ad," Differential mode gain is : ")
18 disp(Ac," Common mode gain is : ")
19 disp(-CMRR," CMRR is : ")

```

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

```
1 //Exa 1.6
2 clc;
3 clear;
4 close;
5 //given data
6 Ad=50; //unitless
7 I=5; //in mA
8 VEE=15; //in Volts
9 VD=0.7; //in Volts
10 VT=25; //in mV
11 //desired value of emitter current is 5 mA
12 IE3=5; //in mA
13 RE=VD/(IE3*10(-3)); //in ohm
14 VB3=VEE-2*VD; //in volts
15 I2=IE3; //in mA
16 R2=VB3/I2; //in kohm
17 IE1=IE3/2; //in mA
18 IE2=IE1; //in mA
19 re=(2*VT)/IE3; //in ohm
20 RC=Ad*re; //in ohm
21 disp("Design values are :")
22 disp(RC," Value of Rc in ohm is : ");
23 disp(RE," Value of RE in ohm is : ");
24 disp(R2," Value of R2 in kohm is : ");
```

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

```
1 //Exa 1.7
2 clc;
3 clear;
```

```

4  close;
5  //given data
6  Ri=600; //in kohm
7  Vopp=5; //in volts
8  VEE=15; //in volts
9  VT=25; //in mVolts
10 VD=0.7; //in Volts
11 BETAac=100; //unitless
12 BETAac=100; //unitless
13 VBE=0.7; //in volts
14 BETAact=BETAac*BETAac; //unitless
15 //formula : Ri=2*BETAact*(2*re1)
16 re1=Ri/(4*BETAact); //in ohm
17 //formula : re1=VT/IE1
18 IE1=(VT*10^(-3))/re1; //in mA
19 IE3=2*IE1; //in mA
20 RE=VD/(IE3*10^(-3)); //in ohm
21 R2=(VEE-2*VD)/IE3; //in kohm
22 disp("Now the voltage drop across Rc determines
       the peak to peak output voltage swing.")
23 disp("We have given Vopp=5volts, since the output is
       balance i.e. differential the voltage drop
       across each collector resistor will become 2.5Vpp
       or 1.25 Volts.")
24 disp("In other words RcIc=1.25 Volts. We have Ic=IE1
       =1.67mA")
25 IC=IE1; //in mA
26 RC=1.25/(IC*10^(-3)); //in ohm
27 disp("Thus the Design components values are :")
28 disp(RC," Value of Rc in ohm is : ");
29 disp(RE," Value of RE in ohm is : ");
30 disp(R2," Value of R2 in kohm is : ");
31 //Answer in the book is not as much accurate as
       calculated by Scilab

```

Scilab code Exa 1.8 Calculate various parameters of differential amplifier

```
1 //Exa 1.8
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=100; // unitless
7 BETAac=100; // unitless
8 VBE3=0.715; //in volts
9 VD1=0.715; //in Volts
10 VZ=6.2; //in Volts
11 VT=25; //in mVolts
12 IZt=41; //in mA
13 VCC=10; //in Volts
14 VEE=-10; //in Volts
15 RC1=2.7; //in kohm
16 RC=4.7; //in kohm
17 //Part (a)
18 VB3=VEE+VZ+VD1; //in volts
19 VE3=VB3-VBE3
20 IE3=(VE3-VEE)/RC1; //in mA
21 disp("As the differential amplifier is symmetrical,
      ICQ1=IE1=ICQ2=IE2");
22 IE2=IE3/2; //in mA
23 ICQ1=IE2; //in mA
24 ICQ2=IE2; //in mA
25 IE1=IE2; //in mA
26 VCEQ=VCC+VBE3-RC*ICQ1 // formula for VCEQ
27 disp("Hence operating point for Q1 and Q2 are : ")
28 disp(VCEQ,"VCEQ in volts is :")
29 disp(ICQ1,"ICQ in mA is :")
30 disp("and the operating point for Q3 will be : ")
31 VCE3=-VBE3-VE3; //in Volts
32 disp(VCE3,"VCE3 in volts is :")
33 IC3=IE3; //in mA
34 disp(IE3,"IE3 in mA is :")
35 //Part (b)
```

```

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

```

Scilab code Exa 1.9 Design a two transistor current source

```

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

```

Scilab code Exa 1.10 Determine Load current

```

1 //Exa 1.10
2 clc;
3 clear;
4 close;
5 //given data
6 VBE=0.7;//in Volts

```



```

7 BETA=120; // unitless
8 disp(" as BETA>>1");
9 VCC=10; //in Volts
10 //KCL at Node a
11 disp(" Writing KCL at Node (a) gives :");
12 disp(" IR=IC1+I");
13 disp(" IR=IC1+IB1+I1");
14 disp(" IR=IC1+IC1/BETA+I1");
15 disp(" IR=IC1(1+1/BETA)+I1");
16 disp(" as BETA>>1");
17 disp(" IR=IC1+I1");
18 //KCL at Node b
19 disp(" Writing KCL at Node (b) gives :");
20 disp(" I1=IC2+I2");
21 disp(" I1=IC2+IB2+IB3");
22 disp(" I1=IC2+IC2/BETA+IB3");
23 disp(" IR=IC2(1+1/BETA)+IB3");
24 disp(" as BETA>>1");
25 disp(" I1=IC2+IB3");
26 //solving both equations
27 disp(" IR=IC1+IC2+IB3");
28 disp(" IR=2IC+IB3")
29 //As transistors are matched
30 VBE1=VBE; //in Volts
31 VBE2=VBE; //in Volts
32 VBE3=VBE; //in Volts
33 disp(" As transistors are matched. IC1=IC2=IC")
34 disp(" IR=2IC+IC3/BETA=2IC+IC/BETA");
35 disp(" Due to current Mirror formed. IC1=IC2=IC3=IC")
36 disp(" IR=IC(2+1/BETA)");
37 disp(" as BETA>>1");
38 disp(" IR=2*IC");
39 IR=(VCC-VBE)/(3.6); //in mA
40 IC=IR/2; //in mA
41 Iload=IC; //in mA
42 disp(Iload,"Load current in the circuit in mA is :")

```

Scilab code Exa 1.11 Design a two transistor pnp current source

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

Scilab code Exa 1.12 Determine various parameters of differential amplifier

```
1 //Exa 1.12
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=110;//unitless
7 BETAac=110;//unitless
8 VBE=0.7;//in volts
9 VEE=15;//in volts
10 VT=25;//in mvolts
11 R=2.7;//in kohm
12 Rc=3.3;//in kohm
13 IR=(VEE-VBE)/R;//in mA
14 IC3=IR;//in mA
```

```

15 IC1=IC3/2; //in mA
16 IC2=IC3/2; //in mA
17 re1=VT/IC1; //in ohm
18 re2=re1; //in ohm
19 // part (i)
20 Ad=(Rc*1000)/re1; // unitless
21 // part (ii)
22 Ri1=2*BETAac*re1*10(-3); //in kohm
23 Ri2=2*BETAac*re2*10(-3); //in kohm
24 disp(Ad," Differential mode voltage gain is : ")
25 disp(" Input resistances are :")
26 disp(Ri1," Ri1 in kohm is : ")
27 disp(Ri2," Ri2 in kohm is : ")

```

Scilab code Exa 1.13 Design Differential Amplifier

```

1 //Exa 1.13
2 clc;
3 clear;
4 close;
5 //given data
6 Ad=200; //unitless
7 Ri=3 //in kohm
8 BETAac=110; //unitless
9 BETAdc=110; //unitless
10 VBE=0.7; //in volts
11 VEE=15; //in volts
12 VT=25; //in mvolts
13 re=Ri/(2*BETAac); //in ohm
14 RC=Ad*re; //in kohm
15 IC1=VT/re; //in mA
16 IR=2*IC1; //in mA
17 IC3=IR; //in mA
18 R=(VEE-VBE)/(IR*10(-3)); //in kohm
19 disp(RC," Value of resistance Rc in kohm is :");

```

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

Scilab code Exa 1.14 Design Differential Amplifier

```
1 //Exa 1.14
2 clc;
3 clear;
4 close;
5 //given data
6 Ad=400; //unitless
7 Ri=3 //in kohm
8 BETAac=110; //unitless
9 BETAdc=110; //unitless
10 VBE=0.7; //in volts
11 VEE=15; //in volts
12 VT=25; //in mvolts
13 //circuit bias current IR
14 IR=3; //in mA
15 R=(VEE-VBE)/(IR); //in kohm
16 re=(2*VT)/IR; //in ohm
17 RC=Ad*re*10^-3; //in kohm
18 Ri=2*BETAac*re*10^-3; //in kohm
19 disp(R," Value of resistance R in kohm is :");
20 disp(RC," Value of resistance Rc in kohm is :");
21 disp(Ri," Value of resistance Ri in kohm is :");
```

Scilab code Exa 1.15 Find differential input resistance

```
1 //Exa 1.15
2 clc;
3 clear;
4 close;
5 //given data
```

```

6 BETAac=100; // unitless
7 BETAdc=100; // unitless
8 VBEon=0.7; //in volts
9 VCC=5; //in volts
10 VEE=-5; //in volts
11 VT=25; //in mVolts
12 R=18.6; //in kohm
13 IR=(VCC-VBEon -VEE)/R; //in mA
14 IC1=IR/2; //in mA
15 IC2=IC1; //in mA
16 re1=(2*VT)/IR; //in ohm
17 re2=re1; //in ohm
18 Ri1=2*BETAac*re1*10^-3; //in kohm
19 Ri2=Ri1; //in kohm
20 disp("Differential input resistances are :")
21 disp(Ri1,"Ri1 in kohm is :")
22 disp(Ri2,"Ri2 in kohm is :")

```

Scilab code Exa 1.16 Find out the value of resistor Rc

