Scilab Textbook Companion for
Electronic Devices
by T. L. Floyd[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

semiconductor basics

Scilab code Exa 1.1 Different diode models

```
//Ex-1.1(a)
V_bias=10;
R_limit=1000;
r_d =10;
//Voltages in Volts, Currents in Amperes,
    Resistances in Ohms
//IDEAL MODEL
disp('IDEAL MODEL')
V_f=0;
I_f=V_bias/R_limit;
V_R_limit=I_f*R_limit;
disp(V_f,'forward voltage in volts');
disp(I_f,'forward current in amperes');
disp(V_R_limit,'voltage across limiting resistor in
    volts');
//PRACTICAL MODEL
disp('PRACTICAL MODEL');
V_f=0.7;
I_f=(V_bias-V_f)/R_limit;
V_R_limit=I_f*R_limit;
disp(V_f,'forward voltage in volts');
```

```
disp(I_f,'forward current in amperes');
disp(V_R_limit,'voltage across limiting resistor in volts');
//COMPLETE MODEL
disp('COMPLETE MODEL')
I_f=(V_bias-0.7)/(R_limit+r_d');
V_f=0.7+I_f*r_d';
V_R_limit=I_f*R_limit;
disp(V_f,'forward voltage in volts');
disp(I_f,'forward current in amperes');
disp(V_R_limit,'voltage across limiting resistor in volts');
//Ex1.1(b)
V_bias=5;
I_R=1*10^-6;
//IDEAL MODEL
disp('IDEAL MODEL');
I_r=0;
V_R=V_bias;
V_R_limit=I_r*R_limit;
disp(I_r,'reverse current in amperes')
disp(V_R,'reverse voltage in volts')
disp(V_R_limit,'voltage across limiting resistor in volts')
//PRACTICAL MODEL
disp('PRACTICAL MODEL')
I_r=0;
V_R=V_bias;
V_R_limit=I_r*R_limit;
disp(I_r,'reverse current in amperes')
disp(V_R,'reverse voltage in volts')
disp(V_R_limit,'voltage across limiting resistor in volts')
//COMPLETE MODEL
disp('COMPLETE MODEL')
I_r=I_R;
V_R_limit=I_r*R_limit;
V_R=V_bias-V_R_limit;
```

```
disp(I_r,'reverse current in amperes')
disp(V_R,'reverse voltage in volts')
disp(V_R_limit,'voltage across limiting resistor in volts')
```

Chapter 2

diode applications

Scilab code Exa 2.1 Average value half wave rectifier

```
//Ex2.1
//Average value of half wave rectifier
V_p=50;     //Peak value is 50V
V_avg=V_p/%pi;
disp(V_avg,'average value of half wave rectifier in volts')
```

Scilab code Exa 2.2.a half wave rectifier

```
//Example-2.2(a)
//let V_in=5*sin(2*%pi*f.*t) be input wave ,hence frequency=1Hz
f=1;
V_p_in=5;
V_pout=V_p_in-0.7;;
disp(V_pout,'half wave rectifier output in volts')
t_d=(asin(0.7/V_p_in))/(2*%pi*f)
```

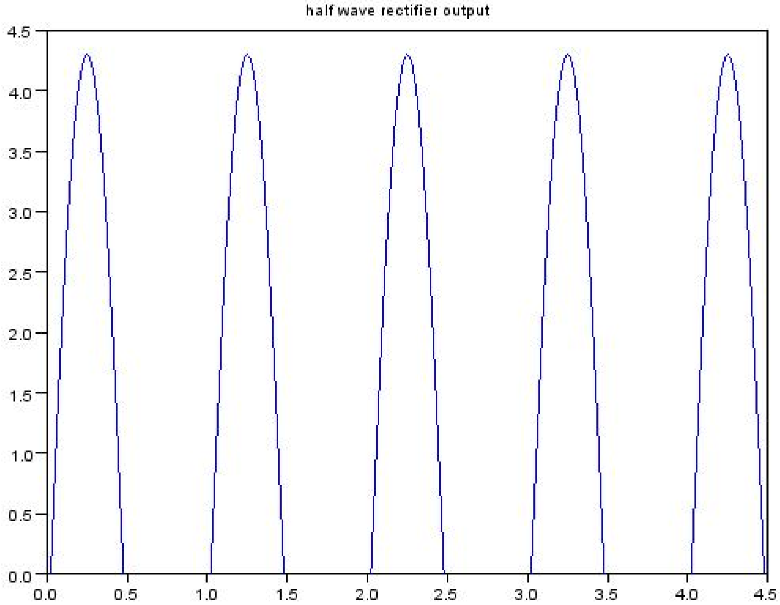


Figure 2.1: half wave rectifier

```
//t_d is the time till which diode will be reverse biased ie, till it reaches knee voltage
T=1/f;
clf();
//let n be double the number of cycles of output shown in graph
for n=0:1:8
    t=T.*n/2:0.0005:T.*(n+1)/2     //time for each half cycle
    if  modulo(n,2)==0 then     //positive half cycle, diode is forward biased
        V_in=V_p_in*sin(2*%pi*f.*t)
        Vout=V_in-0.7             //0.7 is knee voltage of diode
        a=bool2s(Vout>0)          //replace elements of Vout by 0 till input is 0.7
        y=a.*Vout
    else                          //negative half cycle, diode is reverse biased
        [p,q]=size(t);
        y=zeros(p,q);
    end
    plot(t,y)
end
xtitle('half wave rectifier output')
```

Scilab code Exa 2.2.b half wave rectifier

```
//Example-2.2(b)
//let V_in=100*sin(2*%pi*f.*t) be input wave ,hence frequency=1Hz
f=1;
T=1/f;
```

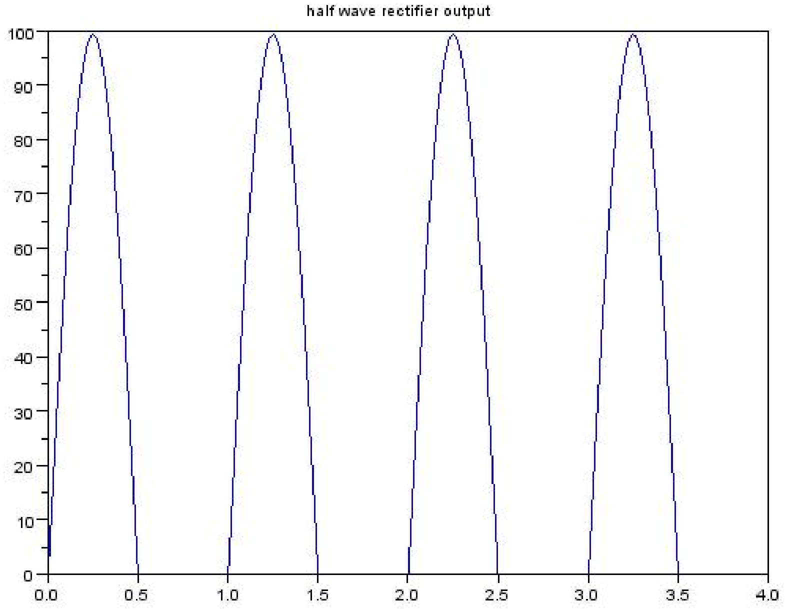


Figure 2.2: half wave rectifier

```
V_p_in=100;
V_pout=(V_p_in-0.7);
disp(V_pout,'output of half wave rectifier in volts')
t_d=(asin(0.7/V_p_in))/(2*%pi*f)
//t_d is the time till which diode will be reverse biased ie, till it reaches knee voltage
clf();
//let n be double the number of cycles of output shown in graph
for n=0:1:7
    t=T.*n/2:0.0005:T.*(n+1)/2     // time for each half cycle
    if  modulo(n,2)==0 then     //positive half cycle
        V_in=V_p_in*sin(2*%pi*f.*t)
        Vout=V_in-0.7              //0.7 is knee voltage of diode
        a=bool2s(Vout>0)           //replace elements of Vout by 0 till input is 0.7
        y=a.*Vout
    else                           //negative half cycle
        [p,q]=size(t);
        y=zeros(p,q);
    end
    plot(t,y)
end
xtitle('half wave rectifier output')
```

Scilab code Exa 2.3 Rectifier peak value

```
//Ex2.3
V_p_in=156;     //Peak input voltage
V_p_pri=156;     //Peak voltage of primary of transformer
```

```
n=1/2;    //Turn ratio is 2:1
V_p_sec=n*V_p_pri;
V_p_out=(V_p_sec-0.7);
disp(V_p_out,'peak output voltage of half wave rectifier in volts')    //Peak output voltage
```

Scilab code Exa 2.4 Average value full wave rectifier

```
//Ex2.4
//Average value of output of full wave rectifier
V_p=15;    //Peak voltage
V_avg=(2*V_p)/%pi;
disp(V_avg,'Average value of output of full wave rectifier in volts')    //Result
```

Scilab code Exa 2.5 PIV full wave

```
//Ex2.5
//Assume frequency of input to be 1Hz
f=1;
T=1/f;
V_p_pri=100;    //Peak voltage across primary winding
n=1/2;          //tun ratio is 2:1
V_p_sec=n*V_p_pri;
V_sec=V_p_sec/2;    //voltage across each secondary is half the total voltage
clf();
subplot(121)
xtitle('voltage across each secondary')
t=0:0.0005:2;
```

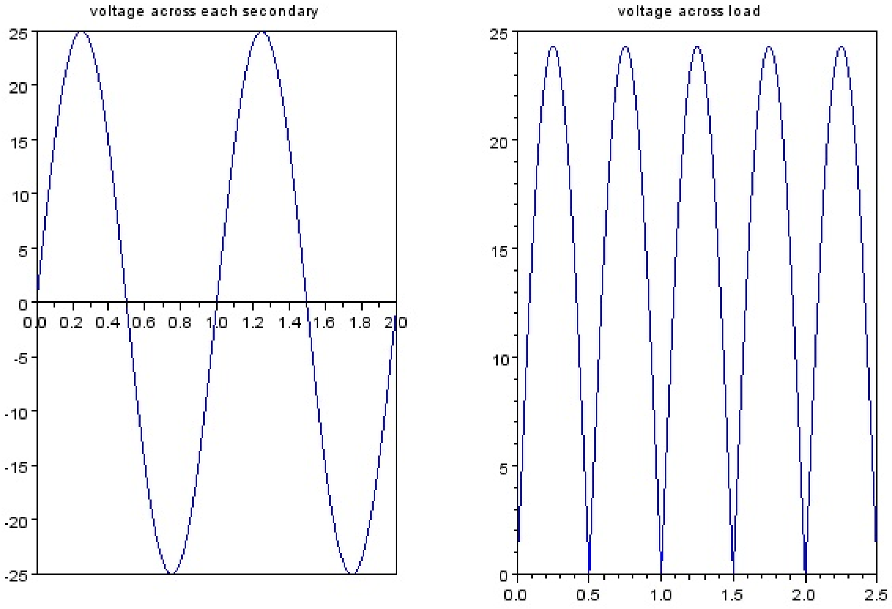


Figure 2.3: PIV full wave

```
x=V_sec*sin(2*%pi*f.*t);
plot(t,x)
subplot(122)
xtitle('voltage across load')
//let n be double the number of cycles of output shown in graph
for n=0:1:4
    t=n.*T/2:0.0005:(n+1).*(T/2);
V_pout=V_sec-0.7;
V=V_pout*sin(2*%pi*f.*t)
a=bool2s(V*(-1)^n>0);
y=(-1)^n.*a.*V;
plot(t,y)
end
disp(V_pout,'full wave rectifier output voltage')
PIV=2*V_pout+0.7;
disp(PIV,'PIV in volts')
```

Scilab code Exa 2.6 Bridge Rectifier

```
//Ex-2.6
V_rms=12;      //rms secondary voltage
V_p_sec=sqrt(2)*V_rms;     //peak secondary voltage
V_th=0.7;                  //knee voltage of diode
V_p_out=V_p_sec-2*V_th;     //in one cycle, 2 diodes conduct
PIV=V_p_out+V_th;          //applying KVL
disp('Peak output voltage in volts= ');
disp(V_p_out);
disp('PIV across each diode in volts= ');
disp(PIV)
```

Scilab code Exa 2.7 Ripple Bridge rectifier

```
//Ex2.7
R_l=2200;    //load resistance in Ohm
C=50*10^-6;    //capacitance in Farad
V_rms=115;    //rms of primary
V_p_pri=sqrt(2)*V_rms;    //peak voltage across primary
n=0.1;    //turn ratio is 10:1
V_p_sec=n*V_p_pri;    //primary voltage across secondary
V_p_rect=V_p_sec-1.4    //unfiltered peak rectified voltage
//we subtract 1.4 because in each cycle 2 diodes conduct & 2 do not
f=120;    //frequency of full wave rectified voltage
V_r_pp=(1/(f*R_l*C))*V_p_rect;    //peak to peak ripple voltage
V_DC=(1-(1/(2*f*R_l*C)))*V_p_rect;
r=V_r_pp/V_DC;
disp(r,'Ripple factor')
```

Scilab code Exa 2.8 Voltage Regulator

```
//Ex2.8
V_REF=1.25;    //in volts
V_R1=V_REF;
R1=220;    //in ohms
I_ADJ=50*10^-6    //in amperes
// MAX VALUE OF R2=5000 Ohms
//V_out=V_REF*(1+(R2/R1))+I_ADJ*R2
R2_min=0;
V_out_min=V_REF*(1+(R2_min/R1))+I_ADJ*R2_min;
R2_max=5000;
V_out_max=V_REF*(1+(R2_max/R1))+I_ADJ*R2_max;
disp(V_out_min,'minimum output voltage in volts');
disp(V_out_max,'maximum output voltage in volts');
```

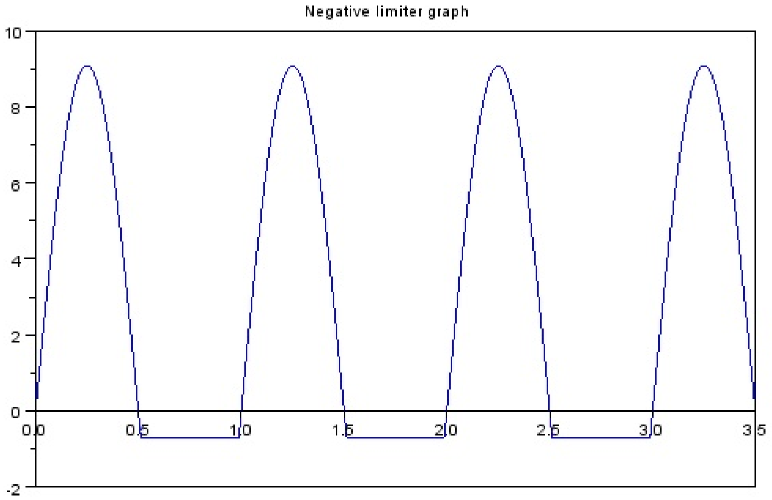


Figure 2.4: Negative diode limiter

Scilab code Exa 2.9 Load regulation percentage

```
//Ex2.9
V_NL=5.18    //No load output voltage
V_FL=5.15    //Full load output voltage
load_reg=((V_NL-V_FL)/V_FL)*100    //In percentage
disp('load regulation percent= ')
disp(load_reg)
```

