

Scilab Textbook Companion for
Integrated Circuits
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July 31, 2019

¹Funded by a grant from the National Mission on Education through ICT, <http://spoken-tutorial.org/NMEICT-Intro>. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website <http://scilab.in>

Book Description

Title: Integrated Circuits

Author: K. R. Botkar

Publisher: Khanna Publishers

Edition: 5

Year: 2010

ISBN: 81-7409-208-0

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

Thick Film And Thin Film Hybrid ICs

Scilab code Exa 2.1 Resistance

```
1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Resistance
3 //Example2.1: a) A resistor has an aspect ratio of
   20:1 and sheet resistance of 200 ohm/square. Find
   out the value of resistance.
4 // b) Find out the number of squares contained in a
   2kiloohm resistor whose sheet resistance is 200
   ohm per square.
5 //Solution: a)
6 clear;
7 clc;
8 function y= myfunction(x,z)//y:resistance , x: sheet
   resistance=200ohm/square, z: aspect ratio=20:1
9 y = x*z //since ,resiatance=sheet resistance
10 disp('resistance is=")
11 disp('ohm',y)
12 endfunction
13
14 // Solution: b)
```



```

15 // we have to find number of square which is to find
    aspect ratio .
16 function s=myfunction1(r,p)//r:resistor=2kohm(or
    2000ohm), p:sheet resistance=200 Ohm/square, s:
    number of square(aspect ratio)
17 s=r/p//since, number of square=(resistor/sheet
    resistance)
18 disp('number of squares are=")// include ";" at the
    time of calling the function
19 disp('squares',s)
20 endfunction
21 //myfunction(200,20/1);myfunction1(2000,200);

```

Scilab code Exa 2.2 Resistance Calculation

```

1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption: Resistance calculation
3 //Example2.2: A thick film resistor is screened with
    a paste off sheet resistivity 10000 ohm/square,
    and the resistor is defined as 0.24 cm long and
    0.06 cm wide. Calculate the resistance R.
4 // Solution:
5 clear;
6 clc;
7 function R=myfunction3(p,l,w)//r:resistor, p=sheet
    resistance=10000 ohm/square, l:length of resistor
    =0.24cm, w:width of the resistor=0.06cm
8     R=p*(l/w)//since, resistance=sheet resistance*(
    length of resistor/width of the resistor)
9     disp('resistance of the thick film resistor is='
    )// at the time of calling the function
    include ";" after it
10     disp('ohm',R)
11 endfunction
12 // myfunction3(10000,0.24,0.06);

```

Scilab code Exa 2.3 Sheet Resistivity

```
1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Sheet Resistivity
3 //Example2.3: Calculate the sheet resistivity of a
   square of thick film resistor material with the
   following properties: bulk resistivity= $10^{-1}$ ohm-
   cm and thick film thickness=10micrometer.
4 //Solution:
5 clear;
6 clc;
7 function Ps=myfunction4(p,t)// Ps:sheet resistance ,
   p:bulk resistivity of thick film= $10^{-1}$ (or 0.01),
   t:thickness of thick film=10micrometer
   (=10*10-4=0.001)
8   Ps=p/t// since , sheet resistance of the film=
   bulk resistance of the film/thickness of the
   film
9   disp('sheet resistivity is=')// include ";" atat
   the time of calling the function
10  disp('ohm per square ',Ps)
11 endfunction
12 //myfunction4(10-1,10*10-4);
```

Scilab code Exa 2.4 Design Capacitor

```
1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Design Capacitor
3 //Example2.4: Design a circular 100pF capacitor with
   the thick film dielectric having dielectric film
   thickness=0.02mm(or 0.002cm), assume Er=100
```

```

4 //Solution: We have to find the radius of circular
   capacitor inorder to design it.
5 clear;
6 clc;
7 function r1= myfunction5(c,t)
8     r1=c*t// constant=capacitor * thickness of thick
       film
9     Er=100//given relative permeability of thick
       film
10    r=sqrt(r1/(Er*pi*8.85*10^-12))//radius of
       circular capacitor , Eo=8,85*10^-12(dielectric
       constant of free space)
11    disp('radius of circular capacitor is=')//
       include ";" at the time of calling the
       function
12    disp('meter ',r)
13 endfunction
14 //myfunction5(100*10^-12,0.002);

```

Scilab code Exa 2.6 Capacitance

```

1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Capacitance
3 //Example2.6: Find out the capacitance of a thick
   film capacitor ,if the dielectric constant Er=100,
   dielectric film thickness=25micrometer and area A
   =0.0625 cm square.
4 //Solution:
5 clear;
6 clc;
7 function c=capacitance(Er,A,t)
8     c=8.8*10^-12*Er*A/(10^-12*t)// capacitance value
       will be 2.2*10^-10 or 220pF, Eo:dielectric
       constant of free space=8.8*10^-12, Er:
       dielectric constant of thick film= 100(given)

```

```

    , A:area of thick film=0.0626 cm square( or
    0.0625*10-4m square), t:thickness of the
    thick film= 25*10-6m)
9    // capacitance=Eo*Er*A/t
10   disp('capacitance is=')// c=2.200D
    -10(=2.2*10-10)F, include ";" at last at the
    time of calling the function
11   disp('pF',c)//pF:pico Farad
12 endfunction
13 //capacitance(100,0.0625*10-4,25*10-6);

```

Scilab code Exa 2.8 Thickness

```

1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Thickness
3 //Example2.8: The bulk resistivity of nichrom is 120
    uohm-cm. Calculate the thickness T in angstroms
    of a film with sheet resistivity of 100ohm/square
    .
4 // Solution:
5 function T=thickness(Ps,p)// Ps: sheet resistivity
    of nichrom=100ohm/square, p:bulk resistivity of
    nichrom=120uohm-cm
6     T=p/(Ps*10-8)// since Ps=p/T and 1 angstrom
    =10-8cm, so dividing by 10-8 here
7     disp('thickness is=')// include ";" at the time
    of calling the function
8     disp('angstrom',T)
9 endfunction
10 //thickness(100,120*10-6);

```

Scilab code Exa 2.9 Length

```

1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Length
3 //Rxample2.9: Calculate the length of a 400ohm thin
   film resistor.Given a sheet resistivity oof 100
   ohm/square and a resistor width of 100um
4 //Solution:
5 clear;
6 clc;
7 function L=extent(r,w,Ps)// L:length of thin film , r
   :resistance of thin film=400ohm, w:width of
   resistor=100um, Ps:sheet resistance=100ohm/square
8   L=r*w/(10^-6*Ps)//since , r=Ps*L/w and length in
   micrometer so dividing by 10^-6.
9   disp('length of thin film is=')// include";" at
   the time of calling the function at last
10  disp('micrometer ',L)
11 endfunction
12 //extent(400,100*10^-6,100);

```

Scilab code Exa 2.10 Absolute Coefficient

```

1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Absolute Coefficient
3 //Example2.10:A thin film resistor measures 150ohmat
   25degree celcius and 151.5ohm at 100degree
   celcius. Calculate its absolute coefficient of
   resistance in parts per million(ppm) per degree
   celcius.
4 //Solution:
5 clear;
6 clc;
7 function TCR=absresistor(Rt1,Rt2,T1,T2)// TCR:
   absolute temperature coefficient of resistance ,
   Rt1:resistance at 100 degree celcius=150ohm, Rt2:
   resistance at 25degree celcius=151.5ohm, T1:

```

```

    temperature=100degree celcius , T2:temperature=25
    degree celcius
8     TCR=(Rt2-Rt1)*10^6/(Rt1*(T1-T2))
9     disp('absolute coefficient of resistance is=")//
        include ";" at the time of calling the
        function at last
10    disp('ppm/degree Celsius',TCR)// ppm: part per
        million
11 endfunction
12 //absresistor(150,151.5,100,25);

```

Scilab code Exa 2.11 Ratio

```

1 //Chapter 2_Thick Film and Thin Film Hybrid ICs
2 //Caption : Ratio
3 //Example2.11: Two thin resistor are measured at 50
    degree celcius and 100degree celsius and are
    found to have the following values:
4 //Temperatur(degree C)          Ra(ohm)
        Rb(ohm)
5 //      50                      50
        100
6 //      100                     51
        102.1
7 //Calculate the ratio TCR in ppm/degree celcius.
8 //Solution:
9 function TCR= ratio(Rat1,Rbt1,Rat2,Rbt2,T1,T2)
10    TCR=(Rat2/Rbt2-Rat1/Rbt1)*10^6/((Rat1/Rbt1)*(T1-
        T2))
11    disp('ratio TCR is=")// include ";" at the time
        of calling the function at last
12    disp('ppm/degree Celsius',TCR)//ppm: part per
        million
13 endfunction
14 //ratio(100,50,102.1,51,100,50);