```

1 //Exa 1.16
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=100; // unitless
7 BETAdc=100; // unitless
8 VBEon=0.7; //in volts
9 VCC=5; //in volts
10 VEE=-5; //in volts
11 VT=25; //in mVolts
12 R=18.6; //in kohm
13 Ad=200; // unitless
14 IR=(VCC-VBEon -VEE)/R; //in mA
15 IC1=IR/2; //in mA

```

```

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

```

Scilab code Exa 1.17 Calculate various parameters of differential amplifier

```

1 //Exa 1.17
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=100; //unitless
7 BETAac=100; //unitless
8 VBE=0.7; //in volts
9 VCC=10; //in volts
10 VEE=-10; //in volts
11 VT=25; //in mVolts
12 R=3.6; //in kohm
13 RC=2.2; //in kohm
14 // part (i) //
15 IR=(VCC-VBE-VEE)/R; //in mA
16 ICQ=IR/2; //in mA
17 VE=-2*VBE; //in Volts
18 VC=VCC-ICQ*RC; //in Volts
19 VCEQ=VC-VE; //in Volts
20 disp(VCEQ,"Operating point VCEQ in volt is : ")
21 // part (ii) //
22 re=VT/ICQ; //in ohm
23 re1=re; //in ohm
24 re2=re; //in ohm
25 reT=re1+re2; //in ohm
26 Ad=(RC*1000)/reT; // unitless
27 disp(Ad,"Differential voltage gain is : ")

```

```

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

```

Scilab code Exa 1.18 Design a three transistor current source

```

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

```

Scilab code Exa 1.19 Design a Widlar current source

```

1 //Exa 1.19
2 clc;
3 clear;
4 close;
5 //given data
6 Io=10;//in uA
7 IR=1;//in mA
8 VBE2=0.7;//in volts
9 VT=25;//in mVolts
10 VCC=20;//in volts
11 R=(VCC-VBE2)/IR;//in kohm

```

```

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

```

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

```

1 //Exa 1.20
2 clc;
3 clear;
4 close;
5 //given data
6 IR=2;//in mA
7 I2=10;//in uA
8 I3=20;//in uA
9 VBE1=0.7;//in volts
10 VT=25;//in mVolts
11 VCC=10;//in volts
12 VEE=-10;//in volts
13 R=(VCC-VBE1-VEE)/IR;//in kohm
14 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.");
15 RE2=(VT/(I2*10^-3))*log(IR/(I2*10^-3));//in kohm
16 RE3=(VT/(I3*10^-3))*log(IR/(I3*10^-3));//in kohm
17 VBE2=VBE1-RE2*I2*10^-6;//in volts
18 VBE3=VBE1-RE3*I3*10^-6;//in volts
19 RE2=RE2/1000;//in kohm
20 RE3=RE3/1000;//in kohm
21 disp(R,"Value of R in kohm is : ")
22 disp(RE2,"Value of RE2 in kohm is : ")

```



```

23 disp(RE3," Value of RE3 in kohm is : ")
24 disp(VBE2," Value of VBE2 in Volt is : ")
25 disp(VBE3," Value of VBE3 in Volt is : ")

```

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

```

1 //Exa 1.21
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=100;//unitless
7 BETAdc=100;//unitless
8 VBE=0.715;//in volts
9 VEE=10;//in volts
10 VT=25;//in mvolts
11 R=5.6;//in kohm
12 N=3;// as three transistors here
13 IR=(VEE-VBE)/(R);//in mA
14 IC1=IR/(1+(1+N)/BETAac);//in mA
15 IC2=IR/(1+(1+N)/BETAac);//in mA
16 IC3=IR/(1+(1+N)/BETAac);//in mA
17 IRC=3*IC1;//in mA
18 disp(IRC," Current through resistor Rc in mA is : ")
19 disp(" Collector Current for each transistor : ")
20 disp(IC1," IC1 in mA is : ");
21 disp(IC2," IC2 in mA is : ");
22 disp(IC3," IC3 in mA is : ");

```

Scilab code Exa 1.22 Design current steering circuit

```

1 //Exa 1.22
2 clc;

```

```

3  clear;
4  close;
5  //given data
6  I4=600;//in uA
7  I2=10;//in uA
8  I3=20;//in uA
9  VCC=10;//in volts
10 VEE=-10;//in volts
11 VBE=0.7;//in volts
12 VEB=0.7;//in volts
13 disp("On examine tthe given circuit , we observe that
      : ")
14 disp("IR=I1=I3");
15 disp(" I2=2*IR");
16 disp(" I4=3*IR");
17 IR=I4/3;//in uA
18 I2=2*IR;//in uA
19 I1=IR;//in uA
20 I3=IR;//in uA
21 R=(VCC-VEB-VBE-VEE)/(IR*10(-3));//in kohm
22 disp(IR,"IR in uA is : ");
23 disp(I1," I1 in uA is : ");
24 disp(I2," I2 in uA is : ");
25 disp(I3," I3 in uA is : ");
26 disp(R,"R in kohm is : ");

```

Scilab code Exa 1.23 Determine various parameters of differential amplifier

```

1 //Exa 1.23
2 clc;
3 clear;
4 close;
5 //given data
6 Vo=5;//in volts
7 BETAac=150;//unitless

```

```

8 BETAdc=150; // unitless
9 VT=25; //in mvolts
10 VCC=10; //in volts
11 VD=0.7; //in volts
12 R1=2.7; //in kohm
13 R2=1.5; //in kohm
14 // part (i) //
15 disp("we have IC1/IC2=exp((VBE1-VBE2)/VT)");
16 disp("Writing KVL for the loop containing both
    emitter base junction yields");
17 disp("VBE1=VBE2=VBE");
18 disp("Hence IC1/IC2=1");
19 disp("IC1=IC2=IC");
20 IR=(VCC-VD)/R1; //in mA
21 disp("Writing KCL at the junction of bases of
    transistors Q1 and Q2 gives : ");
22 disp("IC+2*IB+VBE/R2=IR")
23 disp("IB=IC/BETAac");
24 IC=(IR-VD/R2)/(1+2/BETAac); //in mA
25 IC1=IC; //in mA
26 IC2=IC; //in mA
27 RC=(VCC-Vo)/IC; //in kohm
28 disp(IC1,"IC1 in mA is : ");
29 disp(IC2,"IC2 in mA is : ");
30 disp(RC,"RC in kohm is : ");

```

Scilab code Exa 1.24 Determine various parameters of differential amplifier

```

1 //Exa 1.24
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=100; // unitless
7 BETAdc=100; // unitless

```

```

8 VT=25; //in mvolts
9 VEE=15; //in volts
10 VCC=15; //in volts
11 VBE=0.7; //in volts
12 VEB=-0.7; //in volts
13 R2=2.2; //in kohm
14 RC1=2.5; //in kohm
15 RC6=1.2; //in kohm
16 RE8=1.2; //in kohm
17 disp("The given circuit is consist of three stages
      as :");
18 disp("(i) Dual input balanced output differential
      amplifier comprising of Q1 and Q2.");
19 disp("(ii) Dual input unbalanced output differential
      amplifier comprising of Q5 and Q6.");
20 disp("(iii) Level shifter circuit comprising of Q8
      and RE8.")
21 disp("Transistor Q3, Q4, Q7 & Q9 serves to form
      current multiple source , to give I3=I7=I9=I2");
22 I2=(VEE-VBE)/R2; //in mA
23 IC3=I2; //in mA
24 IC7=I2; //in mA
25 IC9=I2; //in mA
26 IC1=I2/2; //in mA
27 IC2=IC1; //in mA
28 IC5=IC1; //in mA
29 IC6=IC1; //in mA
30 IC8=I2; //in mA
31 IC9=I2; //in mA
32 // calculation of collector to emitter voltages
33 VC1=VCC-IC1*RC1; //in Volts
34 VC2=VC1; //in Volts
35 VCE1=VC1-VEB; //in Volts
36 VCE2=VCE1; //in Volts
37 VE5=VC1-VBE; //in Volts
38 VE6=VE5; //in Volts
39 VC6=VCC-RC6*IC6
40 VCE5=VCC-VE5;

```

```

41 VCE6=VCC-VE6;
42 VE8=VC6-VBE;
43 VCE8=VCC-VE8;
44 // calculation of ac emitter resistances
45 re1=VT/IC1;//in ohm
46 re2=re1;//in ohm
47 re5=re1;//in ohm
48 re6=re1;//in ohm
49 re8=VT/IC8;//in ohm
50 //input resistance of second stage is
51 Ri2=2*BETAac*re6*10(-3);//in kohm
52 // voltage gain of first stage
53 Ad1=(((RC1*Ri2)/(RC1+Ri2)))/(re1*10(-3));
54 //input resistance of third stage is
55 Ri3=BETAac*(re8+RE8);//in kohm
56 // voltage gain of second stage
57 Ad2=(((RC6*Ri3)/(RC6+Ri3)))/(2*re6*10(-3));
58 Ad3=1;
59 //Overall gain of the circuit
60 Ad=Ad1*Ad2*Ad3;
61 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.")
62 //voltage drop across collector resistor
63 VRC6=IC1*RC6;//in volts
64 //Maximum peak to peak output voltage swing
65 Vopp=3.9;// in volt
66 //// part (i)
67 disp("The operating point for each transistor :");
68 disp("For transistor 1");
69 disp(IC1,"IC1 in mA is :");disp(VCE1,"VCE1 in Volt
        is :");
70 disp("For transistor 2");
71 disp(IC2,"IC2 in mA is :");disp(VCE2,"VCE2 in Volt
        is :");
72 disp("For transistor 5");

```

