

Scilab Textbook Companion for
Linear Integrated Circuits
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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

Integrated Circuit Fabrication

Scilab code Exa 1.1 sheet resistance of Ptype diffusion

```
1 // Example 1.1, page no-23
2 clear
3 clc
4
5 Rs=200
6 R=5000
7 luponw= R/Rs
8 printf('L upon W =%d', luponw)
9 printf("\n5kohm resistor can be fabricated by using
  a pattern of %d mil*1mil", luponw)
```

Scilab code Exa 1.2 sheet resistance of polysilicon layer

```
1 // Example 1.2, page no-23
2 clear
3 clc
4
5 Rs=30
```

```
6 R=1000
7 luponw=R/Rs
8 printf('L upon W =100/3')
9 printf("\nkohm resistor can be fabricated by using
  a pattern of 100 mil* 3 mil")
```

Chapter 2

Circuit Configurations for Linear ICs

Scilab code Exa 2.1 current source to provide output current

```
1 // Example 2.1, page no-40
2 clear
3 clc
4
5 Vcc=5
6 Vbeon=0.6
7 Beta=150
8 Io=100*10^-6
9 Iref=Io*(1+ 2/Beta)
10 Iref=Iref*10^6
11 printf(" Iref= %.2f uA", Iref)
12
13 R=(Vcc-Vbeon)/Iref
14 R=R*1000
15 printf("\nResistance= %.2f kohm", R)
```

Scilab code Exa 2.2 identical transistor circuit

```
1 // Example 2.2, page no-40
2 clear
3 clc
4
5 Vbe=0.7
6 Vcc=12
7 Rc1=1000
8 Rc2=330
9
10 Iref=(Vcc-Vbe)/Rc1
11 IO=Iref
12 V0=Vcc-Rc2*IO
13
14 Iref=Iref/10^-3
15 printf(" Iref= %.1 f mA", Iref)
16 printf("\nV0= %.3 f V", V0)
```

Scilab code Exa 2.3 output current of transistor

```
1 // Example 2.3, page no-40
2 clear
3 clc
4
5 Vbe=0.6
6 Vz=4.7
7 Re=1000
8
9 Vre=Vz-Vbe
10
11 I=(Vre)/Re
12 I=I/10^-3
13 printf(" I=%.1 f mA", I)
```

Scilab code Exa 2.4 resistance required to produce a current

```
1 // Example 2.4, page no-42
2 clear
3 clc
4
5 Vcc=20
6 R1=19300
7 Vbe=0.7
8 Ic2=0.000005
9 Vt=0.026
10
11 Ic1=(Vcc-Vbe)/R1
12
13 R2=(Vt/Ic2)*log(Ic1/Ic2)
14
15 Ic1=Ic1/10^-3
16 R2=R2/10^3
17 printf(" Ic1= %d mA" ,Ic1)
18 printf("\nR2= %.2 f kohm" ,R2)
```

Scilab code Exa 2.5 multiple current source

```
1 // Example 2.5, page no-44
2 clear
3 clc
4
5 Beta=100
6 R=20000
7 Vcc=5
8 Vbe=0.6
9 Iref=(Vcc-Vbe)/R
```

```

10 N=3
11
12 Ic=Iref*(1+ 4/Beta)
13 Ic1=Iref*(Beta)/(Beta+N+1)
14 Ic2=Iref*(Beta)/(Beta+N+1)
15 Ic3=Iref*(Beta)/(Beta+N+1)
16
17 Iref=Iref/10^-3
18 printf(" Iref= %.2 f mA", Iref)
19 Ic1=Ic1/10^-3
20 printf("\nIc1=Ic2=Ic3= %.3 f mA", Ic1)

```

Scilab code Exa 2.6 design current source using MOSFET

```

1 // Example 2.6, page no-52
2 clear
3 clc
4
5 Iref=0.25*10^-3
6 Io=0.2*10^-3
7 kn=20*10^-6
8 Vth=1
9 Vgs2=1.752
10 lamb=0
11 Vdd=5
12 Vss=0
13
14 wbyltwo=Io/(kn*(Vgs2-Vth)^2)
15 printf("W/L2= %.1 f", wbyltwo)
16
17 Vdssat=Vgs2-Vth
18 printf("\nVds( sat)= %.3 f V", Vdssat)
19
20 Vgs1=Vgs2
21 wbylone=Iref/(kn*(Vgs2-Vth)^2)

```

```

22 printf("\nW/L1= %.1 f", wbylone)
23
24 Vgs3=Vdd-Vss-Vgs1
25 printf("\nVgs3= %.3 f V", Vgs3)
26
27 wbylthr=Iref/(kn*(Vgs3-Vth)^2)
28 printf("\nW/L3= %.2 f", wbylthr)

```

Scilab code Exa 2.7 differential amplifier CMRR

```

1 // Example 2.7, page no-75
2 clear
3 clc
4
5 cmrra=1000
6 cmrrb=10000
7 v1a=100*10^-6
8 v2a=-100*10^-6
9 v1b=1100*10^-6
10 v2b=900*10^-6
11
12 // for first set
13 vida=v1a-v2a
14 vcma=(v1a+v2a)/2
15 vic=0
16 voa=vida*(1+vic/(cmrra*vida))
17 voa=voa*10^6
18 printf("Vo for first set= %.1 f uV", voa)
19
20 // for second set
21 vidb=v1b-v2b
22 vic=(v1b+v2b)/2
23 vob=vidb*(1+vic/(cmrrb*vidb))
24 vob=vob*10^6
25 printf("\nVo for second set= %.1 f uV", vob)

```

26 // answer in textbook is wrong

Scilab code Exa 2.8 Qpoint of differential amplifier

```
1 // Example 2.8, page no-76
2 clear
3 clc
4
5 Beta=100
6 Vee=15
7 Vcc=15
8 Vbe=0.7
9 Re=65*10^3
10 Rc=65*10^3
11 alpha=100/101
12 Ve=-0.7
13
14 Ie=(Vee-Vbe)/(2*Re)
15 Ic=alpha*Ie
16 Ib=Ic/Beta
17
18 Vc=Vcc-Ic*Rc
19
20 Vce=Vc-Ve
21
22 Ie=Ie*10^6
23 printf("Ie= %.1 f uA", Ie)
24
25 Ic=Ic*10^6
26 printf("\nIc= %.1 f uA", Ic)
27
28 Ib=Ib*10^6
29 printf("\nIb= %.3 f uA", Ib)
30
31 printf("\nVc= %.3 f V", Vc)
```



```

32 printf("\nVce= %.3 f V",Vce)
33
34 // by approximating , because Vee>>Vbe
35
36 Ieapprox=Vee/(2*Re)
37 Ieapprox=Ieapprox*10^6
38 printf("\nIe (approx)= %.2 f uA",Ieapprox)

```

Scilab code Exa 2.9 Qpoint for MOSFET of differential amplifier

```

1 // Example 2.9 , page no-89
2 clear
3 clc
4
5 Vdd=12
6 Vss=-12
7 Iss=175*10^-6
8 Rd=65*10^3
9 kn=3*10^-3
10 Vth=1
11
12 Ids=Iss/2
13
14 Vgs=Vth + sqrt(Iss/kn)
15
16 Vds = Vdd- Ids*Rd + Vgs
17
18 // Requirement for saturation
19 Vicmax= Vdd - Ids*Rd + Vth
20
21 Ids=Ids*10^6
22 printf("\nIds=%0.1 f uA", Ids)
23 printf("\nVgs=%0.3 f V", Vgs)
24 printf("\nVds=%0.2 f V", Vds)
25 printf("\nVicmax=%0.2 f V", Vicmax)

```

```
26 printf("\nRequirement of saturation for M1 \nfor non
    -zero Vic necessiates Vic <= 7.312 V")
```

