Scilab Textbook Companion for Operational Amplifiers & Linear Integrated Circuits by D. A. Bell[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Introduction to Operational Amplifiers

Scilab code Exa 1.1 Voltage follower

```
disp('chapter 1 ex1.1')
disp('given')
disp("input signal=1v")// input signal is 1v
disp("V0=Vi-(Vi/M)")//formula to find o/p voltage
Vi=1
M=200000//Minimum Open loop gain is 50000, Typical M
    is 200000
V0=Vi-(Vi/M)
disp('output voltage for typical open loop gain of
   200000 is')
disp('volt',V0)
M1=50000//Minimum open loop gain
V01=Vi-(Vi/M1)//output for minimum open loop gain
disp('output voltge for minimum open loop gain of
   50000 is')
disp('volt',V01)
```

Scilab code Exa 1.2 Non Inverting amplifier

```
disp('chapter 1 ex1.2')
disp('given')
disp("R2=8.2Kohms,R3=150ohms")//given Resistor
    values
R2=8200
R3=150
Av=(R2+R3)/R3//voltage gain formula
disp("voltage gain for given resistor values" )
disp(Av)
disp("New voltage gain given=75")//voltage gain=75
Av=75
R3=R2/(Av-1)//calculation of R3
disp("New value of resistor R3")
disp('ohms',R3)
```

Scilab code Exa 1.3 Inverting amplifier

```
disp('chapter 1 ex1.3')
disp('given')
disp("R2=8.2Kohms,R1=270ohms")//given resistor
    values
R1=270
R2=8200
Av=R2/R1
disp("voltage gain of inverting amplifier")
disp(Av)
disp("new voltage gain given=60")
Av1=60
R1n=R2/Av1
disp("new value of R1")
disp('Ohms',R1n)
```

Chapter 2

Operational Amplifier Parameters

Scilab code Exa 2.1 Non Inverting amplifier

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

Scilab code Exa 2.2 PSVR

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

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

Scilab code Exa 2.3 Offset voltage

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

Scilab code Exa 2.4 Input impedance

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

```
disp("Rimin=.3Mohm")
disp("Mmin=50000")
Rimin=300000
Mmin=50000
disp("For an voltage follower beta=1")
b=1
Zin=(1+Mmin*b)*Rimin
disp("minimum input impedence")
disp('ohms',Zin)
```

Scilab code Exa 2.5 Output impedance

```
disp('chapter 2 ex2.5')
disp('given')
disp("from 741 datasheet")
disp("Zo=75ohm")
disp("Mmax=200000")
Zo=75
Mmax=200000
disp("For an voltage follower beta=1")
b=1
Zout=Zo/(1+Mmax*b)
disp("Typical output impedence")
disp('ohms',Zout)
```

Chapter 3

Op Amps as DC Amplifiers

Scilab code Exa 3.1 Voltage follower

```
disp('chapter 3 ex3.1')
disp('given')
disp('resistor connected R1=Rs=47kohms')
R1=47000
Rs=47000
disp('IB(max)=500nA and Ii(offset)=20nA')
IBmax=500*10^(-9)
Iioffset=20*10^(-9)
disp('V(max)=IB(max)*Rs')
Vmax=IBmax*Rs
disp('volt',Vmax)
disp('Vioffset=Ii(offset)*Rs')
Vioffset=Iioffset*Rs
disp('volt',Vioffset)
```

Scilab code Exa 3.2 Voltage follower

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

```
disp('given')
disp('resistor connected Rs=47kohms and RL=20kohms')
disp('voltage follower Vs=1Volt')
disp('voltage load VL=Vs*RL/(Rs+RL)')
Rs=47000
RL=20000
Vs=1
VL=Vs*RL/(Rs+RL)
disp(VL)
disp('Zin=(1+M)*Zi')
disp('M=200000 and Zi=2Mohms')
M=200000
Zi=2000000
Zin=(1+M)*Zi
disp('ohms',Zin)
disp('Vi=Vs*Zin/(Rs+Zin)')
Vi=Vs*Zin/(Rs+Zin)
disp('volt',Vi)
disp('Vo=Vi*(1-1/M)')
Vo=Vi*(1-1/M)
disp('volt',Vo)
disp('Zout=Zo/(1+M)')
disp('Zo=75ohms')
Zo=75
Zout=Zo/(1+M)
disp('ohms',Zout)
disp('VL=Vo*RL/(RL+Zout)')
VL=Vo*RL/(RL+Zout)
disp('volt',VL)
```

Scilab code Exa 3.3 Potential divider and voltage follower

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

```
disp('voltage follower VL=5volt')
disp('supply voltage Vcc=15volt')
disp('IL=VL/RL')
RL=1000
VL=5
IL=VL/RL
disp('amperes',IL)
disp('V1=Vcc-VL')
Vcc=15
V1=Vcc-VL
disp('volt',V1)
disp('R1=V1/IL')
R1=V1/IL
disp('ohms',R1)
disp('RL changes by -10%')
disp('VL=Vcc*(RL-.10)/(R1+(RL-.10))')
VL=Vcc*(RL-.10)/(R1+(RL-.10))
disp('volt',VL)
disp('V2=VL=5volts')
V2=5
VL=5
disp('V1=Vcc-VL')
V1=Vcc-VL
disp('volt',V1)
disp('IBmax=500nA and I2=100*IBmax')
disp('R2=V2/I2')
IBmax=500*10^(-9)
I2=100*IBmax
R2=V2/I2
disp('ohms',R2)
disp('R1=V1/I2')
R1=V1/I2
disp('ohms',R1)
```

Scilab code Exa 3.4 Non Inverting amplifier

```
disp('chapter 3 ex3.4')
disp('given')
disp('signal amplitude Vi=15mV')
disp('IBmax=500nA and I2=100*IBmax')
Vi=.015
IBmax=500*10^(-9)
I2=100*IBmax
disp('R3=Vi/I2')
R3=Vi/I2
disp('ohms',R3)
disp('standard value resistor for R3=270ohms')
R3=270
disp('I2=Vi/R3')
I2=Vi/R3
disp('amperes',I2)
disp('Vo=Av*Vi')
Av=66
Vo=Av*Vi
disp('volt',Vo)
disp('R2=Vo/I2-R3')
R2=Vo/I2-R3
disp('ohms',R2)
disp('standard value resistor to give Av>66 R2=18
   kohms')
R2=18000
disp('R1=R2||R3')
R1=R2*R3/(R2+R3)
disp('ohms',R1)
disp('standard value resistor R1=270ohms')
R1=270
disp('ohms',R1)
```

Scilab code Exa 3.5 Non Inverting amplifier

```
disp('chapter 3 ex3.5')
```

```
disp('given')
disp('Redesigning the noninverting amplifier in
    example 3.4 using LF353 BIFET op-amp')
disp('IBmax=200pA and I2=100*IBmax')
disp('let R2=1Mohms and Av=66')
R2=1*10^(6)
Av=66
disp('R3=R2/(Av-1)')
R3=R2/(Av-1)
disp('ohms',R3)
disp('standard value resistor R3=15kohms will give
    Av>66')
R3=15000
disp('ohms',R3)
disp('R1=R2||R3')
R1=R2*R3/(R2+R3)
disp('ohms',R1)
disp('standard value R1=15kohms')
R1=15000
disp('ohms',R1)
```

Scilab code Exa 3.6 Input impedance of non inverting amplifier

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

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

Scilab code Exa 3.7 Inverting amplifier

```
disp('chapter 3 ex3.7')
disp('given')
disp('Designing inverting amplifier using 741 op-amp
   ')
disp('voltage gain Av=50')
disp('output voltage Vo=2.5volt')
Av=50
Vo=2.5
disp('IBmax=500nA and I1=100*IBmax')
IBmax=500*10^(-9)
I1=100*IBmax
disp('V1=Vo/Av')
V1=Vo/Av
disp('volt',V1)
disp('R1=V1/I1')
R1=V1/I1
disp('ohms',R1)
disp('R2=Vo/I1')
R2=Vo/I1
disp('ohms',R2)
disp('R3=R1||R2')
R3=R1*R2/(R2+R1)
disp('ohms',R3)
```

Scilab code Exa 3.8 Inverting amplifier

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

```
disp('given')
disp('Redesigning the inverting amplifier in example 3.7 using LF353 BIFET op-amp')
disp('let R2=1Mohms and Av=50')
R2=1*10^(6)
Av=50
disp('R1=R2/Av')
R1=R2/Av
disp('ohms',R1)
disp('R3=R1||R2')
R3=R1*R2/(R1+R2)
disp('ohms',R3)
```

Scilab code Exa 3.9 Summing amplifier

```
disp('chapter 3 ex3.9')
disp('given')
disp('the direct sum of two inputs which range from .1Volt to 1V0lt')
Vsmin=0.1
Vsmax=1
disp('IBmax=500nA')
disp('I1min=100*IBmax')
IBmax=500*10^(-9)
I1min=100*IBmax
disp('amperes',I1min)
disp('R1=Vsmin/I1min')
R1=Vsmin/I1min
disp('ohms',R1)
disp('using standard value R2=R1=1.8kohms')
R1=1800
R2=1800
disp('for Av=1 R3=R1=1.8kohms')
Av=1
R3=1800
```

```
disp('R4=R1||R2||R3')
R4=R1/3
disp('ohms',R4)
disp('standard value is 560ohms)
```

Scilab code Exa 3.10 Differential and common mode input resistance

```
disp('chapter 3 ex3.10')
disp('given')
disp('The difference of two input signals is to be
    ampliflied by factor of 37')
Av=37
disp('amplitude=50mV')
disp('R2=1Mohms')
R2=1*10^(6)
disp('R1=R2/Av')
R1=R2/Av
disp('ohms',R1)
disp('R3=R1=27kohms')
disp('R4=R2=1Mohms')
R3=27000
R4=1*10^(6)
disp('differential mode input resistance Ridiff=R1+(
    R3+R4)')
Ridiff=R1+(R3+R4)
disp('ohms',Ridiff)
disp('commom mode input resistance Ricm=R1||(R3+R4)'
    )
Ricm=R1*(R3+R4)/(R1+R3+R4)
disp('ohms',Ricm)
```