Scilab code Exa 2.10 Negative diode limiter

```
//Ex2.10
//let input wave be V_in=V_p_in*sin(2*%pi*f*t)
f=1;     //Frequency is 1Hz
T=1/f;
R_1=100;     //Resistances in ohms
R_L=1000;     //Load
V_p_in=10;     //Peak input voltage
V_th=0.7;     //knee voltage of diode
clf();
V_p_out=V_p_in*(R_L/(R_L+R_1));     //peak output voltage
disp(V_p_out,'peak output voltage in volts')
//let n be double the number of cycles of output shown in graph
for n=0:1:6
    t=T.*n/2:0.0005:T.*(n+1)/2     //time for each half cycle
    V_in=V_p_in*sin(2*%pi*f.*t);
    Vout=V_in*(R_L/(R_L+R_1));
    if modulo(n,2)==0 then     //positive half, diode reverse biased
        y=Vout;
    else                          //negative half, diode forward biased
        a=bool2s(Vout<-0.7);     //puts zero to elements for which diode will conduct
        b=bool2s(Vout>-0.7);
        y=-V_th*a+b.*Vout;
    end
        plot(t,y)
    end
xtitle('Negative limiter graph')
```

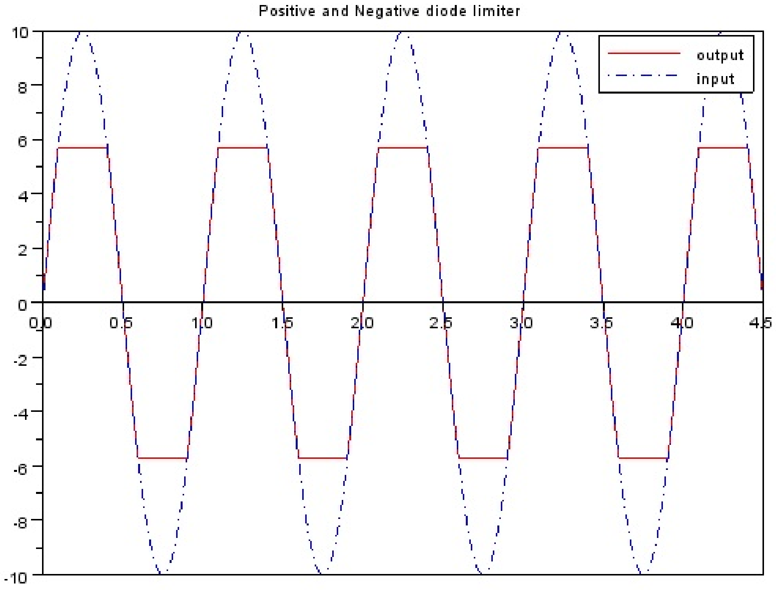


Figure 2.5: Posiive Negative Limiter

Scilab code Exa 2.11 Posiive Negative Limiter

```
//Ex2.11
//let input wave be V_in=V_p_in*sin(2*%pi*f*t)
f=1;    //Frequency is 1Hz
T=1/f;
V_p_in=10;    //Peak input voltage
V_th=0.7;    //knee voltage of diode
clf();
//let n be double the number of cycles of output shown in graph
for n=0:1:8
    t=T.*n/2:0.0005:T.*(n+1)/2    //time for each half cycle
    V_in=V_p_in*sin(2*%pi*f.*t);
    Vout=V_in;
    if modulo(n,2)==0 then    //positive half,D1 conducts till V_in=5.7V
        a=bool2s(Vout<5.7);
        b=bool2s(Vout>5.7);
        y=a.*Vout+5.7*b;    //output follows input till 5.7V then is constant at 5.7V
    else                    //negative half, D2 conducts till V_in=-5.7V
        a=bool2s(Vout<-5.7);
        b=bool2s(Vout>-5.7);
        y=-5.7*a+b.*Vout;    //output follows input till -5.7V then stays constant at -5.7V
    end
        plot(t,y,'r')

        plot(t,V_in,'-.')
       end
       hl=legend(['output','input']);
    xtitle('Positive and Negative diode limiter')
    disp('max output voltage is 5.7V')
    disp('min output voltage is -5.7V')
```

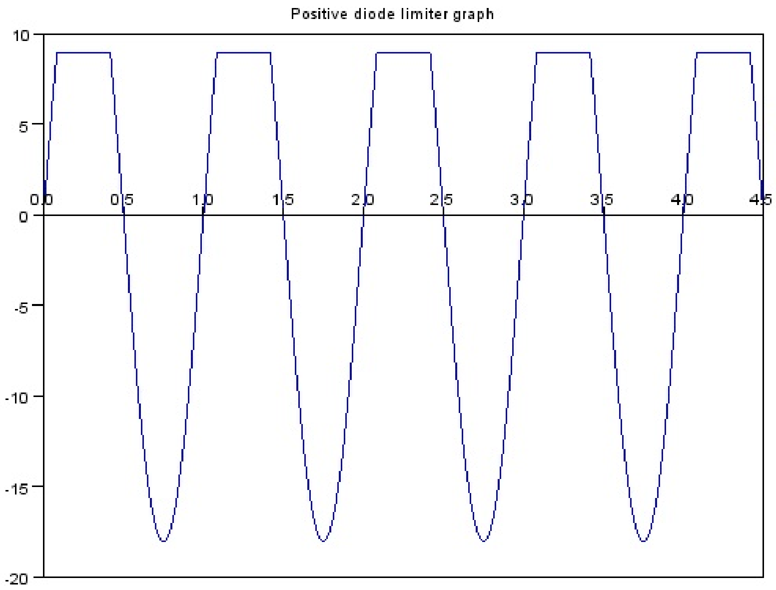


Figure 2.6: Positive diode limiter

Scilab code Exa 2.12 Positive diode limiter

```
//Ex2.12
//Positive diode limiter
//Let input wave be V_in=V_p_in*sin(2*%pi*f*t)
f=1;    //let frequency be 1Hz
T=1/f;
V_p_in=18;    //peak input voltage is 18V
V_supply=12;
R2=100;
```

```
R3=220;     //resistances in ohms
V_bias=V_supply*(R3/(R2+R3));
V=V_bias+0.7;     //waveform clipped at V
clf();
//let n be double the number of cycles of output wave shown in graph
for n=0:1:8
    t=n*T/2:0.0005:T.*(n+1)/2;
    V_in=V_p_in*sin(2*%pi*f.*t);
    Vout=V_in;
    if modulo(n,2)==0 then     //positive half, diode conucts till V
        a=bool2s(Vout<V);
        b=bool2s(Vout>V);
        y=a.*Vout+V*b;
    else                       //negative half cycle, output follows input
      y=Vout;
    end
    plot(t,y)
end
xtitle('Positive diode limiter graph')
disp(V,'diode limiting the voltage at this voltage')
```

Scilab code Exa 2.13 Negative Clamper

```
//Ex2.13
//Negative Clamping circuit
//let input voltage be V_in=V_p_in*sin(2*%pi*f*t)
f=1;     //let frequency be 1Hz
T=1/f;
V_p_in=24;
V_DC=-(V_p_in-0.7);     //DC level added to output
```

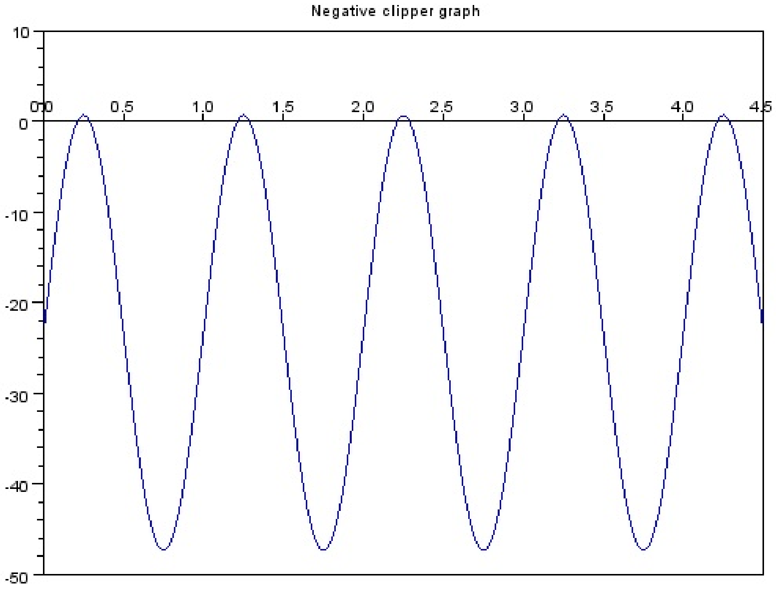


Figure 2.7: Negative Clamper

```
disp(V_DC,'V_DC in volts= ')
for n=0:1:8
    t=n*T/2:0.0005:T.*(n+1)/2;
    V_in=V_p_in*sin(2*%pi*f.*t);
    Vout=V_DC+V_in;
    plot(t,Vout)
end
xtitle('Negative clipper graph')
```

Chapter 3

Special purpose diodes

Scilab code Exa 3.1 Zener impedance

```
//ex3.1
del_V_Z=50*10^-3;     //in volts, from graph
del_I_Z=5*10^-3;     //in amperes, from rgraph
Z_Z=del_V_Z/del_I_Z;
disp(Z_Z,'zener impedance in ohms')
```

Scilab code Exa 3.2 Zener Voltage

```
//ex3.2
I_ZT=37*10^-3;     //IN AMPERES
V_ZT=6.8;     //IN VOLTS
Z_ZT=3.5;     //IN OHMS
I_Z=50*10^-3;     //IN AMPERES
DEL_I_Z=I_Z-I_ZT;
DEL_V_Z=DEL_I_Z*Z_ZT;
V_Z=V_ZT+DEL_V_Z;
disp(V_Z,'voltage across zener terminals (in volts)
   when current is 50 mA')
```

```
I_Z=25*10^-3;     //IN AMPERES
DEL_I_Z=I_Z-I_ZT;
DEL_V_Z=DEL_I_Z*Z_ZT;
V_Z=V_ZT+DEL_V_Z;
disp(V_Z,'voltage across zener terminals (in volts) when current is 25 mA')
```

Scilab code Exa 3.3 Temperature coefficient

```
//ex3.3
V_Z=8.2;     //8.2 volt zener diode
TC=0.0005;     //Temperature coefficient (per degree celsius)
T1=60;     //Temperatures in celsius
T2=25;
DEL_T=T1-T2;
del_V_Z=V_Z*TC*DEL_T;
voltage=V_Z+del_V_Z;
disp(voltage,'zener voltage at 60 degree celsius')
```

Scilab code Exa 3.4 Zener power dissipation

```
//ex3.4
P_D_max=400*10^-3;     //power in watts
df=3.2*10^-3     //derating factor in watts per celsius
del_T=(90-50);     //in celsius, temperature difference
P_D_derated=P_D_max-df*del_T;
disp(P_D_derated,'maximum power dissipated at 90 degree celsius')
```

Scilab code Exa 3.5 Zener voltage regulator

```
//ex3.5
V_Z=5.1;
I_ZT=49*10^-3;
I_ZK=1*10^-3;
Z_Z=7;
R=100;
P_D_max=1;
//At I_ZK, output voltage
V_out=V_Z-(I_ZT-I_ZK)*Z_Z;
V_IN_min=I_ZK*R+V_out;
I_ZM=P_D_max/V_Z;
//at I_ZM, output voltage
V_out=V_Z+(I_ZM-I_ZT)*Z_Z;
V_IN_max=I_ZM*R+V_out;
disp(V_IN_max,'maximum input voltage in volts that can be regulated by the zener diode')
disp(V_IN_min,'minimum input voltage in volts that can be regulated by the zener diode')
```

Scilab code Exa 3.6 Regulation Variable load

```
//ex3.6
V_Z=12;
V_IN=24;
I_ZK=1*10^-3;
I_ZM=50*10^-3;
Z_Z=0;
R=470;
//when I_L=0, I_Z is max and is equal to the total circuit current I_T
```

```
I_T=(V_IN-V_Z)/R;
I_Z_max=I_T;
if I_Z_max<I_ZM then
    I_L_min=0;
end
I_L_max=I_T-I_ZK;
R_L_min=V_Z/I_L_max;
disp(R_L_min,'minimum value of load resistance in ohms')
disp(I_L_min,'minimum curent in amperes')
disp(I_L_max,'maximum curent in amperes')
```

Scilab code Exa 3.7 Zener regulation

```
//ex3.7
V_IN=24;
V_Z=15;
I_ZK=0.25*10^-3;
I_ZT=17*10^-3;
Z_ZT=14;
P_D_max=1;
//output voltage at I_ZK
V_out_1=V_Z-(I_ZT-I_ZK)*Z_ZT;
disp(V_out_1,'output voltage in volts at I_ZK')
I_ZM=P_D_max/V_Z;
//output voltage at I_ZM
V_out_2=V_Z+(I_ZM-I_ZT)*Z_ZT;
disp(V_out_2,'output voltage in volts a I_ZM')
R=(V_IN-V_out_2)/I_ZM;
disp(R,'value of R in ohms for maximum zener current, no load')
disp('closest practical value is 130 ohms')
R=130;
//for minimum load resistance(max load current) zener current is minimum (I_ZK)
```

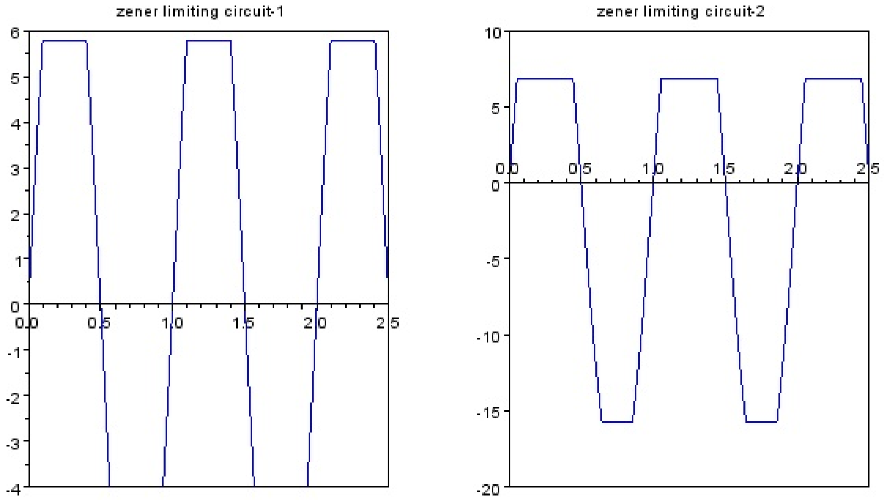


Figure 3.1: Zener limiting

```
I_T=(V_IN-V_out_1)/R;
I_L=I_T-I_ZK;
R_L_min=V_out_1/I_L;
disp(R_L_min,'minimum load resistance in ohms')
```

