

Scilab Textbook Companion for
Operational Amplifiers & Linear Integrated
Circuits
by D. A. Bell¹

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Introduction to Operational Amplifiers

Scilab code Exa 1.1 Voltage follower

```
1 disp('chapter 1 ex1.1')
2 disp('given')
3 disp("input signal=1v")// input signal is 1v
4 disp("V0=Vi-(Vi/M)")//formula to find o/p voltage
5 Vi=1
6 M=200000//Minimum Open loop gain is 50000, Typical M
   is 200000
7 V0=Vi-(Vi/M)
8 disp('output voltage for typical open loop gain of
   200000 is')
9 disp('volt',V0)
10 M1=50000//Minimum open loop gain
11 V01=Vi-(Vi/M1)//output for minimum open loop gain
12 disp('output voltage for minimum open loop gain of
   50000 is')
13 disp('volt',V01)
```

Scilab code Exa 1.2 Non Inverting amplifier

```
1 disp('chapter 1 ex1.2')
2 disp('given')
3 disp("R2=8.2Kohms,R3=150ohms")//given Resistor
  values
4 R2=8200
5 R3=150
6 Av=(R2+R3)/R3//voltage gain formula
7 disp("voltage gain for given resistor values")
8 disp(Av)
9 disp("New voltage gain given=75")//voltage gain=75
10 Av=75
11 R3=R2/(Av-1)//calculation of R3
12 disp("New value of resistor R3")
13 disp('ohms',R3)
```

Scilab code Exa 1.3 Inverting amplifier

```
1 disp('chapter 1 ex1.3')
2 disp('given')
3 disp("R2=8.2Kohms,R1=270ohms")//given resistor
  values
4 R1=270
5 R2=8200
6 Av=R2/R1
7 disp("voltage gain of inverting amplifier")
8 disp(Av)
9 disp("new voltage gain given=60")
10 Av1=60
11 R1n=R2/Av1
12 disp("new value of R1")
13 disp('Ohms',R1n)
```

Chapter 2

Operational Amplifier Parameters

Scilab code Exa 2.1 Non Inverting amplifier

```
1 disp('chapter 2 ex2.1 ')  
2 disp('given ')  
3 disp("voltage gain is 50")  
4 Av=50  
5 disp("typicalCMRR=90db")  
6 disp("common mode input=100mv")  
7 Vicm=.1  
8 CMRR=10^(90/20)  
9 Vo=(Vicm*Av)/CMRR  
10 disp("output voltage is")  
11 disp('volt ',Vo)
```

Scilab code Exa 2.2 PSVR

```
1 disp('chapter 2 ex2.2 ')  
2 disp('given ')
```

```

3 disp("supply voltage=+15V and -15V")
4 disp("ripple voltaage supply=2mV with 120 Hz")
5 Vrip=2*(10^(-3))
6 disp("PSRR for an Op-amp=30uV/V")
7 PSRR=(30*(10^(-6)))
8 disp("output voltage produced by the power ripple=")
9 Vo=Vrip*PSRR
10 disp('volt ',Vo)

```

Scilab code Exa 2.3 Offset voltage

```

1 disp('chapter 2 ex2.3 ')
2 disp('given ')
3 disp("R1=22Kohm R2=22Kohm and tolerance of 20%")
4 disp("from 741 datasheet")
5 disp("Vi(offset)=5mV maximum")
6 disp("Ii(offset)=200nA maximum")
7 Vioffset=.005
8 Iioffset=200*(10^(-9))
9 disp("Ib=500nA")
10 Ib=500*(10^(-9))
11 R1=22000+(22000*0.2)
12 R2=22000-(22000*0.2)
13 Vioffset=Ib*(R1-R2)
14 disp("Vioffset=Ib*(R1-R2)")
15 disp("input offset voltage due to resistors")
16 disp('volt ',Vioffset)

```

Scilab code Exa 2.4 Input impedance

```

1 disp('chapter 2 ex2.4 ')
2 disp('given ')
3 disp("from 741 datasheet")

```

```
4 disp("Rimin=.3Mohm")
5 disp("Mmin=50000")
6 Rimin=300000
7 Mmin=50000
8 disp("For an voltage follower beta=1")
9 b=1
10 Zin=(1+Mmin*b)*Rimin
11 disp("minimum input impedance")
12 disp('ohms ',Zin)
```

Scilab code Exa 2.5 Output impedance

```
1 disp('chapter 2 ex2.5 ')
2 disp('given ')
3 disp("from 741 datasheet")
4 disp("Zo=75ohm")
5 disp("Mmax=200000")
6 Zo=75
7 Mmax=200000
8 disp("For an voltage follower beta=1")
9 b=1
10 Zout=Zo/(1+Mmax*b)
11 disp("Typical output impedance")
12 disp('ohms ',Zout)
```

Chapter 3

Op Amps as DC Amplifiers

Scilab code Exa 3.1 Voltage follower

```
1 disp('chapter 3 ex3.1')
2 disp('given')
3 disp('resistor connected R1=Rs=47kohms')
4 R1=47000
5 Rs=47000
6 disp('IB(max)=500nA and Ii(offset)=20nA')
7 IBmax=500*10^(-9)
8 Iioffset=20*10^(-9)
9 disp('V(max)=IB(max)*Rs')
10 Vmax=IBmax*Rs
11 disp('volt',Vmax)
12 disp('Vioffset=Ii(offset)*Rs')
13 Vioffset=Iioffset*Rs
14 disp('volt',Vioffset)
```

Scilab code Exa 3.2 Voltage follower

```
1 disp('chapter 3 ex3.2')
```

```

2 disp('given')
3 disp('resistor connected Rs=47kohms and RL=20kohms')
4 disp('voltage follower Vs=1Volt')
5 disp('voltage load VL=Vs*RL/(Rs+RL)')
6 Rs=47000
7 RL=20000
8 Vs=1
9 VL=Vs*RL/(Rs+RL)
10 disp(VL)
11 disp('Zin=(1+M)*Zi')
12 disp('M=200000 and Zi=2Mohms')
13 M=200000
14 Zi=2000000
15 Zin=(1+M)*Zi
16 disp('ohms',Zin)
17 disp('Vi=Vs*Zin/(Rs+Zin)')
18 Vi=Vs*Zin/(Rs+Zin)
19 disp('volt',Vi)
20 disp('Vo=Vi*(1-1/M)')
21 Vo=Vi*(1-1/M)
22 disp('volt',Vo)
23 disp('Zout=Zo/(1+M)')
24 disp('Zo=75ohms')
25 Zo=75
26 Zout=Zo/(1+M)
27 disp('ohms',Zout)
28 disp('VL=Vo*RL/(RL+Zout)')
29 VL=Vo*RL/(RL+Zout)
30 disp('volt',VL)

```

Scilab code Exa 3.3 Potential divider and voltage follower

```

1 disp('chapter 3 ex3.3')
2 disp('given')
3 disp('RL=1kohms')

```

```

4 disp('voltage follower VL=5volt')
5 disp('supply voltage Vcc=15volt')
6 disp('IL=VL/RL')
7 RL=1000
8 VL=5
9 IL=VL/RL
10 disp('amperes',IL)
11 disp('V1=Vcc-VL')
12 Vcc=15
13 V1=Vcc-VL
14 disp('volt',V1)
15 disp('R1=V1/IL')
16 R1=V1/IL
17 disp('ohms',R1)
18 disp('RL changes by -10%')
19 disp('VL=Vcc*(RL-.10)/(R1+(RL-.10))')
20 VL=Vcc*(RL-.10)/(R1+(RL-.10))
21 disp('volt',VL)
22 disp('V2=VL=5volts')
23 V2=5
24 VL=5
25 disp('V1=Vcc-VL')
26 V1=Vcc-VL
27 disp('volt',V1)
28 disp('IBmax=500nA and I2=100*IBmax')
29 disp('R2=V2/I2')
30 IBmax=500*10^(-9)
31 I2=100*IBmax
32 R2=V2/I2
33 disp('ohms',R2)
34 disp('R1=V1/I2')
35 R1=V1/I2
36 disp('ohms',R1)

```

Scilab code Exa 3.4 Non Inverting amplifier

```

1 disp('chapter 3 ex3.4')
2 disp('given')
3 disp('signal amplitude Vi=15mV')
4 disp('IBmax=500nA and I2=100*IBmax')
5 Vi=.015
6 IBmax=500*10^(-9)
7 I2=100*IBmax
8 disp('R3=Vi/I2')
9 R3=Vi/I2
10 disp('ohms',R3)
11 disp('standard value resistor for R3=270ohms')
12 R3=270
13 disp('I2=Vi/R3')
14 I2=Vi/R3
15 disp('amperes',I2)
16 disp('Vo=Av*Vi')
17 Av=66
18 Vo=Av*Vi
19 disp('volt',Vo)
20 disp('R2=Vo/I2-R3')
21 R2=Vo/I2-R3
22 disp('ohms',R2)
23 disp('standard value resistor to give Av>66 R2=18
      kohms')
24 R2=18000
25 disp('R1=R2||R3')
26 R1=R2*R3/(R2+R3)
27 disp('ohms',R1)
28 disp('standard value resistor R1=270ohms')
29 R1=270
30 disp('ohms',R1)

```

Scilab code Exa 3.5 Non Inverting amplifier

```

1 disp('chapter 3 ex3.5')

```

```

2 disp('given')
3 disp('Redesigning the noninverting amplifier in
   example 3.4 using LF353 BIFET op-amp')
4 disp('IBmax=200pA and I2=100*IBmax')
5 disp('let R2=1Mohms and Av=66')
6 R2=1*10^(6)
7 Av=66
8 disp('R3=R2/(Av-1)')
9 R3=R2/(Av-1)
10 disp('ohms',R3)
11 disp('standard value resistor R3=15kohms will give
   Av>66')
12 R3=15000
13 disp('ohms',R3)
14 disp('R1=R2||R3')
15 R1=R2*R3/(R2+R3)
16 disp('ohms',R1)
17 disp('standard value R1=15kohms')
18 R1=15000
19 disp('ohms',R1)

```

Scilab code Exa 3.6 Input impedance of non inverting amplifier

```

1 disp('chapter 3 ex3.6')
2 disp('given')
3 disp('standard value of resistor R1=15kohms')
4 disp('Av=66')
5 disp('typical parameters M=100000 and Zi=10^(12)')
6 disp('Zin=(1+M/Av)*Zi')
7 R1=15000
8 Av=66
9 Zi=10^(12)
10 M=100000
11 Zin=(1+M/Av)*Zi
12 disp('ohms',Zin)

```

```
13 disp('Z1in=R1+Zin ')
14 Z1in=R1+Zin
15 disp('ohms ',Z1in)
```

Scilab code Exa 3.7 Inverting amplifier

```
1 disp('chapter 3 ex3.7 ')
2 disp('given ')
3 disp('Designing inverting amplifier using 741 op-amp
   ')
4 disp('voltage gain Av=50 ')
5 disp('output voltage Vo=2.5 volt ')
6 Av=50
7 Vo=2.5
8 disp('IBmax=500nA and I1=100*IBmax ')
9 IBmax=500*10^(-9)
10 I1=100*IBmax
11 disp('V1=Vo/Av ')
12 V1=Vo/Av
13 disp('volt ',V1)
14 disp('R1=V1/I1 ')
15 R1=V1/I1
16 disp('ohms ',R1)
17 disp('R2=Vo/I1 ')
18 R2=Vo/I1
19 disp('ohms ',R2)
20 disp('R3=R1 || R2 ')
21 R3=R1*R2/(R2+R1)
22 disp('ohms ',R3)
```

Scilab code Exa 3.8 Inverting amplifier

```
1 disp('chapter 3 ex3.8 ')
```

```

2 disp('given')
3 disp('Redesigning the inverting amplifier in example
      3.7 using LF353 BIFET op-amp')
4 disp('let R2=1Mohms and Av=50')
5 R2=1*10^(6)
6 Av=50
7 disp('R1=R2/Av')
8 R1=R2/Av
9 disp('ohms',R1)
10 disp('R3=R1||R2')
11 R3=R1*R2/(R1+R2)
12 disp('ohms',R3)

```

Scilab code Exa 3.9 Summing amplifier

```

1 disp('chapter 3 ex3.9')
2 disp('given')
3 disp('the direct sum of two inputs which range from
      .1Volt to 1V0lt')
4 Vsmin=0.1
5 Vsmax=1
6 disp('IBmax=500nA')
7 disp('I1min=100*IBmax')
8 IBmax=500*10^(-9)
9 I1min=100*IBmax
10 disp('amperes',I1min)
11 disp('R1=Vsmin/I1min')
12 R1=Vsmin/I1min
13 disp('ohms',R1)
14 disp('using standard value R2=R1=1.8kohms')
15 R1=1800
16 R2=1800
17 disp('for Av=1 R3=R1=1.8kohms')
18 Av=1
19 R3=1800

```

```

20 disp('R4=R1||R2||R3')
21 R4=R1/3
22 disp('ohms',R4)
23 disp('standard value is 560ohms')

```

Scilab code Exa 3.10 Differential and common mode input resistance

```

1 disp('chapter 3 ex3.10')
2 disp('given')
3 disp('The difference of two input signals is to be
   amplified by factor of 37')
4 Av=37
5 disp('amplitude=50mV')
6 disp('R2=1Mohms')
7 R2=1*10^(6)
8 disp('R1=R2/Av')
9 R1=R2/Av
10 disp('ohms',R1)
11 disp('R3=R1=27kohms')
12 disp('R4=R2=1Mohms')
13 R3=27000
14 R4=1*10^(6)
15 disp('differential mode input resistance Ridiff=R1+(
   R3+R4)')
16 Ridiff=R1+(R3+R4)
17 disp('ohms',Ridiff)
18 disp('common mode input resistance Ricm=R1||(R3+R4)')
19 Ricm=R1*(R3+R4)/(R1+R3+R4)
20 disp('ohms',Ricm)

```

Scilab code Exa 3.11 Output voltage nulling

```

1 disp('chapter 3 ex3.11 ')
2 disp('given ')
3 disp('modifying circuit designed in example 3.10 ')
4 disp('R1=27kohms and R2=1Mohms')
5 disp('R3+R4=R1=27kohms ')
6 R1=27000
7 R2=27000
8 disp('R4/R3=R2/R1=37 ')
9 disp('R3+37R3=27kohms ')
10 R3=27000/(1+37)
11 disp('ohms ',R3)
12 disp('standard value R3=680ohms')
13 R3=680
14 R4=37*R3
15 disp('ohms ',R4)
16 disp('allowing +10% or -10% adjustments of R4')
17 disp('total resistance R%=R4+10%')
18 R5=R4+R4*.10
19 disp('ohms ',R5)
20 disp('variable portion Rv=20% of R4')
21 Rv=.20*R5
22 disp('ohms ',Rv)
23 disp('standard variable resistance is 5kohms')
24 Rv=5000
25 disp('ohms ',Rv)
26 disp('fixed portion of R4 is Rf=R4-Rv')
27 Rf=R5-Rv
28 disp('ohms ',Rf)