```


Chapter 3

Semiconductor Devices Fundamentals

Scilab code Exa 3.2 Resistivity

```
1 //Chapter 3_Semiconductor Devices Fundamentals
2 //Caption : Resistivity
3 //Example3.2: A Sample of Si is doped with  $10^{17}$ 
   phosphorus atoms/cubic cm. What is its
   resistivity? Given  $U_n=700$ square cm/v-sec.
4 //Solution:
5 clear;
6 clc;
7 function Res=resistivity(u,n)//n:doped concentration
   = $10^{17}$  atoms/cubic cm, u: mobility of electrons
   = $700$ square cm/v-sec.
8     q= $1.6 \times 10^{-19}$  //q:charge
9     Res= $1/(q*u*n)$ // since P is negligible.
10    disp('resistivity of the si doped with n-
   dopant is:')// include ";" at the time of
   calling
11    disp('ohm-cm',Res)
12 endfunction
13 // after executing calling resistivity( u=700 and n
```



```

    =10^17)i.e.,                resistivity
    (10^17,700);
14 // Result: Resistivity of the Si doped with n-dopant
    is : 0.089 ohm-cm(approx)

```

Scilab code Exa 3.3 Resistivity of Intrinsic Ge

```

1 //Chapter 3_Semiconductor Devices Fundamentals
2 //Caption : Resistivity of Intrinsic Ge
3 //Example3.3: Find the resistivity of intrinsic Ge
    at 300K. Given un=3900, and up=1900 cm^2/N sec.
    and ni=2.5*10^13 cm^-3for intrinsic Ge.
4 //Solution:
5 function RES=resistivity(un,up)// un:electron
    concentration , up:hole concentration
6     q=1.6*10^-19;//in coulumb
7     ni=2.5*10^13;//concentration in cm^-3
8     RES=1/(q*ni*(un+up))//since n=p=ni
9     disp('resistivity of intrinsic Ge is :')
10    disp('ohm-cm',RES)
11 endfunction
12 //resistivity(3900,1900);

```

Scilab code Exa 3.4 Hole Concentration

```

1 //Chapter 3_Semiconductor Devices Fundamentals
2 //Caption: Hole Concentration
3 //Example3.4: A semiconductor is doped with a
    concentration of 10^17 atoms/cm^3 of rsenic .
    What is the equilibrium hole concentration p at
    300K. Given ni=1.5*10^10 cm^-3
4 // Solution:
5 clear;

```

```

6 clc;
7 function p=holeconcentration(ni,Nd)//ni=intrinsic
   concentration=1.5*10^10 cm^-3, Nd: donar
   concentration; since , Nd>>ni, so Nd=n=10^17 atoms
   /cm^3.
8     p=ni^2/Nd
9     disp('hole concentrartion at 300K is:')
10    disp('per cubic cm',p)
11 endfunction
12 //holeconcentration(1.5*10^10,10^17);

```

Scilab code Exa 3.5 Resistivity of Cu

```

1 //Chapter 3_Semoconductor Devices Fundamentals
2 //Caption: Resistivity of Cu
3 //Example3.5:The resistivity of metal is given by p
   =1/nqu, where n is number of electrons per cubic
   meter, u is mobility ,a nd q is electronic charge
   . Determine the resistivit of copper at room
   temperature. Given n=8.5*10^28 per cubic meter, u
   =3.2*10^-3 m^2/V-sec , at room temperature.
4 //Solution:
5 q=1.6*10^-19;
6 n=8.5*10^28;
7 u=3.2*10^-3;
8 p=1/(n*q*u);
9 disp('resistivity of the copper is :')
10 disp('ohm-meter ',p)
11 // 2.298D-08 means 2.298*10^-8

```

Scilab code Exa 3.6 Bipolar Transistor Parameters

```

1 //Chapter 3_Semoconductor Devices Fundamentals

```

```

2 //Caption : Bipolar Transistor Parameters
3 //Example3.6: Determine Cu,Ccs,Gm,C1,R1,R0 and Ru
   for a bipolar transistor. Given : Ic=0.2 mA, Vcb
   =10V,Vcs=15V,Cuo=0.25pF,Cje=1 pF,Ccso=1.5pF,Bo
   =2000,Tf=0.3ns, n=2*10^-4 and Vo=0.55V for all
   junctions.
4 // Solution:
5 clear;
6 clc;
7 Cuo=0.25;// collector-base depletion region
   capacitance in pico Farad(pF) for zero bias
8 Ccso=1.5 ;// collector-substrate junction
   capacitance in pico Farad(pF) for zero bias
9 q=1.6*10^-19 ;//electron charge in coulomb
10 Ic=0.2 ;//collector current in ampere(A)
11 k=8.6*10^-5;//in eV/K, where 1eV=1.6*10^-19
12 T=300;//absolute temperature in kelvin(K)
13 Vcb=10 ;//forward bias on the junction in volt(v)
14 Vcs=15 ;//collector-substrate bias in volt(V)
15 Cje=1 ;//depletion region capacitance in pico Farad(
   pF)
16 Bo=200;//small signal current gain
17 Tf=0.3;//transit time in forward direction in nano
   seconds(nS)
18 n=2*10^-4;// proportionality constant for Ro and gm
19 Vo=0.55;// bias voltage in volt(V)
20 Cu=Cuo/sqrt(1+(Vcb/Vo));// collector-base
   capacitance
21 disp('Cu is:')
22 disp('pF',Cu)
23 Ccs=Ccso/sqrt(1+(Vcs/Vo));// collector-substrate
   capacitance
24 disp('Ccs is:')
25 disp('pF',Ccs)
26 gm=q*Ic/(k*T*1.6*10^-19);// since k is in eV so
   converting it in Coulomb/Kelvin
27 disp('gm is:')// transconductance of the bipolar
   transistor here

```

```
28 disp('mA/V',gm)
29 Cb=Tf*gm;//diffusion capacitance in pico Farad(pF)
30 C1=Cb+Cje;//small signal capacitance of bipolar
    transistor
31 disp("C1 is:")
32 disp("pF",C1)
33 R1=Bo/gm;// small signal input resistance of bipolar
    transistor
34 disp('R1 is:')
35 disp('kilo Ohm',R1)
36 Ro=1/(n*gm);//small signal output resistance
37 disp('R0 is ')
38 disp('kilo Ohm',Ro)
39 Ru=10*Bo*Ro/10^3;//collector-base resistance
40 disp('Ru is:')
41 disp('Mega Ohm',Ru)
```

Chapter 5

Monolithic Components

Scilab code Exa 5.1 Transit Time

```
1 //Chapter 5_Monolithic Components
2 //Caption : Transit Time
3 //Example5.1: A lateral pnp device base width is 8
   um and the diffusion coefficient for base region
   is 10 cm2/sec. Calculate the base transit time
   and the unity gain frequency.
4 //Solution:
5 function T=transittime(W,D)//W:base width=8um; D:
   base diffusion coefficient=10 sq cm/sec.
6     T= W2/(2*D);// since f(transit frequency
   response )=2*D/(W2)
7     disp('base transit time is:')
8     disp('ns',T*109)// in nanoseconds(ns)
9     F=1/(2*%pi*T)// where F=unity gain frequency
   =1/(2*%pi*transit time)
10    disp('unity gain frequency is:')
11    disp('MHz',F/106)// in Mega Hertz
12 endfunction
13 //transittime((8*10-6),10*10-4);
```

Scilab code Exa 5.2 Unit gain frequency

```
1 //Chapter 5_Monolithic Components
2 //Caption : Unit gain frequency
3 //Example5.2: a) Find F1(unit gain frequency ) for
  the lateral pnp device. Assume diffusion
  coefficient of holes in the base of 0.5 sq cm/sec
  and base width of 10um.
4 // b) Find the Fs(unit gain frequency) for the
  substrate pnp device.Assume D=20 sqcm/sec and W=8
  um.
5 clear;
6 clc;
7 //a)Solution: for the lateral pnp device
8 W1=10*10^-4;//base width in micro centimeter(ucm)
9 D1=0.5;// base diffusion coefficient in sq cm/sec
10 F1=2*D1/(W1^2);
11 disp('unit gain frequency for lateral pnp device is
  ;')
12 disp('MHz',F1/10^6)
13 //b)Solution: for substrate pnp device
14 Ws=8*10^-4;// base in ucm
15 Ds=20;//base diffusion coefficient in sq cm/sec
16 Fs=Ds/(Ws^2);
17 disp('unit gain frequency for substrate pnp device
  is;')
18 disp('MHz',Fs/10^6)
```

