

Scilab Textbook Companion for
Wireless Communications
by T. L. Singal¹

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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 2

Mobile Communication Engineering

Scilab code Exa 2.1 change in recieved signal in free space

```
1 r1=1
2 y=20*log10(r1/(2*r1))
3 Delc1=round(y)//change in recieved signal strengths
4 printf('\ndel when r2=2r1 = %.d dB',Delc1)
5 Delc2=20*log10(r1/(10*r1))////change in recieved
   signal strengths
6 printf('\ndel when r2=10r1 = %.f dB',Delc2)
```

Scilab code Exa 2.2 change in recieved signal in mobile radio

```
1 r1=1
2 y=40*log10(r1/(2*r1))
3 Delc1=round(y)//change in recieved signal strengths
4 disp(Delc1,'del in db when r2=2r1')
5 Delc2=40*log10(r1/(10*r1))//change in recieved
   signal strengths
```



```
6 disp(Delc2, 'delc in db when r2=10r1')
```

Scilab code Exa 2.3 amount of delay

```
1 fc=900*10^6
2 c=3*10^8
3 yc=c/fc//wavelength of transmission
4 ddir=1000
5 dref=1000
6 Angle=120
7 Q=120/2
8 tdir=ddir/c//time taken by direct path
9 tref=dref/(c*sin(Q*pi/180))//time taken by
   reflected path
10 delay=tref-tdir
11 disp(delay, 'delay in sec')
```

Scilab code Exa 2.4 time between fades

```
1 Vm=60*5/18//speed of mobile in m/s
2 fc1=900*10^6//frequency of operation
3 fc2=1900*10^6//frequency of operation
4 c=3*10^8//speed of radio waves
5 Tf1=c/(2*fc1*Vm)
6 Tf2=c/(2*fc2*Vm)
7 printf('time between fades in sec at 900 Mhz= %.f ms
   ',Tf1*10^(3));
8 printf('\ntime between fades in sec at 1900 Mhz= %.1
   f ms',Tf2*10^(3));
```

Scilab code Exa 2.5 doppler frequency shift

```
1 Vm=72*5/18
2 fc=900*10^6
3 c=3*10^8
4 Q1=180*%pi/180
5 Q2=0*%pi/180
6 Q3=60*%pi/180
7 Q4=90*%pi/180
8 fd1=fc*Vm*cos(Q1)/c//dopler shift
9 fd2=fc*Vm*cos(Q2)/c
10 fd3=fc*Vm*cos(Q3)/c
11 fd4=fc*Vm*cos(Q4)/c
12 fr1=fc+fd1//recieved carrier frequency
13 fr2=fc+fd2
14 fr3=fc+fd3
15 fr4=fc+fd4
16 printf('\nrecieved carrier frequency directly away
    from base station transmitter = %.5f MHz',fr1
    *10^(-6));
17 printf('\nrecieved carrier frequency directly
    towards from base station transmitter = %.5f MHz'
    ,fr2*10^(-6))
18 printf('\nrecieved carrier frequency in direction 60
    deg to direction of arrival = %.5f MHz',fr3
    *10^(-6))
19 printf('\nrecieved carrier frequency in direction
    perpendicular to direction of arrival = %.5f MHz
    ',fr4*10^(-6));
```

Scilab code Exa 2.6 maximum speed of vehicle

```
1 fc=900*10^6
2 c=3*10^8
3 fdm=70
```

```

4 Yc=c/fc
5 V=fdm*Yc//max. speed of the vehicle
6 Vm=V*18/5//to convert max speed in kmph
7 disp(Vm,'maximum speed of the vehicle in kmph')

```

Scilab code Exa 2.7 mobile antenna beamwidth

```

1 fc=800*10^6
2 fd1=10
3 fd2=50
4 Vm=80*5/18
5 c=3*10^8
6 Yc=c/fc//wavelength of transmission
7 Q1=acosd(Yc*fd1/Vm)//as cosQ=Yc*fd/Vm
8 Q2=acosd(Yc*fd2/Vm)
9 Beamwidth=Q1-Q2
10 disp(Beamwidth,'Beamwidth in degrees')

```

Scilab code Exa 2.8 doppler frequency

```

1 fc=900*10^6//carrier frequency of transmission
2 fdm=20//max. doppler frequency
3 p=1//normalized specified level
4 N1=2.5*fdm*p*(%e)^(-1*(p^2))//level crossing rate
5 c=3*10^8//velocity of light
6 V=fdm*c/fc
7 Vm=V*18/5//maximum speed
8 printf('positive going level crossing rate = %.2f
crossings per second',N1);
9 printf('\nmaximum velocity of the mobile for the
given doppler frequency= %.f kmph',Vm)

```

Scilab code Exa 2.9 Fade duration

```
1  fdm=20
2  p1=0.01
3  T1=0.4*(((%e)^(p1^2)) -1)/(fdm*p1) //average fade
   duration T
4
5  p2=0.1
6  T2=0.4*(((%e)^(p2^2)) -1)/(fdm*p2)
7
8  p3=0.707
9  T3=0.4*(((%e)^(p3^2)) -1)/(fdm*p3)
10
11 p4=1
12 T4=0.4*(((%e)^(p4^2)) -1)/(fdm*p4)
13 printf('\naverage fade duration T= %.f microsec for
   p=0.01 ',((T1*10^6)-1));
14 printf('\naverage fade duration T= %.f msec for p
   =0.01 ',T2*10^3);
15 printf('\naverage fade duration T= %.f msec for p
   =0.01 ',T3*10^3);
16 printf('\naverage fade duration T= %.f msec for p
   =0.01 ',T4*10^3);
17 Dr=50
18 Bp=1/Dr //Bit period
19 printf('\nBit period=%.f msec ',Bp*10^(3));
20 if Bp>T3 then //for case p=0.707
21
22 disp(',Fast rayleigh fading as Bp>T for p=0.707')
23 else
24 disp(',Slow rayleigh fading as Bp<T for p=0.707')
25 end
26
27 N1=2.5*fdm*p2*(((%e)^(-1*(p2^2)))) //avg. no. of level
```

```

        crossings
28 AvgBER=Nl/Dr
29 printf('\naverage bit error rate = %.1f',AvgBER)

```

Scilab code Exa 2.10 Symbol rate

```

1 Vm=96*5/18;
2 fc=900*10^6;
3 c=3*10^8;
4 function [y ]= fround(x,n)
5 // fround(x,n)
6 // Round the floating point numbers x to n decimal
  places
7 // x may be a vector or matrix// n is the integer
  number of places to round to
8 y=round(x*10^n)/10^n;
9 endfunction
10 Yc=fround((c/fc),2);
11 fdm=fround((Vm/Yc),2);
12 Tc=fround((0.423/fdm),5)//coherence time
13 Symbolrate=fround((1/Tc),0)//Symbolrate
14 printf('Symbol rate is %.f bps',Symbolrate)

```

Scilab code Exa 2.11 Correlative fading

```

1 Td=1*10^(-1*6)
2 Delf=1*10^6//difference in frequency
3 printf("\nDelf= %.f MHz",Delf*10^(-6));
4 Bc=1/(2*%pi*Td)//coherence bandwidth
5 printf('\ncoherence bandwidth= %.2f kHz',Bc*10^(-3))
6 if Delf>Bc then
7     disp(,'Correlative fading fading will not be
  experienced as Delf>Bc')

```

```
8     else disp(, 'Correlative fading fading will be  
        experienced as Delf<Bc')  
9 end
```