```

Chapter 4

Op Amps as AC Amplifiers

Scilab code Exa 4.1 Capacitor coupled voltage follower

```
1 disp('chapter 4 ex4.1')
2 disp('given')
3 disp('capacitor coupled voltage follower design')
4 disp("lower cut off frequency for the circuit =50Hz"
5     )
6 disp('R1=3.9kohms')
7 disp("R1max=0.1Vbe/Ibmax")
8 disp("Vbe=0.7volts")
9 disp("Ibmax=500nA")
10 Vbe=0.7
11 Ibmax=500*10^(-9)
12 R1max=0.1* Vbe/ Ibmax
13 disp("R1max= ",R1max)
14 disp("assume R1=120Kohms")
15 R1=120000
16 f1=50
17 disp("Xc1=R1/10 at F1")
18 disp("C1=1/(2*pi*f1*(R1/10))")
19 C1=1/(2*%pi*f1*(R1/10))
20 disp('farad',C1)
21 R1=3900
```

```

21 disp("Xc2=Rl at f1")
22 disp("C2=1/(2*pi*f1*Rl)")
23 C2=1/(2*%pi*f1*Rl)
24 disp('farad ',C2)
25 disp("The circuit voltage should be normally between
      9 to 18 volts")

```

Scilab code Exa 4.2 Capacitor coupled voltage follower

```

1 disp('chapter 4 ex4.2 ')
2 disp('given ')
3 disp('capacitor coupled voltage follower design
      using BIFET ')
4 disp("lower cut off frequency for the circuit =50Hz"
      )
5 disp('Rl=3.9kohms ')
6 disp("Rlmax=1Mohms")
7 R1=1000000
8 f1=50
9 disp("Xc1=Rl/10 at F1")
10 disp("C1=1/(2*pi*f1*(Rl/10))")
11 C1=1/(2*%pi*f1*(Rl/10))
12 disp('farad ',C1)
13 Rl=3900
14 disp("Xc2=Rl at f1")
15 disp("C2=1/(2*pi*f1*Rl)")
16 C2=1/(2*%pi*f1*Rl)
17 disp('farad ',C2)
18 disp("The circuit voltage should be normally between
      9 to 18 volts")

```

Scilab code Exa 4.3 High Zin Capacitor coupled voltage follower

```

1 disp('chapter 4 ex4.3')
2 disp('given')
3 disp('capacitor coupled voltage follower design')
4 disp("lower cut off frequency for the circuit =50Hz"
      )
5 disp('R1=3.9kohms')
6 disp("R1max=0.1Vbe/Ibmax")
7 disp("Vbe=0.7 volts")
8 disp("Ibmax=500nA")
9 Vbe=0.7
10 Ibmax=500*10^(-9)
11 R1max=0.1* Vbe/ Ibmax
12 disp("R1max= ")
13 disp('ohms',R1max)
14 disp("R1+R2=Rmax")
15 R1=R1max/2
16 R2=R1
17 disp("assume R1=68Kohms")
18 R1=68000
19 f1=50
20 disp("Xc1=R1/10 at F1")
21 disp("C1=1/(2*pi*f1*(R1/10))")
22 C1=1/(2*pi*f1*(R1/10))
23 C2=C1
24 disp('farads',C1)
25 R1=3900
26 disp('farads',C2)
27 M=50000
28 disp("M=50000")
29 disp("Zin=(1+M)*R1")
30 Zin=(1+M)*R1
31 disp('ohms',Zin)
32 disp("The circuit voltage should be normally between
      9 to 18 volts")

```

Scilab code Exa 4.4 Capacitor coupled non inverting amplifier

```
1 disp('chapter 4 ex4.4')
2 disp('given')
3 disp('capacitor coupled non inverting amplifier
  design')
4 disp("lower cut off frequency for the circuit =120Hz
  ")
5 disp('R1=2.2kohms')
6 disp("R1max=0.1Vbe/Ibmax")
7 disp("Vbe=0.7 volts")
8 disp("Ibmax=500nA")
9 Vbe=0.7
10 Ibmax=500*10^(-9)
11 R1max=0.1* Vbe/ Ibmax
12 disp("R1max= ",R1max)
13 R1=120000
14 f1=120
15 disp("R1=18 kohms and R3=270 ohms from example 3.4")
16 disp("Xc1=R1/10 at F1")
17 disp("C1=1/(2*pi*f1*(R1/10))")
18 C1=1/(2*%pi*f1*(R1/10))
19 disp('farads',C1)
20 R1=2200
21 disp("Xc2=R1 at f1")
22 disp("C2=1/(2*pi*f1*R1)")
23 C2=1/(2*%pi*f1*R1)
24 disp('farads',C2)
25 disp("The circuit voltage should be normally between
  9 to 18 volts")
```

Scilab code Exa 4.5 High Zin Capacitor coupled non inverting

```
1 disp('chapter 4 ex4.5')
2 disp('given')
```

```

3 disp('capacitor coupled non inverting high impedance
      follower design')
4 disp("lower cut off frequency for the circuit =200Hz
      ")
5 disp('R1=12kohms')
6 disp("input voltage=15mV")
7 disp("output voltage=3V")
8 disp("Av=Vo/Vi")
9 Vo=3
10 Vi=0.015
11 Av=Vo/Vi
12 disp(Av)
13 disp("for non inverting amplifier Av=(R2+R3)/R3")
14 disp("for BIFET opamp R2=1Mohms")
15 R2=1000000
16 R3=R2/(Av-1)
17 disp(R3,"R3=")
18 f1=200
19 R1=R2-R3
20 disp(R1,"R1=")
21 disp("C2=1/(2*pi*f1*(R3))")
22 C2=1/(2*pi*f1*(R3))
23 disp('farads',C2)
24 disp("C1=1000pF much larger than stray capacitance")
25 R1=12000
26 disp("Xc3=R1/10 at f1")
27 disp("C2=1/(2*pi*f1*(R1/10))")
28 C2=1/(2*pi*f1*(R1/10))
29 disp('farads',C2)
30 disp("The circuit voltage should be normally between
      9 to 18 volts")

```

Scilab code Exa 4.6 Capacitor coupled inverting amplifier

```

1 disp('chapter 4 ex4.6')

```

```

2 disp('given')
3 disp('capacitor coupled inverting amplifier design')
4 disp("frequency range for the circuit =10Hz to 1KHz"
      )
5 disp('R1=250ohms')
6 disp("From inverting amplifier designed in ex 3.7 R1
      =1Kohms")
7 R1=1000
8 f1=10
9 disp("Xc1=R1/10 at F1")
10 disp("C1=1/(2*pi*f1*(R1/10))")
11 C1=1/(2*pi*f1*(R1/10))
12 disp('farads',C1)
13 R1=250
14 disp("Xc2=R1 at f1")
15 disp("C2=1/(2*pi*f1*R1)")
16 C2=1/(2*pi*f1*R1)
17 disp('farads',C2)
18 disp("From inverting amplifier designed in ex 3.7 R2
      =47Kohms")
19 R2=47000
20 disp("Cf=1/(2*pi*f1*R2)")
21 Cf=1/(2*pi*f1*R2)
22 disp('farads',Cf)
23 disp("The circuit voltage should be normally between
      9 to 18 volts")

```

Scilab code Exa 4.7 Capacitor coupled non inverting amplifier

```

1 disp('chapter 4 ex4.7')
2 disp('given')
3 disp('capacitor coupled non inverting amplifier
      design')
4 disp("voltage gain=100")
5 disp("Supply voltage=24v ")

```

```

6 Av=100
7 Vcc=24
8 disp(" Output amplitude=5V")
9 Vo=5
10 disp("lower cut off frequency for the circuit =75Hz"
    )
11 disp(' R1=5.6kohms ')
12 disp(" Ibmax=500nA")
13 Vbe=0.7
14 Ibmax=500*10^(-9)
15 disp(" I2>>Ibmax")
16 I2=100*Ibmax
17 disp(I2," I2=")
18 R1=(Vcc/2)/I2
19 disp(" R1= ")
20 disp(' ohms ',R1)
21 R2=(Vcc/2)/I2
22 disp(R2," R2=")
23 disp(" assume R1=220Kohms")
24 disp(" Vi=Vo/Av")
25 Vi=Vo/Av
26 disp(Vi," Vi=")
27 R1=220000
28 disp(" I4>>Ibmax")
29 I4=100*Ibmax
30 disp(I4," I4=")
31 R4=Vi/I4
32 disp(R4," R4=")
33 disp(" R3+R4=Vo/I4")
34 R3=(Vo/I4)-R4
35 disp(R3," R3=")
36 Rp=(R1*R2)/(R1+R2)
37 disp(Rp," Rp(R1 || R2)=")
38 f1=75
39 disp(" Xc1=Rp/10 at F1")
40 disp(" C1=1/(2*pi*f1*(Rp/10))")
41 C1=1/(2*pi*f1*(Rp/10))
42 disp(' farads ',C1)

```

```
43 R1=5600
44 disp("Xc2=R1/10 at F1")
45 disp("C2=1/(2*pi*f1*(R1/10))")
46 C2=1/(2*pi*f1*(R1/10))
47 disp('farads',C2)
48 disp("C1=1/(2*pi*f1*R4)")
49 C3=1/(2*pi*f1*R4)
50 disp('farads',C3)
51 disp("The circuit voltage should be normally between
      9 to 18 volts")
```

Chapter 5

Op Amp Frequency response and Compensation

Scilab code Exa 5.1 Inverting amplifier

```
1 disp('chapter 5 ex5.1')
2 disp('given')
3 disp('maximum signal voltage Vs=.5 volt')
4 disp('voltage gain Av=10')
5 disp('IBmax=1.5*10^(-6)A and I1=100*IBmax')
6 Vs=.5
7 Av=10
8 IBmax=1.5*10^(-6)
9 I1=100*IBmax
10 disp('amperes', I1)
11 disp('R1=Vs/I1')
12 R1=Vs/I1
13 disp('ohms', R1)
14 disp('R2=Av*R1')
15 R2=Av*R1
16 disp('ohms', R2)
17 disp('R3=R1 || R2')
18 R3=R1*R2/(R1+R2)
19 disp('ohms', R3)
```

Scilab code Exa 5.2 Voltage follower

```
1 disp('chapter 5 ex5.2')
2 disp('given')
3 disp('714 op-amp is used as a voltage follower')
4 disp('voltage gain Av=1')
5 Av=1
6 disp('C1=500pF C2=2000pF C3=1000pF')
```

Scilab code Exa 5.3 Inverting amplifier

```
1 disp('chapter 5 ex5.3')
2 disp('given')
3 disp('LM108 op-amp is used design an inverting
      amplifier')
4 disp('V1=100mV')
5 V1=100*10^(-3)
6 disp('voltage gain Av=3')
7 Av=3
8 disp('IBmax=2nA and I1=100*IBmax')
9 IBmax=2*10^(-9)
10 I1=100*IBmax
11 disp('amperes',I1)
12 disp('R1=V1/I1')
13 R1=V1/I1
14 disp('ohms',R1)
15 disp('standard value R1=470kohms')
16 R1=470000
17 disp('R2=Av*R1')
18 R2=Av*R1
19 disp('ohms',R2)
```

```

20 disp('standard value R2=1.5Mohms')
21 R2=1.5*10^(6)
22 disp('R3=R1||R2')
23 R3=R1*R2/(R1+R2)
24 disp('ohms',R3)
25 disp('Cf=30pF*R1/(R1+R2)')
26 Cf=30*10^(-12)*R1/(R1+R2)
27 disp('farads',Cf)

```

Scilab code Exa 5.4 Inverting amplifier

```

1 disp('chapter 5 ex5.4')
2 disp('given')
3 disp('709 op-amp is used design an inverting
   amplifier')
4 disp('Vs=50mV')
5 Vs=50*10^(-3)
6 disp('voltage gain Av=100')
7 Av=100
8 disp('IBmax=2nA and I1=100*IBmax')
9 IBmax=2*10^(-9)
10 I1=100*IBmax
11 disp('amperes',I1)
12 disp('R1=Vs/I1')
13 R1=Vs/I1
14 disp('ohms',R1)
15 disp('standard value R1=2.2kohms')
16 R1=2200
17 disp('R2=Av*R1')
18 R2=Av*R1
19 disp('ohms',R2)
20 disp('R3=R1||R2')
21 R3=R1*R2/(R1+R2)
22 disp('ohms',R3)
23 disp('Av=100=40dB')

```

Scilab code Exa 5.5 Non Inverting amplifier

```
1 disp('chapter 5 ex5.5 ')
2 disp('given ')
3 disp('709 op-amp is used to design an noninverting
   amplifier ')
4 disp('voltage gain Av=50')
5 Av=50
6 disp('voltage gain Av=50=34dB')
7 disp('compensation components are listed for Av=20dB
   and for Av=40dB')
8 disp('for over compensation use components for Av=20
   dB')
9 disp('C1=500pF R1=1.5kohms C2=20pF')
```

Scilab code Exa 5.6 upper cut off frequency

```
1 disp('chapter 5 ex5.6 ')
2 disp('given ')
3 disp('741 op-amp is used to design an noninverting
   amplifier ')
4 disp('voltage gain Av=100')
5 Av=100
6 disp("F2 occurs at")
7 M=20*log10(Av)
8 disp('db',M)
9 disp("from the graph")
10 disp("from the intersection of the line and open
   loop frequency responce")
11 disp("F2 occurs at" )
12 F2=8000
```

```

13 disp('Hz',F2)
14 disp('709 op-amp is used design an noninverting
    amplifier ')
15 disp("from the graph")
16 disp("from the intersection of the line and open
    loop frequency responce")
17 disp("F2 occurs at" )
18 F2=6000
19 disp('Hz',F2)

```

Scilab code Exa 5.7 Gain bandwidth product

```

1 disp('chapter 5 ex5.7 ')
2 disp('given ')
3 disp('Using the gain-bandwidth product estimate
    upper cut off frequencies in example5.6 ')
4 disp('741 op-amp ')
5 disp('fu=800kHz and Av=100 ')
6 fu=800000
7 Av=100
8 disp('f2=fu/Av ')
9 f2=fu/Av
10 disp('Hz',f2)
11 disp('For 709 op-amp with C1=100pF R1=1.5kohms C2=3
    pF ')
12 disp('cutoff frequency cannot be calculated with
    above compensating components because voltage
    gain doesnt fall off at 20dB per decade
    throughout frequency response ')