Scilab code Exa 5.3 Resistance and Sheet resistance

```
1 //Chapter 5_Monolithic Components
2 //Caption : Resistance and Sheet resistance
```

```

3 //Example5.3: a)A base diffusion layer length is 100
  um and it's width is 10um.The sheet resistance of
  the layer is 100 ohm/square.Calculate its
  resistance.
4 //b) Calculate the sheet resistance of a 20um thick
  ,5 ohm-cm ep-layer.
5 //a) Solution:
6 L=100;//base diffusion layer in um
7 W=10;//base diffusion width in um
8 Rs=100;//sheet resistance in ohm/square
9 R=L*Rs/W;
10 disp('resistance of base diffusion layer is:')
11 disp('Ohm',R)
12 //b) Solution:
13 Pe=5*10^-2;//ep-layer resistivity in ucm
14 t=20*10^-6;//thickness of the layer in um
15 Rse=Pe/t;//sheet resitivity of ep-layer
16 disp('sheet resistance of ep-layer is:')
17 disp('Ohm',Rse)

```

Scilab code Exa 5.4 Capacitance per unit area

```

1 //Chapter 5_Monolithic Components
2 //Caption : Capacitance per unit area
3 //Example5.4: Determine the capacitance per unit
  area of the 400 armstrong gate oxide of a MOSFET
  device relative permittivity of silicon dioxide
  =3.9.
4 //Solution:
5 clear;
6 clc;
7 Eo=8.86*10^-14;//permittivity of free space in F/cm
8 Er=3.9;//relative permittivity of MOSFET device
9 t=0.4*10^-5;//thickness of the gate oxide in cm
10 Co=Eo*Er/t;// since capoacitance(C)=permittivity(E)*

```

```
    area(A)/thicknes(t);          so C/A=e/t
11 disp('capacitance per unit area of gate oxide is:')
12 disp('F/cm^2',Co)
```

Chapter 7

Operational Amplifier Characteristics

Scilab code Exa 7.1 Bipolar Differential Amplifier Parameter

```
1 //Chapter 7_Operational Amplifier Characteristics
2 //Caption : Bipolar Differential Amplifier Parameter
3 //Example7.1: The following specification are given
   for the dual input ,balanced output bipolar
   diferential amplifier :
4 //Rc=2.2 kOhm,Re=4/7kOhm,Rs=50 ohm,Vcc=10V,Vee=-10V
   and Bf=Bo=100. Assume      Vbe=0.7V.
5 //Determine
6 //a)Icq and Vceq
7 //b) Differential-mode voltage fgain , and
8 //c)Input and output resistances.
9 clear;
10 clc;
11 //a)Solution:\
12 Rc=2.2*10^3;// collector resistance in one
   transistor in ohm
13 Re=4.7*10^3;// emitte resitance of one transistor in
   ohm
14 Rs=50;//base or source resitance of one transistor
```

```

    in ohm
15 Vcc=10; // collector power supply in Volt
16 Vee=-10; // negative emitter power supply
17 Bf=100; // gain of the transistor
18 Bo=Bf;
19 Vbe=0.7; //base emitter voltage of one transistor
20 Icq=(abs(Vee)-Vbe)/(2*Re+(Rs/Bf));
21 Vceq=Vcc+Vbe-Rc*Icq;
22 //b) Solution:
23 gm=Icq/(25*10^-3); // where transconductance gm=Ic/Vt
    , Vt=25mV at room temperature, so gm =Ic/25
24 Ad=-gm*Rc; // differential mode voltage gain Icq here
    will be taken as found above not approximated
    to as given book
25 //c) Solution:
26 r=Bo/gm; // input resistance of one transistor
27 Ri=2*r; // differential mode input resistance
28 Ro=Rc; // differential mode output resistance
29 disp('A',Icq*10^3,'operating point collector current
    ')
30 disp('V',Vceq,'collector-to-emitter voltage is:')
31 disp(abs(Ad),'Differential-mode voltage gain')
32 disp('kilo Ohm',Ri/10^3,'Input Resistance')
33 disp('kilo Ohm',Ro/10^3,'Output Resistance')
34 // Note:
35 //value of Icq is taken as 0.0009893 A or 0.9893 mA
    not approximated to 0.98 mA

```

Scilab code Exa 7.2 Rc and Re

```

1 //Chapter 7_Operational Amplifier Characteristics
2 //Caption : Rc and Re
3 //Example7.2: A bipolar differentail amplifier uses
    a transistor having Bo=200 and biased at Icq=100
    uA. Determine Rc and Re so that abs(Ad)=500 and

```

```

    CMRR=80 dB.
4 // Solution:
5 clear;
6 clc;
7 //CMRR in dB is expressed as 20logCMRR, so 80=20
    logCMRR or
8 CMRR=10^(80/20);
9 Icq=100*10^-6; // collector current
10 Vt=25*10^-3; //standard value of threshold voltage at
    room temperature
11 gm=Icq/Vt;
12 Re=CMRR/(2*gm); //since CMRR=2*gm*Re(approx)
13 Ad=500; // absolute value of differential mode
    voltage gain
14 Rc=-Ad/gm; // Collector resistance
15 disp('Mega Ohm',Re/10^6,'emitter resistance(Re) of
    bipolar differential amplifier is:')
16 disp('Kilo Ohm',abs(Rc)/10^3,'collector resistance(
    Rc) of bipolar differential amplifier is:')

```

Scilab code Exa 7.4 Offset Voltage Change

```

1 //Chapter 7_Operation Amplifier Characteristics
2 //Caption : Offset Voltage Change
3 //Example7.4: What is the change in the offset
    voltage of a bipolar transistor amplifier for a
    difference of 10V in the collector-to-emitter
    voltage and Va=250 V. Assume room temperature.
4 //Solution:
5 clear;
6 clc;
7 Vt=25*10^-3; // threshold voltage at room temperature
    in Volt
8 Va=250; //early voltage of the bipolar transistor in
    volt

```

```

9 deltaVce=1;//let us assume 1V of change in Vce(
    collector-to-emitter voltage)
10 deltaVos1=Vt*(-deltaVce/Va);
11 disp('mV',abs(deltaVos1)*10^3,'change in offset
    voltage for 1 V change in Vce is:')
12 for i=1:1,
13     if i==1 then
14         deltaVce=10;// in volt
15         deltaVos=deltaVce*deltaVos1;
16         disp('mV',abs(deltaVos)*10^3,'change in
            offset voltage of bipolar transistor for
            10V collector-to-emitter voltage(Vce)
            difference is:')
17     end
18 end

```

Scilab code Exa 7.5 Temperature Coefficient

```

1 //Chapter 7_Operational Amplifier Characteristics
2 //Caption : Temperature Coefficient
3 //Example7.5: Determine the temperature coefficient
    of the input offset voltage for the bipolar
    differential amplifier having Vos=1.5 mV. What is
    the percentage change in the Vos per degree
    temperature change.
4 //Solution:
5 clear;
6 clc;
7 // temperature coefficient of the input offset
    voltage for the bipolar differential amplifier
    Vos is=dVos/dT=Vos/T;
8 Vos=1.5*10^-3;//input offset voltage for bipolar
    differential transistor amplifier
9 T=300;// assuming room temperature
10 TC=Vos/T;// temperature coefficient of Vos

```

```

11 //percentage change in the Vos per degree
    temperature change will be given by as follow:
12 PC=(TC/Vos)*100;// percentage change(PC) in the Vos
    per degree temperature change
13 disp('%per degree celcius ',PC,'percentage change in
    the Vos per degree temperature change is:')

```

Scilab code Exa 7.14 Effect on Output Voltage

```

1 //Chapter 7_Operational Amplifier Characteristics
2 //Caption : Effect on Output Voltage
3 //Example7.14: For the noninverting OP-Amp with
    input resistance R1 nad feedback resistance R2
    find the effect on output voltage Vo because of
    the common mode voltage Vcm when the input
    voltage Vs changes by 1V. Given CMRR=70 dB.
4 //Solution:
5 clear;
6 clc;
7 CMRR=70;//Common Mode Rejection Ratio in dB
8 // since CMRR=20*log(Vcm/Vdm) dB
9 //so Vdm=Vcm/10^(CMRR/20)
10 //since output voltage of OP-Amp is Vo=(R1+R2)*Vdm/
    R1=(R1+R2)*Vcm/(R1*10^(CMRR/20))
11 R1=100;//assuming input resistance standard value in
    kilo Ohm
12 R2=900;//assuming feedback resistance standard value
    in kilo Ohm
13 Vs=1;//change in input voltage given in question
14 Vcm=Vs;//since change in input voltage is applied to
    noninverting input and through the feedback to
    the inverting iput of the Op-Amp as well.
15 Vo=(R1+R2)*Vcm/(R1*10^(CMRR/20))
16 disp('mV',abs(Vo)*10^3,'change in output voltage due
    to common mode Voltage(Vcm) is:')