Scilab code Exa 3.11 Output voltage nulling

```
disp('chapter 3 ex3.11')
disp('given')
disp('modifying circuit designed in example 3.10')
disp('R1=27kohms and R2=1Mohms')
disp('R3+R4=R1=27kohms')
R1=27000
R2=27000
disp('R4/R3=R2/R1=37')
disp('R3+37R3=27kohms')
R3=27000/(1+37)
disp('ohms',R3)
disp('standard value R3=680ohms')
R3=680
R4=37*R3
disp('ohms',R4)
disp('allowing +10% or-10% adjustments of R4')
disp('total resistance R%=R4+10%')
R5=R4+R4*.10
disp('ohms',R5)
disp('variable portion Rv=20% of R4')
Rv=.20*R5
disp('ohms',Rv)
disp('standard variable resistance is 5kohms')
Rv=5000
disp('ohms',Rv)
disp('fixed portion of R4 is Rf=R4-Rv')
Rf=R5-Rv
disp('ohms',Rf)
```

Chapter 4

Op Amps as AC Amplifiers

Scilab code Exa 4.1 Capacitor coupled voltage follower

```
disp('chapter 4 ex4.1')
disp('given')
disp('capacitor coupled voltage follower design')
disp("lower cut off frequency for the circuit =50Hz"
   )
disp('Rl=3.9kohms')
disp("R1max=0.1Vbe/Ibmax")
disp("Vbe=0.7volts")
disp("Ibmax=500nA")
Vbe=0.7
Ibmax=500*10^(-9)
R1max=0.1* Vbe/ Ibmax
disp("R1max= ",R1max)
disp("assume R1=120Kohms")
R1=120000
f1=50
disp("Xc1=R1/10 at F1")
disp("C1=1/(2*pi*f1*(R1/10))")
C1=1/(2*%pi*f1*(R1/10))
disp('farad',C1)
Rl=3900
```

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

Scilab code Exa 4.2 Capacitor coupled voltage follower

```
disp('chapter 4 ex4.2')
disp('given')
disp('capacitor coupled voltage follower design
   using BIFET')
disp("lower cut off frequency for the circuit =50Hz"
   )
disp('Rl=3.9kohms')
disp("R1max=1Mohms")
R1=1000000
f1=50
disp("Xc1=R1/10 at F1")
disp("C1=1/(2*pi*f1*(R1/10))")
C1=1/(2*%pi*f1*(R1/10))
disp('farad',C1)
Rl=3900
disp("Xc2=Rl at f1")
disp("C2=1/(2*pi*f1*Rl)")
C2=1/(2*%pi*f1*Rl)
disp('farad',C2)
disp("The circuit voltage should be normally between
    9 to 18 volts")
```

Scilab code Exa 4.3 High Zin Capacitor coupled voltage follower

```
disp('chapter 4 ex4.3')
disp('given')
disp('capacitor coupled voltage follower design')
disp("lower cut off frequency for the circuit =50Hz")
disp('Rl=3.9kohms')
disp("R1max=0.1Vbe/Ibmax")
disp("Vbe=0.7volts")
disp("Ibmax=500nA")
Vbe=0.7
Ibmax=500*10^(-9)
R1max=0.1* Vbe/ Ibmax
disp("R1max= ")
disp('ohms',R1max)
disp("R1+R2=Rmax")
R1=R1max/2
R2=R1
disp("assume R1=68Kohms")
R1=68000
f1=50
disp("Xc1=R1/10 at F1")
disp("C1=1/(2*pi*f1*(R1/10))")
C1=1/(2*%pi*f1*(R1/10))
C2=C1
disp('farads',C1)
Rl=3900
disp('farads',C2)
M=50000
disp("M=50000")
disp("Zin=(1+M)*R1")
Zin=(1+M)*R1
disp('ohms',Zin)
disp("The circuit voltage should be normally between 9 to 18 volts")
```

Scilab code Exa 4.4 Capacitor coupled non inverting amplifier

```
disp('chapter 4 ex4.4')
disp('given')
disp('capacitor coupled non inverting amplifier
   design')
disp("lower cut off frequency for the circuit =120Hz
   ")
disp('Rl=2.2kohms')
disp("R1max=0.1Vbe/Ibmax")
disp("Vbe=0.7volts")
disp("Ibmax=500nA")
Vbe=0.7
Ibmax=500*10^(-9)
R1max=0.1* Vbe/ Ibmax
disp("R1max= ",R1max)
R1=120000
f1=120
disp("R1=18 kohms and R3=270 ohms from example 3.4")
disp("Xc1=R1/10 at F1")
disp("C1=1/(2*pi*f1*(R1/10))")
C1=1/(2*%pi*f1*(R1/10))
disp('farads',C1)
Rl=2200
disp("Xc2=Rl at f1")
disp("C2=1/(2*pi*f1*Rl)")
C2=1/(2*%pi*f1*Rl)
disp('farads',C2)
disp("The circuit voltage should be normally between
    9 to 18 volts")
```

Scilab code Exa 4.5 High Zin Capacitor coupled non inverting

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

```
disp('capacitor coupled non inverting high impedence follower design')
disp("lower cut off frequency for the circuit =200Hz")
disp('Rl=12kohms')
disp("input voltage=15mV")
disp("output voltage=3V")
disp("Av=Vo/Vi")
Vo=3
Vi=0.015
Av=Vo/Vi
disp(Av)
disp("for non inverting amplifier Av=(R2+R3)/R3")
disp("for BIFET opamp R2=1Mohms")
R2=1000000
R3=R2/(Av-1)
disp(R3,"R3=")
f1=200
R1=R2-R3
disp(R1,"R1=")
disp("C2=1/(2*pi*f1*(R3))")
C2=1/(2*%pi*f1*(R3))
disp('farads',C2)
disp("C1=1000pF much larger than stray capacitance")
Rl=12000
disp("Xc3=Rl/10 at f1")
disp("C2=1/(2*pi*f1*(Rl/10)")
C2=1/(2*%pi*f1*(Rl/10))
disp('farads',C2)
disp("The circuit voltage should be normally between 9 to 18 volts")
```

Scilab code Exa 4.6 Capacitor coupled inverting amplifier

```
disp('chapter 4 ex4.6')
```

```
disp('given')
disp('capacitor coupled inverting amplifier design')
disp("frequency range for the circuit =10Hz to 1KHz"
    )
disp('Rl=250ohms')
disp("From inverting amplifier designed in ex 3.7 R1
    =1Kohms")
R1=1000
f1=10
disp("Xc1=R1/10 at F1")
disp("C1=1/(2*pi*f1*(R1/10))")
C1=1/(2*%pi*f1*(R1/10))
disp('farads',C1)
Rl=250
disp("Xc2=Rl at f1")
disp("C2=1/(2*pi*f1*Rl)")
C2=1/(2*%pi*f1*Rl)
disp('farads',C2)
disp("From inverting amplifier designed in ex 3.7 R2
    =47Kohms")
R2=47000
disp("Cf=1/(2*pi*f1*R2)")
Cf=1/(2*%pi*f1*R2)
disp('farads',Cf)
disp("The circuit voltage should be normally between
     9 to 18 volts")
```

Scilab code Exa 4.7 Capacitor coupled non inverting amplifier

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

```
Av=100
Vcc=24
disp("Output amplitude=5V")
Vo=5
disp("lower cut off frequency for the circuit =75Hz")
disp('Rl=5.6kohms')
disp("Ibmax=500nA")
Vbe=0.7
Ibmax=500*10^(-9)
disp("I2>>Ibmax")
I2=100*Ibmax
disp(I2,"I2=")
R1=(Vcc/2)/I2
disp("R1= ")
disp('ohms',R1)
R2=(Vcc/2)/I2
disp(R2,"R2=")
disp("assume R1=220Kohms")
disp("Vi=Vo/Av")
Vi=Vo/Av
disp(Vi,"Vi=")
R1=220000
disp("I4>>Ibmax")
I4=100*Ibmax
disp(I4,"I4=")
R4=Vi/I4
disp(R4,"R4=")
disp("R3+R4=Vo/I4")
R3=(Vo/I4)-R4
disp(R3,"R3=")
Rp=(R1*R2)/(R1+R2)
disp(Rp,"Rp(R1||R2)=")
f1=75
disp("Xc1=Rp/10 at F1")
disp("C1=1/(2*pi*f1*(Rp/10))")
C1=1/(2*%pi*f1*(Rp/10))
disp('farads',C1)
```

```
Rl=5600
disp("Xc2=Rl/10 at F1")
disp("C2=1/(2*pi*f1*(Rl/10))")
C2=1/(2*%pi*f1*(Rl/10))
disp('farads',C2)
disp("C1=1/(2*pi*f1*R4)")
C3=1/(2*%pi*f1*R4)
disp('farads',C3)
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

```
disp('chapter 5 ex5.1')
disp('given')
disp('maximum signal voltage Vs=.5volt')
disp('voltage gain Av=10')
disp('IBmax=1.5*10^(-6)A and I1=100*IBmax')
Vs=.5
Av=10
IBmax=1.5*10^(-6)
I1=100*IBmax
disp('amperes',I1)
disp('R1=Vs/I1')
R1=Vs/I1
disp('ohms',R1)
disp('R2=Av*R1')
R2=Av*R1
disp('ohms',R2)
disp('R3=R1||R2')
R3=R1*R2/(R1+R2)
disp('ohms',R3)
```

Scilab code Exa 5.2 Voltage follower

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

Scilab code Exa 5.3 Inverting amplifier

```
disp('chapter 5 ex5.3')
disp('given')
disp('LM108 op-amp is used design an inverting
    amplifier')
disp('V1=100mV')
V1=100*10^(-3)
disp('voltage gain Av=3')
Av=3
disp('IBmax=2nA and I1=100*IBmax')
IBmax=2*10^(-9)
I1=100*IBmax
disp('amperes',I1)
disp('R1=V1/I1')
R1=V1/I1
disp('ohms',R1)
disp('standard value R1=470kohms')
R1=470000
disp('R2=Av*R1')
R2=Av*R1
disp('ohms',R2)
```

```
disp('standard value R2=1.5Mohms')
R2=1.5*10^(6)
disp('R3=R1||R2')
R3=R1*R2/(R1+R2)
disp('ohms',R3)
disp('Cf=30pF*R1/(R1+R2)')
Cf=30*10^(-12)*R1/(R1+R2)
disp('farads',Cf)
```

Scilab code Exa 5.4 Inverting amplifier