```

Scilab code Exa 5.8 Upper cutt off frequency of voltage follower

```

1 disp('chapter 5 ex5.8 ')

```

```

2 disp('given')
3 disp('Using the gain-bandwidth product estimate
      upper cut off frequencies')
4 disp('741 op-amp')
5 disp('fu=800kHz and Av=1')
6 fu=800000
7 Av=1
8 disp('f2=fu/Av')
9 f2=fu/Av
10 disp('Hz',f2)
11 disp('for unity gain R1=R2')
12 disp('Av=(R1+R2)/R1')
13 R1=R2
14 Av=(R1+R2)/R1
15 disp(Av)
16 disp('f2=fu/Av')
17 f2=fu/Av
18 disp('Hz',f2)

```

Scilab code Exa 5.9 Slew rate effects

```

1 disp('chapter 5 ex5.9')
2 disp('given')
3 disp('the output of sine wave Vp=5Volt')
4 disp('the typical slew rate for 741 op-amp S=.5V
      /1*10^(-6)s')
5 Vp=5
6 S=.5/(1*10^(-6))
7 disp('fs=S/(2*pi*Vp)')
8 fs=S/(2*pi*Vp)
9 disp('Hz',fs)
10 disp('The slew rate-limited frequency should be
      equal to cutoff frequency')
11 disp('fs=f2=800kHz')
12 f2=800000

```

```

13 fs=f2
14 disp('Vp=S/(2*%pi*fs)')
15 Vp=S/(2*%pi*fs)
16 disp('volts',Vp)
17 disp('741 op-amp f2=8kHz')
18 f2=8000
19 disp('Vp=S/(2*%pi*f2)')
20 Vp=S/(2*%pi*f2)
21 disp('volts',Vp)

```

Scilab code Exa 5.10 Slew rate effects

```

1 disp('chapter 5 ex5.10')
2 disp('given')
3 disp('the output of sine wave Vp=.35 Volt')
4 disp('the typical slew rate for 741 op-amp S=.5V
      /1*10^(-6)s')
5 disp('f2=800kHz')
6 Vp=.35
7 S=.5/(1*10^(-6))
8 f2=800000
9 disp('tr(f2)=.35/f2')
10 trf2=.35/f2
11 disp('seconds',trf2)
12 disp('tr(s)=Vp/S')
13 trs=Vp/S
14 disp('seconds',trs)
15 disp('trs=1*10^(-6)')
16 trs=1*10^(-6)
17 disp('Vp=trs*S')
18 Vp=trs*S
19 disp('volts',Vp)
20 disp('f2=100kHz')
21 f2=100000
22 disp('tr(f2)=.35/f2')

```

```

23 trf2=.35/f2
24 disp('seconds',trf2)
25 disp('trs=3.5*10^(-6)')
26 trs=3.5*10^(-6)
27 disp('Vp=trs*S')
28 Vp=trs*S
29 disp('volts',Vp)

```

Scilab code Exa 5.11 Input stray capacitance

```

1 disp('chapter 5 ex5.11')
2 disp('given')
3 disp('R1=R3=2.2kohms')
4 disp('R2=220kohms')
5 disp('Rs=220ohms')
6 Rs=220
7 R1=2200
8 R3=2200
9 R2=220000
10 disp('R=R3+R2||(R1+Rs)')
11 R=R3+(R2*(R1+Rs)/(R2+R1+Rs))
12 disp('ohms',R)
13 disp('f=600kHz')
14 f=600000
15 disp('Cs=1/(2*pi*f*10*R)')
16 Cs=1/(2*pi*f*10*R)
17 disp('farads',Cs)

```

Scilab code Exa 5.12 Input stray capacitance

```

1 disp('chapter 5 ex5.12')
2 disp('given')
3 disp('R1=R3=2200ohms')

```

```

4 disp('R2=220kohms')
5 disp('Rs=220ohms')
6 Rs=220
7 R1=2200
8 R3=2200
9 R2=220000
10 disp('R=R2+R3')
11 R=R2+R3
12 disp('ohms',R)
13 disp('f=600kHz')
14 f=600000
15 disp('Cs=1/(2*pi*f*10*R)')
16 Cs=1/(2*pi*f*10*R)
17 disp('farads',Cs)
18 disp('R=R2||(R1+Rs)')
19 R=R2*(R1+Rs)/(R2+R1+Rs)
20 disp('ohms',R)
21 disp('Cs=1/(2*pi*f*10*R)')
22 Cs=1/(2*pi*f*10*R)
23 disp('farads',Cs)
24 disp('R=R3+R2||(R1+Rs)')
25 disp('R1=R3=220ohms')
26 disp('R2=22kohms')
27 disp('Rs=22ohms')
28 Rs=22
29 R1=220
30 R3=220
31 R2=22000
32 R=R3+(R2*(R1+Rs)/(R2+R1+Rs))
33 disp('ohms',R)
34 disp('Cs=1/(2*pi*f*10*R)')
35 Cs=1/(2*pi*f*10*R)
36 disp('farads',Cs)

```

Scilab code Exa 5.13 feedback capacitor

```

1 disp('chapter 5 ex5.13 ')
2 disp('given ')
3 disp('Determining the feedback capacitor')
4 disp('R1=220ohms ')
5 disp('R2=22kohms ')
6 disp('Cs from example 5.12=58pF')
7 R1=220
8 R2=22000
9 Cs=58*10^(-12)
10 disp('C2=R1*Cs/R2')
11 C2=R1*Cs/R2
12 disp('farads ',C2)

```

Scilab code Exa 5.14 load capacitor

```

1 disp('chapter 5 ex5.14 ')
2 disp('given ')
3 disp('Determine the load capacitance')
4 disp('from the data sheet Ro=150ohm')
5 Ro=150
6 disp('f=600kHz')
7 f=600000
8 disp('Cs=1/(2*%pi*f*10*Ro)')
9 Cs=1/(2*%pi*f*10*Ro)
10 disp('farads ',Cs)

```

Scilab code Exa 5.15 feedback capacitance

```

1 disp('chapter 5 ex5.15 ')
2 disp('given ')
3 disp('Determine the feedback capacitance')
4 disp('from the data sheet Ro=150ohm')
5 Ro=150

```

```

6 disp('R2=220kohms')
7 R2=220000
8 disp('load capacitance CL=.1*10^(-6)F')
9 CL=.1*10^(-6)
10 disp('C2=Ro/R2*CL')
11 C2=Ro/R2*CL
12 disp('farads',C2)
13 disp('additional resistor R=470ohm')
14 R=470
15 disp('C2=(Ro+R)/R2*CL')
16 C2=(Ro+R)/R2*CL
17 disp('farads',C2)
18 disp('use 300pF standard value')

```

Scilab code Exa 5.16 Zin mod compensation

```

1 disp('chapter 5 ex5.16')
2 disp('given')
3 disp('calculating R4 and C4 for high Zin Mod for ex
5.4')
4 disp('assuming R3 is a short circuit')
5 disp('circuit is designed to have Av=1/beta')
6 beta=0.01
7 Av=1/beta
8 disp(Av,'Av=')
9 Avindb=20*log10(Av)
10 disp(Avindb,'Av in db=')
11 disp('to reduce next compensating components select
1/beta1=1000=60db')
12 disp('1/beta1=((r1 || r4)+r2)/(r1 || r4)')
13 disp('r2=220kohms,r1=2.2kohm')
14 disp('r14=r1 || r4=r2/(1000-1)')
15 r2=220000
16 r1=2200
17 r14=r2/(1000-1)

```

```

18 disp('ohms',r14)
19 disp('(1/r4)=(1/220)-(1/r1)')
20 g4=(1/r14)-(1/r1)
21 r4=1/g4
22 disp('ohms',r4)
23 disp('use 220ohm std value')
24 r4=220
25 disp('the compensating components for 1/beta1=60db
      are c1=10pf,r1=0,c2=3pf')
26 c1=10*10^(-12)
27 c2=3*10^(-12)
28 r1=0
29 disp('the frequency at which M*beta=1 is found and
      is equal to 2MHz')
30 f2=2000000
31 disp('Xc4<<r4 therefore Xc4=r4/10')
32 Xc4=r4/10
33 disp('ohms',Xc4)
34 disp('C4=1/(2*%pi*f2*Xc4)')
35 C4=1/(2*%pi*f2*Xc4)
36 disp('farads',C4)

```

Chapter 6

Miscellaneous Op Amp Linear Applications

Scilab code Exa 6.1 Voltage source

```
1 disp('chapter 6 ex6.1')
2 disp('given')
3 disp("voltage source to be designed")
4 disp("constant output voltage=6V")
5 Vo=6
6 disp("minimum load resistance=150")
7 disp("available supply voltage=+/-12V")
8 Vcc=12
9 Rl=150
10 disp("from the zener diode specification Vz=6.3")
11 Vz=6.3
12 disp("recommended current for for zener is 20mA")
13 Iz=.02
14 disp("Rl=(Vcc-Vz)/Iz")
15 Rl=(Vcc-Vz)/Iz
16 disp('ohms',Rl)
17 disp("IImax=Vz/Rl")
18 IImax=Vz/Rl
19 disp('amperes',IImax)
```

```

20 disp(" Transistor specification is")
21 disp(" npn  Ie (max) >42mA  Vcemax>Vcc=12V")
22 disp(" Vr1=6V")
23 disp(" PD=Iemax (Vcc-Vr1)")
24 Iemax=0.042
25 Vr1=6
26 Pd=Iemax*(Vcc-Vr1)
27 disp(' watts ',Pd)
28 disp(" hfe (min)=20")
29 disp(" Iomax=Ilmax/hfe (min)")
30 hfe=20
31 Iomax=Ilmax/hfe
32 disp(' amperes ',Iomax)
33 disp(" use opamp with a compesating capacitor")

```

Scilab code Exa 6.2 Precision Voltage source

```

1 disp(' chapter 6 ex6.2 ')
2 disp(' given ')
3 disp(" precision voltage source to be designed")
4 disp(" constant output voltage=9V")
5 Vo=9
6 disp(" available supply voltage=+/-12V")
7 Vcc=12
8 disp(" allow 10% tolerance on zener diode")
9 disp(" Vz=Vo/2")
10 Vz=Vo/2
11 disp(' volts ',Vz)
12 disp(" assuming Vz=4.3V")
13 Vz=4.3
14 disp(" diode current is Iz=20mA")
15 Iz=.02
16 disp(" R1=(Vo-Vz)/Iz")
17 R1=(Vo-Vz)/Iz
18 disp(' ohms ',R1)

```

```

19 disp(" assuming standard value for R1=220")
20 R1=220
21 disp(" for R2,R3,R4 I2>>Ibmax")
22 disp(" Ibmax=500nA")
23 Ibmax=500*10^(-9)
24 disp(" I2=100*Ibmax")
25 I2=100*Ibmax
26 disp(' amperes ', I2)
27 disp(" let R34=R3+R4")
28 disp(" R34=(Vz+0.1*Vz)/I2")
29 R34=(Vz+0.1*Vz)/I2
30 disp(' ohms ', R34)
31 disp(" R4=20% of (R3+R4)")
32 R4=.2*R34
33 disp(' ohms ', R4)
34 disp(" Use 20 Kohms std value")
35 R4=20000
36 disp(" R3=R34-R4")
37 R3=R34-R4
38 disp(' ohms ', R3)
39 disp(" use R3=68Kohms std value")
40 R3=68000
41 disp(" I2=(Vz+0.1*Vz)/(R3+R4)")
42 I2=(Vz+0.1*Vz)/(R3+R4)
43 disp(' amperes ', I2)
44 disp(" R2=(Vo-(Vr3+Vr4))/I2")
45 R2=(Vo-(Vz+0.1*Vz))/I2
46 disp(' ohms ', R2)

```

Scilab code Exa 6.3 Current source

```

1 disp(' chapter 6 ex6.3 ')
2 disp(' given ')
3 disp(" current source to be designed")
4 disp(" constant output current=100mA")

```

```

5 I1=.1
6 disp("maximum load resistance=40ohms")
7 Rlmax=40
8 disp("available supply voltage=+/-12V")
9 Vcc=12
10 disp("for P MOSFET Vdsmax=100 Idmax=210mA Rdon=5")
11 Vdsmax=100
12 Idmax=0.210
13 Rdon=5
14 disp("Vdsmax=Vcc=12")
15 disp("Idmax=I1=100mA")
16 Vdsmax=Vcc
17 Idmax=I1
18 disp("Vlmax=I1*Rlmax")
19 Vlmax=I1*Rlmax
20 disp('volts',Vlmax)
21 disp("Vdsmin=(Id*Rdon)+1")
22 Vdsmin=(I1*Rdon)+1
23 disp('volts',Vdsmin)
24 disp("Vr1(max)=Vcc-Vlmax-Vdsmin")
25 Vr1max=Vcc-Vlmax-Vdsmin
26 disp('volts',Vr1max)
27 disp("R1=Vr1/I1")
28 R1=Vr1max/I1
29 disp('ohms',R1)
30 disp("use R1=56ohms std value")
31 R1=56
32 disp("Vr1=I1*R1")
33 Vr1=I1*R1
34 disp('volts',Vr1)

```

Scilab code Exa 6.4 Precision current sink

```

1 disp('chapter 6 ex6.4')
2 disp('given')

```

```

3 disp("precision current sink to be designed")
4 disp("constant output current=100mA")
5 I1=.075
6 disp("maximum load resistance=50ohms")
7 Rlmax=50
8 disp("available supply voltage=+/-15V")
9 Vcc=15
10 disp("for 2N222N n-channel MOSFET Vdsmax=60 Idmax
      =150mA Rdon=7.5ohm")
11 disp("Vdsmax=Vcc=15")
12 disp("Idmax=I1=75mA")
13 Vdsmax=Vcc
14 Idmax=I1
15 Rdon=7.5
16 disp("Vlmax=I1*Rlmax")
17 Vlmax=I1*Rlmax
18 disp('volts',Vlmax)
19 disp("Vdsmin=(Id*Rdon)+1")
20 Vdsmin=(I1*Rdon)+1
21 disp('volts',Vdsmin)
22 disp("Vr5max=Vcc-Vlmax-Vdsmin")
23 Vr5max=Vcc-Vlmax-Vdsmin
24 disp('volts',Vr5max)
25 disp("R5=Vr5/I1")
26 R5=Vr5max/I1
27 disp('ohms',R5)
28 disp("use R5=120ohms std value")
29 R5=120
30 Vr5=I1*R5
31 disp('volts',Vr5)
32 disp("remaining component calculation is same as for
      ex 6.2")