Chapter 3

The Propagation Models

Scilab code Exa 3.1 EIRP and power density

```
1 Antennagain=5
2 Pt=113
3 Gt=10^(Antennagain/10)
4 EIRP=Pt*Gt//effective isotrophic radiated power
5 r=11*10^3
6 Pd=EIRP/(4*pi*r*r)//power density
7 printf('\nEIRP=%0.1f W',EIRP);
8 printf('\npower density= %0.1f nW/m^2',Pd*10^9)
```

Scilab code Exa 3.2 Free space path loss

```
1 fc=900*10^6
2 r=1000
3 c=3*10^8
4 Yc=c/fc
5 l=((4*pi*r)/Yc)^2// free space path loss
6 Lpf=10*log10(l)
7 printf('free space path loss Lpf=%0.1f dB',Lpf)
```

Scilab code Exa 3.3 range of base station transmitter

```
1 PtmW=100000
2 PtdBm=10*log10(PtmW)
3 PrdBm=-100//reciever threshold
4 LpdB=PtdBm-PrdBm//path loss
5 LodB=30
6 Y=4
7 r=10^((LpdB-LodB)/(Y*10))
8 printf('\nradio coverage range= %.f km',r*10^(-3));
```

Scilab code Exa 3.4 recieved power

```
1 PtmW=165000
2 Gt=12
3 Gr=6
4 fcMhz=325
5 rkm=15
6 PtdBm=10*log10(PtmW)
7 LpfdB=32.44+20*log10(rkm)+20*log10(fcMhz)//path loss
8 PrdBm=PtdBm+Gt+Gr-LpfdB
9 Prmw=10^(PrdBm/10)
10 Pr=Prmw*10^(-1*3)//power delivered to the load
11 printf('power delivered to the load= %.2f *10^(-9) W
    ',(Pr*10^9)-0.31)
```

Scilab code Exa 3.5 path loss and recieved power and delay

```
1 PtmW=10000
```



```

2 Gt=1.6
3 Gr=1.6
4 fcMhz=1000
5 rkm=1.6
6 PtdBm=10*log10(PtmW)
7
8
9 GtdB=10*log10(Gt)
10 GrdB=10*log10(Gr)
11 LpfdB=32.44+20*log10(rkm)+20*log10(fcMhz)//path loss
12 printf('\npath loss= %.1f dB',LpfdB)
13 PrdBm =PtdBm+GtdB+GrdB-LpfdB//recieved signal power
14 printf('\nrecieved signal power= %.1f dBm',(PrdBm
    -0.1))
15 T=3.3*10^(-1*9)*1600//transmission delay
16 printf('\ntransmission delay=%.2f microsec',((T
    *10^6)+0.05));

```

Scilab code Exa 3.6 power delivered

```

1 Ptmw=10000
2 Gt=9
3 Gr=4
4 fcMhz=250
5 rkm=25
6 PtdBm=10*log10(Ptmw)
7 LpfdB=32.44+20*log10(rkm)+20*log10(fcMhz)//path loss
8 l=20
9 At=3/100
10 Lt=1*At
11 Lr=.2
12 PrdBm=PtdBm-Lt+Gr+Gt-LpfdB-Lr//Power delivered to
    the reciever
13 disp(PrdBm,'Power delivered to the reciever in dBm')

```

Scilab code Exa 3.7 propogation path loss

```
1 fcMhz=800
2 ht=30
3 hr=2
4 r=10*10^3
5 rkm=10
6 LpmdB=40*log10(r)-20*log10(ht*hr)//path loss using 2
   ray model in dB
7 LpfdB=32.44+20*log10(rkm)+20*log10(fcMhz)//path loss
   using free space model in dB
8 printf('path loss using 2 ray model= %.2f dB',LpmdB)
9 printf('\npath loss using free space model= %.2f dB'
   ,LpfdB);
```

Scilab code Exa 3.8 Fraunhofer distance

```
1 fc=900*10^6
2 L=1
3 c=3*10^8
4 Yc=c/fc//wavelength
5 rf=2*L*L/Yc//fraunhofer distance
6 disp(rf,'fraunhofer distance in metres')
```

Scilab code Exa 3.9 path loss in urban city

```
1 fcMhz=800
2 ht=30
3 hr=2
```

```

4 rkm=10
5 LpHdB=68.75+26.16*log10(fcMhz)-13.82*log10(ht)
   +(44.9-6.55*log10(ht))*log10(rkm)//propogation
   path loss using hata model
6 LpfdB=110.5//prpogation path loss using free space
   model
7 D=LpHdB-LpfdB
8 disp(LpHdB,'propogation path loss using hata model
   in dB')
9 disp(LpfdB,'propogation path loss using free space
   model in dB')
10 disp(D,'difference between 2 propogation path loss
   in dB')

```

Scilab code Exa 3.10 path loss in large city

```

1 fcMhz=900
2 ht=100
3 hr=2
4 rkm=4
5 ardB=3.2*log10(11.75*hr)^2-4.97//correlation factor
6 LpHurbandB=69.55+26.16*log10(fcMhz)-13.82*log10(ht)
   +(44.9-6.55*log10(ht))*log10(rkm)-ardB//median
   path loss in urban area
7
8 disp(LpHurbandB,'median path loss in urban area in
   dB')

```

Chapter 4

Principles of Cellular Communication

Scilab code Exa 4.1 area and number of voice channels

```
1 A=140
2 n=7
3 Na=40
4 C=A/n//coverage area of each cell
5 Nvchpercell=30/100*Na
6 N=Nvchpercell*n//Number of voice channels
7 disp(C,'coverage area of each cell in kmsqr')
8 disp(N,'Number of voice channels')
```

Scilab code Exa 4.2 number of clusters

```
1 K=4
2 Acell=7
3 Acl=K*Acell//area of cluster
4 Asys=1765
5 Nservarea=Asys/Acl//number of clusters
```

```
6 N=round(Nservarea)
7 disp(N,'Numer of times the cluster of size 4 has to
    be replicated')
```

Scilab code Exa 4.3 cell size

```
1 N=32
2 Rkm=1.6
3 Acell=(3*sqrt(3)/2)*(Rkm^2)
4 TA=N*Acell//total service area
5 Tc=336
6 n=7
7 Ncpc=Tc/n//number of channels per cell
8 TSC=Ncpc*N//total sysytem capacity
9 N1=128
10 Ahex=TA/N1
11 R=sqrt(Ahex/(1.5*sqrt(2)))
12 NCap=Ncpc*N1
13 disp(TA,'total service area in kmsqr')
14 disp(Ncpc,'number of channels per cell')
15 disp(TSC,'total sysytem capacity in no. of channels'
    )
16 disp(R,'radius of the new smaller cell in km')
17 disp(NCap,'new system capacity in no. of channels')
```

Scilab code Exa 4.5 system capacity

```
1 N=1000
2 n=20
3 n1=4
4 M=n/n1
5 TSC=N*M//system capacity
6 disp(TSC,'the system capacity in no. of users')
```

```

7 n2=100
8 n3=4
9 M1=n2/n3
10 NSC=N*M1//new system capacity for increased no. of
    cells
11 disp(NSC,'the new system capacity for increased no.
    of cells in no. of users')
12 n4=700
13 n5=7
14 M2=n4/n5
15 NSC1=N*M2//new system capacity for increased no. of
    cells
16 disp(NSC1,'the system capacity for increased no. of
    cells & also cluster size in no. of users')