```
disp('chapter 5 ex5.4')
disp('given')
disp('709 op-amp is used design an inverting
    amplifier')
disp('Vs=50mV')
Vs=50*10^(-3)
disp('voltage gain Av=100')
Av=100
disp('IBmax=2nA and I1=100*IBmax')
IBmax=2*10^(-9)
I1=100*IBmax
disp('amperes',I1)
disp('R1=Vs/I1')
R1=Vs/I1
disp('ohms',R1)
disp('standard value R1=2.2kohms')
R1=2200
disp('R2=Av*R1')
R2=Av*R1
disp('ohms',R2)
disp('R3=R1||R2')
R3=R1*R2/(R1+R2)
disp('ohms',R3)
disp('Av=100=40dB')
```

Scilab code Exa 5.5 Non Inverting amplifier

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

Scilab code Exa 5.6 upper cut off frequency

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

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

Scilab code Exa 5.7 Gain bandwidth product

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

Scilab code Exa 5.8 Upper cutt off frequency of voltage follower

```
disp('chapter 5 ex5.8')
```

```
disp('given')
disp('Using the gain-bandwidth product estimate
   upper cut off frequencies')
disp('741 op-amp')
disp('fu=800kHz and Av=1')
fu=800000
Av=1
disp('f2=fu/Av')
f2=fu/Av
disp('Hz',f2)
disp('for unity gain R1=R2')
disp('Av=(R1+R2)/R1')
R1=R2
Av=(R1+R2)/R1
disp(Av)
disp('f2=fu/Av')
f2=fu/Av
disp('Hz',f2)
```

Scilab code Exa 5.9 Slew rate effects

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

```
fs=f2
disp('Vp=S/(2*%pi*fs)')
Vp=S/(2*%pi*fs)
disp('volts',Vp)
disp('741 op-amp f2=8kHz')
f2=8000
disp('Vp=S/(2*%pi*f2)')
Vp=S/(2*%pi*f2)
disp('volts',Vp)
```

Scilab code Exa 5.10 Slew rate effects

```
disp('chapter 5 ex5.10')
disp('given')
disp('the output of sine wave Vp=.35Volt')
disp('the typical slew rate for 741 op-amp S=.5V/1*10^(-6)s')
disp('f2=800kHz')
Vp=5
S=.5/(1*10^(-6))
f2=800000
disp('tr(f2)=.35/f2')
trf2=.35/f2
disp('seconds',trf2)
disp('tr(s)=Vp/S')
trs=Vp/S
disp('seconds',trs)
disp('trs=1*10^(-6)')
trs=1*10^(-6)
disp('Vp=trs*S')
Vp=trs*S
disp('volts',Vp)
disp('f2=100kHz')
f2=100000
disp('tr(f2)=.35/f2')
```

```
trf2=.35/f2
disp('seconds',trf2)
disp('trs=3.5*10^(-6)')
trs=3.5*10^(-6)
disp('Vp=trs*S')
Vp=trs*S
disp('volts',Vp)
```

Scilab code Exa 5.11 Input stray capacitance

```
disp('chapter 5 ex5.11')
disp('given')
disp('R1=R3=2.2kohms')
disp('R2=220kohms')
disp('Rs=220ohms')
Rs=220
R1=2200
R3=2200
R2=220000
disp('R=R3+R2||(R1+Rs)')
R=R3+(R2*(R1+Rs)/(R2+R1+Rs))
disp('ohms',R)
disp('f=600kHz')
f=600000
disp('Cs=1/(2*%pi*f*10*R)')
Cs=1/(2*%pi*f*10*R)
disp('farads',Cs)
```

Scilab code Exa 5.12 Input stray capacitance

```
disp('chapter 5 ex5.12')
disp('given')
disp('R1=R3=2200ohms')
```

```
disp('R2=220kohms')
disp('Rs=220ohms')
Rs=220
R1=2200
R3=2200
R2=220000
disp('R=R2+R3')
R=R2+R3
disp('ohms',R)
disp('f=600kHz')
f=600000
disp('Cs=1/(2*%pi*f*10*R)')
Cs=1/(2*%pi*f*10*R)
disp('farads',Cs)
disp('R=R2||(R1+Rs)')
R=R2*(R1+Rs)/(R2+R1+Rs)
disp('ohms',R)
disp('Cs=1/(2*%pi*f*10*R)')
Cs=1/(2*%pi*f*10*R)
disp('farads',Cs)
disp('R=R3+R2||(R1+Rs)')
disp('R1=R3=220ohms')
disp('R2=22kohms')
disp('Rs=22ohms')
Rs=22
R1=220
R3=220
R2=22000
R=R3+(R2*(R1+Rs)/(R2+R1+Rs))
disp('ohms',R)
disp('Cs=1/(2*%pi*f*10*R)')
Cs=1/(2*%pi*f*10*R)
disp('farads',Cs)
```

Scilab code Exa 5.13 feedback capacitor

```
disp('chapter 5 ex5.13')
disp('given')
disp('Determining the feedback capacitor')
disp('R1=220ohms')
disp('R2=22kohms')
disp('Cs from example 5.12=58pF')
R1=220
R2=22000
Cs=58*10^(-12)
disp('C2=R1*Cs/R2')
C2=R1*Cs/R2
disp('farads',C2)
```

Scilab code Exa 5.14 load capacitor

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

Scilab code Exa 5.15 feedback capacitance

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

```
disp('R2=220kohms')
R2=220000
disp('load capacitance CL=.1*10^(-6)F')
CL=.1*10^(-6)
disp('C2=Ro/R2*CL')
C2=Ro/R2*CL
disp('farads',C2)
disp('additional resistor R=470ohm')
R=470
disp('C2=(Ro+R)/R2*CL')
C2=(Ro+R)/R2*CL
disp('farads',C2)
disp('use 300pF standard value')
```

Scilab code Exa 5.16 Zin mod compensation

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

```
disp('ohms',r14)
disp('(1/r4)=(1/220)-(1/r1)')
g4=(1/r14)-(1/r1)
r4=1/g4
disp('ohms',r4)
disp('use 220ohm std value')
r4=220
disp('the compensating components for 1/beta1=60db
   are c1=10pf,r1=0,c2=3pf')
c1=10*10^(-12)
c2=3*10^(-12)
r1=0
disp('the frequency at which M*beta=1 is found and
   is equal to 2MHz')
f2=2000000
disp('Xc4<<r4 therefore Xc4=r4/10')
Xc4=r4/10
disp('ohms',Xc4)
disp('C4=1/(2*%pi*f2*Xc4)')
C4=1/(2*%pi*f2*Xc4)
disp('farads',C4)
```

Chapter 6

Miscellaneous Op Amp Linear Applications

Scilab code Exa 6.1 Voltage source

```
disp('chapter 6 ex6.1')
disp('given')
disp("voltage souurce to be designed")
disp("constant output voltage=6V")
Vo=6
disp("minimum load resistance=150")
disp("available supply voltage=+/-12V")
Vcc=12
Rl=150
disp("from the zener diode specification Vz=6.3")
Vz=6.3
disp("recommended current for for zener is 20mA")
Iz=.02
disp("R1=(Vcc-Vz)/Iz")
R1=(Vcc-Vz)/Iz
disp('ohms',R1)
disp("Ilmax=Vz/Rl")
Ilmax=Vz/Rl
disp('amperes',Ilmax)
```

```
disp("Transistor specification is")
disp("npn  Ie(max)>42mA  Vcemax>Vcc=12V")
disp("Vrl=6V")
disp("PD=Iemax(Vcc-Vrl)")
Iemax=0.042
Vrl=6
Pd=Iemax*(Vcc-Vrl)
disp('watts',Pd)
disp("hfe(min)=20")
disp("Iomax=Ilmax/hfe(min)")
hfe=20
Iomax=Ilmax/hfe
disp('amperes',Iomax)
disp("use opamp with a compesating capacitor")
```

Scilab code Exa 6.2 Precision Voltage source

```
disp('chapter 6 ex6.2')
disp('given')
disp("precision voltage souurce to be designed")
disp("constant output voltage=9V")
Vo=9
disp("available supply voltage=+/-12V")
Vcc=12
disp("allow 10% tolerance on zener diode")
disp("Vz=Vo/2")
Vz=Vo/2
disp('volts',Vz)
disp("assuming Vz=4.3V")
Vz=4.3
disp("diode current is Iz=20mA")
Iz=.02
disp("R1=(Vo-Vz)/Iz")
R1=(Vo-Vz)/Iz
disp('ohms',R1)
```

```
disp("assuming standard value for R1=220")
R1=220
disp("for R2,R3,R4  I2>>Ibmax")
disp("Ibmax=500nA")
Ibmax=500*10^(-9)
disp("I2=100*Ibmax")
I2=100*Ibmax
disp('amperes',I2)
disp("let R34=R3+R4")
disp("R34=(Vz+0.1*Vz)/I2")
R34=(Vz+0.1*Vz)/I2
disp('ohms',R34)
disp("R4=20% 0f (R3+R4)")
R4=.2*R34
disp('ohms',R4)
disp("Use 20 Kohms std value")
R4=20000
disp("R3=R34-R4")
R3=R34-R4
disp('ohms',R3)
disp("use R3=68Kohms std value")
R3=68000
disp("I2=(Vz+0.1*Vz)/(R3+R4)")
I2=(Vz+0.1*Vz)/(R3+R4)
disp('amperes',I2)
disp("R2=(Vo-(Vr3+Vr4))/I2")
R2=(Vo-(Vz+0.1*Vz))/I2
disp('ohms',R2)
```

Scilab code Exa 6.3 Current source

```
disp('chapter 6 ex6.3')
disp('given')
disp("current souurce to be designed")
disp("constant output current=100mA")
```

```
Il=.1
disp("maximum load resistance=40ohms")
Rlmax=40
disp("available supply voltage=+/-12V")
Vcc=12
disp("for P MOSFET Vdsmax=100 Idmax=210mA Rdon=5")
Vdsmax=100
Idmax=0.210
Rdon=5
disp("Vdsmax=Vcc=12")
disp("Idmax=Il=100mA")
Vdsmax=Vcc
Idmax=Il
disp("Vlmax=Il*Rlmax")
Vlmax=Il*Rlmax
disp('volts',Vlmax)
disp("Vdsmin=(Id*Rdon)+1")
Vdsmin=(Il*Rdon)+1
disp('volts',Vdsmin)
disp("Vr1(max)=Vcc-Vlmax-Vdsmin")
Vrlmax=Vcc-Vlmax-Vdsmin
disp('volts',Vrlmax)
disp("R1=Vr1/Il")
R1=Vr1max/Il
disp('ohms',R1)
disp("use R1=56ohms std value")
R1=56
disp("Vr1=Il*R1")
Vr1=Il*R1
disp('volts',Vr1)
```

Scilab code Exa 6.4 Precision current sink