```

Scilab code Exa 6.5 HWR voltmeter

```

1 disp('chapter 6 ex6.5 ')
2 disp('given ')
3 disp("design of half wave rectifier")
4 disp("rms input=1V")
5 Vi=1
6 disp("average meter current 100uA with a resistance
      coil 2.5 K is connected")
7 Iav=100*10^(-6)
8 Rm=2500
9 disp("for HWR Ip=2*Iav/0.637")
10 Ip=2*Iav/0.637
11 disp(' amperes ',Ip)
12 disp("Ip occurs when i/p voltage is at Vp")
13 disp("Vp=1.414*Vi")
14 Vp=1.414*Vi
15 disp(' volts ',Vp)
16 disp("R2=Vp/Ip")
17 R2=Vp/Ip
18 disp(' ohms ',R2)
19 disp("use R2=3.9 Kohm std value and 1Kohm variable
      in series")
20 disp("For Opamp")
21 disp("Vd1=0.7")
22 Vd1=0.7
23 disp("opamp voltage range Vomax=Vd1+Ip*(Rm+R2)")
24 Vomax=Vd1+Ip*(Rm+R2)
25 disp(' volts ',Vomax)
26 disp("input voltage range Vimax=1,414V(peak)")
27 disp("Upper cutoff frequency=1KHz")
28 disp("For LM108")
29 disp("supply voltage can be Vcc=+/-5V to +/-20V")
30 disp("R1=1Mohm")
31 R1=1000000
32 disp("C1=1/(2*pi*fl*(R1/10))")
33 fl=10
34 C1=1/(2*pi*fl*(R1/10))
35 disp(' farads ',C1)
36 disp("for diodes")

```

37 `disp("Irmax=Ip=314uA and F(max)>1KHz")`

Scilab code Exa 6.6 Linear ohmmeter

```
1 disp('chapter 6 ex6.6')
2 disp('given')
3 disp("design a linear ohmmeter circuit")
4 disp("Im=100uA and coil resistance=2.5kohm")
5 Im=100*10(-6)
6 Rm=2500
7 disp("required ohmmeter ranges are 100ohm,1kohm,10
      kohm")
8 R1=100
9 R2=1000
10 R3=10000
11 disp("design voltmeter of full scale deflection of 1
      V to keep min power dissipation")
12 disp("R5=Vrx/Im")
13 Vrx=1
14 Vr5=1
15 R5=Vrx/Im
16 disp('ohms',R5)
17 disp("for opamp A2 Vomax=Vr5+ImRm")
18 Vomax=Vr5+Im*Rm
19 disp("Vimax=Vrx")
20 Vimax=Vrx
21 disp("for current source")
22 disp("Ix=1/100,1/1000,1/10000")
23 Ix3=1/100
24 disp('amperes',Ix3)
25 Ix2=1/1000
26 disp('amperes',Ix2)
27 Ix1=1/10000
28 disp('amperes',Ix1)
29 disp("for p FET Idmax=10mA Vdsm=Vcc")
```

```

30 disp("2N4342 is a suitable device its Vgsoff=5.5v")
31 Vgsoff=5.5
32 Vgsmax=Vgsoff
33 disp("this allows opamp o/p to be atleast 3V below
      to operate safely")
34 disp(" Vr4min=Vgsoff+3")
35 Vr4min=Vgsoff+3
36 disp(' volts ',Vr4min)
37 disp(" use Vr4=10V std")
38 Vr4=10
39 disp(" R4=Vr4/Ix for 100uA,1mA,10mA")
40 R4=Vr4/Ix1
41 disp(' ohms ',R4)
42 R4=Vr4/Ix2
43 disp(' ohms ',R4)
44 R4=Vr4/Ix3
45 disp(' ohms ',R4)
46 disp(" for satisfactory operation Vdsmin=Vgsoff+1")
47 Vdsmin=Vgsoff+1
48 disp(' volts ',Vdsmin)
49 disp(" Vccmin=Vrx+Vdsmin+Vr4")
50 Vccmin=Vrx+Vdsmin+Vr4
51 disp(' volts ',Vccmin)
52 disp(" use Vcc=+-18V")
53 Vcc=18
54 disp(" for opamp A1")
55 disp(" Vomax=Vcc-Vr4+Vgsmax")
56 Vomax=Vcc-Vr4+Vgsmax
57 disp(' volts ',Vomax)
58 disp(" Vimax=Vcc-Vr4")
59 Vimax=Vcc-Vr4
60 disp(' volts ',Vimax)
61 disp(" for potential divider")
62 disp(" I1>>Ibmax for A1")
63 disp(" I1=50uA")
64 I1=50*10^(-6)
65 disp(" V(r1+r2)=Vr4+10%")
66 Vr1r2=Vr4+0.1*Vr4

```

```

67 disp(' volts ',Vr1r2)
68 disp(" R12=R1+R2=Vr1r2/I1")
69 R12=Vr1r2/I1
70 disp(" R2=20% of R1+R2")
71 R2=0.2*R12
72 disp(' ohms ',R2)
73 disp(" use R2=50kohm std value")
74 R2=50000
75 disp(" R1=R12-R2")
76 R1=R12-R2
77 disp(' ohms ',R1)
78 disp(" use R1=150Kohm std value")
79 R1=150000
80 disp(" I1=V(r1+r2)/(R1+R2)")
81 I1=Vr1r2/(R1+R2)
82 disp(' amperes ',I1)
83 disp(" R3=(Vcc-V(r1+r2))/I1")
84 R3=(Vcc-Vr1r2)/I1
85 disp(' ohms ',R3)
86 disp(" use 120Kohm std value")

```

Scilab code Exa 6.7 Instrumentation Amplifier

```

1 disp(' chapter 6 ex6.7 ')
2 disp(' given ')
3 disp(" design a instrument amplifier circuit ")
4 disp(" overall gain=900")
5 Av=900
6 disp(" i/p signal amplitude=15mV")
7 Vi=0.015
8 disp(" Supply voltage=15")
9 Vcc=15
10 disp(" For stage 1")
11 disp(" v1 =Av2")
12 Av1=sqrt(Av)

```

```

13 Av2=Av1
14 disp(Av1,"Av1=Av2=")
15 disp("I2>>Ibmax")
16 disp("Ibmax=500nA")
17 Ibmax=500*10^(-9)
18 disp("I2=100*Ibmax")
19 I2=100*Ibmax
20 disp(' amperes ',I2)
21 disp("R2=Vi/I2")
22 R2=Vi/I2
23 disp(' ohms ',R2)
24 disp("use R2=270ohms std value")
25 disp("Avdif=(2R1+R2)/R2")
26 R2=270
27 disp("R1=R2(Av1-1)/2")
28 R1=R2*(Av1-1)/2
29 disp(' ohms ',R1)
30 disp("Use R1=3.9Kohm std value")
31 R1=3900
32 disp("R3=R1")
33 R3=R1
34 disp("For stage 2")
35 disp("Vo=Av*Vi")
36 Vo=Av*Vi
37 disp(' volts ',Vo)
38 disp("I5>>Ibmax")
39 disp("Ibmax=500nA")
40 disp("I2=100*Ibmax")
41 I5=100*Ibmax
42 disp(' amperes ',I5)
43 disp("R5=Vo/I5")
44 R5=Vo/I5
45 disp(' ohms ',R5)
46 disp("R4=R5/Av2")
47 R4=R5/Av2
48 disp(' ohms ',R4)
49 disp("R6=R4")
50 R6=R4

```

```
51 disp("R7=R5+-20%")
52 R7=R5+0.2*R5
53 disp('ohms',R7)
54 R7=R5-0.2*R5
55 disp('ohms',R7)
56 disp("use 220kohm fixed resistor and 100kohm
      resistor variable")
```

Chapter 7

Signal Processing Circuits

Scilab code Exa 7.1 Precision Half Wave rectifier

```
1 disp('chapter 7 ex7.1')
2 disp('given')
3 disp('Design a nonsaturating precision half wave
   rectifier')
4 disp('peak output Vo=2volt')
5 Vo=2
6 disp('input peak value Vi=.5volt')
7 Vi=0.5
8 disp('frequency f=1MHz')
9 f=1*10^(6)
10 disp('supply voltage Vcc=+or-15volt and Vee=15volt')
    //(using bipolar op-amp)
11 Vcc=15
12 Vee=15
13 disp('I1>IBmax')
14 disp('I1=500*10^(-6)A') //for adequate diode
    current
15 I1=500*10^(-6)
16 disp('R1=Vi/I1')
17 R1=Vi/I1
18 disp('ohms',R1) //standard value
```

```

19 disp('R2=Vo/I1')
20 R2=Vo/I1
21 disp('ohms',R2)
22 disp('use 3.9kohm standard value')
23 R2=3900
24 disp('R3=R1||R2')
25 R3=R1*R2/(R1+R2)
26 disp('ohms',R3) //use 820ohm standard value
27 disp('for diode D1 and D2')
28 disp('Vr>[Vcc-(-Vee)]')
29 Vr=[Vcc-(-Vee)]
30 disp('volts',Vr)
31 disp('trr<T')
32 disp('let trrmax=T/10=1/(10*f)')
33 trrmax=1/(10*f)
34 disp('seconds',trrmax) //compensate the op-amp as a
    voltage follower

```

Scilab code Exa 7.2 Precision full Wave rectifier

```

1 disp('chapter 7 ex7.2')
2 disp('given')
3 disp('Design a precision full-wave rectifier circuit
    ')
4 disp('peak output Vo=2volt')
5 Vo=2
6 disp('input peak value Vi=.5 volt')
7 Vi=0.5
8 disp('frequency f=1MHz')
9 f=1*10^(6)
10 disp('supply voltage Vcc=+or-15volt') //(using
    bipolar op-amp)
11 Vcc=15
12 disp('I1>IBmax')
13 disp('let I1=500*10^(-6)A') //for adequate diode

```

```

        current
14 I1=500*10(-6)
15 disp('R1=Vi/I1')
16 R1=Vi/I1
17 disp('ohms',R1) //standard value
18 disp('R2=2*R1')
19 R2=2*R1
20 disp('ohms',R2) //use two 1kohm resistors in
        series
21 disp('R3=R1||R2')
22 R3=R1*R2/(R1+R2)
23 disp('ohms',R3) //use 680ohm standard value
24 disp('R4=R5=R1=1kohm')
25 R4=1000
26 R5=1000
27 disp('for the output to be 2volt when the input is
        0.5 volt')
28 disp('R6=Vo/Vi*R5')
29 R6=Vo/Vi*R5
30 disp('ohms',R6)
31 disp('use standard value R6=3.9kohm')
32 R6=3900
33 disp('R7=R4||R5||R6')
34 R7=R4*R5*R6/(R4*R5+R5*R6+R6*R4)
35 disp('ohms',R7) //use 470ohm standard value
36 disp('For diode D1 and D2, Vr>30volt and trrmax=0.1
        microsec as in ex7.1')
37 disp('Compensate A1 as a voltage follower')
38 disp('A2 for gain of R6+R4||R5/(R4||R5)')
39 A2=(R6+(R4*R5/(R4+R5)))/(R4*R5/(R4+R5))
40 disp(A2)

```

Scilab code Exa 7.3 High Zin Precision full Wave rectifier

```

1 disp('chapter 7 ex7.3')

```

```

2 disp('given')
3 disp('Design a high input impedance precision full-
    wave rectifier circuit')
4 disp('input peak value Vi=1volt')
5 Vi=1
6 disp('supply voltage Vcc=+or-15volt') //(using
    bipolar op-amp)
7 Vcc=15
8 disp('let I6=500*10^(-6)A') //for adequate diode
    current
9 I6=500*10^(-6)
10 disp('R6=Vi/I6')
11 R6=Vi/I6
12 disp('ohms',R6)
13 disp('use 1.8kohm standard value')
14 R6=1800
15 disp('R4=R5=R6=1.8kohm') //standard value
16 R4=1800
17 R5=1800
18 disp('R3=2*R4')
19 R3=2*R4
20 disp('ohms',R3) //use two 1.8kohm resistors in
    series
21 disp('R1=R3||R4')
22 R1=R3*R4/(R3+R4)
23 disp('ohms',R1) //standard value
24 disp('R2=R6||R5')
25 R2=R6*R5/(R6+R5)
26 disp('ohms',R2) //use 1kohm standard value
27 disp('compensate the op-amps for Av1=2 and A2 as a
    voltage follower')

```

Scilab code Exa 7.4 Peak clipping circuit

```

1 disp('chapter 7 ex7.4')

```

```

2 disp('given')
3 disp('Design an adjustable peak clipping circuit')
4 disp('Vomax=+or-5volt and Vomin=+or-3volt')
5 Vomax=5
6 Vomin=3
7 disp('Vf=0.7 volt')
8 Vf=0.7
9 disp('Vomax=Vz+Vf')
10 Vz=Vomax-Vf
11 disp('volts',Vz) //use a 1N 749 Zener diode
12 disp('I1>Izmin=500*10^(-6)A')
13 disp('let I1min=2*10^(-3)A')
14 I1min=2*10^(-3)
15 disp('R2=Vomin/I1min')
16 R2=Vomin/I1min
17 disp('ohms',R2) //standard value
18 disp('VR4=Vomax-Vomin')
19 VR4=Vomax-Vomin
20 disp('volts',VR4)
21 disp('R4=VR4/I1min')
22 R4=VR4/I1min
23 disp('ohms',R4) //standard potentiometer value
24 disp('for Av=1,R1+R4=R2')
25 Av=1
26 R1=R2-R4
27 disp('ohms',R1)
28 disp('use 470ohm standard value')
29 R1=470
30 disp('R3=(R1+R4)||R2')
31 R3=((R1+R4)*R2)/(R1+R4+R2)
32 disp('ohms',R3) //use 680ohm standard value

```

Scilab code Exa 7.5 Dead zone circuit

```

1 disp('chapter 7 ex7.5')