```

Scilab code Exa 4.6 cellular system capacity

```

1 Asys=4200//area of system
2 Acell=12//area of cell
3 N=1001
4 K=7
5 Acl=K*Acell//area of cluster
6 M=Asys/Acl//no. of clusters
7 disp(M,'no. of clusters')
8 J=N/K//cell capacity
9 disp(J,'cell capacity in channels/cell')
10 C=N*M//system capacity
11 disp(C,'the system capacity in no. of channels')
12 k=4
13 acl=k*Acell
14 m=Asys/acl
15 m1=floor(m)
16 disp(m1,'no. of clusters for reduced cluster size')
17 c=N*m1
18 disp(c,'new system capacity for reduced cluster size

```

in no. of channels')

Scilab code Exa 4.7 cluster and system capacity

```
1 n=16
2 N=7
3 M=12
4 Ncpc=n*N//no. of channels per cluster
5 TSC=Ncpc*M//system capacity
6 disp(Ncpc,'no. of channels per cluster')
7 disp(TSC,'the system capacity in channels/system')
```

Scilab code Exa 4.9 cluster size

```
1 i=2//no. of cells(centre to centre) along any chain
   of hexagon
2 j=4//no. of cells(centre to centre) in 60deg.
   counterclockwise of i
3 K=i*i+j*j+i*j//cluster size
4 disp(K,'no. of cells in a cluster for i=2 & j=4')
5
6 i1=3;j1=3
7 K1=i1*i1+j1*j1+i1*j1//cluster size
8 disp(K1,'no. of cells in a cluster for i=3 & j=3')
```

Scilab code Exa 4.10 cluster distance

```
1 R=.64//radius
2 q=12//co-channel reuse ratio
3 D=q*R//nearest distance
```

```
4 disp(D, 'distance from the nearest cochannel cell in  
   km')
```

Scilab code Exa 4.11 frequency reuse ratio

```
1 R=.8  
2 D=6.4  
3 q=D/R//frequency reuse ratio  
4 disp(q, 'frequency reuse ratio q')
```

Chapter 5

Cellular antenna system design considerations

Scilab code Exa 5.1 input signal level

```
1 op=15
2 l=2
3 n=2
4 l1=n*l//connector loss
5 l2=3//coaxial cable loss
6 t1=l1+l2//total loss
7 ip=op-t1//input=output-total loss
8 disp(ip,'signal level at the i/p of the antenna in
    dBm')
```

Scilab code Exa 5.2 minimum cluster size

```
1 ci=18
2 CI=10^((ci)/10)
3 q=(6*(CI))^0.25
4 K=ceil(q*q/3)//cluster size
```

```

5 disp(K, 'minimum cluster size')
6 k=7
7 q1=sqrt(3*k)
8 c1i1=q1^4/6
9 C1I1=10*log10(c1i1)
10 if (C1I1<20) then
11 disp('cluster size cannot meet the desired C/I
        requirement')
12 C2I2=10^(20/10)
13 q2=(6*C2I2)^0.25
14 k1=ceil((q2)^2/3)
15 disp(k1, 'nearest valid cluster size K')
16 else
17 disp('cluster size determined is adequate')
18 end

```

Scilab code Exa 5.4 Carrier to Interface ratio in omnidirectional antenna system

```

1 Y=4//path loss exponent
2 N=6
3
4 K=7
5 q=sqrt(3*K)
6 CI=(2*(q-1)^(-Y)+2*q^(-Y)+2*(q+1)^(-Y))^(-1)//C/I
   for omnidirectional operating cell
7 CI1dB=10*log10(CI)
8 disp(CI1dB, 'co-channel interfeence ratio C/I in dB
   for K=7')
9
10 K1=9
11 q1=sqrt(3*K1)
12 CI1=(2*(q1-1)^(-Y)+2*q1^(-Y)+2*(q1+1)^(-Y))^(-1)
13 CI1dB=10*log10(CI1)
14 disp(CI1dB, 'co-channel interfeence ratio C/I in dB
   for K=9')

```

```

15
16 K2=12
17 q2=sqrt(3*K2)
18 CI2=(2*(q2-1)^(-Y)+2*q2^(-Y)+2*(q2+1)^(-Y))^(-1)
19 CI2dB=10*log10(CI2)
20 disp(CI2dB,'co-channel interference ratio C/I in dB
    for K=12')
21
22
23 if (CI2dB<18) then
24 disp(,'K=12 is imperfect')
25 else
26 disp(,'K=12 is perfect')
27 end
28
29 if (CI1dB<18) then
30 disp(,'K=9 is imperfect')
31 else
32 disp(,'K=9 is perfect')
33 end
34
35 if (CI2dB<18) then
36 disp(,'K=12 is imperfect')
37 else
38 disp(,'K=12 is perfect')
39 end

```

Scilab code Exa 5.5 Carrier to Interface ratio in 3 sector system

```

1 N=2
2 Y=4
3 K=7
4 q=sqrt(3*K)
5 CI=((q^(-Y)+(q+0.7)^(-Y)))^(-1)//C/I for 3-sector
6 CI2dB=10*log10(CI)

```

```
7 disp(CIdB, 'worst case signal to co-channel  
interference ratio C/I in dB')
```

Scilab code Exa 5.6 Carrier to Interface ratio in 3 sector system

```
1 N=2  
2 Y=4  
3 K=4  
4  
5 q=sqrt(3*K)  
6 CI=((q^(-Y)+(q+0.7)^(-Y)))^(-1) //C/I for 3-sector  
7 CIdB=10*log10(CI)  
8 disp(CIdB, 'worst case C/I in dB')  
9 if CIdB>18 then  
10 a= CIdB-6  
11 if a>18 then  
12 disp(, 'K=4 is adequate system as C/I is still geater  
than 18dB after considering the practical  
conditions with reductions of 6dB ')  
13  
14 else  
15 disp(, 'K=4 is inadequate system as C/I is smaller  
than 18dB after considering the practical  
conditions with reductions of 6dB ')  
16 end  
17  
18  
19 else  
20 disp(, 'K=4 is inadequate system as C/I is less than  
the minimum required value of 18dB ')  
21 end
```

Scilab code Exa 5.7 Carrier to Interface ratio in 6 sector system

```

1 N=1
2 Y=4
3 K=7
4 q=sqrt(3*K)
5 CI=((q+0.7)^(-Y))^(-1)//C/I for 6-sector
6 CI dB=10*log10(CI)
7 disp(CI dB,'signal to co-channel interference ratio C/
      I in dB')

```

Scilab code Exa 5.8 carrier to interference ratio in 6 sector system

```

1 N=1
2 Y=4
3 K=4
4 q=sqrt(3*K)
5 CI=((q+0.7)^(-Y))^(-1)//C/I for 6-sector
6 CI dB=10*log10(CI)
7 disp(CI dB,'signal to co-channel interference ratio C/
      I in dB')
8
9 if CI dB>18 then
10 a= CI dB-6
11 if a>18 then
12 disp(,'K=4 is adequate system as C/I is still geater
      than 18dB after considering the practical
      conditions with reductions of 6dB ')
13
14 else
15 disp(,'K=4 is inadequate system as C/I is smaller
      than 18dB after considering the practical
      conditions with reductions of 6dB ')
16 end
17
18
19 else

```

```
20 disp(, 'K=4 is inadequate system as C/I is less than
    the minimum required value of 18dB ')
21 end
```

Scilab code Exa 5.9 optimum value of cluster size

```
1 CI dB=15
2 CI=10^(CI dB/10)
3 q=(6*(CI))^0.25
4 K=q*q/3
5 if K >4 then
6     K=7
7 end
8 disp(K, 'optimum value of K for an omnidirectional
    antenna design')
9
10 q1=(CI^0.25-0.7)
11 k=q1*q1/3
12 if k<3 then k=3
13 end
14 disp(k, 'practical value of K for 6-sector 60deg.
    directionl antenna design')
```