```
disp('chapter 6 ex6.4')
disp('given')
```

```
disp("precision current sink to be designed")
disp("constant output current=100mA")
Il=.075
disp("maximum load resistance=50ohms")
Rlmax=50
disp("available supply voltage=+/-15V")
Vcc=15
disp("for 2N222N n-channel MOSFET Vdsmax=60 Idmax=150mA Rdon=7.5ohm")
disp("Vdsmax=Vcc=15")
disp("Idmax=Il=75mA")
Vdsmax=Vcc
Idmax=Il
Rdon=7.5
disp("Vlmax=Il*Rlmax")
Vlmax=Il*Rlmax
disp('volts',Vlmax)
disp("Vdsmin=(Id*Rdon)+1")
Vdsmin=(Il*Rdon)+1
disp('volts',Vdsmin)
disp("Vr5max=Vcc-Vlmax-Vdsmin")
Vr5max=Vcc-Vlmax-Vdsmin
disp('volts',Vr5max)
disp("R5=Vr5/Il")
R5=Vr5max/Il
disp('ohms',R5)
disp("use R5=120ohms std value")
R5=120
Vr5=Il*R5
disp('volts',Vr5)
disp("remaining component calculation is same as for ex 6.2")
```

Scilab code Exa 6.5 HWR voltmeter

```
disp('chapter 6 ex6.5')
disp('given')
disp("design of half wave rectifier")
disp("rms input=1V")
Vi=1
disp("average meter curent 100uA with a resistnce coil 2.5 K is connected")
Iav=100*10^(-6)
Rm=2500
disp("for HWR Ip=2*Iav/0.637")
Ip=2*Iav/0.637
disp('amperes',Ip)
disp("Ip occurs when i/p voltage is at Vp")
disp("Vp=1.414*Vi")
Vp=1.414*Vi
disp('volts',Vp)
disp("R2=Vp/Ip")
R2=Vp/Ip
disp('ohms',R2)
disp("use R2=3.9 Kohm std value and 1Kohm variable in series")
disp("For Opamp")
disp("Vd1=0.7")
Vd1=0.7
disp("opamp voltage range Vomax=Vd1+Ip*(Rm+R2)")
Vomax=Vd1+Ip*(Rm+R2)
disp('volts',Vomax)
disp("input voltage range Vimax=1,414V(peak)")
disp("Upper cutoff frequency=1KHz")
disp("For LM108")
disp("supply voltage can be Vcc=+/-5V to +/-20V")
disp("R1=1Mohm")
R1=1000000
disp("C1=1/(2*%pi*fl*(R1/10))")
fl=10
C1=1/(2*%pi*fl*(R1/10))
disp('farads',C1)
disp("for diodes")
```

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

Scilab code Exa 6.6 Linear ohmmeter

```
disp('chapter 6 ex6.6')
disp('given')
disp("design a linear ohmometer circuit")
disp("Im=100uA and coil resistance=2.5kohm")
Im=100*10^(-6)
Rm=2500
disp("required ohmometer ranges are 100ohm,1kohm,10
    kohm")
R1=100
R2=1000
R3=10000
disp("design voltmeter of full scale deflection of 1
    V to keep min power dissipation")
disp("R5=Vrx/Im")
Vrx=1
Vr5=1
R5=Vrx/Im
disp('ohms',R5)
disp("for opamp A2 Vomax=Vr5+ImRm")
Vomax=Vr5+Im*Rm
disp("Vimax=Vrx")
Vimax=Vrx
disp("for current source")
disp("Ix=1/100,1/1000,1/10000")
Ix3=1/100
disp('amperes',Ix3)
Ix2=1/1000
disp('amperes',Ix2)
Ix1=1/10000
disp('amperes',Ix1)
disp("for p FET  Idmax=10mA  Vdsmax-Vcc")
```

```
disp("2N4342 is a suitable device its Vgsoff=5.5v")
Vgsoff=5.5
Vgsmax=Vgsoff
disp("this allows opamp o/p to be atleast 3V below to operate safely")
disp("Vr4min=Vgsoff+3")
Vr4min=Vgsoff+3
disp('volts',Vr4min)
disp("use Vr4=10V std")
Vr4=10
disp("R4=Vr4/Ix for 100uA,1mA,10mA")
R4=Vr4/Ix1
disp('ohms',R4)
R4=Vr4/Ix2
disp('ohms',R4)
R4=Vr4/Ix3
disp('ohms',R4)
disp("for satisfactory operation  Vdsmin=Vgsoff+1")
Vdsmin=Vgsoff+1
disp('volts',Vdsmin)
disp("Vccmin=Vrx+Vdsmin+Vr4")
Vccmin=Vrx+Vdsmin+Vr4
disp('volts',Vccmin)
disp("use Vcc=+-18V")
Vcc=18
disp("for opamp A1")
disp("Vomax=Vcc-Vr4+Vgsmax")
Vomax=Vcc-Vr4+Vgsmax
disp('volts',Vomax)
disp("Vimax=Vcc-Vr4")
Vimax=Vcc-Vr4
disp('volts',Vimax)
disp("for potential divider")
disp("I1>>Ibmax for A1")
disp("I1=50uA")
I1=50*10^(-6)
disp("V(r1+r2)=Vr4+10%")
Vr1r2=Vr4+0.1*Vr4
```

```
disp('volts',Vr1r2)
disp("R12=R1+R2=Vr1r2/I1")
R12=Vr1r2/I1
disp("R2=20%  of R1+R2")
R2=0.2*R12
disp('ohms',R2)
disp("use R2=50kohm std value")
R2=50000
disp("R1=R12-R2")
R1=R12-R2
disp('ohms',R1)
disp("use R1=150Kohm std value")
R1=150000
disp("I1=V(r1+r2)/(R1+R2)")
I1=Vr1r2/(R1+R2)
disp('amperes',I1)
disp("R3=(Vcc-V(r1+r2))/I1")
R3=(Vcc-Vr1r2)/I1
disp('ohms',R3)
disp("use 120Kohm std value")
```

Scilab code Exa 6.7 Instrumentation Amplifier

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

```
Av2=Av1
disp(Av1,"Av1=Av2=")
disp("I2>>Ibmax")
disp("Ibmax=500nA")
Ibmax=500*10^(-9)
disp("I2=100*Ibmax")
I2=100*Ibmax
disp('amperes',I2)
disp("R2=Vi/I2")
R2=Vi/I2
disp('ohms',R2)
disp("use R2=270ohms std value")
disp("Avdif=(2R1+R2)/R2")
R2=270
disp("R1=R2(Av1-1)/2")
R1=R2*(Av1-1)/2
disp('ohms',R1)
disp("Use R1=3.9Kohm std value")
R1=3900
disp("R3=R1")
R3=R1
disp("For stage 2")
disp("Vo=Av*Vi")
Vo=Av*Vi
disp('volts',Vo)
disp("I5>>Ibmax")
disp("Ibmax=500nA")
disp("I2=100*Ibmax")
I5=100*Ibmax
disp('amperes',I5)
disp("R5=Vo/I5")
R5=Vo/I5
disp('ohms',R5)
disp("R4=R5/Av2")
R4=R5/Av2
disp('ohms',R4)
disp("R6=R4")
R6=R4
```

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

Chapter 7

Signal Processing Circuits

Scilab code Exa 7.1 Precision Half Wave rectifier

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

```
disp('R2=Vo/I1')
R2=Vo/I1
disp('ohms',R2)
disp('use 3.9kohm standard value')
R2=3900
disp('R3=R1||R2')
R3=R1*R2/(R1+R2)
disp('ohms',R3)  //use 820ohm standard value
disp('for diode D1 and D2')
disp('Vr>[Vcc-(-Vee)]')
Vr=[Vcc-(-Vee)]
disp('volts',Vr)
disp('trr<T')
disp('let trrmax=T/10=1/(10*f)')
trrmax=1/(10*f)
disp('seconds',trrmax) //compensate the op-amp as a
    voltage follower
```

Scilab code Exa 7.2 Precision full Wave rectifier

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

```
    current
I1=500*10^(-6)
disp('R1=Vi/I1')
R1=Vi/I1
disp('ohms',R1)    //standard value
disp('R2=2*R1')
R2=2*R1
disp('ohms',R2)    //use two 1kohm resistors in
    series
disp('R3=R1||R2')
R3=R1*R2/(R1+R2)
disp('ohms',R3)    //use 680ohm standard value
disp('R4=R5=R1=1kohm')
R4=1000
R5=1000
disp('for the output tobe 2volt when the input is
    0.5volt')
disp('R6=Vo/Vi*R5')
R6=Vo/Vi*R5
disp('ohms',R6)
disp('use standard value R6=3.9kohm')
R6=3900
disp('R7=R4||R5||R6')
R7=R4*R5*R6/(R4*R5+R5*R6+R6*R4)
disp('ohms',R7) //use 470ohm standard value
disp('For diode D1 and D2,Vr>30volt and trrmax=0.1
    microsec as in ex7.1')
disp('Compensate A1 as a voltage follower')
disp('A2 for gain of R6+R4||R5/(R4||R5)')
A2=(R6+(R4*R5/(R4+R5)))/(R4*R5/(R4+R5))
disp(A2)
```

Scilab code Exa 7.3 High Zin Precision full Wave rectifier

```
disp('chapter 7 ex7.3')
```

```
disp('given')
disp('Design a high input impedance precision full-
    wave rectifier circuit')
disp('input peak value Vi=1volt')
Vi=1
disp('supply voltage Vcc=+or-15volt')  //(using
    bipolar op-amp)
Vcc=15
disp('let I6=500*10^(-6)A')  //for adequate diode
    current
I6=500*10^(-6)
disp('R6=Vi/I6')
R6=Vi/I6
disp('ohms',R6)
disp('use 1.8kohm standard value')
R6=1800
disp('R4=R5=R6=1.8kohm')  //standard value
R4=1800
R5=1800
disp('R3=2*R4')
R3=2*R4
disp('ohms',R3)  //use two 1.8kohm resistors in
    series
disp('R1=R3||R4')
R1=R3*R4/(R3+R4)
disp('ohms',R1)  //standard value
disp('R2=R6||R5')
R2=R6*R5/(R6+R5)
disp('ohms',R2)  //use 1kohm standard value
disp('compensate the op-amps for Av1=2 and A2 as a
    voltage follower')
```

Scilab code Exa 7.4 Peak clipping circuit