Scilab code Exa 3.8 Zener limiting

```
//Ex3.8
//let input wave be V_in=V_p_in*sin(2*%pi*f*t)
f=1;     //Frequency is 1Hz
T=1/f;
V_p_in=10;     //Peak input voltage
V_th=0.7;     //forward biased zener
V_Z1=5.1;
```

```
V_Z2=3.3;
clf();
subplot(121)
//let n be double the number of cycles of output shown in graph
for n=0:1:4
    t=T.*n/2:0.0005:T.*(n+1)/2    //time for each half cycle
    V_in=V_p_in*sin(2*%pi*f.*t);
    Vout=V_in;
    if modulo(n,2)==0 then    //positive half, conducts till V_in=5.8V
        a=bool2s(Vout<(V_Z1+V_th));
        b=bool2s(Vout>(V_Z1+V_th));
        y=a.*Vout+(V_Z1+V_th)*b;    //output follows input till 5.8V then is constant at 5.8V
    else                          //negative half, conducts till V_in=-4V
        a=bool2s(Vout<-(V_Z2+V_th));
        b=bool2s(Vout>-(V_Z2+V_th));
        y=-(V_Z2+V_th)*a+b.*Vout;    //output follows input till -4V then stays constant at -4V
    end
        plot(t,y)
    end
xtitle('zener limiting circuit-1')
disp((V_Z1+V_th),'max voltage in volts')
disp(-(V_Z2+V_th),'min voltage in volts')
subplot(122)
xtitle('zener limiting circuit-2')
V_p_in=20;
V_Z1=6.2;
V_Z2=15;
//let n be double the number of cycles of output shown in graph
for n=0:1:4
    t=T.*n/2:0.0005:T.*(n+1)/2    //time for each
```

```
      half cycle
    V_in=V_p_in*sin(2*%pi*f.*t);
    Vout=V_in;
    if modulo(n,2)==0 then    //positive half, conducts till V_in=6.9V
        a=bool2s(Vout<(V_Z1+V_th));
        b=bool2s(Vout>(V_Z1+V_th));
        y=a.*Vout+(V_Z1+V_th)*b;    //output follows input till 6.9V then is constant at 6.9V
    else                    //negative half, conducts till V_in=-15.7V
        a=bool2s(Vout<-(V_Z2+V_th));
        b=bool2s(Vout>-(V_Z2+V_th));
        y=-(V_Z2+V_th)*a+b.*Vout;    //output follows input till -15.7V then stays constant at -15.7V
    end
        plot(t,y)
    end
    disp((V_Z1+V_th),'max voltage in volts')
disp(-(V_Z2+V_th),'min voltage in volts')
```

Chapter 4

Bipolar Junction Transistors

Scilab code Exa 4.1 DC beta

```
//ex4.1
I_C=3.65*10^-3;    //collector current in amperes
I_B=50*10^-6;    //base current in amperes
B_DC=I_C/I_B;
I_E=I_B+I_C;
disp(B_DC,'B_DC')
disp(I_E,'emitter current in amperes')
```

Scilab code Exa 4.2 Current Voltage Analysis

```
//ex4.2
V_BE=0.7;
B_DC=150;
V_BB=5;
V_CC=10;
R_B=10*10^3;
R_C=100;
I_B=(V_BB-V_BE)/R_B;
```

```
I_C=B_DC*I_B;
I_E=I_C+I_B;
V_CE=V_CC-I_C*R_C;
V_CB=V_CE-V_BE;
disp(I_B,'base current in amperes')
disp(I_C,'collector current in amperes')
disp(I_E,'emitter current in amperes')
disp(V_CE,'collector to emitter voltage in volts')
disp(V_CB,'collector to base voltage in volts')
```

Scilab code Exa 4.3 Collector characteristic curve

```
//ex4.3
disp('cant be shown')
```

Scilab code Exa 4.4 DC loadline

```
//ex4.4
V_CE_sat=0.2;
V_BE=0.7;
V_BB=3;
V_CC=10;
B_DC=50;
R_B=10*10^3;
R_C=1*10^3;
I_C_sat=(V_CC-V_CE_sat)/R_C;
I_B=(V_BB-V_BE)/R_B;
I_C=B_DC*I_B;
if I_C>I_C_sat then
    disp('transistor in saturation')
else
    disp('transistor not in saturation')
end
```

Scilab code Exa 4.5 Transistor rating

```
//ex4.5
P_D_max=250*10^-3;      //max power rating of
   transistor in watts
V_CE=6;
I_C=P_D_max/V_CE;
disp(I_C,'collector current that can be handled by
   the transistor(in amperes)')
```

Scilab code Exa 4.6 Maximum Transistor Rating

```
//ex4.6
P_D_max=800*10^-3;
V_BE=0.7;
V_CE_max=15;
I_C_max=100*10^-3;
V_BB=5;
B_DC=100;
R_B=22*10^3;
R_C=10^3;
I_B=(V_BB-V_BE)/R_B;
I_C=B_DC*I_B;
V_R_C=I_C*R_C;     //voltage drop across R_C
V_CC_max=V_CE_max+V_R_C;
P_D=I_C*V_CE_max;
if P_D<P_D_max then
    disp(V_CC_max,'V_CC in volts')
    disp('V_CE_max will be exceeded first
       becauseentire supply voltage V_CC will be
       dropped across the transistor')
end
```

Scilab code Exa 4.7 Derating Power maximum

```
//ex4.7
df=5*10^-3;     //derating factor in watts per degree
    celsius
T1=70;
T2=25;
P_D_max=1;     //in watts
del_P_D=df*(T1-T2);
P_D=P_D_max-del_P_D;
disp(P_D,'Power dissipated max at a temperature of
   70 degree celsius(in watts)')
```

Scilab code Exa 4.8 Transistor amplification

```
//ex4.8
R_C=1*10^3;
r_e=50;
V_b=100*10^-3;
A_v=R_C/r_e;
V_out=A_v*V_b;
disp(A_v,'voltage gain')
disp(V_out,'ac output voltage in volts')
```

Scilab code Exa 4.9 Collector in saturation

```
//ex4.9
V_CC=10;
B_DC=200;
```

```
R_C=10^3;
V_IN=0;
V_CE=V_CC;
disp(V_CE,'when V_IN=0, transistor acts as open switch(cut-off) and collector emitter voltage in volts is')
//now when V_CE_sat is neglected
I_C_sat=V_CC/R_C;
I_B_min=I_C_sat/B_DC;
disp(I_B_min,'minimum value of base current in amperes to saturate transistor')
V_IN=5;
V_BE=0.7;
V_R_B=V_IN-V_BE;    //voltage across base resiatance
R_B_max=V_R_B/I_B_min;
disp(R_B_max,'maximum value of base resistance in ohms when input voltage is 5V')
```

Chapter 5

Transistor Bias Circuits

Scilab code Exa 5.1 DC bias

```
//ex5.1
V_BB=10;
V_CC=20;
B_DC=200;
R_B=47*10^3;
R_C=330;
V_BE=0.7;
I_B=(V_BB-V_BE)/R_B;
I_C=B_DC*I_B;     //Q POINT
V_CE=V_CC-I_C*R_C;     //Q POINT
I_C_sat=V_CC/R_C;
I_c_peak=I_C_sat-I_C;
I_b_peak=I_c_peak/B_DC;
disp(I_C,'q point of I_C in amperes')
disp(V_CE,'Q point of V_CE in volts')
disp(I_b_peak,'peak base current in amperes')
```

Scilab code Exa 5.2 Input resistance

```
//ex5.2
B_DC=125;
R_E=10^3;
R_IN_base=B_DC*R_E;
disp(R_IN_base,'DC input resistance in ohms, looking
    in at the base of transistor')
```

Scilab code Exa 5.3 Voltage divider bias

```
//ex5.3
B_DC=100;
R1=10*10^3;
R2=5.6*10^3;
R_C=1*10^3;
R_E=560;
V_CC=10;
V_BE=0.7
R_IN_base=B_DC*R_E;
//We can neglect R_IN_base as it is equal to 10*R2
disp(R_IN_base,'input resistance seen from base,
   which can be neglected as it is 10 times R2')
V_B=(R2/(R1+R2))*V_CC;
V_E=V_B-V_BE;
I_E=V_E/R_E;
I_C=I_E;
V_CE=V_CC-I_C*(R_C+R_E);
disp(V_CE,'V_CE in volts')
disp(I_C,'I_C in amperes')
disp('Since V_CE>0V, transistor is not in saturation
   ')
```

Scilab code Exa 5.4 Voltage bias PNP

```
//ex5.4
V_EE=10;
V_BE=0.7;
B_DC=150;
R1=22*10^3;
R2=10*10^3;
R_C=2.2*10^3;
R_E=1*10^3;
R_IN_base=B_DC*R_E;     //R_IN_base>10*R2,so it can
   be neglected
disp(R_IN_base,'input resistance in ohms as seen
   from base. it can be neglected as it is greater
   than 10 times R2')
V_B=(R1/(R1+R2))*V_EE;
V_E=V_B+V_BE;
I_E=(V_EE-V_E)/R_E;
I_C=I_E;
V_C=I_C*R_C;
V_EC=V_E-V_C;
disp(I_C,'I_C collector current in amperes')
disp(V_EC,'V_EC emitter-collector voltage in Volts')
```

Scilab code Exa 5.5 PNP Transistor

```
//ex5.5
R1=68*10^3;
R2=47*10^3;
R_C=1.8*10^3;
R_E=2.2*10^3;
V_CC=-6;
V_BE=0.7;
B_DC=75;
R_IN_base=B_DC*R_E;
disp('input resistance as seen from base is not
   greater than 10 times R2 so it should be taken
```

```
into account')
//R_IN_base in parallel with R2
V_B=((R2*R_IN_base)/(R2+R_IN_base)/(R1+(R2*R_IN_base)/(R2+R_IN_base)))*V_CC;
V_E=V_B+V_BE;
I_E=V_E/R_E;
I_C=I_E;
V_C=V_CC-I_C*R_C;
V_CE=V_C-V_E;
disp(I_C,'collector current in amperes')
disp(V_CE,'collector emitter voltage in volts')
```

Scilab code Exa 5.6 Qpoint base bias

```
//ex5.6
V_CC=12;
R_B=100*10^3;
R_C=560;
//FOR B_DC=85 AND V_BE=0.7V
B_DC=85;
V_BE=0.7;
I_C_1=B_DC*(V_CC-V_BE)/R_B;
V_CE_1=V_CC-I_C_1*R_C;
//FOR B_DC=100 AND V_BE=0.6V
B_DC=100;
V_BE=0.6;
I_C_2=B_DC*(V_CC-V_BE)/R_B;
V_CE_2=V_CC-I_C_2*R_C;
%_del_I_C=((I_C_2-I_C_1)/I_C_1)*100;
%_del_V_CE=((V_CE_2-V_CE_1)/V_CE_1)*100;
disp(%_del_I_C,'percent change in collector current')
disp(%_del_V_CE,'percent change in collector emitter voltage')
```

Scilab code Exa 5.7 Emitter bias

```
//ex5.7
V_CC=20;
R_C=4.7*10^3;
R_E=10*10^3;
V_EE=-20;
R_B=100*10^3;
//FOR B_DC=85 AND V_BE=0.7V
B_DC=85;
V_BE=0.7;
I_C_1=(-V_EE-V_BE)/(R_E+(R_B/B_DC));
V_C=V_CC-I_C_1*R_C;
I_E=I_C_1;
V_E=V_EE+I_E*R_E;
V_CE_1=V_C-V_E;
disp(I_C_1)
disp(V_CE_1)
//FOR B_DC=100 AND V_BE=0.6V
B_DC=100;
V_BE=0.6;
I_C_2=(-V_EE-V_BE)/(R_E+(R_B/B_DC));
V_C=V_CC-I_C_2*R_C;
I_E=I_C_2;
V_E=V_EE+I_E*R_E;
V_CE_2=V_C-V_E;
disp(I_C_2)
disp(V_CE_2)
%_del_I_C=((I_C_2-I_C_1)/I_C_1)*100;
%_del_V_CE=((V_CE_2-V_CE_1)/V_CE_1)*100;
disp(%_del_I_C,'percent change in collector currrent')
disp(%_del_V_CE,'percent change in collector emitter voltage')
```

```
//plz note that the answers differ because of the number of places after the decimal that scilab generates
```

Scilab code Exa 5.8 Q point

```
//ex5.8
V_CC=10;
B_DC=100;
R_C=10*10^3;
R_B=100*10^3;
V_BE=0.7;
I_C=(V_CC-V_BE)/(R_C+(R_B/B_DC));
V_CE=V_CC-I_C*R_C;
disp(I_C,'Q point of collector current in amperes')
disp(V_CE,'Q point of collector-emitter voltage in volts')
```

Chapter 6

BJT Amplifiers

Scilab code Exa 6.1 Linear amplifier

```
//ex6.1
disp('graph question, cannot be solved in scilab')
```

Scilab code Exa 6.2 AC Emitter resistance

```
//ex6.2
I_E=2*10^-3;
r_e=25*10^-3/I_E;
disp(r_e,'ac emitter resistance in ohms')
```

Scilab code Exa 6.3 Base voltage

```
//ex6.3
I_E=3.8*10^-3;
B_ac=160;
R1=22*10^3;
```

```
R2=6.8*10^3;
R_s=300;
V_s=10*10^-3;
r_e=25*10^-3/I_E;
R_in_base=B_ac*r_e;
R_in_tot=(R1*R2*R_in_base)/(R_in_base*R1+R_in_base*R2+R1*R2);
V_b=(R_in_tot/(R_in_tot+R_s))*V_s;
disp(V_b,'voltage at the base of the transistor in volts')
```

Scilab code Exa 6.4 Emitter bypass capacitor

```
//ex6.4
R_E=560;
f=2*10^3;     //minimum value of frequency in hertz
X_C=R_E/10;     //minimum value of capacitive reactance
C2=1/(2*%pi*X_C*f);
disp(C2,'value of bypass capacitor in farads')
```

Scilab code Exa 6.5 Effect bypass capacitor

```
 //ex6.5
r_e=6.58;     //from ex6.3
R_C=1*10^3;
R_E=560;
A_v=R_C/(R_E+r_e);
disp(A_v,'gain without bypass capacitor')
A_v=R_C/r_e;
disp(A_v,'gain in the presence of bypass capacitor')
```

Scilab code Exa 6.6 Gain with load

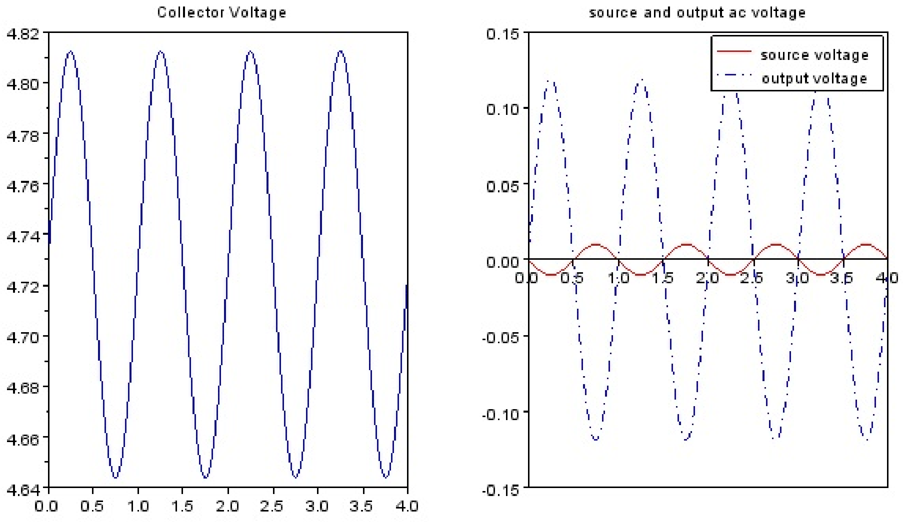
```
//ex6.6
R_C=10^3;
R_L=5*10^3;
r_e=6.58;
R_c=(R_C*R_L)/(R_C+R_L);
disp(R_c,'ac collector resistor in ohms')
A_v=R_c/r_e;
disp(A_v,'gain with load')
```

Scilab code Exa 6.7 Gain swamped amplifier

```
//ex6.7
R_C=3.3*10^3;
R_E1=330;
A_v=R_C/R_E1;
disp(A_v,'approximate voltage gain as R_E2 is
   bypassed by C2')
```

Scilab code Exa 6.8 Common emitter amplifier

```
//ex6.8
B_DC=150;
B_ac=175;
V_CC=10;
V_s=10*10^-3;
```



