Scilab Textbook Companion for Digital Telephony by J. C. Bellamy[1]

Created by
Harish Shenoy
B.Tech
Electronics Engineering
NMIMS, MPSTME
College Teacher
Not decided
Cross-Checked by
TechPassion

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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.

Contents

List of Scilab Codes

Chapter 3

Voice Digitization

Scilab code Exa 3.1 Program to calculate quantization interval and bits needed to encode each sample

```
//Caption:Program to calculate quantization interval
    and bits needed to encode each sample

//Example 3.1

//Page 101

sqr=30//SQR=30dB

q=1*10^[-(sqr-7.78)/20]

disp('Thus 13 quantization intervals arer needed for
    each polarity for a total of 26 intervals in all
    . The number of bitz required are determined as')

N=log2(26)

//Result

//q = 0.078 V
```

```

//N = 4.7 = 5 bits per sample
```

Scilab code Exa 3.2 Program to calculate the minimum bit rate for a PCM encoder must provide for high fidelity

```
//Caption:Program to calculate the minimum bit rate for a PCM encoder must provide for high fidelity

//Example 3.2

//Page 105

dr=40//dynamic range=400dB

SNR=50//signal to noise ratio =5 0dB

SQR=dr+SNR

n=[(SQR-1.76)/6.02]

disp('This can be approximated to 15 bits per sample')

disp('Assuming excess sampling factor using D-type channel, we choose sampling rate as 48KHz')

disp('Therefore required bit rate is')

15*48000

//Result

//720kbps
```

Scilab code Exa 3.4 Program to calculate how many bits per sample can be saved by using DPCM

```
//Caption:Program to calculate how many bits per
   sample can be saved by using DPCM

//Example 3.4

//Page 128

w=800//Omega=800Hz

//x(t)=A sin(2pi.wt), equation for sine wave with
   maximum amplitude

//x'(t)=A(2pi).w.cos(2pi.wt), diff w.r.t time

(2*%pi)*800*(1/8000)

//0.62831*a, x'(t)max

disp('savings in the bits per sample can be
   determined as ')

log2(1/0.628)

//Result

//0.67 bits
```

Chapter 5

Digital Switching

Scilab code Exa 5.1 Program to find the idle path in a three stage 8192 line switch

```
//Caption:Program to find the idle path in a three
   stage 8192 line switch

//Example 5.1

//Page243

//Refer to table 5.2 on page236

disp('From the table, space expansion factor of
   0.234 is 0.002. Hence the utilization of each
   interstage is given by')

0.1/0.234

p=1-[(1-0.427)^2]// probability that one of two
   links in series is busy

disp('Therefore, the expected number of paths to be
   tested are,')
```

```
Np=[1-(0.672)^15]/(1-0.672)

//Result

//Only 3 of the 15 paths should be tested before an
    idle path is found
```

Scilab code Exa 5.2 Program to determine the implementaton complexity of the TS switch

```
//Caption:Program to determine the implementaton
    complexity of the TS switch

//Example 5.2

//Page 253

//Refer to figure 5.19 on page 252

N=80//Number of links

Nc=24//Number of control words

Nb1=7//Number of bits per control word

Nb2=5//Number of bits per control word

disp('The number of crosspoints in the space stage
    is')

Nx=N^2

disp('The total number of memory bits for the space
    stage control store is')
```

```
Nbx=N*Nc*Nb1

disp('The total number of memory bits for the time
    stage is')

Nbt=(N*Nc*8)+(N*Nc*Nb2)

disp('Thus the implementation complexity is ')

Cmplx=Nx+[(Nbx+Nbt)/100]

//Result

//Complexity is 6784 equivalent crosspoint.
```

Scilab code Exa 5.3 Program to determine the implementaton complexity of a 2048 channel

```

//Caption:Program to determine the implementaton
    complexity of a 2048 channel

//Example 5.3

//Page 256

k=7//from equation 5.14 on page 256

disp('Using the value of k')

disp('Using the value of k, the number of crosspoint
     determined are')

2*7*16
```

```
disp('The number of bits of memory can be determined
    are')

N=[2*7*128*4]+[7*128*8]+[7*128*7]

//Result

//The composite implementation complecity is 430
   equivalent crosspoints.
```