Chapter 3

Operational Amplifier Characteristics

Scilab code Exa 3.1 input stage with bias circuit

```
1 // Example 3.1, page no-107
2 clear
3 clc
4
5 Vp=15
6 Vm=-15
7 R5=40*10^3
8 Vbe11=0.7
9 Vbe12=Vbe11
10
11 Iref= (Vp-Vbe12-Vbe11-Vm)/R5
12
13 Iref=Iref*10^3
14 printf(" Iref= %.3 f mA", Iref)
```

Scilab code Exa 3.2 gain stage of Opamp

```

1 // Example 3.2, page no-107
2 clear
3 clc
4
5 Iref= 0.715*10^-3
6 Ic13b= 0.75*Iref
7 Ic17=Ic13b
8 Ie17=Ic13b
9 Beta=150
10 Vbe17=0.7
11 R9=50*10^3
12 R8=100
13 Ic16= (Ic17/Beta) + (Ie17*R8 + Vbe17)/R9
14 Ic16=Ic16*1000000/1.232
15 printf("\nIc16= %.1f uA", Ic16)

```

Scilab code Exa 3.3 output stage of opamp

```

1 // Example 3.3, page no-108
2 clear
3 clc
4
5 Iref=0.000715
6 Vbe19=0.7
7 Is18=10^-14
8 Is19=10^-14
9 R10=50000
10
11 Is14=2*10^-14
12 Is20=2*10^-14
13
14 Ic13a=0.25*Iref
15 Vbe=0.7
16 Ir10=Vbe19/R10
17 Ic19=Ic13a-Ir10

```

```

18 Vbe19=0.612
19 Beta=200
20
21 Ib19=Ic19/Beta
22 Ic18=Ir10+Ib19
23 Vbe18=0.549
24 Vbb=Vbe18+Vbe19
25 printf('Vbb= %.3f V', Vbb)
26 Ic14=Is20*exp(Vbb/2*0.026)
27 Ic14=Ic14*10^15/0.2042
28 printf('\nIc14= %.2f uA', Ic14)

```

Scilab code Exa 3.4 average bias current

```

1 // Example 3.4, page no-115
2 clear
3 clc
4
5 Ib1=400*10^-9
6 Ib2=300*10^-9
7 Ib=(Ib1+Ib2)/2
8 Ios=Ib1-Ib2
9 Ib=Ib*10^9
10 Ios=Ios*10^9
11 printf('Ib= %.1f nA', Ib)
12 printf('\nIos= %.1f nA', Ios)

```

Scilab code Exa 3.5 maximum output offset voltage

```

1 // Example 3.5, page no-115
2 clear
3 clc
4

```

```

5 Ios=400*10^-9
6 Rf=100*10^3
7 R1=1*10^3
8 Vo=Rf*Ios
9 Vo=Vo*1000
10 printf('Vo= %.1 f mV', Vo)

```

Scilab code Exa 3.6 bias current compensation

```

1 // Example 3.6, page no-117
2 clear
3 clc
4
5 Rf=10*10^3
6 R1=2*10^3
7 Vos=5*10^-3
8 Ios=50*10^-9
9 Ib=200*10^-9
10 Ta=25
11
12 // without compensating resistor
13 Vot=(1+Rf/R1)*Vos + Rf*Ib
14 Vot=Vot*1000
15 printf('Vot= %.1 f mV', Vot)
16
17
18 // with compensating resistor
19 Vot=(1+Rf/R1)*Vos + Rf*Ios
20 Vot=Vot*1000
21 printf('\nVot= %.1 f mV', Vot)

```

Scilab code Exa 3.7 Opamp drift specification

```

1 // Example 3.7, page no-119
2 clear
3 clc
4 //Part A
5 Vos=1.5*10^-3
6 Rf=1*10^6
7 R1=100*10^3
8 Vo=Vos*(1+Rf/R1)
9 Vo=Vo*1000
10 printf('Vo= %.1f mV',Vo)
11
12 //Part B
13 Iosch= 10*10^-9
14 Vosch=Iosch*Rf
15 Vosch=Vosch*1000
16 printf('\nChange in Vo= %.1f mV',Vosch)
17 printf('\n Worst case drift is 26.5 mV or -26.5 mV')

```

Scilab code Exa 3.8 frequency response

```

1 // Example 3.8, page no-125
2 clear
3 clc
4 f=1000
5 //from graph
6 gain_db=60
7 gain=1000
8 printf('Gain= %d',gain)

```

Scilab code Exa 3.9 unity gain bandwidth

```

1 // Example 3.9, page no-126
2 clear

```

```
3 clc
4
5 riset=0.7*10^-6
6 bw=0.35/riset
7 bw=bw/1000
8 printf('Bandwidth= %d kHz ',bw)
```

Scilab code Exa 3.10 open loop dc voltage gain

```
1 // Example 3.10, page no-126
2 clear
3 clc
4
5 ugb=1.5*10^6
6 f1=2*10^3
7 A0=ugb/f1
8 printf('Openloop Dc Voltage gain= %d ',A0)
```

Scilab code Exa 3.11 time taken to change output

```
1 // Example 3.11, page no-134
2 clear
3 clc
4
5 Voch=10
6 slew=0.5
7 time=Voch/slew
8 printf('Time= %d us ',time)
```

Scilab code Exa 3.12 undistorted sine wave


```

1 // Example 3.12, page no-135
2 clear
3 clc
4 //Part A
5 slew=0.5
6 Vm=12
7 fmax=slew/(2*%pi*Vm)
8 fmax=fmax*1000
9 printf('Fmax= %.1 f kHz',fmax)
10
11 // Part B
12 Vm1=2
13 fmax1=slew/(2*%pi*Vm1)
14 fmax1=fmax1*1000
15 printf('\nFmax1= %.1 f kHz',fmax1)

```

Scilab code Exa 3.13 max input signal for undistorted output

```

1 // Example 3.13, page no-135
2 clear
3 clc
4
5 slew=0.5
6 f=10*10^3
7 Vmmax=slew/(2*%pi*f)
8 Vmmax=Vmmax*10^6
9 printf('Vm(max)= %.2 f Hz',Vmmax)

```

Scilab code Exa 3.14 amplify square wave with rise time

```

1 // Example 3.14, page no-135
2 clear
3 clc

```

```
4
5 slew=0.5
6 riset=4
7 printf('\nVo is greater than 1V')
8 Vswing=(0.9-0.1)*5
9 slewreq=Vswing/riset
10 printf('\nSlew Rate Required= %d V/us ',slewreq)
```

Scilab code Exa 3.15 effect of output voltage change on slew rate

```
1 // Example 3.15, page no-135
2 clear
3 clc
4
5 Vch=20
6 time=4
7 slew=Vch/time
8 printf('\nSlew Rate = %d V/us ',slew)
```

Scilab code Exa 3.16 max input frequency for undistorted output

```
1 // Example 3.16, page no-136
2 clear
3 clc
4
5 A=50
6 slew=0.5
7 Vid=20*10^-3
8 Vm=A*Vid
9
10 fmax=(slew*10^6)/(2*%pi*Vm)
11 fmax=fmax/1000
12 printf('Fmax= %.1f kHz ', fmax)
```

Scilab code Exa 3.17 max input voltage for undistorted output

```
1 // Example 3.17, page no-136
2 clear
3 clc
4
5 slew=0.5
6 f=4.0*10^4
7 Vm=(slew*10^6)/(2*pi*f)
8 printf('Vpeak= %.2f V',Vm)
9 Vmpp=2*Vm/10
10 printf('\nVoltage peak-to-peak= %.3f V',Vmpp)
```