```
disp('chapter 7 ex7.4')
```

```
disp('given')
disp('Design an adjustable peak clipping circuit')
disp('Vomax=+or-5volt and Vomin=+or-3volt')
Vomax=5
Vomin=3
disp('Vf=0.7volt')
Vf=0.7
disp('Vomax=Vz+Vf')
Vz=Vomax-Vf
disp('volts',Vz)     //use a 1N 749 Zener diode
disp('I1>Izmin=500*10^(-6)A')
disp('let I1min=2*10^(-3)A')
I1min=2*10^(-3)
disp('R2=Vomin/I1min')
R2=Vomin/I1min
disp('ohms',R2)   //standard value
disp('VR4=Vomax-Vomin')
VR4=Vomax-Vomin
disp('volts',VR4)
disp('R4=VR4/I1min')
R4=VR4/I1min
disp('ohms',R4)    //standard potentiometer value
disp('for Av=1,R1+R4=R2')
Av=1
R1=R2-R4
disp('ohms',R1)
disp('use 470ohm standard value')
R1=470
disp('R3=(R1+R4)||R2')
R3=((R1+R4)*R2)/(R1+R4+R2)
disp('ohms',R3)   //use 680ohm standard value
```

Scilab code Exa 7.5 Dead zone circuit

```
disp('chapter 7 ex7.5')
```

```
disp('given')
disp('Design a dead zone circuit using BIFET op-amp'
    )
disp('voltage of 1volt to pass only in upper portion
    ')
disp('peak voltage Vp=3volt')
Vp=3
disp('Vref=Vp-1')
Vref=Vp-1
disp('volts',Vref)
disp('Ir1min=Idmin=500*10^(-6)')
Ir1min=500*10^(-6)
disp('R1=Vref/Ir1min')
R1=Vref/Ir1min
disp('ohms',R1)
disp('use standard value R1=3.9kohm')
R1=3900
disp('R2=R3=R1=3.9kohm')
R2=3900
R3=3900
disp('R4=R1||R2||R3')
R4=R1*R2*R3/(R1*R2+R2*R3+R3*R1)
disp('ohms',R4)
disp('use 1.2kohm standard value')
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

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

```
Vref=3
disp('Ir1min>IBmin for op-amps')
disp('let Ir1min=500*10^(-6)A')  //adequate diode current
Ir1=500*10^(-6)
disp('R1=Vref/Ir1')
R1=Vref/Ir1
disp('ohms',R1)
disp('use 5.6kohm standard value')
R1=5600
disp('R2=R3=R1=5.6kohm')
R2=5600
R3=5600
disp('R4=R1||R2||R3')
R4=R1*R2*R3/(R1*R2+R2*R3+R3*R1)
disp('ohms',R4)
disp('use 1.8kohm standard value')
disp('R11=R22=R33=R1=5.6kohm')
disp('R44=R4=1.8kohm')
disp('R5=R6=R7=R8=R1=5.6kohm')
R5=5600
R6=5600
R7=5600
R8=5600
disp('R9=R5||R6||R7||R8')
R9=R5*R6*R7*R8/(R5*R6*R7+R5*R6*R8+R5*R7*R8+R6*R7*R8)
disp('ohms',R9)   //use 1.5kohm standard value
disp('select the diodes as in ex7.1 and compensate A1 and A2 as a voltage follower')
disp('compensate A3 for Av=(R8+(R5||R6||R7))/R5||R6||R7')
Av=(R8+(R5*R6*R7/(R5*R6+R6*R7+R7*R5)))/(R5*R6*R7/(R5*R6+R6*R7+R7*R5))
disp(Av)
```

Scilab code Exa 7.7 precision clamping circuit

```
disp('chapter 7 ex7.7')
disp('given')
disp('design op-amp circuit using a supply of +or-12
    volt')
disp('voltage Vp=+or-5volt')
disp('frequency f=10kHz square wave from signal
    source with resistance Rs=100ohm')
Vcc=12
Vee=12
Vp=5
Rs=100
f=10000
disp('C1=1/(2*Rs*f)')
C1=1/(2*Rs*f)
disp('farads',C1)   //standard value
disp('v=1%of 5 volt')
v=.01*5
disp('volts',v)
disp('R1=Vp/(C1*v*f)')
R1=Vp/(C1*v*f)
disp('ohms',R1)   //use 22kohm standard value
disp('R2=R1=22kohm')
disp('for diodes D1 and D2,Vr>[Vcc-(-Vee)]')
Vr=[Vcc-(-Vee)]
disp('volts',Vr)
disp('trr<T')
disp('trrmax=1/(10*f)')
trrmax=1/(10*f)
disp('seconds',trrmax)
disp('compensate the op-amp as for a voltage
    follower')
```

Scilab code Exa 7.8 Peak detector circuit

```
disp('chapter 7 ex7.8')
disp('given')
disp('design a peak detector circuit')
disp('pulse-type signal voltage Vp=2.5volt with a
   rise time tr=5*10^(-6)s')
Vp=2.5
tr=5*10^(-6)
disp('output voltage is 2.5v for time th=100*10^(-6)
   s')
th=100*10^(-6)
disp('maximum output error is to be 1%')
disp('use BIFET op-amp for minimum capacitor leakage
   current')
disp('let R1=R2=1Mohm')
disp('C1 discharge current,Id=IrD2=1*10^(-6)A')
Id=1*10^(-6)
disp('v=1% of Vp')
v=.01*Vp
disp('volts',v)
disp('C1=Id*th/v')
C1=Id*th/v
disp('farads',C1)    //standard value
disp('for op-amp A1,Iomax=C1*Vp/tr')
Iomax=C1*Vp/tr
disp('amperes',Iomax)
disp('slewrate=3*Vp/tr')
slewrate=3*Vp/tr
disp('volts/us',slewrate)
```

Scilab code Exa 7.9 Sample and hold circuit

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

```
disp('sample and hold circuit has a signal amplitude
    of 1volt')
Vi=1
disp('holding time th=500*10^(-6)s')
th=500*10^(-6)
disp('for the LF 353 op-amp,IBmax=50pA')
IBmax=50*10^(-12)
disp('for the 2N4391 FET,the gate-source reverse
   current IGS=200nA')
IGS=200*10^(-9)
disp('the channel resistance when on Rd(on)=30ohm')
Rd=30
disp('let R1=R2=1Mohm')
disp('capacitor discharge current Id=IGS=200nA')
Id=200*10^(-9)
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')
disp('let v=0.1% of Vi')
v=.1*Vi/100
disp('volts',v)
disp('C1=Id*th/v')
C1=Id*th/v
disp('farads',C1)    //standard value
disp('for the 2N4391,VGS(off)=10volt maximum')
disp('V1(-)=-10volt and V1(+)=Vo=+1volt')
disp('for 0.1% error due to acquisition time timin
   =7*C1*Rd')
timin=7*C1*Rd
disp('seconds',timin)
```

Chapter 8

Differentiating and Integrating Circuits

Scilab code Exa 8.1 Differentiating circuit

```
disp('chapter 8 ex8.1')
disp('given')
disp('Design a differentiating circuit')
disp('output voltage Vo=5volt')
Vo=5
disp('input changes by 1volt in a time of
   100*10^(-6)')
v=1
t=100*10^(-6)
disp('let I1>IBmax')
disp('I1=500*10^(-6)')
I1=500*10^(-6)
disp('R2=Vo/I1')
R2=Vo/I1
disp('ohms',R2)
disp('C1=I1*t/v')
C1=I1*t/v
disp('farads',C1)
disp('R1=R2/20')
```

```
R1=R2/20
disp('ohms',R1)
disp('use standard value R1=470ohm')
R1=470
disp('ohms',R1)
disp('R3=R2=10kohm')
disp('Vcc>=+or-(Vo+3Volt)')
Vcc=Vo+3
disp('volts',Vcc)
disp('compensate the op-amp for Av=R2/R1')
Av=R2/R1
disp(Av)
```

Scilab code Exa 8.2 slew rate for Differentiating circuit

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

Scilab code Exa 8.3 Integrating Circuit

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

Scilab code Exa 8.4 slew rate for Integrating circuit

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

Chapter 9

Op Amp Nonlinear Circuits

Scilab code Exa 9.1 Capacitor coupled zero crossing detector

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

```
disp('ohms',R2)
disp('use 220kohm standard value and recalculate I2')
R2=220000
disp('I2=VR2/R2')
I2=VR2/R2
disp('amperes',I2)
disp('VR3=Vb=0.1volt')
VR3=0.1
disp('R3=VR3/I2')
R3=VR3/I2
disp('ohms',R3)    //use a 1.8kohm standard value
disp('let VBE=0.7volt')
VBE=0.7
disp('R1=0.1*VBE/IBmax')
R1=0.1*VBE/IBmax
disp('ohms',R1)
disp('use R1=120kohm standard value')
R1=120000
disp('Vi(peak)=Vi/2')
Vipeak=Vi/2
disp('volts',Vipeak)
disp('I1=Vipeak/R1')
I1=Vipeak/R1
disp('amperes',I1)
disp('let v=1volt')
v=1
disp('t=1/(2*f)')
t=1/(2*f)
disp('seconds',t)
disp('C1=I1*t/v')
C1=I1*t/v
disp('farads',C1)
disp('use a 0.015*10^(-6)F standard value to give v<1volt')
```

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

```
disp('chapter 9 ex9.2')
disp('given')
disp('for circuit designed in ex 9.1 estimate
    minimum op-amp slew rate to give a reasonably
    undistorted output')
disp('Vcc=12volt,Vee=12volt and Vosat=1volt')
disp('t=500*10^(-6)s')
disp('R1=120kohm and C1=0.015*10^(-6)F')
Vcc=12
Vee=-12
Vosat=1
t=500*10^(-6)
R1=120000
C1=0.015*10^(-6)
disp('vo=+Vosat-[-Vosat]=(Vcc-1)-(Vee+1)')
vo=(Vcc-1)-(Vee+1)
disp('volts',vo)
disp('T=0.1*t')
T=0.1*t
disp('seconds',T)
disp('Smin=vo/T')
Smin=vo/T
disp('V/us',Smin)
disp('for a maximum phase shift of 2.9degree with a
    sine wave input')
disp('Xc1=R1/20')
Xc1=R1/20
disp('ohms',Xc1)
disp('fmin=1/(2*%pi*Xc1*C1)')
fmin=1/(2*%pi*Xc1*C1)
disp('Hz',fmin)
```