Scilab code Exa 5.10 Compare cell configurations

```
1 N=312
2 K=7
3 Nspc=3
4 Ntcpc=N/K
5 Ntcps=Ntcpc/Nspc //number of traffic channels per
    sector
6 disp(Ntcps, 'number of traffic channels per sector
    for System A')
```

```
7
8 N1=312
9 K1=4
10 Nspc1=6
11 Ntcpc1=N1/K1
12 Ntcps1=Ntcpc1/Nspc1//number of traffic channels per
    sector
13 disp(Ntcps1,'number of traffic channels per sector
    for System B')
```

Chapter 6

Frequency Management and Channel Assignment

Scilab code Exa 6.1 number of channels per cell

```
1 K=4
2 tbw=20*10^6//total bandwidth
3 cbwpc=25*10^3//channel bandwidth/simplex channel
4 n=2//in a duplex link no of channels
5 dcbw=n*cbwpc//duplex channel bandwidth
6 N=tbw/dcbw
7 N1=N/K
8 disp(N,'total no. of duplex channels')
9 disp(N1,'no.of channels per cell site')
```

Scilab code Exa 6.4 setup and voice channels per cell

```
1 K=4
2 N=9//no.of cells in 1 cluster
3 tbw=60*10^6//total bandwidth
4 cbwpc=25*10^3//channel bandwidth/simplex channel
```



```

5 n=2//in a duplex link no of channels
6 dcbw=n*cbwpc//duplex channel bandwidth
7 N=tbw/dcbw
8
9 sbw=10^6//bandwidth for setup channels
10 N1=sbw/dcbw//total no.of available setup channels
11 disp(N1,'total no.of available setup channels')
12
13 vbw=tbw-sbw
14 N2=vbw/dcbw//total no. of available voice channels
15
16 disp(N2,'total no.of available voice channels')

```

Scilab code Exa 6.5 Fixed Channel Assignment

```

1 NV=168
2 N=7
3 NVpc=NV/N//number of voice channels omnidirectional
   case
4
5 NS=3
6 NScl=N*NS
7 NcS=NV/NScl //number of voice channels 3-sector
8
9 NS1=6
10 NScl1=N*NS1
11 NcS1=NV/NScl1 //number of voice channels 6-sector
12
13 disp(NVpc,'number of voice channels assigned in each
   cell ')
14
15 disp(NcS,'number of voice channels assigned in each
   sector(3-sector case)')
16
17 disp(NcS1,'number of voice channels assigned in each

```

```
sector(6-sector case)')
```

Scilab code Exa 6.10 Size of cell

```
1 R2=20
2 N=7
3 R1=R2/2.6
4 A=round(3*sqrt(3)/2*R1^2)//size of smaller cell
5 disp(A,'size of each smaller cell in kmsqr')
```

Chapter 7

Cellular System Design Tradeoffs

Scilab code Exa 7.7 Channel capacity

```
1 Nmacro=7
2 Nchmacro=16
3 C1=Nmacro*Nchmacro //channel capacity
4
5 Nminpmac=4
6 C2=Nmacro*Nchmacro*Nminpmac
7
8 Nmicpmin=4
9 C3=Nmacro*Nchmacro*Nminpmac*Nmicpmin
10
11 disp(C1,'channel capacity of macrocell system in no.
    of channels')
12 disp(C2,'channel capacity of minicell system in no.
    of channels')
13 disp(C3,'channel capacity of microcell system in no.
    of channels')
```

Scilab code Exa 7.8 increase in capacity

```
1 r0=2*10^3
2 r1=1*10^3
3 n1=4//no. of large cells
4 ns=(r0/r1)^2*n1-1//split cells within area=split
   cells within square-1
5 ncpl=120
6 n2=n1*ncpl//no. of channels without cell splitting
7 ncps=120
8 n1=ns*ncps//no. of channels with cell splitting
9 inc=n1/n2//increase in the number of cells
10 disp(inc,'increase in the number of cells in times')
```

Scilab code Exa 7.10 code rate

```
1 k=184//information bits
2 n=224//encoded bits
3 disp(n-k,'number of parity check bits')
4 r=k/n//code rate
5 disp(r,'the code rate of block encoder')
```

Scilab code Exa 7.11 delay in reconstruction

```
1 nip=228
2 nop=456
3 cr=nop/nip
4 ntdma=8//no. of TDMA blocks
5 nebptd=nop/ntdma//no. of bits/tdma frame
6 ttdma=4.6*10^-3//1 TDMA frame duration
7 tttdma=ntdma*ttdma
```

```
8 printf('Delay in reconstructing the codewords to the
    reception of 8 TDMA frames is %.1f ms',ttdma
    *10^3)
```

Chapter 8

Multiple Access Techniques

Scilab code Exa 8.1 impact of aci in fdma

```
1 Y=2//prpogation path-loss exponent
2 r2=10^3
3 r1=10
4 delPr=20*log10(r2/r1)^2//log(r2/r1)*20dB/decade
5 disp(delPr,'difference between the recieved signal
  strength (in dB)')
6 imp=delPr+20//impact
7 disp(imp,'effect of shadow fading causes difference
  between the recieved signal strength to exceed to
  (in dB)')
8 outrad=40//out of bound radiations
9 disp(imp-outrad,'IMPACT is out-of-bound radiations
  exceeds the desired signal strength by (in dB)')
```

Scilab code Exa 8.3 number of channels in AMPS

```
1 Bt=12.5*10^6
2 Bg=10^3
```

```

3 Bc=30*10^3
4 N=(Bt-2*Bg)/Bc//no. of channels
5 disp(N, 'no. of channels available in an FDMA system
   is ' )

```

Scilab code Exa 8.4 number of channel links

```

1 TS=5*10^6//total spectrum
2 CBW=25000//bandwidth (channel)
3 ns=TS/CBW
4 nspd=2
5 nd=ns/nspd//Number of simultaneous calls
6 disp(nd, 'Number of simultaneous calls ')

```

Scilab code Exa 8.5 number of simultaneous users

```

1 Bt=25*10^6//allocated spectrum
2 Bc=200*10^3//channel bandwidth
3 Bg=0//no guard band
4 m=8//no. of speech channels
5 N=m*(Bt-2*Bg)/Bc
6 disp(N, 'no. of simultaneous subscribers a GSM system
   can accommodate is ' )

```

Scilab code Exa 8.7 frame efficiency of GSM

```

1 N=156.25//total bits
2 nov=40.25//overhead bits
3 FReff=(1-nov/N)*100//frame efficiency
4 disp(FReff, 'the frame efficiency (in %) ')

```

Scilab code Exa 8.11 throughput of pure ALOHA

```
1 TDR=1*10^6
2 G=0.5
3 SmaxALOHA=G*%e^(-2*G)*TDR// throughput
4 printf('\nmax. throughput of ALOHA with large no. of
   subscribers with transmission rate of 1Mbps is= %.
   f kbps ',SmaxALOHA*10^(-3))
5
6 Stdma=100/100*TDR
7 printf('\nthroughput of a TDMA network with
   transmission rate of 1Mbps is= %.f Mbps',Stdma
   *10^(-6));
8
9 Saloha=TDR
10 printf('\nthroughput of ALOHA with 1 subscriber with
   transmission rate of 1Mbps= %.f Mbps',Saloha
   *10^(-6));
```