```

```

2 disp('given')
3 disp('Design a dead zone circuit using BIFET op-amp'
      )
4 disp('voltage of 1volt to pass only in upper portion
      ')
5 disp('peak voltage Vp=3volt')
6 Vp=3
7 disp('Vref=Vp-1')
8 Vref=Vp-1
9 disp('volts',Vref)
10 disp('Ir1min=Idmin=500*10^(-6)')
11 Ir1min=500*10^(-6)
12 disp('R1=Vref/Ir1min')
13 R1=Vref/Ir1min
14 disp('ohms',R1)
15 disp('use standard value R1=3.9kohm')
16 R1=3900
17 disp('R2=R3=R1=3.9kohm')
18 R2=3900
19 R3=3900
20 disp('R4=R1||R2||R3')
21 R4=R1*R2*R3/(R1*R2+R2*R3+R3*R1)
22 disp('ohms',R4)
23 disp('use 1.2kohm standard value')
24 disp('select the diodes as in ex7.1 and compensate
      the op-amp as a voltage follower')

```

Scilab code Exa 7.6 precision clipping circuit

```

1 disp('chapter 7 ex7.6')
2 disp('given')
3 disp('Design a precision clipping circuit to clip
      100kHz sine wave')
4 disp('Vref for A1=3volt')
5 disp('Vref for A2=-3volt')

```

```

6 Vref=3
7 disp('Ir1min>IBmin for op-amps')
8 disp('let Ir1min=500*10^(-6)A') //adequate diode
   current
9 Ir1=500*10^(-6)
10 disp('R1=Vref/Ir1')
11 R1=Vref/Ir1
12 disp('ohms',R1)
13 disp('use 5.6kohm standard value')
14 R1=5600
15 disp('R2=R3=R1=5.6kohm')
16 R2=5600
17 R3=5600
18 disp('R4=R1||R2||R3')
19 R4=R1*R2*R3/(R1*R2+R2*R3+R3*R1)
20 disp('ohms',R4)
21 disp('use 1.8kohm standard value')
22 disp('R11=R22=R33=R1=5.6kohm')
23 disp('R44=R4=1.8kohm')
24 disp('R5=R6=R7=R8=R1=5.6kohm')
25 R5=5600
26 R6=5600
27 R7=5600
28 R8=5600
29 disp('R9=R5||R6||R7||R8')
30 R9=R5*R6*R7*R8/(R5*R6*R7+R5*R6*R8+R5*R7*R8+R6*R7*R8)
31 disp('ohms',R9) //use 1.5kohm standard value
32 disp('select the diodes as in ex7.1 and compensate
   A1 and A2 as a voltage follower')
33 disp('compensate A3 for Av=(R8+(R5||R6||R7))/R5||R6
   ||R7')
34 Av=(R8+(R5*R6*R7/(R5*R6+R6*R7+R7*R5)))/(R5*R6*R7/(R5
   *R6+R6*R7+R7*R5))
35 disp(Av)

```

Scilab code Exa 7.7 precision clamping circuit

```
1 disp('chapter 7 ex7.7')
2 disp('given')
3 disp('design op-amp circuit using a supply of +or-12
    volt')
4 disp('voltage Vp=+or-5volt')
5 disp('frequency f=10kHz square wave from signal
    source with resistance Rs=100ohm')
6 Vcc=12
7 Vee=12
8 Vp=5
9 Rs=100
10 f=10000
11 disp('C1=1/(2*Rs*f)')
12 C1=1/(2*Rs*f)
13 disp('farads',C1) //standard value
14 disp('v=1%of 5 volt')
15 v=.01*5
16 disp('volts',v)
17 disp('R1=Vp/(C1*v*f)')
18 R1=Vp/(C1*v*f)
19 disp('ohms',R1) //use 22kohm standard value
20 disp('R2=R1=22kohm')
21 disp('for diodes D1 and D2, Vr>[Vcc-(-Vee)]')
22 Vr=[Vcc-(-Vee)]
23 disp('volts',Vr)
24 disp('trr<T')
25 disp('trrmax=1/(10*f)')
26 trrmax=1/(10*f)
27 disp('seconds',trrmax)
28 disp('compensate the op-amp as for a voltage
    follower')
```

Scilab code Exa 7.8 Peak detector circuit

```

1 disp('chapter 7 ex7.8 ')
2 disp('given ')
3 disp('design a peak detector circuit ')
4 disp('pulse-type signal voltage Vp=2.5volt with a
      rise time tr=5*10^(-6)s ')
5 Vp=2.5
6 tr=5*10^(-6)
7 disp('output voltage is 2.5v for time th=100*10^(-6)
      s ')
8 th=100*10^(-6)
9 disp('maximum output error is to be 1%')
10 disp('use BIFET op-amp for minimum capacitor leakage
      current ')
11 disp('let R1=R2=1Mohm')
12 disp('C1 discharge current ,Id=IrD2=1*10^(-6)A')
13 Id=1*10^(-6)
14 disp('v=1% of Vp')
15 v=.01*Vp
16 disp('volts ',v)
17 disp('C1=Id*th/v')
18 C1=Id*th/v
19 disp('farads ',C1) //standard value
20 disp('for op-amp A1,Iomax=C1*Vp/tr ')
21 Iomax=C1*Vp/tr
22 disp('amperes ',Iomax)
23 disp('slewrates=3*Vp/tr ')
24 slewrates=3*Vp/tr
25 disp('volts/us ',slewrates)

```

Scilab code Exa 7.9 Sample and hold circuit

```

1 disp('chapter 7 ex7.9 ')
2 disp('given ')
3 disp('design the circuit using LF353 BIFET op-amps
      and a 2N4391 FET')

```

```

4 disp('sample and hold circuit has a signal amplitude
      of 1volt')
5 Vi=1
6 disp('holding time th=500*10^(-6)s')
7 th=500*10^(-6)
8 disp('for the LF 353 op-amp,IBmax=50pA')
9 IBmax=50*10^(-12)
10 disp('for the 2N4391 FET,the gate-source reverse
      current IGS=200nA')
11 IGS=200*10^(-9)
12 disp('the channel resistance when on Rd(on)=30ohm')
13 Rd=30
14 disp('let R1=R2=1Mohm')
15 disp('capacitor discharge current Id=IGS=200nA')
16 Id=200*10^(-9)
17 disp('for a 0.2% total error ,allow 0.1% due to
      capacitor discharge and a 0.1% charging error for
      0.1% error due to discharge during the holding
      time')
18 disp('let v=0.1% of Vi')
19 v=.1*Vi/100
20 disp('volts ',v)
21 disp('C1=Id*th/v')
22 C1=Id*th/v
23 disp('farads ',C1) //standard value
24 disp('for the 2N4391 ,VGS(off)=10volt maximum')
25 disp('V1(-)=-10volt and V1(+)=Vo=+1volt')
26 disp('for 0.1% error due to acquisition time timin
      =7*C1*Rd')
27 timin=7*C1*Rd
28 disp('seconds ',timin)

```

Chapter 8

Differentiating and Integrating Circuits

Scilab code Exa 8.1 Differentiating circuit

```
1 disp('chapter 8 ex8.1')
2 disp('given')
3 disp('Design a differentiating circuit')
4 disp('output voltage Vo=5volt')
5 Vo=5
6 disp('input changes by 1volt in a time of
      100*10(-6)')
7 v=1
8 t=100*10(-6)
9 disp('let I1>IBmax')
10 disp('I1=500*10(-6)')
11 I1=500*10(-6)
12 disp('R2=Vo/I1')
13 R2=Vo/I1
14 disp('ohms',R2)
15 disp('C1=I1*t/v')
16 C1=I1*t/v
17 disp('farads',C1)
18 disp('R1=R2/20')
```

```

19 R1=R2/20
20 disp('ohms',R1)
21 disp('use standard value R1=470ohm')
22 R1=470
23 disp('ohms',R1)
24 disp('R3=R2=10kohm')
25 disp('Vcc>=+or -(Vo+3Volt)')
26 Vcc=Vo+3
27 disp('volts',Vcc)
28 disp('compensate the op-amp for Av=R2/R1')
29 Av=R2/R1
30 disp(Av)

```

Scilab code Exa 8.2 slew rate for Differentiating circuit

```

1 disp('chapter 8 ex8.2')
2 disp('given')
3 disp('Determine required minimum slew rate for
   circuit designed in example 8.1')
4 disp('output voltage Vo=5volt')
5 Vo=5
6 disp('input rise time tri=100*10^(-6)')
7 tri=100*10^(-6)
8 disp('C1=.05*10^(-6)F and R2=10kohm')
9 C1=.05*10^(-6)
10 R2=10000
11 disp('output rise time tro=30%of input rise time')
12 tro=.30*tri
13 disp('seconds',tro)
14 disp('Smin=Vo/tro')
15 Smin=Vo/tro
16 disp('V/us',Smin)
17 disp('fc=1/(2*%pi*R2*C1)')
18 fc=1/(2*%pi*R2*C1)
19 disp('Hz',fc)

```

Scilab code Exa 8.3 Integrating Circuit

```
1 disp('chapter 8 ex8.3')
2 disp('given')
3 disp('Design an integrating circuit to produce a
   triangular output wave form')
4 disp('peak to peak amplitude of v=4volt') //(using a
   BIFET op-amp)
5 v=4
6 disp('The input voltage Vi=+or-5volt square wave
   with frequency of 500Hz')
7 Vi=5
8 f=500
9 disp('C1>stray capacitance')
10 disp('let C1=.1*10^(-6)F') //(standard value)
11 C1=.1*10^(-6)
12 disp('t=T/2=1/(2*f)')
13 t=1/(2*f)
14 disp('seconds',t)
15 disp('I1=C1*v/t')
16 I1=C1*v/t
17 disp('Amperes',I1)
18 disp('R1=Vi/I1')
19 R1=Vi/I1
20 disp('ohms',R1) //(use a 12kohm standard value
   with a 470ohm connected in series)
21 disp('R2=20*R1')
22 R2=20*R1
23 disp('ohms',R2) //(use a 270kohm
   standard value)
24 disp('R3=R1=12.5kohm') //(use a 12kohm standard
   value)
```

Scilab code Exa 8.4 slew rate for Integrating circuit

```
1 disp('chapter 8 ex8.4')
2 disp('given')
3 disp('Determine required minimum slew rate for
   circuit designed in example 8.3')
4 disp('output voltage Vo=4volt')
5 Vo=4
6 disp('change in time t=1*10^(-3)')
7 t=1*10^(-3)
8 disp('let C1=.1*10^(-6)F')    //(standard value)
9 C1=.1*10^(-6)
10 disp('R1=12.5kohm')
11 R1=12500
12 disp('Smin=Vo/(t/10)')
13 Smin=Vo/(t/10)
14 disp('V/us',Smin)
15 disp('fc=1/(2*%pi*R1*C1)')
16 fc=1/(2*%pi*R1*C1)
17 disp('Hz',fc)
```

Chapter 9

Op Amp Nonlinear Circuits

Scilab code Exa 9.1 Capacitor coupled zero crossing detector

```
1 disp('chapter 9 ex9.1')
2 disp('given')
3 disp('design a suitable circuit using 741 op-amp
      with a supply of +or-12volt')
4 disp('capacitor coupled zero crossing detector to
      handle 1kHz square wave input with peak-to-peak
      amplitude of 6volt')
5 Vi=6
6 f=1000
7 Vcc=12
8 disp('I2>IBmax')
9 disp('let I2=100*500nA')
10 IBmax=500*10^(-9)
11 I2=100*500*10^(-9)
12 disp('let Vb=0.1volt')
13 Vb=0.1
14 disp('VR2=Vcc-Vb')
15 VR2=Vcc-Vb
16 disp('volts',VR2)
17 disp('R2=VR2/I2')
18 R2=VR2/I2
```

```

19 disp('ohms',R2)
20 disp('use 220kohm standard value and recalculate I2'
    )
21 R2=220000
22 disp('I2=VR2/R2')
23 I2=VR2/R2
24 disp('amperes',I2)
25 disp('VR3=Vb=0.1 volt')
26 VR3=0.1
27 disp('R3=VR3/I2')
28 R3=VR3/I2
29 disp('ohms',R3) //use a 1.8kohm standard value
30 disp('let VBE=0.7 volt')
31 VBE=0.7
32 disp('R1=0.1*VBE/IBmax')
33 R1=0.1*VBE/IBmax
34 disp('ohms',R1)
35 disp('use R1=120kohm standard value')
36 R1=120000
37 disp('Vi(peak)=Vi/2')
38 Vipeak=Vi/2
39 disp('volts',Vipeak)
40 disp('I1=Vipeak/R1')
41 I1=Vipeak/R1
42 disp('amperes',I1)
43 disp('let v=1 volt')
44 v=1
45 disp('t=1/(2*f)')
46 t=1/(2*f)
47 disp('seconds',t)
48 disp('C1=I1*t/v')
49 C1=I1*t/v
50 disp('farads',C1)
51 disp('use a 0.015*10^(-6)F standard value to give v
    <1 volt')

```

Scilab code Exa 9.2 slew rate for Capacitor coupled zero crossing detector

```
1 disp('chapter 9 ex9.2')
2 disp('given')
3 disp('for circuit designed in ex 9.1 estimate
      minimum op-amp slew rate to give a reasonably
      undistorted output')
4 disp('Vcc=12volt ,Vee=12volt and Vosat=1volt')
5 disp('t=500*10^(-6)s')
6 disp('R1=120kohm and C1=0.015*10^(-6)F')
7 Vcc=12
8 Vee=-12
9 Vosat=1
10 t=500*10^(-6)
11 R1=120000
12 C1=0.015*10^(-6)
13 disp('vo=+Vosat -[-Vosat]=(Vcc-1)-(Vee+1)')
14 vo=(Vcc-1)-(Vee+1)
15 disp('volts ',vo)
16 disp('T=0.1*t')
17 T=0.1*t
18 disp('seconds ',T)
19 disp('Smin=vo/T')
20 Smin=vo/T
21 disp('V/us ',Smin)
22 disp('for a maximum phase shift of 2.9degree with a
      sine wave input')
23 disp('Xc1=R1/20')
24 Xc1=R1/20
25 disp('ohms ',Xc1)
26 disp('fmin=1/(2*%pi*Xc1*C1)')
27 fmin=1/(2*%pi*Xc1*C1)
28 disp('Hz ',fmin)
```

Scilab code Exa 9.3 Inverting Schmitt trigger circuit

```
1 disp('chapter 9 ex9.3')
2 disp('given')
3 disp('design an inverting Schmitt trigger circuit to
   have trigger points of +or-2volt')
4 disp('using 741 op-amp with a supply of +or-12volt')
5 disp('I2>IBmax')
6 disp('let I2=50*10^(-6)A')
7 IBmax=500*10^(-9)
8 I2=50*10^(-6)
9 Vcc=12
10 disp('VR2=UTP=2volt')
11 VR2=2
12 disp('R2=VR2/I2')
13 R2=VR2/I2
14 disp('ohms',R2)
15 disp('use 39kohm standard value and recalculate I2')
16 R2=39000
17 disp('I2=VR2/R2')
18 I2=VR2/R2
19 disp('amperes',I2)
20 disp('VR1=Vosat-VR2=(Vcc-1)-VR2')
21 VR1=(Vcc-1)-VR2
22 disp('volt',VR1)
23 disp('R1=VR1/I2')
24 R1=VR1/I2
25 disp('ohms',R1)
26 disp('use 180kohm standard value')
```