Scilab code Exa 9.3 Inverting Schmitt trigger circuit

```
disp('chapter 9 ex9.3')
disp('given')
disp('design an inverting Schmitt trigger circuit to
    have trigger points of +or-2volt')
disp('using 741 op-amp with a supply of +or-12volt')
disp('I2>IBmax')
disp('let I2=50*10^(-6)A')
IBmax=500*10^(-9)
I2=50*10^(-6)
Vcc=12
disp('VR2=UTP=2volt')
VR2=2
disp('R2=VR2/I2')
R2=VR2/I2
disp('ohms',R2)
disp('use 39kohm standard value and recalculate I2')
R2=39000
disp('I2=VR2/R2')
I2=VR2/R2
disp('amperes',I2)
disp('VR1=Vosat-VR2=(Vcc-1)-VR2')
VR1=(Vcc-1)-VR2
disp('volt',VR1)
disp('R1=VR1/I2')
R1=VR1/I2
disp('ohms',R1)
disp('use 180kohm standard value')
```

Scilab code Exa 9.4 Noninverting Schmitt trigger circuit

```
disp('chapter 9 ex9.4')
disp('given')
disp('design an noninverting Schmitt trigger circuit
    to have UTP=+3volt and LTP=-5volt')
disp('using 741 op-amp with a supply of +or-15volt
   and Vf=0.7volt')
Vcc=15
Vf=0.7
disp('design first for the UTP')
disp('for adequate diode forward current,let I2
   =500*10^(-6)A')
I2=500*10^(-6)
disp('VR1=UTP=3volt')
VR1=3
disp('R1=VR1/I2')
R1=VR1/I2
disp('ohms',R1)
disp('use 5.6kohm standard value and recalculate I2'
   )
R1=5600
disp('I2=VR1/R1')
I2=VR1/R1
disp('amperes',I2)
disp('VR2=|Vo|-Vf')
VR2=(Vcc-1)-Vf
disp('volts',VR2)
disp('R2=VR2/I2')
R2=VR2/I2
disp('ohms',R2)
disp('use series connected 22kohm and 2.7kohm
   standard value resistors')
disp('now design for LTP,using already selected
   resistance R1=5.6kohm')
disp('VR1=LTP=5volt')
VR1=5
disp('I3=VR1/R1')
I3=VR1/R1
disp('amperes',I3)
```

```
disp('VR3=|Vo|-Vf')
VR3=(Vcc-1)-Vf
disp('volts',VR3)
disp('R3=VR3/I3')
R3=VR3/I3
disp('ohms',R3)
disp('use 15kohm standard value')
disp('select tha diodes,minimum reverse voltage,Vr>
    Vcc=15volt')
disp('trr<=min pulse width/10')
```

Scilab code Exa 9.5 UTP and LTP Noninverting Schmitt trigger circuit

```
disp('chapter 9 ex9.5')
disp('given')
disp('for circuit designed in ex 9.4 calculate the
    actual UTP and LTP using standard resistance
    values')
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')
Vcc=15
Vf=0.7
R1=5600
R2=24700
R3=15000
disp('I2=(|Vo|-Vf)/R2')
I2=((Vcc-1)-Vf)/R2
disp('amperes',I2)
disp('UTP=I2*R1')
UTP=I2*R1
disp('volts',UTP)
disp('I3=(|Vo|-Vf)/R3')
I3=((Vcc-1)-Vf)/R3
disp('amperes',I3)
```

```
disp('LTP=-I3*R1')
LTP=-I3*R1
disp('volts',LTP)
```

Scilab code Exa 9.6 Astable Multivibrators

```
disp('chapter 9 ex9.6')
disp('given')
disp('design an astable multivibrator to have a+or-9
    volt output with frequency f=1kHz')
disp('using BIFET op-amp for Vo=+or-9volt')
Vo=9
disp('Vcc=+or-(Vo+1)')
Vcc=Vo+1
disp('volts',Vcc)
disp('select UTP and LTP<Vo')
disp('let |UTP|=|LTP|=0.5volt')
UTP=0.5
LTP=-0.5
disp('let R2=1Mohm')
R2=1*10^(6)
disp('I3=(|Vo|-UTP)/R2')
I3=(Vo-UTP)/R2
disp('amperes',I3)
disp('R3=UTP/I3')
R3=UTP/I3
disp('ohms',R3)
disp('use 5.6kohm standard value')
disp('let C1=0.1*10^(-6)F')
C1=0.1*10^(-6)
disp('t=1/(2*f)')
t=1/(2*f)
disp('seconds',t)
disp('I1=C1*(UTP-LTP)/t')
I1=C1*(UTP-LTP)/t
```

```
disp('amperes',I1)
disp('R1=(Vo-UTP)/I1')
R1=(Vo-UTP)/I1
disp('ohms',R1)
disp('use 39kohm and3.3kohm in series')
```

Scilab code Exa 9.7 Monostable Multivibrators

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

```
disp('volts',E)
disp('Eo=-(+Vosat-VR2)')
Eo=-(Vcc-1-VR2)
disp('volts',Eo)
disp('ec=Vosat')
ec=Vcc-1
disp('volts',ec)
disp('C2=PW/((R1||R2)*ln[(E-Eo)/(E-ec)])')
C2=PW/((R1*R2/(R1+R2))*2.303*log10([(E-Eo)/(E-ec)]))
disp('farads',C2)
disp('R3max=0.1*VBE/IBmax')
R3max=0.1*VBE/IBmax
disp('ohms',R3max)
disp('use 120kohm standard value')
R3=120000
disp('C1=0.1*t/R3')
C1=0.1*t/R3
disp('farads',C1)
disp('use 91pF standard value')
```

Chapter 10

Signal Generators

Scilab code Exa 10.1 Triangular and rectangular signal generator

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

```
disp('use 270kohm standard value and recalculate I3')
R2=270000
disp('I3=Vosat/R2')
I3=(Vcc-1)/R2
disp('amperes',I3)
disp('R3=UTP/I3')
R3=Vo/2/I3
disp('ohms',R3)     //use 47kohm and 1kohm
disp('integrator circuit')
disp('let C1 charging current I1min=50*10^(-6)A')
I1min=50*10^(-6)
disp('lowest frequency f1,PWmax=80%of Tmax')
PWmax=0.80*1/f1
disp('watts',PWmax)
disp('C1=I1min*t/v')
C1=I1min*PWmax/Vo
disp('farads',C1)     //standard value
disp('R4+R5+R6=(+Vosat-Vf)/I1min')
disp('R9=R4+R5+R6')
R9=(Vcc-1-Vf)/I1min
disp('ohms',R9)
disp('If2=I1min*f2/f1')
If2=I1min*f2/f1
disp('amperes',If2)
disp('R5+R6=(+Vosat-Vf)/If2')
disp('R8=R5+R6')
R8=(Vcc-1-Vf)/If2
disp('ohms',R8)
disp('R4=(R4+R5+R6)-(R5+R6)')
R4=R9-R8
disp('ohms',R4)   //use 250kohm standard value potentiometer
disp('PWmin=20% of Tmax')
PWmin=.20*1/f1
disp('watts',PWmin)
disp('R6=(R5+R6)*PWmin/PWmax')
R6=R8*PWmin/PWmax
```

```
disp('ohms',R6)
disp('use 6.8kohm standard value')
R6=6800
disp('R5=(R5+R6)-R6')
R5=R8-R6
disp('ohms',R5)    //standard value of potentiometer
disp('R7=R6=6.8kohm')
```

Scilab code Exa 10.2 Phase shift oscillator

```
disp('chapter 10 ex10.2')
disp('given')
disp('design a phase shift oscillator to have output
    frequency of 3.5kHz')
disp('using 741 op-amp with a supply of +or-12volt')
Vcc=12
f=3500
disp('I1>IBmax')
disp('let I1=50*10^(-6)A')
IBmax=500*10^(-9)
I1=50*10^(-6)
disp('Vo=+or-(Vcc-1)')
Vo=Vcc-1
disp('volts',Vo)
disp('R2=Vo/I1')
R2=Vo/I1
disp('ohms',R2)    //standard value
disp('let Av=29')
Av=29
disp('R1=R2/Av')
R1=R2/Av
disp('ohms',R1)
disp('use 6.8kohm to give Av>29')
R1=6800
disp('R=R1=6.8kohm')
```

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

Scilab code Exa 10.3 Phase shift oscillator

```
disp('chapter 10 ex10.3')
disp('given')
disp('design a phase shift oscillator to have output
    frequency of 6kHz and to give maximum output of
   +or-3volt')
Vo=3
f=6000
disp('let I2=1mA when diodes are forward-biased,i.e
   peak output Vp=3volt and Vf=0.7volt')
I2=1*10^(-3)
Vf=0.7
disp('R1=Vo/29/I2')
R1=Vo/29/I2
disp('ohms',R1)
disp('use 100ohm standard value')
R1=100
disp('R2=29*R1')
R2=29*R1
disp('ohms',R2)
disp('R3=2*Vf/I2')
R3=2*Vf/I2
disp('ohms',R3)
disp('use 1.5kohm standard value')
R3=1500
disp('R4=R2-R3')
R4=R2-R3
disp('ohms',R4)
disp('R5=0.4*R4')
```

```
R5=0.4*R4
disp('ohms',R5)    //use a 1kohm potentiometer
disp('R6=0.8*R4')
R6=0.8*R4
disp('ohms',R6)  //use 1.2kohm standard value
disp('R=R1=100ohm')
R=100
disp('C=1/(2*%pi*R*f*sqrt(6))')
C=1/(2*%pi*R*f*sqrt(6))
disp('farads',C)  //standard value
disp('diodes D1 through D4,trrmax=T/10')
trrmax=1/(f*10)
disp('seconds',trrmax)
disp('Vrmax>Vcc=+or-15volt')
disp('the IN914 has trr=4ns and Vrmax=75volt use IN914 diodes')
```

Scilab code Exa 10.4 Wein bridge oscillator

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

```
disp('let R4=R2=1kohm')
R4=1000
disp('R3=2*R4')
R3=2*R4
disp('ohms',R3)
disp('use 2.2kohm standard value to give Av>3')
```