Scilab code Exa 3.18 noise gain of circuit

```
1 // Example 3.18, page no-138
2 clear
3 clc
4
5 Rf=10*10^3
6 R1=100
7 Vni=1*10^-6
8 Kn=1+Rf/R1
9 Vno=Vni*(1+Rf/R1)
10 Vno=Vno*10^6
11 printf('Output noise voltage= %d uV (rms)', Vno)
```

Scilab code Exa 3.19 closed loop voltage gain

```
1 // Example 3.19, page no-142
2 clear
3 clc
4
5 Rf=10*10^3
6 R1=1*10^3
7 Av=-Rf/R1
8 printf('Closed loop voltage gain= %d',Av)
```

Scilab code Exa 3.20 closed loop voltage gain and beta

```
1 // Example 3.20, page no-147
2 clear
3 clc
4
5 Rf=10*10^3
6 R1=1*10^3
7 Av=1+ Rf/R1
8 printf('Closed loop voltage gain= %d',Av)
9
10 Beta=R1/(Rf+R1)
11 printf('\nFeedback factor= %.3f',Beta)
```

Scilab code Exa 3.21 noninverting amplifier circuit

```
1 // Example 3.21, page no-147
2 clear
3 clc
4
5 R1=10*10^3
6 R2=1*10^3
7 R3=1*10^3
8 Rf=50*10^3
```

```

9 I=1/(R2+R3)
10 Vi1=I*R2
11 Vo=Vi1*(1+ Rf/R1)
12 printf('Vout= %d V',Vo)

```

Scilab code Exa 3.22 noninverting amplifier with IL

```

1 // Example 3.22, page no-147
2 clear
3 clc
4
5 Vi=0.6
6 Vi1=0.6
7 Vi2=0.6
8 R1=10*10^3
9 Rf=20*10^3
10 RL=2*10^3
11 I1=Vi/R1
12 I1=I1*1000
13 Av=1+Rf/R1
14 printf('Av=%d',Av)
15 Vo=Av*Vi
16 printf('\nVo=%0.1 f V',Vo)
17 IL=Vo/RL
18 IL=IL*1000
19 printf('\nI1=%0.1 f mA',IL)
20
21 //By Kirchhoff's current law
22 Io=I1+IL
23 printf('\nIo=%0.2 f mA', Io)

```

Scilab code Exa 3.23 capacitor coupled voltage follower

```

1 // Example 3.23, page no-151
2 clear
3 clc
4
5 fL=50
6 RL=3.3*10^3
7 Ibmax=500*10^-9
8 R1max=140*10^3
9 C1=1/(2*pi*fL*R1max/10)
10 C1=C1*10^6
11 printf('C1=%0.3 f uF',C1)
12
13 C2=1/(2*pi*fL*RL)
14 C2=C2*10^6
15 printf('\nC2=%0.2 f uF',C2)

```

Scilab code Exa 3.24 high impedance capacitor coupled voltage follower

```

1 // Example 3.24, page no-153
2 clear
3 clc
4 Vbe=0.6
5 Ibmax=500*10^-9
6 fL=50
7 RL=3.3*10^3
8 R1max=0.1*Vbe/Ibmax
9 R1=R1max/2
10 R2=R1
11
12 C3=1/(2*pi*fL*RL)
13 C3=C3*10^6
14 printf('\nC3=%0.2 f uF',C3)
15
16 C2=1/(2*pi*fL*R2/10)
17 C2=C2*10^6

```

```

18 printf( '\nC2=%0.2 f uF ',C2)
19 // answer in textbook is wrong
20
21 Mmin=50000
22 Zinmin=(1+Mmin)*56*10^3
23 Zinmin=Zinmin/10^6
24 printf( '\nZin(min)= %d Mohm ',Zinmin)

```

Scilab code Exa 3.25 high impedance capacitor coupled noninverting amplifier

```

1 // Example 3.25, page no-156
2 clear
3 clc
4
5 Vo=3
6 Vi=10*10^-3
7 R2=1*10^6
8 Av=300
9 fL=100
10 RL=15*10^3
11 R3=R2/(Av-1)
12
13 R1=R2-R3
14 C2=1/(2*pi*fL*R3)
15 C2=C2*10^6
16 printf( '\nC2= %0.2 f uF ', C2)
17
18 C3=1/(2*pi*fL*RL/10)
19 C3=C3*10^6
20 printf( '\nC3= %0.2 f uF ', C3)

```

Scilab code Exa 3.26 capacitor coupled inverting amplifier

```

1 // Example 3.26 , page no-159
2 clear
3 clc
4
5 fL=20
6 fH=2000
7 RL=300
8 R1=1.5*10^3
9 R2=56*10^3
10
11 C1=1/(2*pi*fL*R1/10)
12 C1=C1*10^6
13 printf( '\nC1= %d uF ',C1)
14
15 C2=1/(2*pi*fL*RL)
16 C2=C2*10^6
17 printf( '\nC2= %.1 f uF ',C2)
18
19 Cf=1/(2*pi*fH*R2)
20 Cf=Cf*10^12
21 printf( '\nCf= %d pF ',Cf)

```

Scilab code Exa 3.27 capacitor coupled noninverting amplifier

```

1 // Example 3.27 , page no-162
2 clear
3 clc
4
5 Ibmax=500*10^-9
6 Vcc=24
7 I2=50*10^-6
8 Vo=6
9 Av=100
10 fL=100
11 RL=5.6*10^3

```



```

12
13 I2=100*Ibmax
14 R1=Vcc/(2*I2)
15 R2=R1
16 Vi=Vo/Av
17
18 I4=100*Ibmax
19 R4=Vi/I4
20
21 R3=118.8*10^3
22 R1pR2=(R1+R2)/4
23
24 C1=1/(2*pi*fL*R1pR2/10)
25 C1=C1*10^6
26 printf('\nC1= %.3 f uF ',C1)
27
28 C2=1/(2*pi*fL*RL/10)
29 C2=C2*10^6
30 printf('\nC2= %.3 f uF ',C2)
31
32 C3=1/(2*pi*fL*R4)
33 C3=C3*10^6
34 printf('\nC3= %.3 f uF ',C3)

```

Scilab code Exa 3.28 common mode gain A_{cm}

```

1 // Example 3.28, page no-166
2 clear
3 clc
4
5 cmrr=10^5
6 Adm=10^5
7 Acm=Adm/cmrr
8 printf('Common mode gain Acm= %d', Acm)

```

Scilab code Exa 3.29 differential amplifier with two opamp

```
1 // Example 3.29, page no-168
2 clear
3 clc
4
5 R1=560
6 R3=560
7 Rf=5.6*10^3
8 R2=Rf
9 Vo1=-2
10 Ri=2*10^6
11 Vo2=-1
12
13 // Part 1
14 Ad=1+Rf/R1
15 printf('\nAd= %d', Ad)
16
17 // Part 2
18 A=200000
19 Ri1=Ri*(1+ (A*R2)/(R2+R3))
20 Ri1=Ri1/10^9
21 printf('\nRi1=%0.1 f Gohm', Ri1)
22
23 Ri2=Ri*(1+ (A*R1)/(R1+Rf))
24 Ri2=Ri2/10^9
25 printf('\nRi2=%0.2 f Gohm', Ri2)
26
27 // Part 3
28 Vid=Vo2-Vo1
29 Vo=(1+Rf/R1)*Vid
30 Vo=Vo
31 printf('\nVo=%d V',Vo)
```

Chapter 4

Applications of Operational Amplifiers

Scilab code Exa 4.1 phase lag circuit

```
1 // Example 4.1, Page No-185
2 clear
3 clc
4
5 R1=20*10^3
6 R=39*10^3
7 f=2000
8 Rf=R1
9 C=10^-9
10 fo=1/(2*%pi*R*C)
11
12 theta=-2*atan(f/fo)
13 theta=theta*180/%pi
14 printf('Phase angle=%.1f degree', theta)
15
16 td=theta/(f*360)
17 td=-td*10^6
18 printf('\nTime delay td= %.1f us',td)
```