Scilab code Exa 5.5 Program to determine the implementaton complexity of a 131072 channel

```

//Caption:Program to determine the implementaton
   complexity of a 131,072 channel

//Example 5.5

//Page 261

disp('The space switch can be designed bt take the
   first space stage. A value of 32 is chosen as a
   convenient binary number.')

n=32//binary w.r.t (N/2)^2

k=27//determined as a blocking probability of 0.0015

//Refer equations 5.18 and 5.19

Nx=[2*1024*27]+[27+(32^2)]

Nx=[2*1024*27]+[27*(32^2)]
```

```
Nbx=[2*27*128*32*5]+{27*128*32*5}

Nbt=[2*1024*128*8]

Nbtc=[2*1024*128*7]

cmplx=[Nx+{(Nbx+Nbt+Nbtc)/100}]

//Result

//Complexity is 138,854 equivalent crosspoint.
```

Chapter 6

Digital Modulation and Radio Systems

Scilab code Exa 6.4 Program to determine system gain of 10Mbps 2Ghz digital microwave repeater using 4 PSK modulation

```

//Caption: Program to determine system gain of 10
   Mbps, 2Ghz digital microwave repeater using 4 PSK
    modulation

//Example 6.4

//Page 325

//Refer to figure 6.17 on page 300

disp('From figure, Eb/N0 for 4 psk modulation can be
    determined 10.7 dB.')

//Using equation 3.24 from Appendix C

disp('SNR detector is 3dB higher than Eb/N0,
   therefore')
```

```
snr=13.7//SNR=13.7dB

disp('Since 4 PSK modulation provides 2bps/Hz, the sampling rate is 5 MHz, which is Nqyuist rate, therefore')

a1=10*log10(125000000000000)

a2=10*log10(1.3)

A0=a1-13.7-7-3-a2

disp('At a carrier frequency of 2GHz, the wavelength is')

(3*10^8)/(2*10^9)

FM=116+60+20*log10(0.15)-5-20*log10(4*%pi*5*10^4)//Fade Margin can be found by Equation 6.31

//Result
//A0 = 116dB
//wavelength = 0.15 m
//Fade Margin = 38.5 dB
```

Chapter 7

Network Synchronization Control and Management

Scilab code Exa 7.2 Program to determine relative accuracy of maintaining a mutual slip rate ojective of one slip in 20hrs

```

//Caption:Program to determine relative accuracy of
   maintaining a mutual slip rate ojective of one
   slip in 20hrs

//Example 7.2

//Page 350

disp('The slip rate objective implies that thee
   frame rate produced by one clock can be different
    than the frame rate produced by the other clock
   by no more then')

dF=(1/20*60*60)

dF=[1/(20*60*60)]

```

```
disp('Since there are 8000 frame per second, the
   relative accuracy is determined as')

ans=[dF/8000]

//Result

//Hence the clock must be accurate to 1.7 parts in
   10^9.
```

Scilab code Exa 7.3 Program to determine the minimum and maximum input channel rate accommodated by an M12 multiplexer

```

//Caption:Program to determine the minimum and
   maximum input channel rate accommodated by an M12
    multiplexer

//Example 7.3

//Page 354

disp("The maximum information rate per channel is
   determined as")

Imax=[(6.312*288)/1176]

disp('The minimum information rate per channel is
   determined as')

Imin=[(6.312*287)/1176]

disp('Since there are three possible combinations of
    two errors in the C bits, the probability of
   misinterpreting an S bit is')
```

```
3*(10^-6)^2

1176/6.312//duration of each master frame

[(3*10^-12)/(186*10^-6)]

//Result

//0.016*10^-6 misframes per second
```

Chapter 8

Fiber Optic Transmission System

Scilab code Exa 8.1 Program to determine the loss limit and the multimode dispersion limit of a graded index FOC

```

//Caption:Program to determine the loss limit and
    the multimode dispersion limit of a graded index
    FOC

//Example 8.1

//Page 388

//Refer to figure 8.2 on page 385

Pin=42//input power = 42dB

disp('The attenuation of a multimode fiber operating
     at 820nm is approximately 3db/km. Thus,')

A=3//attenuation