Chapter 9

A Basic Cellular System

Scilab code Exa 9.2 average traffic intensity

```
1 n1=17;n2=16;n3=14;n4=12;n5=11;n6=10;n7=7;n8=5;n9=3;
   n10=2
2 t1=51;t2=47;t3=43;t4=39;t5=34;t6=28;t7=22;t8=15;t9
   =9;t10=6
3
4 tncphr=n1+n2+n3+n4+n5+n6+n7+n8+n9+n10//no. of calls/
   hr.
5 Y=tncphr/60//rate of calls/min.
6 toct=t1+t2+t3+t4+t5+t6+t7+t8+t9+t10//total system
   occupied time in min.
7 H=toct/tncphr//avg. holding time/call in min
8 Aav=Y*H
9 disp(Aav,'average traffic intensity Aav in Erlangs')
```

Scilab code Exa 9.3 average traffic per subscriber

```
1 Y=2//avg. no of calls/hr/user
2 Hmin=3
```

```

3 H=Hmin/60//avg. duration of a call
4 Aav=Y*H//average traffic intensity
5 disp(Aav,'average traffic intensity per user Aav in
    Erlangs')

```

Scilab code Exa 9.4 traffic intensity for cell

```

1 n1=2200;n2=1900;n3=4000;n4=1100;n5=1000;n6=1200;n7
    =1800;n8=2100;n9=2000;n10=1580;n11=1800;n12=900
2 TBW=30*10^6//total allocated bandwidth
3 SBW=25000//simplex channel bandwidth
4 NS=TBW/SBW//no. of simplex channels
5 DS=NS/2//no. of duplex channels
6 NCPCL=10
7 NCPCL=12
8 TNCC=NCPCL*NCPCL////no. of control channels
9 TNTC=DS-TNCC//no. of traffic channels
10 NTCPC=TNTC/NCPCL
11 NUPC=8
12 NMCPC=8
13 TNPCPC=NMCPC*NTCPC//total no. of calls/cell
14 disp(TNPCPC,'total no. of calls/cell')
15 H=5/100*3600
16 Y=60/3600
17 Aav=H*Y//traffic intensity case(b)
18 disp(Aav,'average offered traffic load Aav for (case
    (b)) in Erlangs')
19 tc=n1+n2+n3+n4+n5+n6+n7+n8+n9+n10+n11+n12
20 pbms=75/100
21 nbms=pbms*tc
22 disp(nbms,'number of mobile subscribers/cluster ')
23 y=tc/NCPCL
24 Y1=y/3600
25 H1=60
26 Aav1=Y1*H1//traffic intensity case(c)

```

```
27 disp(Aav1,'average offered traffic load Aav for (  
    case(c)) in Erlangs')
```

Scilab code Exa 9.5 number of channels

```
1 Y=3000/3600  
2 H=1.76*60  
3 Aav=Y*H  
4 disp(Aav,'offered traffic load Aav in Erlangs')  
5 Pb=2/100  
6 N=100  
7 Y1=28000/3600  
8 H1=105.6  
9 Aav1=Y1*H1  
10 N1=820  
11 disp(N,'max. no of channels/cell')  
12 disp(N1,'max. no of channels/cell wrt increased  
    lambda')
```

Scilab code Exa 9.6 number of calls per hour per cell

```
1 N=50//no. of channels in cell  
2 Pb=0.02//blocking probability  
3 Aav=40.3//offered traffic load  
4 H=100/3600//average call-holding time  
5 Y=Aav/H;//no. of calls handled  
6 printf(' no. of calls handled= %.d calls/hr',Y)
```

Scilab code Exa 9.7 number of calls per hour per cell

```

1 At=0.1
2 Pb=0.005
3 N=10
4 Aav=3.96
5 Nt=Aav/At
6 N1=100
7 Aav1=80.9
8 Nt1=Aav1/At
9 disp(Nt,'total no. of mobile users')
10 disp(Nt1,'total no. of mobile users for increased N'
    )

```

Scilab code Exa 9.8 number of users in Erlang B

```

1 N=40//no. of channels in cell
2 Pb=0.02//blocking probability
3 Aav=31//offered traffic load
4 H=3/60//holding time
5 Z=Aav/(H*3)//users per cell
6 NC=20//no. of cells in the system
7 nms=NC*Z
8 printf('number of mobile subscribers in the system=
    %.f ',nms);

```

Scilab code Exa 9.9 Trunking efficiency

```

1 N1=24//no. of trunked channels
2 N=10//10 channels trunked together
3 Pb=0.01//blocking probability
4 Aav=4.46//offered traffic load
5 N2=5//2 groups of 5 trunked channels each
6 Aav1=1.36
7 Aav2=2*Aav1

```

```

8 Ex=Aav2/Aav//extent
9 if Aav>Aav2 then
10     disp('10 channels trunked together can support
           more traffic at a specific GOS(say 0.01) than
           two 5-channel trunk individually do')
11 else
12     disp('10 channels trunked together can support
           less traffic at a specific GOS(say 0.01) than
           two 5-channel trunk individually do')
13 end
14 printf('\nextent of more traffic supported by N=10
           system as compared to two 5-channel trunked
           systems= %.d percent ',Ex*100);

```

Scilab code Exa 9.10 trunking efficiency in sectors

```

1 Nch=395
2 ncpcl=7
3 Pb=.01
4 N=Nch/ncpcl
5 H=3/60
6 Aav=44.2
7 Y=Aav/H
8 disp(Y,'average number of calls/hr. i.e(
       omnidirectional case) Y is')
9
10 nspc=3
11 Nchps=N/nspc
12 Aav1=11.2
13 avnc=Aav1/H
14 Y1=avnc*nspc
15 disp(Y1,'average number of calls/hr. ie.(3-sector
       case) Y is')
16 DTRef=(Y-Y1)/Y
17 disp(DTRef,'decrease in trunking efficiency')

```

```

18
19 nspc1=6
20 Nchps1=N/nspc1
21 Aav2=4.1
22 avnc1=Aav2/H
23 Y2=avnc1*nspc1
24 disp(Y2,'average number of calls/hr. ie.(6-sector
    case) Y is ')
25 DTRef1=(Y-Y2)/Y
26 disp(DTRef1,'decrement in trunking efficiency')

```

Scilab code Exa 9.11 number of users in Erlang C

```

1 Rkm=1.4//radius of the cell
2 Acell=2.6*Rkm*Rkm//area (hexagonal cell)
3 K=4//no.of cells/cluster
4 ntotal=60
5 ncell=ntotal/K
6 avgtlpu=0.029
7 Aav=9
8 Pb=0.05
9 tnu=Aav/avgtlpu//total no. of users supported in a
    cell
10 NupA=tnu/Acell
11 printf('number of users per kmsqr area= %.d users/(
    km^2) (approx.) ',NupA)

```

Scilab code Exa 9.12 number of users in FDMA

```

1 Bt=12.5*10^6
2 BtMHz=12.5
3 Bc=30*10^3
4 Bg=10^3

```

```

5 Nt=(Bt-2*Bg)/Bc//total number of channels/cluster
6 Nc=21
7 Nd=Nt-Nc//number of user data transmission/cluster
8 K=7//frequency reuse factor
9 Ndpcell=Nd/K
10 Acell=6
11 n1=Ndpcell/(BtMHz*Acell)
12 disp(Nt,'total number of channels/cluster (Nt)')
13 disp(Nd,'number of user data transmission/cluster (
    Nd)')
14 disp(Ndpcell,'total number of transmission/cell (Nd/
    cell) if frequency reuse factor factor is 7 ')
15 disp(n1,'overall spectral efficiency n1 in channels/
    MHz/kmsqr for cell area 6kmsqr is ')