```

```
17 //Note:
18 // CMRR,Vdm,Vo may be of either polarity. Here
    absolute value is calculated
```

Scilab code Exa 7.15 Slew rate and Fmax

```
1 //Chapter 7_Operational Amplifier Characteristics
2 //Caption : Slew rate and Fmax
3 //Example7.15: For type 741 Op-Amp following
    parameter are given.Quiescent collector current
    Ic=9.5 uA, Cc=30 pF. Peak amplitude of input
    voltage Vm=15V.
4 //a)Determine the slew rate
5 //b)Determine full power bandwidth Fmax for the slew
    rate as obtained from part (a).
6 clear;
7 clc;
8 //a)Solution:
9 Ic=9.5*10^-6;// operating collector current in A
10 Cc=30*10^-12;// parasitic capacitance
11 SlewRate=2*Ic/Cc;
12 disp('V/us',SlewRate/10^6,'Slew rate is:')
13 //b)Solution:
14 Vm=15;//amplitude of input voltage in Volt
15 Fmax=SlewRate/(2*pi*Vm);// full power bandwidth
16 disp('kHz',Fmax/10^3,'full power bandwidth Fmax for
    the Slew Rate obtained above is:')
```

Scilab code Exa 7.16 Largest Amplitude

```
1 //Chapter 7_Operational Amplifier Characteristics
2 //Caption : Largest Amplitude
```

```

3 //Example7.16: An amplifier has a 10 kHz sinewave
   input signal. Find the largest amplitude that the
   output of the amplifier can be, without
   distortion owing to slew rate limiting. Given
   slew rate=0.5V/u sec.
4 //Solution:
5 clear;
6 clc;
7 Fmax=10*10^3; //frequency of sinewave input signal in
   Hz
8 SlewRate=0.5*10^6; //given in question in V/sec
9 Vm=SlewRate/(2*pi*Fmax); //Since Fmax=slew rate/(2*
   pi*Vm)
10 disp('V(peak)',Vm,'largest amplitude that the output
   of the amplifier can be without distortion owing
   to slew rate limitation is:')
11 //Note:
12 // calculated amplitude is 7.9577 V, which can be
   approximated to 8 V

```

Scilab code Exa 7.17 Maximum allowable frequency

```

1 //Chapter 7_Operational Amplifier Characteristics
2 //Caption : Maximum allowable frequency
3 //Example7.17: When a low frequency sinusoidal
   waveform is applied to an input of the
   noninverting Op-Amp the amplifier responds
   linearly over an output range from -10V to +10V.
   If R1=R2 and the slew rate of the amplifier is 50
   V/u sec, what is the maximum allowable frequency
   of an input sinusoid if the output signal swing
   is to be maintained from -10V to +10V without
   distortion? resistance and R2 is feedback
   resistance.
4 //Solution

```

```
5 clear;
6 clc;
7 SlewRate=50/10^-6; //in V/sec
8 Vo=10-(-10); //from question output is ranging from
   -10V to +10V
9 Vom=Vo; //where Vom is the maximum value of Vo
10 //therefore
11 Fmax=SlewRate/(2*pi*Vom);
12 disp('kHz',Fmax/10^3,'maximum allowable frequency of
   an input sinusoidal for output swing maintained
   from -10V to +10v is:')
13 //Note:
14 // obtained maximum allowable amplitude is 397.88736
   kHz which can be approximated to 400 kHz
```

Chapter 8

Applications of Operational Amplifier

Scilab code Exa 8.1 Device Temperature

```
1 //Chapter 8_Applications of Operational Amplifier
2 //Caption : Device Temperature
3 //Example8.1:The Heat generated by a linear IC,uA
   741 is 200 mW.If the thermal resistance is 150
   degree Celsius/Watt and the ambient temperature
   is 25 degree celsius.calculate the device
   temperature.
4 //Solution:
5 clear;
6 clc;
7 Pd=200*10^-3;//heat generated
8 Rt=150;//thermal resistance
9 Ta=25;//ambient temperature in degree celsius
10 //assuming thermal equilibrium conditon
11 Td=Pd*Rt+Ta;
12 disp('degree celsius',Td,'The device temperature is:
   ')
```

Scilab code Exa 8.2 Device Temperature

```
1 //Chapter 8_Applications of Operational Amplifier
2 //Caption : Device Temperature
3 //Example8.2: For the device in Example8.1, Pmax
   =500 mW. Determine the device temperature after
   equilibrium is attained for an ambient
   temperature of 75 degree celsius and if the
   device is subjected to maximum heat generation.
   Maximum allowable device temperature is 150
   degree Celsius.
4 //Solution:
5 clear;
6 clc;
7 Pmax=500*10-3;
8 Pd=Pmax; //since device is subjected to maximum heat
   generation
9 Rt=150; //thermal resitance
10 Ta=75; //ambient temperature
11 Td=Pd*Rt+Ta;
12 disp('degree celsius',Td,'device temperature is:')
```

Scilab code Exa 8.3 Device Temperature

```
1 //Chapter 8_Applications of Operational Amplifier
2 //Caption : Device Temperature
3 //Example8.3:a)The ambient temperature of the device
   of Example8.2 rises above 90 degree celsius.
   What is the new value of Td if it still generates
   500 mW?
4 //a) Solution:
5 clear;
```

```

6  clc;
7  Pd=500*10-3;
8  Rt=150; //thermal resistance
9  Ta=90; //ambient temperature
10 Td=Pd*Rt+Ta;
11 disp('degree celsius',Td,'New value of device
    temperature is:')

```

Scilab code Exa 8.4 Device Temperature

```

1  //Chapter 8_Applications of Operational Amplifier
2  //Caption : Device Temperature
3  //Example8.4: Forced air cooling provided for the
    device in Example8.3 lowers the ambient
    temperature at 60 degree celsius.What is
    temperature of the device?
4  //Solution:
5  clear;
6  clc;
7  Pd=500*10-3;
8  Rt=150; //thermal resistance
9  Ta=60; //ambient temperature
10 Td=Pd*Rt+Ta;
11 disp('degree celsius',Td,'Temperature of the device
    is:')

```

Scilab code Exa 8.7 Output Voltage

```

1  //Chapter 8_Applications of Operational Amplifier
2  //Caption : Output Voltage
3  //Example8.7: In the summing amplifier(inverting
    mode) the signals to be combined are V1=3V, V2=2v
    , and V3=1V.The input resistor are R1=R2=R3=3

```

```

        kilo ohm.The feeedback resistor Rf=1 kilo ohm.
        Consider ideal Op-Amp,determine Vo.
4 //Solution:
5 clear;
6 clc;
7 V1=3;//input signal
8 V2=2;//input signal
9 V3=1;//input signal
10 Rf=1*10^3;//feedback resitor
11 R1=3*10^3;//input resistor in ohm
12 R2=R1;//input resistor in ohm
13 R3=R2;//input resistor in ohm
14 Vo=-(Rf/R1*V1+Rf/R2*V2+Rf/R3*V3);
15 disp('V',Vo,'Output Voltage of summing amplifier is:
        ')

```

Scilab code Exa 8.8 Vp and Vo

```

1 //Chapter 8_Applications of Operational Amplifier
2 //Caption : Vp and Vo
3 //Example8.8: In the circuit of non-inverting
    summing Op-Amp, V1=+2V, V2=-4V, V3=+5V. input
    resistors for all the three input signal are same
    and are equal to 1 kilo Ohm.The feedback
    resistor Rf is 2 kilo ohm. Determine the voltage
    Vp at the noninverting pin of the Op-Amp and the
    output Vo. Assume ideal Op=Amp.
4 //Solution:
5 clear;
6 clc;
7 Rf=2*10^3;//feedback resistor
8 R1=1*10^3;
9 R2=R1;
10 R3=R2;
11 V1=2;

```

```
12 V2=-4;
13 V3=5;
14 n=3; //no of inputs
15 Vp=(Rf/R1*V1+Rf/R2*V2+Rf/R3*V3)/n;
16 Vo=(1+Rf/R1)*Vp;
17 disp('V',Vp,'voltage at noninverting pin is:')
18 disp('V',Vo,'output voltage voltage of noninverting
    summing Op-Amp is:')
```