Collector Voltage

source and output ac voltage

Figure 6.1: Common emitter amplifier

```
R_s=600;
R1=47*10^3;
R2=10*10^3;
R_E1=470;
R_E2=470;
R_C=4.7*10^3;
R_L=47*10^3;
R_IN_base=B_DC*(R_E1+R_E2);
//since R_IN_base is ten times more than R2,it can be neglected in DC voltage calculation
V_B=(R2/(R2+R1))*V_CC;
V_E=V_B-0.7;
I_E=V_E/(R_E1+R_E2);
I_C=I_E;
V_C=V_CC-I_C*R_C;
disp(V_C,'dc collector voltage in volts')
r_e=25*10^-3/I_E;
//base resistance
```

```
R_in_base=B_ac*(r_e+R_E1);
//total input resistance
R_in_tot=(R1*R2*R_in_base)/(R1*R2+R_in_base*R1+R_in_base*R2);
attenuation=R_in_tot/(R_s+R_in_tot);
//ac collector resistance
R_c=R_C*R_L/(R_C+R_L);
//voltage gain from base to collector
A_v=R_c/R_E1;
//overall voltage gain A_V
A_V=A_v*attenuation;
//rms voltage at collector V_c
V_c=A_V*V_s;
Max_V_c_p=V_C+sqrt(2)*V_c;
Min_V_c_p=V_C-sqrt(2)*V_c;
V_out_p=sqrt(2)*V_c;
//assume frequency to be 1Hz
f=1;
t=0:0.0005:4;
y=V_C+V_c*sin(2*%pi*f.*t);
clf();
subplot(121)
xtitle('Collector Voltage')
plot(t,y)
subplot(122)
xtitle('source and output ac voltage')
x=-V_s*sin(2*f*%pi.*t);
z=V_out_p*sin(2*%pi*f.*t);
plot(t,x,'r')
plot(t,z,'-.')
h1=legend(['source voltage';'output voltage'])
```

Scilab code Exa 6.9 Current gain

```
//ex6.9
```

```
R_E=10^3;
R_L=10^3;
R1=18*10^3;
R2=18*10^3;
B_ac=175;
V_CC=10;
V_BE=0.7;
V_in=1;
//ac emitter resistance R_e
R_e=(R_E*R_L)/(R_E+R_L);
//resistance from base R_in_base
R_in_base=B_ac*R_e;
//total input resiatance R_in_tot
R_in_tot=(R1*R2*R_in_base)/(R1*R2+R1*R_in_base+R2*R_in_base);
disp(R_in_tot,'total input resistance in ohms')
V_E=((R2/(R1+R2))*V_CC)-V_BE;
I_E=V_E/R_E;
r_e=25*10^-3/I_E;
A_v=R_e/(r_e+R_e);
disp(A_v,'voltage gain')
//ac emitter current I_e
//V_e=A_v*V_b=1V
V_e=1;
I_e=V_e/R_e;
I_in=V_in/R_in_tot;
A_i=I_e/I_in;    //current gain
disp(A_i,'current gain')
A_p=A_i;    //power gain
//since R_L=R_E, one half of the total power is disspated to R_L
A_p_load=A_p/2;
disp(A_p_load,'power gain delivered to load')
```

Scilab code Exa 6.10 Darlington emitter follower

```
//ex6.10
V_CC=12;
V_BE=0.7;
R_C=10^3;
r_e_ce=5;    //for common emitter amplifier
R1=10*10^3;
R2=22*10^3;
R_E=22;
R_L=8;
B_DC=100;
B_ac=100;
V_B=((R2*B_DC^2*R_E/(R2+B_DC^2*R_E))/(R1+(R2*B_DC^2*R_E/(R2+B_DC^2*R_E))))*V_CC;
V_E=V_B-2*V_BE;
I_E=V_E/R_E;
r_e=25*10^-3/I_E;    //for darlington emitter-follower
P_R_E=I_E^2*R_E;    //power dissipated by R_E
P_Q2=(V_CC-V_E)*I_E    //power dissipated by transistor Q2
R_e=R_E*R_L/(R_E+R_L);    //ac emitter resistance of darlington emitter follower
R_in_tot=R1*R2*B_ac^2*(R_e+r_e)/(R1*R2+R1*B_ac^2*(r_e+R_e)+R2*B_ac^2*(r_e+R_e));    //total input resistance of darlington
R_c=R_C*R_in_tot/(R_C+R_in_tot);    //effective ac resistance
A_v_CE=R_c/r_e_ce;
disp(A_v_CE,'voltage gain of common emitter amplifier')
A_v_EF=R_e/(r_e+R_e);
disp(A_v_EF,'voltage gain of darlington emitter follower')
A_v=A_v_CE*A_v_EF;
disp(A_v,'overall voltage gain')
```

Scilab code Exa 6.11 Common base amplifier

```
//ex6.11
B_DC=250;
R_C=2.2*10^3;
R_E=1*10^3;
R_L=10*10^3;
R1=56*10^3;
R2=12*10^3;
V_BE=0.7;
V_CC=10;
//since B_DC*R_E>>R2
V_B=(R2/(R1+R2))*V_CC;
V_E=V_B-V_BE;
I_E=V_E/R_E;
r_e=25*10^-3/I_E;
R_in=r_e;    //input resistance
R_c=R_C*R_L/(R_C+R_L);    //ac collector resistance
A_v=R_c/r_e;
//current gain is almost 1
//power gain is approximately equal to voltage gain
A_p=A_v;
A_i=1;
disp(R_in,'input resistance in ohms')
disp(A_v,'voltage gain')
disp(A_i,'current gain')
disp(A_p,'power gain')
```

Scilab code Exa 6.12 Voltage gain decibel

```
//ex6.12
A_v1=10;
```

```
A_v2=15;
A_v3=20;
A_v=A_v1*A_v2*A_v3;     //overall voltage gain
disp(A_v,'overall voltage gain')
A_v1_dB=gain_in_decibel_voltage(A_v1);
A_v2_dB=gain_in_decibel_voltage(A_v2);
A_v3_dB=gain_in_decibel_voltage(A_v3);
A_v_dB=A_v1_dB+A_v2_dB+A_v3_dB;
disp(A_v_dB,'total voltage gain in decibels')
```

Chapter 7

Field Effect Transistors

Scilab code Exa 7.1 cutoff FET

```
//ex7.1
V_GS_off=-4;
I_DSS=12*10^-3;
R_D=560;
V_P=-1*V_GS_off;
V_DS=V_P;
I_D=I_DSS;
V_R_D=I_D*R_D;     //voltage across resistor
V_DD=V_DS+V_R_D;
disp(V_DD,'The value of V_DD required to put the
   device in the constant current area of operation
   of JFET')
```

Scilab code Exa 7.2 Drain current

```
//ex7.2
disp('The p-channel JFET requires a positive gate to
    source voltage. The more positive the voltage,
```

```
    the lesser the drain current. Any further
    increase in V_GS keeps the JFET cut off, so I_D
    remains 0')
```

---

check Appendix AP 6 for dependency:

`value_of_I_D.sci`

Scilab code Exa 7.3 JFET current voltage

```
//ex7.3
I_DSS=9*10^-3;
V_GS_off=-8;
V_GS=0;
I_D=value_of_I_D(9*10^-3,0,-8);
disp(I_D,'Value of I_D for V_GS=0V')
I_D=value_of_I_D(9*10^-3,-1,-8);
disp(I_D,'Value of I_D for V_GS=-1V')
I_D=value_of_I_D(9*10^-3,-4,-8);
disp(I_D,'Value of I_D for V_GS=-4V')
```

---

check Appendix AP 6 for dependency:

`value_of_I_D.sci`

Scilab code Exa 7.4 JFET transconductance

```
//ex7.4
I_DSS=3*10^-3;
V_GS_off=-6;
y_fs_max=5000*10^-6;
V_GS=-4;
g_m0=y_fs_max;
g_m=g_m0*(1-(V_GS/V_GS_off));
```

```
I_D=value_of_I_D(3*10^-3,-4,-6)
disp(g_m,'forward transconductance in Siemens')
disp(I_D,'value of I D in amperes')
```

Scilab code Exa 7.5 JFET input resistance

```
V_GS=-20;
I_GSS=-2*10^-9;
R_IN=abs((-20/(2*10^-9)))
disp(R_IN,'Input Resistance in Ohms')
```

Scilab code Exa 7.6 Self bias

```
//ex7.5
V_DD=15;
V_G=0;
I_D=5*10^-3;
R_D=1*10^3;
R_G=10*10^6;
R_S=220;
V_S=I_D*R_S;
V_D=V_DD-I_D*R_D;
V_DS=V_D-V_S;
V_GS=V_G-V_S;
disp(V_DS,'Drain to source voltage in volts');
disp(V_GS,'Gate to source voltage in volts');
```

Scilab code Exa 7.7 Q point JFET

```
//ex7.6
```

```
I_D=6.25*10^-3;
V_GS=-5;
R_G=abs((V_GS/I_D))
disp(R_G,'Gate resistance in Ohms')
```

check Appendix AP 6 for dependency:

`value_of_I_D.sci`

Scilab code Exa 7.8 Self bias Q point

```
//EX7.8
I_DSS=25*10^-3;
V_GS_off=15;
V_GS=5;
I_D=value_of_I_D(25*10^-3,5,15)
R_S=abs((V_GS/I_D))
disp(I_D,'Drain current in Amperes')
disp(R_S,'Source resistance in Ohms')
```

Scilab code Exa 7.9 Midpoint bias

```
//ex7.9
I_DSS=12*10^-3;
V_GS_off=-3;
V_DD=12;
V_D=6;
I_D=I_DSS/2;      //MIDPOINT BIAS
V_GS=V_GS_off/3.4;      //MIDPOINT BIAS
R_S=abs((V_GS/I_D))
R_D=(V_DD-V_D)/I_D
disp(R_S,'Source Resistance in Ohms')
disp(R_D,'Drain Resistance in Ohms')
```

Scilab code Exa 7.10 Graphical analysis

```
//ex7.10
R_S=680;
I_D=0;
V_GS=I_D*R_S;     //FOR I_D=0A
disp(V_GS,'V_GS in Volts, at I_D=0A')
I_DSS=4*10^-3;
I_D=I_DSS;
V_GS=I_D*R_S;     //FOR I_D=4mA
disp(V_GS,'V_GS in Volts, at I_D=4mA')
disp('Plotting load line using the values of V_GS at
    I_D=0 and 4mA, we find the intersection of load
   line with transfer characteristic to get Q-point
   values of V_GS=-1.5V and I_D=2.25mA')
```

Scilab code Exa 7.11 Voltage Divider bias

```
//ex7.11
V_DD=12;
V_D=7;
R_D=3.3*10^3;
R_S=2.2*10^3;
R_1=6.8*10^6;
R_2=1*10^6;
I_D=(V_DD-V_D)/R_D;
V_S=I_D*R_S;
V_G=(R_2/(R_1+R_2))*V_DD;
V_GS=V_G-V_S;
disp(I_D,'Drain current in amperes')
disp(V_GS,'Gate to source voltage in volts')
```

Scilab code Exa 7.12 Graph voltage divider

```
//ex7.12
R_1=2.2*10^6;
R_2=R_1;
V_DD=8;
R_S=3.3*10^3;
V_GS=(R_2/(R_1+R_2))*V_DD;      //FOR I_D=0A
V_G=V_GS;
disp(V_GS,'V_GS in Volts, at I_D=0A')
I_D=(V_G-0)/R_S;      //FOR V_GS=0V
disp(I_D,'I_D in Amperes,at V_GS=0V')
disp('Plotting load line using the value of V_GS=4V
    at I_D=0 and I_D=1.2mA at V_GS=0V, we find the
    intersection of load line with transfer
    characteristic to get Q-point values of V_GS=-1.8
   V and I_D=1.8mA')
```

---

check Appendix AP 6 for dependency:

`value_of_I_D.sci`

Scilab code Exa 7.13 DMOSFET

```
//ex7.13
I_DSS=10*10^-3;
V_GS_off=-8;
V_GS=-3;
I_D=value_of_I_D(10*10^-3,-3,-8)
disp(I_D,'Drain current when V_GS=-3V in Amperes')
V_GS=3;
I_D=value_of_I_D(10*10^-3,3,-8)
disp(I_D,'Drain current when V_GS=3V in Amperes')
```

check Appendix AP 5 for dependency:

`value_of_K.sci`

Scilab code Exa 7.14 EMOSFET

```
//EX7.14
I_D_on=500*10^-3;
V_GS=10;
V_GS_th=1;
K=value_of_K(500*10^-3,10,1)
V_GS=5;
I_D=K*(V_GS-V_GS_th)^2;
disp(I_D,'Drain current')
```

Scilab code Exa 7.15 DMOSFET bias

```
//ex7.15
I_DSS=12*10^-3;
V_DD=18;
R_D=620;
I_D=I_DSS;
V_DS=V_DD-I_D*R_D;
disp(V_DS,'Drain to sorce voltage in volts')
```

check Appendix AP 5 for dependency:

`value_of_K.sci`

Scilab code Exa 7.16 EMOSFET bias

```
//ex7.16
I_D_on=200*10^-3;
V_DD=24;
R_D=200;
V_GS=4;
V_GS_th=2;
R_1=100*10^3;
R_2=15*10^3;
K=value_of_K(200*10^-3,4,2)
V_GS=(R_2/(R_1+R_2))*V_DD;
I_D=K*(V_GS-V_GS_th)^2;
V_DS=V_DD-I_D*R_D;
disp(V_DS,'Drain to Source voltage in Volts')
disp(V_GS,'Gate to Source voltage in Volts')
```

Scilab code Exa 7.17 EMOSFET drain current

```
//EX7.17
V_GS_on=3;
V_GS=8.5;      //DISPLAYED ON METER
V_DS=V_GS;
V_DD=15;
R_D=4.7*10^3;
I_D=(V_DD-V_DS)/R_D;
disp(I_D,'Drain current in Amperes')
```

Chapter 8

FET Amplifiers

Scilab code Exa 8.1 Voltage gain

```
//ex8.1
g_m=4*10^-3;
R_d=1.5*10^3;
A_v=g_m*R_d;
disp(A_v,'Voltage gain')
```

Scilab code Exa 8.2 Rds effect

```
//ex8.2
r_ds=10*10^3;
R_d=1.5*10^3;    //from previous question
g_m=4*10^-3;     //from previous question
A_v=g_m*((R_d*r_ds)/(R_d+r_ds));
disp(A_v,'Voltage gain')
```

Scilab code Exa 8.3 External source resistance

```
//ex8.3
R_s=560;
R_d=1.5*10^3;
g_m=4*10^-3;
A_v=(g_m*R_d)/(1+(g_m*R_s))
disp(A_v,'Voltage gain')
```

Scilab code Exa 8.4 Unloaded amplifier

```
//ex8.4
V_DD=12;
V_in=100*10^-3;
R_D=3.3*10^3;
I_DSS=12*10^-3;
V_GS_off=-3;
R_S=910;
a=(R_S^2)/(V_GS_off^2);     //we take V_GS_off
   positive so that we take current negative
b=(-1)*(((2*R_S)/(V_GS_off))-(1/I_DSS));
c=1;
p1=poly([c b a],'x','c')
A=roots(p1)
I_D=(-1)*A(1);     //make the value of current
   positive
V_D=V_DD-I_D*R_D;
V_GS=-I_D*R_S;
g_m0=(2*I_DSS)/(abs(V_GS_off));
g_m=g_m0*(1-(V_GS/V_GS_off));
V_out=g_m*R_D*V_in;     //rms value
v_out=V_out*1.414*2;     //peak to peak dc value
disp(v_out,'output dc voltage (peak to peak) in
   volts')
```