```

```
LL=(Pin/A)//Loss Limit

disp('Using 2 Gbps-km as typical BDP of graded index
    multimode fiber , the multimode dispersion
   distance is determined as')

Dl=(2000/90)//Dispersion limit

//Result

//Loss Limit = 14 km

//Dispersion Limit = 22.2 km
```

Scilab code Exa 8.2 Program to determine the loss limit and the chromatic dispersion limit of a high performance SMF FOC

```

//Caption:Program to determine the loss limit and
   the chromatic dispersion limit of a high
   performance SMF FOC

//Example 8.2

//Page 389

//Refer figure 8.2 on page 385

disp('The attenuation of single-mode fibre operating
    at 1300nm is approximately 0.35dB/km. Thus,')

Pin=42//input power = 42dB

A=0.35

```

```
LL=(Pin/A)//Loss Limit

disp('Using 250 Gbps-km as BDP of a silica single-
   mode fiber , the chromatic dispersion limit is
   determined as')

Cd=(250000/417)//Chromatic dispersion limit

//Result

//Loss Limit = 120 km

//Chromatic Dispersion Limit = 599.52 = 600 km
```

Scilab code Exa 8.3 Program to determine the BDP of SMF system and DS SMF system using DFB LD

```

//Caption:Program to determine the BDP of SMF system
    and DS SMF system using DFB LD

//Example 8.3

//Page 393

//Refer to table 8.1 on page 392, also to figure 8.6
    on page 391

smf=16

smf=16//dispersion co-efficient of SMF at 1550nm

sw=0.4//spectral width of the source

BDP=[250/(smf*sw)]//assuming line code as NRZ
```

```
disp('The BDP of the DS SMF system is determined as'
  )

smf=3.5//dispersion co-efficient of DS SMF at 1550nm

BDP=[250/(smf*sw)]//assuming line code as NRZ

//Result

//BDP = 39 Gbps=km (SMF)

//BDP = 179 Gbps-km (DS SMF)
```

Scilab code Exa 8.4 Program to determine the difference in wavelength of two optical signal

```

//Caption:Program to determine the difference in
  wavelength of two optical signal

//Example 8.4

//Page 402

c=3*10^8//speed of light

wl=1500*10^-9//wavlength =1500nm

f=[(3*10^8)/wl]

disp('Thus the upper and lower frequencies are
  determined as 200,001 and 199,999 GHz
  respectively. The corresponding wavelengths are')

```

```
lam1=[c/(199999*10^9)]

lam2=[c/(200001*10^9)]

//Result

//The difference in wavelenghts is 0.015nm
```

Scilab code Exa 8.5 Program to determine the system gain

```

//Caption:Program to determine the system gain

//Example 8.5

//Page 405

//Refer to table 8.2 and figure 8.8 on page 394

dr=565//data rate

wl=1550*10^-9//wavelength

disp('The use of 5B6B line code implies the line
    data rate is,')

565*(6/5)

//678Mbps

disp('The receiver sensitivity for 678 Mbps is
    determined from fig 8.8 or table 8.2 as ')

rsen=-34.5

```

```
A=(-5-rsen)//system gain

BDP=[500/(17*0.4)]

BDPs=[73.6/0.678]

lossp=(0.2+0.2)*(65)

lossm=A-lossp

//Result

//System gain = 29.5 dB

//BDP = 73.6 Gbps

//BDP spacing = 109 km

//Path Loss = 26 dB

//Loss Margin = 3.5 dB
```

Scilab code Exa 8.6 Program to determine the range of SPE data rates that can be accomodated by the byte stuffing operation

```

//Caption:Program to determine the range of SPE data
    rates that can be accomodated by the byte
   stuffing operation

//Example 8.6

//Page 415

frames=4*9*87//Four SPE frames
```

```
rate=8*frames*2000//normal rate SPE

disp('When positive byte stuffing is used to
   accomodate a slow incoming SPE rate, 3131 bytes
   of data are transmitted in four frames. Thus, the
    lowest slip rate is')

Rmin=8*3131*2000//minimum SPE rate

disp('When negative byte stuffing is used to
   accomodate a fast incoming SPE rate, 3133 bytes
   of data are transmitted in four frames. Thus, the
    highest slip rate is')

Rmax=8*3133*2000//maximum SPE rate

//Result

//Normal SPE rate = 50.112 Mbps

//Minimum SPE rate = 50.096 Mbps

//Maximum SPE rate = 50.128 Mbps
```