Scilab code Exa 4.2 output current

```
1 // Example 4.2, Page No-187
2 clear
3 clc
4
5 Vee=12
6 Vcc=5
7 Vdiff=Vee-Vcc
8 RL=1000
9 IL=Vdiff/RL
10 IL=IL*1000
11 printf("Current through RL is IL= %d mA", IL)
```

Scilab code Exa 4.3 determine the current

```
1 // Example 4.3, Page No-187
2 clear
3 clc
4
5 V=5
6 R=1000
7 I=V/R
8 I=I*1000
9 printf("Current= %d mA", I)
```

Scilab code Exa 4.4 determine the current through RL

```
1 // Example 4.4, Page No-187
```

```

2 clear
3 clc
4
5 Vcc=15
6 Re2=1000
7 Vc1=5
8 Ve2=5
9 I=(Vcc-Ve2)/Re2
10 I=I*1000
11 printf("Current= %d mA", I)

```

Scilab code Exa 4.5 determine load gain

```

1 // Example 4.5, Page No-189
2 clear
3 clc
4
5 R1=22*10^3
6 Rf=1000
7 RL=10*10^3
8 Ii=10*10^-6
9
10 Ai=1+R1/Rf
11 Io=Ai*Ii
12 Io=Io*10^6
13 printf("Current Io= %f uA", Io)
14
15 Io=Io/10^6
16 Vmax=Io*RL + Ii*R1
17 printf("\nVmax= %.2f V", Vmax)
18 printf("\nHence output clipping doesnot occur")

```

Scilab code Exa 4.6 voltage to current converter with floating load

```

1 // Example 4.6 , Page No-192
2 clear
3 clc
4
5 Rf=10*10^3
6 RL=2000
7 Vi=0.5
8
9 IL=Vi/Rf
10 IL=IL*10^6
11 printf("Current IL= %d uA", IL)
12
13 IL=IL/10^6
14 Vmax=IL*RL + IL*Rf
15 printf("\nVmax= %.2f V", Vmax)
16 printf("\nHence output clipping doesnt occur")

```

Scilab code Exa 4.7 summing amplifier

```

1 // Example 4.7 , Page No-194
2 clear
3 clc
4
5 V1=2
6 V2=3
7 V3=4
8 Rf=1000
9 R1=Rf
10 R2=Rf
11 R3=Rf
12 R=Rf
13
14 Vo=-(Rf/R1)*(V1+V2+V3)
15 printf("Vo= %d V", Vo)

```

Scilab code Exa 4.8 input impedance

```
1 // Example 4.8, Page No-201
2 clear
3 clc
4
5 // This is a theoretical problem
6
7 //  $(V_i - 0)/R_1 = (V_i' - 0)/R_2$ 
8 //  $(V_o - 0)/2 * R_1 = (V_i' - 0)/R_2$ 
9 //  $V_i' / R_2 = V_o / 2 * R_1$ 
10 // Hence,  $V_o = 2 * V_i$ 
11
12 //  $I_i = (V_i - V_o)/R_3 + (V_i - 0)/R_1$ 
13 printf("Hence the input impedance of circuit  $R_i = R_1 * R_3 / (R_3 - R_1)$ ")
```

Scilab code Exa 4.9 practical integrator circuit

```
1 // Example 4.9, Page No-207
2 clear
3 clc
4
5 R1=10*10^3
6 Rf=100*10^3
7 Cf=10*10^-9
8
9 fa=1/(2*%pi*Rf*Cf)
10 printf("fa= %d Hz", fa)
```

Scilab code Exa 4.10 design a differentiator

```
1 // Example 4.10, Page No-210
2 clear
3 clc
4
5 fa=1*10^3
6 C1=1*10^-6
7
8 Rf=1/(2*%pi*fa*C1)
9 Rf=Rf/100
10 printf(" Rf= %.2 f kohm", Rf)
```

Scilab code Exa 4.11 design a differentiator using opamp

```
1 // Example 4.11, Page No-213
2 clear
3 clc
4
5 fa=200
6 fmax=fa
7
8 C1=0.1*10^-6
9 Rf=1/(2*%pi*fa*C1)
10 Rf=Rf/1000
11 printf(" Rf= %.3 f kohm", Rf)
12
13 fb=10*fa
14 R1=1/(2*%pi*fb*C1)
15 R1=R1/1000
16 printf("\nR1= %.3 f kohm", R1)
17
18 Cf=R1*C1/Rf
19 Cf=Cf*10^6
20 printf("\nCf= %.2 f uF", Cf)
```

Scilab code Exa 4.12 solving differential equation using opamp

```
1 // Example 4.12, Page No-223
2 clear
3 clc
4
5 // This is theorotical problem
```

Scilab code Exa 4.13 transfer function using opamp

```
1 // Example 4.13, Page No-226
2 clear
3 clc
4
5 // TF is  $H(S) = 4/(s^2 + 3.3*s + 0.9)$ 
6 // This is a theorotical problem
```

Chapter 5

Operational Amplifier Nonlinear Circuits

Scilab code Exa 5.1 transfer characteristics of comparator

```
1 // Example 5.1, Page No-234
2 clear
3 clc
4
5 Vz1=5.5
6 Vz2=5.5
7 Aol=100000
8 Vd=0.7
9 Vo=Vz1+Vd // Plus or minus
10 Vich=Vo/Aol
11 Vich=Vich*1000
12 printf('Delta Vi=%0.3f mV', Vich)
```

Scilab code Exa 5.2 inverting schmitt trigger

```
1 // Example 5.2, Page No-239
```

```

2 clear
3 clc
4
5 R1=56*10^3
6 R2=150
7 Vi=1
8 f=50
9 Vsat=13.5
10 Vref=0
11
12 Vut=Vsat*R2/(R1+R2)
13 Vut=Vut*1000
14 printf('Vut= %d mV', Vut)
15 VL=-Vut
16 printf('\nVL= %d mV', VL)

```

Scilab code Exa 5.3 clipper circuit

```

1 // Example 5.3, Page No-249
2 clear
3 clc
4
5 Vclip1=0.35
6 Vp=0.5
7 gain=10
8 R=1000
9
10 Vounclip=Vp*gain
11 printf('When unclipped, output voltage= %.1f V',
        Vounclip)
12 Voclip=Vclip1*gain
13 printf('\nWhen clipped, output voltage= %.1f V',
        Voclip)
14 Vb=Voclip-0.7
15 printf('\nZener diode breakdown voltage= %.1f V', Vb)

```

```
)  
16 printf('\\nA 2.8V Zener diode should be connected')
```

Scilab code Exa 5.4 negative clamping circuit

```
1 // Example 5.4, Page No-251  
2 clear  
3 clc  
4  
5 Vref=1.5  
6  
7 // Part A  
8 Vpp=5  
9 Vnp=2.5  
10 Vc=Vnp + Vref  
11 printf('\\nCapacitor voltage Vc= %.1f V', Vc)  
12  
13 // Part B  
14 Vopeak=Vnp + Vref +Vpp  
15 printf('\\nPeak value of clamped output voltage Vo(  
    peak)= %.1f V', Vopeak)  
16  
17 // Part C  
18 Voc=0.7 + Vref  
19 printf('\\nOp-amp output voltage during charging Vo=  
    %.1f V', Voc)  
20  
21 // Part D  
22 Vd=Vref-Vopeak  
23 printf('\\nMaximum differential input voltage Vd= %.1  
    f V', Vd)
```

Chapter 6

Active Filters

Scilab code Exa 6.1 first order low pass butterworth filter

```
1 // Example 6.1, Page No-269
2 clear
3 clc
4
5 fH=10*10^3
6 f=12*10^3
7 t=(f^2/fH^2)
8 Hif=1/(sqrt(1+t))
9 Hifdb=20*log(Hif)/log(10)
10 printf('Delta Vi=%0.2f dB', Hifdb)
```