Scilab code Exa 10.5 signal generator

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

```
R1=18000
disp('R2max=Vomax/Vi*R1')
R2max=Vomax/Vi*R1
disp('ohms',R2max)
disp('R2min=Vomin/Vi*R1')
R2min=Vomin/Vi*R1
disp('ohms',R2min)
disp('for R2,use a 100kohm potentiometer in series
    with a 1.8kohm resistor')
disp('I3>IBmax')
disp('let I3=50*10^(-6)A')
I3=50*10^(-6)
disp('R4=VR4/I3')
R4=VR4/I3
disp('ohms',R4)    //standard potentiometer
disp('R3=VR3/I3')
VR3=Vcc-2.5
R3=VR3/I3
disp('ohms',R3)
disp('use 220kohm to give larger output adjustment
    than required')
disp('R5=R3=220kohm')
disp('Xc1<R1 at fmin')
disp('let Xc1=R1/10 at fmin')
disp('C1=1/(2*%pi*fmin*R1/10)')
C1=1/(2*%pi*fmin*R1/10)
disp('farads',C1)   //standard value
```

Chapter 11

Active Filters

Scilab code Exa 11.1 All pass circuit

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

```
disp('ohms',R3)
disp('for a 90degree phase shift,Xc1=R3')
disp('C1=1/(2*%pi*f*R3)')
C1=1/(2*%pi*f*R3)
disp('farads',C1)
disp('use 3600pF standard value')
C1=3600*10^(-12)
disp('for a 80degree phase shift,R3=tan(theta1/2)/(w
    *C1)')
theta1=80
R3=tan(theta1*%pi/180/2)/(2*%pi*f*C1)
disp('ohms',R3)
disp('for a 100degree phase shift,R3=tan(theta2/2)/(
    w*C1)')
theta2=100
R3=tan(theta2*%pi/180/2)/(2*%pi*f*C1)
disp('ohms',R3)
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

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

```
disp('R2=R1=120kohm')
R1=120000
R2=120000
disp('Xc1=R1 at fc')
disp('C1=1/(2*%pi*fc*R1)')
C1=1/(2*%pi*fc*R1)
disp('farads',C1)
disp('use 1300pF standard value')
```

Scilab code Exa 11.3 Second order low pass filter

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

```
C1=1/(2*%pi*fc*sqrt(2)*R2)
disp('farads',C1)
disp('use 1600pF standard value')
C1=1600*10^(-12)
disp('C2=2*C1')
C2=2*C1
disp('farads',C2)
```

Scilab code Exa 11.4 First order active high pass filter

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

Scilab code Exa 11.5 second order active high pass filter

```
disp('chapter 11 ex11.5')
disp('given')
disp('design a second order high-pass filter to have
    cutoff frequency 12kHz')
disp('from 715 data sheet,IBmax=1.5*10^(-6)A')
fc=12000
IBmax=1.5*10^(-6)
disp('R2=70mV/IBmax')
R2=70*10^(-3)/IBmax
disp('ohms',R2)
disp('R1=R2/2')
R1=R2/2
disp('ohms',R1)
disp('use 22kohm and 1.5kohm in series')
disp('R3=R2=47kohm')
R3=47000
R2=47000
disp('R2=sqrt(2)*Xc2 at fc')
disp('C2=1/(2*%pi*fc*R2/sqrt(2))')
C2=1/(2*%pi*fc*R2/sqrt(2))
disp('farads',C2)
disp('use 390pF standard value')
disp('C1=C2=390pF')
disp('from 715 data sheet the op-amp unity gain
    cutoff frequency is fu=11MHz')
Av=1
fu=11*10^(6)
disp('f2=fu/Av')
f2=fu/Av
disp('Hz',f2)
```

Scilab code Exa 11.6 Third order low pass filter

```
disp('chapter 11 ex11.6')
disp('given')
```

```
disp('design a third order active low-pass filter to
    have cutoff frequency 30kHz')
fc=30000
disp('-20dB per decade stage(first order)')
disp('select C1=1000pF')
C1=1000*10^(-12)
disp('Xc1=R1 at fc/0.65')
disp('R1=0.65/(2*%pi*fc*C1)')
R1=0.65/(2*%pi*fc*C1)
disp('ohms',R1)    //use 3.4kohm+or-1%standard value
disp('R2=R1=3.4kohm')    //use 3.3kohm standard value
disp('-40dB per decade stage(second order)')
disp('select C3=1000pF')
C3=1000*10^(-12)
disp('Xc3=sqrt(2)*R4 at fc/0.8')
disp('R4=0.8/(2*%pi*fc*sqrt(2)*C3)')
R4=0.8/(2*%pi*fc*sqrt(2)*C3)
disp('ohms',R4)    //use two 5.9kohm+or-1% parallel-
   connected
disp('C2=2*C3')
C2=2*C3    //standard value
disp('farads',C2)
disp('R3=R4=2.95kohm')
R3=2950
disp('R5=R4+R3')
R5=R4+R3
disp('ohms',R5)    //use 5.6kohm standard value
```

Scilab code Exa 11.7 Third order high pass filter

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

```
disp('-20dB per decade stage(first order)')
disp('let R1=120kohm')
R1=120000
disp('Xc1=R1 at 0.65*fc')
disp('C1=1/(2*%pi*0.65*fc*R1)')
C1=1/(2*%pi*0.65*fc*R1)
disp('farads',C1)
disp('this is so small that it can be affected by stray capacitance and redesign selecting C1')
disp('select C1=1000pF')
C1=1000*10^(-12)
disp('R1=1/(2*%pi*0.65*fc*C1)')
R1=1/(2*%pi*0.65*fc*C1)
disp('ohms',R1)   //use 12kohm standard value
disp('R2=R1=12kohm')
disp('-40dB per decade stage(second order)')
disp('select C3=1000pF')
C3=1000*10^(-12)
disp('R4=sqrt(2)*Xc3 at 0.8*fc')
disp('R4=sqrt(2)/(2*%pi*0.8*fc**C3)')
R4=sqrt(2)/(2*%pi*0.8*fc*C3)
disp('ohms',R4)   //use 14kohm+or-1% standard value
disp('C2=C3=1000pF')
disp('R3=R4/2')
R3=R4/2
disp('ohms',R3)  //use 6.98kohm standard value
disp('R5=R4=14.06kohm')   //use 15kohm standard value
```

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

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

```
disp('from 741 data sheet ,the op-amp unity gain
   cutoff frequency is fu=800kHz')
disp('f=fu/Av')
fu=800000
Av=1
f=fu/Av
disp('Hz',f)
disp('the circuit upper cutoff frequency is ,fc=0.65*
   f')
fc=0.65*f
disp('Hz',fc)
```

Scilab code Exa 11.9 Single stage band pass filter

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

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

Scilab code Exa 11.10 Bandpass Filter

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

Scilab code Exa 11.11 State variable bandpass filter

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

```
disp('design a bandpass filter to have f1=10.3kHz f2
    =10.9kHz")
f1=10300
f2=10900
disp("select C1=C2=1000pF")
C1=1000*10^(-12)
C2=1000*10^(-12)
disp("fo=sqrt(f1*f2)")
fo=sqrt(f1*f2)
disp('Hz',fo)
disp("R5=R6=1/(2*%pi*C1*f1)")
R6=1/(2*%pi*C1*f1)
R5=R6
disp('ohms',R6)
disp("Use 15kohm std value")
R5=15000
disp("R1=R3=R4=R7=R8=R6=R5=15kOhm")
disp("Q=fo/(f2-f1)")
Q=fo/(f2-f1)
disp(Q)
R1=R5
disp("R2=R1*(2Q-1)")
R2=R1*(2*Q-1)
disp('ohms',R2)
disp("use 511kohm+/- 1%")
```

Chapter 12

DC Voltage Regulators

Scilab code Exa 12.1 DC voltage source

```
disp('chapter 12 ex12.1')
disp('given')
disp("the dc voltage source is designed in ex 6.1
   has")
disp("Vs=Vcc=12V     Vo=6.3V        R1=270ohm       ")
disp("D1 is zener diode   Ilmax=42mA")
Vs=12
Vcc=12
Vo=6.3
R1=270
Ilmax=.042
disp("supply resistance=25 ohm")
Rs=25
disp("from datasheet Zz=7ohm")
Zz=7
disp("at 10% change in Vs")
DVs=.1*Vs
disp('volts',DVs)
DVo=DVs*Zz/R1
disp(DVo,"DVo=")
disp("Line regulation=(DVo for 10%Vs change)*100/Vo"
```

```
)
LR=(DVo)*100/Vo
disp(LR,"LR in percentage")
DVo=Ilmax*Rs*Zz/R1
disp(DVo,"DVo=")
disp("Load regulation=(DVo for DIl=Ilmax)*100/Vo")
LR=(DVo)*100/Vo
disp(LR,"Load regulation in percentage=")
Vro=Zz/R1
disp(Vro,"Vro=Vrs*")
disp("Ripple rejection=20*log(Vrs/Vro)")
RR=20*log10(1/Vro)
disp(RR,"Ripple Rejection in DB= ")
```

Scilab code Exa 12.2 Voltage Regulator

```
disp('chapter 12 ex12.2')
disp('given')
disp("output =12V")
Vo=12
disp("max load current=50mA")
Il=.05
disp("Vsmin=Vo+3 V")
Vsmin=Vo+3
disp( 'volts',Vsmin)
disp("allowing Vrs=2V(p to p)")
Vrs=2
disp("Vs=Vsmin+Vrs/2")
Vs=Vsmin+Vrs/2
disp('volts',Vs)
disp("let Vz=Vs/2")
Vz=Vs/2
disp('volts',Vz)
disp("Iz=20mA")
Iz=.02
```

```
disp("R1=(Vs-Vz)/Iz")
R1=(Vs-Vz)/Iz
disp('ohms',R1)
disp("R1=390 ohm std value")
R1=390
disp("let I2>>Ibmax     I2=50uA")
I2=50*10^(-6)
disp("R2=(Vo-Vz)/I2")
Vz=8.2
R2=(Vo-Vz)/I2
disp('ohms',R2)
disp("R2=68kohm std value")
R2=68000
disp("I2=(Vo-Vz)/R2")
I2=(Vo-Vz)/R2
disp('amperes',I2)
disp("R3=Vz/Iz")
R3=Vz/I2
disp('ohms',R3)
disp("use 150 k ohm std value")
R3=150000
disp("select C1=50uF")
C1=50*10^(-6)
disp("Q1 specification")
disp("Vcemax=Vsmax=Vs+Vrs/2")
Vcemax=Vs+Vrs/2
disp('volts',Vcemax)
Ie=Il
disp("P=Vce*Il=(Vs-Vo)*Il")
P=(Vs-Vo)*Il
disp('watts',P)
disp("A 2N718 is a suitable device")
```

Scilab code Exa 12.3 analysing Voltage Regulator