Scilab code Exa 9.4 Noninverting Schmitt trigger circuit

```

1 disp('chapter 9 ex9.4')
2 disp('given')
3 disp('design an noninverting Schmitt trigger circuit
      to have UTP=+3volt and LTP=-5volt')
4 disp('using 741 op-amp with a supply of +or-15volt
      and Vf=0.7volt')
5 Vcc=15
6 Vf=0.7
7 disp('design first for the UTP')
8 disp('for adequate diode forward current ,let I2
      =500*10^(-6)A')
9 I2=500*10^(-6)
10 disp('VR1=UTP=3volt')
11 VR1=3
12 disp('R1=VR1/I2')
13 R1=VR1/I2
14 disp('ohms',R1)
15 disp('use 5.6kohm standard value and recalculate I2')
16 R1=5600
17 disp('I2=VR1/R1')
18 I2=VR1/R1
19 disp('amperes',I2)
20 disp('VR2=|Vo|-Vf')
21 VR2=(Vcc-1)-Vf
22 disp('volts',VR2)
23 disp('R2=VR2/I2')
24 R2=VR2/I2
25 disp('ohms',R2)
26 disp('use series connected 22kohm and 2.7kohm
      standard value resistors')
27 disp('now design for LTP,using already selected
      resistance R1=5.6kohm')
28 disp('VR1=LTP=5volt')
29 VR1=5
30 disp('I3=VR1/R1')
31 I3=VR1/R1
32 disp('amperes',I3)

```

```

33 disp('VR3=|Vo|-Vf')
34 VR3=(Vcc-1)-Vf
35 disp('volts',VR3)
36 disp('R3=VR3/I3')
37 R3=VR3/I3
38 disp('ohms',R3)
39 disp('use 15kohm standard value')
40 disp('select the diodes,minimum reverse voltage,Vr>
      Vcc=15volt')
41 disp('trr<=min pulse width/10')

```

Scilab code Exa 9.5 UTP and LTP Noninverting Schmitt trigger circuit

```

1 disp('chapter 9 ex9.5')
2 disp('given')
3 disp('for circuit designed in ex 9.4 calculate the
      actual UTP and LTP using standard resistance
      values')
4 disp('using 741 op-amp with a supply of +or-15volt,
      Vf=0.7volt,R1=5.6kohm,R2=22kohm+2.7kohm and R3=15
      kohm')
5 Vcc=15
6 Vf=0.7
7 R1=5600
8 R2=24700
9 R3=15000
10 disp('I2=(|Vo|-Vf)/R2')
11 I2=((Vcc-1)-Vf)/R2
12 disp('amperes',I2)
13 disp('UTP=I2*R1')
14 UTP=I2*R1
15 disp('volts',UTP)
16 disp('I3=(|Vo|-Vf)/R3')
17 I3=((Vcc-1)-Vf)/R3
18 disp('amperes',I3)

```

```

19 disp('LTP=-I3*R1')
20 LTP=-I3*R1
21 disp('volts',LTP)

```

Scilab code Exa 9.6 Astable Multivibrators

```

1 disp('chapter 9 ex9.6')
2 disp('given')
3 disp('design an astable multivibrator to have a+or-9
      volt output with frequency f=1kHz')
4 disp('using BIFET op-amp for Vo=+or-9volt')
5 f = 1000;
6 Vo=9
7 disp('Vcc=+or-(Vo+1)')
8 Vcc=Vo+1
9 disp('volts',Vcc)
10 disp('select UTP and LTP<Vo')
11 disp('let |UTP|=|LTP|=0.5 volt')
12 UTP=0.5
13 LTP=-0.5
14 disp('let R2=1Mohm')
15 R2=1*10^(6)
16 disp('I3=(|Vo|-UTP)/R2')
17 I3=(Vo-UTP)/R2
18 disp('amperes',I3)
19 disp('R3=UTP/I3')
20 R3=UTP/I3
21 disp('ohms',R3)
22 disp('use 5.6kohm standard value')
23 disp('let C1=0.1*10^(-6)F')
24 C1=0.1*10^(-6)
25 disp('t=1/(2*f)')
26 t=1/(2*f)
27 disp('seconds',t)
28 disp('I1=C1*(UTP-LTP)/t')

```

```

29 I1=C1*(UTP-LTP)/t
30 disp('amperes',I1)
31 disp('R1=(Vo-UTP)/I1')
32 R1=(Vo-UTP)/I1
33 disp('ohms',R1)
34 disp('use 39kohm and3.3kohm in series')

```

Scilab code Exa 9.7 Monostable Multivibrators

```

1 disp('chapter 9 ex9.7')
2 disp('given')
3 disp('design a monostable multivibrator to have
      output pulse width 1ms when triggered by 2volt
      ,100*10(-6)s input pulse')
4 disp('using 741 op-amp with a supply of +or-12volt')
5 PW=1*10(-3)
6 t=100*10(-6)
7 disp('I2>IBmax')
8 disp('let I2=50*10(-6)A and VBE=0.7volt')
9 IBmax=500*10(-9)
10 I2=50*10(-6)
11 VBE=0.7
12 Vcc=12
13 disp('let VR2<Vi')
14 disp('let VR2=0.5volt')
15 VR2=0.5
16 disp('R2=VR2/I2')
17 R2=VR2/I2
18 disp('ohms',R2) //standard value
19 disp('R1=(Vcc-VR2)/I2')
20 R1=(Vcc-VR2)/I2
21 disp('ohms',R1)
22 disp('use 220kohm standard value')
23 R1=220000
24 disp('E=VR2-[-Vosat]')

```

```

25 E=VR2-[-Vcc+1]
26 disp('volts',E)
27 disp('Eo=-(+Vosat-VR2)')
28 Eo=-(Vcc-1-VR2)
29 disp('volts',Eo)
30 disp('ec=Vosat')
31 ec=Vcc-1
32 disp('volts',ec)
33 disp('C2=PW/((R1||R2)*ln[(E-Eo)/(E-ec)])')
34 C2=PW/((R1*R2/(R1+R2))*2.303*log10([(E-Eo)/(E-ec)]))
35 disp('farads',C2)
36 disp('R3max=0.1*VBE/IBmax')
37 R3max=0.1*VBE/IBmax
38 disp('ohms',R3max)
39 disp('use 120kohm standard value')
40 R3=120000
41 disp('C1=0.1*t/R3')
42 C1=0.1*t/R3
43 disp('farads',C1)
44 disp('use 91pF standard value')

```

Chapter 10

Signal Generators

Scilab code Exa 10.1 Triangular and rectangular signal generator

```
1 disp('chapter 10 ex10.1')
2 disp('given')
3 disp('design a triangular rectangular signal
    generator to have 5volt triangular output')
4 disp('frequency ranging from 200Hz to 2kHz and a
    duty cycle adjustable from 20% to 80%')
5 disp('using bipolar op-amps with a supply of +or-15
    volt')
6 Vcc=15
7 Vo=5
8 f1=200
9 f2=2000
10 disp('Schmitt circuit design')
11 disp('I3>IBmax')
12 disp('let I3=50*10(-6)A and Vf=0.7 volt')
13 IBmax=500*10(-9)
14 I3=50*10(-6)
15 Vf=0.7
16 disp('R2=Vosat/I3')
17 R2=(Vcc-1)/I3
18 disp('ohms',R2)
```

```

19 disp('use 270kohm standard value and recalculate I3'
    )
20 R2=270000
21 disp('I3=Vosat/R2')
22 I3=(Vcc-1)/R2
23 disp('amperes',I3)
24 disp('R3=UTP/I3')
25 R3=Vo/2/I3
26 disp('ohms',R3) //use 47kohm and 1kohm
27 disp('integrator circuit')
28 disp('let C1 charging current I1min=50*10^(-6)A')
29 I1min=50*10^(-6)
30 disp('lowest frequency f1 ,PWmax=80%of Tmax')
31 PWmax=0.80*1/f1
32 disp('watts',PWmax)
33 disp('C1=I1min*t/v')
34 C1=I1min*PWmax/Vo
35 disp('farads',C1) //standard value
36 disp('R4+R5+R6=(+Vosat-Vf)/I1min')
37 disp('R9=R4+R5+R6')
38 R9=(Vcc-1-Vf)/I1min
39 disp('ohms',R9)
40 disp('If2=I1min*f2/f1')
41 If2=I1min*f2/f1
42 disp('amperes',If2)
43 disp('R5+R6=(+Vosat-Vf)/If2')
44 disp('R8=R5+R6')
45 R8=(Vcc-1-Vf)/If2
46 disp('ohms',R8)
47 disp('R4=(R4+R5+R6)-(R5+R6)')
48 R4=R9-R8
49 disp('ohms',R4) //use 250kohm standard value
    potentiometer
50 disp('PWmin=20% of Tmax')
51 PWmin=.20*1/f1
52 disp('watts',PWmin)
53 disp('R6=(R5+R6)*PWmin/PWmax')
54 R6=R8*PWmin/PWmax

```

```

55 disp('ohms',R6)
56 disp('use 6.8kohm standard value')
57 R6=6800
58 disp('R5=(R5+R6)-R6')
59 R5=R8-R6
60 disp('ohms',R5) //standard value of potentiometer
61 disp('R7=R6=6.8kohm')

```

Scilab code Exa 10.2 Phase shift oscillator

```

1 disp('chapter 10 ex10.2')
2 disp('given')
3 disp('design a phase shift oscillator to have output
   frequency of 3.5kHz')
4 disp('using 741 op-amp with a supply of +or-12volt')
5 Vcc=12
6 f=3500
7 disp('I1>IBmax')
8 disp('let I1=50*10^(-6)A')
9 IBmax=500*10^(-9)
10 I1=50*10^(-6)
11 disp('Vo=+or-(Vcc-1)')
12 Vo=Vcc-1
13 disp('volts',Vo)
14 disp('R2=Vo/I1')
15 R2=Vo/I1
16 disp('ohms',R2) //standard value
17 disp('let Av=29')
18 Av=29
19 disp('R1=R2/Av')
20 R1=R2/Av
21 disp('ohms',R1)
22 disp('use 6.8kohm to give Av>29')
23 R1=6800
24 disp('R=R1=6.8kohm')

```

```

25 R=6800
26 disp('C=1/(2*%pi*R*f*sqrt(6))')
27 C=1/(2*%pi*R*f*sqrt(6))
28 disp('farads',C) //use 2700pF standard value

```

Scilab code Exa 10.3 Phase shift oscillator

```

1 disp('chapter 10 ex10.3')
2 disp('given')
3 disp('design a phase shift oscillator to have output
      frequency of 6kHz and to give maximum output of
      +or-3volt')
4 Vo=3
5 f=6000
6 disp('let I2=1mA when diodes are forward-biased, i.e
      peak output Vp=3volt and Vf=0.7volt')
7 I2=1*10^(-3)
8 Vf=0.7
9 disp('R1=Vo/29/I2')
10 R1=Vo/29/I2
11 disp('ohms',R1)
12 disp('use 100ohm standard value')
13 R1=100
14 disp('R2=29*R1')
15 R2=29*R1
16 disp('ohms',R2)
17 disp('R3=2*Vf/I2')
18 R3=2*Vf/I2
19 disp('ohms',R3)
20 disp('use 1.5kohm standard value')
21 R3=1500
22 disp('R4=R2-R3')
23 R4=R2-R3
24 disp('ohms',R4)
25 disp('R5=0.4*R4')

```

```

26 R5=0.4*R4
27 disp('ohms',R5) //use a 1kohm potentiometer
28 disp('R6=0.8*R4')
29 R6=0.8*R4
30 disp('ohms',R6) //use 1.2kohm standard value
31 disp('R=R1=100ohm')
32 R=100
33 disp('C=1/(2*%pi*R*f*sqrt(6))')
34 C=1/(2*%pi*R*f*sqrt(6))
35 disp('farads',C) //standard value
36 disp('diodes D1 through D4, trrmax=T/10')
37 trrmax=1/(f*10)
38 disp('seconds',trrmax)
39 disp('Vrmax>Vcc=+or-15volt')
40 disp('the IN914 has trr=4ns and Vrmax=75volt use
      IN914 diodes')

```

Scilab code Exa 10.4 Wein bridge oscillator

```

1 disp('chapter 10 ex10.4')
2 disp('given')
3 disp('design a wein bridge oscillator to have output
      frequency of 15kHz')
4 disp('using BIFET op-amp with a supply of +or-12volt
      ')
5 Vcc=12
6 f=15000
7 disp('select ,C=C1=C2=0.01*10^(-6)F')
8 C=0.01*10^(-6)
9 disp('R=1/(2*%pi*C*f)')
10 R=1/(2*%pi*C*f)
11 disp('ohms',R)
12 disp('use 1kohm standard value')
13 R=1000
14 disp('R1=R2=R=1kohm')

```

```

15 disp('let R4=R2=1kohm')
16 R4=1000
17 disp('R3=2*R4')
18 R3=2*R4
19 disp('ohms',R3)
20 disp('use 2.2kohm standard value to give Av>3')

```

Scilab code Exa 10.5 signal generator

```

1 disp('chapter 10 ex10.5')
2 disp('given')
3 disp('design a signal generator output stage to
      afford output amplitude from +or-0.1 to 5volt')
4 Vom=0.1
5 Vomax=5
6 disp('dc voltage level control over a range of +or
      -2.5volt')
7 disp('signal applied output stage has a +or-1volt
      amplitude and frequency ranging from 50Hz to 20
      kHz')
8 Vi=1
9 fmin=50
10 fmax=20000
11 VR4=2.5-(-2.5)
12 disp('using a bipolar op-amp with a +or-15volt
      supply')
13 Vcc=15
14 disp('I1>IBmax')
15 disp('let I1=50*10^(-6)A')
16 IBmax=500*10^(-9)
17 I1=50*10^(-6)
18 disp('R1=Vi/I1')
19 R1=Vi/I1
20 disp('ohms',R1)
21 disp('use 18kohm standard value')