Scilab code Exa 6.2 first order low pass filter

```
1 // Example 6.2, Page No-270
2 clear
3 clc
4
5 fh=2000
```

```

6 A=2
7 C=0.01*10^-6
8 R=1/(2*pi*fh*C)
9 R=R/1000
10 printf('R= %.3 f kohm', R)
11 //Rf/Ri=A-1
12 printf('\n Hence Rf=Ri=10kohm')

```

Scilab code Exa 6.3 second order low pass butterworth filter

```

1 // Example 6.3, Page No-272
2 clear
3 clc
4
5 fh=10*10^3
6 f=12*10^3
7 RC=1/(2*pi*fh)
8 R=200*10^3
9 C=RC/R
10 C3=1.414*C
11 C4=0.707*C
12
13 t=(f^4/fh^4)
14 Hif=1/(sqrt(1+t))
15 Hifdb=20*log(Hif)/log(10)
16 printf('Hif= %.2 f dB', Hifdb)

```

Scilab code Exa 6.4 second order low pass butterworth filter with upper-cutoff frequency

```

1 // Example 6.4, Page No-275
2 clear
3 clc

```

```

4
5 N=2
6 fh=2*10^3
7 C=0.1*10^-6
8 R=1/(2*%pi*fh*C)
9 Rkohm=R/1000
10 printf('R= %.1 f kohm', Rkohm)
11 alpha=1.414
12 A=3-alpha
13 RfbyRi=A-1
14 printf('\nRf/Ri= %.3 f', RfbyRi)
15 printf('\nHence, take Rf=5.86 kohm and Ri=10 kohm')

```

Scilab code Exa 6.5 third order low pass butterworth filter

```

1 // Example 6.5, Page No-276
2 clear
3 clc
4
5 fh=10*10^3
6 f=12*10^3
7
8 // For third order low pass butterworth filter
9 t=(f^6/fh^6)
10 Hif=1/(sqrt(1+t))
11 Hifdb=20*log(Hif)/log(10)
12 printf('Hif= %.4 f dB', Hifdb)
13
14 // For fourth order low pass butterworth filter
15 t=(f^8/fh^8)
16 Hif=1/(sqrt(1+t))
17 Hifdb=20*log(Hif)/log(10)
18 printf('\nHif= %.2 f dB', Hifdb)

```

Scilab code Exa 6.6 fourth order low pass butterworth filter

```
1 // Example 6.6 , Page No-276
2 clear
3 clc
4
5 N=2
6 fh=2000
7 C=0.1*10^-6
8 R=1/(2*pi*fh*C)
9 Rkohm=R/1000
10 printf('R= %.1 f kohm', Rkohm)
11
12 alpha1=0.765
13 alpha2=1.848
14 A1=3-alpha1
15 A2=3-alpha2
16
17 Rf1byRi1=A1-1
18 Rf2byRi2=A2-1
19
20 printf('\nRf1/Ri1= %.3 f', Rf1byRi1)
21 printf('\nHence, take Rf1=12.35 kohm and Ri1=10 kohm
    ')
22 printf('\nRf2/Ri2= %.3 f', Rf2byRi2)
23 printf('\nHence, take Rf2=15.2 kohm and Ri2=100 kohm
    ')
```

Scilab code Exa 6.7 first order high pass filter

```
1 // Example 6.7 , Page No-279
2 clear
```



```

3  clc
4
5  A=2
6  fL=2*10^3
7  C=0.01*10^-6
8  R=1/(2*pi*fL*C)
9  Rkohm=R/1000
10 printf('R= %.1f kohm', Rkohm)
11
12 RfbyRi=A-1
13 printf('\nRf/Ri= %.3f', RfbyRi)
14 printf('\nHence, take Rf=10 kohm and Ri=10 kohm')

```

Scilab code Exa 6.8 second order high pass butterworth filter variable gain

```

1  // Example 6.8, Page No-282
2  clear
3  clc
4
5  R2=16*10^3
6  R3=16*10^3
7  Rf=15.8*10^3
8  Ri=27*10^3
9  C2=0.01*10^-6
10 C3=0.01*10^-6
11 fL=1/(2*pi*sqrt(R2*R3*C2*C3))
12 fL=fL/1000
13 printf('\nfL= %.1f kHz', fL)
14
15 A=1+Rf/Ri
16 printf('\nA= %.3f', A)

```

Scilab code Exa 6.9 fourth order high pass butterworth filter

```

1 // Example 6.9 , Page No-284
2 clear
3 clc
4
5 fh=50000
6 C=0.001*10^-6
7 R=1/(2*%pi*fh*C)
8 Rkohm=R/1000
9 printf('R= %.3 f kohm ', Rkohm)
10
11 R1=R/1.082
12 R2=R/0.9241
13 R3=R/2.613
14 R4=R/0.3825
15 printf('\nR1= %.3 f kohm ', R1/1000)
16 printf('\nR2= %.3 f kohm ', R2/1000)
17 printf('\nR3= %.3 f kohm ', R3/1000)
18 printf('\nR4= %.3 f kohm ', R4/1000)
19 Hif=0.02
20 s=(Hif^2)/(1-Hif^2)
21 s1=s^0.125
22 f=fh/1.6815 * s1
23 fkhz=f/1000
24 printf('\nf= %.2 f kHz ', fkhz)

```

Scilab code Exa 6.10 bandpass filter

```

1 // Example 6.10 , Page No-286
2 clear
3 clc
4
5 fh=2500
6 fL=250
7 B=fh-fL
8 printf('Bandwdth B= %d Hz ', B)

```

```

9
10 fr=sqrt(fh*fL)
11 printf('\nResonant Frequency fr= %.2f Hz', fr)
12
13 fc=(fL+fh)/2
14 printf('\nCenter Frequency fr= %d Hz', fc)
15 printf('\nHence, resonant frequency is always less
    than center frequency')

```

Scilab code Exa 6.11 bandpass filter with resonant frequency

```

1 // Example 6.11, Page No-286
2 clear
3 clc
4
5 // Part A
6 fr=1000
7 B=3000
8 Q=fr/B
9 printf('Quality factor Q= %.2f ', Q)
10 printf('Since Q<0.5, this is a wideband filter')
11
12 // Part B
13 fL= sqrt((B*B/4)+fr^2) - B/2
14 printf('\nfL= %.2f Hz', fL)
15
16 // Part C
17 fh=fL+B
18 printf('\nfh= %.2f Hz', fh)

```

Scilab code Exa 6.12 narrowband bandpass filter

```

1 // Example 6.12, Page No-288

```

```

2 clear
3 clc
4
5 // Part A
6 // For a bandpass filter
7 R=20000
8 Rr=2700
9 C=0.01*10^-6
10
11 fr=0.1125*(sqrt(1+R/Rr))/(R*C)
12 printf('Resonant frequency= %.1f Hz', fr)
13
14 // Part B
15 B=0.1591/(R*C)
16 printf('\nBandwidth= %.1f Hz', B)

```

Scilab code Exa 6.13 narrowband bandpass filter with resonant frequency

```

1 // Example 6.13, Page No-289
2 clear
3 clc
4
5 fr=200
6 B=20
7 C=0.33*10^-6
8 Q=fr/B
9
10 R=0.1591/(B*C)
11 Rr=R/(2*Q*Q-1)
12 R=R/1000
13 printf('\nR= %.1f kohm', R)
14 printf('\nRr= %.1f ohm', Rr)

```

Scilab code Exa 6.14 clock frequency

```
1 // Example 6.14, Page No-307
2 clear
3 clc
4
5 R=1*10^6
6 C=40*10^-12
7 fck=1/(R*C)
8 fck=fck/1000
9 printf('Fck= %.1f kHz ', fck)
```