```
disp('chapter 12 ex12.3')
disp('given')
disp("considering example 12.2")
disp("supply source resistance=10ohm")
Rs=10
disp("from IN756 datasheet Zz=8ohm")
Zz=8
disp("At 10% change in Vs=16V is")
Vs=16
DVs=.1*Vs
disp('volts',DVs)
disp("DVo=DVs*Zz*(R2+R3)/(R1*R3)")
disp("R2=68000  R1=390   R3=150000")
R2=68000
R1=390
R3=150000
DVo=DVs*Zz*(R2+R3)/(R1*R3)
disp('volts',DVo)
disp("Line regulation=(DVo for 10%Vs change)*100/Vo
    and Vo=12V")
Vo=12
LR=(DVo)*100/Vo
disp(LR,"LR in percentage")
disp("for Il change of 50mA")
Il=0.05
disp("DVo=Il*Rs")
DVs=Il*Rs
disp('volts',DVs)
DVo=DVs*Zz*(R2+R3)/(R1*R3)
disp('volts',DVo)
disp("Load regulation=(DVo for DIl=Ilmax)*100/Vo")
LR=(DVo)*100/Vo
disp(LR,"Load regulation in percentage=")
disp("Vro=Vrs*Zz*(R2+R3)/(R1*R3)")
y=Zz*(R2+R3)/(R1*R3)
disp(y,"Vro=Vrs*")
disp("Ripple rejection=20*log(Vrs/Vro)")
RR=20*log10(1/y)
```

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

Scilab code Exa 12.4 DC Voltage Regulator

```
disp('chapter 12 ex12.4')
disp('given')
disp("output =10V to 15V")
Vomax=15
disp("max load current=4000mA")
Il=.4
disp("Vsmin=Vomax+3 V")
Vsmin=Vomax+3
disp('volts',Vsmin)
disp("allowing Vrs=3V(p to p)")
Vrs=3
disp("Vs=Vsmin+Vrs/2")
Vs=Vsmin+Vrs/2
disp('volts',Vs)
disp("ZENER CIRCUIT")
disp("let Vz=Vo/2")
Vz=Vomax/2
disp('volts',Vz)
disp("Iz=20mA")
Iz=.02
disp("R1=(Vo-Vz)/Iz")
R1=(Vomax-Vz)/Iz
disp('ohms',R1)
disp("R1=330 ohm std value")
R1=390
disp("POTENTIAL DIVIDER")
disp("let I2>>Ibmax      I2=50uA Vomin=10")
I2=50*10^(-6)
Vomin=10
disp("R2=(Vomin-Vz)/I2")
Vz=7.5
```

```
R2=(Vomin-Vz)/I2
disp('ohms',R2)
disp("R2=47kohm std value")
R2=47000
disp("I2=(Vomin-Vz)/R2")
I2=(Vomin-Vz)/R2
disp('amperes',I2)
disp("R34=R3+R4=Vz/Iz")
R34=Vz/I2
disp('ohms',R34)
disp("when Vo is at its max,moving contact is at
   bottom of R4")
disp("I2=Vomax/(R2+R34)")
I2=Vomax/(R2+R34)
disp('amperes',I2)
disp("R3=Vz/Iz")
R3=Vz/I2
disp('ohms',R3)
disp("use 100 k ohm std value")
R3=100000
disp("R4=(R3+R4)-R3")
R4=R34-R3
disp('ohms',R4)
disp("use 50 k ohm std value")
disp("CAPACITOR")
disp("select C1=100uF")
C1=100*10^(-6)
disp("Q1 specification")
disp("Vcemax=Vsmax=Vs+Vrs/2")
Vcemax=Vs+Vrs/2
disp('volts',Vcemax)
Ie=Il
disp("P=Vce*Il=(Vs-Vomin)*Il")
P=(Vs-Vomin)*Il
disp('watts',P)
disp("A 2N3055 is a suitable device")
disp("Q2 specification")
disp("Vcemax=Vsmax=Vs+Vrs/2")
```

```
Vcemax=Vs+Vrs/2
disp('volts',Vcemax)
disp("Ie=Il/hFE1 ,hFE1=20 for Q1")
hFE1=20
Ie=Il/hFE1
disp('amperes',Ie)
disp("P=Vce*Il=(Vs-Vomin)*Il")
P=(Vs-Vomin)*Il
disp('watts',P)
disp("A 2N3904 is a suitable device")
disp("R5 Calculation")
disp("let Ie2min=0.5mA,Vbe1=0.7")
Ie2min=0.5*10^(-3)
Vbe1=0.7
disp("R5=(Vomin+Vbe1)/Ie2min")
R5=(Vomin+Vbe1)/Ie2min
disp('ohms',R5)
disp("R5=18kohm std value")
disp("OPERATIONAL AMPLIFIER")
disp("because I2 is sselected for bipolar opamp
    either a bipolar or BIFEt opamp can be used")
disp("supply voltage Vs=19.5V")
Vs=19.5
disp("Input supply voltage range=Vs/2-Vz")
ipvoltage==(Vs/2)-Vz
disp('volts',ipvoltage)
```

Scilab code Exa 12.5 Voltage Regulator

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

```
R6=0.5/Isc
disp('ohms',R6)
disp("Let Ic3=5mA")
Ic3=.005
disp("R7=Vs/Ic3")
disp("Vs=16")
Vs=16
R7=Vs/Ic3
disp('ohms',R7)
disp("Ib1max=Ilmax/hfe1    Ilmax=50mA   hfe1=50")
hfe1=50
Ilmax=.05
Ib1max=Ilmax/hfe1
disp('amperes',Ib1max)
disp("Vr7=1mA*R7")
Vr7=.001*3300
disp('volts',Vr7)
disp("yhis volatage drop is too large for circuit to operate satisfactorily")
disp("to overcome we make use of darlington pair ")
disp("hfe2=50")
hfe2=50
disp("Ib2max=Ilmax/(hfe1*hfe2)")
Ib2max=Ilmax/(hfe1*hfe2)
disp('amperes',Ib2max)
disp("under normal operating conditions Vr7=Ib2max*R7")
Vr7=Ib2max*3300
disp('volts',Vr7)
```

Scilab code Exa 12.6 foldback current limiting circuit

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

```
o/p current=400mA when limited foldback to 200mA")
Ilmax=0.4
Isc=0.2
disp("Vr6=0.5 at short circuit")
disp("R6=0.5/Isc")
R6=0.5/Isc
disp('ohms',R6)
disp("use 2.7 ohm std value")
R6=2.7
disp("Vr6=Ilmax*R6")
Vr6=Ilmax*R6
disp('volts',Vr6)
disp("Vr8=Vr6-0.5     Vr6=1")
Vr8=1-0.5
disp('volts',Vr8)
disp("Ir8>>Ib3     hfe3=50   Ic3=5mA")
Ic3=0.005
hfe3=50
disp("Ib3=Ic3/hfe3")
Ib3=Ic3/hfe3
disp('amperes',Ib3)
disp("let Ir8=1mA")
Ir8=0.001
disp("R8=Vr8/Ir8")
R8=Vr8/Ir8
disp('ohms',R8)
disp("use 470 ohm std value")
R8=470
disp("using average level of Vo=12.5")
Vo=12.5
disp("R9=(Vo-Vr8)/Ir8")
R9=(Vo-Vr8)/Ir8
disp('ohms',R9)
disp("R7=Vs/Ic3     Vs=19.5")
Vs=19.5
R7=Vs/Ic3
disp('ohms',R7)
```

```
disp(" hfe2=50       hfe1=20")
hfe2=50
hfe1=20
disp("Ib2max=Ilmax/(hfe1*hfe2)")
Ib2max=Ilmax/(hfe1*hfe2)
disp('amperes',Ib2max)
disp("  Vr7=Ib2max*R7")
Vr7=Ib2max*R7
disp('volts',Vr7)
```

Scilab code Exa 12.7 Positive Voltage Regulator

```
disp('chapter 12 ex12.7')
disp('given')
disp("voltage regulator to have o/p voltage=18V")
Vo=18
disp("I2>>error amplifier input bias current")
disp("Let I2=1mA")
I2=0.001
disp("Vr2=Vref=7.15")
Vr2=7.15
Vref=7.15
disp("R2=Vref/I2")
R2=Vref/I2
disp('ohms',R2)
disp("use 6.8 kohm std value")
R2=6800
disp("I2=7.15/6.8k")
I2=7.15/6800
disp('amperes',I2)
disp("R1=(Vo-Vr2)/I2")
R1=(Vo-Vr2)/I2
disp('ohms',R1)
disp("use 10 kohm std value")
R1=10000
```

```
disp("for satisfactory operatiom of series pass
    transistor")
disp("Let Vs-Vo=5V    Vs=Vo+5  ")
Vs=Vo+5
disp('volts',Vs)
disp("Inteernal circuit current is approximately ")
disp("I=Istandby+Iref=25mA")
I=0.025
disp("Internal power dissipation excluding series
    pass transistor ")
disp("Pi=(Istandby+Iref)*Vs")
Pi=(I)*Vs
disp('watts',Pi)
disp("Maximum power dissipated in series pass
    transistor")
disp("P=(specified Pdmax)-Pi     Pdmax=1000mW")
Pdmax=1
P=Pdmax-Pi
disp('watts',P)
disp("Maximum load current=P/(Vs-Vo)")
Ilmax=P/(Vs-Vo)
disp('amperes',Ilmax)
```

Scilab code Exa 12.8 LM217 Voltage Regulator

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

```
disp('ohms',R1)
disp("use 270ohm std value and recalculate I1")
R1=270
disp("I1=Vref/R1")
I1=Vref/R1
disp('amperes',I1)
disp("R2=(Vo-Vr1)/I1, Vr1=1.25")
Vr1=1.25
R2=(Vo-Vr1)/I1
disp('ohms',R2)
disp("use 1.5kohm and 220 ohm in series")
```