```

```

22 R1=18000
23 disp('R2max=Vomax/Vi*R1')
24 R2max=Vomax/Vi*R1
25 disp('ohms',R2max)
26 disp('R2min=Vomin/Vi*R1')
27 R2min=Vomin/Vi*R1
28 disp('ohms',R2min)
29 disp('for R2,use a 100kohm potentiometer in series
      with a 1.8kohm resistor')
30 disp('I3>IBmax')
31 disp('let I3=50*10(-6)A')
32 I3=50*10(-6)
33 disp('R4=VR4/I3')
34 R4=VR4/I3
35 disp('ohms',R4) //standard potentiometer
36 disp('R3=VR3/I3')
37 VR3=Vcc-2.5
38 R3=VR3/I3
39 disp('ohms',R3)
40 disp('use 220kohm to give larger output adjustment
      than required')
41 disp('R5=R3=220kohm')
42 disp('Xc1<R1 at fmin')
43 disp('let Xc1=R1/10 at fmin')
44 disp('C1=1/(2*%pi*fmin*R1/10)')
45 C1=1/(2*%pi*fmin*R1/10)
46 disp('farads',C1) //standard value

```

Chapter 11

Active Filters

Scilab code Exa 11.1 All pass circuit

```
1 disp('chapter 11 ex11.1 ')
2 disp('given ')
3 disp('design an all-pass circuit to have phase lag
   from 80degree to100degree')
4 disp('using a 741op-amp the input signal has a 1
   volt amplitude and a 5kHz frequency')
5 Vi=1
6 f=5000
7 disp('I1>IBmax ')
8 disp('let I1=50*10^(-6)A')
9 IBmax=500*10^(-9)
10 I1=50*10^(-6)
11 disp('R1=Vi/I1 ')
12 R1=Vi/I1
13 disp('ohms ',R1)
14 disp('use 18kohm standard value')
15 R1=18000
16 disp('R2=R1=18kohm ')
17 R2=18000
18 disp('R3=R1 || R2 ')
19 R3=R1*R2/(R1+R2)
```

```

20 disp('ohms',R3)
21 disp('for a 90degree phase shift ,Xc1=R3')
22 disp('C1=1/(2*%pi*f*R3)')
23 C1=1/(2*%pi*f*R3)
24 disp('farads',C1)
25 disp('use 3600pF standard value')
26 C1=3600*10(-12)
27 disp('for a 80degree phase shift ,R3=tan(theta1/2)/(w
      *C1)')
28 theta1=80
29 R3=tan(theta1*%pi/180/2)/(2*%pi*f*C1)
30 disp('ohms',R3)
31 disp('for a 100degree phase shift ,R3=tan(theta2/2)/(
      w*C1)')
32 theta2=100
33 R3=tan(theta2*%pi/180/2)/(2*%pi*f*C1)
34 disp('ohms',R3)
35 disp('for R3,use a 6.8kohm fixed value resistor in
      series with a 5kohm variable resistor to give a
      total resistance adjustable from 6.8kohm to 11.8
      kohm')

```

Scilab code Exa 11.2 First order active low pass filter

```

1 disp('chapter 11 ex11.2')
2 disp('given')
3 disp('design a first order active low-pass filter to
      have cutoff frequency 1kHz')
4 disp('R1=70mV/IBmax')
5 disp('let IBmax=500*10(-9)A')
6 IBmax=500*10(-9)
7 R1=70*10(-3)/IBmax
8 fc=1000
9 disp('ohms',R1)
10 disp('use 120kohm standard value')

```

```

11 disp('R2=R1=120kohm')
12 R1=120000
13 R2=120000
14 disp('Xc1=R1 at fc')
15 disp('C1=1/(2*%pi*fc*R1)')
16 C1=1/(2*%pi*fc*R1)
17 disp('farads',C1)
18 disp('use 1300pF standard value')

```

Scilab code Exa 11.3 Second order low pass filter

```

1 disp('chapter 11 ex11.3')
2 disp('given')
3 disp('design a second order low-pass filter to have
      cutoff frequency 1kHz')
4 disp('the frequency response of 741 extends to 800
      kHz when its voltage gain is 1 so 741op-amp is
      suitable')
5 disp('R1+R2=70mV/IBmax')
6 disp('R4=R1+R2')
7 disp('let IBmax=500*10^(-9)A')
8 IBmax=500*10^(-9)
9 R4=70*10^(-3)/IBmax
10 fc=1000
11 disp('ohms',R4)
12 disp('R2=R1=70kohm')
13 disp('use 68kohm standard value')
14 R1=68000
15 R2=68000
16 disp('R3=R1+R2')
17 R3=R1+R2
18 disp('ohms',R3)
19 disp('use 150kohm standard value')
20 disp('Xc1=sqrt(2)*R2 at fc')
21 disp('C1=1/(2*%pi*fc*sqrt(2)*R2)')

```

```

22 C1=1/(2*%pi*fc*sqrt(2)*R2)
23 disp('farads',C1)
24 disp('use 1600pF standard value')
25 C1=1600*10^(-12)
26 disp('C2=2*C1')
27 C2=2*C1
28 disp('farads',C2)

```

Scilab code Exa 11.4 First order active high pass filter

```

1 disp('chapter 11 ex11.4')
2 disp('given')
3 disp('design a first order active high-pass filter
   to have cutoff frequency 5kHz')
4 disp('using LM108 op-amp which has extremely low
   input bias current, should be treated as BIFET op-
   amp therefore C1=1000pF')
5 C1=1000*10^(-12)
6 fc=5000
7 disp('R1=1/(2*%pi*fc*C1)')
8 R1=1/(2*%pi*fc*C1)
9 disp('ohms',R1)
10 disp('use 31.6kohm+or-1% standard value')
11 disp('R1=R2=31.6kohm')
12 disp('from LM108 gain/frequencyresponse .the op-amp
   unity gain frequency is fu=1MHz')
13 Av=1
14 fu=1*10^(6)
15 disp('f2=fu/Av')
16 f2=fu/Av
17 disp('Hz',f2)

```

Scilab code Exa 11.5 second order active high pass filter

```

1 disp('chapter 11 ex11.5')
2 disp('given')
3 disp('design a second order high-pass filter to have
      cutoff frequency 12kHz')
4 disp('from 715 data sheet ,IBmax=1.5*10^(-6)A')
5 fc=12000
6 IBmax=1.5*10^(-6)
7 disp('R2=70mV/IBmax')
8 R2=70*10^(-3)/IBmax
9 disp('ohms',R2)
10 disp('R1=R2/2')
11 R1=R2/2
12 disp('ohms',R1)
13 disp('use 22kohm and 1.5kohm in series')
14 disp('R3=R2=47kohm')
15 R3=47000
16 R2=47000
17 disp('R2=sqrt(2)*Xc2 at fc')
18 disp('C2=1/(2*pi*fc*R2/sqrt(2))')
19 C2=1/(2*pi*fc*R2/sqrt(2))
20 disp('farads',C2)
21 disp('use 390pF standard value')
22 disp('C1=C2=390pF')
23 disp('from 715 data sheet the op-amp unity gain
      cutoff frequency is fu=11MHz')
24 Av=1
25 fu=11*10^(6)
26 disp('f2=fu/Av')
27 f2=fu/Av
28 disp('Hz',f2)

```

Scilab code Exa 11.6 Third order low pass filter

```

1 disp('chapter 11 ex11.6')
2 disp('given')

```

```

3 disp('design a third order active low-pass filter to
      have cutoff frequency 30kHz')
4 fc=30000
5 disp('-20dB per decade stage(first order)')
6 disp('select C1=1000pF')
7 C1=1000*10^(-12)
8 disp('Xc1=R1 at fc/0.65')
9 disp('R1=0.65/(2*pi*fc*C1)')
10 R1=0.65/(2*pi*fc*C1)
11 disp('ohms',R1) //use 3.4kohm+or-1%standard value
12 disp('R2=R1=3.4kohm') //use 3.3kohm standard value
13 disp('-40dB per decade stage(second order)')
14 disp('select C3=1000pF')
15 C3=1000*10^(-12)
16 disp('Xc3=sqrt(2)*R4 at fc/0.8')
17 disp('R4=0.8/(2*pi*fc*sqrt(2)*C3)')
18 R4=0.8/(2*pi*fc*sqrt(2)*C3)
19 disp('ohms',R4) //use two 5.9kohm+or-1% parallel-
      connected
20 disp('C2=2*C3')
21 C2=2*C3 //standard value
22 disp('farads',C2)
23 disp('R3=R4=2.95kohm')
24 R3=2950
25 disp('R5=R4+R3')
26 R5=R4+R3
27 disp('ohms',R5) //use 5.6kohm standard value

```

Scilab code Exa 11.7 Third order high pass filter

```

1 disp('chapter 11 ex11.7')
2 disp('given')
3 disp('design a third order active high-pass filter
      to have cutoff frequency 20kHz')
4 fc=20000

```

```

5 disp('−20dB per decade stage(first order)')
6 disp('let R1=120kohm')
7 R1=120000
8 disp('Xc1=R1 at 0.65*fc')
9 disp('C1=1/(2*%pi*0.65*fc*R1)')
10 C1=1/(2*%pi*0.65*fc*R1)
11 disp('farads',C1)
12 disp('this is so small that it can be affected by
      stray capacitance and redesign selecting C1')
13 disp('select C1=1000pF')
14 C1=1000*10^(-12)
15 disp('R1=1/(2*%pi*0.65*fc*C1)')
16 R1=1/(2*%pi*0.65*fc*C1)
17 disp('ohms',R1) //use 12kohm standard value
18 disp('R2=R1=12kohm')
19 disp('−40dB per decade stage(second order)')
20 disp('select C3=1000pF')
21 C3=1000*10^(-12)
22 disp('R4=sqrt(2)*Xc3 at 0.8*fc')
23 disp('R4=sqrt(2)/(2*%pi*0.8*fc**C3)')
24 R4=sqrt(2)/(2*%pi*0.8*fc*C3)
25 disp('ohms',R4) //use 14kohm+or−1% standard value
26 disp('C2=C3=1000pF')
27 disp('R3=R4/2')
28 R3=R4/2
29 disp('ohms',R3) //use 6.98kohm standard value
30 disp('R5=R4=14.06kohm') //use 15kohm standard
    value

```

Scilab code Exa 11.8 Highest signal frequency in 3rd order HPF

```

1 disp('chapter 11 ex11.8')
2 disp('given')
3 disp('the circuit designed in ex11.7 estimate the
      highest frequency')

```

```

4 disp('from 741 data sheet ,the op-amp unity gain
      cutoff frequency is fu=800kHz')
5 disp('f=fu/Av')
6 fu=800000
7 Av=1
8 f=fu/Av
9 disp('Hz',f)
10 disp('the circuit upper cutoff frequency is ,fc=0.65*
      f')
11 fc=0.65*f
12 disp('Hz',fc)

```

Scilab code Exa 11.9 Single stage band pass filter

```

1 disp('chapter 11 ex11.9')
2 disp('given')
3 disp('design a single stage bandpass filter')
4 disp('voltage gain Av=1 and a pass band from 300Hz
      to 30kHz')
5 Av=1
6 f2=30000
7 f1=300
8 disp('select C2=1000pF')
9 C2=1000*10^(-12)
10 disp('Xc2=R2 at f2')
11 disp('R2=1/(2*%pi*f2*C2)')
12 R2=1/(2*%pi*f2*C2)
13 disp('ohms',R2) //use 5.36kohm+or-1% standard
      value
14 disp('R3=R2=5.36kohm') //use 5.6kohm standard
      value
15 disp('for Av=1,R1=R2=5.36kohm')
16 R1=5360
17 disp('C1=1/(2*%pi*f1*R1)')
18 C1=1/(2*%pi*f1*R1)

```

```
19 disp('farads',C1) //standard value
```

Scilab code Exa 11.10 Bandpass Filter

```
1 disp('chapter 11 ex11.10')
2 disp('given')
3 disp('design a bandpass filter using 741 op-amp')
4 disp('the center frequency fo=1kHz and pass band is
      to be +or-33Hz on each side')
5 disp('B=33+33=66')
6 fo=1000
7 B=66
8 disp('Q=fo/B')
9 Q=fo/B
10 disp(Q)
11 disp('R2=R3=120kohm')
12 R2=120000
13 disp('C=2*Q/(2*pi*fo*R2)')
14 C=2*Q/(2*pi*fo*R2)
15 disp('farads',C)
16 disp('C1=C2=C=0.0403*10^(-6)F')
17 disp('R1=R2/2')
18 R1=R2/2
19 disp('ohms',R1) //use 60.4kohm+or-1% standard
      value
20 disp('R4=R1/(2*Q*Q-1)')
21 R4=R1/(2*Q*Q-1)
22 disp('ohms',R4)
```

Scilab code Exa 11.11 State variable bandpass filter

```
1 disp('chapter 11 ex11.11')
2 disp('given')
```

```

3 disp('design a bandpass filter to have f1=10.3kHz f2
      =10.9kHz')
4 f1=10300
5 f2=10900
6 disp(" select C1=C2=1000pF")
7 C1=1000*10^(-12)
8 C2=1000*10^(-12)
9 disp(" fo=sqrt(f1*f2)")
10 fo=sqrt(f1*f2)
11 disp('Hz',fo)
12 disp("R5=R6=1/(2*pi*C1*f1)")
13 R6=1/(2*pi*C1*f1)
14 R5=R6
15 disp('ohms',R6)
16 disp("Use 15kohm std value")
17 R5=15000
18 disp("R1=R3=R4=R7=R8=R6=R5=15kOhm")
19 disp("Q=fo/(f2-f1)")
20 Q=fo/(f2-f1)
21 disp(Q)
22 R1=R5
23 disp("R2=R1*(2Q-1)")
24 R2=R1*(2*Q-1)
25 disp('ohms',R2)
26 disp("use 511kohm+/- 1%")

```

Chapter 12

DC Voltage Regulators

Scilab code Exa 12.1 DC voltage source

```
1 disp('chapter 12 ex12.1 ')
2 disp('given ')
3 disp("the dc voltage source is designed in ex 6.1
      has")
4 disp("Vs=Vcc=12V    Vo=6.3V    R1=270ohm    ")
5 disp("D1 is zener diode    IImax=42mA")
6 Vs=12
7 Vcc=12
8 Vo=6.3
9 R1=270
10 IImax=.042
11 disp("supply resistance=25 ohm")
12 Rs=25
13 disp("from datasheet Zz=7ohm")
14 Zz=7
15 disp("at 10% change in Vs")
16 DVs=.1*Vs
17 disp('volts ',DVs)
18 DVo=DVs*Zz/R1
19 disp(DVo,"DVo=")
20 disp("Line regulation=(DVo for 10%Vs change)*100/Vo")
```

```

    )
21 LR=(DVo)*100/Vo
22 disp(LR,"LR in percentage")
23 DVo=Ilmax*Rs*Zz/R1
24 disp(DVo,"DVo=")
25 disp("Load regulation=(DVo for DIl=Ilmax)*100/Vo")
26 LR=(DVo)*100/Vo
27 disp(LR,"Load regulation in percentage=")
28 Vro=Zz/R1
29 disp(Vro,"Vro=Vrs*")
30 disp("Ripple rejection=20*log(Vrs/Vro)")
31 RR=20*log10(1/Vro)
32 disp(RR,"Ripple Rejection in DB= ")