Scilab code Exa 8.5 AC load effect

```
//ex8.5
R_D=3.3*10^3;
R_L=4.7*10^3;
R_d=(R_D*R_L)/(R_D+R_L);     //Equivalent drain
    resistance
g_m=3.25*10^-3;     //from previous question
V_in=100*10^-3;     //previous question
V_out=g_m*R_d*V_in;
disp(V_out,'Output voltage rms value in Volts')
```

Scilab code Exa 8.6 Input resistance

```
//ex8.6
I_GSS=30*10^-9;
V_GS=10;
R_G=10*10^6;
R_IN_gate=V_GS/I_GSS;
R_in=(R_IN_gate*R_G)/(R_IN_gate+R_G);     //parallel
    combination
disp(R_in,'Input resistance in ohms, as seen by
    signal source')
```

Scilab code Exa 8.7 DMOSFET amplifier

```
//ex8.7
I_DSS=200*10^-3;
g_m=200*10^-3;
V_in=500*10^-3;
V_DD=15;
R_D=33;
R_L=8.2*10^3;
```

```
I_D=I_DSS;      //Amplifier is zero biased
V_D=V_DD-I_D*R_D;
R_d=(R_D*R_L)/(R_D+R_L);
V_out=g_m*R_d*V_in;
disp(V_D,'DC output voltage in Volts')
disp(V_out,'AC output voltage in volts')
```

Scilab code Exa 8.8 MOSFET Q points

```
//ex8.8
disp('Part A: Q point: V_GS=-2V I_D=2.5mA. At V_GS
   =-1V, I_D=3.4mA, At V_GS=-3V, I_D=1.8mA. So peak
   to peak drain current is the difference of the
   two drain currents=1.6mA')
disp('Part B: Q point: V_GS=0V I_D=4mA. At V_GS=1V,
   I_D=5.3mA, At V_GS=-1V, I_D=2.5mA. So peak to
   peak drain current is the difference of the two
   drain currents=2.8mA')
disp('Part C: Q point: V_GS=8V I_D=2.5mA. At V_GS=9V
   , I_D=3.9mA, At V_GS=7V, I_D=1.7mA. So peak to
   peak drain current is the difference of the two
   drain currents=2.2mA')
```

---

check Appendix AP 5 for dependency:

`value_of_K.sci`

Scilab code Exa 8.9 EMOSFET amplifier

```
//ex8.9
R_1=47*10^3;
R_2=8.2*10^3;
R_D=3.3*10^3;
```

```
R_L=33*10^3;
I_D_on=200*10^-3;
V_GS=4;
V_GS_th=2;
g_m=23*10^-3;
V_in=25*10^-3;
V_DD=15;
V_GS=(R_2/(R_1+R_2))*V_DD;
K=value_of_K(200*10^-3,4,2);
I_D=K*(V_GS-V_GS_th)^2;
V_DS=V_DD-I_D*R_D;
R_d=(R_D*R_L)/(R_D+R_L);
V_out=g_m*V_in*R_d;
disp(V_DS,'Drain to source voltage in volts(V_DS)')
disp(I_D,'Drain current (I_D) inAmperes')
disp(V_GS,'Gate to source voltage (V_GS) in volts')
disp(V_out,'AC output voltage in volts')
```

Scilab code Exa 8.10 Common gate amplifier

```
//ex8.10
V_DD=-15;    //p=channel MOSFET
g_m=2000*10^-6;    //minimum value from datasheets
R_D=10*10^3;
R_L=10*10^3;
R_S=4.7*10^3;
R_d=(R_D*R_L)/(R_D+R_L);    //effective drain
   resistance
A_v=g_m*R_d;
R_in_source=1/g_m;
R_in=(R_in_source*R_S)/(R_in_source+R_S);    //
   signal souce sees R_S in parallel with input
   resistance at source terminal(R_in_source)
disp(A_v,'minimum voltage gain')
disp(R_in,'Input resistance seen from signal source
```

```
    in ohms')
```

Chapter 9

Power Amplifiers

Scilab code Exa 9.1 classA power amplifier

```
//ex9.1
V_CC=15;
R_C=1*10^3;
R_1=20*10^3;
R_2=5.1*10^3;
R_3=5.1*10^3;
R_4=15*10^3;
R_E_1=47;
R_E_2=330;
R_E_3=16;
R_L=16;      //SPEAKER IS THE LOAD;
B_ac_Q1=200;
B_ac_Q2=B_ac_Q1;
B_ac_Q3=50;
//R_c1=R_C||[R_3||R_4||B_acQ2*B_ac_Q3*(R_E_3||R_L)]
   is ac collector resistance
R=(R_E_3*R_L)/(R_E_3+R_L);
R=B_ac_Q2*B_ac_Q3*R;
R=(R*R_4)/(R+R_4);
R=(R*R_3)/(R+R_3);
R_c1=(R*R_C)/(R_C+R);     //ac collector resistance
```

```
//V_B=((R_2||(B_acQ1*(R_E_1+R_E_2)))/(R_1+(R_2||B_acQ1*(R_E_1+R_E_2))))*V_CC;
//This is the base voltage;
//LET R=(R_2||(B_acQ1*(R_E_1+R_E_2)))
R=(R_2*B_ac_Q1*(R_E_1+R_E_2))/(R_2+B_ac_Q1*(R_E_1+R_E_2));
V_B=R*V_CC/(R_1+R);
I_E=(V_B-0.7)/(R_E_1+R_E_2);
r_e_Q1=25*10^-3/I_E;
A_v1=(-1)*(R_c1)/(R_E_1+r_e_Q1);    //voltage gain of 1st stage
//total input resistance of 1st stage is R_in_tot_1=R_1||R_2||B_ac_Q1*(R_E_1+r_e_Q1);
R_in_tot_1=(R_1*(R_2*B_ac_Q1*(R_E_1+r_e_Q1)/(R_2+B_ac_Q1*(R_E_1+r_e_Q1))))/(R_1+(R_2*B_ac_Q1*(R_E_1+r_e_Q1)/(R_2+B_ac_Q1*(R_E_1+r_e_Q1))));
A_v2=1;    //gain of darlington voltage-follower
A_v_tot=A_v1*A_v2;    //total gain
A_p=(A_v_tot^2)*(R_in_tot_1/R_L);    //power gain
disp(A_v_tot,'Voltage gain')
disp(A_p,'Power gain')
```

Scilab code Exa 9.2 class A efficiency

```
//ex9.2
V_in=176*10^-3;
R_in=2.9*10^3;    //total input resistance from previous question
A_p=42429;    //power gain from previous question
V_CC=15;
I_CC=0.6;    //emitter current
P_in=V_in^2/R_in;
P_out=P_in*A_p;
P_DC=I_CC*V_CC;
eff=P_out/P_DC;
```

```
disp(eff,'efficiency')
```

Scilab code Exa 9.3 class AB pushpull

```
//ex9.3
V_CC=20;
R_L=16;
V_out_peak=V_CC;
I_out_peak=V_CC/R_L;
disp(V_out_peak,'ideal maximum peak output voltage
   in volts')
disp(I_out_peak,'ideal maximum current in amperes')
```

Scilab code Exa 9.4 Single supply pushpull

```
//ex9.4
V_CC=20;
R_L=16;
V_out_peak=V_CC/2;
I_out_peak=V_out_peak/R_L;
disp(V_out_peak,'ideal maximum output peak voltage
   in volts')
disp(I_out_peak,'ideal maximum current in amperes')
```

Scilab code Exa 9.5 Power of amplifier

```
//ex9.5
V_CC=20;
R_L=8;
B_ac=50;
```

```
r_e=6;
V_out_peak=V_CC/2;
V_CEQ=V_out_peak;
I_out_peak=V_CEQ/R_L;
I_c_sat=I_out_peak;
P_out=0.25*I_c_sat*V_CC;
P_DC=(I_c_sat*V_CC)/%pi;
R_in=B_ac*(r_e+R_L);
disp(P_out,'maximum ac output power in Watts');
disp(P_DC,'maximum DC output power in Watts');
disp(R_in,'input resistance in ohms');
```

Scilab code Exa 9.6 MOSFET pushpull amplifier

```
//ex9.6
V_DD=24;
V_in=100*10^-3;
R1=440;
R2=5.1*10^3;
R3=100*10^3;
R4=10^3;
R5=100;
R7=15*10^3;
R_L=33;
V_TH_Q1=2;
V_TH_Q2=-2;
I_R1=(V_DD-(-V_DD))/(R1+R2+R3);
V_B=V_DD-I_R1*(R1+R2);    //BASE VOLTAGE
V_E=V_B+0.7;    //EMITTER VOLTAGE
I_E=(V_DD-V_E)/(R4+R5);    //EMITTER CURRENT
V_R6=V_TH_Q1-V_TH_Q2;    //VOLTAGE DROP ACROSS R6
I_R6=I_E;
R6=V_R6/I_R6;
r_e=25*10^-3/I_E;    //UNBYPASSED EMITTER RESISTANCE
A_v=R7/(R5+r_e);    //VOLTAGE GAIN
```

```
V_out=A_v*V_in;
P_L=V_out^2/R_L;
disp(R6,'value of resistance R6 in ohms fot AB
   operation')
disp(P_L,'power across load in watts')
```

Scilab code Exa 9.7 class C amplifier

```
//ex9.7
f=200*10^3;     //frequency in hertz
I_c_sat=100*10^-3;
V_ce_sat=0.2;
t_on=1*10^-6;
T=1/f;     //time period of signal
P_D_avg=(t_on/T)*I_c_sat*V_ce_sat;
disp(P_D_avg,'average power dissipation in Watts')
```

Scilab code Exa 9.8 class C efficiency

```
//ex9.8
P_D_avg=4*10^-3;     //from previous question
V_CC=24;
R_c=100;
P_out=(0.5*V_CC^2)/R_c;
n=(P_out)/(P_out+P_D_avg);     //n is efficiency
disp(n,'efficiency')
```

Chapter 10

Amplifier Frequency Response

check Appendix AP 4 for dependency:

`gain_in_decibel_power.sci`

check Appendix AP 3 for dependency:

`gain_in_decibel_voltage.sci`

Scilab code Exa 10.1 Gain in decibel

```
//ex10.1
//P out/P in=250;
A_p_dB=gain_in_decibel_power(250)
disp(A_p_dB,'Power gain when power gain is 250')
A_p_dB=gain_in_decibel_power(100)
disp(A_p_dB,'Power gain when power gain is 100')
A_v_dB=gain_in_decibel_voltage(10)
disp(A_v_dB,'Voltage gain when voltage gain is 10')
A_v_dB=gain_in_decibel_power(0.5)
disp(A_v_dB,'Power gain when voltage gain is 0.5')
A_v_dB=gain_in_decibel_voltage(0.707)
disp(A_v_dB,'Voltage gain when voltage gain is 0.707
    ')
```

Scilab code Exa 10.2 Critical frequency

```
//ex10.2
//input voltage=10V
//at −3dB voltage gain from table is 0.707
v_out=0.707*10;
disp(v_out,'output voltage in volts at −3dB gain')
//at −6dB voltage gain from table is 0.5
v_out=0.5*10;
disp(v_out,'output voltage in volts at −6dB gain')
//at −12dB voltage gain from table is 0.25
v_out=0.25*10;
disp(v_out,'output voltage in volts at −12dB gain')
//at −24dB voltage gain from table is 0.0625
v_out=0.0625*10;
disp(v_out,'output voltage in volts at −24dB gain')
```

Scilab code Exa 10.3 Lower critical frequency

```
//ex10.3
R_in=1*10^3;
C1=1*10^-6;
A_v_mid=100;    //mid range voltage gain
f_c=1/(2*%pi*R_in*C1);
//at f_c, capacitive reactance is equal to
   resistance(X_C1=R_in)
attenuation=0.707;
//A_v is gain at lower critical frequency
A_v=0.707*A_v_mid;
disp(f_c,'lower critical frequency in hertz')
disp(attenuation,'attenuation at lower critical
   frequency')
```

```
disp(A_v,'gain at lower critical frequency')
```

Scilab code Exa 10.4 Voltage gains

```
//ex10.4
A_v_mid=100;
//At 1Hz frequency,voltage gain is 3 dB less than at
    midrange. At -3dB, the voltage is reduced by a
   factor of 0.707
A_v=0.707*A_v_mid;
disp(A_v,'actual voltage gain at 1Hz frequency')
//At 100Hz frequency,voltage gain is 20 dB less than
    at critical frequency (f_c ). At -20dB, the
   voltage is reduced by a factor of 0.1
A_v=0.1*A_v_mid;
disp(A_v,'actual voltage gain at 100Hz frequency')
//At 10Hz frequency,voltage gain is 40 dB less than
   at critical frequency (f_c). At -40dB, the
   voltage is reduced by a factor of 0.01
A_v=0.01*A_v_mid;
disp(A_v,'actual voltage gain at 10Hz frequency')
```

Scilab code Exa 10.5 Output RC circuit

```
//ex10.5
R_C=10*10^3;
C3=0.1*10^-6;
R_L=10*10^3;
A_v_mid=50;
f_c=1/(2*%pi*(R_L+R_C)*C3);
disp(f_c,'lower critical frequency in hertz')
//at midrange capacitive reactance is zero
X_C3=0;
```

```
attenuation=R_L/(R_L+R_C);
disp(attenuation,'attenuation at midrange frequency')
//at critical frequency, capacitive reactance equals total resistance
X_C3=R_L+R_C;
attenuation=R_L/(sqrt((R_C+R_L)^2+X_C3^2));
disp(attenuation,'attenuation at critical frequency')
A_v=0.707*A_v_mid;
disp(A_v,'gain at critical frequency')
```

Scilab code Exa 10.6 Bypass RC circuit BJT

```
//ex10.6
B_ac=100;
r_e=12;
R1=62*10^3;
R2=22*10^3;
R_S=1*10^3;
R_E=1*10^3;
C2=100*10^-6;
//Base circuit impedance= parallel combination of R1, R2, R_S
R_th=(R1*R2*R_S)/(R1*R2+R2*R_S+R_S*R1);
//Resistance looking at emitter
R_in_emitter=r_e+(R_th/B_ac);
//resistance of equivalent bypass RC is parallel combination of R_E,R_in_emitter
R=(R_in_emitter*R_E)/(R_E+R_in_emitter);
f_c=1/(2*%pi*R*C2);
disp(f_c,'critical frequency of bypass RC circuit in hertz')
```

Scilab code Exa 10.7 input RC circuit FET

```
//ex10.7
V_GS=-10;
I_GSS=25*10^-9;
R_G=10*10^6;
C1=0.001*10^-6;
R_in_gate=abs((V_GS/I_GSS));
R_in=(R_in_gate*R_G)/(R_G+R_in_gate);
f_c=1/(2*%pi*R_in*C1);
disp(f_c,'critical frequency in hertz')
```

Scilab code Exa 10.8 Low frequency response FET

```
//ex10.8
V_GS=-12;
I_GSS=100*10^-9;
R_G=10*10^6;
R_D=10*10^3;
C1=0.001*10^-6;
C2=0.001*10^-6;
R_in_gate=abs((V_GS/I_GSS));
R_in=(R_in_gate*R_G)/(R_G+R_in_gate);
R_L=R_in;     //according to question
f_c_input=1/(2*%pi*R_in*C1);
disp(f_c_input,'critical frequency of input RC
   circuit in hertz')
f_c_output=1/(2*%pi*(R_D+R_L)*C2)
disp(f_c_output,'critical frequency of output RC
   circuit in hertz')
```