```

73 disp(IC5,"IC5 in mA is :");disp(VCE5,"VCE5 in Volt
    is :");
74 disp("For transistor 6");
75 disp(IC6,"IC6 in mA is :");disp(VCE6,"VCE6 in Volt
    is :");
76 disp("For transistor 8");
77 disp(IC8,"IC8 in mA is :");disp(VCE8,"VCE8 in Volt
    is :");
78 //// part (ii)
79 disp(Ad,"Overall voltage gain of the circuit is : ")
    ;
80 //// part (iii)
81 disp(Vopp,"Maximum peak to peak output voltage swing
    is ");
82 //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

```

1 //Exa 1.25
2 clc;
3 clear;
4 close;
5 //given data
6 BETAmin=80;//unitless
7 BETAmax=120;//unitless
8 IE=400;//in uA
9 VT=25;//in mvolts
10 VEE=15;//in volts
11 VCC=15;//in volts
12 VBE=0.7;//in volts
13 VEB=-0.7;//in vol
14 IE1=IE/2;//in uA
15 IE2=IE1;//in uA
16 IBmax=IE1/(1+BETAmin);//in uA

```

```

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

```

Scilab code Exa 1.26 Determine various parameters of differential amplifier

```

1 //Exa 1.26
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=100; //unitless
7 BETAadc=100; //unitless
8 VT=25; //in mvolts
9 VEE=10; //in volts
10 VCC=10; //in volts
11 VBE=0.7; //in volts
12 VEB=-0.7; //in volts
13 RC2=2.7; //in kohm
14 RC1=2.7; //in kohm
15 RC3=1.5; //in kohm
16 RC4=1.5; //in kohm
17 RE1=5; //in kohm
18 RE2=10; //in kohm
19 RE3=10; //in kohm
20 IE1=(VEE-VBE)/(2*RE1); //in mA
21 IC1=IE1;
22 //as Q1 and Q2 are identical
23 IC2=IC1;
24 VC1=VCC-RC1*IC1;

```

```

25 VE1=-0.7;//in Volts
26 VE2=0.7;//in Volts
27 VCE1=VC1-VE1;
28 VCE2=VCE1;
29 disp("Writing KVL for the base emitter loop of
      tarnsistor Q3 will determine IC3 as :");
30 disp("VCC-RC2*IC2-VBE3-RE3*2*IE3+VEE=0")
31 IE3=(VCC-RC2*IC2-VBE+VEE)/(2*RE3);//in mA
32 IE4=IE3;//in mA
33 VC3=VCC-RC3*IE3;//in Volts
34 VC4=VC3;//in Volts
35 VE3=VC1-VBE;//in Volts
36 VCE3=VC3-VE3;//in Volts
37 VCE4=VCE3;//in Volts
38 disp("Thus operating point for Q1 & Q2 becomes : ")
39 disp(IC1,"ICQ in mA is : ");disp(VCE1,"VCEQ in volts
      is : ")
40 disp("And operating point for Q3 & Q4 becomes : ")
41 disp(IE3,"ICQ in mA is : ");disp(VCE3,"VCEQ in volts
      is : ")
42
43 re1=VT/IC1;//in ohm
44 re2=re1;//in ohm
45 re3=VT/IE3;//in ohm
46 re4=re3;//in ohm
47 Ri2=2*BETAac*re3;//in ohm
48 Ri2=Ri2*10^-3;//in kohm
49 Ad1=((RC1*Ri2)/(RC1+Ri2))/(re1*10^-3);
50 Ad2=RC4/(2*re4*10^-3);
51 Ad=Ad1*Ad2;
52 disp(Ad,"Overall voltage gain is : ");
53 Ri1=2*BETAac*re1;//in ohm
54 Ri1=Ri1/1000;//in kohm
55 disp(Ri1,"Input resistance of the cascaded
      differential amplifier in kohm is : ");
56 Ro2=RC4;//in kohm
57 disp(Ro2,"Output resistance of the cascaded
      differential amplifier in kohm is : ");

```

Scilab code Exa 1.27 Design a level shifter circuit

```
1 //Exa 1.27
2 clc;
3 clear;
4 close;
5 //given data
6 BETAac=100; //unitless
7 BETAac=100; //unitless
8 VT=25; //in mvolts
9 VEE=10; //in volts
10 VCC=10; //in volts
11 VBE=0.7; //in volts
12 VD=0.7; //in volts
13 IE6=2; //in mA
14 IE1=3.25; //in mA
15 Ri2=1.538; //in kohm
16 RC1=2.5; //in kohm
17 re8=3.85; //in kohm
18 RE8=1.2; //in kohm
19 RC6=1.2; //in kohm
20 RE=VD/(IE6*10^-3); //in ohm
21 R=(VEE-2*VD)/IE6; //in kohm
22 VB5=8.74; //in Volts
23 VE5=VB5-VBE;
24 R1=VE5/IE6; //in kohm
25 re1=VT/IE1; //in ohm
26 re2=re1; re5=re1; re6=re1; //in ohm
27 re8=VT/6.5; //in ohm
28 Ri2=2*BETAac*re6*10^-3; //in kohm
29 Ad1=(1000*(RC1*Ri2)/((RC1+Ri2)))/re1;
30 Ri3=BETAac*(re8*10^-3+RE8); //in kohm
31 Ad2=(1000*(RC6*Ri3)/(RC6+Ri3))/(2*re6);
32 Ad=Ad1*Ad2;
```

```

33 VRC6=RC6*IE1;//in Volts
34 Vopp=VRC6;//in Volts
35 disp(RE,"value of RE in ohm is : ");
36 disp(R,"value of R in kohm is : ");
37 disp(VE5,"value of VE5 in Volt is : ");
38 disp(R1,"value of R1 in kohm is : ");
39 disp(re1,"AC emitter resistances re1=re2=re5=re6 in
    ohms are :");
40 disp(re8,"Abd re8 in ohm is : ");
41 disp(Ri2,"Input resistance of 2nd stage Ri2 in kohm
    is");
42 disp(Ad1,"Voltage gain of 1st stage is");
43 disp(Ad2,"Voltage gain of 2nd stage is");
44 Ad3=1;
45 disp(Ad3,"Voltage gain of 3rd stage is");
46 disp(Ad,"Overall Voltage gain of the circuit is");
47 disp(VRC6,"Voltage drop across collector resistor in
    volt is");
48 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

```
1 //Exa 2.2
2 clc;
3 clear;
4 close;
5 //given data
6 Iio=20;//in nA
7 IB=100;//in nA
8 //Iio=IB1-IB2
9 disp("Eqn(1) : Iio=IB1-IB2=20");
10 //IB=(IB1+IB2)/2
11 disp("Eqn(2) : 2*IB=IB1+IB2=200");
12 disp("Adding two equations gives :");
13 IB1=(200+20)/2;//in nA
14 disp(IB1,"IB1 in nA is : ");
15 IB2=IB1-Iio;//in nA
16 disp(IB2,"IB2 in nA is : ");
```

Scilab code Exa 2.3 Calculate output voltage

```

1 //Exa 2.3
2 clc;
3 clear;
4 close;
5 //given data
6 G=120; // unitless
7 To=20; //in degree centigrade
8 T=50; //in degree centigrade
9 Dvoff=0.13; //in mV/degree centigrade
10 //input change
11 dVin=Dvoff*(T-To); //in mVolt
12 //output change
13 Vo=G*dVin; //in mVolt
14 disp(Vo, "Output voltage in mVolt is :")

```

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

```

1 //Exa 2.4
2 clc;
3 clear;
4 close;
5 //given data
6 dt=5; //in uSec
7 Vp=5; //in Volt
8 dV=(0.9-0.1)*Vp
9 SR=dV/dt; //in V/uSec
10 disp(SR, "Calculated SR in V/uSec is : ");
11 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

```

1 //Exa 2.5

```

```

2  clc;
3  clear;
4  close;
5  //given data
6  Vo=10; //in Volt
7  SR=1; //in V/uSec
8  dV=(0.9-0.1)*Vo
9  dt=dV/SR; //in uSec
10 disp(dt,"Rise time in uSec is : ")

```

Scilab code Exa 2.6 Find out the time for output change

```

1  //Exa 2.6
2  clc;
3  clear;
4  close;
5  //given data
6  V1=-5; //in Volt
7  V2=5; //in Volt
8  SR=0.5; //in V/uSec
9  dV=V2-V1; // in Volt
10 dt=dV/SR; //in uSec
11 disp(dt,"Rise time in uSec is : ");

```

Scilab code Exa 2.7 Calculate maximum voltage

```

1  //Exa 2.7
2  clc;
3  clear;
4  close;
5  //given data
6  fm=50; //in kHz
7  SR=0.5; //in V/uSec