Chapter 9

Active Filters

Scilab code Exa 9.6 Determine Q Fl and Fh

```
1 //Chapter 9_Active Filters
2 //Caption : Determine Q Fl and Fh
3 //Example9.6:A certain two-pole band pass filter
   response is required with a centre frequency of 2
   kHz and a 3 dB bandwidth of 400 Hz. Determine Q,
   Fl and Fh.
4 //Solution:
5 clear;
6 clc;
7 Fo=2*10^3;//centre frequency in Hz
8 BW=400;//3 dB bandwidth
9 Q=Fo/BW;// Q-factor of band pass filter
10 Fl=Fo*sqrt(1+1/(4*Q^2))-Fo/(2*Q);
11 Fh=Fo*sqrt(1+1/(4*Q^2))+Fo/(2*Q);
12 disp('Hz',Fl,'lower cutt off frequency is:')
13 disp('Hz',Fh,'Higher cutt off frequency is:')
```

Scilab code Exa 9.12 Unity gain frequency and Capacitor determination

```

1 //Chapter 9_Active Filters
2 //Caption : Unity gain frequency and Capacitor
  determination
3 //Example9.12: a)Determine the unity gain frequency ,
  Fo,of a switched capacitor integrator having
  following specifications:Fclk=1 kHz, C1=1 pF,and
  C2=15.9 pF
4 //b)What is the value of capacitor for an RC
  integrator having R=1.6 mega Ohm and Fo as
  obtained in part(a).
5 //a)Solution:
6 clear;
7 clc;
8 C1=1*10^-12;//source capacitor in F
9 C2=15.9*10^-12;//feedback capacitor
10 Fclk=1*10^3;//clock frequency or switching frequency
11 Fo=1*(C1/C2)*Fclk/(2*%pi);
12 disp('Hz',Fo,'unity gain frequency is:')
13 //b)Solution:
14 R=1.6*10^6;//resistor of RC integrator in Ohm
15 C=1/(2*%pi*Fo*R);
16 disp('nF',C*10^9,'for Rc integrator value of
  capacitor needed is:')
17 // Note:
18 // Obtained results are approximated to nearest
  values ,thus Fo=10 Hz and C=10 nF

```

Chapter 10

Special Purpose Amplifiers

Scilab code Exa 10.3 Class B Power Amplifier

```
1 //Chapter 10_Special Purpose Amplifiers
2 //Caption : Class B Power Amplifier
3 //Example10.3: A class-B audio power amplifier has a
    supply voltage of  $\text{abs}(V_{cc})=15\text{V}$ . The closed loop
    gain  $A_v=50$  and the amplifier has to deliver 10W
    of power into an 8 ohm load.Find:
4 //a)the peak output voltage swing
5 //b)the peak output current swing
6 //c)the input signal required(rms)
7 //d)the total power from the power supply
8 //e)the power dissipated in the amplifier
9 //f)the power conversion efficiency
10 clear;
11 clc;
12 //a)Solution:
13 Po=10;//power in Watt
14 Rl=8;//load resistance in Ohm;
15 Vorms=sqrt(Po*Rl);// since output power  $P_o=V_{\text{orms}}^2/R_l$ 
16 Vom=sqrt(2)*Vorms;//peak output voltage swing
17 disp('V',abs(Vom),'The peak output Voltage swing:')
```



```

18 //b) Solution:
19 Iom=Vom/Rl;
20 disp('A',abs(Iom),'The peak output current swing is:
      ')
21 //c) Solution:
22 Av=50;//closed loop gain
23 Vsrms=Vorms/Av;
24 disp('V',Vsrms,'The input rms signal required is:')
25 //d) Solution:
26 Vcc=15;//absolute value of poer supply in volt
27 Pin=2*Vcc*Iom/%pi;// since Iorms*2^(1/2)=Iom
28 disp('W',Pin,'The total power from power supply is:')
      )
29 //e) Solution:
30 Pd=(2/%pi)*Vcc*sqrt(2*Po/Rl)-Po;
31 disp('W',Pd,'The power dissipated in the amplifier
      is:')
32 //f) Solution:
33 n=(Po/Pin)*100;
34 disp('%',n,'The power conversion efficiency is:')
35 //Note:
36 //Vcc,Vom and Iom can be of either polarity but here
      only absolute value is considered and calculated

```

Scilab code Exa 10.4 Power Output

```

1 //Chapter 10_Special Purpose Amplifier
2 //Caption : Power Output
3 //Example10.4: For the amplifier of Example10.3,
      find the power output level at which the power
      dissipation will bw maximum and the maximum power
      dissipation .
4 //Solution:
5 clear;
6 clc;

```

```

7 Vcc=15; //power supply in volt
8 Rl=8; //load resistance in ohm
9 //since  $P_d = 2 * V_{cc} / \pi * \sqrt{2 * P_o / R_l} - P_o$ 
10 //to determine the value of  $P_o$  at which  $P_d$  is
    maximum we differentiate above equation and
    equate to zero ,we find  $P_o$  as
11  $P_o = 2 * V_{cc}^2 / (\pi^2 * R_l)$ ;
12 // there fore maximum power dissipated is
13  $P_{dmax} = 2 * V_{cc} / \pi * \sqrt{2 * P_o / R_l} - P_o$ ;
14 disp('W',Po,'The power output level for maximum
    power dissipation is:')
15 disp('W',Pdmax,'Maximum power dissipation for
    corresponding output power level is;')
```

Scilab code Exa 10.8 LM4250 Parameters

```

1 //Chapter 10_Special Purpose Amplifiers
2 //Caption : LM4250 Parameters
3 //Example10.8: The micropower programmable Op-Amp LM
    4250 is supplied by 3 v source(absolute value)
    source.Determine the value of set resistor for
    Iset=0.1 uA if Rset is connected to (a)Vee and (b
    )ground. (c)determine the quiescent supply
    current and the quiescent power dissipation.
4 clear;
5 clc;
6 //a)Solution:
7 Vcc=3; //power supply in Volt
8 Vee=-Vcc; //negative power supply in Volt
9 Iset=0.1*10^-6; //bias setting current in A;
10 Rset=(Vcc+abs(Vee)-0.5)/Iset;
11 disp('mega Ohm',Rset/10^6,'The bias setting current
    resistor for Vee=-10 V is:')
12 //b)Solution:
13 clear Vee;
```

```

14 Vee=0; //since Rset is connected to ground
15 Rset=(Vcc+abs(Vee)-0.5)/Iset;
16 disp('mega Ohm',Rset/10^6,'The bias setting current
      resistor for Vee=0 V is:')
17 //c) Solution:
18 Qcurrent=5*Iset;
19 Qpower=(Vcc+3)*Qcurrent; //where abs(Vee)=3 V
20 disp('uA',Qcurrent*10^6,'The quiescent current
      supply is:')
21 disp('uW',Qpower*10^6,'The quiescent power
      dissipated is:')

```

Scilab code Exa 10.9 Common Emitter Amplifier Parameters

```

1 //Chapter 10_Special Purpose Amplifiers
2 //Caption : Common Emitter Amplifier Parameters
3 //Example10.9: A single common emitter amplifier has
      following device and circuit parameters: Rb=60
      Ohm, Rs=40 Ohm, Cu=1.5 pF, Cl=1 pF, ft=1.6 GHz at Ic
      =2.5 mA quiescent current. Determine each of the
      following for two values of Rl: 30 Ohm and 100
      Ohm. a) f1 b) F2 (c) BW (d) Avmid (e) avmid*Bw.
4 clear;
5 clc;
6 Ft=1.6*10^9; //reduced unity gain frequency in Hz
7 Ic=2.5*10^-3; //collector current in A
8 Vt=25*10^-3; //threshold voltage at room temperature
9 gm=Ic/Vt; //transconductance
10 Cu=1.5*10^-12;
11 Cl=1*10^-12;
12 Rs=40;
13 Rb=60;
14 C2=gm/(2*%pi*Ft)-Cu
15 for i=1:2,
16     if i==1 then