Chapter 9

Digital Mobile Telephony

Scilab code Exa 9.1 Progam to determine the probability of maximum interference of a 64 channel CDMA system

```

//Caption:Progam to determine the probability of maximum interference of a 64 channel CDMA system

//Example 9.1

//Page 447

disp('The probability of 63 destructive interferers is merely the probability of occurence of 63 equally likely binary events,')

Pmax=(0.5)^63//maximum probability

disp('The value of a desired receive signal is the autocorrelation of a codeword with itself and can therefore be represented as a value of 64. ')

disp('The mean and varience of a sum of 63 such variable are 0 and 63, respectively. The signal-
```

```
    to−interference ratio is now determined as, ')

a=[(64^2)/63]

SIR=10*log10(a)

//Result

//Signal to interference ratio = 18.1 dB
```

Chapter 10

Data and Asynchronous Transfer Mode Network

Scilab code Exa 10.1 Program to determine the amount of transmission capacity

```

//Caption:Program to determine the amount of transmission capacity

//(a)Assume the link-by-link error control (b)Assume end-to-end error control (c)Repeat the calculation for a bit error probability of 10^-5

//Example 10.1

//Page 472

//(a)With link-by-link

frame=1000*10^-8

disp('The expected number of bits of transmission capacity required to retransmit is')
```

```
frame*1000

//(b)With end-to-end

frames=10*10^-5//corrupted frame

disp('The expected number of bits of transmission
   capacity required is')

frames*1000

//(c)With bit error 10^-5

ans1=1000*10^-5

ans1=1000*10^-5*1000

ans=10*10^-2*1000

//Result

//(a)0.01 bit/link

//(b)0.1 bit/link

//(c)1. 10 bits/link

//(c)2. 100 bits/link
```

Scilab code Exa 10.3 Program to determine the probability that the delay of an ATM voice cell

```

//Caption:Program to determine the probability that
```

```
    the delay of an ATM voice cell

//Example 10.3

//Page 488

disp('Assuming the access link is 90% utilized on
    average.')

disp('The queuing theory is provided in Chapter 12.
    It involves determining the probability that the
    DSI access queue contains enough cells to
    represent 10msec of transmission time')

tm=[(53*8)/(192*8000)]

disp('Therefore, 10 msec delay represents 10/0.276 =
     36.2 cell times.')

p=(0.9)*{%e^[-(1-0.9)*36.2]}//Refer to equation
    12.25 in chap 12

disp("Result")

disp("P(>10msec) = 2.5% delay will be displayed by
    more than 10 msec ")
```

Chapter 11

Digital Subscriber Access

Scilab code Exa 11.1 Program to determine the distance limit imposed by the need to echo E bit in a BRI ST interface

```
//Caption:Program to determine the distance limit imposed by the need to echo E bit in a BRI S/T interface

//Example 11.1

//Page 501

//Refer to figure 11.5 on page 500

disp('By seeing the figure , it can be seen that the minimum delay between a terminal transmitting D bit and receiving it back in the following E bit is seven bit times')

disp('At a 192 kbps data rate the duration of bit is 5.2 usec. Thus, the total round trip propagation time is ')

```

```
7*5.2//usec

disp('Assuming no appreciable circuitry delays in
   the NT,')

c=3*10^8// speed of light

Lmax=(36.4*10^-6)*(1/3)*c

disp('Because round trip propagation involves both
   direction of transmission')

Dmax=(1/2)*Lmax

disp("Result")

disp("Maximum length of wire(Lmax) = 3640 m = 3.64
   km")

disp("Maximum distance(Dmax)= 1820 m = 1.82 km")
```

Scilab code Exa 11.2 Program to determine the theoretical maximum data rate of a prefectly equalized voiceband modem

```

//Caption:Program to determine the theoretical
   maximum data rate of a prefectly equalized
   voiceband modem

//Example 11.2

//Page 513

disp('The signal-to-quantizing-noise ratio(SQR) is
   given in chap3 to be on the order of 36dB, which
```

```
   corresponds to power ratio of 3981.')

disp('Using this value in Shannon theorem for the
   theoretical capacity of a channel yield,')

SNR=3981

C=3100*[log2(1+SNR)]

disp("Result")

disp("data rate = 37 kbps")
```