```

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

Scilab code Exa 2.8 Find the limiting frequency

```
1 //Exa 2.8
2 clc;
3 clear;
4 close;
5 //given data
6 SR=6; //in V/uSec
7 //formula : SR=2*%pi*fm*Vm
8 // part (i) Vm=1 volt
9 Vm=1; //in Volts
10 fm=((SR*10^6)/(2*%pi*Vm))/1000; //in kHz
11 disp(fm,"when Vm=1 volt the limiting frequency in
    KHz is :")
12 // part (ii) Vm=10 volt
13 Vm=10; //in Volts
14 fm=((SR*10^6)/(2*%pi*Vm))/1000; //in kHz
15 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

```
1 //Exa 3.1
2 clc;
3 clear;
4 close;
5 // given data
6 R1=1.5;//in kohm
7 RF=15;//in kohm
8 A=2*10^5;//unitless
9 Ri=1;//in Mohm
10 Ro=75;//in ohm
11 fo=5;//in Hz
12 AF=1+RF/R1;//unitless
13 B=1/AF;//unitless
14 RiF=(1+A*B)*Ri*10^6;//in ohm
15 RoF=Ro/(1+A*B);//in ohm
16 fF=fo*(1+A*B);//in ohm
17 disp(AF,"Close loop voltage gain AF is : ");
18 disp(RiF,"Value of RiF in ohm is : ")
19 disp(RoF,"Value of RoF in ohm is : ")
20 disp(fF/1000,"Value of fF in KHz is : ")
```

Scilab code Exa 3.2 Design closed loop non inverting amplifier

```
1 //Exa 3.2
2 clc;
3 clear;
4 close;
5 // given data
6 AF=100; // unitless
7 A=2*10^5; // unitless
8 Ri=1; //in Mohm
9 Ro=75; //in ohm
10 //let R1 =1 ohm
11 R1=1; //in ohm
12 //formula : AF=1+RF/R1
13 RF=(AF-1)*R1; //in kohm
14 B=1/AF; //unitless
15 RiF=(1+A*B)*Ri*10^6; //in ohm
16 RoF=Ro/(1+A*B); //in ohm
17 disp(RF," Value of RiF in kohm is : ");
18 disp(RiF," Value of RiF in ohm is : ")
19 disp(RoF," Value of RoF in ohm is : ")
```

Scilab code Exa 3.3 Design closed loop non inverting amplifier

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



```

9 fo=5; //in Hz
10 Ri=1; //in Mohm
11 Ro=75; //in ohm
12 //let 1+AB=A; as A>>>1
13 RiF=A*Ri*10^6; //in ohm
14 RoF=Ro/A; //in ohm
15 fF=fo*A; //in ohm
16 disp(RiF," Value of RiF in ohm is : ")
17 disp(RoF," Value of RoF in ohm is : ")
18 disp(fF/10^6," Value of fF in MHz is : ")

```

Scilab code Exa 3.4 Design inverting amplifier

```

1 //Exa 3.4
2 clc;
3 clear;
4 close;
5 // given data
6 R1=50; //in Kohm
7 AF=-6; //unitless
8 // here AF=-RF/R1
9 RF=-AF*R1; //in kohm
10 disp(RF," Value of RF in Kohm is : ")

```

Scilab code Exa 3.5 Determine various parameters of opamp

```

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

```

```

8 Ro=75; //in ohm
9 fo=5; //in Hz
10 R1=50; //in kohm
11 RF=300; //in kohm
12 K=RF/(R1+RF); // unitless
13 B=R1/(R1+RF); // unitless
14 AF=-(A*K/(1+A*B)); // unitless
15 RiF=R1; //in kohm ; ideal
16 RoF=Ro/(1+A*B); //in ohm
17 fF=-(A*K*fo/AF); //in Hz
18 disp(AF,"Close loop voltage gain AF is : ");
19 disp(RiF,"Value of RiF in ohm is : ")
20 disp(RoF,"Value of RoF in ohm is : ")
21 disp(fF/1000,"Value of fF in KHz is : ")

```

Scilab code Exa 3.6 Design an inverting summing amplifier

```

1 //Exa 3.6
2 clc;
3 clear;
4 close;
5 // given data
6 disp("We have  $V_o = (-R_F/R) * (V_1 + V_2 + V_3)$ ");
7 disp("To produce 3 times the sum of three inputs, i.
      e.  $V_o = 3 * (V_1 + V_2 + V_3)$ ");
8 disp("hence  $R_F/R = 3$  or  $R_F = 3 * R$ ");
9 // let R1=R2=R3=R=10kohm
10 R=10; //in kohm
11 R1=R; //in kohm
12 R2=R; //in kohm
13 R3=R; //in kohm
14 RF=3*R; //in Kohm
15 disp(RF,"Value of RF in Kohm is : ")

```

Scilab code Exa 3.7 Design inverting opamp circuit

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

Scilab code Exa 3.8 Design inverting opamp circuit

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

Scilab code Exa 3.9 Design preamplifier for a microphone

```
1 //Exa 3.9
2 clc;
3 clear;
4 close;
5 // given data
6 Vo=1.5; //in Volts
7 Vin=10; //in mVolts
8 RiF=500; //in kohm
9 R1=500; //in kohm
10 AF=Vo/(Vin*10^-3); // unitless
11 RF=AF*R1; //in Kohm
12 disp(RF/1000,"The value of RF in Mohm is :");
13 disp("This value becomes too large for most of the
    practical circuit. Thus we make use of op-amp
    with T-Network.");
14 disp("We have  $AF = -R2/R1 * (1 + R3/R2 + R3/R4)$ ");
15 disp("Choose arbitraly  $R2/R1 = R3/R1 = 5$ , then solving
    this equation.")
16 //Microphone resistance is Rm=1.2 Kohm
17 R1eff=100; //in Kohm
18 Rm=1.2; //in Kohm
19 R1=R1eff-Rm
20 R3=5*R1;
21 R2=R3; //in Kohm
22 R4=R3/28; //in Kohm
23 disp(R1,"Value of R1 in Kohm is : ")
24 disp(R2,"Value of R2 in Kohm is : ")
25 disp(R3,"Value of R3 in Kohm is : ")
26 disp(R4,"Value of R4 in Kohm is : ")
```

Chapter 4

Basic application of an opamp

Scilab code Exa 4.2 Determine V_o for adder subtractor

```
1 //Exa 4.2
2 clc;
3 clear;
4 close;
5 // given data
6 disp("As the input impedance 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  $V_a=V_b=V$ ");
7 disp("writing KCL at node (b) we have  $(6-V)/30+(8-V)/40+(0-V)/30=0$ ");
8 V=48/11; //in volts
9 disp(V,"Voltage V in Volt is ; ");
10 disp("writing KCL at node (a) we have  $(3-V)/10+(4-V)/20=(V-V_o)/40$ ");
11 V_o=- (20-7*V); //in Volts
12 disp(V_o,"Output Voltage of the circuit  $V_o$  in Volt is
      ; ");
```

Scilab code Exa 4.3 Find values for constant A and B

```
1 //Exa 4.3
2 clc;
3 clear;
4 close;
5 // given data
6 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 ");
7 // case (i) when V1 acting alone V2=0;
8 disp("case (i) when V1 acting alone V2=0 and the
      output is given as");
9 disp("Vo1=(1+100/10)*Va");
10 disp("Va=99*V1/(11+99)");
11 disp("Vo1=(110/10)*(99/110)*V1=9.9V1");
12 disp("Thus the gain A=Vo1/V1=9.9");
13 // case (ii) when V2 acting alone V1=0;
14 disp("case (ii) when V2 acting alone V1=0 and the
      output is given as");
15 disp("Vo2=(-100/10)*V2");
16 disp("Thus the gain B=Vo2/V2=-10");
```

Scilab code Exa 4.4 Determine values of unknown resistors

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

```

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

```

Scilab code Exa 4.5 Determine output of the circuit

```

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

```

Scilab code Exa 4.7 Determine output of the circuit

```

1 //Exa 4.7
2 clc;

```

```

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

```

Scilab code Exa 4.8 Determine input impedance

```

1 //Exa 4.9
2 clc;
3 clear;
4 close;
5 // given data
6 R1=10; //in Kohm
7 R4=8; //in Kohm
8 R5=3; //in Kohm
9 RF=45; //in Kohm

```



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

Scilab code Exa 4.9 Determine the gain for an instrumentation amplifier

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

Scilab code Exa 4.10 Determine output voltage for an instrumentation amplifier

```
1 //Exa 4.10
2 clc;
3 clear;
4 close;
5 // given data
6 VA=3;//in mVolt
7 VB=5;//in mVolt
8 R1=10;//in Kohm
9 R2=10;//in Kohm
10 R3=45;//in Kohm
11 R4=8;//in Kohm
12 R5=3;//in Kohm
```

```

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

```

Scilab code Exa 4.12 Determine an instrumentation amplifier

```

1 //Exa 4.12
2 clc;
3 clear;
4 close;
5 // given data
6 RF=10; //in Kohm
7 R1=10; //in Kohm
8 R2=R1; //in Kohm
9 R3=R1; //in Kohm
10 R5max=50; //in Kohm
11 ADmin=5; // unitless
12 ADmax=200; // unitless
13 //Formula : ADmin=1+2*R4/R5max
14 R4=(ADmin-1)*(R5max/2); //in Kohm
15 //Formula : ADmax=1+2*R4/R5min
16 R5min=(2*R4)/(ADmax-1); //in Kohm
17 disp(" Thus design values of resistors in Kohm are : "
      );

```

```

18 disp(R1,"R1");
19 disp(R2,"R2");
20 disp(R3,"R3");
21 disp(R4,"R4");
22 disp(RF,"RF");
23 disp(R5min,"R5min");
24 disp(R5max,"R5max");

```

Scilab code Exa 4.13 Calculate output voltage