```

```

17     Rl=30; //load resistance
18     F1=1/(2*%pi*(Rs+Rb)*(C2+Cu*(1+gm*Rl))); //
        first break frequency
19     F2=1/(2*%pi*Rl*(Cu+C1)); //second break
        frequency
20     BW=F1; //since single common emitter
        amplifier so n=1 thus BW=F1*sqrt(2^(1/n)
        -1), i.e., BW=F1
21     Avmid=-gm*Rl; //mid frequency gain
22     GBW=Avmid*BW; // gain-bandwidth product
23     disp('*****For Rl=30 Ohm*****')
24     disp('MHz',F1/10^6,'first break frequency is
        :')
25     disp('MHz',F2/10^6,'second break frequency
        is:')
26     disp('MHz',BW/10^6,'Bandwidth is:')
27     disp(abs(Avmid),'mid frequency gain is:')
28     disp('MHz',abs(GBW)/10^6,'gain-bandwidth
        product is:')
29     else
30     Rl=100; //load resistance in ohm
31     F1=1/(2*%pi*(Rs+Rb)*(C2+Cu*(1+gm*Rl))); //
        first break frequency
32     F2=1/(2*%pi*Rl*(Cu+C1)); //second break
        frequency
33     BW=F1; //since single common emitter
        amplifier so n=1 thus BW=F1*sqrt(2^(1/n)
        -1), i.e., BW=F1
34     Avmid=-gm*Rl; //mid frequency gain
35     GBW=Avmid*BW; // gain-bandwidth product
36     disp('*****For Rl=100 Ohm*****')
37     disp('MHz',F1/10^6,'first break frequency is
        :')
38     disp('MHz',F2/10^6,'second break frequency
        is:')
39     disp('MHz',BW/10^6,'Bandwidth is:')
40     disp(abs(Avmid),'mid frequency gain is:')
41     disp('MHz',abs(GBW)/10^6,'gain-bandwidth

```

```
42         product is:')  
43     end
```

Chapter 11

Nonlinear Circuit Application

Scilab code Exa 11.4 Time taken

```
1 //Chapter 11_Nonlinear Circuit Application
2 //Caption :Time taken
3 //Example11.4: b)Type 741 Op-amp is used as a
   comparator and its slew rate is 0.5V/us.How long
   will it change from +10 V to -10v?
4 //b)Solution:
5 clear;
6 clc;
7 deltaVo=10-(-10);
8 SlewRate=0.5*10^-6;
9 t=deltaVo/SlewRate;
10 disp('us',t/10^6,'time taken by the output voltage
   to change from +10 V to -10 V is:')
```

Scilab code Exa 11.5 Rise Time

```
1 //Chapter 11_Nonlinear Circuit Application
2 //Caption : Rise Time
```

```

3 //Example11.5: The upper 3-dB frequency of an Op-Amp
   is 1MHz. Calculate the rise time of the output.
   If the upper 3-dB frequency of the Op-Amp is
   increased to 50 MHz by reducing the gain such
   that gain bandwidth product remains constant, then
   find out the new rise time. Discuss the effect of
   increasing bandwidth on accuracy of comparator.
4 //Solution:
5 clear;
6 clc;
7 F3dB=1*10^6; //upper 3-dB frequency of Op-Amp
8 Tr=0.35/F3dB; //from definition of rise time
9 disp('n sec',Tr*10^9,'Rise time of the output is:')
10 F3dB1=50*10^6;
11 Tr1=0.35/F3dB1;
12 disp('n sec',Tr1*10^9,'Rise time of the output is:')

```

Scilab code Exa 11.11 Design Peak Detector

```

1 //Chapter 11_Nonlinear Circuit Application
2 //Caption :Design Peak Detector
3 //Example11.11: Design a positive peak detector
   using type uA 760 comparator that can respond to
   a 100 mV(pp),5 MHz sinusoidal input signal.The
   device has following specifications. Response
   time=25 ns, propagation time=12 ns, and Input
   bias current=8uA.
4 //Solution:
5 clear;
6 clc;
7 Vp=50*10^-3; //since peak-peak voltage is 100 mV
8 f=5*10^6;
9 T=200*10^-9;
10 t=15*10^-9 //since rise time(t) should be greater
   than propagation delay(12ns)

```

```
11 deltaVc=Vp*(1-cos(4*t/T*90*(%pi)/180));
12 Ib=8*10^-6;//input bias current
13 C=Ib/(deltaVc/T);
14 disp('mV',deltaVc*10^3,'voltage change is:')
15 disp('pF',C*10^12,'capacitor value is:')
16 //Note:
17 // the Exact value as calculated is taken to
    calculate C, so C=293.59555 pF. If approx value
    of deltaVc is taken as 5 mV then C=320 pF
```

Chapter 12

Signal Generators

Scilab code Exa 12.6 555 Timer

```
1 //Chapter 12_Signal Generators
2 //Caption : 555 Timer
3 //Example12.6: Calculate (a)Tc (b)Td, and (c)the
   free running frequency for the timer 555
   connected in astable mode. Given Ra=6.8 kilo Ohm;
   Rb=3.3 kilo Ohm; C=0.1 uF. What is the duty cycle
   ,d, of the circuit?
4 //Solution:
5 clear;
6 clc;
7 Ra=6.8*10^3;
8 Rb=3.3*10^3;
9 C=0.1*10^-6;
10 // Using equation for astable multivibrator we have
11 Tc=0.69*(Ra+Rb)*C;//charging time
12 Td=0.69*Rb*C;//discharging time
13 f=1.44/((Ra+2*Rb)*C);//free running frequency
14 d=Rb/(Ra+2*Rb);//duty cycle
15 disp('ms',Tc*10^3,'charging time of 555 timer in
   astable mode is:')
16 disp('ms',Td*10^3,'discharging time of 555 timer in
```

```

    astable mode is:')
17 disp('kHz',f/10^3,'free running frequency of 555
    timer in astable mode is:')
18 disp(d,'duty cycle of 555 timer in astable mode is:')
    )

```

Scilab code Exa 12.11 Design

```

1 //Chapter 12_Signal Generators
2 //Caption : Design
3 //Example12.11: A 555 one shot circuit with Vcc=16 V
    is to have a 2 ms output pulse width.Design a
    suitable Circuit.Ithres=0.25 uA(max.) from data
    sheet of the device.
4 //Solution:
5 clear;
6 clc;
7 Ithres=0.25*10^-6;
8 T=2*10^-3//output pulse width
9 Vcc=16;//power supply to 555
10 //The value of minimum capacitor charging current Ic
    should be much greater than the threshold
    Current Ithres
11 Icmn=1000*Ithres;//since Icmn>>Ithres
12 Ra=Vcc/(3*Icmn);
13 C=T/(1.1*Ra);
14 disp('kilo Ohm',Ra/10^3,'resistance design is:')
15 disp('uF',C*10^6,'Capacitor design is:')

```

Scilab code Exa 12.12 Generating pulse by 555 timer

```

1 //Chapter 12_Signal Generators
2 //Caption : Generating pulse by 555 timer

```

```

3 //Example12.12:(a)Design a 555 astable multivibrator
   to generate an output pulse with pulse
   repetition frequency(PRF)=4 kHz and a duty cycle
   of 60%.Given Vcc=15V.
4 //(b)Analyse the circuit designed in part (a) to
   determine the actual PRF and duty cycle. Given
   Ithres=25 uA(max.) for timer 555.
5 clear;
6 clc;
7 //a)Solution:
8 d=60*10^-2;//duty cycle given
9 PRF=4*10^3;
10 Vcc=15;//power supply
11 T=1/PRF;//where T=Tc+Td
12 Tc=d*T;
13 Td=T-Tc;
14 Ithres=25*10^-6;
15 Icmn=1*10^-3;//since Icmn>>Ithres ,so assuming
   Icmn=1 mA
16 R=Vcc/(3*Icmn);//where R=Ra+Rb
17 C=Tc/(0.7*R);
18 Rb=Td/(0.7*C);
19 Ra=R-Rb;
20 disp('kilo Ohm',Ra/10^3,'Designed resistor(Ra) for
   555 timer in astable mode is:')
21 disp('kilo Ohm',Rb/10^3,'Designed resistor(Rb) for
   555 timer in astable mode is:')
22 disp('uF',C*10^6,'Designed Capacitor for 555 timer
   in astable mode is:')
23 //b)Solution:
24 //from equation of charging
25 Tc1=0.7*R*C;
26 Td1=0.7*Rb*C;
27 T1=Tc1+Td1;
28 PRFa=1/T1;
29 da=Tc1/(Tc1+Td1)*100;
30 disp('kHz',PRFa/10^3,'actual Pulse Repetition
   Frequency is:')