Scilab code Exa 10.9 Low frequency response BJT

```
//ex10.9
B_ac=100;
r_e=16;
R1=62*10^3;
R2=22*10^3;
R_S=600;
R_E=1*10^3;
R_C=2.2*10^3;
R_L=10*10^3;
C1=0.1*10^-6;
C2=10*10^-6;
C3=0.1*10^-6;
//input RC circuit
R_in=(B_ac*r_e*R1*R2)/(B_ac*r_e*R1+B_ac*r_e*R2+R1*R2);
f_c_input=1/(2*%pi*(R_S+R_in)*C1);
disp(f_c_input,'input frequency in hertz')
//For bypass circuit; Base circuit impedance= parallel combination of R1, R2, R_S
R_th=(R1*R2*R_S)/(R1*R2+R2*R_S+R_S*R1);
//Resistance looking at emitter
R_in_emitter=r_e+(R_th/B_ac);
//resistance of equivalent bypass RC is parallel combination of R_E,R_in_emitter
R=(R_in_emitter*R_E)/(R_E+R_in_emitter);
f_c_bypass=1/(2*%pi*R*C2);
disp(f_c_bypass,'critical frequency of bypass RC circuit in hertz')
f_c_output=1/(2*%pi*(R_C+R_L)*C3)
disp(f_c_output,'output frequency circuit in hertz')
R_c=R_C*R_L/(R_C+R_L);
A_v_mid=R_c/r_e;
```

```
attenuation=R_in/(R_in+R_S);
A_v=attenuation*A_v_mid;    //overall voltage gain
A_v_mid_dB=20*log10(A_v);
disp(A_v_mid_dB,'overall voltage gain in dB')
```

Scilab code Exa 10.10 input RC circuit BJT

```
//ex10.10
B_ac=125;
C_be=20*10^-12;
C_bc=2.4*10^-12;
R1=22*10^3;
R2=4.7*10^3;
R_E=470;
R_S=600;
R_L=2.2*10^3;
V_CC=10;
V_B=(R2/(R1+R2))*V_CC;
V_E=V_B-0.7;
I_E=V_E/R_E;
r_e=25*10^-3/I_E;
//total resistance of input circuit is parallel combination of R1,R2,R_s,B_ac*r_e
R_in_tot=B_ac*r_e*R1*R2*R_S/(B_ac*r_e*R1*R2+B_ac*r_e*R1*R_S+B_ac*r_e*R2*R_S+R1*R2*R_S);
R_c=R_C*R_L/(R_C+R_L)
A_v_mid=R_c/r_e;
C_in_Miller=C_bc*(A_v_mid+1)
C_in_tot=C_in_Miller+C_be;
f_c=1/(2*%pi*R_in_tot*C_in_tot);
disp(R_in_tot, 'total resistance of circuit in ohms')
disp(C_in_tot,'total capacitance in farads')
disp(f_c,'critical frequency in hertz')
```

Scilab code Exa 10.11 Critical frequency BJT output

```
//ex10.11
C_bc=2.4*10^-12;    //from previous question
A_v=99;    //from previous question
R_C=2.2*10^3;
R_L=2.2*10^3;
R_c=R_C*R_L/(R_C+R_L);
C_out_Miller=C_bc*(A_v+1)/A_v;
f_c=1/(2*%pi*R_c*C_bc);    //C_bc is almost equal to
    C_in_Miller
disp(R_c,'equivalent resistance in ohms')
disp(C_out_Miller,'equivalent capacitance in farads'
    )
disp(f_c,'critical frequency in hertz')
```

Scilab code Exa 10.12 FET capacitors

```
//ex10.12
C_iss=6*10^-12;
C_rss=2*10^-12;
C_gd=C_rss;
C_gs=C_iss-C_rss;
disp(C_gd,'gate to drain capacitance in farads')
disp(C_gs,'gate to source capacitance in farads')
```

Scilab code Exa 10.13 Critical frequency FET input

```
//ex10.13;
```

```
C_iss=8*10^-12;
C_rss=3*10^-12;
g_m=6500*10^-6;     //in Siemens
R_D=1*10^3;
R_L=10*10^6;
R_s=50;
C_gd=C_rss;
C_gs=C_iss-C_rss;
R_d=R_D*R_L/(R_D+R_L);
A_v=g_m*R_d;
C_in_Miller=C_gd*(A_v+1);
C_in_tot=C_in_Miller+C_gs;
f_c=1/(2*%pi*C_in_tot*R_s);
disp(f_c,'critical frequency of input RC circuit in
   hertz')
```

Scilab code Exa 10.14 Critical frequency FET input

```
//ex10.14
C_gd=3*10^-12;     //from previous question
A_v=6.5;     //from previous question
R_d=1*10^3;     //from previous question
C_out_Miller=C_gd*(A_v+1)/A_v;
f_c=1/(2*%pi*R_d*C_out_Miller);
disp(f_c,'critical frequency of the output circuit
   in hertz')
```

Scilab code Exa 10.15 Bandwidth

```
//ex10.15
f_cu=2000;
f_cl=200;
BW=f_cu-f_cl;
```

```
disp(BW,'bandwidth in hertz')
```

Scilab code Exa 10.16 Bandwidth transistor

```
//ex10.16;
f_T=175*10^6;      //in hertz
A_v_mid=50;
BW=f_T/A_v_mid;
disp(BW,'bandwidth in hertz')
```

Scilab code Exa 10.17 Bandwidth 2stage amplifier

```
//ex10.17
f_cl=1*10^3;      //lower critical frequency of 2nd
   stage in hertz
f_cu=100*10^3;      //upper critical frequency of 1st
   stage in hertz
BW=f_cu-f_cl;
disp(BW,'bandwidth in hertz')
```

Scilab code Exa 10.18 Bandwidth 2stage amplifier

```
//ex10.18
n=2;     //n is the number of stages of amplifier
f_cl=500;
f_cu=80*10^3;
f_cl_new=f_cl/(sqrt(2^(1/n)-1));
f_cu_new=f_cu*(sqrt(2^(1/n)-1));
BW=f_cu_new-f_cl_new;
disp(BW,'bandwidth in hertz')
```

Chapter 11

Thyristors and Other Devices

Scilab code Exa 11.1 Four layer diode

```
//ex11.1
V_AK=20;    //VOLTAGE ACROSS ANODE
I_A=1*10^-6;
R_AK=V_AK/I_A;
disp(R_AK,'RESISTANCE IN OHMS')
```

Scilab code Exa 11.2 Anode current

```
//ex11.2
R_S=10^3;
V_BIAS=110;
V_BE=0.7;
V_CE_sat=0.1;
V_A=V_BE+V_CE_sat;    //VOLTAGE ACROSS ANODE
V_R_s=V_BIAS-V_A;    //VOLTAGE ACROSS R_S
I_A=V_R_s/R_S;
disp(I_A,'Anode current in amperes')
```

Scilab code Exa 11.3 Unijunction transistor

```
//ex11.3
n=0.6;
V_BB=20;
V_pn=0.7;
V_P=n*V_BB+V_pn;
disp(V_P,'peak point emitter voltage in volts')
```

Scilab code Exa 11.4 turn on off UJT

```
//ex11.4
V_BB=30;
V_P=14;
I_P=20*10^-6;
V_V=1;
I_V=10*10^-3;
x=(V_BB-V_P)/I_P;
y=(V_BB-V_V)/I_V;
disp('ohms',x,'R1 should be less than',)
disp('ohms',y,'R1 should be more than')
```

Scilab code Exa 11.5 Critical angle

```
//ex11.5
n2=1.3;     //cladding index
n1=1.35;     //core index
theta=acos(n2/n1);
t=theta*180/%pi;
disp(t,'critical angle in degrees')
```

Chapter 12

The Operational Amplifier

Scilab code Exa 12.1 CMRR opamp

```
//ex12.1
A_ol=100000;    //open loop voltage gain
A_cm=0.2;    //common mode gain
CMRR=A_ol/A_cm;
CMRR_dB=20*log10(CMRR);
disp(CMRR,'CMRR')
disp(CMRR_dB,'CMRR in decibels')
```

Scilab code Exa 12.2 Slew rate

```
//ex12.2
del_t=1;    // in microseconds
//lower limit is -9V and upper limit is 9V from the
   graph
del_V_out=9-(-9);
slew_rate=del_V_out/del_t;
disp(slew_rate,'slew rate in volts per microseconds'
   )
```

Scilab code Exa 12.3 Non inverting amplifier

```
//ex12.3
R_f=100*10^3;
R_i=4.7*10^3;
A_cl_NI=1+(R_f/R_i);
disp(A_cl_NI,'closed loop voltage gain')
```

Scilab code Exa 12.4 Inverting amplifier

```
//ex12.4
R_i=2.2*10^3;
A_cl=-100;    //closed loop voltage gain
R_f=abs(A_cl)*R_i;
disp(R_f,'value of R_f in ohms')
```

Scilab code Exa 12.5 Impedance noninverting amplifier

```
//ex12.5
Z_in=2*10^6;
Z_out=75;
A_ol=200000;
R_f=220*10^3;
R_i=10*10^3;
B=R_i/(R_i+R_f);    //B is attenuation
Z_in_NI=(1+A_ol*B)*Z_in;
Z_out_NI=Z_out/(1+A_ol*B);
A_cl_NI=1+(R_f/R_i);
disp(Z_in_NI,'input impedance in ohms')
```

```
disp(Z_out_NI,'output impedance in ohms')
disp(A_cl_NI,'closed loop voltage gain')
```

Scilab code Exa 12.6 Voltage follower impedance

```
//ex12.6
B=1;    //voltage follower configuration
A_ol=200000;
Z_in=2*10^6;
Z_out=75;
Z_in_VF=(1+A_ol)*Z_in;
Z_out_VF=Z_out/(1+A_ol);
disp(Z_in_VF,'input impedance in ohms')
disp(Z_out_VF,'output impedance in ohms')
```

Scilab code Exa 12.7 Impedance inverting amplifier

```
//ex12.7
R_i=1*10^3;
R_f=100*10^3;
Z_in=4*10^6;
Z_out=50;
A_ol=50000;
B=R_i/(R_i+R_f);    //attenuation
Z_in_I=R_i;    //almost equal to R_i
Z_out_I=Z_out/(1+(A_ol*B));
A_cl_I=-R_f/R_i;
disp(Z_in_I,'input impedance in ohms')
disp(Z_out_I,'output impedance in ohms')
disp(A_cl_I,'closed loop voltage gain')
```

---

check Appendix AP 2 for dependency:

`open_loop_gain.sci`

Scilab code Exa 12.8 Open Loop gain

```
//ex12.8
f_c_ol=100;
A_ol_mid=100000;
f=0;
A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
disp(A_ol,'open loop gain when f=0Hz');
f=10;
A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
disp(A_ol,'open loop gain when f=10Hz')
f=100;
A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
disp(A_ol,'open loop gain when f=100Hz')
f=1000;
A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
disp(A_ol,'open loop gain when f=1000Hz')
```

check Appendix AP 1 for dependency:

`phase_shift.sci`

Scilab code Exa 12.9 phase RC lag

```
//ex12.9
f_c=100;
f=1;
theta=phase_shift(f,f_c);
disp(theta,'phase lag when f=1Hz (in degrees)')
f=10;
theta=phase_shift(f,f_c);
```

```
disp(theta,'phase lag when f=10Hz (in degrees)')
f=100;
theta=phase_shift(f,f_c);
disp(theta,'phase lag when f=100Hz (in degrees)')
f=1000;
theta=phase_shift(f,f_c);
disp(theta,'phase lag when f=1000Hz (in degrees)')
f=10000;
theta=phase_shift(f,f_c);
disp(theta,'phase lag when f=10000Hz (in degrees)')
```

check Appendix AP 1 for dependency:

`phase_shift.sci`

Scilab code Exa 12.10 Gain and phase lag

```
//ex12.10
A_v1=40;    //all gains are in decibels
A_v2=32;
A_v3=20;
f_c1=2*10^3;
f_c2=40*10^3;
f_c3=150*10^3;
f=f_c1;
A_ol_mid=A_v1+A_v2+A_v3;
theta_1=phase_shift(f,f_c1);
theta_2=phase_shift(f,f_c2);
theta_3=phase_shift(f,f_c3);
theta_tot=theta_1+theta_2+theta_3;
disp(A_ol_mid,'open loop midrange gain in decibels')
disp(theta_tot,'total phase lag in degrees')
```

Scilab code Exa 12.11 Closed loop bandwidth

```
//ex12.11
A_ol_mid=150000;    //open loop midrange gain
B=0.002;    //feedback attenuation
BW_ol=200;    //open loop bandwidth
BW_cl=BW_ol*(1+B*A_ol_mid);
disp(BW_cl,'closed loop bandwidth in hertz')
```

Scilab code Exa 12.12 Amplifier bandwidth

```
//ex12.12
BW=3*10^6;    //unity gain bandwidth
A_ol=100;    //open loop gain
disp("non-inverting amplifier")
R_f=220*10^3;
R_i=3.3*10^3;
A_cl=1+(R_f/R_i);    //closed loop gain
BW_cl=BW/A_cl;
disp(BW_cl,'closed loop bandwidth in hertz')
disp("inverting amplifier")
R_f=47*10^3;
R_i=1*10^3;
A_cl=-R_f/R_i;
BW_cl=BW/(abs(A_cl));
disp(BW_cl,'closed loop bandwidth in hertz')
```

Chapter 13

Basic Opamp Circuits

Scilab code Exa 13.1 Comparator

```
//ex13.1
R2=1*10^3;
R1=8.2*10^3;
V=15;
V_REF=R2*V/(R1+R2);
disp(V_REF,'V_REF in volts')
V_max=12;     //maximum output level of op-amp
V_min=-12;     //minimum output voltage of comparator
f=1;     //assume frequency of input wave to be 1
   hertz
t=0:0.001:3;
V_in=5*sin(2*%pi*f.*t)
clf();
subplot(121)
xtitle('Input to comparator-1')
plot(t,V_in)
subplot(122)
xtitle('Output of Comparator-1')
a=bool2s(V_in>=V_REF)
```

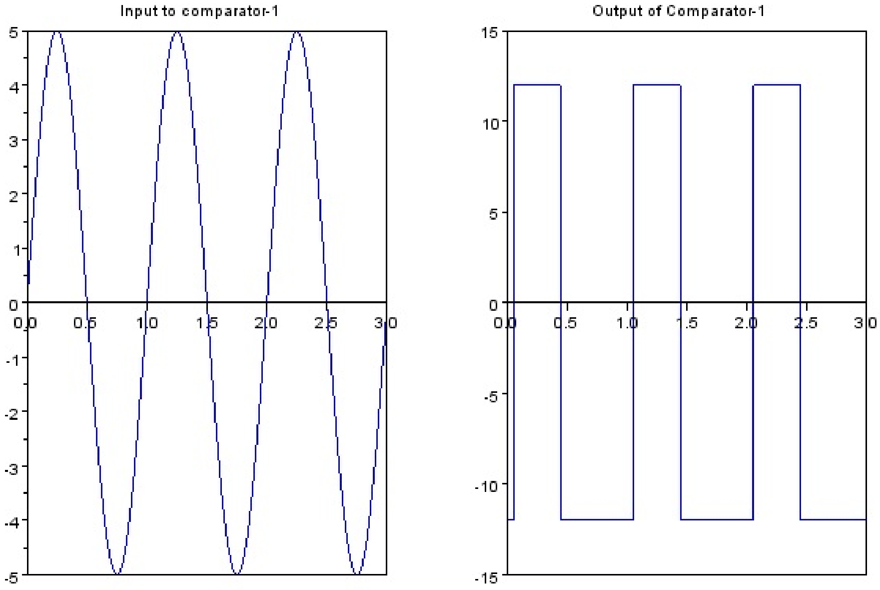


Figure 13.1: Comparator

```
b=~a;
y=V_max*a+V_min*b;
plot(t,y)
disp(V_max,'max output voltage in volts')
disp(V_min,'min output voltage in volts')
```