```

1 //Exa 4.13
2 clc;
3 clear;
4 close;
5 // given data
6 Vdc=10;//in Volt
7 R1=10;//in Kohm
8 R2=10;//in Kohm
9 R3=100;//in Kohm
10 RF=100;//in Kohm
11 // Part(i) Balance Bridge : RA=RB=RC=RT=150ohm and
    VAB=0
12 RA=150;//in ohm
13 RB=150;//in ohm
14 RC=150;//in ohm
15 RT=150;//in ohm
16 VAB=0;//in Volt
17 Vo=(-RF/R1)*VAB;
18 // Part(ii) Unbalance Bridge : RT=200ohm
19 RT=200;//in ohm
20 VA=(RA/(RA+RT))*Vdc;
21 VB=(RB/(RB+RC))*Vdc;
22 VAB=VA-VB;//in Volt
23 Vo=(-RF/R1)*VAB;
24 disp(0,"Balance bridge have output voltage Vo in

```

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

Scilab code Exa 4.15 Design a practical integrator circuit

```
1 //Exa 4.15
2 clc;
3 clear;
4 close;
5 // given data
6 Gain=10;// Unitless
7 fb=10;//in KHz
8 //Assuming fa=fb/10
9 fa=fb/10;//in KHz
10 // Formula :  $fa = 1/(2 * pi * RF * CF)$ 
11 RFCF=1/(2*%pi*fa);
12 //Assuming R1=1Kohm
13 R1=1;//in Kohm
14 RF=10*R1;//in Kohm
15 CF=RFCF/RF;//in uF
16 Rcomp=(R1*RF)/(R1+RF);// in Kohm
17 disp(RF,"Value of RF in Kohm is : ");
18 disp(CF,"Value of CF in uF is : ");
19 disp(Rcomp*1000,"Value of Rcomp in ohm is : ");
```

Scilab code Exa 4.16 Design a circuit

```
1 //Exa 4.16
2 clc;
3 clear;
4 close;
```

```

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

```

Scilab code Exa 4.22 Design a practical differentiator

```

1 //Exa 4.22
2 clc;
3 clear;
4 close;
5 // given data
6 fa=1.5; //in KHz
7 fmax=1.5; //in KHz
8 C1=0.1; //in uF
9 RF=1/(2*%pi*fa*C1); //in Kohm
10 fb=10*fa; //in Khz
11 R1=1/(2*%pi*fb*C1); //in Kohm
12 CF=(R1*C1)/RF; //in uF
13 Rcomp=RF; //in Kohm
14 disp(RF,"Value of resistance RF in Kohm is : ")
15 disp(R1*1000,"Value of resistance R1 in ohm is : ")
16 disp(CF,"Value of Capacitance CF in uF is : ")
17 disp(Rcomp,"Value of resistance Rcomp in Kohm is : ")
   )

```

Scilab code Exa 4.25 Design a practical differentiator circuit

```
1 //Exa 4.25
2 clc;
3 clear;
4 close;
5 // given data
6 C1=0.1;//in uF
7 f=100;//in Hz
8 T=1/f;//in sec
9 // Given also  $R1C1=0.2*T$ ;
10 R1=(0.2*T)/(C1*10^-6);//in ohm
11 RF=0.05/(C1*10^-6);//in ohm
12 CF=(R1*C1)/RF;//in uF
13 disp(R1/1000,"Value of resistance R1 in ohm is : ")
14 disp(RF/1000,"Value of resistance RF in Kohm is : ")
15 disp(CF,"Value of Capacitance CF in uF is : ")
```

Chapter 5

Waveform Generators

Scilab code Exa 5.1 Design a square wave generator

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

Scilab code Exa 5.2 Design a square wave generator

```

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

```

Scilab code Exa 5.3 Determine output signal frequency

```

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

```

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

```

1 // Exa 5.4
2 clc;
3 clear;

```



```

4  close;
5  // given data
6  Ton=100;//in mSEC
7  Toff=200;//in mSEC
8  BETA=0.2;//unitless
9  //Let R1=1 Kohm
10 R1=1;//in Kohm
11 R2=R1*(1-BETA)/BETA;//in Kohm
12 // Assuming C=10 uF
13 C=10;//in uF
14 R3=Ton*10^-3/(C*10^-6*0.41);//in Kohm
15 R4=Toff*10^-3/(C*10^-6*0.41);// in Kohm
16 disp(R1,"Value of R1 in Kohm is ; ")
17 disp(R2,"Value of R2 in Kohm is ; ")
18 disp(R3/1000,"Value of R3 in Kohm is ; ")
19 disp(R4/1000,"Value of R4 in Kohm is ; ")
20 disp(C,"Value of C in uF is ; ")

```

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

```

1  // Exa 5.5
2  clc;
3  clear;
4  close;
5  // given data
6  Vo=7.5;//in Volt
7  fo=1;// in KHz
8  DutyCycle=60;//in %
9  disp("Zener diode has to be used at the output to
      limit the output at +7.5 volt or -7.5 volt.");
10 disp("Thus choose Vz=Vz1=Vz2=6.8 volt as VD=0.7 volt
      ")
11 Vz=6.8;// in volt
12 Vz1=6.8;// in volt
13 Vz2=6.8;// in volt

```

```

14 VD=0.7; // in volt
15 T=1/fo; //in mSec
16 // duty cycle 60% gives Ton & Toff
17 Ton=0.6*T; //in mSec
18 Toff=T-Ton; //in mSec
19 // choosing R2=1.16*R1
20 R1=1; //in Kohm
21 C=0.1; //in uF
22 R2=1.16*R1; //in Kohm
23 R3=Ton*10^-3/(C*10^-6); //in ohm
24 R4=Toff*10^-3/(C*10^-6); //in ohm
25 disp(R1," Value of R1 in Kohm is ; ")
26 disp(R2," Value of R2 in Kohm is ; ")
27 disp(R3/1000," Value of R3 in Kohm is ; ")
28 disp(R4/1000," Value of R4 in Kohm is ; ")
29 disp(C," Value of C in uF is ; ");

```

Scilab code Exa 5.6 Determine frequency of oscillation and duty cycle

```

1 // Exa 5.6
2 clc;
3 clear;
4 close;
5 // given data
6 RA=6.8; //in Kohm
7 RB=3.3; //in Kohm
8 C=0.1; //in uF
9 fo=1.45/((RA+2*RB)*C); // in KHz
10 d=(RA+RB)/(RA+2*RB);
11 disp(fo,"Frequency of oscillation in Khz is ; ");
12 disp(d*100,"Duty cycle in % is :");

```

Scilab code Exa 5.7 Design an astable multivibrator

```

1 // Exa 5.7
2 clc;
3 clear;
4 close;
5 // given data
6 fo=50; //in KHz
7 d=75/100; // unitless
8 C=1; //in nF
9 disp("RA+2RB=1/(0.693*fo*10^3*C*10^-9); // in Kohm");
10 disp("RA+2RB=28.9 Kohm");
11 disp("d=0.75=(RA+RB)/(RA+2*RB)");
12 disp("It gives RA=2*RB");
13 RA=28.9/2; // in Kohm
14 RB=RA/2; //in Kohm
15 disp(RA,"Value of RA in Kohm is :");
16 disp(RB,"Value of RB in Kohm is :");

```

Scilab code Exa 5.8 Design 555 timer as an astable multivibrator

```

1 // Exa 5.8
2 clc;
3 clear;
4 close;
5 // given data
6 fo=800; // in Hz
7 d=60/100; // unitless
8 T=1/fo; //in Sec
9 TC=0.6*T; //in Sec
10 TD=T-TC; //in Sec
11 C=0.01; //in uF
12 C2=10; //in uF
13 RB=TD/(0.69*C*10^-6); //in ohm
14 RA=(TC-0.69*RB*C*10^-6)/(0.69*C*10^-6); //in ohm
15 disp(RA/1000,"Value of RA in Kohm is ; ")
16 disp(RB/1000,"Value of RB in Kohm is ; ")

```

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

Scilab code Exa 5.9 Design 555 timer as an astable multivibrator

```
1 // Exa 5.9
2 clc;
3 clear;
4 close;
5 // given data
6 fo=700;// in Hz
7 d=50/100;// unitless
8 T=1/fo;//in Sec
9 TC=0.5*T;//in Sec
10 TD=T-TC;//in Sec
11 C=0.1;//in uF
12 RB=TD/(0.69*C*10^-6);//in ohm
13 RA=TC/(0.69*C*10^-6);//in ohm
14 disp(RA/1000,"Value of RA in Kohm is ; ")
15 disp(RB/1000,"Value of RB in Kohm is ; ")
16 disp(TC*1000,"We have TC=TD in mSEC is :")
```

Scilab code Exa 5.10 Design an astable multivibrator

```
1 // Exa 5.10
2 clc;
3 clear;
4 close;
5 // given data
6 fo=1;// in KHz
7 d=40/100;// unitless
8 T=1/fo;//in Sec
9 TC=0.4*T;//in mSec
```

```

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

```

Scilab code Exa 5.11 Design IC555 as a monostable multivibrator

```

1 // Exa 5.11
2 clc;
3 clear;
4 close;
5 // given data
6 T=100;// in uSec
7 C=15;//in
8 R=T*10^-6/(1.1*C*10^-9);//in ohm
9 disp(R/1000,"To obtain a output pulse at 100uSec
rsistor required in Kohm is :")
10 //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

```

1 // Exa 5.12
2 clc;
3 clear;
4 close;
5 // given data
6 VCC=15;//in Volt
7 T=10;//in mSec