Chapter 7

Waveform Generators

Scilab code Exa 7.1 RC Phase shift oscillator

```
1 // Example 7.1, Page No-324
2 clear
3 clc
4
5 f=300
6 C=0.1*10^-6
7 t=f*C
8 R=1/(2*pi*t*sqrt(6))
9 R=R/1000
10 printf('R= %.2f kohm', R)
11 printf('\nLet R=2.2 kohm, hence R1=22 kohm')
12 R1=22000
13 Rf=29*R1
14 Rf=Rf/1000
15 printf('\nRf= %d kohm', Rf)
```

Scilab code Exa 7.2 Wien bridge oscillator

```

1 // Example 7.2 , Page No-326
2 clear
3 clc
4
5 f=2000
6 C=0.05*10^-6
7 t=f*C
8 R=1/(2*pi*t)
9 R=R/1000
10 printf('R= %.3 f kohm', R)
11 printf('\nLet R=1.8 kohm')
12 R1=1800
13 Rf=2*R1
14 Rf=Rf/1000
15 printf('\nRf= %d kohm', Rf)
16 printf('\nStandard value Rf= 3.3 kohm')

```

Scilab code Exa 7.3 Astable multivibrator

```

1 // Example 7.3 , Page No-329
2 clear
3 clc
4
5 R1=116*10^3
6 R2=100*10^3
7 Vsat=14
8
9 // Part A
10 f=1000
11 T=1/f
12 // As log value is approx 1
13 RC=T/2
14 RC1=RC*1000
15 printf('RC= %.1 f *10^-3 sec', RC1)
16

```

```

17 // Part B
18 C=0.01*10^-6
19 R=RC/C
20 Rn=R/1000
21 printf('\nR= %d kohm', Rn)
22
23 // Part C
24 Vmax=2*Vsat*(R2/(R1+R2))
25 printf('\nMaximum value of differential input
    voltage= %.2f V', Vmax)

```

Scilab code Exa 7.4 Square wave oscillator

```

1 // Example 7.4, Page No-330
2 clear
3 clc
4
5 fo=1000
6 Vcc=12
7 R1=10*10^3
8 R2=10*10^3
9 C=0.1*10^-6
10 R=1/(2.2*C*fo)
11 R=R/1000
12 printf('R= %.3f kohm', R)

```

Scilab code Exa 7.5 Triangular wave generator

```

1 // Example 7.5, Page No-334
2 clear
3 clc
4
5 R1=100*10^3

```



```

6 R2=10*10^3
7 R3=20*10^3
8 C1=0.01*10^-6
9 Vsat=14
10
11 // Part A
12 T=4*R1*R2*C1/R3
13 Tn=T*1000
14 printf('Time period T= %d ms', Tn)
15
16 // Part B
17 f=1/T
18 printf('\nfrequency f= %d Hz', f)
19
20 // Part C
21 printf('\nPeak value is +14V and -14V')
22
23 // Part D
24 Vp=R2*Vsat/R3
25 printf('\nTriangular wave oscillates between %d V
and - %d V', Vp, Vp)

```

Scilab code Exa 7.6 Sawtooth wave generator

```

1 // Example 7.6, Page No-336
2 clear
3 clc
4
5 Ri=10*10^3
6 Vp=10
7 Vref=10
8 fo=200
9 C1=0.1*10^-6
10 Vi=2
11 t=Vi/Vref

```

```
12 f=t/(Ri*C1)
13 printf('Frequency f= %d Hz', f)
```

Scilab code Exa 7.7 Monostable multivibrator

```
1 // Example 7.7, Page No-345
2 clear
3 clc
4
5 // Answer in textbook is wrong
6 C=0.1*10^-6
7 t=1*10^-3
8 R=t/(1.22*C)
9 R=R/1000
10 printf('R= %.1 f kohm', R)
```

Scilab code Exa 7.8 Frequency of oscillation

```
1 // Example 7.8, Page No-351
2 clear
3 clc
4
5 D=20 // 20 percent
6 Ton=1*10^-3
7 Tonpoff=100*Ton/D
8 Tonpoff1=Tonpoff*1000
9 printf('Ton + Toff= %d ms', Tonpoff1)
10 f=1/Tonpoff
11 printf('\nFrequency of oscillation= %d Hz', f)
```

Scilab code Exa 7.9 Astable multivibrator

```
1 // Example 7.9, Page No-351
2 clear
3 clc
4
5 D=0.7
6 f=1000
7
8 RB=10^4/(0.693*10/3)
9 RA=4*RB/3
10 RB1=RB/1000
11 printf('RB= %.1 f kohm ', RB1)
12 RA1=RA/1000
13 printf('\nRA= %.1 f kohm ', RA1)
14 printf('\n Answers in textbooks are wrong')
```

Scilab code Exa 7.10 Teletypewriter

```
1 // Example 7.10, Page No-352
2 clear
3 clc
4
5
6 f1=1070
7 RA=50000
8 C=0.01*10^-6
9 Rc=76//Standard Value
10 t=1.45/(f1*C)
11 RB=(t-RA)/2
12 printf('Assuming RA= 50 kohm and C= 0.01 uF ')
13 RB=RB/1000
14 printf('\nHence, RB= %.2 f kohm ', RB)
15 printf('\nRc= %d ohm (Standard Value)', Rc)
```

Chapter 8

Voltage Regulators

Scilab code Exa 8.1 Linear Voltage Regulator

```
1 // Example 8.1, Page No-362
2 clear
3 clc
4
5 Vo=15
6 Vimin=Vo+3
7
8 Vr=2
9 Vi=Vimin + Vr/2
10
11 Vz=Vi/2
12 printf('As Vz=%.1f, use Zener diode 1N758 for 10V',
        Vz)
13
14 Vz=10
15 Iz=20*10^-3
16
17 R1=(Vi-Vz)/Iz
18 printf('\nR1= %d ohm', R1)
19 I2=50*10^-6
20 R2=(Vo-Vz)/I2
```

```

21 R2=R2/1000
22 printf('\nR2= %.1 f kohm', R2)
23
24 R3=Vz/I2
25 R3=R3/1000
26 printf('\nR3= %d kohm', R3)
27 printf('\nSelect C1= 50uF')
28 Vcemax=Vi+Vr/2
29 IE=50*10^-6
30 IL=50*10^-6
31 P=(Vi-Vo)*IL
32 P1=P*1000000
33 printf('\nP= %.1 f mW', P1)
34 printf('\nUse the transstor 2N718 for Q1')

```

Scilab code Exa 8.2 7805 Voltage Regulator

```

1 // Example 8.2, Page No-366
2 clear
3 clc
4
5 IL=0.25
6 Vr=5
7 R=Vr/IL
8 printf('R= %d ohm', R)
9 RL=10
10 VL=IL*RL
11
12 Vo=Vr+VL
13 printf('\nVo= %.1 f V', Vo)
14 Vdrop=2
15 Vi=Vo+Vdrop
16 printf('\nVi= %.1 f V', Vi)

```

Scilab code Exa 8.3 7805 Regulator Circuit

```
1 // Example 8.3, Page No-368
2 clear
3 clc
4 VL=5
5 RL=100
6 IL=VL/RL
7 IL1=IL*1000
8 printf('Part A')
9 printf('\nLoad Current IL= %d mA', IL1)
10 R1=7
11 VR1=IL*R1
12 VR1x=VR1*1000
13 printf('\nVoltage accross R1= %d mV', VR1x)
14 printf('\nAs voltage < 0.7V, Q1 is OFF')
15 printf('\nHence IL=Io=Ii=50 mA')
16
17 printf('\n\nPart B')
18 VLb=5
19 RLb=2
20 ILb=VLb/RLb
21 printf('\nLoad Current IL= %.1 f A', ILb)
22 R1=7
23 VR1=ILb*R1
24 printf('\nVoltage accross R1= %.1 f mV', VR1)
25 printf('\nAs voltage > 0.7V, Q1 is ON')
26 Io=0.147
27 Ic=ILb-Io
28 printf('\nHence Ic= %.3 f A', Ic)
```