Chapter 12

Traffic Analysis

Scilab code Exa 12.1 Program to calculate how often do two calls arrive with less than 1 milisec between them

```
//Caption:Program to calculate how often do two
    calls arrive with less than 0.01 sec between them

//Example 12.1

//Page 524

disp('The average arrival rate is')

lam=(3600/10000)//arrivals per sec

disp('From equation 12.2, the probability on arrival
     in 0.01-sec interval is')//equation on page 524

P0=(%e^-0.0278)

disp('Thus 2.7% arrivals occur withnin 0.01 sec of
    the pervious arrival. Since the arrival rate is
    2.78 arrivals per second, the rate of occurrence
```

```
of intervarrival time less than 0.01 sec is')

2.78*0.027

disp("Result")

disp("0.075 times/sec")
```

Scilab code Exa 12.2 Program to calculate the probability that eight or more arrivals occur in an chosen 30 sec

```

//Caption:Program to calculate the probability that
    eight or more arrivals occur in an chosen 30 sec

//Example 12.2

//Page 526

disp('The average number of arrivals in a 30 sec
    interval is,')

lamt=4*(30/60)

disp('The probability of eight or more arrivals is,'
    )

P0=1

P1=[(2^1)/(1)]

P2=[(2^2)/(1*2)]

P3=[(2^3)/(1*2*3)]

```

```
P4=[(2^4)/(1*2*3*4)]

P5=[(2^5)/(1*2*3*4*5)]

P6=[(2^6)/(1*2*3*4*5*6)]

P7=[(2^7)/(1*2*3*4*5*6*7)]

i=1-{(%e^-2)*[P0+P1+P2+P3+P4+P5+P6+P7]}

disp("Result")

disp("P(2) = 0.0011")
```

Scilab code Exa 12.3 Program to calculate the probability that a 1000 bit data block experiences exaclty 4 errors while being transmitted over a link having error

```

//Caption:Program to calculate the probability that
   a 1000 bit data block experiences exaclty 4
   errors while being transmitted over a link having
    10^-5 error rate

//Example 12.3

//Page 527

disp('Assuming inpendenterror , we can obtain the
   probability of exactly 4 errors directly from the
    Poisson distribution. The average number of
   errors is ,')

lamt=[(10^3)*(10^-5)]

```

```
disp('Thus,')

P4={[(0.01^4)/(1*2*3*4)]*%e^-0.01}

disp("Result")

disp("P(4) = 4.125*10^-10")
```

Scilab code Exa 12.4 Program to calculate the percentage of total traffic carried by first five ckt and traffic carried by all other remaining

```

//Caption:Program to calculate the percentage of total traffic carried by first five ckt and traffic carried by all other remaining

//Example 12.4

//Page 529

disp('The Traffic intensity of system is,')

A=1*2

disp('The raffic intensity carried by i active ckt is exactly i erlangs. Hence the traffic carried by 1st 5 ckt is,')

P1=[(1*2^1)/(1)]

P2=[(2*2^2)/(1*2)]

P3=[(3*2^3)/(1*2*3)]

P4=[(4*2^4)/(1*2*3*4)]
```

```
P5=[(5*2^5)/(1*2*3*4*5)]

A5={(%e^-2)*[P1+P2+P3+P4+P5]}

disp('All of remaining ckts carry,')

Ar=2-1.89

disp("Result")

disp("A(5) = 1.89 erlangs")

disp("A(remaining) = 0.11 erlangs")
```

Scilab code Exa 12.5 Program to calculate how much traffic can the trunk group carry

```
//Caption:Program to calculate how much traffic can
    the trunk group carry

//Example 5.5

//Page 534

//Refer figure 12.5 on page 533

disp('From fig, it can be that the output circuit
    utilization for B=0.1 and N=24 is 0.8.')

N=24

op=0.8

```

```
disp('Thus the carried traffic intensity is ')

N*op

disp('Since the blocking probability is 0.1, the
   maximum level of offered traaffic is,')

A=[19.2/(1-0.1)]

disp("Result")

disp("A = 21.3 erlangs")
```