```

```

8 ILED=20; //in mA
9 Vf=1.4; //in Volt
10 VBE=0.7; //in Volt
11 VCEsat=0.2; //in Volt
12 C=0.22; //in uF
13 R=T*10^-3/(1.1*C*10^-6); //in ohm
14 //output of the device
15 Vo=VCC-2*VBE-VCEsat;
16 R5=(Vo-Vf)/(ILED*10^-3); //in ohm
17 disp(R/1000,"Value of R in Kohm is ; ")
18 disp(Vo,"Output of the device in volt is : ")
19 disp(R5,"Value of RB in Kohm is ; ")
20 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

```

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

```

Scilab code Exa 5.14 Design a triangular wave generator

```
1 // Exa 5.14
2 clc;
3 clear;
4 close;
5 // given data
6 fo=2;// in KHz
7 Vopp=5;//in volts
8 Vsat=13;//in Volts
9 // Let the value of R2 used be 10 Kohm
10 R2=10;//in Kohm
11 R3=(2*R2*Vsat)/Vopp;//in Kohm
12 // Let C1=0.1 uF
13 C1=0.1;// in uF
14 R1=R3/(4*fo*103*C1*10-6*R2);// in ohm
15 disp(R1/1000,"Value of R1 in Kohm is ; ");
16 disp(C1,"Value of C1 in uF is ; ");
17 disp(R2,"Value of R2 in Kohm is ; ");
18 disp(R3,"Value of R3 in Kohm is ; ");
```

Scilab code Exa 5.15 Find amplitude and frequency

```
1 // Exa 5.15
2 clc;
3 clear;
4 close;
5 // given data
6 Vcc=12;//in Volt
7 R1=10;//in Kohm
8 R2=100;//in Kohm
9 R3=820;//in Kohm
```

```

10 // Let Vsat=10 volt
11 Vsat=10;//in volt
12 // part (a)
13 Vopp=2*R2*Vsat/R3;//in Volt
14 disp(Vopp,"Amplitude of triangular wave in volt is :
      ")
15 Vopp=Vsat-(-Vsat);// in Volt
16 disp(Vopp,"Amplitude of square wave in volt is : ")
17 // part (b)
18 C1=0.1;// in uF
19 fo=R3*1000/(4*R1*1000*R2*1000*C1*10^-6);// in Hz
20 disp(fo/1000,"Frequenci in KHz is :");

```

Scilab code Exa 5.16 Design a phase shift oscillator

```

1 // Exa 5.16
2 clc;
3 clear;
4 close;
5 // given data
6 fo=1;// in KHz
7 // choose C=.01 uF
8 C=.01;// in uF
9 R=1/(2*%pi*sqrt(6)*fo*1000*C*10^-6);// in ohm
10 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");
11 R1=35.6;// in Kohm
12 RF=29*R1;//in ohm
13 disp("Hence desired components values are :");
14 disp(C,"Value of C in uF is ; ");
15 disp(R/1000,"Value of R in Kohm is ; ");
16 disp(R1,"Value of R1 in Kohm is ; ");
17 disp(RF/1000,"Value of RF in Mohm is ; ");
18 // Note : Answer in the book is wrong

```

Scilab code Exa 5.17 Design a Wein bridge oscillator

```
1 // Exa 5.17
2 clc;
3 clear;
4 close;
5 // given data
6 fo=1; // in KHz
7 // choose C=.01 uF
8 C=.01; // in uF
9 R=1/(2*%pi*fo*1000*C*10^-6); // in ohm
10 // choosing R1=10 Kohm
11 R1=10; // in Kohm
12 RF=2*R1; //in Kohm
13 disp("Hence desired components values are :");
14 disp(C,"Value of C in uF is ; ");
15 disp(R/1000,"Value of R in Kohm is ; ");
16 disp(R1,"Value of R1 in Kohm is ; ");
17 disp(RF,"Value of RF in Kohm is ; ");
```

Scilab code Exa 5.19 Determine frequency of oscillation

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

Scilab code Exa 5.20 Determine various parameters of opamp

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

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

```
1 // Exa 5.21
2 clc;
3 clear;
4 close;
5 // given data
6 RT=50; //in Kohm
```

```

7 CT=0.001; //in uF
8 V=20; //in Volt
9 C=10; //in uF
10 fo=0.25/(RT*10^3*CT*10^-6); //in Hz
11 df1=7.8*fo/V; //in Hz
12 dfc=sqrt(df1/(2*pi*3.6*10^3*C*10^-6)); //in Hz
13 disp(fo/1000,"Free running frequency in KHz is :");
14 disp(df1/1000,"Lock range in KHz is :");
15 disp(dfc,"Capture range in Hz is :");

```

Scilab code Exa 5.22 Determine frequency of reference oscillator

```

1 // Exa 5.22
2 clc;
3 clear;
4 close;
5 // given data
6 fomax=100; // in KHz
7 Resolution=2; //in Hz
8 flowest=Resolution; //in Hz
9 fclk=fomax*2.2; //in KHz
10 // formula: 2^n=fclk/flowest
11 n=(log10(fclk*1000/flowest))/log10(2);
12 disp(fclk,"Frequency of reference oscillator in KHz
    is :");
13 disp(ceil(n),"No. of bits needed is :");

```

Chapter 6

Active Filters

Scilab code Exa 6.2 Determine cut off frequency

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

Scilab code Exa 6.3 Design a first order low pass filter

```
1 // Exa 6.3
2 clc;
```

```

3 clear;
4 close;
5 // given data
6 fc=2; //in KHz
7 AF=2; //unitless
8 // let C=0.01 uF
9 C=0.01; //in uF
10 R=(1/(2*%pi*fc*1000*C*10^-6))/1000; //in Kohm
11 R=ceil(R);
12 // Bias compensation Rbc
13 //Rbc=R1*RF/(R1+RF) ohm
14 disp("Bias compensation :R=R1*RF/(R1+RF)=Rdash/2 ohm
      ");
15 //Rdash=R1=RF=2*R; //in ohm
16 Rdash=2*R; //in ohm
17 R1=2*R; //in ohm
18 RF=2*R; //in ohm
19 R1=RF; //in kohm
20 disp("Component values are :");
21 disp(R1,"R1=RF in Kohm is ;");
22 disp(R,"R in Kohm is ;");

```

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

```

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

```

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

Scilab code Exa 6.5 Design a first order high pass filter

```
1 // Exa 6.5
2 clc;
3 clear;
4 close;
5 // given data
6 fc=1; //in KHz
7 AF=2; //unitless
8 // let C=0.01 uF
9 C=0.01; //in uF
10 R=(1/(2*%pi*fc*1000*C*10^-6))/1000; //in Kohm
11 disp("AF=1+RF/R1=2 gives RF=R1=Rdash")
12 //For Bias compensation
13 //Rbc=R1*RF/(R1+RF) ohm
14 disp("Bias compensation :R=R1*RF/(R1+RF)=Rdash/2 ohm
      ");
15 //Rdash=R1=RF=2*R; //in ohm
16 Rdash=2*R; //in ohm
17 R1=2*R; //in ohm
18 RF=2*R; //in ohm
19 R1=RF; //in kohm
20 disp("Component values are :");
21 disp(R1,"R1=RF in Kohm is ;");
22 disp(R,"R in Kohm is ;");
```

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

```
1 // Exa 6.6
2 clc;
3 clear;
```

```

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

```

Scilab code Exa 6.7 Determine the type and frequency of filter

```

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

```

```

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

```

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

```

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

```

Scilab code Exa 6.9 Calculate critical frequency

```

1 // Exa 6.9
2 clc;
3 clear;

```



```

4  close;
5  // given data
6  R2=20; //in Kohm
7  R3=20; //in Kohm
8  R=R2; //in Kohm
9  C2=0.47; //in uF
10 C3=0.47; //in uF
11 C=C2; //in uF
12 RF=56; //in Kohm
13 R1=56; //in Kohm
14 AF=1+RF/R1; // unitless
15 alfa=3-AF; // unitless
16 Klp=1.238; // unitless
17 disp(alfa,"Value of alfa is :");
18 disp("alfa=1 corresponds to chebyshev filter
      response.");
19 f3dB=Klp/(2*pi*R*1000*C*10^-6); //in Hz
20 disp(f3dB,"Critical frequency in Hz is :")

```

Scilab code Exa 6.10 Design a second order low pass filter

```

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

```

```

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

```

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

```

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

```

Scilab code Exa 6.12 Design a second order high pass filter

```

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

```

Scilab code Exa 6.13 Design a band pass filter

```

1 // Exa 6.13
2 clc;
3 clear;
4 close;
5 // given data
6 fL=200; //in Hz
7 fH=1; //in KHz
8 AFBP=4; //unitless
9 //for LP section design
10 //assume C=0.01 uF

```