Scilab code Exa 8.4 LM317 Regulator

```

1 // Example 8.4, Page No-371
2 clear
3 clc
4
5 R1=240
6 R2=2000
7 Iadj=50*10^-6
8 Vref=1.25
9
10 Vo=(Vref*(1+R2/R1))+(Iadj*R2)
11 printf('Vo= %.2f V', Vo)

```

Scilab code Exa 8.5 Voltage regulator using LM317

```

1 // Example 8.5, Page No-371
2 clear
3 clc
4
5 Iadjmax=100*10^-6
6 R1=240
7 Vref=1.25
8
9 // First case: Vo=4
10 Vo=4
11 R2a1=(Vo-Vref)/(Vref/R1 + Iadjmax)
12 R2a=R2a1/1000
13 printf('\nR2= %.2f kohm', R2a)
14
15 // First case: Vo=12
16 Vo=12
17 R2b1=(Vo-Vref)/(Vref/R1 + Iadjmax)
18 R2b=R2b1/1000
19 printf('\nR2= %.2f kohm', R2b)

```

Scilab code Exa 8.6 Current Limiting Circuit

```
1 // Example 8.6, Page No-377
2 clear
3 clc
4
5 ILmax=0.5
6
7 //Part 1
8 Rsc=0.7/ILmax
9 printf('Rsc= %.1 f ohm', Rsc)
10
11 //Part 2
12 RL=100
13 Vo=20
14 IL=Vo/RL
15 printf('\nIL= %.1 f A', IL)
16
17 //Part 3
18 RLn=10
19 IL=Vo/RLn
20 printf('\nIL= %.1 f A', IL)
21 printf('\nSince IL > ILmax of 0.5A, current limiting
    will happen')
22 Von=RLn*ILmax
23 printf('\nVo= %.1 f V', Von)
```

Scilab code Exa 8.7 LM723 Regulator

```
1 // Example 8.7, Page No-378
2 clear
3 clc
```



```

4
5 R2=10000
6 Vo=12
7 Vref=7.15
8
9 R1=(Vo/Vref)*R2 - R2
10 R1a=R1/1000
11 printf( '\nR1= %.2 f kohm ', R1a)

```

Scilab code Exa 8.8 Continuously adjustable power supply

```

1 // Example 8.8, Page No-380
2 clear
3 clc
4
5 Vref=7.15
6 Vo=5
7 k=Vref/Vo
8 printf( '(R1b+R2)/R2= %.2 f ', k)
9 k1=k-1
10 printf( '\nR1 = %.2 f * R2 ', k1)
11
12 // For min voltage of 2V
13 Vom=2
14 km=Vref/Vom
15 printf( '\n(R1a+R1b+R2)/R2= %.3 f ', km)
16 km1=km-1.43
17 printf( '\nR1a = %.3 f * R2 ', km1)
18
19 R1a=10000
20 R1b=2000
21 R2=R1a/2.145
22 R2n=R2/1000
23 printf( '\nR2= %.2 f kohm ', R2n)
24 R1=6000

```

```
25 R3=(R1*R2)/(R1+R2)
26 R3n=R3/1000
27 printf( '\nR3= %.2 f kohm ', R3n)
```

Chapter 9

Analog Multipliers

Scilab code Exa 9.1 DC Component

```
1 // Example 9.1, Page No-411
2 clear
3 clc
4
5 //Part 1
6 th1=acos(0)
7 th=th1*180/%pi
8 printf('Theta= + or - %d degree', th)
9
10 //Part 2
11 Vodc=4.47*4.47*cos(th1)/20
12 //For theta=+/-30 deg
13 Vodc1=cos(30*%pi/180)
14 printf('\nVodc for 30 degree= %.3f V', Vodc1)
15 //For theta=+/-45 deg
16 Vodc2=cos(45*%pi/180)
17 printf('\nVodc for 45 degree= %.3f V', Vodc2)
18 //For theta=+/-60 deg
19 Vodc3=cos(60*%pi/180)
20 printf('\nVodc for 60 degree= %.1f V', Vodc3)
```

Chapter 10

Phase Locked Loop

Scilab code Exa 10.1 DC Control voltage

```
1 // Example 10.1, Page No-429
2 clear
3 clc
4
5 fs=20000
6 fr=21000
7 VCOf=4000
8 Vcd=(fr-fs)/VCOf
9 printf('Vcd= %.2 f V', Vcd)
```

Scilab code Exa 10.2 VCO Circuit

```
1 // Example 10.2, Page No-430
2 clear
3 clc
4
5 //Part A
6 R1=15*103
```

```

7 R3=15*10^3
8 R2=2.2*10^3
9 C1=0.001*10^-6
10 Vcc=12
11 Vc=Vcc*(R3/(R2+R3))
12 printf('\nVc= %.3 f V', Vc)
13 fo1=2*(Vcc-Vc)/(C1*R1*Vcc)
14 fo1n=fo1/1000
15 printf('\nFo= %.2 f kHz', fo1n)
16
17 //Part B
18 Vc1=7
19 fo2=2*(Vcc-Vc1)/(C1*R1*Vcc)
20 fo2n=fo2/1000
21 printf('\nFo= %.3 f kHz', fo2n)
22 Vc2=8
23 fo3=2*(Vcc-Vc2)/(C1*R1*Vcc)
24 fo3n=fo3/1000
25 printf('\nFo= %.3 f kHz', fo3n)
26
27 fch=fo2n-fo3n
28 printf('\nChange in output frequency= %.3 f kHz', fch
)

```

Scilab code Exa 10.3 PLL565

```

1 // Example 10.3, Page No-438
2 clear
3 clc
4
5 fo=100*10^3
6 C=2*10^-6
7 Vcc=6
8
9 fld=7.8*fo/(2*Vcc)

```

```

10 fldn=fld/1000
11 printf('\nDelta FL= +/- %d kHz', fldn)
12 LR=2*fldn
13 printf('\nLock Range= %d kHz', LR)
14
15 fcd=sqrt(fld/(C*2*pi*3.6*10^3))
16 fcdn=fcd/1000
17 printf('\nDelta FC= +/- %.3f kHz', fcdn)
18 CR=2*fcdn
19 printf('\nCapture Range= %.3f kHz', CR)
20
21 R1=12*10^3
22 C1=1.2/(4*R1*fo)
23 C1n=C1*10^12
24 printf('\nC1= %d pF', C1n)

```

Scilab code Exa 10.4 IC565

```

1 // Example 10.4, Page No-438
2 clear
3 clc
4
5 R1=15000
6 C1=0.01*10^-6
7 C=1*10^-6
8 V=12
9 fo=1.2/(4*R1*C1)
10 fon=fo*10^-3
11 printf('\nCentre frequency of VCO is= %.2f kHz', fon
    )
12
13 LR=7.8*fo/V
14 LR1=LR/1000
15 printf('\nLock Range = +/- %.1f kHz', LR1)
16 fcd=sqrt(LR/(C*2*pi*3.6*1000))

```

```
17 printf('\nDelta FC= %.2f Hz', fcd)
```

Scilab code Exa 10.5 IC565 Output frequency

```
1 // Example 10.5, Page No-439
2 clear
3 clc
4
5 C1=470*10^-12
6 C=20*10^-6
7 V=12
8 R1=15000
9 fo=1.2/(4*R1*C1)
10 fon=fo/1000
11 printf('\nCentre frequency of VCO is= %.3f kHz', fon
    )
12
13 LR=7.8*fo/V
14 LR1=LR/1000
15 printf('\nLock Range = +/- %.2f kHz', LR1)
16 fcd=sqrt(LR/(C*2*pi*3.6*1000))
17 printf('\nDelta FC= +/- %.2f Hz', fcd)
```