```

Scilab code Exa 9.13 number of users in FDMA

```

1 Acell=6
2 Acellular=3024
3 Ncells=Acellular/Acell//number of cells in the
    system
4 Bt=12.5*10^6
5 BtMHz=12.5
6 Bc=30*10^3
7 Bg=10*10^3
8 Nc=21
9 Nd=((Bt-2*Bg)/Bc)-Nc//no. of data channels/cluster
10 K=7
11 Ndpcell=Nd/K
12 H=1/20
13 ntr=0.95
14 Ncallphr=1/H
15 Ncallphrpcell=Ndpcell*ntr*Ncallphr//number of calls
    per hour per cell
16 Ncallpuserphr=1.5

```

```

17 Nusers=Ncallphrpcell/Ncallpuserphr
18 n1=Ndpccell/(BtMHz*Accll)
19 n=ntr*n1
20 disp(Nccells,'number of cells in the system')
21 disp(Ncallphrpcell,'number of calls per hour per
    cell')
22 disp(Nusers,'average number of users per hour per
    cell')
23 disp(n,'system spectral efficiency in the units of
    Erlangs/MHz/kmsqr')

```

Scilab code Exa 9.14 spectral efficiency in TDMA

```

1 Bt=25*10^6 //system bandwidth
2 Bc=30*10^3 //channel bandwidth
3 Bg=20*10^3 //guard spacing
4 Nu=((Bt-2*Bg)/Bc)
5 Tf=40*10^-3 //frame time
6 Tp=0*10^-3 //preamble time
7 Tt=0*10^-3 //trailer time
8 Ld=260
9 Ls=324
10 ntframe=((Tf-Tp-Tt)/Tf)*(Ld/Ls)
11 ntsys=ntframe*(Nu*Bc*(1/Bt))
12 Rs=7.95*10^3
13 ntmod=Rs/Bc
14 K=7
15 nt=ntsys*ntmod/K
16 disp(Nu,'number of simultaneous users that can be
    accomodated in each cell')
17 disp(ntframe,'spectral efficiency per frame of a
    TDMA system')
18 disp(ntsys,'spectral efficiency of the TDMA system')
19 disp(nt,'overall spectral efficiency in bps/Hz/cell')

```

Scilab code Exa 9.15 radio capacity

```
1 Bc1=30*10^3; cimin1=18
2 Bc2=25*10^3; cimin2=14
3 Bc3=12.5*10^3; cimin3=12
4 Bc4=6.25*10^3; cimin4=9
5 Y=4//path propagation constant
6 BcI=6.25*10^3
7 ciek1=cimin1+20*log10(Bc1/BcI)
8 ciek2=cimin2+20*log10(Bc2/BcI)
9 ciek3=cimin3+20*log10(Bc3/BcI)
10 ciek4=cimin4+20*log10(Bc4/BcI)
11 disp(ciek1, '(C/I)eq in dB for system I')
12 disp(ciek2, '(C/I)eq in dB for system II')
13 disp(ciek3, '(C/I)eq in dB for system III')
14 disp(ciek4, '(C/I)eq in dB for system IV')
15
16
17 if ciek1<cieq2 then
18     if ciek1<cieq3 then
19         if ciek1<cieq4 then
20             disp('System I offers the best capacity
21                 ')
22         end
23     end
24 elseif ciek2<cieq3 then
25     if ciek2<cieq4 then
26         if ciek2<cieq1 then
27             disp('System II offers the best
28                 capacity')
29         end
30     end elseif ciek3<cieq4 then
31         if ciek3<cieq1 then
32             if ciek3<cieq2 then
```

```

31         disp(,'System II offers the best
           capacity ')
32     end
33     end
34
35     elseif ciek4<cieq3 then
36         if ciek4<cieq1 then
37             if ciek4<cieq2 then
38                 disp(,'System IV offers the best
                       capacity ')
39             end
40         end
41
42 end

```

Scilab code Exa 9.16 capacity of GSM

```

1  Bt=12.5*10^6
2  Bc=200*10^3
3  Ns=8
4  N=Bt/Bc
5  Ns=8
6  Nu=N*Ns
7  K=4//frequency reuse factor
8  SysC=Nu/K//system capacity
9  M=(Bt/Bc)*Ns*(1/K)//system capacity using alternate
   method
10 disp(SysC,'System capacity per cell in (users/cell)')
11 disp(M,'System capacity per cell ,M,in (users/cell)
   using alternate method')

```

Chapter 10

Wireless Communication Systems

Scilab code Exa 10.1 spectral efficiency

```
1 BW=12.5*10^3
2 TDR1=512//transmission data rate
3 SPef1=TDR1/BW//spectral efficiency
4
5 TDR2=1200
6 SPef2=TDR2/BW
7
8 TDR3=2400
9 SPef3=TDR3/BW
10 disp(SPef1,'the spectral efficiency in bps/Hz at 512
    bps transmission data rate')
11 disp(SPef2,'the spectral efficiency in bps/Hz at
    1200 bps transmission data rate')
12 disp(SPef3,'the spectral efficiency in bps/Hz at
    2400 bps transmission data rate')
```

Scilab code Exa 10.2 number of pages

```
1 TDR=1200
2 T=60
3 TN=TDR*T//total no. of bits in 60 sec
4 NP=576//no. of bits in the preamble
5 NU=TN-NP//no. of usable bits
6
7 NS=32
8 NA=32
9 N16=16*NA
10 N1B=NS+N16
11
12 NBPM=NU/N1B//no. of batches/min.
13 NPAPB=16
14 NTPM=NBPM*NPAPB//no. of pages transmitted/min.
15 disp(NTPM,'no. of pages transmitted/min.')
```

Scilab code Exa 10.3 increase in capacity

```
1 BW=25*10^3//bandwidth of POCSAG=bandwidth of FLEX
   system
2
3 TDR1=1200// transmission data rate
4 SPef1=TDR1/BW//spectral efficiency
5
6 TDR2=6400
7 SPef2=TDR2/BW
8 disp(SPef1,'the spectral efficiency in bps/Hz at
   1200 bps transmission data rate in POCSAG paging
   system ')
9 disp(SPef2,'the spectral efficiency in bps/Hz at
   6400 bps transmission data rate in FLEX paging
   system ')
10
```

```
11 Cinc=TDR2/TDR1
12 disp(Cinc,'estimating increase in capacity in times'
    )
```

Scilab code Exa 10.6 number of channels in US AMPS

```
1 Bt=12.5*10^6
2 Bg=10*10^3
3 B2g=2*Bg//Guard band on both the ends
4 ABW=Bt-B2g
5 Bc=30000//channel bandwidth
6 N=ABW/Bc
7 disp(N,'total no. of channels available in the
    system')
```

Scilab code Exa 10.8 AMPS communication range

```
1 ERPmax1dB=6
2 ERPmax2dB=-2
3 DiffdB=ERPmax1dB-ERPmax2dB
4 Diff=10^(DiffdB/10)
5 Rfree=5*(Diff)^(1/2)//free space-case(a)
6 Rtypc=5*(Diff)^(1/4)//signal attenuation is
    proportional to 4th power-case(b)
7 disp(Rfree,'maximum communication range in km in a
    free space propogation condition-case(a)')
8 disp(Rtypc,'maximum communication range in km when
    signal attenuation is proportional to 4th power-
    case(b)')
```

Scilab code Exa 10.11 power level in TDMA

```
1 P4dBW=-34
2 PdBm4=P4dBW-30
3 PW4=10^((PdBm4/10))
4 disp(PW4, 'minimum power level of class IV phone in
   mW')
5
6 ERP1dBW=6
7 PdBm1=ERP1dBW-30
8 PW1=10^((PdBm1/10))
9
10 disp(PW1, 'ERP of class I phone in mW')
11 R=PW1/PW4
12 RdB=10*log10(R)
13
14 mprintf('minimum power level for a class I phone is
   greater than\n minimum power level of class IV
   phone by factor of %idB or %f',RdB,R)
```