Scilab code Exa 13.2 Trigger points

```
//ex13.2
R1=100*10^3;
R2=R1;
V_out_max=5;
V_UTP=R2*V_out_max/(R1+R2);
V_LTP=-V_out_max*R2/(R1+R2);
disp(V_UTP,'upper trigger point in volts')
disp(V_LTP,'lower trigger point in volts')
```

Scilab code Exa 13.3 Comparator hysteris Zener bounding

```
//ex13.3
R1=100*10^3;
R2=47*10^3;
V_R1=4.7+0.7;     //one zener is always forward biased with forward voltage 0.7V
//V_R1 can be positive or negative
I_R1=V_R1/R1;
I_R2=I_R1;
V_R2=R2*I_R2;
V_out=V_R1+V_R2;     //positive or negative
V_UTP=R2*V_out/(R1+R2);
V_LTP=-V_out*R2/(R1+R2);
```

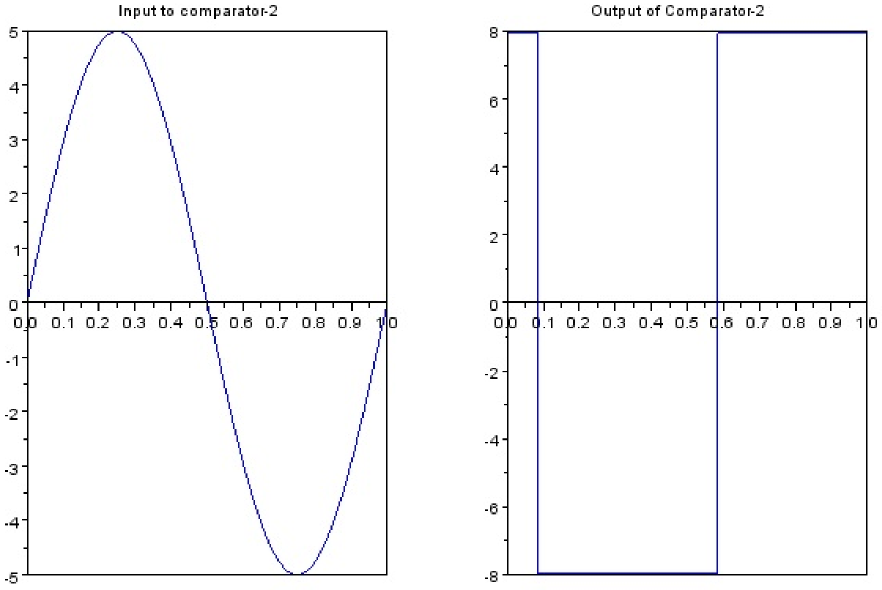


Figure 13.2: Comparator hysteris Zener bounding

```
f=1;     //assume frequency of input as 1 Hertz
t=0:0.001:1;
T=1/f;
V_in=5*sin(2*%pi*f.*t)
subplot(121)
xtitle('Input to comparator-2')
plot(t,V_in)
subplot(122)
xtitle('Output of Comparator-2')
t1=(1/(2*%pi*f))*asin((V_UTP/5))
a=bool2s(t<t1)
b=bool2s(t>((T/2)+t1))
a=bool2s(a|b)
b=~a;
y=V_out*a-V_out*b;
plot(t,y)
disp(V_out,'max output voltage in volts')
disp(-V_out,'min output voltage in volts')
```

Scilab code Exa 13.4 Summing amplifier unity gain

```
//ex13.4
V_IN1=3;
V_IN2=1;
V_IN3=8;
//all resistors are of equal value so weight of each
    input is 1
V_OUT=-(V_IN1+V_IN2+V_IN3);
disp(V_OUT,'output voltage in volts')
```

Scilab code Exa 13.5 Summing amplifier

```
//ex13.5
```

```
R_f=10*10^3;
R1=1*10^3;
R2=R1;
R=R1;
V_IN1=0.2;
V_IN2=0.5;
V_OUT=-(R_f/R)*(V_IN1+V_IN2);
disp(V_OUT,'output voltage of the summing amplifier
   in volts')
```

Scilab code Exa 13.6 Averaging amplifier

```
//ex13.6
R_f=25*10^3;
R1=100*10^3;
R2=R1;
R3=R1;
R4=R1;
R=R1;
V_IN1=1;
V_IN2=2;
V_IN3=3;
V_IN4=4;
V_OUT=-(R_f/R)*(V_IN1+V_IN2+V_IN3+V_IN4);
disp(V_OUT,'output voltage in volts')
V_IN_avg=(V_IN1+V_IN2+V_IN3+V_IN4)/4;
if abs(V_OUT)==V_IN_avg then
    disp('the amplifier produces an output whose
       magnitude is the mathematical average of the
       input voltages')
end
```

Scilab code Exa 13.7 Scaling adder

```
//ex13.4
V_IN1=3;
V_IN2=2;
V_IN3=8;
R_f=10*10^3;
R1=47*10^3;
R2=100*10^3;
R3=10*10^3;
weight_of_input1=R_f/R1;
weight_of_input2=R_f/R2;
weight_of_input3=R_f/R3;
V_OUT=-(weight_of_input1*V_IN1+weight_of_input2*
   V_IN2+weight_of_input3*V_IN3);
disp(weight_of_input1,'weight_of_input1')
disp(weight_of_input2,'weight_of_input2')
disp(weight_of_input3,'weight_of_input3')
disp(V_OUT,'output voltage in volts')
```

Scilab code Exa 13.8 Opamp integrator

```
//ex13.8
R_i=10*10^3;
C=0.01*10^-6;
V_in=2.5-(-2.5);
PW=100*10^-6;     //pulse width
T=2*PW;
A=2.5;
op_change_cap_charge=-V_in/(R_i*C);
op_change_cap_discharge=V_in/(R_i*C);
disp(op_change_cap_charge,'rate of change of output
   voltage with respect to time when capacitor is
   charging (in Volts per sec)')
disp(op_change_cap_discharge,'rate of change of
```

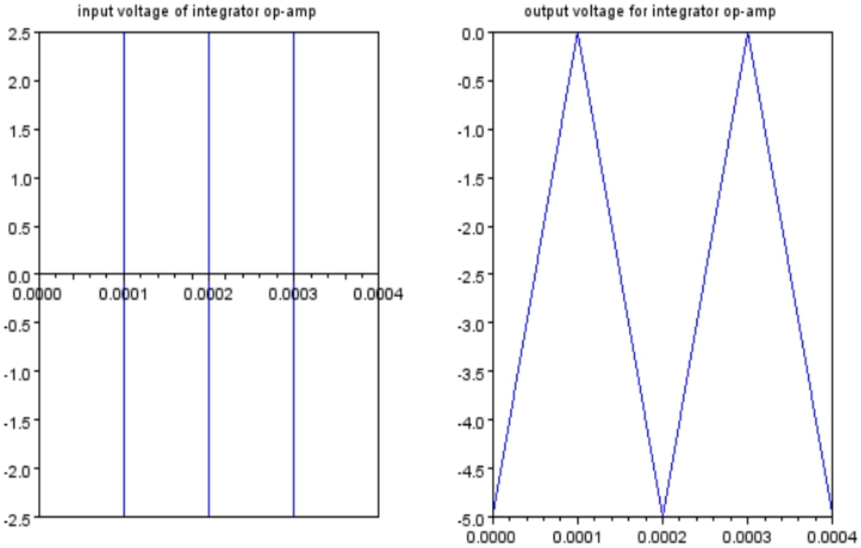


Figure 13.3: Opamp integrator

```
   output voltage with respect to time when
   capacitor is discharging (in Volts per sec)')
del_V_OUT=op_change_cap_discharge*PW;
disp(-del_V_OUT,'when input is positive , the slope
   is negative , when input is negative , the slope
   is negative. So, the output is a triangular wave
   varying from zero to')
subplot(121)
xtitle('input voltage of op-amp differentiator')
t=0:10^-7:2*T;
a=bool2s(t>=T/2 & t<=T)
b=bool2s(t>=1.5*T & t<=2*T)
a=bool2s(a|b)
b=~a;
y=-A*b+A*a;
plot(t,y)
subplot(122)
xtitle('output voltage of op-amp diferentiator')
x=[];
A=del_V_OUT;
for t=0:10^-7:2*T
   tcor = t- floor(t/T)*T;
    if tcor >= 0 & tcor < (T/2) then
         x_temp = -A +(2*A/T)*tcor;
      end;
      if tcor >= (T/2) & tcor <T then
           x_temp = A - (2*A/T)*tcor;
        end
         x = [x, x_temp];
     end;
t=0:10^-7:2*T;
plot(t,x)
```

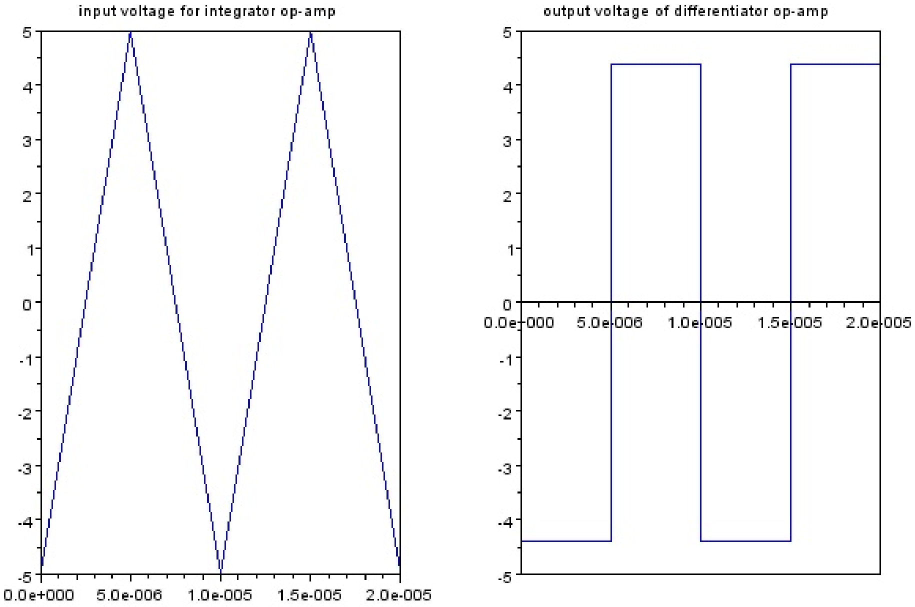


Figure 13.4: Opamp differentiator

Scilab code Exa 13.9 Opamp differentiator

```
//ex13.9
R_f=2.2*10^3;
C=0.001*10^-6;
Vc=5-(-5);
A=5;
time_const=R_f*C;
T=10*10^-6;
t=T/2;
slope=Vc/t;
V_out=slope*time_const;    //V_out is negative when input is positive and V_out is positive when input is negative
disp(V_out,'output voltage in volts is a square wave with peak voltages positive and negative of')
subplot(121)
xtitle('input voltage for integrator op-amp')
x=[];
for t=0:10^-8:2*T
   tcor = t- floor(t/T)*T;
    if tcor >= 0 & tcor < (T/2) then
         x_temp = -A +(4*A/T)*tcor;
      end;
      if tcor >= (T/2) & tcor <T then
           x_temp = 3*A - (4*A/T)*tcor;
        end
         x = [x, x_temp];
     end;
     t=0:10^-8:2*T;
     plot(t,x)
subplot(122)
xtitle('output voltage of differentiator op-amp')
a=bool2s(t>=T/2 & t<=T)
b=bool2s(t>=1.5*T & t<=2*T)
a=bool2s(a|b)
b=~a;
y=V_out*a-V_out*b;
```

```
plot(t,y)
disp(V_out,'max output voltage in volts')
disp(-V_out,'min output voltage in volts')
```

Chapter 14

Special Purpose Opamp Circuits

Scilab code Exa 14.1 Gain setting resistor

```
//ex14.1
R1=25*10^3;
R2=R1;
A_cl=500;     //closed loop voltage gain
R_G=2*R1/(A_cl-1);
disp(R_G,'value of the external gain setting
   resistor in ohms')
```

Scilab code Exa 14.2 Voltage gain Instrumentation amplifier

```
//ex14.2
R1=25.25*10^3;     //internal resistors
R2=R1;
R_G=510;
A_v=(2*R1/R_G)+1;
disp(A_v,'voltage gain')
```

```
BW=60*10^3;
disp(BW,'bandwidth from graph, in hertz')
```

Scilab code Exa 14.3 Isolation amplifier

```
//ex14.3
disp("cannot be shown in scilab")
```

Scilab code Exa 14.4 Voltage gain Isolation amplifier

```
//ex14.4
R_f1=22*10^3;
R_i1=2.2*10^3;
R_f2=47*10^3;
R_i2=10*10^3;
A_v1=(R_f1/R_i1)+1;     //voltage gain of input stage
A_v2=(R_f2/R_i2)+1;     //voltage gain of output
   stage
A_v=A_v1*A_v2;
disp(A_v,'total voltage gain of the isolation
   amplifier')
```

Scilab code Exa 14.5 Transconductance OTA

```
//ex14.5
g_m=1000*10^-6;
V_in=25*10^-3;
I_out=g_m*V_in;
disp(I_out,'output current in amperes')
```

Scilab code Exa 14.6 Voltage gain OTA

```
//ex14.6
V_BIAS=9;
V=V_BIAS;
R_BIAS=33*10^3;
R_L=10*10^3;
K=16;     //in microSiemens per microAmpere
I_BIAS=(V_BIAS-(-V)-1.4)/R_BIAS;
g_m=K*I_BIAS;
A_v=g_m*R_L;
disp(A_v,'voltage gain')
```

Scilab code Exa 14.7 Output OTA amplitude modulator

```
//ex14.7
V_MOD_max=10;
V_MOD_min=1;
V=9;
V_in=50*10^-3;
R_BIAS=56*10^3;
R_L=10*10^3;
K=16;     //in microSiemens per microAmpere
I_BIAS_max=(V_MOD_max-(-V)-1.4)/R_BIAS;
g_m_max=K*I_BIAS_max;
A_v_max=g_m_max*R_L;
V_out_max=A_v_max*V_in;
I_BIAS_min=(V_MOD_min-(-V)-1.4)/R_BIAS;
g_m_min=K*I_BIAS_min;
A_v_min=g_m_min*R_L;
```