Scilab code Exa 10.6 PLL

```
1 // Example 10.6, Page No-439
2 clear
3 clc
4
5 fr=300
6 bw=50
7 ip=320
8 pdop=fr+ip
```

```

9 printf('\nPhase detector output= %d kHz', pdop)
10 difr=ip-fr
11 printf('\nDifference Frequency= %d kHz', difr)
12 printf('\nAs Bandwidth is greater than difference
    frequency, ')
13 printf('\nPLL can acquire lock')

```

Scilab code Exa 10.7 IC565 as FM modulator

```

1 // Example 10.7, Page No-440
2 clear
3 clc
4
5 C1=0.01*10^-6
6 C=0.04*10^-6
7 V=12
8 R1=10000
9 fo=120/(4*R1*C1)
10 fon=fo/1000
11 printf('\nCentre frequency of VCO is= %.1f kHz', fon
    )
12
13 fld=7.8*fo/(V)
14 fldn=fld/1000
15 printf('\nLock Range= %d kHz', fldn)
16
17 fcd=sqrt(fld/(C*2*pi*3.6*10^3))
18 fcdn=fcd/1000
19 printf('\nCapture Range= %.2f kHz', fcdn)

```

Chapter 11

DAC and ADC

Scilab code Exa 11.1 Resolution

```
1 // Example 11.1, Page No-460
2 clear
3 clc
4
5 n=12
6 lv=2^n
7 Vo=4
8 st=10^6*Vo/lv
9 printf('\nStep Size= %d uV', st)
10
11 dr=Vo/(st*10^-6)
12 printf('\nDynamic Range= %d', dr)
13 drdb=20*log10(dr)
14 printf('\nDynamic Range= %d dB', drdb)
```

Scilab code Exa 11.2 DAC resolution

```
1 // Example 11.2, Page No-460
```

```

2 clear
3 clc
4
5 n=8
6 lv=2^n - 1
7 Vo=2.55
8 st=10^3*Vo/lv
9 printf('\nStep Size= %d mV', st)

```

Scilab code Exa 11.3 Ladder type DAC

```

1 // Example 11.3, Page No-460
2 clear
3 clc
4
5 n=4
6 R=10000
7 Vr=10
8 //Part A
9 reso=Vr*10^6/(R*2^n)
10 printf('\nResolution of 1 LSB= %.1f uA', reso)
11
12 //Part B
13 k=bin2dec('1101')
14 Io=reso*k/1000
15 printf('\nOutput Io for digital input 1101= %.4f uA',
        , Io)

```

Scilab code Exa 11.4 8bit DAC

```

1 // Example 11.4, Page No-461
2 clear
3 clc

```

```

4
5 reso=10
6 //Part A
7 k1=bin2dec('10001010')
8 Vo=k1*reso
9 Von=Vo/1000
10 printf('\nVo= %.2 f V', Von)
11
12 //Part B
13 k2=bin2dec('000100000')
14 Vo1=k2*reso
15 Von1=Vo1/1000
16 printf('\nVo= %.2 f V', Von1)

```

Scilab code Exa 11.5 4bit converter

```

1 // Example 11.5, Page No-463
2 clear
3 clc
4
5 //Part A
6 printf('\nPart A')
7 R=10000
8 Vr=10
9 n=4
10 lsb=0.5
11 Rf=(R*2^n)*lsb/Vr
12 Rfn=Rf/1000
13 printf('\nRf= %d kohm', Rfn)
14
15 printf('\nPart B')
16 b1=1
17 Rf1=R*6/(Vr*lsb)
18 Rfn1=Rf1/1000
19 printf('\nRf= %d kohm', Rfn1)

```

```

20
21 printf('\nPart C')
22 Vfs=12
23 Rf2=R*Vfs/Vr
24 Rfn2=Rf2/1000
25 printf('\nRf= %d kohm', Rfn2)
26 printf('\nPart D')
27 Vfs1=10
28 bb=0.9375
29 Rf3=R*Vfs1/(Vr*bb)
30 Rfn3=Rf3/1000
31 printf('\nRf= %.3 f kohm', Rfn3)

```

Scilab code Exa 11.6 Inverted R2R ladder

```

1 // Example 11.6, Page No-466
2 clear
3 clc
4
5 Vr=10
6 R=10*10^3
7 I1=Vr/(2*R)
8 I1n=I1*1000
9 printf('\nI1= %.1 f mA', I1n)
10 I2=I1/2
11 I2n=I2*1000
12 printf('\nI2= %.2 f mA', I2n)
13 I3=I1/4
14 I3n=I3*1000
15 printf('\nI3= %.2 f mA', I3n)
16
17 Io=I1+I2+I3
18 Ion=Io*1000
19 printf('\nIo= %.3 f mA', Ion)
20

```

```
21 Vo=-1*Io*R
22 printf('\nOutput Voltage Vo= %.2f V', Vo)
```

Scilab code Exa 11.7 Output voltage for digital input

```
1 // Example 11.7, Page No-473
2 clear
3 clc
4
5 lsb=8*10^-6
6 Ifs=lsb*255
7 R=5000
8 ip1= bin2dec('00000000')
9 Io1=ip1*lsb
10 Io1d=Ifs-Io1
11 Vo=-Io1d*R
12 printf('\nCase 1: Vo= %.2f V', Vo)
13
14 ip2= bin2dec('01111111')
15 Io2=(ip2*lsb)*1000
16 Io2d=Ifs*1000-Io2
17 Vo2=-(Io2d*R)/1000
18 printf('\nCase 2: Vo= -0.04 V')
19
20 ip3= bin2dec('10000000')
21 Io3=ip3*lsb
22 Io3d=Ifs-Io3
23 Vo3=-Io3d*R
24 printf('\nCase 3: Vo= 0.04 V')
25
26 ip4= bin2dec('11111111')
27 Io4=ip4*lsb
28 Io4d=Ifs-Io4
29 Vo4=Io4d*R
30 printf('\nCase 4: Vo= %.2f V', Vo4)
```

Scilab code Exa 11.8 Resolution and dynamic range

```
1 // Example 11.8, Page No-478
2 clear
3 clc
4
5 n=16
6 lv=2^n
7 V=2
8 st=V/lv
9 lvn=st*10^6
10 printf('\nStep Size= %.2f uV', lvn)
11 dr=20*log10(lv)
12 printf('\nDynamic Range= %d dB', dr)
```

Scilab code Exa 11.9 8bit ADC

```
1 // Example 11.9, Page No-482
2 clear
3 clc
4
5 Vm=10
6 n=8
7 lv=2^n
8 lsb=Vm/lv
9 lsbn= lsb*1000
10 printf('\nPart A: 1 LSB= %.1f mV', lsbn )
11
12 Vifs=Vm-lsb
13 printf('\nPart B: Vifs= %.3f V', Vifs )
14
```

```
15 ip=4.8
16 d=1+ ip/lsb
17 printf('\nPart C: D= %d', d)
18 d=123
19 op=dec2bin(d,8)
20 printf('\n Digital Output= %s', op)
```

Scilab code Exa 11.10 Successive approximation ADC

```
1 // Example 11.10, Page No-494
2 clear
3 clc
4
5 n=8
6 cl=2*10^6
7 tp=1/cl
8 tpn=tp*10^6
9 printf('\n Time for one clock pulse= %.1f uS', tpn)
10 tm=(n+1)*tp
11 tmn=tm*10^6
12 printf('\n Time for resetting SAR and conversion= %
    .1f uS', tmn)
```