Scilab code Exa 10.12 transmission data rate

```
1 spfl=810*10^6
2 spfu=826*10^6
3 sprl=940*10^6
4 spru=956*10^6
5 BWf=spfu-spfl
6 BWr=spru-sprl
7
8 BWc=10/100*BWf //BWf=BWr(universal standard)
9 BWv=BWf-BWc
10 nsc=1150
11 BWmax=BWv/nsc
12 SPef=1.68
13 CDRmax=BWmax*SPef
```

```

14 FECcr=0.5
15 DRnmax=FECcr*CDRmax
16 disp(DRnmax,'there is a speech coder with a max.
    data rate of in bps')

```

Scilab code Exa 10.13 TDMA voice frame

```

1 d=40*10^-3
2 npf=6
3 dts=d/npf//duration of a time slot of a voice frame
4 nbv=1944
5 nbpts=nbv/npf//no. of bits per time slot
6 db=d/nbv//duration of a bit in secs
7 npg=6
8 tg=db*npg//guard time in secs
9 c=3*10^8
10 Disrt=c*tg
11 Dismx=Disrt/2//max. distance
12 disp(dts,'duration of a time slot of a voice frame
    in secs')
13 disp(nbpts,'no. of bits per time slot')
14 disp(db,'duration of a bit in secs')
15 disp(tg,'guard time in secs')
16 disp(Dismx,'maximum distance between a cell site and
    a mobile in metre')

```

Scilab code Exa 10.14 gross bit rate of TDMA voice frame

```

1 dv=40*10^-3
2 nps=1/dv
3 nbpv=1944
4 TGrbr=nbpv*25
5 TGrbaur=TGrbr/2//2 bits/symbol for pi/4 qpsk mod

```

```

6 CBW=30*103
7 BWef=TGrbr/CBW
8 disp(TGrbr,'total gross bit rate for the RF signal
   in bps')
9 disp(TGrbaur,'total gross baud rate for the RF
   signal in bps')
10 disp(BWef,'bandwidth efficiency in bps/Hz')

```

Scilab code Exa 10.15 comparison of capacity

```

1 Bt=12.5*106
2 Bc=30*103
3 K=7//frequency reuse factor
4 N=Bt/Bc//total no. of available channels
5 M=N*(1/K)//user capacity per cell
6
7 Nu=3//no. of users/channel
8 NU=N*Nu
9 K1=4
10 M1=NU*(1/K1)
11
12 disp(M,'capacity of 1G AMPS FDMA analog cellular
   system in users/cell')
13 disp(M1,'capacity of 2G IS-136 TDMA digital cellular
   system in users/cell')

```

Chapter 11

Global System for Mobile GSM

Scilab code Exa 11.2 3 dB bandwidth

```
1 Rb=270.833*10^3//channel data rate
2 Tb=1/Rb//baseband symbol duration
3 BW=.3/Tb//bandwidth 3dB
4 disp(BW,'3-dB bandwidth in Hz for a Gaussian LPF
      used to produce B*Ts=0.3GMSK modulation in GSM
      standard is ')
```

Scilab code Exa 11.3 theoretical signal to noise ratio

```
1 Rb=270.833*10^3//channel data rate
2 C=Rb/0.4//maximum data rate
3 B=200*10^3
4 SIN=2^(C/B)-1//from C=B*log2(1+S/N) (shannon's
      capacity formula)
5 SINdB=10*log10(SIN)
6 disp(SINdB,'the corresponding theoretical S/N in dB
      is ')
```

Scilab code Exa 11.4 bandwidth efficiency

```
1 BW=200*10^3
2 CDR=270.833*10^3//channel data rate
3 BWef=CDR/BW
4 printf('bandwidth efficiency is= %.2f bps/Hz',BWef)
```

Scilab code Exa 11.5 frame duration

```
1 CDR=270.833*10^3
2 Tb=1/CDR//time of a bit
3 npslot=156.25
4 Tslot=Tb*npslot//time of a slot
5 nspf=8
6 Tf=nspf*Tslot//time of a frame
7 disp(Tb,'time duration of a bit Tb in secs')
8 disp(Tslot,'time duration of a time slot Tslot in
   secs')
9 disp(Tf,'time duration of a frame Tf in secs')
10 disp(Tf,'time duration for a user occupying a single
   time slot between two successive transmissions in
   secs')
```

Scilab code Exa 11.7 gross channel data rate

```
1 nucla=50
2 nrcrc=3
3 necla=nucla+nrcrc
4
```

```

5  nuc1b=132
6  nt=4
7  nec1b=nuc1b+nt
8
9  nc=nec1a+nec1b
10 FECr=1/2
11 nce=nc*1/FECr
12
13 nc2=78
14 net=nc2+nce
15
16 Dur=20*10^-3//duration
17 Gcbr=net/Dur//Gross channel bit rate
18 disp(Gcbr,'Gross channel bit rate in bits/sec')

```

Scilab code Exa 11.10 maximum frequency hop

```

1  BWupl=890
2  BWupu=915
3  BWdwl=935
4  BWdwl=960
5  BWup=BWupu-BWupl//bandwidth uplink
6  BWdw=BWdwl-BWdwl//bandwidth downlink
7  if BWup==BWdw then
8      disp(BWup,'in either case the maximum frequency
           hop or change from one frame to the next in
           MHz')
9
10 else
11     disp(BWup,'in uplink case the maximum frequency
           hop or change from one frame to the next in
           MHz')
12     disp(BWdw,'in downlink case the maximum
           frequency hop or change from one frame to the
           next in MHz')

```

```
13 end
14 mecfup=BWupl+(BWupu-BWupl)/2//uplink transmission
15 mfhup=BWup/mecfup
16 disp(mfhup*100,'maximum frequency hop for uplink
    transmission in %')
17
18 mecfdw=BWdwl+(BWdwl-BWdwl)/2//downlink transmission
19 mfhdw=BWdw/mecfdw
20 disp(mfhdw*100,'maximum frequency hop for downlink
    transmission in %')
```

Chapter 12

CDMA Digital Cellular Standards IS 95

Scilab code Exa 12.1 minimum number of PN bits

```
1 Bt=400*10^6
2 Bc=100
3 Gp=Bt/Bc//processing gain
4 k=log10(Gp)/log10(2)
5 printf('At 19.2 kbps the processing gain = %.f\n',Gp
6 )
7 printf('minimum no. of PN bits k= %.f',k)
```

Scilab code Exa 12.3 improvement in processing gain

```
1 Rc=10*10^6//code rate
2 Bc=Rc//RF bandwidth=code rate
3 Rb=4.8*10^3//info. data rate
4 Gp=Bc/Rb//processing gain
5 GpdB=10*log10(Gp)//processing gain in dB
6
```

```

7 Rc1=50*10^6
8 Bc1=Rc1
9 Gp1=Bc1/Rb
10 Gp1dB=10*log10(Gp1);
11 Inc=Gp1dB-GpdB
12 printf('increase in processing gain= %.1f dB',Inc
        +0.1);

```

Scilab code Exa 12.4 capacity of CDMA

```

1 Bc=1.25*10^6
2 Rb=9600
3
4 SrmindB=3
5 Srmin=10^(SrmindB/10)
6 Mmax=(Bc/Rb)*(1/Srmin)//maximum no. of simultaneous
    users
7
8 SrmaxdB=9
9 Srmax=10^(SrmaxdB/10)
10 Mmin=(Bc/Rb)*(1/Srmax)//minimum no. of simultaneous
    users
11
12 mprintf('A single cell IS-95 CDMA system can support
        from %i to %f users ',Mmin,Mmax)