```

Scilab code Exa 12.2 Voltage Regulator

```

1 disp('chapter 12 ex12.2')
2 disp('given')
3 disp("output =12V")
4 Vo=12
5 disp("max load current=50mA")
6 Il=.05
7 disp("Vsmin=Vo+3 V")
8 Vsmin=Vo+3
9 disp('volts',Vsmin)
10 disp("allowing Vrs=2V(p to p)")
11 Vrs=2
12 disp("Vs=Vsmin+Vrs/2")
13 Vs=Vsmin+Vrs/2
14 disp('volts',Vs)
15 disp("let Vz=Vs/2")
16 Vz=Vs/2
17 disp('volts',Vz)
18 disp("Iz=20mA")
19 Iz=.02

```

```

20 disp("R1=(Vs-Vz)/Iz")
21 R1=(Vs-Vz)/Iz
22 disp('ohms',R1)
23 disp("R1=390 ohm std value")
24 R1=390
25 disp("let I2>>Ibmax      I2=50uA")
26 I2=50*10^(-6)
27 disp("R2=(Vo-Vz)/I2")
28 Vz=8.2
29 R2=(Vo-Vz)/I2
30 disp('ohms',R2)
31 disp("R2=68kohm std value")
32 R2=68000
33 disp("I2=(Vo-Vz)/R2")
34 I2=(Vo-Vz)/R2
35 disp('amperes',I2)
36 disp("R3=Vz/Iz")
37 R3=Vz/I2
38 disp('ohms',R3)
39 disp("use 150 k ohm std value")
40 R3=150000
41 disp("select C1=50uF")
42 C1=50*10^(-6)
43 disp("Q1 specification")
44 disp("Vcemax=Vsmax=Vs+Vrs/2")
45 Vcemax=Vs+Vrs/2
46 disp('volts',Vcemax)
47 Ie=I1
48 disp("P=Vce*I1=(Vs-Vo)*I1")
49 P=(Vs-Vo)*I1
50 disp('watts',P)
51 disp("A 2N718 is a suitable device")

```

Scilab code Exa 12.3 analysing Voltage Regulator

```

1 disp('chapter 12 ex12.3')
2 disp('given')
3 disp("considering example 12.2")
4 disp("supply source resistance=10ohm")
5 Rs=10
6 disp("from IN756 datasheet Zz=8ohm")
7 Zz=8
8 disp("At 10% change in Vs=16V is")
9 Vs=16
10 DVs=.1*Vs
11 disp('volts',DVs)
12 disp("DVo=DVs*Zz*(R2+R3)/(R1*R3)")
13 disp("R2=68000 R1=390 R3=150000")
14 R2=68000
15 R1=390
16 R3=150000
17 DVo=DVs*Zz*(R2+R3)/(R1*R3)
18 disp('volts',DVo)
19 disp("Line regulation=(DVo for 10%Vs change)*100/Vo
      and Vo=12V")
20 Vo=12
21 LR=(DVo)*100/Vo
22 disp(LR,"LR in percentage")
23 disp("for I1 change of 50mA")
24 I1=0.05
25 disp("DVo=I1*Rs")
26 DVs=I1*Rs
27 disp('volts',DVs)
28 DVo=DVs*Zz*(R2+R3)/(R1*R3)
29 disp('volts',DVo)
30 disp("Load regulation=(DVo for DI1=I1max)*100/Vo")
31 LR=(DVo)*100/Vo
32 disp(LR,"Load regulation in percentage=")
33 disp("Vro=Vrs*Zz*(R2+R3)/(R1*R3)")
34 y=Zz*(R2+R3)/(R1*R3)
35 disp(y,"Vro=Vrs*")
36 disp("Ripple rejection=20*log(Vrs/Vro)")
37 RR=20*log10(1/y)

```

38 `disp(RR," Ripple Rejection in DB= ")`

Scilab code Exa 12.4 DC Voltage Regulator

```
1 disp('chapter 12 ex12.4')
2 disp('given')
3 disp("output =10V to 15V")
4 Vomax=15
5 disp("max load current=4000mA")
6 Il=.4
7 disp(" Vsmin=Vomax+3 V")
8 Vsmin=Vomax+3
9 disp(' volts ',Vsmin)
10 disp(" allowing Vrs=3V(p to p)")
11 Vrs=3
12 disp(" Vs=Vsmin+Vrs/2")
13 Vs=Vsmin+Vrs/2
14 disp(' volts ',Vs)
15 disp("ZENER CIRCUIT")
16 disp(" let Vz=Vo/2")
17 Vz=Vomax/2
18 disp(' volts ',Vz)
19 disp(" Iz=20mA")
20 Iz=.02
21 disp(" R1=(Vo-Vz)/Iz")
22 R1=(Vomax-Vz)/Iz
23 disp(' ohms ',R1)
24 disp(" R1=330 ohm std value")
25 R1=390
26 disp("POTENTIAL DIVIDER")
27 disp(" let I2>>Ibmax      I2=50uA  Vommin=10")
28 I2=50*10^(-6)
29 Vommin=10
30 disp(" R2=(Vommin-Vz)/I2")
31 Vz=7.5
```

```

32 R2=(Vomin-Vz)/I2
33 disp('ohms',R2)
34 disp("R2=47kohm std value")
35 R2=47000
36 disp("I2=(Vomin-Vz)/R2")
37 I2=(Vomin-Vz)/R2
38 disp('amperes',I2)
39 disp("R34=R3+R4=Vz/Iz")
40 R34=Vz/I2
41 disp('ohms',R34)
42 disp("when Vo is at its max,moving contact is at
      bottom of R4")
43 disp("I2=Vomax/(R2+R34)")
44 I2=Vomax/(R2+R34)
45 disp('amperes',I2)
46 disp("R3=Vz/Iz")
47 R3=Vz/I2
48 disp('ohms',R3)
49 disp("use 100 k ohm std value")
50 R3=100000
51 disp("R4=(R3+R4)-R3")
52 R4=R34-R3
53 disp('ohms',R4)
54 disp("use 50 k ohm std value")
55 disp("CAPACITOR")
56 disp("select C1=100uF")
57 C1=100*10^(-6)
58 disp("Q1 specification")
59 disp("Vcemax=Vsmax=Vs+Vrs/2")
60 Vcemax=Vs+Vrs/2
61 disp('volts',Vcemax)
62 Ie=I1
63 disp("P=Vce*I1=(Vs-Vomin)*I1")
64 P=(Vs-Vomin)*I1
65 disp('watts',P)
66 disp("A 2N3055 is a suitable device")
67 disp("Q2 specification")
68 disp("Vcemax=Vsmax=Vs+Vrs/2")

```

```

69 Vcemax=Vs+Vrs/2
70 disp('volts',Vcemax)
71 disp("Ie=I1/hFE1 ,hFE1=20 for Q1")
72 hFE1=20
73 Ie=I1/hFE1
74 disp('amperes',Ie)
75 disp("P=Vce*I1=(Vs-Vomin)*I1")
76 P=(Vs-Vomin)*I1
77 disp('watts',P)
78 disp("A 2N3904 is a suitable device")
79 disp("R5 Calculation")
80 disp("let Ie2min=0.5mA, Vbe1=0.7")
81 Ie2min=0.5*10(-3)
82 Vbe1=0.7
83 disp("R5=(Vomin+Vbe1)/Ie2min")
84 R5=(Vomin+Vbe1)/Ie2min
85 disp('ohms',R5)
86 disp("R5=18kohm std value")
87 disp("OPERATIONAL AMPLIFIER")
88 disp("because I2 is sselected for bipolar opamp
      either a bipolar or BIFEt opamp can be used")
89 disp("supply voltage Vs=19.5V")
90 Vs=19.5
91 disp("Input supply voltage range=Vs/2-Vz")
92 ipvoltage=(Vs/2)-Vz
93 disp('volts',ipvoltage)

```

Scilab code Exa 12.5 Voltage Regulator

```

1 disp('chapter 12 ex12.5')
2 disp('given')
3 disp("voltage regulator in 12.2 to have short
      circuit o/p current=60mA")
4 Isc=.06
5 disp("R6=0.5/Isc")

```

```

6 R6=0.5/Isc
7 disp('ohms',R6)
8 disp("Let Ic3=5mA")
9 Ic3=.005
10 disp("R7=Vs/Ic3")
11 disp("Vs=16")
12 Vs=16
13 R7=Vs/Ic3
14 disp('ohms',R7)
15 disp("Ib1max=Ilmax/hfe1    Ilmax=50mA    hfe1=50")
16 hfe1=50
17 Ilmax=.05
18 Ib1max=Ilmax/hfe1
19 disp('amperes',Ib1max)
20 disp("Vr7=Ib1max*R7")
21 Vr7=.001*3300
22 disp('volts',Vr7)
23 disp("this voltage drop is too large for circuit to
        operate satisfactorily")
24 disp("to overcome we make use of darlington pair ")
25 disp("hfe2=50")
26 hfe2=50
27 disp("Ib2max=Ilmax/(hfe1*hfe2)")
28 Ib2max=Ilmax/(hfe1*hfe2)
29 disp('amperes',Ib2max)
30 disp("under normal operating conditions Vr7=Ib2max*
        R7")
31 Vr7=Ib2max*3300
32 disp('volts',Vr7)

```

Scilab code Exa 12.6 foldback current limiting circuit

```

1 disp('chapter 12 ex12.6')
2 disp('given')
3 disp("design feedback limit for 12.4 and max circuit")

```

```

        o/p current=400mA when limited foldback to 200mA
    ")
4  Ilmax=0.4
5  Isc=0.2
6  disp("Vr6=0.5 at short circuit")
7  disp("R6=0.5/Isc")
8  R6=0.5/Isc
9  disp('ohms',R6)
10 disp("use 2.7 ohm std value")
11 R6=2.7
12 disp("Vr6=Ilmax*R6")
13 Vr6=Ilmax*R6
14 disp('volts',Vr6)
15 disp("Vr8=Vr6-0.5      Vr6=1")
16 Vr8=1-0.5
17 disp('volts',Vr8)
18 disp("Ir8>>Ib3      hfe3=50   Ic3=5mA")
19 Ic3=0.005
20 hfe3=50
21 disp("Ib3=Ic3/hfe3")
22 Ib3=Ic3/hfe3
23 disp('amperes',Ib3)
24 disp("let Ir8=1mA")
25 Ir8=0.001
26 disp("R8=Vr8/Ir8")
27 R8=Vr8/Ir8
28 disp('ohms',R8)
29 disp("use 470 ohm std value")
30 R8=470
31 disp("using average level of Vo=12.5")
32 Vo=12.5
33 disp("R9=(Vo-Vr8)/Ir8")
34 R9=(Vo-Vr8)/Ir8
35 disp('ohms',R9)
36 disp("R7=Vs/Ic3      Vs=19.5")
37 Vs=19.5
38 R7=Vs/Ic3
39 disp('ohms',R7)

```

```

40 disp(" hfe2=50      hfe1=20")
41 hfe2=50
42 hfe1=20
43 disp(" Ib2max=I1max/(hfe1*hfe2)")
44 Ib2max=I1max/(hfe1*hfe2)
45 disp(' amperes ', Ib2max)
46 disp(" Vr7=Ib2max*R7")
47 Vr7=Ib2max*R7
48 disp(' volts ', Vr7)

```

Scilab code Exa 12.7 Positive Voltage Regulator

```

1 disp(' chapter 12 ex12.7 ')
2 disp(' given ')
3 disp(" voltage regulator to have o/p voltage=18V")
4 Vo=18
5 disp(" I2>>error amplifier input bias current")
6 disp(" Let I2=1mA")
7 I2=0.001
8 disp(" Vr2=Vref=7.15")
9 Vr2=7.15
10 Vref=7.15
11 disp(" R2=Vref/I2")
12 R2=Vref/I2
13 disp(' ohms ', R2)
14 disp(" use 6.8 kohm std value")
15 R2=6800
16 disp(" I2 =7.15/6.8k")
17 I2=7.15/6800
18 disp(' amperes ', I2)
19 disp(" R1=(Vo-Vr2)/I2")
20 R1=(Vo-Vr2)/I2
21 disp(' ohms ', R1)
22 disp(" use 10 kohm std value")
23 R1=10000

```

```

24 disp("for satisfactory operation of series pass
      transistor")
25 disp("Let  $V_s - V_o = 5V$     $V_s = V_o + 5$   ")
26 Vs=Vo+5
27 disp('volts ',Vs)
28 disp("Internal circuit current is approximately ")
29 disp("I=Istandby+Iref=25mA")
30 I=0.025
31 disp("Internal power dissipation excluding series
      pass transistor ")
32 disp("Pi=(Istandby+Iref)*Vs")
33 Pi=(I)*Vs
34 disp('watts ',Pi)
35 disp("Maximum power dissipated in series pass
      transistor")
36 disp("P=(specified Pdmax)-Pi   Pdmax=1000mW")
37 Pdmax=1
38 P=Pdmax-Pi
39 disp('watts ',P)
40 disp("Maximum load current=P/(Vs-Vo)")
41 Ilmax=P/(Vs-Vo)
42 disp('amperes ',Ilmax)

```

Scilab code Exa 12.8 LM217 Voltage Regulator

```

1 disp('chapter 12 ex12.8 ')
2 disp('given ')
3 disp("voltage regulator to have o/p voltage=9V")
4 Vo=9
5 disp("I1 >> (Iadj=100uA)")
6 disp("Let I1=5mA")
7 I1=0.005
8 disp("R1=Vref/I1   Vref=1.25V")
9 Vref=1.25
10 R1=Vref/I1

```

```
11 disp('ohms',R1)
12 disp("use 270ohm std value and recalculate I1")
13 R1=270
14 disp("I1=Vref/R1")
15 I1=Vref/R1
16 disp(' amperes ',I1)
17 disp("R2=(Vo-Vr1)/I1 , Vr1=1.25")
18 Vr1=1.25
19 R2=(Vo-Vr1)/I1
20 disp('ohms',R2)
21 disp("use 1.5kohm and 220 ohm in series")
```