```

11 C=0.01; //in uF
12 R=1/(2*pi*fH*1000*C*10^-6); //in ohm
13 disp("For low pass section design component values
      are :");
14 disp(R/1000,"Value of R in Kohm is :");
15 disp(C,"Value of C in uF is :");
16 //for HP section design
17 //assume C=0.05 uF
18 C=0.05; //in uF
19 R=1/(2*pi*fL*1000*C*10^-6); //in ohm
20 disp("For high pass section design component values
      are :");
21 disp(R,"Value of R in Kohm is :");
22 disp(C,"Value of C in uF is :");
23 disp("We have AFBP=AFHP*AFLP=4");
24 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. ");
25 disp("R=10 Kohm");
26 fc=sqrt(fH*fL*1000); //in Hz
27 BW=fH*1000-fL; //in Hz
28 Q=fc/BW; //unitless
29 disp(fc,"Center frequency in Hz is : ");
30 disp(BW,"BW in Hz is :");
31 disp(Q,"Selectivity is :");
32 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

```

1 // Exa 6.14
2 clc;
3 clear;
4 close;

```

```

5 // given data
6 fL=2; //in KHz
7 fH=2.5; //in KHz
8 AF=-5; //unitless
9 fc=sqrt(fH*1000*fL*1000); //in Hz
10 BW=fH*1000-fL*1000; //in Hz
11 Q=fc/BW; //unitless
12 disp(fc,"Center frequency in Hz is : ");
13 disp(BW,"BW in Hz is :");
14 disp(Q,"Selectivity is :");
15 disp("Hence Q is within limit  $1 < Q < 10$  for a single op-
      amp band pass filter.");
16 //assume C=0.01 uF
17 C=0.01; //in uF
18 R2=2/(2*pi*C*10^-6*BW); //in Kohm
19 R1=-R2/(2*AF); //in KOhm
20 R3=R1/((4*pi*pi*R1*R2*fc*1000*fc*1000*C*C*10^-12)
      -1); //in Kohm
21 disp(R1/1000,"Value of R1 in Kohm is :")
22 disp(R2/1000,"Value of R2 in Kohm is :")
23 disp(R3*1000,"Value of R3 in ohm is :")
24 disp(C,"Value of C in uF is :")

```

Scilab code Exa 6.15 Design a filter to meet the specifications

```

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

```

```

        cascaded. ");
10 fc1=fc; //in Hz
11 fc2=fc; //in Hz
12 fc3=fc; //in Hz
13 Q1=0.51*Q; //unitless
14 Q2=0.51*Q; //unitless
15 Q3=0.51*Q; //unitless
16 AF1=-(-AF)^(1/3); //unitless
17 disp("A single op-amp band passed filter can be
        design with specifications :");
18 disp(fc,"Center frequency in Hz is : ");
19 disp(AF1,"AF1 is :");
20 disp(Q1,"Q1 is : ");

```

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

```

1 // Exa 6.16
2 clc;
3 clear;
4 close;
5 // given data
6 f=2; //in KHz
7 fi_degree=-135; //in degree
8 fi_radian=fi_degree*(%pi/180);
9 disp("A phase shift of -135 degree is achieved by an
        all pass phase lag filter.");
10 //assume C=0.1 uF and R1=RF=10 Kohm
11 C=0.1; //in uF
12 R1=10; //in Kohm
13 RF=10; //in Kohm
14 R=tan(-fi_radian/2)/(2*%pi*f*1000*C*10^-6);
15 disp("Component values are :");
16 disp(R1,"Value of R1 in Kohm is :");
17 disp(RF,"Value of RF in Kohm is :");
18 disp(R/1000,"Value of R in Kohm is :");

```

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

Scilab code Exa 6.17.a Find type of response

```
1 // Exa 6.17a
2 clc;
3 clear;
4 close;
5 // given data
6 R=10; //in Kohm
7 R1=R; //in Kohm
8 R2=R; //in Kohm
9 R3=R; //in Kohm
10 Rf=5.6; //in Kohm
11 R4=Rf; //in Kohm
12 R5=Rf; //in Kohm
13 RA=2.7; //in Kohm
14 RB=1.5; //in Kohm
15 C=0.01; //in uF
16 C1=C; //in uF
17 C2=C; //in uF
18 alfa=3*RB/(RA+RB);
19 disp("The type of response will be determined by the
      value of damping coefficient.");
20 disp(alfa,"Value of alfa is :");
21 disp("This value correspondes to the chebyshev
      response.");
```

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

```
1 // Exa 6.17b
2 clc;
3 clear;
```

```

4  close;
5  // given data
6  R=10; //in Kohm
7  R1=R; //in Kohm
8  R2=R; //in Kohm
9  R3=R; //in Kohm
10 Rf=5.6; //in Kohm
11 R4=Rf; //in Kohm
12 R5=Rf; //in Kohm
13 RA=2.7; //in Kohm
14 RB=1.5; //in Kohm
15 C=0.01; //in uF
16 C1=C; //in uF
17 C2=C; //in uF
18 fc=1/(2*%pi*Rf*1000*C*10^-6); //in Hz
19 Klp=1.238; //unitless
20 fH=fc*Klp; //in Hz
21 Khp=1/Klp; //unitless
22 fL=fc*Khp //in Hz
23 disp(fc/1000,"Critical frequency in KHz is : ");
24 disp(fH/1000,"High cut-off frequency in KHz is : ");
25 disp(fL/1000,"Low cut-off frequency in KHz is : ");
    //

```

Scilab code Exa 6.17.c Determine band pass center frequency

```

1  // Exa 6.17c
2  clc;
3  clear;
4  close;
5  // given data
6  R=10; //in Kohm
7  R1=R; //in Kohm
8  R2=R; //in Kohm
9  R3=R; //in Kohm

```



```

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

```

Scilab code Exa 6.17.d Determine band pass bandwidth

```

1 // Exa 6.17d
2 clc;
3 clear;
4 close;
5 // given data
6 R=10; //in Kohm
7 R1=R; //in Kohm
8 R2=R; //in Kohm
9 R3=R; //in Kohm
10 Rf=5.6; //in Kohm
11 R4=Rf; //in Kohm
12 R5=Rf; //in Kohm
13 RA=2.7; //in Kohm
14 RB=1.5; //in Kohm
15 C=0.01; //in uF
16 C1=C; //in uF
17 C2=C; //in uF
18 alfa=3*RB/(RA+RB); // unitless
19 Q=1/alfa; // unitless
20 fc=1/(2*%pi*Rf*1000*C*10^-6); //in Hz
21 BW=fc/Q; //in Hz

```

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

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

```
1 // Exa 6.17e
2 clc;
3 clear;
4 close;
5 // given data
6 R=10; //in Kohm
7 R1=R; //in Kohm
8 R2=R; //in Kohm
9 R3=R; //in Kohm
10 Rf=5.6; //in Kohm
11 R4=Rf; //in Kohm
12 R5=Rf; //in Kohm
13 RA=2.7; //in Kohm
14 RB=1.5; //in Kohm
15 C=0.01; //in uF
16 C1=C; //in uF
17 C2=C; //in uF
18 alfa=3*RB/(RA+RB); //in unitless
19 Q=1/alfa; //in unitless
20 disp(Q,"The band pass gain at center frequency is :")
    );
```

Chapter 7

Non Linear Circuits

Scilab code Exa 7.3 Design a schmitt trigger

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

Scilab code Exa 7.4 Determine threshold voltages and hysteresis voltage

```

1 // Exa 7.4
2 clc;
3 clear;
4 close;
5 // given data
6 VSat=13;//in Volt
7 R1=270;//in ohm
8 R2=39;//in Kohm
9 Vut=R1*VSat/(R1+R2*1000);//in Volt
10 Vlt=R1*(-VSat)/(R1+R2*1000);//in Volt
11 VH=Vut-Vlt;//in Volt
12 disp(Vut*1000,"The upper threshold voltage in mVolt
    is :");
13 disp(Vlt*1000,"The lower threshold voltage in mVolt
    is :");
14 disp(VH*1000,"Hysteresis voltage in mVolt is :");

```

Scilab code Exa 7.5 Design a schmitt trigger circuit

```

1 // Exa 7.5
2 clc;
3 clear;
4 close;
5 // given data
6 VSat=13;//in Volt
7 Vut=2;//in Volt
8 Vlt=-1;//in Volt
9 // Assume R1=10 Kohm
10 R1=10;//in Kohm
11 R2=((VSat/Vut)-1)*R1;//in Kohm
12 R3=((-VSat/Vlt)-1)*R1;//in Kohm
13 disp(R1,"Value of R1 in Kohm is :");
14 disp(R2,"Value of R2 in Kohm is :");
15 disp(R3,"Value of R1 in Kohm is :");

```

Chapter 8

Analog Multiplier and Operational Transconductance Amplifier

Scilab code Exa 8.1 Find Transfer Function

```
1 // Exa 8.1
2 clc;
3 clear;
4 close;
5 // given data
6 disp("We have : ");
7 disp("Io1=gm1*V1");
8 disp("Io2=-gm2*Vo");
9 disp("I=Io1+Io2=gm1*V1-gm2*Vo");
10 disp("We also have : I=(Vo-V1)*s*C");
11 disp("From above two eqn :");
12 disp("gm1*V1-gm2*Vo=(Vo-V1)*s*C");
13 disp("Arranging terms to get Vo/V1 we have : ");
14 disp("Transfer Function : V0/V1=(gm1+s*C)/(gm2+s*C)"
      );
```