```

```
31 disp('%',da,'actual duty cycle is:')
```

Scilab code Exa 12.20 Waveform Generator

```
1 //Chapter 12_Signal Generators
2 //Caption : Waveform Generator
3 //Example12.20: Design a waveform generator using
   type 8038 IC.The frequency of Oscillation is 5
   kHz and the duty cycles is 50%.From data sheet ,
   typical values for the device at Vcc=5 V are as
   follws:
4 //Voh=3.6 V; Vol=0.2 V; I1l=-1.6 mA and Ilh=40 uA.
5 //Solution:
6 clear;
7 clc;
8 Fo=5*10^3;
9 //for 50% duty cycle Tp=Tn
10 Vcc=5;//in volt
11 Vol=0.2;//in Volt
12 Voh=3.6;//in volt
13 I1l=-1.6*10^-3;
14 Ilh=40*10^-6;
15 Tp=1/(2*Fo);
16 C=0.01;//assuming the Capacitor value in uF for
   optimum design
17 Ra=Tp/(1.66*C);
18 Rb=2*Ra*Tp/(1.66*Ra*C+Tp);
19 R2min=(Vcc-Vol)/(2*10^-3-abs(I1l));//since I1l is
   negative
20 R2max=(Vcc-Voh)/(1*10^-6+Ilh);//since Ilh is
   positive
21 disp('kilo Ohm',Ra*10^3,'designed value of Ra is:')
22 disp('kilo Ohm',Rb*10^3,'designed value of Rb is:')
23 disp('kilo Ohm',R2min/10^3,'minimum pull-up resistor
   is:')
```

```
24 disp('kilo Ohm',R2max/10^3,'maximum pull-up resistor  
is:')
```

Chapter 13

Voltage Regulators

Scilab code Exa 13.3 Maximum Efficiency and Power

```
1 //Chapter 13_Voltage Regulators
2 //Caption : Maximum Efficiency and Power
3 //Example13.3: Calculate the maximum efficiency and
   associated power dissipation for the 5 V MC7805
   series regulator.The input ripple is 10 V and the
   load current is 1 A. The output is between 4.75
   to 5.25 for  $v \leq V_{in} \leq 20$  V.
4 //Solution:
5 clear;
6 clc;
7 Vo=5;
8 Vin=17;//since for MC7805 a maximum of 7.5 V is
   added to the ripple.Since 10 V ripple is given so
   Vin=10+7=17 V
9 Il=1;//load current in ampere
10 n=Vo/Vin*100;//series pass regulator overall
   efficiency
11 Pd=(Vin-Vo)*Il;
12 disp('%',n,'maximum efficiency for 5V MC7805 series
   regulator is:')
13 disp('W',Pd,'power dissipation for the 5V MC7805
```

series regulator is:')

Scilab code Exa 13.14 Inductor and Capacitor

```
1 //Chapter 13_Voltage Regulators
2 //Caption : Inductor and Capacitor
3 //Example13.14: A switching voltage regulator
   operates at a switching frequency of 30kHz and is
   to supply a load current  $I_o$  of 1 A at a dc
   output voltage  $V_o$  of +10V. The dc input voltage is
    $V_{in}=20V$  and the output(peak-peak) ripple factor
   is not to exceed 0.05%. Assume  $R_l=10$  Ohm.
4 //a)Find the value of the filter inductor L such
   that the maximum change or ripple in the current
   through the inductor will not exceed 40% of the
   average or dc current.
5 //b)Find the value of the outpur capacitor CL for L1
   =100 uH and for L2=500 uH.
6 clear;
7 clc;
8 //a)Solution:
9 Rl=10;
10 D=0.5;
11 T=2.5;
12 fs=30*10^3;
13 L=Rl*T*(1-D)/fs;
14 disp('uH',L/10^-6,'filter inductor L to ensure
   maximum ripple in the current through the
   inductor will not exceed 40% of the dc current is
   :')
15 //b)Solution:
16 L1=100*10^-6;
17 RF=0.05*10^2;//output (peak-peak)ripple factor
   maximum limit
18 //for ripple factor condition we have
```

```
19 CL1=1/(15*fs^2*L1*RF);
20 disp('*****For L=100 uH*****')
21 disp('uF',CL1*10^10,'output capacitor is:')
22 disp('*****For L=500 uH*****')
23 L2=500*10^-6;
24 CL2=1/(15*fs^2*L2*RF);
25 disp('uF',CL2*10^10,'output capacitor is:')
```

Chapter 15

Phase Locked Loops

Scilab code Exa 15.2 Output Signal Frequency

```
1 //Chapter 15_Phase Locked Loops
2 //Caption : Output Signal Frequency
3 //Example 15.2: A PLL has a  $K_o$  of  $2*\%pi(1\text{kHz})/V$ , a
   Kv of 500 per sec , and a free running frequency
   of 500Hz.
4 //a) For a constant input signal frequency of 250 Hz
   and 1kHz.find vf.
5 clear;
6 clc;
7 //a) Solution :
8  $K_o=2*\%pi*10^3$ ; // VCO gain in kHz/V
9  $K_v=500$ ; //loop bandwidth in per second
10  $W_c=500$ ; //Free running frequency of VCO in PLL or  $2*
   \%pi*500$ 
11 //Wi=angular input signal frequency in Hz
12 //Wo=angular output signal frequency in Hz
13 //since  $vf=(W_o(t)-W_c)/K_o$ 
14 //under locked condition  $W_o=W_i$ , so  $vf=(W_o-W_c)/K_o$ 
15 for i=1:2,
16     if i==1 then
17          $W_o=250$ ;
```

```

18         //or
19         Fo=2*%pi*Wo; //in Hz
20 vf=(Fo-2*%pi*500)/Ko;
21 disp('*****For input signal frequency W=250 Hz
        *****')
22 disp('V',vf,'output signal voltage of PLL for Wo
        =250 Hz is:')
23 else
24     Wo=1000;
25     Fo=2*%pi*Wo; //in Hz
26     vf=(Fo-2*%pi*500)/Ko;
27     disp('*****For input signal frequency Wo=1
            kHz*****')
28     disp('V',vf,'output signal voltage of PLL for
            Wo=1kHz is:')
29 end
30 end

```

Scilab code Exa 15.3 VCO and Phase detector

```

1 //Chapter 15_Phase Locked Loops
2 //Caption : VCO and Phase detector
3 //Example15.3: A PLL has free running frequency Wc
    =500 kHz,bandwith of low pass filter=10kHz.
    Suppose an input signal of frequency 600kHz is
    applied.Will the loop acquire lock? What is VCO
    output frequency? The phase detector produces sum
    and difference frequency components.
4 //Solution:
5 clear;
6 clc;
7 BW=10; //bandwidth of low pass filter in kHz
8 Fi=600; //input frequency in kHz
9 Fc=500; //free running frequency in kHz
10 // Output from phase detector is

```

```

11 Sum=Fi+Fc;
12 Difference=Fi-Fc;
13 disp('kHz',Sum,'sum frequency component of phase
    detector in kHz')
14 disp('kHz',Difference,'difference frequency
    component of phase detector in kHz')
15 if Sum>BW then
16     if Difference>BW then
17         disp('Both Sum and Difference frequency
            components are outside the passband of low-
            pass filter')
18         disp('Loop will not acquire lock')
19         disp('VCO frequency will be its free running
            frequency')
20 end
21 end

```

Scilab code Exa 15.4 Second Order Butterworth Filter

```

1 //Chapter 15_Phase Locked Loops
2 //Caption : Second Order Butterworth Filter
3 //Example 15.4: A Synthesizer using PLL has  $K_v=5*\%pi$ 
    rad/s. What value of low-pass filter bandwidth
    should be used so that the closed-loop system
    approximates a second-order Butterworth filter?
4 //Solution:
5 clear;
6 clc;
7 //For Butterworth filter the damping ratio(Dr) is
8 Dr=0.707;
9 Kv=5*%pi;
10 Wl=Kv*(2*Dr)^2;//since  $(Wl/Kv)^2=2*Dr$ 
11 disp('rad/sec',Wl,'low pass filter bandwidth')
12 // BW for closed loop system is
13 BW=sqrt(Kv*Wl);// since  $BW=W_n$ , where  $W_n$ =natural

```

```

    frequency ,BW=bandwidth of closed loop system
14 Wn=real(BW);
15 t=2.2/Wn;
16 disp('rad/sec',BW,'bandwidth of closed loop system
    is:')
17 disp('sec',t,'corresponding system rise time is:')

```

Scilab code Exa 15.5 Lock Range

```

1 //Chapter 15_Phase Locked Loops
2 //Caption : Lock Range
3 //Example15.5: A PLL has a VCO with Ko=25kHz/V and
    Fc=50kHz.The amplifier gain is A=2 and the phase
    detector has a maximum output voltage swing of
    +0.7V and -0.7V. Find the lock range of the PLL.
    Assume filter gain equal to unity.
4 //Solution:
5 clear;
6 clc;
7 k1=2*0.7/%pi;//positive maximum gain value of phase
    detector
8 k2=-k1;//negative maximum gain value of phase
    detector
9 A=2;// amplifier gain
10 Ko=25;// VCO gain in kHz
11 //positive maximum output voltage swing of phase
    detector is
12 V1=k1*%pi/2;
13 //Negative maximum output voltage swing of phase
    detector is
14 V2=k2*%pi/2;
15 Vf1=k1*A*%pi/2;//Positive maximum control voltage
    available to drive VCO
16 Vf2=k2*A*%pi/2;//negative maximum control voltage
    available to drive VCO