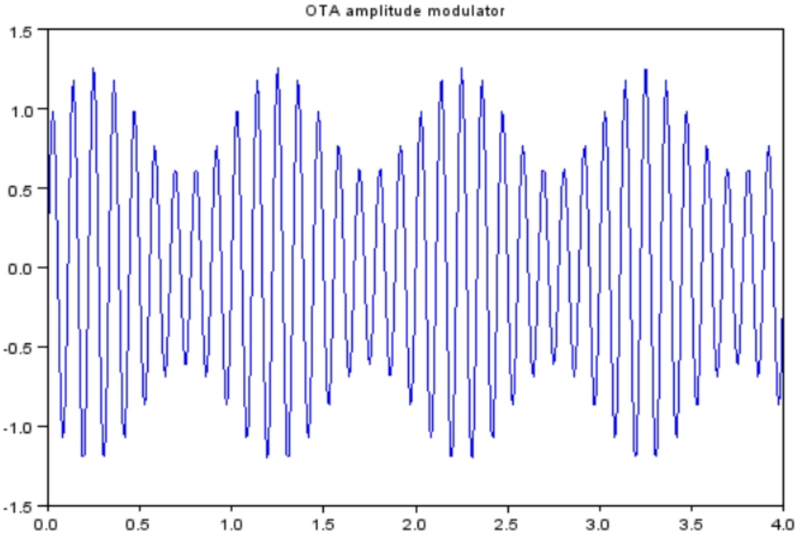


Figure 14.1: Output OTA amplitude modulator

```
V_out_min=A_v_min*V_in;
t=0:0.01:4;
f=1;     //assume frequency 1 hertz
y=((V_out_max/4-V_out_min/4)*sin(2*%pi*f.*t)+(
   V_out_min/2+V_out_max/2)/2).*sin(2*9*%pi*f.*t);
plot(t,y)
xtitle('OTA amplitude modulator')
```

Scilab code Exa 14.8 Output log amplifier

```
//ex14.8
V_in=2;
I_R=50*10^-9;
R1=100*10^3;
//voltage output for log amplifier
V_OUT=-0.025*log(V_in/(I_R*R1));
disp(V_OUT,'output voltage in volts')
```

Scilab code Exa 14.9 Transistor log amplifier

```
//ex14.9
V_in=3;
I_EBO=40*10^-9;
R1=68*10^3;
//voltage output for log amplifier
V_OUT=-0.025*log(V_in/(I_EBO*R1));
disp(V_OUT,'output voltage in volts')
```

Scilab code Exa 14.10 Antilog amplifier

```
//ex14.10
I_EBO=40*10^-9;
V_in=175.1*10^-3;
R_f=68*10^3;
V_OUT=-I_EBO*R_f*exp(V_in/0.025);
disp(V_OUT,'output voltage in volts')
```

Chapter 15

Active Filters

Scilab code Exa 15.1 Band pass filter

```
//EX15.1
f0=15*10^3;    //center frequency in hertz
BW=1*10^3;
Q=f0/BW;
if Q>10 then
    disp(Q,'narrow band filter')
end
```

Scilab code Exa 15.2 Butterworth response

```
//ex15.2
R2=10*10^3;
R1=0.586*R2;    //FOR BUTTERWORTH RESPONSE
disp(R1,'R1 in ohms')
disp('5.6kilo ohm will be ideally close to maximally
    flat butterworth response')
```

Scilab code Exa 15.3 Sallen Key lowpass filter

```
//ex15.3
R_A=1*10^3;
R2=1*10^3;
R_B=R_A;
R=R_A;
C_A=0.022*10^-6;
C_B=C_A;
C=C_A;
f_c=1/(2*%pi*R*C);     //critical frequency
R1=0.586*R2;     //for butterworth response
disp(f_c,'critical frequency in hertz')
disp(R1,'value of R1 in ohms')
```

Scilab code Exa 15.4 4 pole filter

```
//ex15.4
f_c=2860;
R=1.8*10^3;
C=1/(2*%pi*f_c*R);
R2=R;
R1=0.152*R2;     //BUTTERWORTH RESPONSE IN FIRST STAGE
R4=R;
R3=1.235*R4;     //BUTTERWORTH RESPONSE IN SECOND STAGE
disp(C,'capacitance in farads');
disp(R1,'R1 in ohms for butterworth response in first stage')
disp(R3,'R3 in ohms for butterworth response in second stage')
```

Scilab code Exa 15.5 Sallen Key highpass filter

```
//ex15.5
f_c=10*10^3;      //critical frequency in hertz
R=33*10^3;      //Assumption
R2=R;
C=1/(2*%pi*f_c*R);
R1=0.586*R2;      //for butterworth response
disp(C,'Capacitance in Farads')
disp(R1,'R1 in ohms taking R2=33kilo-ohms')
R1=3.3*10^3;      //Assumption
R2=R1/0.586;      //butterworth response
disp(R2,'R2 in ohms taking R1=3.3kilo-ohms')
```

Scilab code Exa 15.6 Cascaded filter

```
//ex15.6
R1=68*10^3;
R2=180*10^3;
R3=2.7*10^3;
C=0.01*10^-6;
f0=(sqrt((R1+R3)/(R1*R2*R3)))/(2*%pi*C);
A0=R2/(2*R1);
Q=%pi*f0*C*R2;
BW=f0/Q;
disp(f0,'center frequency in hertz')
disp(A0,'maximum gain')
disp(BW,'bandwidth in hertz')
```

Scilab code Exa 15.7 State variable filter

```
//ex15.7
R4=10^3;
```

```
C1=0.022*10^-6;
R7=R4;
C2=C1;
R6=R4;
R5=100*10^3;
f_c=1/(2*%pi*R4*C1);     //critical frequency in hertz for each integrator
f0=f_c     //center frequency
Q=(1+(R5/R6))/3;
BW=f0/Q;
disp(f0,'center frequency in hertz')
disp(Q,' value of Q')
disp(BW,'bandwidth in hertz')
```

Scilab code Exa 15.8 Band stop filter

```
//ex15.8
R4=12*10^3;
C1=0.22*10^-6;
R7=R4;
C2=C1;
R6=3.3*10^3;
Q=10;
f0=1/(2*%pi*R7*C2);
R5=(3*Q-1)*R6;
disp(f0,'center frequency in hertz')
disp(R5,'R5 in ohms')
disp('Nearest value is 100 kilo-ohms')
```

Chapter 16

Oscillators

Scilab code Exa 16.1 Wien bridge oscillator

```
//ex16.1
R1=10*10^3;
R2=R1;
R=R1;
C1=0.01*10^-6;
C2=C1;
C=C1;
R3=1*10^3;
r_ds=500;
f_r=1/(2*%pi*R*C);
disp(f_r,'resonant frequency of the  Wein-bridge oscillator in Hertz')
//closed loop gain A_v=3 to sustain oscillations
A_v=3;
//A_v=(R_f+R_i)+1 where R_i is composed of R3 and r_ds
R_f=(A_v-1)*(R3+r_ds);
disp(R_f,'value of R_f in ohms')
```

Scilab code Exa 16.2 Phase shift oscillator

```
//ex16.2
A_cl=29;     //A_cl=R_f/R_i;
R3=10*10^3;
R_f=A_cl*R3;
disp(R_f,'value of R_f in ohms')
//let R1=R2=R3=R and C1=C2=C3=C
R=R3;
C3=0.001*10^-6;
C=C3;
f_r=1/(2*%pi*sqrt(6)*R*C);
disp(f_r,'frequency of oscillation in Hertz')
```

Scilab code Exa 16.3 FET Colpitts oscillator

```
//ex16.3
C1=0.1*10^-6;
C2=0.01*10^-6;
L=50*10^-3;     //in Henry
C_T=C1*C2/(C1+C2);     //total capacitance
f_r=1/(2*%pi*sqrt((L*C_T)));
disp(f_r,'frequency of oscillation in Hertz when Q>10')
Q=8;     //when Q drops to 8
f_r=(1/(2*%pi*sqrt((L*C_T))))*sqrt((Q^2/(1+Q^2)));
disp(f_r,'frequency of oscillation in hertz when Q=8')
```

Scilab code Exa 16.4 Triangular wave oscillator

```
//ex16.4
R1=10*10^3;
```

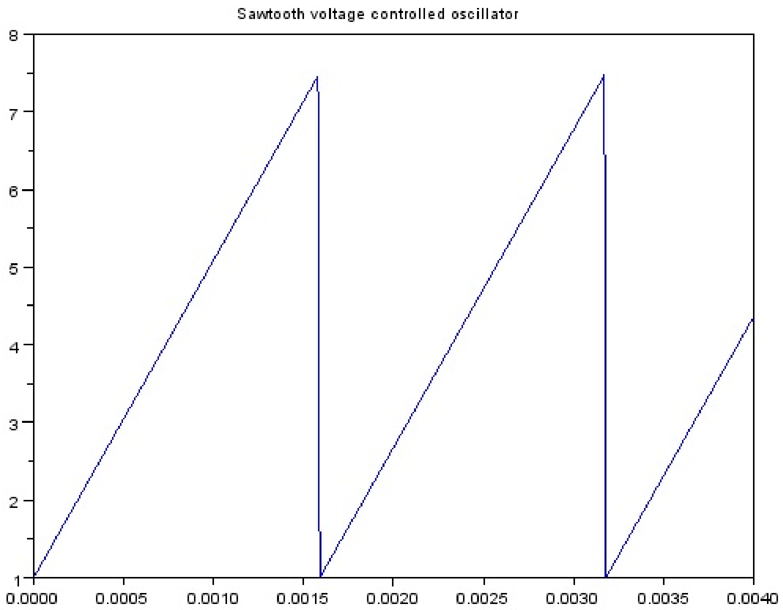


Figure 16.1: Sawtooth VCO

```
R2=33*10^3;
R3=10*10^3;
C=0.01*10^-6;
f_r=(1/(4*R1*C))*(R2/R3);
disp(f_r,'frequency of oscillation in hertz')
//the value of R1 when frequency of oscillation is 20 kHz
f=20*10^3;
R1=(1/(4*f*C))*(R2/R3);
disp(R1,'value of R1 in ohms to make frequency 20 kiloHertz')
```

Scilab code Exa 16.5 Sawtooth VCO

```
//ex16.5
V=15;
C=0.0047*10^-6;
R3=10*10^3;
R4=R3;
R2=10*10^3;
R1=68*10^3;
R_i=100*10^3;
V_G=R4*V/(R3+R4);    //gate voltage at which PUT turns on
V_p=V_G;    //neglecting 0.7V, this the peak voltage of sawtooth wave
disp(V_p,'neglecting 0.7V, this the peak voltage of sawtooth wave in volts')
V_F=1;    //minimum peak value of sawtooth wave
V_pp=V_p-V_F;
disp(V_pp,'peak to peak amplitude of the sawtooth wave in volts')
V_IN=-V*R2/(R1+R2);
f=(abs(V_IN)/(R_i*C))*(1/(V_pp));
disp(f,'frequency of the sawtooth wave')
T=1/f;
xtitle('Sawtooth voltage controlled oscillator')
x=[];
for t=0:1*10^-5:4*10^-3
   tcor = t- floor(t/T)*T;
           x_temp = (V_pp/T)*tcor + 1;
         x = [x, x_temp];
     end;
     t=0:1*10^-5:4*10^-3
     plot(t,x)
```

Scilab code Exa 16.6 555 timer

```
//ex16.6
R1=2.2*10^3;
R2=4.7*10^3;
C_ext=0.022*10^-6;
f_r=1.44/((R1+2*R2)*C_ext);
disp(f_r,'frequency of the 555 timer in hertz')
duty_cycle=((R1+R2)/(R1+2*R2))*100;
disp(duty_cycle,'duty cycle in percentage')
```

Chapter 17

Voltage Regulators

Scilab code Exa 17.1 Percentage line regulation

```
//Ex17.1
Del_V_out=0.25;
V_out=15;
Del_V_in=5;    //All voltages in Volts
line_regulation=((Del_V_out/V_out)/Del_V_in)*100;
disp(line_regulation,'line regulation in %/V')
```

Scilab code Exa 17.2 Load regulation percentage

```
//Ex17.2
V_NL=12;    //No load output voltage in Volts
V_FL=11.9;    //Full load output voltage in Volts
I_F=10;    //Full load current in milli-Amperes
load_regulation=((V_NL-V_FL)/V_FL)*100;
load_reg=load_regulation/I_F;
disp('load regulation as percentage change from no
   load to full load')
disp(load_regulation)
```

```
disp('load regulation as percentage change per
   milliampere')
disp(load_reg);
```

Scilab code Exa 17.3 Series regulator

```
//Ex17.3
//All voltages are in Volts and Resistances in Ohms
V_REF=5.1     //Zener voltage
R2=10*10^3;
R3=10*10^3;
V_out=(1+(R2/R3))*V_REF;
disp(V_out,'output voltage in volts')
```

Scilab code Exa 17.4 Overload protection

```
//Ex-17.4
R4=1;     //Resistance in Ohms
I_L_max=0.7/R4;
disp(I_L_max,'maximum current provided to load(in
   amperes)')
```

Scilab code Exa 17.5 Shunt regulator

```
//Ex17.5
V_IN=12.5;     //maximum input voltage in volts
R1=22;     //In Ohms
//Worst case of power dissipation is when V_OUT=0V
V_OUT=0;
V_R1=V_IN-V_OUT;     //Voltage across R1
```

```
P_R1=(V_R1*V_R1)/R1;     //maximum power dissipated
   by R1
disp(P_R1,'maximum power dissipated by R1 in WATTS')
```

Scilab code Exa 17.6 Positive linear voltage regulator

```
//Ex17.6
disp('SAME AS EX-2.8 in CHAPTER-2')
```

Scilab code Exa 17.7 External pass filter

```
//Ex17.7
I_max=700*10^-3;     //in Amperes
R_ext=0.7/I_max;
disp(R_ext,'value of resistor in Ohms for which max
   current is 700mA')
```

Scilab code Exa 17.8 Power rating 7824

```
//Ex17.8
V_OUT=24;     //Output voltage in Volts
R_L=10;     //Load resistance in Ohms
V_IN=30;     //Input voltage in Volts
I_max=700*10^-3;     //maximum interal current in
   Amperes
I_L=V_OUT/R_L;     //load current in amperes
I_ext=I_L-I_max;     //current through the external
   pass transistor in Amperes
P_ext_Qext=I_ext*(V_IN-V_OUT);     //power dissipated
```

```
disp(P_ext_Qext,'power dissiated(in WATTS) by the
    external pass transistor')
disp('For safety purpose, we choose a power
    transistor with rating more than this, say 15W')
```

Scilab code Exa 17.9 Current regulator

```
//Ex17.9
V_out=5;     //7805 gives output voltage of 5V
I_L=1;     //constant current of 1A
R1=V_out/I_L;
disp(R1,'The value of current-setting resistor in
    ohms is')
```

Chapter 18

Programmable Analog Arrays

Scilab code Exa 18.1 Switching capacitor

```
//Ex18.1
C=1000*10^-12;    //Switche capacitor value in
   farads
R=1000;    //resistance in ohms
T=R*C;    //Time period
f=1/T;    //Frequency at which switch should operate
disp(f,'Frequency at which each switch should
   operate(in hertz)' )
disp('Duty cycle should be 50%')
```

Appendix

Scilab code AP 1 Phase shift in degrees

```
function theta=phase_shift(f,f_c)
    theta_rad=-atan((f/f_c))
    theta=theta_rad*180/%pi;
endfunction
```

Scilab code AP 2 Open loop gain

```
function A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
    A_ol=A_ol_mid/(sqrt(1+(f/f_c_ol)^2))
endfunction
```

Scilab code AP 3 Voltage gain in decibel

```
function A_v_dB=gain_in_decibel_voltage(A_v)
    A_v_dB=20*log10(A_v)
endfunction
```

Scilab code AP 4 Power gain in decibel

```
function A_p_dB=gain_in_decibel_power(A_p)
    A_p_dB=10*log10(A_p)
endfunction
```

Scilab code AP 5 value of K

```
//VALUE OF K
```

```
function [k]=value_of_K(I_D_on,V_GS,V_GS_th)
          k=I_D_on/((V_GS-V_GS_th)^2)
endfunction
```

Scilab code AP 6 Drain current value

```
//value of I_D
function [i_d]= value_of_I_D(I_DSS,V_GS,V_GS_off)
    i_d=I_DSS*(1-(V_GS/V_GS_off))^2;
endfunction
```