Scilab code Exa 8.2 Find Transfer Function

```
1 // Exa 8.2
2 clc;
3 clear;
4 close;
5 // given data
6 disp("We have : ");
7 disp("Io1=gm1*(V1-Vo)");
8 disp("Io2=gm2*(V1-Vo)");
9 disp("But Vc=Io1/s*C1");
10 disp("So Io2=gm2(Io1/s*C1-Vo)");
11 disp("We also have : Io2=(Vo-V1)*s*C2");
12 disp("Substituting for Io1 gives :");
13 disp("gm2*((gm1*(V1-Vo)-s*C1*Vo)/s*C1=(Vo-V1)/s*C2)");
14 disp("gm1*gm2*V1-gm1*gm2*Vo-gm2*s*C1*Vo=s^2*C1*C2*Vo
    -s^2*C1*C2*V1");
15 disp("Arranging terms to get Vo/V1 we have : ");
16 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

```
1 // Exa 8.3
2 clc;
3 clear;
4 close;
5 // given data
6 disp("We have : ");
7 disp("Io1=gm1*(V1-V2)");
8 disp("Io2=gm2*Vo");
```

```

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

```

Scilab code Exa 8.4 Find Transfer Function

```

1 // Exa 8.4
2 clc;
3 clear;
4 close;
5 // given data
6 disp("We have : ");
7 disp(" Io1=gm1*(V1-Vdash)");
8 disp("We also have Io1=s*CVo");
9 disp(" Io2=gm2*Vo and Io3=-gm3*Vdash");
10 disp("Now we have : s*CVo=gm1*(V1-Vdash)");
11 disp("or V1-Vdash=s*CV0/gm1 or Vdash=V1-s*CV0/gm1");
12 disp("So we have : Io3=-gm3*(V1-s*CV0/gm1)");
13 disp("Also Io2=-Io3 or Io3=-gm2*Vo");
14 disp("So we have -gm2*Vo=-gm3*((gm1*V1-s*C*Vo)/gm1)");
15 disp("or gm1*gm2*Vo+gm3*s*C*Vo=gm1*gm3*V1");
16 disp("Arranging terms to get Vo/V1 we have : ");
17 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

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

Scilab code Exa 9.2 Design a current source using 7808 regulator


```

1 //Exa 9.2
2 clc;
3 clear;
4 close;
5 //given data
6 Vreg=8;//in volts as IC 7808 is given
7 IL=100;//in mA
8 IR=100;//in mA
9 Iq=0;//in mA
10 RL=50;//in ohms
11 // let find the value of resistor to deliver
    required current
12 R=Vreg/(IR*10^-3);// in ohms; so current must be in
    amperes
13 disp(R,"Required Resistance in ohms : ");
14 disp("output is given by: Vo = IR*R+IL*RL");
15 Vo = (IR*10^-3)*R+(IL*10^-3)*RL;
16 disp(Vo);
17 //considering 2 volt dropout
18 Vdropout=2;//in volts
19 VI=Vo+Vdropout;
20 disp(VI,"Input voltage must be(in volts): ");

```

Scilab code Exa 9.3 Calculate output current

```

1 //Exa 9.3
2 clc;
3 clear;
4 close;
5 //given data
6 RL1=100;//in ohms
7 RL2=8;//in ohms
8 RL3=1;//in ohms
9 VEBon=0.7;//in volts
10 Beta=25;

```

```

11 R=5; //in ohms
12 //device used 7808 so V=8 volts
13 V=8;
14 // part(i) for a laod of 100 ohms
15 IL1=V/RL1; //in amperes
16 VacR1=IL1*R;
17 disp(VacR1,"VacR(in volts) : ")
18 disp(" Which is less than the given VEBon.Hence
      Transistor remains OFF.")
19 //so Io=IL and Ic=0
20 Io1=IL1; //in amperes;
21 Ic1=0;
22 disp(Ic1,Io1,"Ic and Io for the 100 ohms load(in
      amperes): ")
23 // part(ii) for a laod of 8 ohms
24 IL2=V/RL2; //in amperes
25 VacR2=IL2*R;
26 disp(VacR2,"The voltage across R will be(in volts) :
      ")
27 disp(" Which is greater than the given VEBon.Hence
      Transistor will be ON.")
28 //expression for Io
29 Io2=((IL2+(Beta*VEBon)/R))/(Beta+1); //in amperes;
30 Ic2=IL2-Io2;
31 disp(Ic2,Io2,"Ic and Io for the 8 ohms load(in
      amperes): ")
32
33 // part(iii) for a laod of 1 ohms
34 IL3=V/RL3; //in amperes
35 VacR3=IL3*R;
36 disp(VacR3,"VacR(in volts) : ")
37 disp(" Which is greater than the given VEBon.Hence
      Transistor will be ON.")
38 //expression for Io
39 Io3=((IL3+(Beta*VEBon)/R))/(Beta+1); //in amperes;
40 Ic3=IL3-Io3;
41 disp(Ic3,Io3,"Ic and Io for the 1 ohms load(in
      amperes): ")

```

Scilab code Exa 9.4 Design adjustable voltage regulator using LM317

```
1 //Exa 9.4
2 clc;
3 clear;
4 close;
5 //given data
6 //for the given IC LM317:
7 Iadj=100;//in micro amperes
8 Vref=1.25;//in volts
9 R1=240;//in ohms
10 //(i) For Vo=2 volts
11 //on solving equation  $V_o=V_{ref}(1+R_2/R_1)+R_2*I_{adj}$ 
12  $V_o=2$ ;//in volts
13  $R_2=(V_o-V_{ref})/((V_{ref}/R_1)+I_{adj}*10^{-6})$ ;
14 disp(R2,"for Output 2 volts the requires value of
    resistance R2(in ohms) : ")
15 //(i) For Vo=12 volts
16 Vo1=12;//in volts
17 //on solving equation  $V_o=V_{ref}(1+R_2/R_1)+R_2*I_{adj}$ 
18  $R_{21}=(V_{o1}-V_{ref})/(V_{ref}/R_1+I_{adj}*10^{-6})$ ;
19 disp(R21,"for Output 12 volts the requires value of
    resistance R2(in ohms) : ")
20 //use potentiometer for adjustable value
21 disp("Hence use 3kohm potentiometer to set R2.")
```

Scilab code Exa 9.5 Calculate minimum and maximum output voltage

```
1 //Exa 9.5
2 clc;
3 clear;
```

```

4 close;
5 //given data
6 //for the given IC LM317:
7 Iadj=100;//in micro amperes
8 Vref=1.25;//in volts
9 R1=240;//in ohms
10 //we have output equation  $V_o=V_{ref}(1+R_2/R_1)+R_2*I_{adj}$ 
11 R2min=0;//in ohms
12 R2max=3000;//in ohms
13 Vomn=Vref*(1+R2min/R1)+R2min*Iadj*10-6;//in volts
14 Vomax=Vref*(1+R2max/R1)+R2max*Iadj*10-6;//in volts
15 disp(Vomn,"Minimum output voltage(in volts) is : ")
16 disp(Vomax,"Maximum output voltage(in volts) is : ")

```

Scilab code Exa 9.6 Design a voltage regulator using IC723

```

1 //Exa 9.6
2 clc;
3 clear;
4 close;
5 //given data
6 //IC 723
7 Vsense=0.7//in volts
8 Vo=5;//in volts
9 Im=50;//in mA
10 Id=1;//in mA
11 Vr=7;//in volts
12  $R_1=(V_r-V_o)/(I_d*10^{-3})$ ;
13  $R_2=V_o/(I_d*10^{-3})$ ;
14  $R_3=(R_1*R_2)/(R_1+R_2)$ ;
15  $R_{cl}=V_{sense}/(I_m*10^{-3})$ ;
16 disp("various resistance values for the circuit is
      as follows : ")
17 disp(R1,"R1 :")
18 disp(R2,"R2 :")

```

```
19 disp(R3,"R3 :")
20 disp(Rc1,"Rc1 :")
```

Scilab code Exa 9.7 Design a voltage regulator using IC723

```
1 //Exa 9.7
2 clc;
3 clear;
4 close;
5 //given data
6 // IC 723
7 Id=1;//in mA
8 Vsense=0.7;//in volts
9 Vo=15;//in volts
10 Im=50;//in mA
11 Vr=7;//in volts
12 R1=(Vo-Vr)/(Id*10^-3);
13 R2=Vr/(Id*10^-3);
14 R3=(R1*R2)/(R1+R2);
15 Rc1=Vsense/(Im*10^-3);
16 disp("various resistance values for the circuit is
    as follows : ")
17 disp(R1,"R1 :")
18 disp(R2,"R2 :")
19 disp(R3,"R3 :")
20 disp(Rc1,"Rc1 :")
```

Scilab code Exa 9.8 Design a regulated power supply

```
1 //Exa 9.8
2 clc;
3 clear;
4 close;
```

```

5 //given data
6 Im=100;//in mA
7 Vr=7;//in volts
8 R2=10;//in kohm
9 Vsense=0.7;//in volts
10 //using equation Vo=((R1+R2)/R2)*Vr
11 //for Vo=10 volts assuming R2=10kohm
12 disp("Eqn is given by Vo=((R1+R2)/R2)*Vr")
13 Vo=10;//in volts
14 R1=((Vo*R2)/Vr)-R2//it gives 3R2=7R1;
15 disp(R1,"Value of resistance R1(in kohms): ")
16 //now let output voltage is 15 volts
17 Vo=15;//in volts
18 R1=((Vo*R2)/Vr)-R2//it gives 3R2=7R1;
19 disp(R1,"Value of resistance R1(in kohms): ")
20 R3=(R1*R2)/(R1+R2);
21 disp(R3,"value of resistance R3 in kohms : ")
22 Rcl=Vsense/(Im*10^-3);//in ohms
23 disp(Rcl,"Value of Rcl is ohms is : ");

```