```

```
17 //maximum VCO frequency swing that can be obtained
    is
18 Fh=Ko*Vf1;//positive maximum VCO frequency swing
19 Fl=Ko*Vf2;// Negative maximum VCO frequency swing
20 // so lock range of PLL is
21 f=Fh-Fl;
22 disp('kHz',f,'The lock range of the PLL is:')
```

Chapter 16

Bipolar and MOS Digital Gate Circuits

Scilab code Exa 16.2 Noise Margin

```
1 //Chapter 16_Bipolar and MOS Digital Gate Circuits
2 //Caption : Noise Margin
3 //Example 16.2: An RTL gate has the worst case
  voltages listed below:
4 // Temp(degree C)          Voh(V)          Vih(V)
      Vil(V)          Vol(V)
5 //      -55              1.014              1.01
      0.718          0.710
6 //      25                0.844              0.815
      0.565          0.300
7 //      125              0.673              0.67
      0.325          0.320
8 //Calculte the worst case NMI and NMh noise margins.
9 //Solution:
10 clear;
11 clc;
12 T=[-55;25;125]; // temperatures in degree celsius
      given in table
13 for j=1:3,
```

```

14 if j==1 then
15     disp('Noise margins for T=-55 degree celsius are
        :')
16     NMl=0.718-0.710; // since NMl=Vil-Vol
17     NMh=1.014-1.01; // since NMh=Vih-Voh
18     disp('Volt',NMl,'lower limit of noise margin at
        -55 degree celsius is:')
19     disp('volt',NMh,'upper limit of noise limit at
        -55 degree celsius is:')
20 elseif j==2 then
21     disp('Noise margin for T=25 degree celsius are:')
22     NMl=0.565-0.300;
23     NMh=0.844-0.815;
24     disp('Volt',NMl,'lower limit of noise margin at
        25 degree celsius is:')
25     disp('Volt',NMh,'upper limit of noise margin at
        25 degree celsius is:')
26 elseif j==3 then
27     disp('Noise margin for T=125 degree celsius are:
        ')
28     NMl=0.325-0.320;
29     NMh=0.673-0.670;
30     disp('Volt',NMl,'lower limit of noise margin at
        125 degree celsius is:')
31     disp('Volt',NMh,'uppwr limit of noise margin at
        125 degree celsius is:')
32 end
33 end

```

Scilab code Exa 16.3 Fanouts

```

1 //Chapter 16_Bipolar and MOS Digital Gate Circuits
2 //Caption : Fanouts
3 //Example 16.3: A TTL gate is guaranteed to sink 10

```

```

    mA without exceeding an output voltage  $V_{ol}=0.4V$ 
    and to source 5mA without dropping below  $V_{oh}=2.4V$ 
    . If  $I_{ih}=100\mu A$  at 2.4V and  $I_{il}=1mA$  at 0.4V,
    calculate the low-state and high-state fan-outs.
4 // Solution:
5 clear;
6 clc;
7 // for TTL gate
8 // fanout at low output is= collector saturation
  current of output transistor/load current of the
  driven gate.
9 // fanout for high output is=source current in
  driving gate/input current of load gate
10 // from question given
11  $I_{c3}=10*10^{-3}$ ; // collector saturation current at
  output transistor
12  $I_e=1*10^{-3}$ ; // load current of driven gate
13  $I_{e4}=5*10^{-3}$ ; // source current in driving gate
14  $I_{c1}=100*10^{-6}$ ; // input current of load gate
15  $F_l=I_{c3}/I_e$ ;
16 disp(Fl, 'fan out at low output state is:')
17  $F_h=I_{e4}/I_{c1}$ ;
18 disp(Fh, 'fan out at high output state is:')

```

Scilab code Exa 16.12 NMOS operating region

```

1 //Chapter 16_Bipolar and MOS Digital Gate Circuits
2 //Caption : NMOS operating region
3 //Example 16.12: A NMOS transistor with  $K=20\mu A/V^2$ 
  and  $V_{th}=1.5V$  is operated at  $V_{gs}=5V$  and  $I_{ds}=100\mu A$ .
  Determine the region of the operation on I-V
  characteristics and find  $V_{ds}$ .
4 //Solution:
5 clear;
6 clc;

```



```

7 K=20*10^-6;
8 Vgs=5;
9 Vth=1.5;
10 Ids=100*10^-6;
11 Id=(K/2)*(Vgs-Vth)^2;
12 disp('uA',Id/10^-6,'drain current in saturation
      region')
13 if Id>Ids then
14     disp('region of operation of NMOS transistor on
      I-V characteristics is LINEAR REGION')
15 end
16 //since NMOS lies in LINEAR REGION so Ids=(K/2)*(2*(
      Vgs-Vth)*Vds-Vds^2); thus substituting the values
      we have
17 //100*10^-6==(20*10^-6/2)*(2*(5-1.5)*Vds-Vds^2);
18 //so Vds^2-7*Vds+10=0; equivalent to quadratic
      equation of form aX^2+b*X+c=0
19 Vds=poly(0,'Vds');
20 p=Vds^2-7*Vds+10;//equation whose roots has to be
      found
21 z=roots(p);
22 z=real(z)
23 if (z(1)<(Vgs-Vth)) then
24     disp('Volt',z(1),'drain to source voltage(Vds)
      in this Linear Region is:')
25 elseif (z(2)<(Vgs-Vth)) then
26     disp('Volt',z(2),'drain to source voltage(Vds)
      in this Linear Region is:')
27 end

```

Scilab code Exa 16.13 Power Dissipation

```

1 //Chapter 16_Bipolar and MOS Digital Gate Circuits
2 //Caption : Power Dissipation
3 // Example16.13: Calculate the maximum power

```

```

    dissipated by saturated load NMOS inverter for
    following given values: Vdd=5V;Vth=1.5V; device
    transconductance parameter for load device Kl
    =23.34*10-6 A/V2.Assume Vo=0V in low state.
4 // Solution:
5 clear;
6 clc;
7 Vdd=5; // drain voltage of NMOS inverter in Volt
8 Vth=1.5; // threshold voltage of NMOS inverter in
    Volt
9 Kl=23.34*10-6; // transconductance Parameter for
    load device
10 // since maximum power can be obtained if maximum
    device current flows which is when Vo=low i.e.,0
    V. So,for saturation region of operation we have
    Id=Kl*(Vgs-Vth)2/2;
11 // for saturated load inverter Vgs=Vds and
12 //Vds=Vdd in low output condition ,so Id=Kl*(Vdd-Vth)
    2/2
13 Id=23.34*10-6*(Vdd-Vth)2/2;
14 Pmax=Id*Vdd;
15 disp('mW',Pmax/10-3, 'maximum power dissipated by
    saturated load NMOS inverter is:')

```

Scilab code Exa 16.14 AC Power

```

1 //Chapter 16_Bipolar and MOS Digital Gate Circuits
2 //Caption : AC Power
3 //Example16.14: Calculate the ac power dissipated by
    a CMOS inverter which drives a 20pF load.Given f
    =1MHz and Vdd=10V.
4 //Solution:
5 clear;
6 clc;
7 Ct=20*10-12; // load capacitor in Farad

```

```
8 Vdd=10; //drain voltage supply in Volt
9 f=1*10^6; //frequency at which output voltage changes
10 //since P=Ct*Vdd^2*f
11 P=20*10^-12*(10)^2*10^6;
12 disp('W',P, 'ac power dissipated by a CMOS inverter
      is:')
```

Chapter 17

Light Emitting Diodes and Liquid Crystal Displays

Scilab code Exa 17.2 Viewing distance

```
1 //Chapter 17_Light Emitting Diodes and Liquid
   Crystal Displays
2 //Caption :Viewing distance
3 //Example17.2: Find out the viewinnng distance d for
   a seven segmant LED display for a character
   height of 1cm and a height angle of 3 meters.
4 //Solution:
5 clear;
6 clc;
7 //d:viewing distance
8 h=1*10^-2;//height of character in cm
9 0=3;//height angle in meters
10 // equivaqlent to height angle of 3 meters
11 d=h/tan(0.167*%pi/180);//where 3 meters height angle
   is equivalent to 0.167 degrees.
12 disp('meters',d,'viewing distance is:')
```