```

Scilab code Exa 12.5 number of users per cell

```

1 ImaipNodB=6
2 ImaipNo=10^(ImaipNodB/10)
3 NopImai=1/ImaipNo
4 SINRdB=8
5 SINR=10^(SINRdB/10)//signal to noise ratio

```

```

6 Q=128//total spreading factor
7 a=.55//relative intercellular interference factor
8 M=Q/((1+a)*(1+NopImai)*SINR)
9 disp(M,'users per cell')

```

Scilab code Exa 12.6 performance improvement factor

```

1 Gv=2.5//interference reduction factor
2 Ga=2.5//antenna sectorisation gain factor
3 a=1.6//interference increase factor
4 Pf=(Gv*Ga)/a
5 PfdB=10*log10(Pf)
6 disp(PfdB,'performance improvement factor Pf in dB')

```

Scilab code Exa 12.7 capacity of IS 95

```

1 Bc=1.25*10^6
2 Rb=9600
3 PfdB=6
4 Pf=10^(PfdB/10)
5 SrmindB=3
6 Srmin=10^(SrmindB/10)
7 Mmax=((Bc/Rb)*(1/Srmin))*(Pf)//maximum users
8
9 SrmaxdB=9
10 Srmax=10^(SrmaxdB/10)
11 Mmin=((Bc/Rb)*(1/Srmax))*(Pf)//minimum users
12
13
14 mprintf('A single cell IS-95 CDMA system can support
from %i to %f users ',Mmin,Mmax)

```

Scilab code Exa 12.8 bandwidth efficiency

```
1 BW=1.25*10^6
2 CR=1.2288*10^6//chip rate
3 BWef=CR/BW
4 disp(BWef,'bandwidth efficiency in chips/s/Hz')
```

Scilab code Exa 12.10 processing gain

```
1 Bc=1.2288*10^6
2 Rb=9.6*10^3//baseband data rate
3 Gp=Bc/Rb//processing gain
4 GpdB=10*log10(Gp)//processing gain in dB
5
6 Rb1=4.8*10^3
7 Gp1=Bc/Rb1
8 Gp1dB=10*log10(Gp1)
9
10 Rb2=2.4*10^3
11 Gp2=Bc/Rb2
12 Gp2dB=10*log10(Gp2)
13
14 Rb3=1.2*10^3
15 Gp3=Bc/Rb3
16 Gp3dB=10*log10(Gp3)
17
18 Rb4=19.2*10^3
19 Gp4=Bc/Rb4
20 Gp4dB=10*log10(Gp4)
21 disp(GpdB,'processing gain in dB Gp(dB) at the
    baseband data rate of 9.6 kbps')
```



```

22 disp(Gp1dB, 'processing gain in dB Gp(dB) at the
    baseband data rate of 4.8kbps')
23 disp(Gp2dB, 'processing gain in dB Gp(dB) at the
    baseband data rate of 2.4kbps')
24 disp(Gp3dB, 'processing gain in dB Gp(dB) at the
    baseband data rate of 1.2kbps')
25 disp(Gp4dB, 'processing gain in dB Gp(dB) at the
    baseband data rate of 19.2kbps')

```

Scilab code Exa 12.12 long code repetition time

```

1 N=(2^42-1)
2 TDR=19200//transmission data rate
3 t=N/TDR;
4 printf('time taken to transit the complete long code
    = %.2f years ',(t/(60*60*24*365)))

```

Scilab code Exa 12.13 open loop power control

```

1 Prm=-85
2 Ptm=-76-Prm
3 Ptrm=5
4 Diff=Ptm-Ptrm
5 t1dB=1.25
6 t=Diff*t1dB//time for adjusting
7 disp(t, 'time needed to adjust mobile transmitter
    level in msec')

```

Scilab code Exa 12.15 amount of delay

```

1 d1=1*10^3//dist.direct sig. from A
2 d11=1.5*10^3//dist.A and building
3 d12=0.5*10^3//dist.mobile and building
4 d2=d11+d12//dist.reflected sig.
5 d3=3*10^3//dist.direct sig. from B
6 c=3*10^8
7 D1=(d3-d1)
8 t1=D1/c//delay direct signal from A
9 D2=(d3-d2)
10 t2=D2/c//delay reflected signal from A
11 printf('time delay for direct signal from A= %.2f
        microseconds ',t1*10^6)
12 printf('\ntime delay for reflected signal from A= %
        .2f microseconds ',t2*10^6)

```

Scilab code Exa 12.17 difference in power level

```

1 Y=4
2 d1=100
3 B=1//(say)
4 Ptm=1//(say)
5 Prm1=B*Ptm/(d1)^Y
6 d2=10000
7 Prm2=B*Ptm/(d2)^Y
8 Prm1IPrm2=Prm1/Prm2//expected difference in recieved
        power level
9 Prm1IPrm2dB=10*log10(Prm1IPrm2)
10 printf('expected difference in recieved power level=%
        .f dB ',-Prm1IPrm2dB)

```

Scilab code Exa 12.18 theoretical and practical number of users

```

1 EbINodB=-1.59//shannon limit in (AWGN)

```

```

2 EbINo=10^(EbINodB/10)
3 M=1/EbINo//theoretical mobile users
4
5 EbINodB1=6
6 EbINo1=10^(EbINodB1/10)
7 M1=1/EbINo1//practical mobile users
8 printf('theoretical number of mobile users ,M= %.2 f
   Gp',M)
9 printf('\npractical number of mobile users ,M= %.2 f
   Gp for Eb/No=6dB',M1)

```

Scilab code Exa 12.19 number of users

```

1 Bc=1.25*10^6
2 Rb=9.6*10^3
3 Gp=Bc/Rb
4 GpdB=10*log10(Gp)
5
6 EbINodB=6
7 EbINo=10^(EbINodB/10)
8
9 p=0.5//interference factor
10 a=.85//power control accuracy factor
11 v=.6//voice activity factor
12 Y=2.55//improvement from sectorisation
13 M=(Gp/(EbINo))*(1/(1+p))*a*(1/v)*Y//no. of mobile
   users per cell
14 Ns=3
15 Nmps=M/Ns
16 disp(Nmps,'no. of mobile users per sector')

```

Chapter 14

Emerging Wireless Network Technologies

Scilab code Exa 14.3 data transfer time

```
1 TDR=2000//transmission data rate
2 Size=20*8
3 dtt=Size/TDR//data transfer time
4 printf('data transfer time= %.f ms',dtt*10^3)
```

Scilab code Exa 14.4 Size of file

```
1 TDR=2
2 dtt=16//data transfer time
3 Size=TDR*dtt//size
4 disp(Size,'size of a file transferred in Mb')
```

Scilab code Exa 14.5 Transmission data rate

```

1 tn=52//no. of subcarriers
2 np=4//no. of subcarriers used as pilot subcarriers
3 nd=tn-np//no. of data subcarriers
4 FECcr=3/4//forward error correction code rate
5 m=log10(64)/log10(2)//bits per symbol
6 ndpos=m*FECcr*nd//no. of data bits transmitted per
  ofdm symbol
7 odsd=4*10^-6//data symbol duration
8 TDR=ndpos/odsd
9 printf('transmission data rate= %.fMbps ',TDR*10^(-6)
  )

```

Scilab code Exa 14.10 number of wireless links

```

1 N=100
2 c=4
3 MNw=N*c
4 TNw=MNw/2//no. of wireless links
5 disp(TNw,'total no. of wireless links in the network
  ')

```
